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STUDY OF A FAIL-SAFE ABORT SYSTEM FOR AN ACTIVELY COOLED HYPERSONIC AIRCRAFT

— COMPUTER PROGRAM DOCUMENTATION —

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ABSTRACT

This report is a user's manual for the Fail-Safe Abort System TEMPerature Analysis Program, FASTEMP. This program was used to analyze fail-safe abort systems for an actively cooled hypersonic aircraft (Contract NASA-Langley, NAS1-13631). FASTEMP analyzes the steady state or transient temperature response of a thermal model defined in rectangular, cylindrical, conical and/or spherical coordinate system. FASTEMP provides the user with a large selection of subroutines for heat transfer calculations. The various modes of heat transfer available from these subroutines are:

- o Heat storage
- o Conduction
- o Radiation
- o Heat addition or generation
- o Convection
- o Fluid flow

These modes of heat transfer can be simulated by the program in the solution of one, two, or three dimensional heat transfer problems. The modes may be modeled by rectangular, cylindrical, conical and/or spherical geometries. Any combination of modes and geometries is allowed for analysis of either transient response or steady state temperatures.

The program obtains its solution using the backward-difference method. The maximum number of nodes that may be solved depends upon the thermal model and the solution method used with an absolute maximum of 9999 nodes.

The program is written in a combination of Fortran IV and Assembler language, COMPASS, for the CDC Series 6000 and CYBER Series Computers. Minimum core requirements are 47000_8 core locations on the Scope operating system.

This report contains general information on the program and is designed to aid the engineer in setting up a problem and obtaining solutions with a fast turnaround. Program structure, solution techniques, input data and program output are discussed. A sample problem is presented and program usage is discussed. The program input/output is designed for utilization of customary engineering units.

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NOMENCLATURE

Symbol	Definition
A	Area, in^2
CP	CDC Central Processor
C_p	Specific heat at Constant Pressure, Btu/lb-°R
F	Radiation View Factor
h	Heat Transfer Coefficient, Btu/hr-ft^2-°R
k	Thermal Conductivity, Btu/hr-ft-°R
$\dot{m}$	Mass Flow Rate, lb/hr
Ø	Stands for alphabetic letter O
Q	Heat Flux, Btu/hr
ΔT	Temperature Difference, °R
T	Temperature, °R
T_m	Boundary Temperature, °R
V	Volume, in^3
ΔX	Conduction Path Length, in
ε	Emissivity
ρ	Density, lb/ft^3
σ	Stefan-Boltzmann constant, 0.1714×10^{-8}, Btu/hr-ft^2-°R^4
b	Superscript, means leave a blank in given card column

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1. INTRODUCTION

This user's manual for the FASTEMP Heat Transfer Computer Program contains general information on program usage. The heat transfer program consists of a Thermal Analyzer (control subroutine) and user called subroutines, which are described in this user's manual. The computer code was written in Fortran IV and Assembler language (COMPASS) for the CDC 6000 and CYBER series computers. The user called subroutines are described in Appendix A.

This program was developed to analyze transient and steady state heat transfer problems. A problem is set up by defining a model which is made up of a finite number of lumped elemental volumes or nodes. Nodes are connected with the appropriate heat transfer terms. The user may model a very complex problem and is only limited by the amount of core available and solution accuracy. (Solution accuracy is discussed in Section 7.) The user may set up one, two or three dimensional problems using the following modes of heat transfer:

- o heat storage
- o conduction
- o radiation
- o convection
- o heat flux
- o fluid flow

The modes of heat transfer may be modeled with rectangular, cylindrical, conical and/or spherical geometries.

The program obtains a solution for temperatures using the backward finite difference method for the heat balance equations. This method results in a set of simultaneous equations which are solved. Several matrix solutions are available which optimize core or computer time. The maximum number of nodes (equations) in the thermal model depends on the selection of heat transfer modes and the matrix solution chosen as well as available computer core. The absolute maximum number of nodes which may be run is 9999 nodes. This limit is imposed by programming constraints using a four column field to specify node numbers.

The primary output of the computer program is a tabulation of the temperature of each node at problem times specified by the user. Additional output is printed for some heat transfer subroutines as described in Appendix A.

This user's manual is based on the program write-ups presented in References (1) and (2). The program reported herein and the referenced program are data compatible although operational on different computers for over nine years. Reference (2) program contains additional subroutines which allow building thermal models using phase change, aeroheating or orbital flux calculations, and other analysis oriented subroutines.

2. PROGRAM STRUCTURE

FASTEMP contains a thermal analyzer control subroutine which interfaces between the user and the computer system. The user initiates the job by compiling a subroutine (EQDAT) which calls heat transfer mode subroutines. The compiled EQDAT subroutine is loaded with the thermal analyzer controller and the library of user called subroutines and execution is initiated. The user then supplies data for the called subroutines and a model is analyzed by the program. A heat transfer problem may be analyzed using a full set of data, called a basic case, or a partial set of data which are changes to a previously run case. (Input for basic and change cases is discussed in Section 4.)

Job control language (JCL) cards are also required for each job to load and execute the program. The JCL is a function of the computer system and is not covered in this report.

After loading, the execution of the main program is initiated. The control subroutine calls the subroutine EQDAT which is required and compiled for each job. This subroutine in turn calls the subroutines needed to describe the model to be analyzed. The call establishes the order in which the subroutine data must be input to the program. An example of Subroutine EQDAT is shown below:

```
SUBROUTINE EQDAT
CALL SRA      )
CALL DRA      )
    .         )
    .         )   Subroutines called by user
    .         )
CALL RRA      )
RETURN
END
```

In developing an effective tool useful for analysis of both small models (less than 20 nodes) and large models (over 100 nodes), the program was structured into input, setup and computing sections.

These are designed as the M (minus), the Z (zero), and the P (plus) phases of the program as denoted by the sign of the control key. The M phase preprocesses the input data cards for a case. Error messages are written if any data cards are missing (if required), unrecognizable or in the wrong order. If the case being processed is a change case, the cards will be merged with those of the case being changed. The program has two levels of change case capability. Any number of change cases may be run which change the basic case. A change case may also be run which changes the most recent change case. The Z phase reads the numeric input values, performs error checks, computes constants using geometrical data and stores the data for use by the P phase. The P phase computes the heat flux terms for each node, solves the heat balance matrix for node temperatures, and controls the output of the program.

Several computer clocking points are provided in the program. The computer time at the beginning of the M phase will be printed with the message time expended = XX CP (SEC). The computer time at the end of the Z phase will be printed with the same message. At the end of a case, the clocking printed is the amount of time for the P phase (time step calculations). All clocking times are computer central processor times and are printed in seconds.

The Thermal Analyzer control subroutine uses a dynamic core allocation subroutine which allows the core requirement for the program to vary in size as a function of the size of the model being analyzed. The program prints the number of locations used by the subroutines and that remaining of the core size specified for the job at several stages in the running of a case. The printed messages are self explanatory.

The P phase is used to compute temperatures from data supplied by the user. The analysis is a time transient calculation at intervals composed of a user supplied time step schedule. A time step is processed in the following manner. The P phase calls Subroutine TIMST to calculate the time step interval from user data. Then Subroutine EQDAT is called. Subroutine EQDAT calls the heat transfer method subroutines which compute and store the matrix coefficients for each heat transfer term. Properties which are a function of node temperature are evaluated at the known temperatures at the beginning of a time step. Values which are a function of problem time are evaluated for backward finite differences at the time at the end of the time step. Subroutine SOLVE is called after the matrix coefficients have been computed and stored by Subroutine EQDAT. Subroutine SOLVE calls the matrix solution subroutine (MSOLV), and the print subroutine (PRINT). Subroutine MSOLV is called to compute the node temperatures and Subroutine PRINT is called to output the results (if requested). The computed temperatures are stored as the known temperatures for use during the next time step, the matrix locations are set to zero, the problem time is updated, and the above computations are repeated.

3. SOLUTION METHODS

A heat transfer problem is analyzed by defining a model consisting of a finite number of nodes. The nodes or elemental volumes are considered to be isothermal at any given time during the analysis. A heat balance is written for each node using the heat transfer subroutines which are explained in Appendix A. Most of the terms in the heat balance are heat flux terms, however, some are energy terms, e.g. fluid transport terms ($\dot{m}\, C_p\, \Delta T$). In this report the term heat balance includes heat flux terms and energy terms. The heat balance for a node is not restricted to any number of terms for a given mode of heat transfer, and the heat balance for a node may be written as:

$$\Sigma Q \text{ stored} = \Sigma Q \text{ conduction} + \Sigma Q \text{ convection} + \Sigma Q \text{ radiation} + \Sigma Q \text{ misc.}$$

All terms in the equations have the units of Btu/hr. Program temperatures are in degrees Rankine internally although input of initial temperatures and output of computed temperatures may be in either Rankine or Fahrenheit at the users option. A consistent set of units is used for dimensions, e.g., lengths are input in inches and areas in square inches except where otherwise specified.

The thermal analyzer uses heat balance equations formulated for each node using the backward finite difference method (Reference (3)). A set of simultaneous equations results with coefficients stored in matrix form. The user may optionally select one of several different matrix solutions (called METHODS) to optimize the core requirements or solution time.

3.1 BACKWARD DIFFERENCE SOLUTION (METHODS 3 THROUGH 8)

The backward difference heat balance equation expresses all heat fluxes in terms of the temperatures and boundary conditions at the end of a time step. The general form of the backward difference heat balance for one node is:

$$\frac{\rho\, C_p\, V\, (T' - T^\circ)}{\Delta\tau} = \frac{kA}{\Delta X}\,(T'_m - T') + hA\,(T'_m - T') + \sigma\varepsilon FA\,(T'^4_m - T'^4) + Q'_m$$

where T' = unknown node temperature at end of time step

T° = known node temperature at beginning of time step

T'_m = known boundary or unknown surrounding node temperatures at the end of time step

This expression is used to represent a set of simultaneous equations, linear in in T with the exception of the T^4 radiative heat flux terms. An approximate linearized term is substituted for radiative terms to allow the simultaneous solution of equations which are linear in T. (The approximation used for linearization is presented in Appendix B.) The backward difference equation solution is always stable. However, increasing the time step increases truncation errors in the solution and the user must tailor his time step to the boundary conditions. A general discussion of this aspect is given in Reference (3).

Thermal models produce matrices which can vary widely with respect to the connection of equations represented by the matrix coefficients. The thermal analyzer has several matrix solution methods to allow the user to specify the most efficient solution technique for a given problem. The efficiency of the specialized solutions results from reductions in computer core storage and/or running time. A brief description of methods 3, 4, 6 and 8 supplied in this program is given below.

Method 3 - This method uses a full square matrix. Method 3 may be used for any backward difference problem, however, it will waste computer core space for many problems.

Method 4 - This method uses a tridiagonal matrix which consists of terms on the principal diagonal and the first term on each side of the principal diagonal. This solution uses minimum computer core. This type of matrix results, for example, from a one dimensional thermal model.

Method 6 - This method uses a K-diagonal matrix which consists of the principal diagonal terms and K terms on each side of the principal diagonal terms. The value of K (the half band-width) may be specified by the user or automatically computed by FASTEMP. FASTEMP will also determine the minimum storage for the heat balance equations and set the solution method to 6, if advantageous.

Method 8 - This method uses the Gauss-Siedel iterative solution The only matrix terms stored are the principal diagonal terms, nonzero off diagonal terms, and the constant terms. This solution will use a very small computer core space for many problems compared to the other methods discussed above. No computations are performed on zero off diagonal terms. The relative economy of using this solution will increase with problem size. The method is not recommended for models with zero or low mass nodes.

4. PROGRAM INPUT

The input for a FASTEMP analysis consists of three distinct types: Job Control Language (JCL) cards, subroutine specification cards, and model input data. Figure 1 shows the order of the input card groups for a job that consists of one case. Data input forms are given in Appendices A and C.

The JCL input is shown in Figure 1 as groups 1, 4 and 12. These cards are a requirement of the computer system being used. The JCL card input is not presented in this user's manual since the computer system requirements are frequently changed. The user should contact the computer support group for the current JCL input requirements.

The user is allowed to code FORTRAN subroutines for inclusion in EQDAT calls. These are input as shown in Figure 1 as group 2. Group 3 is Subroutine EQDAT which calls the heat transfer subroutines, e.g., SRA (heat storage), DRA (conduction), etc.

The model input data is shown in Figure 1 as groups 4 through 10. This data describes the model being analyzed and is explained in the remainder of this section. Group 11 is the last FASTEMP data card.

4.1 PROGRAM SPECIFICATION CARDS

FASTEMP uses a dynamic loading technique which loads into the computer core only those subroutines required for each job. The Thermal Analyzer Subprogram is called by the main program and in turn requires user coding of subroutine EQDAT.

The heat transfer method subroutines described in Appendix A must be called from Subroutine EQDAT. The subroutines supplied are independent and may be called in any order. However, the input data for the heat transfer method subroutines must be in the same order that the subroutines are called in Subroutine EQDAT. Failure to do this will cause a program error and a message to be printed. An example of Subroutine EQDAT is shown below:

Card Column	Contents	
7-22	SUBROUTINE^{b}EQDAT	
7-15	CALL^{b}QCRA	as many subroutine calls as required
7-14	CALL^{b}SRA	
.	.	
.	.	
7-12	RETURN	
7-9	END	

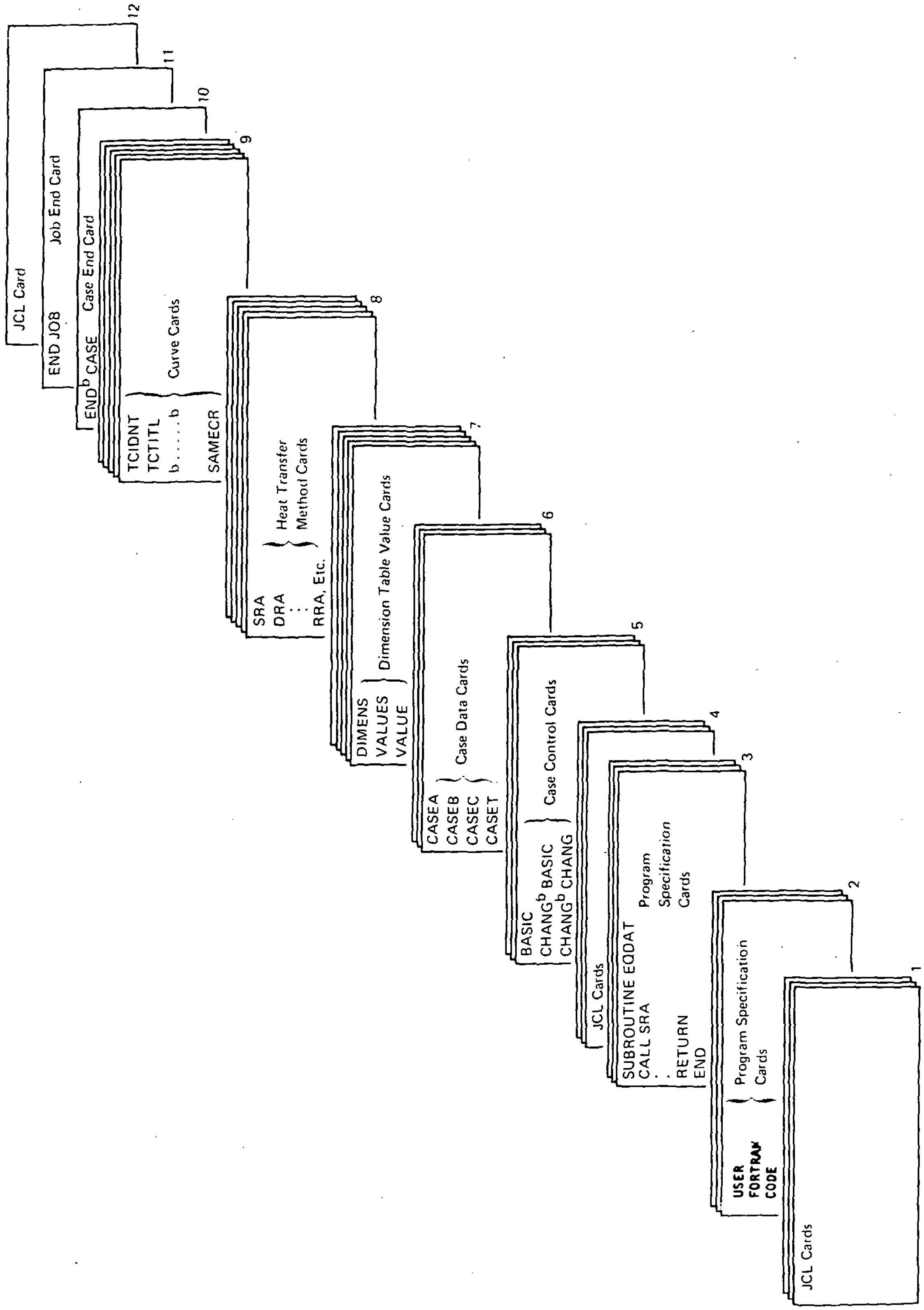


FIGURE 1 - INPUT CARD ORDER

All calls to heat transfer method subroutines start in column 7 and are standard FORTRAN cards. Heat transfer method subroutines may be called more than once in Subroutine EQDAT but they must be separated by a call to a different subroutine to correctly separate data groups. Data input format options are grouped and may be a reason for calling a subroutine more than once as explained in Section 4.4.

The card names must be punched in the card columns shown. Integer values on the case cards are indicated by a single card column number and must be right justified. Real values are designated with two card column numbers and must be punched with a decimal point and within the field shown.

4.2 CASE DATA CARDS

The CASEA card specifies a title for the case which is printed as the first line on each program output sheet. The CASEA card format is:

Card Column	Name	Value
1-5	CN	CASEA
7-80	TITLE	User title

The CASEB card contains the alphanumeric case name, the number of nodes, a print control, an orbit control option, the solution method number, and a nonsequential node option. The CASEB data card format is:

Card Column	Name	Value
1-5	CN	CASEB
10-15	NCASE	Alphanumeric case name
20	NCA	Number of nodes
25	MPRNT	Master print control
30	NØRBIT	Number of orbits
35	METHOD	Finite difference solution method
		3 - backward difference (square matrix)
		4 - backward difference (tridiagonal matrix)
		6 - backward difference (K-diagonal matrix)
		8 - backward difference (Gauss-Seidel iteration)
50	NSW	Nonsequential node option
		0 - use sequential nodes
		1 - use nonsequential nodes

The master print control may be used to surpress or to print subroutine and curve data input. MPRNT is used in conjunction with a print control on the subroutine and curve data cards (NPRNT). The value MPRNT + NPRNT is computed for each subroutine and each curve and the following criteria is used:

if (MPRNT + NPRNT) > 0 subroutine or curve data not printed

if (MPRNT + NPRNT) $\leq$ 0 subroutine or curve data printed

The orbit control option, NORBIT, is used to recycle the program through the time history NORBIT times with initial temperatures continually updated. This is used primarily to simulate orbit operation but can also be used to calculate steady state conditions.

Cases may be run with either sequential or nonsequential node numbering. The sequential option requires the nodes to be numbered 1 through NCA and the node numbers and equation numbers are the same. The nonsequential node option allows node numbers of 1 through 9999 and the equation numbers (1 through NCA) are assigned in the order that the nodes are encountered in the input data.

The CASEC card contains the case beginning time, the case final time, the maximum temperature allowed, the minimum temperature allowed, the initial temperature option, a constant to be added to all initial temperatures and a solution method parameter. The CASEC data card format is:

Card Column	Name	Value
1-5	CN	CASEC
11-20	BTIME	Beginning time
21-30	FTIME	Final time
31-40	TMAX	Maximum temperature allowed (°R) - any computed temperature above this value will cause termination of the case
41-50	TMIN	Minimum temperature allowed (°R) - any computed temperature below this value will cause termination of the case
51-60	TEQAL	Initial temperature option if TEQAL > 0 - set all initial temperatures to TEQAL = 0 - read initial temperatures from CASET cards < 0 - use final temperatures from preceding case as initial temperatures
61-70	ADD2T	Constant which is added to all initial temperatures

CASET cards are only required if the value for TEQAL on the CASEC card is zero. An initial temperature must be input for each node, five temperatures per card. For a sequential node case, the temperatures must be input in the order 1 through NCA. For the nonsequential use, the initial temperatures must be input in the order of the equations. The equation order is a result of the order in which the program encounters the node numbers in the user's subroutine data and care must be exercised when modeling change cases which add or remove subroutine data cards and would change code number appearance order.

A number of cases may be run serially with the final temperatures of each case used as the initial temperatures for the following case. The number of nodes in the following case must be less than or equal to the number of nodes in the preceding case. A larger number of nodes in the succeeding case will cause an error to be counted, values to be assumed for the missing temperatures and one time step to be run. Initial temperatures will be assigned using the equation order from the previous case.

The CASET data card format is:

Card Column	Name	Value
1-5	CN	CASET
11-20 21-30 31-40 41-50 51-60	TI	Initial temperature values (input in equation number order)

The case data is checked for errors, during the Z-phase, and errors may cause the following messages to be output:

1) number of nodes wrong
2) method wrong
3) matrix half bandwidth wrong
4) beginning or final time wrong
5) T_{max} or T_{min} wrong
6) too few CASET cards
7) too few temperatures from last case

Missing or incorrect data values are assumed and counted as errors. The assumed values which are used may cause or hide other errors. If errors are detected, the program will run only one time step.

4.3 DIMENSION TABLE CARDS

The dimension table is used to input values which are required by the heat transfer subroutines. The dimension table input is optional since it need not be used for heat transfer subroutines data input. (See discussion of subroutine data input - Section 4.4.) The dimension table is input by a group of cards. The first card in the group must be a DIMENS card which has the following format:

Card Column	Name	Value
1-6	CN	DIMENS
10	NVAL	Number of dimension table values

The remaining cards in the group may be either VALUE or VALUES cards. The VALUE card specifies an index and one dimension table value. The VALUE data card format is:

Card Column	Name	Value
1-5	CN	VALUE
10	IND	Index of Value
11-25	VAL	Value

The VALUES card specifies the value of four consecutive dimension table values. The VALUES data card format is:

Card Column	Name	Value
1-6	CN	VALUES
10	IND	Index of first value
11-25	VAL1	Value IND
26-40	VAL2	Value IND+1
41-55	VAL3	Value IND+2
56-70	VAL4	Value IND+3

Dimension table values may be input in any order. If a value is input more than once, the last value specified will be used for the case. If a table value index is out of the range specified for the table, that index will extend the table by as many values as required only when IND > NVAL from DIMENS card. Dimension table values which have not been defined will contain a large number (1.265×10^{322}). The card columns indicated for the number of dimension table values (NVAL) and the value index (IND) specify the right hand column of a four digit integer field, and digits in these fields must be right justified. The data card columns for the table values represent real data fields and values in these fields should be punched with a decimal point with right justification necessary for exponent (if used).

4.4 HEAT TRANSFER METHOD SUBROUTINE CARDS

The heat transfer method subroutines are used to describe the model being analyzed. Subroutines are available to compute various modes of heat transfer, e.g., heat storage, conduction, radiation, convection, heat flux, and fluid flow. These subroutines are available with rectangular, cylindrical, conical and spherical geometries to facilitate the description of the model.

The subroutine data is input in groups of cards. One group of subroutine data is input for each subroutine in the same order that the subroutines are called in Subroutine EQDAT. A group of data input for a heat transfer method subroutine must start with a zero card number. The zero data card format is:

Card Column	Name	Value
1-6	SN	Subroutine name (SRA, DRA, etc.)
14	NCARD	0
22	NPRNT	Subroutine input data print control if (NPRNT + MPRNT) > 0, input data not printed ≤ 0, input data printed
26	NFMT	Format if NFMT = 0, 1 general format 1 2 general format 2
30-70	IVAL	Integer data for some subroutines - 4 column fields

The subroutine name must be punched starting in card column one. All other values on this card are integer values and must be right justified in the card columns shown. The remaining cards included in the group of data input for each subroutine are input with either General Formal 1 or General Format 2.

General Formal 1 provides for the input of decimal data directly on the subroutine data cards. The data card format for General Format 1 is:

Card Column	Name	Value
1-6	SN	Subroutine name (SRA, DRA, etc.)
10	CC	Change code (See Section 4.9.3)
14	NCARD	Card number

Card Column	Name	Value
18	NX1	Integer data fields
22	NX2	
26	NX3	
30	NX4	
31-40	X1	Real data fields
41-50	X2	
51-60	X3	
61-70	X4	

The subroutine name must be punched starting in column one. Integer values are indicated by a single card column number and must be right justified. Real values are designated with two card column numbers and must be punched with a decimal point within the field shown. (Any exponent is right justified.)

General Formal 2 requires the use of the dimension table described in Section 4.3. Only integer values are input on the card. Some of the integer values refer to locations in the dimension table where the decimal data is input. The data card format for General Formal 2 is:

Card Column	Name	Value
1-6	SN	Subroutine name (SRA, DRA, etc.)
10	CC	Change code
14	NCARD	Card number
15-70	NX1-NX14	14 fields with 4 columns each

The subroutine name must be punched starting in column one. All other values on this type of card are integers and must be right justified in their data fields.

Card numbers are not required for a base case or change case; however, if individual cards are to be altered or added in a change case, card numbers must be used to identify the cards to be changed or added. No order of card numbers is required and any number of cards may use the same number. All cards with the same number are dropped in a change case, if requested.

All subroutines are available in General Format 2; however, the number of subroutines available in General Format 1 is considerably smaller. Some heat transfer method subroutines require more data input than is possible on a single card using General Formal 1.

The use of General Format 1 has the advantage of having the numeric values on the subroutine input card where they may be easily checked. An advantage in using General Format 2 is that the same dimension table location may be used for a series of node dimensions or multipliers and changing one value in the dimension table effectively changes these values used throughout the case. A model may be set up in such a way that both general formats are desired for the same subroutines. This requires that the subroutine be called twice in Subroutine EQDAT and be separated by another data subroutine. A complete description of the heat transfer method subroutines is given in Appendix A.

The heat transfer method subroutine data is checked for errors, during the Z phase, and the following messages may be output:

1) Node number wrong
2) Node connection wrong
3) Subroutine references wrong dimension table value
4) Subroutine called had no data.

Additional information is output after the heat transfer method subroutine data has been processed in the Z phase:

1) A nonsequential node case will output an equation number/node number table which allows the equations to be identified. This is required to check out matrix error messages
2) A table listing the number of references for an equation number
3) A table listing the number of internodal connections for each equation
4) The total number of internodal connections
5) The maximum internodal connection band (the matrix half bandwidth)
6) A table listing the minimum equation number that is coupled to the equation listed
7) A table listing the maximum equation number that is coupled to the equation listed.

4.5 CURVE CARDS

The curves required for a case are each identified by a curve relative number (NRELN), a type (NTYPE), and a class (NCLAS). Curve relative number is generally assigned by the user, and the type and class are denoted according to the usage of the curve. Throughout this manual curves are designated by a three number system, i.e., "(NRELN, NTYPE, NCLAS)." The curves are a functional form which consists of one independent variable as a function of 0 through 2 independent variables (1 through 3 dimensional curves). The number of dimensions and the independent variables for a curve are selected by the user. All independent variable values must be computed before a curve may be used. Commonly used curve arguments are set up automatically in the program; however, the user may specify and set up special curve arguments.

The curves required for a case may be input by two methods; same curve and temporary curve. Any required curve may be input by any method.

The same curve method specifies that the required curve be the same as another curve. Input of this second curve by temporary curve method will satisfy the input requirement for the first curve. The SAMECR data card format is:

Card Column	Name	Value
1-6	CN	SAMECR
10	NRELN	Required curve relative number
14	NTYPE	Required curve type
18	NCLAS	Required curve class
30	NRELN2	Relative number of same curve
34	NTYPE2	Type of same curve
38	NCLAS2	Class of same curve

The temporary curve method inputs the required curve directly by cards. The curve is input by a set of consecutive cards. The first card must be the curve identification card (TCIDNT). This card specifies the curve identification, the curve form and other information which describes the curve. The TCIDNT data card format is:

Card Column	Name	Value
1-6	CN	TCIDNT
10	NRELN	Curve relative number
14	NTYPE	Curve type
18	NCLAS	Curve class
22	--	--
26	NPRNT	Print control if (NPRNT + MPRNT) > 0, input data not printed $\leq$ 0, input data printed
30	NDIMN	Curve "dimension," may be values (0 to 3) (see discussion below)
34 42	NPTSi	Number of points argument i (i - 1, 2)
38 46	NARGi	Argument i type (i = 1, 2)

The second card is the curve title card (TCTITL) which is optional. The TCTITL data card format is:

Card Column	Name	Value
1-6	CN	TCTITL
7-80	CT	Curve title

The remaining cards are the curve value cards. The curve value data card format is:

Card Column	Name	Value
1-6	CN	Blank field
11-25 26-40 41-55 56-70	CV	Curve values

For curves with a value of NDIMN = 1 or 0, the dependent value is a constant, i.e., a function of no independent variable. The constant value is input in the second data field of the value card as shown in Figure 2A.

Curves which are a function of one independent variable, y = f(x), have a value of NDIMN = 2. The NDIMN = 2 option is a curve which is interpolated linearly between points. The curve values are input with two point pairs per card as shown in Figure 2B.

All curves with multiple independent variables must be input with a regular grid, e.g., an NDIMN = 3 curve is represented as y = f(x,z) and the sets of x values must be the same for all values of z. The three dimensional curve values are input in the following manner: 1) starting on the first curve value card, the values for independent variable one are input in ascending order, four per card; 2) starting on a new card, the values for independent variable two are input in ascending order four values per card; 3) starting on a new card, the values for the dependent variable are input in the order of all values for the second independent variable are input in the order of the first independent variable, all values for the second independent variable and the second value of the first independent variable, etc. An example of the input for a three dimensional curve is shown in Figure 2C.

During the loading of a curve, extensive checks are made. Any errors which are detected are written on the output. These messages consist of the following:

1) A curve has an invalid identification
2) A curve has been input which is not required
3) A curve has been input more than once
4) The same curve requested is missing
5) A curve has an invalid dimension
6) A curve has an incorrect number of values
7) A curve has incorrect arguments
8) A curve has independent variables which are not in ascending order
9) A curve requested is missing.

If any errors are detected, an error message is written specifying that the curve has been rejected.

The card columns for the data fields of the SAMECR and TCIDNT cards specify the right hand card column of a four digit integer field. The data values must be right justified in these fields. The card columns for the curve value cards specify a real data field. These values should be punched with a decimal point with any exponent right justified.

The user must specify the arguments used to perform a table lookup. The independent variable arguments are specified on the TCIDNT card. The following commonly used argument numbers are specified by the program:

Argument Number	Argument
1	Time Method 3 through 8 - end of time step
2	Temperature (can be the temperature of a node or other values - see heat transfer method subroutine writeups in Appendix A).
650+NN	Temperature of Equation NN.

Other arguments are automatically computed for the heat transfer method subroutines and these arguments are defined in the subroutine writeups (Appendix A). The user may set up arguments for a specific use, e.g., altitude, velocity, Mach number, etc., by using Subroutine Curves (see Appendix A). It is recommended that special arguments be limited to argument numbers 11 through 19 to avoid conflict with built-in curve arguments.

Two curves are always required for a case: 1) the calculation interval or time step curve (1, 10, 1), and 2) the print interval for outputting results (1, 10, 2). The input of these curves may be satisfied by either of the two methods of inputting a curve, i.e., temporary curves or same curves.

FASTEMP	GENERAL HEAT TRANSFER	TEMPORARY CURVE INPUT 2

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS1 34	NARG1 38	NPTS2 42	NARG2 46	NPTS3 50	NARG3 54	NPTS4 58	NARG4 62	NPTS5 66	NARG5 70	
TCIDNT	?	?	?			1											

1 6	7 80
TCTITL	SAMPLE^{b}CURVE^{b}1D^{b}Y = CONSTANT

	11 25	26 40	41 55	56 70	
		constant			

FIGURE 2A - SAMPLE CURVE INPUT FOR NDIMN = 1

FASTEMP	GENERAL HEAT TRANSFER	TEMPORARY CURVE INPUT 2

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS1 34	NARG1 38	NPTS2 42	NARG2 46	NPTS3 50	NARG3 54	NPTS4 58	NARG4 62	NPTS5 66	NARG5 70	
TCIDNT	?	?	?			2	5	?									

1 6	7 80
TCTITL	SAMPLE^{b}CURVE^{b}2D^{b}Y = f(x)

	11 25	26 40	41 55	56 70	
	X_1	$Y(X_1)$	X_2	$Y(X_2)$	
	X_3	$Y(X_3)$	X_4	$Y(X_4)$	
	X_5	$Y(X_5)$			

FIGURE 2B - SAMPLE CURVE INPUT FOR NDIMN = 2

FASTEMP	GENERAL HEAT TRANSFER	TEMPORARY CURVE INPUT 2

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS1 34	NARG1 38	NPTS2 42	NARG2 46	NPTS3 50	NARG3 54	NPTS4 58	NARG4 62	NPTS5 66	NARG5 70	
TCIDNT	?	?	?			3	5	?	3	?							

1 6	7 80
TCTITL	SAMPLE^b CURVE^b 3D^bY = f(X,Z)

	11 25	26 40	41 55	56 70	
	X_1	X_2	X_3	X_4	
	X_5				
	Z_1	Z_2	Z_3		
	$Y(X_1, Z_1)$	$Y(X_1, Z_2)$	$Y(X_1, Z_3)$	$Y(X_2, Z_1)$	
	$Y(X_2, Z_2)$	$Y(X_2, Z_3)$	$Y(X_3, Z_1)$	$Y(X_3, Z_2)$	
	$Y(X_3, Z_3)$	$Y(X_4, Z_1)$	$Y(X_4, Z_2)$	$Y(X_4, Z_3)$	
	$Y(X_5, Z_1)$	$Y(X_5, Z_2)$	$Y(X_5, Z_3)$		

FIGURE 2C - SAMPLE CURVE INPUT FOR NDIMN = 3

4.6 CASE END CARD

A case end card should be the last card in each case. The case end data card format is:

Card Column	Name	Value
1-8	CN	END^{b}CASE

4.7 COMMENT CARDS

Comment cards may be placed anywhere in the user's data for convenience in identifying data. These cards will not appear in the subroutine output and are only printed out by the input sorting section. The comment data card format is:

Card Column	Name	Value
1-6	CN	*
7-80	CMMT	User's comments

4.8 MULTIPLE AND CHANGE CASE CONTROL CARDS

The program provides for multiple cases to be run in a single job submittal. The first case run is assumed to be a BASIC case and no BASIC card is needed. Parametric analyses may be run by inputting a BASIC case and then running several change cases which vary desired parameters. Three types of cases may be run after the first base case, i.e., a BASIC case, a CHANG^{b}BASIC, and a CHANG^{b}CHANG case. These cards immediately follow the END^{b}CASE card of the preceding case.

4.8.1 Basic Card - The BASIC case control card is used to input a full set of data which is independent from any previously run case. The BASIC data card format is:

Card Column	Name	Value
1-5	CN	BASIC

4.8.2 Change Basic Card - The CHANG^{b}BASIC case control card must be used to input changes to a BASIC case. The changes inserted for this change case always modify the last BASIC case which was input. The CHANG^{b}BASIC data card format is:

Card Column	Name	Value
1-11	CN	CHANG^{b}BASIC

4.8.3 Change Change Card - The CHANG^{b}CHANG case control card must be used to input changes to the last change case which was input. A CHANG^{b}CHANG case may be used after a CHANG^{b}BASIC case or CHANG^{b}CHANG case. The CHANG^{b}CHANG data card format is:

Card Column	Name	Value
1-11	CN	CHANG^{b}CHANG

4.9 CHANGE CASE DATA CARDS

Change cases may input data to modify any of the case input in groups 6, 7, 8, and 9 of Figure 1. Heat transfer method subroutines which were not called in Subroutine EQDAT cannot be added in a change case. The input data card groups for a change case must be input in the same order as the base case. To provide for the use of a subroutine which is not required in the base case, a call to that subroutine may be inserted in Subroutine EQDAT, and only a zero card input in the proper order in the base case. Data cards for that subroutine may then be added in the change case. The restriction of using only those subroutines called in Subroutine EQDAT applies to all cases which are input for a job submittal.

4.9.1 Case Data Changes - Any of the case data cards may be altered in a change case by inputting the new case card in the change case. Any card not present in the change case data will be taken from the base case. All CASET cards as well as a CASEC card must be input in a change case if any of the initial temperature values are to be changed by CASET cards.

4.9.2 Dimension Table Changes - Any of the dimension table data may be changed in a change case. The number of values in the dimension table may be increased or decreased in size in a change case. Dimension table values may be input with either the VALUES or VALUE cards. The change case cards are merged after the dimension table values from the base data, therefore values input in the change case will replace values from the base case.

4.9.3 Heat Transfer Subroutine Changes - Any of the data for the heat transfer method subroutines may be changed. Temperature nodes may be added or deleted or the data for base nodes may be changed. The changes input for a change case are merged with the base case data using the change code in column 10 and card numbers in column 14. The change code is ignored in a BASIC case. There are four change options available which have the following change codes.

Change Code	Function
X	The change code X will delete all cards for a subroutine and must be input on a zero card in the change case input.
R	The change code R indicates that the card(s) from the base case will be replaced by the card input in the change case. For this option the card number must be nonzero.

Change Code	Function
D	The change code D indicates that the card(s) from the base case with the proper card number will be deleted from the change case.
"blank"	The blank (and other characters not noted above) change code field will add the card from the change case input.

Change cards for the heat transfer method subroutines must be input in the same general format as those in the base case unless a new zero card (using X for change code) is input to change the format. Change cards may be input in any order in subroutine data cards with the exception of the zero card, which must be the first card if it is changed.

4.9.4 Curves Changes - Curves input as change case data may either be added to the change case or may replace curves in the base case. No provision is allowed for deleting a curve and it will be labeled as a curve which is not required, if it was replaced. A complete curve must be input for temporary curves, i.e., the TCIDNT, TCTITL and all value cards. No provision is made for changing individual values in a curve.

4.10 JOB END CARD

The last card in a job submittal is the ENDJØB card. This card informs the program that the last case has been read. The ENDJØB data card format is:

Card Column	Name	Value
1-6	CN	ENDJØB

5. PROGRAM OUTPUT

The output of the Thermal Analyzer Subroutine consists of three types of information: 1) output of the input data; 2) output of the results; and 3) output of error and warning messages. Most of the output of the input data is optional as specified by the user. The method of controlling the output of input data is discussed in Section 4. Output of the program contains some sections which are always printed,however, the majority of the output of the results of a case is under the user's control (e.g. node temperatures may be output at any problem time). Output of node temperatures is controlled by the print interval curve (1, 10, 2). Error messages are output specifying incorrect input data. Errors found in the input data cause the program to compute one time step only and to terminate the case. (See Section 7 for an explanation of the procedure used.)

The first page of output gives the computer time at the beginning of the M-phase and the number of core locations available for storing the data for the case and the matrix.

The next page of output for each case gives the computer time at the start of the case, the date, and the subroutines called by Subroutines EQDAT and SØLVE which require input data. Cards which have been rejected in the M-phase processing are also printed on this page (see Section 2). This output is continued on succeeding pages as required.

The next page of output gives the case specification data from the CASEB and CASEC data cards. The title from the CASEA card and the case name from the CASEB card replace the standard page header title and case name on this page and all following pages of output. Any errors in the case data will cause messages to be printed on this page of output.

The next page of output gives the dimension table if one is used. Any undefined dimension table values will contain the number 1.265×10^{322}.

The next output from the program is the input data for the heat transfer method subroutines called by Subroutines EQDAT and SØLVE. This output is optional and the user may specify individually which subroutine data will be printed. The output for each subroutine starts on a new page and continues on subsequent pages as required. Errors in the heat transfer method subroutine input data will cause messages to be printed on the output immediately after the card containing the error is processed. Any CDC hardware error codes occur for the next card which is not printed prior to error and should be noted when debugging jobs.

Following the processing of the heat transfer subroutine data in the Z-phase, several tables are output which contain information about the heat balance matrix. If a nonsequential node number case is input, a table is output of node numbers versus equation number. Tables are output which give: the number of times each node number is referenced by a heat transfer method subroutine; the number of internodal connections for each node; and the total number of internodal connections. The maximum internodal connection band or matrix half bandwidth is also output. Two tables are printed which contain the minimum and maximum equation that a given equation has connections in the thermal model.

The next section of the output is the curve input data. This output is also optional and the curve data printed may be specified by the user. Same curve messages are output with the temporary curve data. Error messages will be output for curves which are incorrect and have been rejected.

After the curve data output, two messages are output giving the number of locations available before and after the core was requested for the matrix. The time used to the beginning of the P-phase is also output.

The results of the problem solution may be output as specified by the user. The temperatures for each node may be output at any problem time. Some heat transfer subroutines have additional output which, if desired, is printed at each computed time step. Tables of maximum and minimum temperatures for each node and the problem times for which they were computed are output after the last time step is computed.

The next page of output gives the P-phase computer time elapsed for the case, the number of time steps computed and the number of errors detected. This is normally the last page of output for a case.

6. SAMPLE PROBLEM

The sample problem presented in this section illustrates the setup of a model for a typical heat transfer problem. The sample problem does not contain all of the possible combinations of program options which are available, however, enough of the options are used to allow the user to gain a familiarity with the general setup of the deck.

The sample problem is a three dimensional heat transfer analysis which has both steady state and transient computations. Modes of heat transfer considered include heat storage, conduction, radiation, convection, and interface conductance.

The model used in this analysis is shown on Figure 3. It consists of a symmetrical section of the lower insulated surface of an actively cooled hypersonic aircraft external skin panel. Aerodynamic heat transfer through the insulated surface is absorbed by methanol/water coolant circulated through Dee-shaped tubes bonded to the inboard surface of the skin. Coolant temperature at the panel inlet was assumed to be 0°F and coolant flowrate equal to 77 lb/hr per tube. The panel skin and coolant tube were assumed to be constructed of aluminum with the back-up material of 4 lb/ft^3 Johns-Manville Microfiber insulation, and the outer skin of titanium. The basic model dimensions (i.e. panel length, tube diameter, tube pitch, and material thicknesses) are shown in Figure 3, with corresponding node number identifications. A total of 208 nodes was used. The nonsequential node numbering option was used, which allows identification of different materials or sections of the model with groups of node numbers.

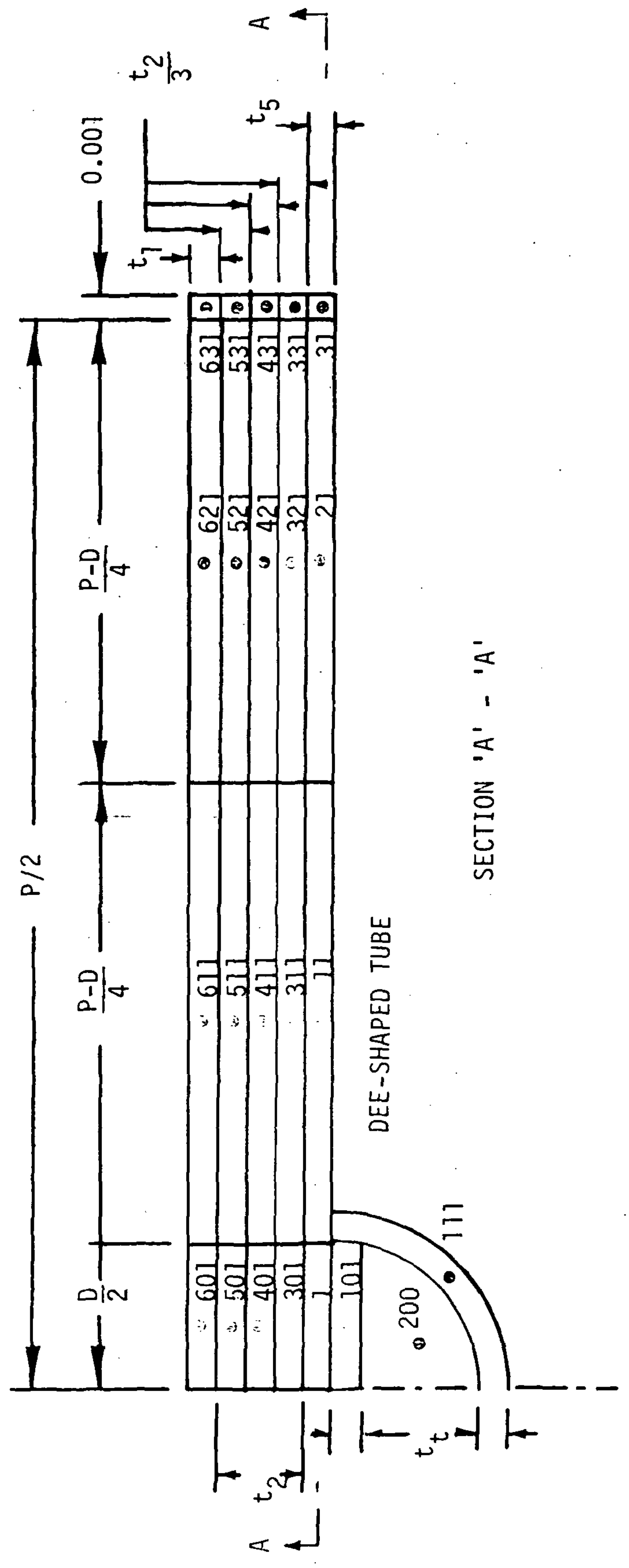
All nodes of the model are three-dimensional and are described by rectangular geometry, with the exception of those for the coolant within the tube, which are defined by cylindrical geometry. Nodal dimensions as well as values required by the heat transfer subroutines were input on the dimension table. Figure 4 illustrates the dimension table input parameters for the sample problem. The variable terms shown on the dimension table refer to model node dimensions and coolant Reynolds number transition from laminar (Re_L) to turbulent (Re_T) flow. Use of the dimension table, as illustrated here, provides a considerable degree of flexibility for implementing model or subroutine changes.

The mission profile used for this sample problem included an initial steady state cruise condition at Mach 4.5 and an altitude of 90,000 ft. During this time flowrate through the coolant tube was maintained at 77 lbm/hr, with a panel inlet coolant temperature of 0°F. At a time of -15 seconds, a total failure of the cooling system was imposed. This was followed at a time of 0 seconds by initiation of an abort descent trajectory resulting in lower aerodynamic heating rates. It was assumed that the cooling system failure was of a nature which caused instantaneous depletion of the coolant in the tube. Aerodynamic heat transfer rates during cruise and the abort trajectory were input in terms of external surface heat transfer coefficients and adiabatic wall temperatures versus time. These were calculated separately from other analyses based on aircraft geometry and parameters of flight altitude, velocity, and angle of attack versus time. Two cases were run for the sample problem. The first case, or base case, calculated coolant and panel structure temperature distributions and coolant pressure drop during cruise prior to cooling system failure. The second case, or change case, calculated panel transient temperatures versus time from cooling system failure (-15 seconds) through the abort trajectory (600 seconds).

Initial temperatures for the base case were input for each node as an example of the CASET card input. This was not necessary for this problem since steady state equilibrium temperatures were computed by starting the case at a time of -300 seconds and computing time steps with no heat storage until time equals -15 seconds. (See Section 7 for a discussion of the method used to compute steady state temperatures.) Temperatures were computed at the calculation intervals of 30 seconds for the base case and 5 seconds for the change case as given in curve (1, 10, 1). Print output of all node temperatures is controlled by curve (1, 10, 2) and was performed at 100 second and 15 second intervals for the base case and change case, respectively. Material property values (e.g. density, specific heat, thermal conductivity, etc.) as well as interface conductance values were input in curve form either as constants or versus time or temperature. Curve inputs were also used to describe other parameters required by the heat transfer subroutines such as external surface heat transfer coefficients, adiabatic wall temperatures, coolant flowrate, coolant friction factor, etc. A total of 29 curve inputs was used for the sample problem.

Heat storage was computed for all nodes except those of the coolant by Subroutine SRA. Conduction was computed by Subroutines DRA, DRB, and DRC. DRA was used to compute a conduction heat flux between nodes of the same material (e.g. nodes 1 and 11). DRB was used to compute a conduction heat flux between two nodes of different materials which are separated by an interface conductance (e.g. nodes 1 and 301). Subroutine DRC was used to compute conduction between two nodes of the same material which are separated by an interface conductance (e.g. nodes 1 and 101). Aerodynamic heating to the external surface (nodes 601-639) was computed by Subroutine VRA, with heat transfer coefficient and adiabatic wall temperature inputs. External radiation heat fluxes from nodes 601-639 to a 59°F sink temperature were computed by Subroutine RRA. The forced convection Subroutine VCA was used to maintain the coolant at the panel inlet (node 200) at 0°F by inputting a very high heat transfer coefficient and a 0°F adiabatic wall temperature. Subroutine FLUID B was used for the base case to compute convection heat transfer between the coolant and the tube wall as well as pressure drop down the length of the tube. Laminar flow was assumed for this case to apply below coolant Reynolds numbers of 2100, with a step change to turbulent flow at higher Reynolds numbers.

Figure 5 shows a listing of the input data cards. This listing includes the program specification cards (i.e., Subroutine EQDAT). The job control language (JCL) cards are not listed in Figure 5. Figure 6 shows the output for the sample problem. Sheets 1 through 23 show all of the output possible from the Thermal Analyzer Subprogram for this sample problem during the M and Z phases. The user may partially or totally prevent the output of the subroutine data (Sheets 5 through 15) and the curve data (Sheets 17 through 21). The remainder of the output (Sheets 24 through 28) show the output from the P phase. A change case was setup for this model as shown in Figure 5, to run the transient analysis. Figure 5 shows the method to eliminate a complete subroutine's data (X in column 10 of FLUID B card). This simulates loss of coolant fluid at -15 seconds. Only part of the output for this transient is shown.



P	PITCH (4 IN.)	
D	TUBE DIAMETER (0.25 IN.)	
L	PANEL LENGTH (240 IN.)	
t_t	TUBE WALL THICKNESS (0.035 IN.)	
t_1	SURFACE MATERIAL THICKNESS (0.02 IN.)	
t_2	BACKUP MATERIAL THICKNESS (0.25 IN.)	

NODES	
1-39	PANEL SKIN
101-119	TUBE
200-209	COOLANT
301-539	BACKUP MATERIAL
601-639	SURFACE MATERIAL

FIGURE 3 - COMPUTER PROGRAM MODEL - CROSS SECTION

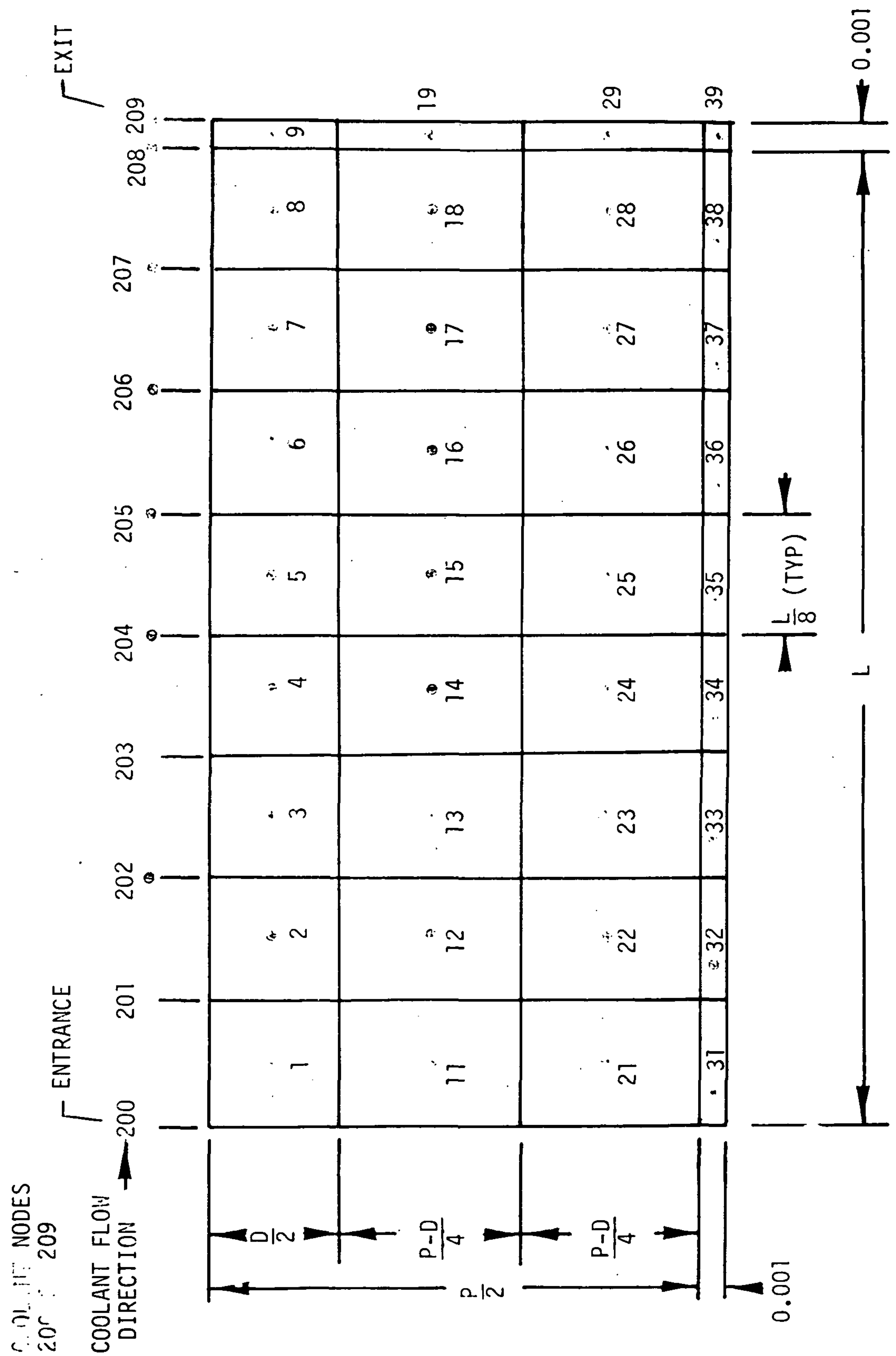


FIGURE 3A - COMPUTER PROGRAM MODEL - SECTION A-A

FASTEMP		GENERAL HEAT TRANSFER	DIMENSION TABLE INPUT 1	
1 6	NPTS 10			
DIMENS				
1 6	No. 9–10	11 25	26 40	41 55	56 70

1 6	No. 9–10	11 25	26 40	41 55	56 70
VALUES	01	(L/8)	0.001	t_s	1.
	05	$(\frac{P-D}{4})$	$(\frac{D}{2})$	t_t	$\frac{\pi}{4}(D+t_t)$
	09	$(\frac{L}{16}) + 0.0005$	1.	$(\frac{P-D}{8}) + 0.0005$	$(\frac{P-D}{4} + \frac{D}{2})/2$
	13	$\frac{D}{4} + \frac{\pi}{8}(D+t_t)$	1.	1.	0.
	17	90.	1.	0.	0.
	21	Re_L	Re_T	0.	$\frac{\pi D}{(\pi+2)}$
	25	$\frac{\pi D^2}{8}$	$\frac{L}{16}$	0.5	$\frac{\pi D}{4}$
	29	$1.5\ (\frac{L}{8})$	$2.5\ (\frac{L}{8})$	$3.5\ (\frac{L}{8})$	$4.5\ (\frac{L}{8})$
	33	$5.5\ (\frac{L}{8})$	$6.5\ (\frac{L}{8})$	$7.5\ (\frac{L}{8})$	L+0.0005
	37	t_1	t_2	0.3333	3.
	41	$t_s/2$	$t_2/6$	$t_1/2$	$\frac{DL}{16}$
	45	0.0005D	$\frac{(P-D)L}{32}$	0.0005(P-D)	0.000125L
	49	$\pi D^2/16$			
	53				
	57				
	61				
	65				
	69				
	73				
	77				
	81				
	85				

FIGURE 3B - COMPUTER PROGRAM MODEL - DIMENSION TABLE

```
      SUBROUTINE EQDAT
      CALL ORA
      CALL ORB
      CALL ORC
      CALL SRA
      CALL VRA
      CALL VCA
      CALL FLUIDB
      CALL RRA
      RETURN
      END
```

```
CASEA  INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE
CASEB        MP7   208              6    00       1
CASEC       -300.       -15.        3500.     300.                  460.
CASET       250.        250.        500.      500.      900.
CASET       900.        1350.       1350.     1550.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        250.        500.      500.      900.
CASET       900.        1350.       1350.     1550.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        250.        500.      500.      900.
CASET       900.        1350.       1350.     1550.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        250.        500.      500.      900.
CASET       900.        1350.       1350.     1550.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       250.        500.        900.      1350.     1550.
CASET       140.        140.        140.      140.      140.
CASET       140.        140.        140.      140.      75.
CASET       90.         109.        110.      115.      120.
CASET       125.        130.        130.      0.        15.
```

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 1)

```
CASET   30.        45.        60.        75.        90.
CASET   105.       120.       120.
DIMENS  49
VALUES  0130.                 .001            .04              1.
VALUES  05.9375               .125            .035             .2238
VALUES  0915.                 1.              .4693            .5313
VALUES  13.1744               1.              1.               0.
VALUES  1790.                 1.              0.               0.
VALUES  212100.               2101.           0.               .1528
VALUES  25.02454              15.             .5               .1963
VALUES  2945.                 75.             105.             135.
VALUES  33165.                195.            225.             240.
VALUES  37          .02              .25             .3333             3.
VALUES  41          .02              .0417           .01               3.75
VALUES  45.000125             28.13           .00186           .03
VALUES  49.01227
ORA           0               2
ORA           5  31  32       1         1    2    3   10
ORA           6 331 332       4         1    2   38   39
ORA           7 431 432       4         1    2   38   39
ORA           8 531 532       4         1    2   38   39
ORA           9 631 632       5         1    2   37    4
ORA          10  32  33       1         1    2    3   10
ORA          11 332 333       4         1    2   38   39
ORA          12 432 433       4         1    2   38   39
ORA          13 532 533       4         1    2   38   39
ORA          14 632 633       5         1    2   37    4
ORA          15  33  34       1         1    2    3   10
ORA          16 333 334       4         1    2   38   39
ORA          17 433 434       4         1    2   38   39
ORA          18 533 534       4         1    2   38   39
ORA          19 633 634       5         1    2   37    4
ORA          20  34  35       1         1    2    3   10
ORA          21 334 335       4         1    2   38   39
ORA          22 434 435       4         1    2   38   39
ORA          23 534 535       4         1    2   38   39
ORA          24 634 635       5         1    2   37    4
ORA          25  35  36       1         1    2    3   10
ORA          26 335 336       4         1    2   38   39
ORA          27 435 436       4         1    2   38   39
ORA          28 535 536       4         1    2   38   39
ORA          29 535 636       5         1    2   37    4
ORA          30  36  37       1         1    2    3   10
ORA          31 336 337       4         1    2   38   39
ORA          32 436 437       4         1    2   38   39
ORA          33 536 537       4         1    2   38   39
ORA          34 636 637       5         1    2   37    4
ORA          35  37  38       1         1    2    3   10
ORA          36 337 338       4         1    2   38   39
ORA          37 437 438       4         1    2   38   39
ORA          38 537 538       4         1    2   38   39
ORA          39 637 638       5         1    2   37    4
ORA          40  38  39       1         9    2    3   10
ORA          41 338 339       4         9    2   38   39
ORA          42 438 439       4         9    2   38   39
ORA          43 538 539       4         9    2   38   39
ORA          44 638 639       5         9    2   37    4
ORA          45  21  22       1         1    5    3   10
ORA          46 321 322       4         1    5   38   39
ORA          47 421 422       4         1    5   38   39
ORA          48 521 522       4         1    5   38   39
ORA          49 621 622       5         1    5   37    4
ORA          50  22  23       1         1    5    3   10
ORA          51 322 323       4         1    5   38   39
ORA          52 422 423       4         1    5   38   39
```

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 2)

DRA	53	522	523	4	1	5	38	39
DRA	54	622	623	5	1	5	37	4
DRA	55	23	24	1	1	5	3	10
DRA	56	323	324	4	1	5	38	39
DRA	57	423	424	4	1	5	38	39
DRA	58	523	524	4	1	5	38	39
DRA	59	623	624	5	1	5	37	4
DRA	60	24	25	1	1	5	3	10
DRA	61	324	325	4	1	5	38	39
DRA	62	424	425	4	1	5	38	39
DRA	63	524	525	4	1	5	38	39
DRA	64	624	625	5	1	5	37	4
DRA	65	25	26	1	1	5	3	10
DRA	66	325	326	4	1	5	38	39
DRA	67	425	426	4	1	5	38	39
DRA	68	525	526	4	1	5	38	39
DRA	69	625	626	5	1	5	37	4
DRA	70	26	27	1	1	5	3	10
DRA	71	326	327	4	1	5	38	39
DRA	72	426	427	4	1	5	38	39
DRA	73	526	527	4	1	5	38	39
DRA	74	626	627	5	1	5	37	4
DRA	75	27	28	1	1	5	3	10
DRA	76	327	328	4	1	5	38	39
DRA	77	427	428	4	1	5	38	39
DRA	78	527	528	4	1	5	38	39
DRA	79	627	628	5	1	5	37	4
DRA	80	28	29	1	9	5	3	10
DRA	81	328	329	4	9	5	38	39
DRA	82	428	429	4	9	5	38	39
DRA	83	528	529	4	9	5	38	39
DRA	84	628	629	5	9	5	37	4
DRA	85	11	12	1	1	5	3	10
DRA	86	311	312	4	1	5	38	39
DRA	87	411	412	4	1	5	38	39
DRA	88	511	512	4	1	5	38	39
DRA	89	611	612	5	1	5	37	4
DRA	90	12	13	1	1	5	3	10
DRA	91	312	313	4	1	5	38	39
DRA	92	412	413	4	1	5	38	39
DRA	93	512	513	4	1	5	38	39
DRA	94	612	613	5	1	5	37	4
DRA	95	13	14	1	1	5	3	10
DRA	96	313	314	4	1	5	38	39
DRA	97	413	414	4	1	5	38	39
DRA	98	513	514	4	1	5	38	39
DRA	99	613	614	5	1	5	37	4
DRA	100	14	15	1	1	5	3	10
DRA	101	314	315	4	1	5	38	39
DRA	102	414	415	4	1	5	38	39
DRA	103	514	515	4	1	5	38	39
DRA	104	614	615	5	1	5	37	4
DRA	105	15	16	1	1	5	3	10
DRA	106	315	316	4	1	5	38	39
DRA	107	415	416	4	1	5	38	39
DRA	108	515	516	4	1	5	38	39
DRA	109	615	616	5	1	5	37	4
DRA	110	16	17	1	1	5	3	10
DRA	111	316	317	4	1	5	38	39
DRA	112	416	417	4	1	5	38	39
DRA	113	516	517	4	1	5	38	39
DRA	114	616	617	5	1	5	37	4
DRA	115	17	18	1	1	5	3	10
DRA	116	317	318	4	1	5	38	39
DRA	117	417	418	4	1	5	38	39

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 3)

ORA	118	517	518	4	1	5	38	39
ORA	119	617	618	5	1	5	37	4
ORA	120	18	19	1	9	5	3	10
ORA	121	318	319	4	9	5	38	39
ORA	122	418	419	4	9	5	38	39
ORA	123	518	519	4	9	5	38	39
ORA	124	618	619	5	9	5	37	4
ORA	125	1	2	1	1	6	3	10
ORA	126	301	302	4	1	6	38	39
ORA	127	401	402	4	1	6	38	39
ORA	128	501	502	4	1	6	38	39
ORA	129	601	602	5	1	6	37	4
ORA	130	2	3	1	1	6	3	10
ORA	131	302	303	4	1	6	38	39
ORA	132	402	403	4	1	6	38	39
ORA	133	502	503	4	1	6	38	39
ORA	134	602	603	5	1	6	37	4
ORA	135	3	4	1	1	6	3	10
ORA	136	303	304	4	1	6	38	39
ORA	137	403	404	4	1	6	38	39
ORA	138	503	504	4	1	6	38	39
ORA	139	603	604	5	1	6	37	4
ORA	140	4	5	1	1	6	3	10
ORA	141	304	305	4	1	6	38	39
ORA	142	404	405	4	1	6	38	39
ORA	143	504	505	4	1	6	38	39
ORA	144	504	605	5	1	6	37	4
ORA	145	5	6	1	1	6	3	10
ORA	146	305	306	4	1	6	38	39
ORA	147	405	406	4	1	6	38	39
ORA	148	505	506	4	1	6	38	39
ORA	149	605	606	5	1	6	37	4
ORA	150	6	7	1	1	6	3	10
ORA	151	306	307	4	1	6	38	39
ORA	152	406	407	4	1	6	38	39
ORA	153	506	507	4	1	6	38	39
ORA	154	606	607	5	1	6	37	4
ORA	155	7	8	1	1	6	3	10
ORA	156	307	308	4	1	6	38	39
ORA	157	407	408	4	1	6	38	39
ORA	158	507	508	4	1	6	38	39
ORA	159	607	608	5	1	6	37	4
ORA	160	8	9	1	9	6	3	10
ORA	161	308	309	4	9	6	38	39
ORA	162	408	409	4	9	6	38	39
ORA	163	509	509	4	9	6	38	39
ORA	164	608	609	5	9	6	37	4
ORA	165	31	21	1	11	1	3	10
ORA	166	331	321	4	11	1	38	39
ORA	167	431	421	4	11	1	38	39
ORA	168	531	521	4	11	1	38	39
ORA	169	631	621	5	11	1	37	4
ORA	170	21	11	1	5	1	3	10
ORA	171	321	311	4	5	1	38	39
ORA	172	421	411	4	5	1	38	39
ORA	173	521	511	4	5	1	38	39
ORA	174	621	611	5	5	1	37	4
ORA	175	11	1	1	12	1	3	10
ORA	176	311	301	4	12	1	38	39
ORA	177	411	401	4	12	1	38	39
ORA	178	511	501	4	12	1	38	39
ORA	179	611	601	5	12	1	37	4
ORA	180	32	22	1	11	1	3	10
ORA	181	332	322	4	11	1	38	39
ORA	182	432	422	4	11	1	38	39

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 4)

ORA	183	532	522	4	11	1	38	39
ORA	184	632	622	5	11	1	37	4
ORA	185	22	12	1	5	1	3	10
ORA	186	322	312	4	5	1	38	39
ORA	187	422	412	4	5	1	38	39
ORA	188	522	512	4	5	1	38	39
ORA	189	622	612	5	5	1	37	4
ORA	190	12	2	1	12	1	3	10
ORA	191	312	302	4	12	1	38	39
ORA	192	412	402	4	12	1	38	39
ORA	193	512	502	4	12	1	38	39
ORA	194	612	602	5	12	1	37	4
ORA	195	33	23	1	11	1	3	10
ORA	196	333	323	4	11	1	38	39
ORA	197	433	423	4	11	1	38	39
ORA	198	533	523	4	11	1	38	39
ORA	199	633	623	5	11	1	37	4
ORA	200	23	13	1	5	1	3	10
ORA	201	323	313	4	5	1	38	39
ORA	202	423	413	4	5	1	38	39
ORA	203	523	513	4	5	1	38	39
ORA	204	623	613	5	5	1	37	4
ORA	205	13	3	1	12	1	3	10
ORA	206	313	303	4	12	1	38	39
ORA	207	413	403	4	12	1	38	39
ORA	208	513	503	4	12	1	38	39
ORA	209	613	603	5	12	1	37	4
ORA	210	34	24	1	11	1	3	10
ORA	211	334	324	4	11	1	38	39
ORA	212	434	424	4	11	1	38	39
ORA	213	534	524	4	11	1	38	39
ORA	214	634	624	5	11	1	37	4
ORA	215	24	14	1	5	1	3	10
ORA	216	324	314	4	5	1	38	39
ORA	217	424	414	4	5	1	38	39
ORA	218	524	514	4	5	1	38	39
ORA	219	624	614	5	5	1	37	4
ORA	220	14	4	1	12	1	3	10
ORA	221	314	304	4	12	1	38	39
ORA	222	414	404	4	12	1	38	39
ORA	223	514	504	4	12	1	38	39
ORA	224	614	604	5	12	1	37	4
ORA	225	35	25	1	11	1	3	10
ORA	226	335	325	4	11	1	38	39
ORA	227	435	425	4	11	1	38	39
ORA	228	535	525	4	11	1	38	39
ORA	229	635	625	5	11	1	37	4
ORA	230	25	15	1	5	1	3	10
ORA	231	325	315	4	5	1	38	39
ORA	232	425	415	4	5	1	38	39
ORA	233	525	515	4	5	1	38	39
ORA	234	625	615	5	5	1	37	4
ORA	235	15	5	1	12	1	3	10
ORA	236	315	305	4	12	1	38	39
ORA	237	415	405	4	12	1	38	39
ORA	238	515	505	4	12	1	38	39
ORA	239	615	605	5	12	1	37	4
ORA	240	36	26	1	11	1	3	10
ORA	241	335	326	4	11	1	36	39
ORA	242	436	426	4	11	1	38	39
ORA	243	536	526	4	11	1	38	39
ORA	244	636	626	5	11	1	37	4
ORA	245	26	16	1	5	1	3	10
ORA	246	326	316	4	5	1	38	39
ORA	247	426	416	4	5	1	38	39

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 5)

DRA	248	526	516	4	5	1	38	39
DRA	249	626	616	5	5	1	37	4
DRA	250	16	6	1	12	1	3	10
DRA	251	316	305	4	12	1	38	39
DRA	252	416	405	4	12	1	38	39
DRA	253	516	506	4	12	1	38	39
DRA	254	616	606	5	12	1	37	4
DRA	255	37	27	1	11	1	3	10
DRA	256	337	327	4	11	1	38	39
DRA	257	437	427	4	11	1	38	39
DRA	258	537	527	4	11	1	38	39
DRA	259	637	627	5	11	1	37	4
DRA	260	27	17	1	5	1	3	10
DRA	261	327	317	4	5	1	38	39
DRA	252	427	417	4	5	1	38	39
DRA	263	527	517	4	5	1	38	39
DRA	254	627	617	5	5	1	37	4
DRA	265	17	7	1	12	1	3	10
DRA	266	317	307	4	12	1	38	39
DRA	207	417	407	4	12	1	38	39
DRA	268	517	507	4	12	1	38	39
DRA	269	617	607	5	12	1	37	4
DRA	270	38	28	1	11	1	3	10
DRA	271	338	328	4	11	1	38	39
DRA	272	438	428	4	11	1	38	39
DRA	273	538	528	4	11	1	38	39
DRA	274	638	628	5	11	1	37	4
DRA	275	28	18	1	5	1	3	10
DRA	276	328	318	4	5	1	38	39
DRA	277	428	418	4	5	1	38	39
DRA	278	528	518	4	5	1	38	39
DRA	279	628	618	5	5	1	37	4
DRA	280	18	8	1	12	1	3	10
DRA	281	318	308	4	12	1	38	39
DRA	282	418	408	4	12	1	38	39
DRA	283	518	508	4	12	1	38	39
DRA	284	618	608	5	12	1	37	4
DRA	285	39	29	1	11	2	3	10
DRA	286	339	329	4	11	2	38	39
DRA	287	439	429	4	11	2	38	39
DRA	288	539	529	4	11	2	38	39
DRA	289	639	629	5	11	2	37	4
DRA	290	29	19	1	5	2	3	10
DRA	291	329	319	4	5	2	38	39
DRA	292	429	419	4	5	2	38	39
DRA	293	529	519	4	5	2	38	39
DRA	294	629	619	5	5	2	37	4
DRA	295	19	9	1	12	2	3	10
DRA	296	319	309	4	12	2	38	39
DRA	297	419	409	4	12	2	38	39
DRA	298	519	509	4	12	2	38	39
DRA	299	619	609	5	12	2	37	4
DRA	300	101	102	2	1	6	7	10
DRA	305	102	103	2	1	6	7	10
DRA	310	103	104	2	1	6	7	10
DRA	315	104	105	2	1	6	7	10
DRA	320	105	106	2	1	6	7	10
DRA	325	106	107	2	1	6	7	10
DRA	330	107	108	2	1	6	7	10
DRA	335	108	109	2	9	6	7	10
DRA	340	111	112	2	1	8	7	10
DRA	345	112	113	2	1	8	7	10
DRA	350	113	114	2	1	8	7	10
DRA	355	114	115	2	1	8	7	10
DRA	360	115	116	2	1	8	7	10

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 6)

DRA	365	116	117	2	1	8	7	10
DRA	370	117	118	2	1	8	7	10
DRA	375	118	119	2	9	8	7	10
DRA	380	101	111	2	13	1	7	10
DRA	385	102	112	2	13	1	7	10
DRA	390	103	113	2	13	1	7	10
DRA	395	104	114	2	13	1	7	10
DRA	400	105	115	2	13	1	7	10
DRA	405	106	116	2	13	1	7	10
DRA	410	107	117	2	13	1	7	10
DRA	415	108	118	2	13	1	7	10
DRA	420	109	119	2	13	2	7	10
DRA	425	331	431	4	38	2	1	40
DRA	426	431	531	4	36	2	1	40
DRA	427	332	432	4	38	2	1	40
DRA	428	432	532	4	38	2	1	40
DRA	429	333	433	4	38	2	1	40
DRA	430	433	533	4	38	2	1	40
DRA	431	334	434	4	38	2	1	40
DRA	432	434	534	4	38	2	1	40
DRA	433	335	435	4	38	2	1	40
DRA	434	435	535	4	38	2	1	40
DRA	435	336	436	4	38	2	1	40
DRA	436	436	536	4	38	2	1	40
DRA	437	337	437	4	38	2	1	40
DRA	438	437	537	4	38	2	1	40
DRA	439	338	438	4	38	2	1	40
DRA	440	438	538	4	38	2	1	40
DRA	441	339	439	4	38	2	2	40
DRA	442	439	539	4	38	2	2	40
DRA	443	321	421	4	38	5	1	40
DRA	444	421	521	4	38	5	1	40
DRA	445	322	422	4	38	5	1	40
DRA	446	422	522	4	38	5	1	40
DRA	447	323	423	4	38	5	1	40
DRA	448	423	523	4	38	5	1	40
DRA	449	324	424	4	38	5	1	40
DRA	450	424	524	4	38	5	1	40
DRA	451	325	425	4	38	5	1	40
DRA	452	425	525	4	38	5	1	40
DRA	453	326	426	4	38	5	1	40
DRA	454	426	526	4	38	5	1	40
DRA	455	327	427	4	38	5	1	40
DRA	456	427	527	4	38	5	1	40
DRA	457	328	428	4	38	5	1	40
DRA	458	428	528	4	38	5	1	40
DRA	459	329	429	4	38	5	2	40
DRA	460	429	929	4	38	5	2	40
DRA	461	311	411	4	38	5	1	40
DRA	462	411	511	4	38	5	1	40
DRA	463	312	412	4	38	5	1	40
DRA	464	412	512	4	38	5	1	40
DRA	465	313	413	4	38	5	1	40
DRA	466	413	513	4	38	5	1	40
DRA	467	314	414	4	38	5	1	40
DRA	468	414	514	4	38	5	1	40
DRA	469	315	415	4	38	5	1	40
DRA	470	415	515	4	38	5	1	40
DRA	471	316	416	4	38	5	1	40
DRA	472	416	516	4	38	5	1	40
DRA	473	317	417	4	38	5	1	40
DRA	474	417	517	4	38	5	1	40
DRA	475	318	418	4	38	5	1	40
DRA	476	418	518	4	38	5	1	40
DRA	477	319	419	4	38	5	2	40

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 7)

ORA	478	419	519	4		38	5	2	40				
ORA	479	301	401	4		38	6	1	40				
ORA	480	401	501	4		38	6	1	40				
ORA	481	302	402	4		38	6	1	40				
ORA	482	402	502	4		38	6	1	40				
ORA	483	303	403	4		38	6	1	40				
ORA	484	403	503	4		38	6	1	40				
ORA	485	304	404	4		38	6	1	40				
ORA	486	404	504	4		38	6	1	40				
ORA	487	305	405	4		38	6	1	40				
ORA	488	405	505	4		38	6	1	40				
ORA	489	306	406	4		38	6	1	40				
ORA	490	406	506	4		38	6	1	40				
ORA	491	307	407	4		38	6	1	40				
ORA	492	407	507	4		38	6	1	40				
ORA	493	308	408	4		38	6	1	40				
ORA	494	408	508	4		38	6	1	40				
ORA	495	309	409	4		38	6	2	40				
ORA	496	409	509	4		38	6	2	40				
ORB	0			2									
ORB	1	1	301	1	4	41	44	42	44	44	2	4	4
ORB	2	2	302	1	4	41	44	42	44	44	2	4	4
ORB	3	3	303	1	4	41	44	42	44	44	2	4	4
ORB	4	4	304	1	4	41	44	42	44	44	2	4	4
ORB	5	5	305	1	4	41	44	42	44	44	2	4	4
ORB	6	6	306	1	4	41	44	42	44	44	2	4	4
ORB	7	7	307	1	4	41	44	42	44	44	2	4	4
ORB	8	8	308	1	4	41	44	42	44	44	2	4	4
ORB	9	9	309	1	4	41	45	42	45	45	2	4	4
ORB	10	11	311	1	4	41	46	42	46	46	2	4	4
ORB	11	12	312	1	4	41	46	42	46	46	2	4	4
ORB	12	13	313	1	4	41	46	42	46	46	2	4	4
ORB	13	14	314	1	4	41	46	42	46	46	2	4	4
ORB	14	15	315	1	4	41	46	42	46	46	2	4	4
ORB	15	16	316	1	4	41	46	42	46	46	2	4	4
ORB	16	17	317	1	4	41	46	42	46	46	2	4	4
ORB	17	18	318	1	4	41	46	42	46	46	2	4	4
ORB	18	19	319	1	4	41	47	42	47	47	2	4	4
ORB	19	21	321	1	4	41	46	42	46	46	2	4	4
ORB	20	22	322	1	4	41	46	42	46	46	2	4	4
ORB	21	23	323	1	4	41	46	42	46	46	2	4	4
ORB	22	24	324	1	4	41	46	42	46	46	2	4	4
ORB	23	25	325	1	4	41	46	42	46	46	2	4	4
ORB	24	26	326	1	4	41	46	42	46	46	2	4	4
ORB	25	27	327	1	4	41	46	42	46	46	2	4	4
ORB	26	28	328	1	4	41	46	42	46	46	2	4	4
ORB	27	29	329	1	4	41	47	42	47	47	2	4	4
ORB	28	31	331	1	4	41	48	42	48	48	2	4	4
ORB	29	32	332	1	4	41	48	42	48	48	2	4	4
ORB	30	33	333	1	4	41	48	42	48	48	2	4	4
ORB	31	34	334	1	4	41	48	42	48	48	2	4	4
ORB	32	35	335	1	4	41	48	42	48	48	2	4	4
ORB	33	36	336	1	4	41	48	42	48	48	2	4	4
ORB	34	37	337	1	4	41	48	42	48	48	2	4	4
ORB	35	38	338	1	4	41	48	42	48	48	2	4	4
ORB	36	39	339	1	4	41	49	42	49	49	2	4	4
ORB	37	501	601	4	5	42	44	43	44	44	3	4	4
ORB	38	502	602	4	5	42	44	43	44	44	3	4	4
ORB	39	503	603	4	5	42	44	43	44	44	3	4	4
ORB	40	504	604	4	5	42	44	43	44	44	3	4	4
ORB	41	505	605	4	5	42	44	43	44	44	3	4	4
ORB	42	506	606	4	5	42	44	43	44	44	3	4	4
ORB	43	507	607	4	5	42	44	43	44	44	3	4	4
ORB	44	508	608	4	5	42	44	43	44	44	3	4	4
ORB	45	509	609	4	5	42	45	43	45	45	3	4	4

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 8)

DPB	46	511	611	4	5	42	46	43	46	46	3	4	4
DPB	47	512	612	4	5	42	46	43	46	46	3	4	4
DPB	48	513	513	4	5	42	46	43	46	46	3	4	4
DPB	49	514	614	4	5	42	46	43	46	46	3	4	4
DPB	50	515	615	4	5	42	46	43	46	46	3	4	4
DPB	51	516	616	4	5	42	46	43	46	46	3	4	4
DPB	52	517	617	4	5	42	46	43	46	46	3	4	4
DPB	53	518	618	4	5	42	46	43	46	46	3	4	4
DPB	54	519	619	4	5	42	47	43	47	47	3	4	4
DPB	55	521	621	4	5	42	46	43	46	46	3	4	4
DPB	56	522	622	4	5	42	46	43	46	46	3	4	4
DPB	57	523	623	4	5	42	46	43	46	46	3	4	4
DPB	58	524	624	4	5	42	46	43	46	46	3	4	4
DPB	59	525	625	4	5	42	46	43	46	46	3	4	4
DPB	60	526	626	4	5	42	46	43	46	46	3	4	4
DPB	61	527	627	4	5	42	46	43	46	46	3	4	4
DPB	62	528	628	4	5	42	46	43	46	46	3	4	4
DPB	63	529	629	4	5	42	47	43	47	47	3	4	4
DPB	64	531	631	4	5	42	48	43	48	48	3	4	4
DPB	65	532	632	4	5	42	48	43	48	48	3	4	4
DPB	66	533	633	4	5	42	48	43	48	48	3	4	4
DPB	67	534	634	4	5	42	48	43	48	48	3	4	4
DPB	68	535	635	4	5	42	48	43	48	48	3	4	4
DPB	69	536	636	4	5	42	48	43	48	48	3	4	4
DPB	70	537	637	4	5	42	48	43	48	48	3	4	4
DPB	71	538	638	4	5	42	48	43	48	48	3	4	4
DPB	72	539	639	4	5	42	49	43	49	49	3	4	4
DPC	0			2									
DPC	5	1	101	1			1	6	14				
DPC	10	2	102	1			1	6	14				
DPC	15	3	103	1			1	6	14				
DPC	20	4	104	1			1	6	14				
DPC	25	5	105	1			1	6	14				
DPC	30	6	106	1			1	6	14				
DPC	35	7	107	1			1	6	14				
DPC	40	8	108	1			1	6	14				
DPC	45	9	109	1			2	6	14				
SPA	0			2									
SRA	5	31		1		1	2	3	4				
SPA	10	32		1		1	2	3	4				
SRA	15	33		1		1	2	3	4				
SRA	20	34		1		1	2	3	4				
SPA	25	35		1		1	2	3	4				
SRA	30	36		1		1	2	3	4				
SRA	35	37		1		1	2	3	4				
SRA	40	38		1		1	2	3	4				
SRA	45	39		1		2	2	3	4				
SRA	50	21		1		1	5	3	4				
SRA	55	22		1		1	5	3	4				
SPA	60	23		1		1	5	3	4				
SRA	65	24		1		1	5	3	4				
SPA	70	25		1		1	5	3	4				
SRA	75	26		1		1	5	3	4				
SRA	80	27		1		1	5	3	4				
SRA	85	28		1		1	5	3	4				
SRA	90	29		1		2	5	3	4				
SRA	95	11		1		1	5	3	4				
SRA	100	12		1		1	5	3	4				
SRA	105	13		1		1	5	3	4				
SPA	110	14		1		1	5	3	4				
SRA	115	15		1		1	5	3	4				
SRA	120	16		1		1	5	3	4				
SRA	125	17		1		1	5	3	4				
SRA	130	18		1		1	5	3	4				
SPA	135	19		1		2	5	3	4				

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 9)

SRA	140	1	1	1	6	3	4
SRA	145	2	1	1	6	3	4
SRA	150	3	1	1	6	3	4
SRA	155	4	1	1	6	3	4
SRA	160	5	1	1	6	3	4
SRA	165	6	1	1	6	3	4
SRA	170	7	1	1	6	3	4
SRA	175	8	1	1	6	3	4
SRA	180	9	1	2	6	3	4
SRA	185	101	2	1	6	7	4
SRA	190	102	2	1	6	7	4
SRA	195	103	2	1	6	7	4
SRA	200	104	2	1	6	7	4
SRA	205	105	2	1	6	7	4
SRA	210	106	2	1	6	7	4
SRA	215	107	2	1	6	7	4
SRA	220	108	2	1	6	7	4
SRA	225	109	2	2	6	7	4
SRA	230	111	2	1	8	7	4
SRA	235	112	2	1	8	7	4
SRA	240	113	2	1	8	7	4
SRA	245	114	2	1	8	7	4
SRA	250	115	2	1	8	7	4
SRA	255	116	2	1	8	7	4
SRA	260	117	2	1	8	7	4
SRA	265	118	2	1	8	7	4
SRA	270	119	2	2	8	7	4
SRA	275	301	4	1	6	38	39
SRA	276	401	4	1	6	38	39
SRA	277	501	4	1	6	38	39
SRA	278	601	5	1	6	37	4
SRA	279	302	4	1	6	38	39
SRA	280	402	4	1	6	38	39
SRA	281	502	4	1	6	38	39
SRA	282	602	5	1	6	37	4
SRA	283	303	4	1	6	38	39
SRA	284	403	4	1	6	38	39
SRA	285	503	4	1	6	38	39
SRA	286	603	5	1	6	37	4
SRA	287	304	4	1	6	38	39
SRA	288	404	4	1	6	38	39
SRA	289	504	4	1	6	38	39
SRA	290	604	5	1	6	37	4
SRA	291	305	4	1	6	38	39
SRA	292	405	4	1	6	38	39
SRA	293	505	4	1	6	38	39
SRA	294	605	5	1	6	37	4
SRA	295	306	4	1	6	38	39
SRA	296	406	4	1	6	38	39
SRA	297	506	4	1	6	38	39
SRA	298	606	5	1	6	37	4
SRA	299	307	4	1	6	38	39
SRA	300	407	4	1	6	38	39
SRA	301	507	4	1	6	38	39
SRA	302	507	5	1	6	37	4
SRA	303	308	4	1	6	38	39
SRA	304	408	4	1	6	38	39
SRA	305	508	4	1	6	38	39
SRA	306	608	5	1	6	37	4
SRA	307	309	4	2	6	38	39
SRA	308	409	4	2	6	38	39
SRA	309	509	4	2	6	38	39
SRA	310	609	5	2	6	37	4
SRA	311	311	4	1	5	38	39
SRA	312	411	4	1	5	38	39

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 10)

SRA	313	511	4	1	5	38	39
SRA	314	611	5	1	5	37	4
SRA	315	312	4	1	5	38	39
SRA	316	412	4	1	5	38	39
SRA	317	512	4	1	5	38	39
SRA	318	512	5	1	5	37	4
SRA	319	313	4	1	5	38	39
SRA	320	413	4	1	5	38	39
SRA	321	513	4	1	5	38	39
SRA	322	613	5	1	5	37	4
SRA	323	314	4	1	5	38	39
SRA	324	414	4	1	5	38	39
SRA	325	514	4	1	5	38	39
SRA	326	614	5	1	5	37	4
SRA	327	315	4	1	5	38	39
SRA	328	415	4	1	5	38	39
SRA	329	515	4	1	5	38	39
SRA	330	615	5	1	5	37	4
SRA	331	316	4	1	5	38	39
SRA	332	416	4	1	5	38	39
SRA	333	516	4	1	5	38	39
SRA	334	616	5	1	5	37	4
SRA	335	317	4	1	5	38	39
SRA	336	417	4	1	5	38	39
SRA	337	517	4	1	5	38	39
SRA	338	617	5	1	5	37	4
SRA	339	318	4	1	5	38	39
SRA	340	418	4	1	5	38	39
SRA	341	518	4	1	5	38	39
SRA	342	618	5	1	5	37	4
SRA	343	319	4	2	5	38	39
SRA	344	419	4	2	5	38	39
SRA	345	519	4	2	5	38	39
SRA	346	619	5	2	5	37	4
SRA	347	321	4	1	5	38	39
SRA	348	421	4	1	5	38	39
SRA	349	521	4	1	5	38	39
SRA	350	621	5	1	5	37	4
SRA	351	322	4	1	5	38	39
SRA	352	422	4	1	5	38	39
SRA	353	522	4	1	5	38	39
SRA	354	622	5	1	5	37	4
SRA	355	323	4	1	5	38	39
SRA	356	423	4	1	5	38	39
SRA	357	523	4	1	5	38	39
SRA	358	623	5	1	5	37	4
SRA	359	324	4	1	5	38	39
SRA	360	424	4	1	5	38	39
SRA	361	524	4	1	5	38	39
SRA	362	624	5	1	5	37	4
SRA	363	325	4	1	5	38	39
SRA	364	425	4	1	5	38	39
SRA	365	525	4	1	5	38	39
SRA	366	625	5	1	5	37	4
SRA	367	326	4	1	5	38	39
SRA	368	426	4	1	5	38	39
SRA	369	526	4	1	5	38	39
SRA	370	626	5	1	5	37	4
SRA	371	327	4	1	5	38	39
SRA	372	427	4	1	5	38	39
SRA	373	527	4	1	5	38	39
SRA	374	627	5	1	5	37	4
SRA	375	328	4	1	5	38	39
SRA	376	428	4	1	5	38	39
SRA	377	528	4	1	5	38	39

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 11)

SRA	378	528		5	1	5	37	4
SRA	379	329		4	2	5	38	39
SRA	380	429		4	2	5	38	39
SRA	381	529		4	2	5	38	39
SRA	382	629		5	2	5	37	4
SRA	383	331		4	1	2	38	39
SRA	384	431		4	1	2	38	39
SRA	385	531		4	1	2	38	39
SRA	386	631		5	1	2	37	4
SRA	387	332		4	1	2	38	39
SRA	388	432		4	1	2	38	39
SRA	389	532		4	1	2	38	39
SRA	390	632		5	1	2	37	4
SRA	391	333		4	1	2	38	39
SRA	392	433		4	1	2	38	39
SRA	393	533		4	1	2	38	39
SRA	394	633		5	1	2	37	4
SRA	395	334		4	1	2	38	39
SRA	396	434		4	1	2	38	39
SRA	397	534		4	1	2	38	39
SRA	398	634		5	1	2	37	4
SRA	399	335		4	1	2	38	39
SRA	400	435		4	1	2	38	39
SRA	401	535		4	1	2	38	39
SRA	402	635		5	1	2	37	4
SRA	403	336		4	1	2	38	39
SRA	404	436		4	1	2	38	39
SRA	405	536		4	1	2	38	39
SRA	406	636		5	1	2	37	4
SRA	407	337		4	1	2	38	39
SRA	408	437		4	1	2	38	39
SRA	409	537		4	1	2	38	39
SRA	410	637		5	1	2	37	4
SRA	411	338		4	1	2	38	39
SRA	412	438		4	1	2	38	39
SRA	413	538		4	1	2	38	39
SRA	414	638		5	1	2	37	4
SRA	415	339		4	2	2	38	39
SRA	416	439		4	2	2	38	39
SRA	417	539		4	2	2	38	39
SRA	418	639		5	2	2	37	4
VRA	0			2				
VRA	1	601	1	1		1	6	15
VRA	2	602	1	1		1	6	15
VRA	3	603	1	1		1	6	15
VRA	4	604	1	1		1	6	15
VRA	5	605	1	1		1	6	15
VRA	6	606	1	1		1	6	15
VRA	7	607	1	1		1	6	15
VRA	8	608	1	1		1	6	15
VRA	9	609	1	1		2	6	15
VRA	10	611	1	1		1	5	15
VRA	11	612	1	1		1	5	15
VRA	12	613	1	1		1	5	15

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 12)

```
VRA        13  614    1    1              1    5   15
VRA        14  615    1    1              1    5   15
VRA        15  616    1    1              1    5   15
VRA        16  617    1    1              1    5   15
VRA        17  618    1    1              1    5   15
VRA        18  619    1    1              2    5   15
VRA        19  621    1    1              1    5   15
VRA        20  622    1    1              1    5   15
VRA        21  623    1    1              1    5   15
VRA        22  624    1    1              1    5   15
VRA        23  625    1    1              1    9   15
VRA        24  626    1    1              1    5   15
VRA        25  627    1    1              1    5   15
VRA        26  628    1    1              1    5   15
VRA        27  629    1    1              2    5   15
VRA        28  631    1    1              1    2   15
VRA        29  632    1    1              1    2   15
VRA        30  633    1    1              1    2   15
VRA        31  634    1    1              1    2   15
VRA        32  635    1    1              1    2   15
VRA        33  636    1    1              1    2   15
VRA        34  637    1    1              1    2   15
VRA        35  638    1    1              1    2   15
VRA        36  639    1    1              2    2   15
VCA         0              2
VCA         5  200  200  200         6   16        17   18    1
FLUIDB      0   27         2         3   21   22                                     1
FLUIDB      5    0  200  201    3    3   -1   49    1   24   25   26   27          20
FLUIDB     10    0  101    0             -1    4   44    4
FLUIDB     15    1  111    0             -1    1   28    4
FLUIDB     20    0  201  202    3    3   -1   49    1   24   25   29   27          20
FLUIDB     25    0  102    0             -1    4   44    4
FLUIDB     30    1  112    0             -1    1   28    4
FLUIDB     35    0  202  203    3    3   -1   49    1   24   25   30   27          20
FLUIDB     40    0  103    0             -1    4   44    4
FLUIDB     45    1  113    0             -1    1   28    4
FLUIDB     50    0  203  204    3    3   -1   49    1   24   25   31   27          20
FLUIDB     55    0  104    0             -1    4   44    4
FLUIDB     60    1  114    0             -1    1   28    4
FLUIDB     65    0  204  205    3    3   -1   49    1   24   25   32   27          20
FLUIDB     70    0  105    0             -1    4   44    4
FLUIDB     75    1  115    0             -1    1   28    4
FLUIDB     80    0  205  206    3    3   -1   49    1   24   25   33   27          20
FLUIDB     85    0  106    0             -1    4   44    4
FLUIDB     90    1  116    0             -1    1   28    4
FLUIDB     95    0  206  207    3    3   -1   49    1   24   25   34   27          20
FLUIDB    100    0  107    0             -1    4   44    4
FLUIDB    105    1  117    0             -1    1   28    4
FLUIDB    110    0  207  208    3    3   -1   49    1   24   25   35   27          20
FLUIDB    115    0  108    0             -1    4   44    4
FLUIDB    120    1  118    0             -1    1   28    4
FLUIDB    125    0  208  209    3    3   -1   49    2   24   25   36   27          20
FLUIDB    130    0  109    0             -1    2    6    4
FLUIDB    135    1  119    0             -1    2   28    4
RRA         0              2
RRA         1  601    1    5    1         1    6   15
RRA         2  602    1    5    1         1    6   15
RRA         3  603    1    5    1         1    6   15
RRA         4  604    1    5    1         1    6   15
RRA         5  605    1    5    1         1    6   15
RRA         6  606    1    5    1         1    6   15
RRA         7  607    1    5    1         1    6   15
RRA         8  608    1    5    1         1    6   15
RRA         9  609    1    5    1         2    6   15
RRA        10  611    1    5    1         1    5   15
```

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 13)

```
RRA        11 612   1   5   1       1   9  15
RRA        12 613   1   5   1       1   5  15
RRA        13 614   1   5   1       1   5  15
RRA        14 615   1   5   1       1   5  15
RRA        15 616   1   5   1       1   5  15
RRA        16 617   1   5   1       1   5  15
RRA        17 618   1   5   1       1   5  15
RRA        18 619   1   5   1       2   5  15
RRA        19 621   1   5   1       1   5  15
RRA        20 622   1   5   1       1   5  15
RRA        21 623   1   5   1       1   5  15
RRA        22 624   1   5   1       1   9  15
RRA        23 625   1   5   1       1   5  15
RRA        24 626   1   5   1       1   5  15
RRA        25 627   1   5   1       1   5  15
RRA        26 628   1   5   1       1   5  15
RRA        27 629   1   5   1       2   5  15
RRA        28 631   1   5   1       1   2  15
RRA        29 632   1   5   1       1   2  15
RRA        30 633   1   5   1       1   2  15
RRA        31 634   1   5   1       1   2  15
RRA        32 635   1   5   1       1   2  15
RRA        33 636   1   5   1       1   2  15
RRA        34 637   1   5   1       1   2  15
RRA        35 638   1   5   1       1   2  15
RRA        36 639   1   5   1       2   2  15
TCIDNT    1  10   1             2   4   1
TCTITLCALCULATION INTERVAL
           -300.            30.             -14.9          30.
           -14.9            5.              1000.          5.
TCIDNT    1  10   2             2   4   1
TCTITLPRINT INTERVAL
           -300.            100.            -14.9          100.
           -14.9            15.             1000.          15.
TCIDNT    1   1   0            -2   2   1
TCTITLALUMINUM DENSITY
           -300.            0.              -14.9          170.
TCIDNT    1   2   0             2   6   2
TCTITLALUMINUM CP
           360.             0.154           460.           0.185
           560.             0.207           660.           0.217
           860.             0.23            960.           0.241
TCIDNT    1   3   0             2   7   2
TCTITL THERMAL CONDUCTIVITY - FACE SHEET - AL ALLOY
           360.0            57.5            560.0          71.5
           710.0            85.5            860.0          99.4
           960.0            103.5           1060.0         105.0
           2000.            105.
SAMECR    2   1   0             1   1   0
SAMECR    2   2   0             1   2   0
TCIDNT    2   3   0             2   3   2
TCTITL THERMAL CONDUCTIVITY - TUBE - 6061-T6 AL
           360.0            92.2            1060.0         107.0
           2000.            107.
TCIDNT    3   1   0             2   7   2
TCTITL DENSITY - FLUID - METHONAL AND WATER 6 TO 4 - THAR031174-1
           400.             58.9            460.           57.5
           520.             56.0            580.           54.1
           640.             52.0            700.           50.0
           760.             47.6
TCIDNT    3   2   0             2   2   2
TCTITL SPECIFIC HEAT - FLUID - METHANOL AND WATER 6 TO 4 - THAR031174-2
           400.             .895            760.           .994
TCIDNT    3   3   0             2   2   2
TCTITL THERMAL CONDUCTIVITY - FLUID - METHANOL AND WATER 6 TO 4 - THAR031174-3
```

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 14)

```
           400.                 .199                 760.                .174
TCIONT   3   8    0                2   20    2
TCTITL VISCOSITY - FLUID - METHANOL ANI WATER 6 TO 4 - THARD31174-4
           400.                 .019                 420.                .0103
           440.                 .005                 460.                .0036
           480.                 .0024                500.                .0016
           520.                 .00121               540.                .00093
           560.                 .0007                580.                .00056
           600.                 .00044               620.                .000355
           640.                 .000288              660.                .000235
           710.                 .000142              760.                .000095
           810.                 .000068              860.                .000053
           910.                 .000045             1460.                .000035
TCIONT   4   1    0               -2    2    1
TCTITLJM MICRO-FIBER 4PCF INSUL DENSITY
          -300.                 0.                   -14.9               4.
TCIONT   4   2    0                2    6    2
TCTITLJM MICRO-FIBER INSUL 4PCF SPECIFIC HEAT
           460.                 .18                  660.                .2
           860.                 .23                 1060.                .25
          1260.                 .26                 1460.                .27
TCIONT   4   3    0                2    6    2
TCTITLJM MICRO-FIBER INSUL 4PCF THERMAL COND.
           460.                 .0188                660.                .0281
           860.                 .0385               1060.                .051
          1260.                 .0635               1460.                .0823
TCIONT   5   1    0               -2    2    1
TCTITLTITANIUM DENSITY
          -300.                 0.                   -14.9               285.
TCIONT   5   2    0                2    4    2
TCTITLTITANIUM SPECIFIC HEAT
           360.                 .1157                560.                .1364
           960.                 .1458               2960.                .15
TCIONT   5   3    0                2    4    2
TCTITLTITANIUM THERMAL CONDUCTIVITY
           360.                 3.787                560.                4.581
           960.                 5.889               2960.                13.88
TCIONT   5   4    0                1
TCTITLEXTERNAL SURF EMISSIVITY 0.8
                                0.8
TCIONT   1   5    0                1
TCTITLINTERFACE COND. - TUBE/SKIN 20/.006
                                3333.
TCIONT   2   5    0                1
TCTITLINTERFACE COND. - SKIN/BACKUP 2.16/.01
                                216.
TCIONT   3   5    0                1
TCTITLINTERFACE COND. - BACKUP/SURFACE 10000
                                10000.
TCIONT 200  15    0                1
TCTITL HTC - NODE 200
                                100000.
TCIONT 200  13    1                1
TCTITLCOOLANT INITIAL TEMPERATURE
                                460.
TCIONT   1  15    0                2   16    1
TCTITLEXTERNAL HT XFER COEFF MACH 4.5 LOWER SURF REVISED TRAJ.
          -300.                 6.55                 0.                  6.55
           5.                   11.15                10.                 11.1
           40.                  6.                   55.                 4.27
           75.                  4.                   155.                5.95
           180.                 5.                   215.                4.5
           245.                 4.6                  285.                6.1
           343.                 10.6                 370.                11.5
           400.                 11.9                 600.                12.1
```

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 15)

```
TCIONT   1  13   1          2  15   1
TCTITLEXTERNAL TAW MACH 4.5 LOWER SURF REVISED TRAJ.
             -330.          1770.          0.             1770.
             5.             1695.          10.            1640.
             40.            1230.          55.            1195.
             75.            1125.          155.           855.
             180.           750.           215.           675.
             245.           630.           285.           580.
             345.           510.           370.           488.
             400.           460.
TCIONT   3  19   1
TCTITLFLOWRATE PER TUBE MACH 4.5 LOWER INSUL SHIELD
                            77.
TCTITL FRICTION FACTOR VS REYNOLDS NUMBER
             1.             16.            2.             8.
             4.             4.             8.             2.
             16.            1.             32.            .5
             64.            .25            100.           .16
             200.           .08            300.           .0533
             400.           .04            500.           .032
             600.           .0267          700.           .0229
             800.           .02            900.           .0178
             1000.          .016           1100.          .0145
             1200.          .0133          1300.          .0123
             1400.          .0114          1500.          .0107
             1600.          .01            1700.          .0094
             1800.          .0089          1900.          .0084
             2000.          .008           2100.          .00762
             2101.          .01168         2500.          .01119
             5000.          .00941         7500.          .0085
             10000.         .0079          20000.         .00665
             40000.         .00559         60000.         .00505
             1.0          E5.00445         1.001        E5.00456
             2.0          E5.004           5.0          E5.00333
             1.0          E6.0029
TCIONT   1  17   0                1
TCTITLRAD. VIEW FACTOR
                            1.
TCIONT   1  13   2                1
TCTITLRAD. SINK TEMP.
                            519.
END CASE
CHANG BASIC
CASEA        TRANSIENT
CASEC       -15.       600.      2000.      100.      -1.
FLUID9   X   0
END CASE
ENDJOB
```

FIGURE 4 - SAMPLE PROBLEM INPUT DATA CARD LISTING (SHEET 16)

```
JOB STARTED [illegible] TIME EXPENDED =    6.460 SEC            AVAILABLE COMMON LENGTH = 21596         T(1) LCN = 047642B

FASTEMP COMP[illegible]
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 1)

```
                  SUBROUTINE EQDAT
000102            CALL ORA
000103            CALL OPB
000104            CALL ORC
000105            CALL SRA
000106            CALL VRA
000107            CALL VCA
000110            CALL FLUIDB
000111            CALL PRA
000112            RETURN
000113            END
```

```
EQDAT

SUBPROGRAM LENGTH
000120

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

BLOCK NAMES AND LENGTHS
           -   000117

VARIABLE ASSIGNMENTS
W          -   00000001

START OF CONSTANTS
000015

START OF TEMPORARIES
000015

START OF INDIRECTS
000020

UNUSED COMPILER SPACE
005400
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 2)

```
HEATRAN*                     GENERAL HEAT TRANSFER PROGRAM.**75/12/08.*20.57.01.* PAGE   1            CASE=BASIC   SEQ= 1
                             TIME EXPENDED=   8.541 CP(SEC)
THE FOLLOWING ROUTINES ARE CALLED IN ORDER.

           DFA
           CPA
           TPC
           SRA
           VRA
           VCA
           FLUIDB
           RRA

                   END OF CASE REACHED ON INPUT. CARDS READ =    995
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 3)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.C1.* PAGE 2 CASE=BASIC SEC= 1

CASE = MP7 ELEMENTS = 208 METHOD = 6

K-DIAGONAL MATRIX..K = 207

BEGIN TIME = -300.0000 ENDING TIME = -15.0000

TMAX = 3500.00 TMIN = 300.00

TEMPERATURES ARE READ. ADD 460.000 NCA = 208

INITIAL TEMPERATURES DEGREE FAHRENHEIT

TIME= -300.0000

(1)	250.0000	250.0000	500.0000	500.0000	900.0000	900.0000	1350.0000	1350.0000	1550.0000	1550.0000	(10)
(11)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(20)
(21)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(30)
(31)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(40)
(41)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	250.0000	500.0000	500.0000	900.0000	(50)
(51)	900.0000	1350.0000	1350.0000	1550.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(60)
(61)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(70)
(71)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(80)
(81)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(90)
(91)	250.0000	250.0000	500.0000	500.0000	900.0000	900.0000	1350.0000	1350.0000	1550.0000	1550.0000	(100)
(101)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(110)
(111)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(120)
(121)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(130)
(131)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	250.0000	500.0000	500.0000	900.0000	(140)
(141)	900.0000	1350.0000	1350.0000	1550.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(150)
(151)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(160)
(161)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(170)
(171)	250.0000	500.0000	900.0000	1350.0000	1550.0000	250.0000	500.0000	900.0000	1350.0000	1550.0000	(180)
(181)	140.0000	140.0000	140.0000	140.0000	140.0000	140.0000	140.0000	140.0000	140.0000	75.0000	(190)
(191)	90.0000	105.0000	110.0000	115.0000	120.0000	125.0000	130.0000	130.0000	0.0000	15.0000	(200)
(201)	30.0000	45.0000	60.0000	75.0000	90.0000	105.0000	120.0000	120.0000	(208)		

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 4)

HEATFAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 3 CASE= HP7 SEQ= 1

START OF DIMENSION TABLE LOADING.

49 LCNBSS FOR *DIMENVALUE REFERENCE LOCATION = 624, CORE=0510218

DIMENSION TABLE**** 49 VALUES.

VALUES FOR DIMENSION TABLE NUMBER 1
NO CVALUE FOR TABLE 1

(1)	30.0000000E+00	(2)	10.0000000E-04	(3)	40.0000000E-03	(4)	10.0000000E-01
(5)	93.7[illegible]E-02	(6)	12.5000000E-02	(7)	35.0000000E-03	(8)	22.3400000E-02
(9)	[illegible]E+00	(10)	10.0000000E-01	(11)	46.9300000E-02	(12)	53.1300000E-02
(13)	17.4400000E-02	(14)	10.0000000E-01	(15)	10.0000000E-01	(16)	0.
(17)	[illegible]E+03	(18)	10.0000000E-01	(19)	0.	(20)	0.
(21)	21.[illegible]E+02	(22)	21.0150000E+02	(23)	0.	(24)	15.2800000E-02
(25)	24.54[illegible]E-03	(26)	15.0000000E+03	(27)	50.0000000E-02	(28)	19.5300000E-02
(29)	[illegible]E+00	(30)	75.0000000E+03	(31)	10.5000000E+01	(32)	13.5000000E+01
(33)	[illegible]E+01	(34)	19.5000000E+01	(35)	22.5000000E+01	(36)	24.0000000E+01
(37)	20.[illegible]E-03	(38)	25.0000000E-02	(39)	33.3300000E-02	(40)	30.0000000E-01
(41)	20.[illegible]E-03	(42)	41.7000000E-03	(43)	10.0000000E-03	(44)	37.5000000E-01
(45)	12.5[illegible]E-05	(46)	28.1300000E+00	(47)	18.8000000E-04	(48)	30.0000000E-03
(49)	12.2700000E-03						

END OF DIMENSION TABLE LOADING.

LOCATIONS USED = 624 LOCATIONS AVAILABLE = 20923
209 LCNBSS FOR *IPOINT REFERENCE LOCATION = 624, CORE=0510218

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 5)

HEATRAN*INS HT SHIELD MACH 4.9 .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 4 CASE= HP7 SEC= 1

THE FOLLOWING DATA BELONGS TO ROUTINE ORA

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80	
ORA		0	-0	-0	2	-1	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0-0
ORA		2	1	2	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		6	3	4	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		7	5	8	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		8	7	9	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		9	9	10	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		10	2	11	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		11	4	12	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		12	6	13	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		13	8	14	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		14	10	15	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		15	11	16	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		16	12	17	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		17	13	18	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		18	14	19	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		19	15	20	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		20	16	21	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		21	17	22	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		22	18	23	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		23	19	24	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		24	20	25	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		25	21	26	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		26	22	27	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		27	23	28	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		28	24	29	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		29	25	30	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		30	26	31	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		31	27	32	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		32	28	33	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		33	29	34	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		34	30	35	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		35	31	36	1	-1	1	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		36	32	37	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		37	33	38	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		38	34	39	4	-1	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		39	35	40	5	-1	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		40	36	41	1	-1	9	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		41	37	42	4	-1	9	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		42	38	43	4	-1	9	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		43	39	44	4	-1	9	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		44	40	45	5	-1	9	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		45	46	47	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		46	48	49	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		47	50	51	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		48	52	53	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		49	54	55	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		50	47	56	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		51	49	57	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		52	51	58	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		53	53	59	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		54	55	60	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		55	56	61	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		56	57	62	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0
ORA		57	58	63	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0

AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-08
AREA/DX= 1.1111E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 2.3146E-07
AREA/DX= 5.5556E-09
AREA/DX= 2.2222E-07
AREA/DX= 4.6296E-07
AREA/DX= 4.6296E-07
AREA/DX= 4.6296E-07
AREA/DX= 1.1111E-07
AREA/DX= 1.0417E-04
AREA/DX= 2.1699E-04
AREA/DX= 2.1699E-04
AREA/DX= 2.1699E-04
AREA/DX= 5.2083E-05
AREA/DX= 1.0417E-04
AREA/DX= 2.1699E-04
AREA/DX= 2.1699E-04

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 6)

HEATSAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 5 CASE= MP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
URA		58	59	64	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		59	60	65	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		60	61	66	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		61	62	67	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		62	63	68	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		63	64	69	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		64	65	70	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		65	66	71	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		66	67	72	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		67	68	73	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		68	69	74	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		69	70	75	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		70	71	76	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		71	72	77	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		72	73	78	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		73	74	79	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		74	75	80	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		75	76	81	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		76	77	82	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		77	78	83	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		78	79	84	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		79	80	85	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		80	81	86	1	-0	9	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.0833E-04
URA		81	82	87	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3398E-04
URA		82	83	88	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3393E-04
URA		83	84	89	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3393E-04
URA		84	85	90	5	-0	9	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		85	91	92	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		86	93	94	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		87	95	96	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		88	97	99	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		89	99	100	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		90	97	101	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		91	94	102	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		92	95	103	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		93	98	104	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		94	100	105	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		95	101	106	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		96	102	107	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		97	103	108	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		98	104	109	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		99	105	110	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		100	106	111	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		101	107	112	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		102	108	113	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		103	109	114	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		104	110	115	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		105	111	116	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		106	112	117	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
URA		107	113	118	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		108	114	119	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		109	115	120	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		110	116	121	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
URA		111	117	122	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1699E-04
URA		112	118	123	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		113	119	124	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1599E-04
URA		114	120	125	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2083E-05
URA		115	121	126	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 7)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 6   CASE= MP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
ORA		116	122	127	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
ORA		117	123	128	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
ORA		118	124	129	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1593E-04
ORA		119	125	130	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.2383E-05
ORA		120	126	131	1	-0	9	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.0833E-04
ORA		121	127	132	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3393E-04
ORA		122	128	133	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3393E-04
ORA		123	129	134	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3393E-04
ORA		124	130	135	5	-0	9	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0417E-04
ORA		125	136	137	1	-0	1	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		126	138	139	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		127	140	141	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		128	142	143	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		129	144	145	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		130	137	146	1	-0	1	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		131	139	147	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		132	141	148	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		133	143	149	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		134	145	150	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		135	146	151	1	-0	1	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		136	147	152	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		137	148	153	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		138	149	154	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		139	150	155	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		140	151	156	1	-0	1	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		141	152	157	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		142	153	158	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		143	154	159	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		144	155	160	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		145	156	161	1	-0	1	5	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		146	157	162	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		147	158	163	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		148	159	164	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		149	160	165	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		150	161	166	1	-0	1	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		151	162	167	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		152	163	168	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		153	164	169	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		154	165	170	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		155	166	171	1	-0	1	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		156	167	172	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		157	168	173	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		158	169	174	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.8932E-05
ORA		159	170	175	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.9444E-06
ORA		160	171	176	1	-0	9	6	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.7778E-05
ORA		161	172	177	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.7966E-05
ORA		162	173	178	4	-0	9	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.7966E-05
ORA		163	174	179	4	-0	9	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	5.7966E-05
ORA		164	175	180	5	-0	9	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3980E-05
ORA		165	1	46	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
ORA		166	3	48	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443979
ORA		167	5	50	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
ORA		168	7	52	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443979
ORA		169	9	54	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
ORA		170	46	91	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106667
ORA		171	48	93	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
ORA		172	50	95	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
ORA		173	52	97	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 8)

HEATRAN*INS AT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 7 CASE= MP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
DRA		174	54	99	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
DRA		175	91	136	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
DRA		176	93	138	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		177	95	140	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		178	97	142	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		179	99	144	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
DRA		180	2	47	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
DRA		181	4	49	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		182	6	51	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		183	8	53	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		184	10	55	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
DRA		185	47	92	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106667
DRA		186	49	94	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		187	51	96	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		188	53	98	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		189	55	100	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
DRA		190	92	137	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
DRA		191	94	139	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		192	96	141	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		193	98	143	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		194	100	145	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
DRA		195	11	56	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
DRA		196	12	57	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		197	13	58	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		198	14	59	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		199	15	60	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
DRA		200	56	101	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106667
DRA		201	57	102	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		202	58	103	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		203	59	104	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		204	60	105	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
DRA		205	101	146	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
DRA		206	102	147	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		207	103	148	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		208	104	149	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		209	105	150	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
DRA		210	16	61	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
DRA		211	17	62	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		212	18	63	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		213	19	64	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		214	20	65	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
DRA		215	61	106	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106667
DRA		216	62	107	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		217	63	108	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		218	64	109	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200
DRA		219	65	110	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
DRA		220	106	151	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
DRA		221	107	152	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		222	108	153	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		223	109	154	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392081
DRA		224	110	155	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
DRA		225	21	66	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
DRA		226	22	67	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		227	23	68	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		228	24	69	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443879
DRA		229	25	70	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
DRA		230	66	111	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106667
DRA		231	67	112	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222200

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 9)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 8 CASE= MP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
ORA		232	68	113	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		233	69	114	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		234	70	115	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
ORA		235	111	156	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
ORA		236	112	157	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		237	113	158	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		238	114	159	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		239	115	160	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
ORA		240	26	71	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
ORA		241	27	72	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		242	28	73	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		243	29	74	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		244	30	75	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
ORA		245	71	116	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106567
ORA		246	72	117	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		247	73	118	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		248	74	119	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		249	75	120	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
ORA		250	116	151	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
ORA		251	117	152	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		252	118	153	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		253	119	154	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		254	120	155	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
ORA		255	31	75	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
ORA		256	32	77	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		257	33	78	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		258	34	79	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		259	35	80	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
ORA		260	76	121	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106567
ORA		261	77	122	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		262	78	123	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		263	79	124	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		264	80	125	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
ORA		265	121	166	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
ORA		266	122	167	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		267	123	168	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		268	124	169	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		269	125	170	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
ORA		270	36	81	1	-0	11	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.213083
ORA		271	37	82	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		272	38	83	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		273	39	84	4	-0	11	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.443179
ORA		274	40	85	5	-0	11	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106542
ORA		275	81	126	1	-0	5	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.106567
ORA		276	82	127	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		277	83	128	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		278	84	129	4	-0	5	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.222222
ORA		279	85	130	5	-0	5	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.053333
ORA		280	126	171	1	-0	12	1	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.188218
ORA		281	127	172	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		282	128	173	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		283	129	174	4	-0	12	1	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.392381
ORA		284	130	175	5	-0	12	1	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.094109
ORA		285	41	86	1	-0	11	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	7.1028E-06
ORA		286	42	87	4	-0	11	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.4796E-05
ORA		287	43	88	4	-0	11	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.4796E-05
ORA		288	44	89	4	-0	11	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.4796E-05
ORA		289	45	90	5	-0	11	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.5514E-06

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 10)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.31.* PAGE 9.

CASE= HP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	-74	-80		
ORA		290	86	131	1	-0	5	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.5556E-06
ORA		291	87	132	4	-0	5	2	39	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	7.4067E-06
ORA		292	88	133	4	-0	5	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	7.4067E-06
ORA		293	89	134	4	-0	5	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	7.4067E-06
ORA		294	90	135	5	-0	5	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.7778E-06
ORA		295	131	176	1	-0	12	2	3	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	6.2733E-06
ORA		296	132	177	4	-0	12	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3069E-05
ORA		297	133	178	4	-0	12	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3069E-05
ORA		298	134	179	4	-0	12	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.3069E-05
ORA		299	135	180	5	-0	12	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.1372E-06
ORA		300	141	182	2	-0	1	5	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		305	142	183	2	-0	1	6	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		310	143	184	2	-0	1	6	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		315	144	185	2	-0	1	6	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		320	145	186	2	-0	1	5	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		325	146	187	2	-0	1	6	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		330	147	188	2	-0	1	6	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2153E-05
ORA		335	148	189	2	-0	9	5	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.4306E-05
ORA		340	150	191	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		345	151	192	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		350	152	193	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		355	153	194	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		360	154	195	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		365	155	196	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		370	156	197	2	-0	1	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	2.1758E-05
ORA		375	157	198	2	-0	9	8	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	4.3517E-05
ORA		380	181	190	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		385	182	191	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		390	183	192	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		395	184	193	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		400	185	194	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		405	186	195	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		410	187	196	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		415	188	197	2	-0	13	1	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.501720
ORA		420	189	198	2	-0	13	2	7	10	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.6724E-05
ORA		425	3	[illegible]	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		426	5	7	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		427	4	5	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		428	6	9	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		429	12	13	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		430	13	14	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		431	17	18	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		432	18	19	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		433	22	23	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		434	23	24	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		435	27	28	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		436	28	29	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		437	32	33	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		438	33	34	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		439	37	38	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		440	38	39	4	-0	38	2	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	.033300
ORA		441	42	43	4	-0	38	2	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0000E-06
ORA		442	43	44	4	-0	38	2	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.0000E-06
ORA		443	48	50	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA		444	50	52	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA		445	49	51	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA		446	51	53	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA		447	57	58	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 11)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 10 CASE= MP7 SEQ= 1

1----5 -10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
ORA	448	58	59	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	449	62	63	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	450	63	64	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	451	57	58	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	452	68	69	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	453	72	73	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	454	73	74	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	455	77	78	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	456	78	79	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	457	82	83	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	458	83	84	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	459	87	[illegible]	4	-0	38	5	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	9.3750E-04
ORA	460	[illegible]	[illegible]	4	-0	38	5	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	9.3750E-04
ORA	461	93	95	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	462	95	97	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	463	94	96	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	464	98	99	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	465	[illegible]	103	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	466	[illegible]	104	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	467	107	[illegible]	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	468	[illegible]	109	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	469	112	113	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	29.125000
ORA	470	113	114	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	471	117	118	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	472	118	119	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	473	122	123	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	474	123	124	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	29.125000
ORA	475	127	[illegible]	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	476	[illegible]	129	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	28.125000
ORA	477	132	133	4	-0	38	5	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	9.3750E-04
ORA	478	133	134	4	-0	38	5	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	9.3750E-04
ORA	479	[illegible]	140	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	480	140	142	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	481	139	141	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	482	142	143	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	483	147	148	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	484	148	149	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	485	152	153	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	486	153	154	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	487	157	[illegible]	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	488	158	159	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	489	[illegible]	153	4	-0	38	5	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	490	153	164	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	491	157	[illegible]	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	492	[illegible]	169	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	493	172	173	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	494	173	174	4	-0	38	6	1	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	3.750000
ORA	495	177	178	4	-0	38	6	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2500E-04
ORA	496	178	179	4	-0	38	6	2	40	-0	-0	-0	-0	-0	-0	-0	0-0	AREA/DX=	1.2500E-04

ROUTINE ORA LOADED. NCFOL = -0 NCFOL ACTUAL = 392

LOCATIONS REQUESTED = 0 NEW CURVES REQUESTED= 4
LOCATIONS USED = 833 LOCATIONS AVAILABLE = 20293
LOADING INFORMATION -12954 -12165 -10517

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 12)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JP INSUL .25 IN. TUBE **75/12/08.*20.57.(1.* PAGE 11 CASE= MP7 SEQ= 1

THE FOLLOWING DATA BELONGS TO ROUTINE DRB

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
ORB		0	-0	-0	2	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0-0		
ORB		1	135	133	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		2	137	139	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		3	146	147	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		4	151	152	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		5	156	157	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		6	161	162	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		7	166	167	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		8	171	172	1	4	41	44	42	44	44	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.064100
ORB		9	176	177	1	4	41	45	42	45	45	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	1.92000+03
ORB		10	91	93	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		11	92	94	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		12	101	102	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		13	106	107	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		14	111	112	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		15	116	117	1	4	41	45	42	46	45	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		16	121	122	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		17	126	127	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		18	131	132	1	4	41	47	42	47	47	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	127.659574
ORB		19	46	48	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		20	47	49	1	4	41	45	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		21	56	57	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		22	61	62	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		23	66	67	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		24	71	72	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		25	76	77	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		26	81	82	1	4	41	46	42	46	46	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.5318E-03
ORB		27	86	87	1	4	41	47	42	47	47	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	127.659574
ORB		28	1	3	1	4	41	48	42	48	48	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		29	2	4	1	4	41	48	42	48	48	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		30	11	12	1	4	41	48	42	48	49	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		31	16	17	1	4	41	48	42	48	48	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		32	21	22	1	4	41	48	42	48	49	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		33	26	27	1	4	41	48	42	49	48	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		34	31	32	1	4	41	48	42	48	48	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		35	36	37	1	4	41	48	42	48	48	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	8.000000
ORB		36	41	42	1	4	41	49	42	49	49	2	4	4	-0	-0	-0	0-0	X1/A1/B/BB	19.553302
ORB		37	142	144	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		38	143	145	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		39	149	150	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		40	154	155	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		41	159	160	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		42	164	165	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		43	169	170	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		44	174	175	4	5	42	44	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.133440
ORB		45	179	180	4	5	42	45	43	44	44	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	4.0032E+03
ORB		46	37	39	4	5	42	45	43	45	45	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		47	98	100	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		48	104	105	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		49	109	110	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		50	114	115	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		51	119	120	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		52	124	125	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789
ORB		53	129	130	4	5	42	46	43	46	46	3	4	4	-0	-0	-0	0-0	X1/A1/B/BB	.017789

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 13)

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HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.01.* PAGE  12          CASE=   MP7  SEQ= 1

1----6 -10 -14 -18 -22 -26 -30  -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
ORB             54 134 135   4   5   42   47   43   47   47    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB 256.170213
ORB             55  52  54   4   5   42   46   43   46   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             56  53  55   4   5   42   46   43   45   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             57  59  60   4   5   42   45   43   46   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             58  64  65   4   5   42   46   43   46   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             59  69  70   4   5   42   45   43   46   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             60  74  75   4   5   42   45   43   46   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             61  79  80   4   5   42   45   43   46   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             62  84  85   4   5   42   46   43   45   46    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB    .017789
ORB             63  89  90   4   5   42   47   43   47   47    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB 256.170213
ORB             64   7   9   4   5   42   48   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             65   8  10   4   5   42   49   43   49   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             66  14  15   4   5   42   49   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             67  19  20   4   5   42   48   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             68  24  25   4   5   42   49   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             69  29  30   4   5   42   49   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             70  34  35   4   5   42   48   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             71  39  40   4   5   42   48   43   48   48    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  16.680000
ORB             72  44  45   4   5   42   49   43   49   49    3    4    4   -0   -0   -0   0-0          X1/A1/B/BB  40.782396
ROUTINE  ORB    LOADED. NCFOL =  -0 NCFOL ACTUAL =  72
                                                    LOCATIONS REQUESTED =     0   NEW CURVES REQUESTED=     2
                                                              LOCATIONS USED =  833      LOCATIONS AVAILABLE = 20291
                                                                              LOADING INFORMATION  -12165 -11800 -10817


HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.01.* PAGE  13          CASE=   MP7  SEQ= 1

THE FOLLOWING DATA BELONGS TO ROUTINE ORC

1----6 -10 -14 -18 -22 -26 -30  -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
ORC              0  -0  -0   2  -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0  -0-0
ORC              5 130 181   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             10 137 182   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             15 146 183   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             20 151 184   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             25 156 185   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             30 161 186   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             35 166 187   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             40 171 188   1  -0   -0    1    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=      .026042
ORC             45 176 189   1  -0   -0    2    6   14   -0   -0   -0   -0   -0   -0   -0   0-0      AREA/DX=   5.6506E-07
ROUTINE  ORC    LOADED. NCFOL =  -0 NCFOL ACTUAL =   9
                                                    LOCATIONS REQUESTED =     0   NEW CURVES REQUESTED=     1
                                                              LOCATIONS USED =  833      LOCATIONS AVAILABLE = 20290
                                                                              LOADING INFORMATION  -11800 -11777 -10817
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FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 14)

HEATRAN*INS HT SHIELD MACH 4.6EL .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 14 CASE= MP7 SEQ= 1

THE FOLLOWING DATA BELONGS TO ROUTINE SRA

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
SRA		0	-0	-0	2	[illegible]	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0-0		
SRA		5	1	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		10	2	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		15	11	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		20	16	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		25	21	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		30	26	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		35	31	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		40	36	-0	1	[illegible]	1	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.5000E-03
SRA		45	41	-0	1	[illegible]	2	2	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	8.3333E-08
SRA		50	46	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		55	47	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		60	56	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		65	61	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		70	66	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		75	71	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		80	76	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		85	81	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		90	86	-0	1	[illegible]	2	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	7.8125E-05
SRA		95	91	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		100	92	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		105	101	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		110	106	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		115	111	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		120	116	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		125	121	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		130	126	-0	1	[illegible]	1	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.343750
SRA		135	131	-0	1	[illegible]	2	5	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	7.8125E-05
SRA		140	[illegible]	-0	1	[illegible]	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		145	137	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		150	[illegible]	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		155	151	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		160	156	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		165	[illegible]	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		170	166	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		175	171	-0	1	-1	1	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.312500
SRA		180	175	-0	1	-1	2	6	3	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.04167E-05
SRA		185	181	-0	2	-1	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		190	182	-0	2	-1	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		195	183	-0	2	-1	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		200	184	-0	2	-1	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		205	185	-0	2	-1	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		210	186	-0	2	[illegible]	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		215	187	-0	2	[illegible]	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		220	188	-0	2	[illegible]	1	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.273437
SRA		225	189	-0	2	[illegible]	2	6	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	9.11458E-06
SRA		230	190	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		235	191	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		240	192	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		245	193	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		250	194	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		255	195	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		260	[illegible]	-0	2	[illegible]	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562
SRA		265	197	-0	2	-0	1	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.489562

FIGURE 5 – SAMPLE PROBLEM OUTPUT (SHEET 15)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 15 CASE= MP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
SRA		274	133	-0	2	-0	2	8	7	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6319E-05
SRA		275	138	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		276	140	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		277	142	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		278	144	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		279	139	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		280	141	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		281	143	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		282	145	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		283	147	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		284	148	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		285	149	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		286	150	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		287	152	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		288	153	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		289	154	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		290	155	-0	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		291	157	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		292	158	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		293	159	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		294	160	-0	5	-0	1	6	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		295	162	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		296	163	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		297	164	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		298	165	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		299	167	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		300	168	-0	4	-0	1	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		301	169	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		302	170	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		303	172	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		304	173	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		305	174	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.652377
SRA		306	175	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	.156250
SRA		307	177	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.1699E-05
SRA		308	178	-0	4	-0	2	6	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.1699E-05
SRA		309	179	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	2.1699E-05
SRA		310	180	-0	5	-0	2	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2083E-06
SRA		311	93	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		312	95	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		313	97	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		314	99	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		315	94	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		316	95	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		317	98	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		318	100	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		319	102	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		320	103	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		321	104	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		322	105	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		323	107	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		324	108	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		325	109	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		326	110	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		327	112	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		328	113	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		329	114	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		330	115	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		331	117	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 16)

HEATRAN*INS HT SHIELD MACH [illegible]5L .25 IN JM INSUL .25 IN. TUDE **75/12/08.*20.57.(1.* PAGE 16 CASE= MP7 SEQ= 1

1----6	-10	-14	-18	-22	-26	-30	-34	-38	-42	-46	-50	-54	-58	-62	-66	-70	71-80			
SRA		332	116	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		333	119	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		334	120	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		335	122	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		336	123	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		337	124	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		338	125	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		339	127	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		340	128	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		341	129	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		342	130	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		343	132	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6274E-04
SRA		344	133	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6274E-04
SRA		345	134	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6274E-04
SRA		346	135	-0	5	-0	2	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	3.9062E-05
SRA		347	48	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		348	50	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		349	52	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		350	54	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		351	49	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		352	51	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		353	53	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		354	55	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		355	57	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		356	58	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		357	59	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		358	60	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		359	62	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		360	63	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		361	64	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		362	65	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		363	67	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		364	68	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		365	69	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		366	70	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		367	72	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		368	73	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		369	74	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		370	75	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		371	77	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		372	78	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		373	79	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		374	80	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		375	82	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		376	83	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		377	84	-0	4	-0	1	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	4.882324
SRA		378	85	-0	5	-0	1	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.171875
SRA		379	87	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6274E-04
SRA		380	88	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6274E-04
SRA		381	89	-0	4	-0	2	5	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.6274E-04
SRA		382	90	-0	5	-0	2	5	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	3.9062E-05
SRA		383	3	-0	4	-0	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2078E-03
SRA		384	5	-0	4	-0	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2078E-03
SRA		385	7	-0	4	-0	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2078E-03
SRA		386	9	-0	5	-0	1	2	37	4	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	1.2500E-03
SRA		387	4	-0	4	-0	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2078E-03
SRA		388	6	-0	4	-0	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2078E-03
SRA		389	8	-0	4	-0	1	2	38	39	-0	-0	-0	-0	-0	-0	-0	0-0	VOL*3600=	5.2078E-03

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 17)

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HEATRAN*INS AT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE  17          CASE=   MP7  SEQ= 1

1----6 -10 -14 -18 -22 -26 -30  -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
SRA        390  10  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        391  12  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2078E-03
SRA        392  13  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        393  14  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2078E-03
SRA        394  15  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        395  17  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2078E-03
SRA        396  18  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        397  19  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2078E-03
SRA        398  20  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        399  22  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        400  23  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        401  24  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2078E-03
SRA        402  25  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        403  27  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2078E-03
SRA        404  28  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        405  29  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        406  30  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        407  32  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        408  33  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        409  34  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        410  35  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        411  37  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        412  38  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        413  39  -0   4  -0    1    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  5.2079E-03
SRA        414  40  -0   5  -0    1    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.2500E-03
SRA        415  42  -0   4  -0    2    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.7359E-07
SRA        416  43  -0   4  -0    2    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.7359E-07
SRA        417  44  -0   4  -0    2    2   38   39   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  1.7359E-07
SRA        418  45  -0   5  -0    2    2   37    4   -0   -0   -0   -0   -0   -0   -0   0-0        VOL*3600=  4.1667E-08
ROUTINE  SRA   LOADED. NCFOL =  -0 NCFOL ACTUAL = 198
                                                 LOCATIONS REQUESTED =      0   NEW CURVES REQUESTED=     8
                                                         LOCATIONS USED =    833     LOCATIONS AVAILABLE = 20282
                                                                                  LOADING INFORMATION  -11777 -11376 -10817
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 18)

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HEATRAN*INS AT SHIELD MACH ..... .25 IN JP INSUL .25 IN. TUBE   **79/12/08.*20.57.01.* PAGE  18          CASE=   MP7  SEQ= 1

THE FOLLOWING DATA BELONGS TO  ROUTINE  VRA

1----6 -10 -14  -18 -22 -26 -30   -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
VRA          0   -0  -0   2  -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0  -0   -0-0
VRA          1  144   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          2  145   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          3  150   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          4  155   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          5  160   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          6  165   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          7  170   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          8  175   1   1  -0   -0    1    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .026042
VRA          9  180   1   1  -0   -0    2    6   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  8.6806E-07
VRA         10   99   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         11  100   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         12  105   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         13  110   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         14  115   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         15  120   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         16  125   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         17  130   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         18  135   1   1  -0   -0    2    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  6.5104E-06
VRA         19   54   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         20   55   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         21   60   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         22   65   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         23   70   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         24   75   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         25   80   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         26   85   1   1  -0   -0    1    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=     .195312
VRA         27   90   1   1  -0   -0    2    5   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  6.5104E-06
VRA         28    9   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         29   10   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         30   15   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         31   20   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         32   25   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         33   30   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         34   35   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         35   40   1   1  -0   -0    1    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  2.0833E-04
VRA         36   45   1   1  -0   -0    2    2   15   -0   -0   -0   -0   -0   -0  -0   0-0       AREA=  6.9444E-09
ROUTINE  VRA    LOADED.  NCPVL =  -0 NCFOL ACTUAL =  36
                                                   LOCATIONS REQUESTED =     0   NEW CURVES REQUESTED=     2
                                                            LOCATIONS USED =  833     LOCATIONS AVAILABLE = 20280
                                                                            LOADING INFORMATION  -11376 -11299 -10817
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 19)

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HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.01.* PAGE  19            CASE=   MP7  SEQ= 1

THE FOLLOWING DATA BELONGS TO ROUTINE VCA

1----6 -10 -14 -18 -22 -26 -30  -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
VCA          0  -0  -0   2  -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0  -0  -0-0
VCA          5 193 200 203  -0    6   16   -0   17   18    1   -0   -0   -0   -0  -0   0-0                  AREA=      8.5221E-05
ROUTINE  VCA    LOADED. NCFOL =  -0 NCFOL ACTUAL =   1
                                                  LOCATIONS REQUESTED =     0   NEW CURVES REQUESTED=       2
                                                            LOCATIONS USED =   833    LOCATIONS AVAILABLE = 20278
                                                                           LOADING INFORMATION  -11299 -11292 -10817


HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.01.* PAGE  20            CASE=   MP7  SEC= 1

THE FOLLOWING DATA BELONGS TO ROUTINE FLUIDB

1----6 -10 -14 -18 -22 -26 -30  -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
FLUIDB       0  27  -0   2  -0    3   21   22   -0   -0   -0   -0   -0   -0   -0  -0  -0-0
                                                            406 LCNBSS FOR *FLUIDB-0-  REFERENCE LOCATION =    833, CORE=0513428

FLUIDB      5   0 200 201   3    3   -1   49    1   24   25   26   27   -0   -0   -0    0-0
FLUIDB     10   0 101   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     15   1 111   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     20   0 201 202   3    3   -1   49    1   24   25   29   27   -0   -0   -0    0-0
FLUIDB     25   0 102   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     30   1 112   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     35   0 202 203   3    3   -1   49    1   24   25   30   27   -0   -0   -0    0-0
FLUIDB     40   0 103   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     45   1 113   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     50   0 203 204   3    3   -1   49    1   24   25   31   27   -0   -0   -0    0-0
FLUIDB     55   0 104   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     60   1 114   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     65   0 204 205   3    3   -1   49    1   24   25   32   27   -0   -0   -0    0-0
FLUIDB     70   0 105   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     75   1 115   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     80   0 205 206   3    3   -1   49    1   24   25   33   27   -0   -0   -0    0-0
FLUIDB     85   0 106   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     90   1 116   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB     95   0 206 207   3    3   -1   49    1   24   25   34   27   -0   -0   -0    0-0
FLUIDB    100   0 107   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB    105   1 117   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB    110   0 207 208   3    3   -1   49    1   24   25   35   27   -0   -0   -0    0-0
FLUIDB    115   0 108   0  -0   -0   -1    4   44    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB    120   1 118   0  -0   -0   -1    1   28    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB    125   0 208 209   3    3   -1   49    2   24   25   36   27   -0   -0   -0    0-0
FLUIDB    130   0 109   0  -0   -0   -1    2    6    4   -0   -0   -0   -0   -0   -0    0-0
FLUIDB    135   1 119   0  -0   -0   -1    2   28    4   -0   -0   -0   -0   -0   -0    0-0
ROUTINE  FLUIDB LOADED. NCFOL =  27 NCFOL ACTUAL =  27
                                                  LOCATIONS REQUESTED =   406   NEW CURVES REQUESTED=       5
                                                            LOCATIONS USED =  1239    LOCATIONS AVAILABLE = 19867
                                                                           LOADING INFORMATION  -11292 -11272 -10817
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FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 20)

ORIGINAL PAGE IS
OF POOR QUALITY

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HEATRAN*INS HT SHIELD MACH 4.5  - .25 IN JP INSUL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE  21           CASE=   HP7  SEQ= 1

THE FOLLOWING DATA BELONGS TO SUBROUTINE RRA

1----6 -10 -14 -18 -22 -26 -30     -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 7:-80
RRA          0  -0   -0             -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0-0
RRA          1 144    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          2 145    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          3 150    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          4 155    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          5 160    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          6 165    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          7 170    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          8 175    1    5        -0    1    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   4.4635E-11
RRA          9 180    1    5        -0    2    6   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   1.4978E-15
RRA         10  99    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         11 100    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         12 105    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         13 110    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         14 115    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         15 120    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         16 125    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         17 130    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         18 135    1    5        -0    2    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   1.1159E-14
RRA         19  54    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         20  59    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         21  60    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         22  65    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         23  70    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         24  75    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         25  80    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         26  85    1    5        -0    1    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.3477E-10
RRA         27  90    1    5        -0    2    5   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   1.1159E-14
RRA         28   5    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         29  10    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         30  15    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         31  20    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         32  25    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         33  30    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         34  35    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         35  40    1    5        -0    1    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   3.5709E-13
RRA         36  45    1    5        -0    2    2   15   -0   -0   -0   -0   -0   -0   -0   0-0       AREA=   1.1903E-17
ROUTINE  RRA    LOADED. NCFOL  =   -0 NCFOL ACTUAL =   36
                                                 LOCATIONS REQUESTED =     0    NEW CURVES REQUESTED=     3
                                                         LOCATIONS USED =  1239     LOCATIONS AVAILABLE = 19864
                                                                        LOADING INFORMATION  -11272 -11159 -10917
                                                                        LOADING INFORMATION  -11159 -11154 -10917
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FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 21)

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HEATRAN*INS HT SHIELD MACH 6.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.01.* PAGE  22          CASE=   MP7  SEQ= 1
                                       TABLE OF EQUATION TO NODE NUMBER CORRESPONDENCE
(  1)   31 (  2)   32 (  3)  331 (  4)  332 (  5)  431 (  6)  432 (  7)  531 (  8)  532 (  9)  631 ( 10)  632
( 11)   33 ( 12)  333 ( 13)  433 ( 14)  533 ( 15)  633 ( 16)   34 ( 17)  334 ( 18)  434 ( 19)  534 ( 20)  634
( 21)   35 ( 22)  335 ( 23)  435 ( 24)  535 ( 25)  635 ( 26)   36 ( 27)  336 ( 28)  436 ( 29)  536 ( 30)  636
( 31)   37 ( 32)  337 ( 33)  437 ( 34)  537 ( 35)  637 ( 36)   38 ( 37)  338 ( 38)  438 ( 39)  538 ( 40)  635
( 41)   39 ( 42)  339 ( 43)  439 ( 44)  539 ( 45)  639 ( 46)   21 ( 47)   22 ( 48)  321 ( 49)  322 ( 50)  421
( 51)  422 ( 52)  521 ( 53)  522 ( 54)  621 ( 55)  622 ( 56)   23 ( 57)  323 ( 58)  423 ( 59)  523 ( 60)  623
( 61)   24 ( 62)  324 ( 63)  424 ( 64)  524 ( 65)  624 ( 66)   25 ( 67)  325 ( 68)  425 ( 69)  525 ( 70)  625
( 71)   26 ( 72)  326 ( 73)  426 ( 74)  526 ( 75)  626 ( 76)   27 ( 77)  327 ( 78)  427 ( 79)  527 ( 80)  627
( 81)   28 ( 82)  328 ( 83)  428 ( 84)  528 ( 85)  628 ( 86)   29 ( 87)  329 ( 88)  429 ( 89)  529 ( 90)  629
( 91)   11 ( 92)   12 ( 93)  311 ( 94)  312 ( 95)  411 ( 96)  412 ( 97)  511 ( 98)  512 ( 99)  611 (100)  612
(101)   13 (102)  313 (103)  413 (104)  513 (105)  613 (106)   14 (107)  314 (108)  414 (109)  514 (110)  614
(111)   15 (112)  315 (113)  415 (114)  515 (115)  615 (116)   16 (117)  316 (118)  416 (119)  516 (120)  616
(121)   17 (122)  317 (123)  417 (124)  517 (125)  617 (126)   18 (127)  318 (128)  418 (129)  518 (130)  618
(131)   19 (132)  319 (133)  419 (134)  519 (135)  619 (136)    1 (137)    2 (138)  301 (139)  302 (140)  401
(141)  402 (142)  501 (143)  502 (144)  601 (145)  602 (146)    3 (147)  303 (148)  403 (149)  503 (150)  603
(151)    4 (152)  304 (153)  404 (154)  504 (155)  604 (156)    5 (157)  305 (158)  405 (159)  505 (160)  605
(161)    6 (162)  306 (163)  406 (164)  506 (165)  606 (166)    7 (167)  307 (168)  407 (169)  507 (170)  607
(171)    8 (172)  308 (173)  408 (174)  508 (175)  608 (176)    9 (177)  309 (178)  409 (179)  509 (180)  609
(181)  101 (182)  102 (183)  103 (184)  104 (185)  105 (186)  106 (187)  107 (188)  108 (189)  109 (190)  111
(191)  112 (192)  113 (193)  114 (194)  115 (195)  116 (196)  117 (197)  118 (198)  119 (199)  200 (200)  201
(201)  202 (202)  203 (203)  204 (204)  205 (205)  206 (206)  207 (207)  208 (208)  209
                                       TABLE OF NODE REFERENCES
(  1)    4 (  2)    5 (  3)    5 (  4)    6 (  5)    5 (  6)    6 (  7)    5 (  8)    6 (  9)    6 ( 10)    7
( 11)    5 ( 12)    6 ( 13)    6 ( 14)    6 ( 15)    7 ( 16)    5 ( 17)    6 ( 18)    6 ( 19)    6 ( 20)    7
( 21)    5 ( 22)    5 ( 23)    5 ( 24)    6 ( 25)    7 ( 26)    5 ( 27)    5 ( 28)    6 ( 29)    6 ( 30)    7
( 31)    5 ( 32)    5 ( 33)    5 ( 34)    5 ( 35)    7 ( 36)    5 ( 37)    6 ( 38)    6 ( 39)    6 ( 40)    7
( 41)    4 ( 42)    5 ( 43)    5 ( 44)    6 ( 45)    6 ( 46)    5 ( 47)    6 ( 48)    6 ( 49)    7 ( 50)    6
( 51)    7 ( 52)    5 ( 53)    7 ( 54)    7 ( 55)    8 ( 56)    6 ( 57)    7 ( 58)    7 ( 59)    7 ( 60)    8
( 61)    5 ( 62)    7 ( 63)    7 ( 64)    7 ( 65)    8 ( 66)    6 ( 67)    7 ( 68)    7 ( 69)    7 ( 70)    8
( 71)    5 ( 72)    7 ( 73)    7 ( 74)    7 ( 75)    8 ( 76)    6 ( 77)    7 ( 78)    7 ( 79)    7 ( 80)    8
( 81)    5 ( 82)    7 ( 83)    7 ( 84)    7 ( 85)    8 ( 86)    5 ( 87)    6 ( 88)    6 ( 89)    6 ( 90)    7
( 91)    5 ( 92)    6 ( 93)    6 ( 94)    7 ( 95)    6 ( 96)    7 ( 97)    7 ( 98)    7 ( 99)    7 (100)    8
(101)    5 (102)    7 (103)    7 (104)    7 (105)    8 (106)    6 (107)    7 (108)    7 (109)    7 (110)    8
(111)    6 (112)    7 (113)    7 (114)    7 (115)    8 (116)    6 (117)    7 (118)    7 (119)    7 (120)    8
(121)    6 (122)    7 (123)    7 (124)    7 (125)    8 (126)    6 (127)    7 (128)    7 (129)    7 (130)    8
(131)    5 (132)    6 (133)    6 (134)    6 (135)    7 (136)    5 (137)    6 (138)    5 (139)    6 (140)    5
(141)    5 (142)    5 (143)    6 (144)    6 (145)    7 (146)    6 (147)    6 (148)    6 (149)    6 (150)    7
(151)    5 (152)    6 (153)    6 (154)    6 (155)    7 (156)    6 (157)    6 (158)    6 (159)    6 (160)    7
(161)    6 (162)    6 (163)    6 (164)    6 (165)    7 (166)    6 (167)    6 (168)    6 (169)    6 (170)    7
(171)    6 (172)    6 (173)    6 (174)    6 (175)    7 (176)    5 (177)    5 (178)    5 (179)    5 (180)    6
(181)    5 (182)    6 (183)    6 (184)    6 (185)    6 (186)    6 (187)    6 (188)    6 (189)    5 (190)    4
(191)    5 (192)    5 (193)    5 (194)    5 (195)    5 (196)    6 (197)    5 (198)    4 (199)    2 (200)    2
(201)    2 (202)    2 (203)    2 (204)    2 (205)    2 (206)    2 (207)    2 (208)    1
                          TOTAL REFERENCES =  1253
COLUMN REFERENCES
(  1)  112 (  2)  124 (  3)  125 (  4)  128 (  5)  142 (  6)  115 (  7)  125 (  8)  124 (  9)  122 ( 10)  135
                   CONNECTED NODE DELTA, LEFT=    45 RIGHT=    45.....WITH TOTAL CONNECTORS =   518
                                                   ATAP DATA SETUP =  1800.....RECORDS WRITTEN =   9
                          CONNECTORS REQUESTED.
(  1)    3 (  2)    4 (  3)    4 (  4)    5 (  5)    4 (  6)    5 (  7)    4 (  8)    5 (  9)    3 ( 10)    4
( 11)    4 ( 12)    5 ( 13)    5 ( 14)    5 ( 15)    4 ( 16)    4 ( 17)    5 ( 18)    5 ( 19)    5 ( 20)    4
( 21)    4 ( 22)    5 ( 23)    5 ( 24)    5 ( 25)    4 ( 26)    4 ( 27)    5 ( 28)    5 ( 29)    5 ( 30)    4
( 31)    4 ( 32)    5 ( 33)    5 ( 34)    5 ( 35)    4 ( 36)    4 ( 37)    5 ( 38)    5 ( 39)    5 ( 40)    4
( 41)    3 ( 42)    4 ( 43)    4 ( 44)    4 ( 45)    3 ( 46)    4 ( 47)    5 ( 48)    5 ( 49)    6 ( 50)    5
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 22)

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 23 CASE= MP7 SEQ= 1

(51)	6 (52)	5 ([illegible])	6 (54)	4 (55)	5 (56)	5 (57)	6 (58)	6 (59)	6 (60)	5
(61)	5 (62)	6 ([illegible])	6 (64)	6 (65)	5 (66)	5 (67)	6 (68)	6 (69)	6 (70)	5
(71)	5 (72)	6 ([illegible])	5 (74)	5 (75)	5 (76)	5 (77)	6 (78)	6 (79)	6 (80)	5
(81)	5 (82)	5 ([illegible])	6 (84)	6 (85)	5 (86)	4 (87)	5 (88)	5 (89)	5 (90)	4
(91)	4 (92)	5 ([illegible])	5 (94)	6 (95)	5 (96)	5 (97)	5 (98)	6 (99)	4 (100)	5
(101)	5 (102)	[illegible]	6 (104)	6 (105)	5 (106)	5 (107)	6 (108)	6 (109)	6 (110)	5
(111)	5 (112)	[illegible]	[illegible] (114)	6 (115)	5 (116)	5 (117)	6 (118)	6 (119)	6 (120)	5
(121)	5 (122)	[illegible]	[illegible] (124)	5 (125)	5 (126)	5 (127)	6 (128)	6 (129)	6 (130)	5
(131)	4 (132)	[illegible]	5 (134)	5 (135)	4 (136)	4 (137)	5 (138)	4 (139)	5 (140)	4
(141)	5 (142)	4 ([illegible])	5 (144)	3 (145)	4 (146)	5 (147)	5 (148)	5 (149)	5 (150)	4
(151)	5 (152)	[illegible]	5 (154)	5 (155)	4 (156)	5 (157)	5 (158)	5 (159)	5 (160)	4
(161)	5 (162)	[illegible]	5 (164)	5 (165)	4 (166)	5 (167)	5 (168)	5 (169)	5 (170)	4
(171)	5 (172)	5 ([illegible])	5 (174)	5 (175)	4 (176)	4 (177)	4 (178)	4 (179)	4 (180)	3
(181)	5 (182)	5 ([illegible])	6 (184)	6 (185)	6 (186)	6 (187)	6 (188)	6 (189)	5 (190)	4
(191)	5 (192)	[illegible]	5 (194)	5 (195)	5 (196)	5 (197)	5 (198)	4 (199)	3 (200)	6
(201)	5 (202)	5 ([illegible])	6 (204)	6 (205)	6 (206)	6 (207)	6 (208)	3		

MATRIX METHOD STORAGE.....3.......6......8......9
43472 14864 1650 9504 (11228)

METHOD 8 IS ITERATION WHILE METHODS 3, 6 AND 9 ARE DIRECT

MINIMUM NODE NUMBER CONNECTED TO EQN(-)

(1)	2 (2)	1 (3)	1 (4)	2 (5)	3 (6)	4 (7)	5 (8)	6 (9)	7 (10)	8
(11)	2 (12)	4 (13)	6 (14)	8 (15)	10 (16)	11 (17)	12 (18)	13 (19)	14 (20)	15
(21)	16 (22)	17 (23)	18 (24)	19 (25)	20 (26)	21 (27)	22 (28)	23 (29)	24 (30)	25
(31)	26 (32)	27 (33)	28 (34)	29 (35)	30 (36)	31 (37)	32 (38)	33 (39)	34 (40)	35
(41)	36 (42)	37 (43)	38 (44)	39 (45)	40 (46)	1 (47)	2 (48)	3 (49)	4 (50)	5
(51)	6 (52)	7 (53)	8 (54)	9 (55)	10 (56)	11 (57)	12 (58)	13 (59)	14 (60)	15
(61)	15 (62)	17 (63)	18 (64)	19 (65)	20 (66)	21 (67)	22 (68)	23 (69)	24 (70)	25
(71)	25 (72)	27 (73)	28 (74)	29 (75)	30 (76)	31 (77)	32 (78)	33 (79)	34 (80)	35
(81)	36 (82)	37 (83)	38 (84)	39 (85)	40 (86)	41 (87)	42 (88)	43 (89)	44 (90)	45
(91)	46 (92)	47 (93)	48 (94)	49 (95)	50 (96)	51 (97)	52 (98)	53 (99)	54 (100)	55
(101)	55 (102)	57 (103)	58 (104)	59 (105)	60 (106)	61 (107)	62 (108)	63 (109)	64 (110)	65
(111)	66 (112)	67 (113)	68 (114)	69 (115)	70 (116)	71 (117)	72 (118)	73 (119)	74 (120)	75
(121)	75 (122)	77 (123)	78 (124)	79 (125)	80 (126)	81 (127)	82 (128)	83 (129)	84 (130)	85
(131)	85 (132)	87 (133)	88 (134)	89 (135)	90 (136)	91 (137)	92 (138)	93 (139)	94 (140)	95
(141)	96 (142)	97 (143)	98 (144)	99 (145)	100 (146)	101 (147)	102 (148)	103 (149)	104 (150)	105
(151)	105 (152)	107 (153)	108 (154)	109 (155)	110 (156)	111 (157)	112 (158)	113 (159)	114 (160)	115
(161)	116 (162)	117 (163)	118 (164)	119 (165)	120 (166)	121 (167)	122 (168)	123 (169)	124 (170)	125
(171)	126 (172)	127 (173)	128 (174)	129 (175)	130 (176)	131 (177)	132 (178)	133 (179)	134 (180)	135
(181)	136 (182)	137 (183)	146 (184)	151 (185)	156 (186)	161 (187)	166 (188)	171 (189)	176 (190)	181
(191)	182 (192)	183 (193)	184 (194)	185 (195)	186 (196)	187 (197)	188 (198)	189 (199)	181 (200)	181
(201)	182 (202)	183 (203)	184 (204)	185 (205)	186 (206)	187 (207)	188 (208)	189		

MAXIMUM NODE NUMBER CONNECTED TO EQN(-)

(1)	45 (2)	47 (3)	48 (4)	49 (5)	50 (6)	51 (7)	52 (8)	53 (9)	54 (10)	55
(11)	55 (12)	57 (13)	58 (14)	59 (15)	60 (16)	61 (17)	62 (18)	63 (19)	64 (20)	65
(21)	66 (22)	67 (23)	68 (24)	69 (25)	70 (26)	71 (27)	72 (28)	73 (29)	74 (30)	75
(31)	76 (32)	77 (33)	78 (34)	79 (35)	80 (36)	81 (37)	82 (38)	83 (39)	84 (40)	85
(41)	86 (42)	87 (43)	88 (44)	89 (45)	90 (46)	91 (47)	92 (48)	93 (49)	94 (50)	95
(51)	96 (52)	97 (53)	98 (54)	99 (55)	100 (56)	101 (57)	102 (58)	103 (59)	104 (60)	105
(61)	105 (62)	107 (63)	108 (64)	109 (65)	110 (66)	111 (67)	112 (68)	113 (69)	114 (70)	115
(71)	116 (72)	117 (73)	118 (74)	119 (75)	120 (76)	121 (77)	122 (78)	123 (79)	124 (80)	125
(81)	126 (82)	127 (83)	128 (84)	129 (85)	130 (86)	131 (87)	132 (88)	133 (89)	134 (90)	135
(91)	136 (92)	137 (93)	138 (94)	139 (95)	140 (96)	141 (97)	142 (98)	143 (99)	144 (100)	145
(101)	146 (102)	147 (103)	148 (104)	149 (105)	150 (106)	151 (107)	152 (108)	153 (109)	154 (110)	155
(111)	156 (112)	157 (113)	158 (114)	159 (115)	160 (116)	161 (117)	162 (118)	163 (119)	164 (120)	165
(121)	166 (122)	167 (123)	168 (124)	169 (125)	170 (126)	171 (127)	172 (128)	173 (129)	174 (130)	175

HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE **75/12/08.*20.57.01.* PAGE 24 CASE= MP7 SEQ= 1

(131)	176 (132)	177 (133)	178 (134)	179 (135)	180 (136)	181 (137)	182 (138)	140 (139)	147 (140)	142
(141)	148 (142)	144 (143)	149 (144)	145 (145)	150 (146)	183 (147)	152 (148)	153 (149)	154 (150)	155
(151)	184 (152)	157 (153)	158 (154)	159 (155)	160 (156)	185 (157)	162 (158)	163 (159)	164 (160)	165
(161)	186 (162)	167 (163)	168 (164)	169 (165)	170 (166)	187 (167)	172 (168)	173 (169)	174 (170)	175
(171)	188 (172)	177 (173)	178 (174)	179 (175)	180 (176)	189 (177)	175 (178)	179 (179)	180 (180)	179
(181)	200 (182)	201 (183)	202 (184)	203 (185)	204 (186)	205 (187)	206 (188)	207 (189)	208 (190)	200
(191)	201 (192)	202 (193)	203 (194)	204 (195)	205 (196)	206 (197)	207 (198)	208 (199)	200 (200)	201
(201)	202 (202)	203 (203)	204 (204)	209 (205)	206 (206)	207 (207)	208 (208)	207		

LOCATIONS USED = 1239 LOCATIONS AVAILABLE = 19863

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 23)

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HEATRAN*INS HT SHIELD MACH W.5L .25 IN JP INSUL .25 IN. TUBE   **75/12/08.*20.57.81.* PAGE  25        CASE=  MP7  SEQ= 1

                              START OF TEMPORARY CURVE LOADING.

( 1)     11001 ( 2)     10000 ( 3)      40300 ( 4)      50300 ( 5)     20300 ( 6)     20500 ( 7)     30500 ( 8)     10500
( 9)     10200 (10)     10100 (11)      20200 (12)      20100 (13)     40200 (14)     40100 (15)     50200 (16)     50100
(17)     11301 (18)     11300 (19)    2001301 (20)    2001500 (21)     30100 (22)     30200 (23)     31901 (24)     30300
(25)     30800 (26)     30400 (27)      11700 (28)      11302 (29)     11002
                THE ABOVE ARE CURVE IDENTIFICATIONS IN ORDER OF REQUEST BY SUBROUTINES

                              CURVE DATA TO BE USED IS LISTED BELOW.

CURVE NO.    1              CALCULATION INTERVAL
         NRELN =    1  NTYPE =  10  NCLAS =   1  MATRL =  -0  NDIMN =   2    NPNT1 =    4     RARG1 =   1
              ARGUMENT                VALUE                 ARGUMENT                VALUE

          -30.0000000E+01       30.0000000E+00       -14.9000000E+00       30.0000000E+00
          -14.9000000E+00       50.0000000E-01        10.0000000E+02       50.0000000E-01
CURVE NO.    2              PRINT INTERVAL
         NRELN =    1  NTYPE =  10  NCLAS =   2  MATRL =  -0  NDIMN =   2    NPNT1 =    4     RARG1 =   1
              ARGUMENT                VALUE                 ARGUMENT                VALUE

          -30.0000000E+01       10.0000000E+01       -14.9000000E+00       10.0000000E+01
          -14.9000000E+00       15.0000000E+00        10.0000000E+02       15.0000000E+00
CURVE NO.    3              ALUMINUM DENSITY
         NRELN =    1  NTYPE =   1  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =    4     RARG1 =   1
              ARGUMENT                VALUE                 ARGUMENT                VALUE

          -30.0000000E+01       0.                   -14.9000029E+00        0.
          -14.9000000E+00       17.0000000E+01       -13.9000000E+00       17.0000000E+01
CURVE NO.    4              ALUMINUM CP
         NRELN =    1  NTYPE =   2  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =    6     RARG1 =   2
              ARGUMENT                VALUE                 ARGUMENT                VALUE

           36.0000000E+01       16.4000000E-02        46.0000000E+01       18.5000000E-02
           56.0000000E+01       20.7000000E-02        66.0000000E+01       21.7000000E-02
           86.0000000E+01       23.0000000E-02        96.0000000E+01       24.1000000E-02
CURVE NO.    5              THERMAL CONDUCTIVITY - FACE SHEET - AL ALLOY
         NRELN =    1  NTYPE =   3  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =    7     RARG1 =   2
              ARGUMENT                VALUE                 ARGUMENT                VALUE

           36.0000000E+01       57.5000000E+00        56.0000000E+01       71.5000000E+00
           71.0000000E+01       85.5000000E+00        86.0000000E+01       99.4000000E+00
           96.0000000E+01       10.3500000E+01        10.6000000E+02       10.5000000E+01
           20.0000000E+02       10.5000000E+01
CURVE NO.    6     I.D. =     20100  WAS TO BE THE SAME AS CURVE I.D. =    10100
CURVE NO.    7     I.D. =     20200  WAS TO BE THE SAME AS CURVE I.D. =    10200
CURVE NO.    8              THERMAL CONDUCTIVITY - TUBE - 6061-T6 AL
         NRELN =    2  NTYPE =   3  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =    3     RARG1 =   2
              ARGUMENT                VALUE                 ARGUMENT                VALUE

           36.0000000E+01       92.2000000E+00        10.6000000E+02       10.7000000E+01
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 24)

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HEATRAN*INS HT SHIELD MACH . .. .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.01.* PAGE  26          CASE=   MP7  SEC= 1
          ARGUMENT                VALUE                 ARGUMENT              VALUE
        20.0000000E+02        10.7000000E+01

CURVE NO.    9                DENSITY - FLUID - METHONAL AND WATER 6 TO 4 - THAR031174-1
        NRELN =   3  NTYPE =   1  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =   7     RARG1 =   2
          ARGUMENT                VALUE                 ARGUMENT              VALUE

        40.0000000E+01        58.9000000E+00        46.0000000E+01        57.5000000E+00
        52.0000000E+01        56.0000000E+00        58.0000000E+01        54.1000000E+00
        64.0000000E+01        52.0000000E+00        70.0000000E+01        50.0000000E+00
        76.0000000E+01        47.5000000E+00

CURVE NO.   10                SPECIFIC HEAT - FLUID - METHANOL AND WATER 6 TO 4 - THAR031174-2
        NRELN =   3  NTYPE =   2  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =   2     RARG1 =   2
          ARGUMENT                VALUE                 ARGUMENT              VALUE

        40.0000000E+01        69.5000000E-02        76.0000000E+01        99.4000000E-02

CURVE NO.   11                THERMAL CONDUCTIVITY - FLUID - METHANOL AND WATER 6 TO 4 - THAR03
        NRELN =   3  NTYPE =   3  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =   2     RARG1 =   2
          ARGUMENT                VALUE                 ARGUMENT              VALUE

        40.0000000E+01        19.9000000E-02        76.0000000E+01        17.4000000E-02

CURVE NO.   12                VISCOSITY - FLUID - METHANOL AND WATER 6 TO 4 - THAR031174-4
        NRELN =   3  NTYPE =   8  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =  20     RARG1 =   2
          ARGUMENT                VALUE                 ARGUMENT              VALUE

        40.0000000E+01        19.0000000E-03        42.0000000E+01        10.3000000E-03
        44.0000000E+01        60.0000000E-04        45.0000000E+01        36.0000000E-04
        48.0000000E+01        24.0000000E-04        50.0000000E+01        16.0000000E-04
        52.0000000E+01        12.1000000E-04        54.0000000E+01        93.0000000E-05
        56.0000000E+01        70.0000000E-05        58.0000000E+01        56.0000000E-05
        60.0000000E+01        44.0000000E-05        62.0000000E+01        35.5000000E-05
        64.0000000E+01        28.8000000E-05        66.0000000E+01        23.5000000E-05
        71.0000000E+01        14.2000000E-05        76.0000000E+01        95.0000000E-06
        81.0000000E+01        68.0000000E-06        86.0000000E+01        53.0000000E-06
        91.0000000E+01        45.0000000E-06        14.6000000E+02        35.0000000E-06

CURVE NO.   13                JM MICRO-FIBER 4PCF INSUL DENSITY
        NRELN =   4  NTYPE =   1  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =   4     RARG1 =   1
          ARGUMENT                VALUE                 ARGUMENT              VALUE

       -30.0000000E+01        0.                   -14.9000029E+00        0.
       -14.9000000E+00        40.0000000E-01       -13.9000000E+00        40.0000000E-01

CURVE NO.   14                JM MICRO-FIBER INSUL 4PCF SPECIFIC HEAT
        NRELN =   4  NTYPE =   2  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =   6     RARG1 =   2
          ARGUMENT                VALUE                 ARGUMENT              VALUE

        46.0000000E+01        18.0000000E-02        66.0000000E+01        20.0000000E-02
        86.0000000E+01        23.0000000E-02        10.6000000E+02        25.0000000E-02
        12.6000000E+02        26.0000000E-02        14.6000000E+02        27.0000000E-02

CURVE NO.   15                JM MICRO-FIBER INSUL 4PCF THERMAL COND.
        NRELN =   4  NTYPE =   3  NCLAS =   0  MATRL =  -0  NDIMN =   2    NPNT1 =   6     RARG1 =   2
          ARGUMENT                VALUE                 ARGUMENT              VALUE

        46.0000000E+01        18.8000000E-03        65.0000000E+01        23.1000000E-03
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 25)

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HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE  27          CASE=  MP7  SEQ= 1
                    ARGUMENT           VALUE              ARGUMENT          VALUE

                 96.0000000E+01     38.5000000E-03     10.6000000E+02     51.0000000E-03
                 12.6000000E+02     63.5000000E-03     14.6000000E+02     82.3000000E-03
CURVE NO.   16              TITANIUM DENSITY
             NRELN =    5  NTYPE =    1  NCLAS =    0  MATRL =  -0  NDIMN =   2    NPNT1 =   4    RARG1 =   1
                    ARGUMENT           VALUE              ARGUMENT          VALUE

                -30.0000000E+01      0.                -14.9000029E+00     0.
                -14.9000000E+00     28.5000000E+01     -13.9000000E+00    28.5000000E+01
CURVE NO.   17              TITANIUM SPECIFIC HEAT
             NRELN =    5  NTYPE =    2  NCLAS =    0  MATRL =  -0  NDIMN =   2    NPNT1 =   4    RARG1 =   2
                    ARGUMENT           VALUE              ARGUMENT          VALUE

                 36.0000000E+01     11.5700000E-02     56.0000000E+01     13.6400000E-02
                 96.0000000E+01     14.6800000E-02     29.6000000E+02     15.0000000E-02
CURVE NO.   18              TITANIUM THERMAL CONDUCTIVITY
             NRELN =    5  NTYPE =    3  NCLAS =    0  MATRL =  -0  NDIMN =   2    NPNT1 =   4    RARG1 =   2
                    ARGUMENT           VALUE              ARGUMENT          VALUE

                 36.0000000E+01     37.9700000E-01     56.0000000E+01     45.8100000E-01
                 95.0000000E+01     58.8900000E-01     29.6000000E+02     13.8800000E+00
CURVE NO.   19              EXTERNAL SURF EMISSIVITY 0.8
               NRELN =    5  NTYPE =   4  NCLAS =   0        CONSTANT VALUE =        80.0000000E-02
CURVE NO.   20              INTERFACE COND. - TUBE/SKIN 20/.005
               NRELN =    1  NTYPE =   5  NCLAS =   0        CONSTANT VALUE =        33.3300000E+02
CURVE NO.   21              INTERFACE COND. - SKIN/BACKUP 2.16/.01
               NRELN =    2  NTYPE =   5  NCLAS =   0        CONSTANT VALUE =        21.6000000E+01
CURVE NO.   22              INTERFACE COND. - BACKUP/SURFACE 10000
               NRELN =    3  NTYPE =   5  NCLAS =   0        CONSTANT VALUE =        10.0000000E+03
CURVE NO.   23               HTC - NODE 200
               NRELN = 200  NTYPE =  15  NCLAS =   0        CONSTANT VALUE =        10.0000000E+04
CURVE NO.   24              COOLANT INITIAL TEMPERATURE
               NRELN = 200  NTYPE =  13  NCLAS =   1        CONSTANT VALUE =        46.0000000E+01
CURVE NO.   25              EXTERNAL HT XFER COEFF MACH 4.5 LOWER SURF REVISED TRAJ.
             NRELN =    1  NTYPE =   15  NCLAS =    0  MATRL =  -0  NDIMN =   2    NPNT1 =  16    RARG1 =   1
                    ARGUMENT           VALUE              ARGUMENT          VALUE

                -30.0000000E+01     65.5000000E-01      0.                65.5000000E-01
                 50.0000000E-01     11.1500000E+00     10.0000000E+00     11.1000000E+00
                 40.0000000E+00     60.0000000E-01     55.0000000E+00     42.7000000E-01
                 75.0000000E+00     40.0000000E-01     15.5000000E+01     59.5000000E-01
                 13.0000000E+01     50.0000000E-01     21.5000000E+01     45.0000000E-01
                 24.5000000E+01     46.0000000E-01     28.5000000E+01     61.0000000E-01
                 34.5000000E+01     10.6000000E+00     37.0000000E+01     11.5000000E+00
                 40.0000000E+01     11.9000000E+00     60.0000000E+01     12.1000000E+00
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 26)

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HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE  28          CASE=   HP7  SEQ= 1

CURVE NO.    26              EXTERNAL TAW MACH 4.5 LOWER SURF REVISED TRAJ.
                NRELN =    1  NTYPE =  13  NCLAS =    1  MATRL =  -0  NUIMN =    2    NPNT1 =  15    RARG1 =    1
                   ARGUMENT               VALUE                ARGUMENT                VALUE

               -30.0000000E+01        17.7000000E+02        0.                     17.7000000E+02
                50.0000000E-01        16.9500000E+02        10.0000000E+00         16.4000000E+02
                40.0000000E+00        12.9000000E+02        55.0000000E+00         11.9500000E+02
                75.0000000E+00        11.2500000E+02        15.5000000E+01         85.5000000E+01
                18.0000000E+01        75.0000000E+01        21.5000000E+01         67.5000000E+01
                24.5000000E+01        63.0000000E+01        28.5000000E+01         58.0000000E+01
                34.5000000E+01        51.0000000E+01        37.0000000E+01         48.8000000E+01
                40.0000000E+01        46.0000000E+01

CURVE NO.    27              FLOWRATE PER TUBE MACH 4.5 LOWER INSUL SHIELD
                  NRELN =    3  NTYPE =  19  NCLAS =    1      CONSTANT VALUE =          77.0000000E+00

CURVE NO.    28              RAD. VIEW FACTOR
                  NRELN =    1  NTYPE =  17  NCLAS =    0      CONSTANT VALUE =          10.0000000E-01

CURVE NO.    29              RAD. SINK TEMP.
                  NRELN =    1  NTYPE =  13  NCLAS =    2      CONSTANT VALUE =          51.9000000E+01
                                                                 LOCATIONS USED =   1578     LOCATIONS AVAILABLE = 19524
                                                                               DROPPED DIMEN TABLE=1
                                                                 LOCATIONS USED =   1578     LOCATIONS AVAILABLE = 20018
                                                             208 LCNBSS FOR *DUMMY USE   REFERENCE LOCATION =    1578, CORE=052713B
                             TIME EXPENDED=   27.943 CP(SEC)
                                                                 LOCATIONS USED =   1786     LOCATIONS AVAILABLE = 19810
                                                           14656 LCNBSS FOR *MATRIX      REFERENCE LOCATION =    1786, CORE=053233B
                                                             208 LCNBSS FOR *(CONSTANT)  REFERENCE LOCATION =   16442, CORE=107733B
                                                                 LOCATIONS USED = 16650      LOCATIONS AVAILABLE =   4946
ROUTINE ORA    EXTRAPOLATED CURVE    40300 18.1000000E+02
ROUTINE SRA    EXTRAPOLATED CURVE    40200 18.1000000E+02
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 27)

```
HEATFAN*INS IT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.C1.* PAGE   1          CASE=   MP7  SEQ= 1

TIME =   -300.0000          INITIAL TEMPERATURES          DEGREE FAHRENHEIT
    (   1)= 250.00  (   2)= 250.00  (   3)= 250.00  (   4)= 250.00  (   5)= 250.00  (   6)= 250.00  (   7)= 250.00  (   8)= 250.00
    (   9)= 250.00  (  11)= 250.00  (  12)= 250.00  (  13)= 250.00  (  14)= 250.00  (  15)= 250.00  (  16)= 250.00  (  17)= 250.00
    (  18)= 250.00  ( 434)= 900.00  (  21)= 250.00  (  22)= 250.00  (  23)= 250.00  (  24)= 250.00  (  25)= 250.00  (  26)= 250.00
    (  27)= 250.00  (  28)= 250.00  (  29)= 250.00  (  31)= 250.00  (  32)= 250.00  (  33)= 250.00  (  34)= 250.00  (  35)= 250.00
    (  36)= 250.00  (  37)= 250.00  (  38)= 250.00  (  39)= 250.00  ( 101)= 140.00  ( 102)= 140.00  ( 103)= 140.00  ( 104)= 140.00
    ( 105)= 140.00  ( 106)= 140.00  ( 107)= 140.00  ( 108)= 140.00  ( 109)= 140.00  ( 111)=  75.00  ( 112)=  90.00  ( 113)= 105.00
    ( 114)= 110.00  ( 115)= 115.00  ( 116)= 120.00  ( 117)= 125.00  ( 118)= 130.00  ( 119)= 130.00  ( 200)=   0.00  ( 201)=  15.00
    ( 202)=  30.00  ( 203)=  45.00  ( 204)=  60.00  ( 205)=  75.00  ( 206)=  90.00  ( 207)= 105.00  ( 208)= 120.00  ( 209)= 120.00
    ( 301)= 500.00  ( 302)= 500.00  ( 303)= 500.00  ( 304)= 500.00  ( 305)= 500.00  ( 306)= 500.00  ( 307)= 500.00  ( 308)= 500.00
    ( 309)= 500.00  ( 311)= 500.00  ( 312)= 500.00  ( 313)= 500.00  ( 314)= 500.00  ( 315)= 500.00  ( 316)= 500.00  ( 317)= 500.00
    ( 318)= 500.00  ( 319)= 500.00  ( 321)= 500.00  ( 322)= 500.00  ( 323)= 500.00  ( 324)= 500.00  ( 325)= 500.00  ( 326)= 500.00
    ( 327)= 500.00  ( 328)= 500.00  ( 329)= 500.00  ( 331)= 500.00  ( 332)= 500.00  ( 333)= 500.00  ( 334)= 500.00  ( 335)= 500.00
    ( 336)= 500.00  ( 337)= 500.00  ( 338)= 500.00  ( 339)= 500.00  ( 401)= 900.00  ( 402)= 900.00  ( 403)= 900.00  ( 404)= 900.00
    ( 405)= 900.00  ( 406)= 900.00  ( 407)= 900.00  ( 408)= 900.00  ( 409)= 900.00  ( 411)= 900.00  ( 412)= 900.00  ( 413)= 900.00
    ( 414)= 900.00  ( 415)= 900.00  ( 416)= 900.00  ( 417)= 900.00  ( 418)= 900.00  ( 419)= 900.00  ( 421)= 900.00  ( 422)= 900.00
    ( 423)= 900.00  ( 424)= 900.00  ( 425)= 900.00  ( 426)= 900.00  ( 427)= 900.00  ( 428)= 900.00  ( 429)= 900.00  ( 431)= 900.00
    ( 432)= 900.00  ( 433)= 900.00  (  19)= 250.00  ( 435)= 900.00  ( 436)= 900.00  ( 437)= 900.00  ( 438)= 900.00  ( 439)= 900.00
    ( 501)=1350.00  ( 502)=1350.00  ( 503)=1350.00  ( 504)=1350.00  ( 505)=1350.00  ( 506)=1350.00  ( 507)=1350.00  ( 508)=1350.00
    ( 509)=1350.00  ( 511)=1350.00  ( 512)=1350.00  ( 513)=1350.00  ( 514)=1350.00  ( 515)=1350.00  ( 516)=1350.00  ( 517)=1350.00
    ( 518)=1350.00  ( 519)=1350.00  ( 521)=1350.00  ( 522)=1350.00  ( 523)=1350.00  ( 524)=1350.00  ( 525)=1350.00  ( 526)=1350.00
    ( 527)=1350.00  ( 528)=1350.00  ( 529)=1350.00  ( 531)=1350.00  ( 532)=1350.00  ( 533)=1350.00  ( 534)=1350.00  ( 535)=1350.00
    ( 536)=1350.00  ( 537)=1350.00  ( 538)=1350.00  ( 539)=1350.00  ( 601)=1550.00  ( 602)=1550.00  ( 603)=1550.00  ( 604)=1550.00
    ( 605)=1550.00  ( 606)=1550.00  ( 607)=1550.00  ( 608)=1550.00  ( 609)=1550.00  ( 611)=1550.00  ( 612)=1550.00  ( 613)=1550.00
    ( 614)=1550.00  ( 615)=1550.00  ( 616)=1550.00  ( 617)=1550.00  ( 618)=1550.00  ( 619)=1550.00  ( 621)=1550.00  ( 622)=1550.00
    ( 623)=1550.00  ( 624)=1550.00  ( 625)=1550.00  ( 626)=1550.00  ( 627)=1550.00  ( 628)=1550.00  ( 629)=1550.00  ( 631)=1550.00
    ( 632)=1550.00  ( 633)=1550.00  ( 634)=1550.00  ( 635)=1550.00  ( 636)=1550.00  ( 637)=1550.00  ( 638)=1550.00  ( 639)=1550.00
                                          LOCATIONS USED = 17690     LOCATIONS AVAILABLE =   3906
                                          LOCATIONS USED = 17690     LOCATIONS AVAILABLE =   3906

TIME =   -200.0000          DEGREE FAHRENHEIT     K2 =       4     INTERP
    (   1)=  53.26  (   2)=  92.14  (   3)= 117.90  (   4)= 142.66  (   5)= 125.24  (   6)= 122.89  (   7)= 137.65  (   8)= 152.31
    (   9)= 152.69  (  11)=  95.59  (  12)= 125.96  (  13)= 149.85  (  14)= 173.69  (  15)= 157.93  (  16)= 154.37  (  17)= 163.24
    (  18)= 181.92  ( 434)= 511.47  (  21)= 125.83  (  22)= 154.17  (  23)= 176.62  (  24)= 199.49  (  25)= 184.47  (  26)= 193.81
    (  27)= 133.93  (  28)= 205.93  (  29)= 205.94  (  31)= 125.81  (  32)= 154.19  (  33)= 176.64  (  34)= 199.50  (  35)= 184.49
    (  36)= 130.82  (  37)= 133.94  (  38)= 203.85  (  39)= 207.02  ( 101)=  53.29  ( 102)=  86.31  ( 103)= 112.19  ( 104)= 137.21
    ( 105)= 123.54  ( 106)= 117.20  ( 107)= 132.01  ( 108)= 146.74  ( 109)= 147.47  ( 111)=  47.10  ( 112)=  90.22  ( 113)= 105.20
    ( 114)= 131.47  ( 115)= 115.09  ( 116)= 111.78  ( 117)= 126.72  ( 118)= 141.50  ( 119)= 142.46  ( 200)=   -.00  ( 201)=  11.21
    ( 202)=  35.87  ( 203)=  53.11  ( 204)=  69.60  ( 205)=  86.34  ( 206)= 103.19  ( 207)= 119.76  ( 208)= 135.01  ( 209)= 136.01
    ( 301)= 215.23  ( 302)= 239.40  ( 303)= 257.16  ( 304)= 277.69  ( 305)= 264.66  ( 306)= 260.73  ( 307)= 271.20  ( 308)= [illegible]
    ( 309)= 281.95  ( 311)= 239.74  ( 312)= 261.41  ( 313)= 278.71  ( 314)= 298.41  ( 315)= 285.94  ( 316)= 282.04  ( 317)= 292.03
    ( 318)= 302.14  ( 319)= 261.79  ( 321)= 261.29  ( 322)= 281.87  ( 323)= 298.35  ( 324)= 317.38  ( 325)= 305.34  ( 326)= [illegible]
    ( 327)= 311.03  ( 328)= 320.75  ( 329)= 231.94  ( 331)= 261.30  ( 332)= 281.89  ( 333)= 298.37  ( 334)= 317.39  ( 335)= [illegible]
    ( 336)= 301.51  ( 337)= 311.10  ( 338)= 320.75  ( 339)= 207.09  ( 401)= 462.00  ( 402)= 472.41  ( 403)= 480.73  ( 404)= 494.05
    ( 405)= 495.45  ( 406)= 482.71  ( 407)= 496.99  ( 408)= 492.04  ( 409)= 492.12  ( 411)= 471.50  ( 412)= 481.50  ( 413)= 489.65
    ( 414)= 502.59  ( 415)= 495.14  ( 416)= 491.55  ( 417)= 495.80  ( 418)= 500.73  ( 419)= 501.57  ( 421)= 481.41  ( 422)= 491.16
    ( 423)= 493.15  ( 424)= 511.46  ( 425)= 504.39  ( 426)= 500.96  ( 427)= 505.11  ( 428)= 509.88  ( 429)= 510.57  ( 431)= 481.41
    ( 432)= 491.16  ( 433)= 499.15  (  19)= 192.04  ( 435)= 504.39  ( 436)= 500.97  ( 437)= 505.11  ( 438)= 509.99  ( 439)= 510.67
    ( 501)= 642.14  ( 502)= 645.45  ( 503)= 649.92  ( 504)= 656.40  ( 505)= 652.94  ( 506)= 650.94  ( 507)= 652.46  ( 508)= 654.59
    ( 509)= 655.23  ( 511)= 645.28  ( 512)= 649.49  ( 513)= 652.93  ( 514)= 659.25  ( 515)= 655.88  ( 516)= 653.91  ( 517)= 655.45
    ( 518)= 657.55  ( 519)= 653.12  ( 521)= 649.33  ( 522)= 653.47  ( 523)= 656.87  ( 524)= 662.91  ( 525)= 659.68  ( 526)= 657.88
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 28)

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HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE   2          CASE=   MP7  SEC= 1

   ( 527)= 653.34  ( 528)= 661.39  ( 529)= 666.30  ( 531)= 649.33  ( 532)= 653.47  ( 533)= 656.87  ( 534)= 662.91  ( 535)= 659.68
   ( 536)= 657.80  ( 537)= 659.34  ( 538)= 661.33  ( 539)= 727.40  ( 601)= 723.24  ( 602)= 725.20  ( 603)= 725.79  ( 604)= 729.58
   ( 605)= 729.40  ( 606)= 727.32  ( 607)= 727.92  ( 608)= 728.89  ( 609)= 729.50  ( 611)= 724.05  ( 612)= 725.99  ( 613)= 727.57
   ( 614)= 730.72  ( 615)= 729.15  ( 616)= 728.10  ( 617)= 728.71  ( 618)= 729.68  ( 619)= 727.31  ( 621)= 725.80  ( 622)= 727.71
   ( 623)= 729.29  ( 624)= 732.29  ( 625)= 730.79  ( 626)= 729.78  ( 627)= 730.40  ( 628)= 731.36  ( 629)= 729.00  ( 631)= 725.80
   ( 632)= 727.71  ( 633)= 721.29  ( 634)= 732.30  ( 635)= 730.79  ( 636)= 729.78  ( 637)= 730.41  ( 638)= 731.36  ( 639)= 727.44

TIME =    -100.0000            DEGREE FAHRENHEIT    K2 =        7      INTERP
   (   1)=  57.77  (   2)=  89.32  (   3)= 113.86  (   4)= 135.06  (   5)= 154.23  (   6)= 172.17  (   7)= 130.51  (   8)= 143.35
   (   9)= 143.65  (  11)=  93.51  (  12)= 123.02  (  13)= 145.88  (  14)= 165.69  (  15)= 183.63  (  16)= 200.44  (  17)= 181.49
   (  18)= 173.43  ( 434)= 507.57  (  21)= 123.57  (  22)= 151.24  (  23)= 172.76  (  24)= 191.46  (  25)= 208.43  (  26)= 224.32
   (  27)= 187.54  (  28)= 198.78  (  29)= 110.83  (  31)= 123.59  (  32)= 151.26  (  33)= 172.77  (  34)= 191.48  (  35)= 208.44
   (  36)= 224.33  (  37)= 187.55  (  38)= 198.79  (  39)= 198.97  ( 101)=  51.99  ( 102)=  83.68  ( 103)= 109.34  ( 104)= 120.65
   ( 105)= 143.91  ( 106)= 155.94  ( 107)= 125.05  ( 108)= 137.98  ( 109)= 138.53  ( 111)=  45.98  ( 112)=  77.77  ( 113)= 102.53
   ( 114)= 123.95  ( 115)= 143.33  ( 116)= 161.47  ( 117)= 119.78  ( 118)= 132.84  ( 119)= 133.49  ( 200)=   -.00  ( 201)=  17.35
   ( 202)=  33.95  ( 203)=  43.92  ( 204)=  65.32  ( 205)=  80.22  ( 206)=  34.53  ( 207)= 109.45  ( 208)= 123.94  ( 209)= 123.84
   ( 301)= 215.01  ( 302)= 238.06  ( 303)= 255.47  ( 304)= 270.69  ( 305)= 284.57  ( 306)= 297.57  ( 307)= 267.41  ( 308)= 275.69
   ( 309)= 275.76  ( 311)= 233.35  ( 312)= 260.41  ( 313)= 276.34  ( 314)= 291.47  ( 315)= 304.66  ( 316)= 317.12  ( 317)= 288.34
   ( 318)= 297.11  ( 319)= 255.99  ( 321)= 260.72  ( 322)= 280.77  ( 323)= 295.54  ( 324)= 310.45  ( 325)= 323.13  ( 326)= 335.04
   ( 327)= 307.32  ( 328)= 315.92  ( 329)= 276.31  ( 331)= 260.74  ( 332)= 280.79  ( 333)= 296.55  ( 334)= 310.46  ( 335)= 323.15
   ( 336)= 335.05  ( 337)= 307.54  ( 338)= 315.93  ( 339)= 199.04  ( 401)= 463.08  ( 402)= 473.49  ( 403)= 481.88  ( 404)= 489.74
   ( 405)= 495.22  ( 406)= 502.47  ( 407)= 487.74  ( 408)= 492.32  ( 409)= 492.41  ( 411)= 472.70  ( 412)= 482.92  ( 413)= 491.10
   ( 414)= 493.37  ( 415)= 504.35  ( 416)= 510.83  ( 417)= 496.82  ( 418)= 501.26  ( 419)= 502.21  ( 421)= 482.93  ( 422)= 492.88
   ( 423)= 500.33  ( 424)= 507.57  ( 425)= 513.95  ( 426)= 519.70  ( 427)= 506.23  ( 428)= 510.37  ( 429)= 511.37  ( 431)= 482.94
   ( 432)= 492.83  ( 433)= 500.84  (  19)= 173.55  ( 435)= 513.96  ( 436)= 519.71  ( 437)= 506.24  ( 438)= 510.38  ( 439)= 511.44
   ( 501)= 643.83  ( 502)= 648.15  ( 503)= 651.63  ( 504)= 654.79  ( 505)= 657.70  ( 506)= 660.22  ( 507)= 654.12  ( 508)= 655.05
   ( 509)= 655.70  ( 511)= 647.01  ( 512)= 651.29  ( 513)= 654.75  ( 514)= 657.94  ( 515)= 660.66  ( 516)= 663.07  ( 517)= 657.18
   ( 518)= 653.07  ( 519)= 684.74  ( 521)= 651.16  ( 522)= 655.36  ( 523)= 658.76  ( 524)= 661.69  ( 525)= 664.41  ( 526)= 666.79
   ( 527)= 661.07  ( 528)= 662.86  ( 529)= 667.83  ( 531)= 651.16  ( 532)= 655.37  ( 533)= 658.75  ( 534)= 661.69  ( 535)= 664.41
   ( 536)= 665.78  ( 537)= 661.07  ( 538)= 652.86  ( 539)= 728.91  ( 601)= 724.88  ( 602)= 726.82  ( 603)= 728.40  ( 604)= 729.32
   ( 605)= 731.13  ( 606)= 732.20  ( 607)= 729.51  ( 608)= 730.38  ( 609)= 730.09  ( 611)= 725.69  ( 612)= 727.62  ( 613)= 725.19
   ( 614)= 730.60  ( 615)= 731.90  ( 616)= 732.35  ( 617)= 730.30  ( 618)= 731.16  ( 619)= 728.84  ( 621)= 727.44  ( 622)= 729.35
   ( 623)= 730.30  ( 624)= 732.25  ( 625)= 733.51  ( 626)= 734.54  ( 627)= 731.36  ( 628)= 732.78  ( 629)= 730.48  ( 631)= 727.44
   ( 632)= 729.35  ( 633)= 731.30  ( 634)= 732.25  ( 635)= 733.51  ( 636)= 734.54  ( 637)= 731.97  ( 638)= 732.79  ( 639)= 728.94

                                 MAXIMUM NODE TEMPERATURES REACHED
   (   1)= 113.97  (   2)= 137.00  (   3)= 228.39  (   4)= 267.25  (   5)= 300.79  (   6)= 330.29  (   7)= 242.46  (   8)= 262.59
   (   9)= 263.02  (  11)= 183.56  (  12)= 242.38  (  13)= 285.68  (  14)= 321.93  (  15)= 353.23  (  16)= 380.65  (  17)= 298.91
   (  18)= 317.57  ( 434)= 812.73  (  21)= 238.84  (  22)= 293.99  (  23)= 334.63  (  24)= 368.66  (  25)= 398.04  (  26)= 423.68
   (  27)= 347.15  (  28)= 364.55  (  29)= 364.80  (  31)= 238.87  (  32)= 294.02  (  33)= 334.66  (  34)= 369.69  (  35)= 398.07
   (  36)= 423.71  (  37)= 347.17  (  38)= 364.58  (  39)= 364.96  ( 101)= 105.98  ( 102)= 169.95  ( 103)= 215.98  ( 104)= 255.35
   ( 105)= 293.35  ( 106)= 327.26  ( 107)= 231.21  ( 108)= 251.63  ( 109)= 252.45  ( 111)=  93.41  ( 112)= 157.85  ( 113)= 205.27
   ( 114)= 245.03  ( 115)= 273.48  ( 116)= 303.77  ( 117)= 220.42  ( 118)= 241.15  ( 119)= 242.16  ( 200)=   -.00  ( 201)=  37.14
   ( 202)=  69.96  ( 203)=  99.08  ( 204)= 125.53  ( 205)= 149.59  ( 206)= 171.58  ( 207)= 195.40  ( 208)= 219.54  ( 209)= 219.54
   ( 301)= 364.35  ( 302)= 411.41  ( 303)= 445.99  ( 304)= 474.95  ( 305)= 499.95  ( 306)= 521.94  ( 307)= 455.48  ( 308)= 473.40
   ( 309)= 469.54  ( 311)= 409.52  ( 312)= 453.57  ( 313)= 485.98  ( 314)= 513.13  ( 315)= 536.57  ( 316)= 557.10  ( 317)= 495.89
   ( 318)= 509.57  ( 319)= 442.13  ( 321)= 450.84  ( 322)= 492.14  ( 323)= 522.57  ( 324)= 548.06  ( 325)= 570.06  ( 326)= 589.26
   ( 327)= 531.34  ( 328)= 544.08  ( 329)= 440.89  ( 331)= 450.86  ( 332)= 492.15  ( 333)= 522.60  ( 334)= 548.08  ( 335)= 573.08
   ( 336)= 589.28  ( 337)= 531.97  ( 338)= 545.01  ( 339)= 365.06  ( 401)= 722.47  ( 402)= 746.08  ( 403)= 763.43  ( 404)= 777.96
   ( 405)= 739.51  ( 406)= 801.53  ( 407)= 769.70  ( 408)= 776.22  ( 409)= 775.45  ( 411)= 742.84  ( 412)= 765.09  ( 413)= 781.47
   ( 414)= 795.18  ( 415)= 807.02  ( 416)= 817.39  ( 417)= 786.47  ( 418)= 793.53  ( 419)= 784.46  ( 421)= 763.59  ( 422)= 784.46
   ( 423)= 797.84  ( 424)= 812.72  ( 425)= 823.84  ( 426)= 833.54  ( 427)= 804.58  ( 428)= 811.17  ( 429)= 802.49  ( 431)= 763.60
   ( 432)= 784.47  ( 433)= 799.85  (  19)= 317.83  ( 435)= 823.85  ( 436)= 833.55  ( 437)= 804.59  ( 438)= 811.18  ( 439)= 800.23
   ( 501)= 938.81  ( 502)= 949.25  ( 503)= 955.20  ( 504)= 961.01  ( 505)= 966.03  ( 506)= 970.44  ( 507)= 957.31  ( 508)= 958.31
   ( 509)= 960.65  ( 511)= 945.84  ( 512)= 954.81  ( 513)= 961.42  ( 514)= 966.95  ( 515)= 971.73  ( 516)= 975.91  ( 517)= 963.44
   ( 518)= 966.28  ( 519)= 983.58  ( 521)= 954.09  ( 522)= 962.52  ( 523)= 968.73  ( 524)= 973.93  ( 525)= 978.42  ( 526)= 982.34
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 29)

```
HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JP INSLL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE   3          CASE=   MP7   SEQ= 1
( 527)= 970.64  ( 528)= 973.30  ( 529)= 995.29  ( 531)= 954.10  ( 532)= 962.52  ( 533)= 968.73  ( 534)= 973.93  ( 535)= 978.42
( 536)= 943.34  ( 537)= 970.65  ( 538)= 973.31  ( 539)=1035.19  ( 601)=1027.36  ( 602)=1031.00  ( 603)=1033.69  ( 604)=1035.93
( 605)=1037.87  ( 606)=1039.57  ( 607)=1034.50  ( 608)=1035.66  ( 609)=1035.37  ( 611)=1029.27  ( 612)=1032.79  ( 613)=1035.38
( 614)=1037.55  ( 615)=1039.42  ( 616)=1041.06  ( 617)=1036.17  ( 618)=1037.29  ( 619)=1034.42  ( 621)=1032.41  ( 622)=1035.72
( 623)=1033.15  ( 624)=1040.21  ( 625)=1041.97  ( 626)=1043.51  ( 627)=1038.91  ( 628)=1039.96  ( 629)=1037.21  ( 631)=1032.41
( 632)=1035.72  ( 633)=1033.16  ( 634)=1040.21  ( 635)=1041.97  ( 636)=1043.51  ( 637)=1038.92  ( 638)=1039.96  ( 639)=1035.22

                      TIMES MAXIMUM NODE TEMPERATURES REACHED
(   1)=-270.00  (   2)=-270.00  (   3)=-270.00  (   4)=-270.00  (   5)=-270.00  (   6)=-270.00  (   7)=-270.00  (   8)=-270.00
(   9)=-270.00  (  11)=-270.00  (  12)=-270.00  (  13)=-270.00  (  14)=-270.00  (  15)=-270.00  (  16)=-270.00  (  17)=-270.00
(  18)=-270.00  ( 434)=-270.00  (  21)=-270.00  (  22)=-270.00  (  23)=-270.00  (  24)=-270.00  (  25)=-270.00  (  26)=-270.00
(  27)=-270.00  (  28)=-270.00  (  29)=-270.00  (  31)=-270.00  (  32)=-270.00  (  33)=-270.00  (  34)=-270.00  (  35)=-270.00
(  36)=-270.00  (  37)=-270.00  (  38)=-270.00  (  39)=-270.00  ( 101)=-270.00  ( 102)=-270.00  ( 103)=-270.00  ( 104)=-270.00
( 105)=-270.00  ( 106)=-270.00  ( 107)=-270.00  ( 108)=-270.00  ( 109)=-270.00  ( 111)=-270.00  ( 112)=-270.00  ( 113)=-270.00
( 114)=-270.00  ( 115)=-270.00  ( 116)=-270.00  ( 117)=-270.00  ( 118)=-270.00  ( 119)=-270.00  ( 200)=  -15.00  ( 201)=-270.00
( 202)=-270.00  ( 203)=-270.00  ( 204)=-270.00  ( 205)=-270.00  ( 206)=-270.00  ( 207)=-270.00  ( 208)=-270.00  ( 209)=-270.00
( 301)=-270.00  ( 302)=-270.00  ( 303)=-270.00  ( 304)=-270.00  ( 305)=-270.00  ( 306)=-270.00  ( 307)=-270.00  ( 308)=-270.00
( 309)=-270.00  ( 311)=-270.00  ( 312)=-270.00  ( 313)=-270.00  ( 314)=-270.00  ( 315)=-270.00  ( 316)=-270.00  ( 317)=-270.00
( 318)=-270.00  ( 319)=-270.00  ( 321)=-270.00  ( 322)=-270.00  ( 323)=-270.00  ( 324)=-270.00  ( 325)=-270.00  ( 326)=-270.00
( 327)=-270.00  ( 328)=-270.00  ( 329)=-270.00  ( 331)=-270.00  ( 332)=-270.00  ( 333)=-270.00  ( 334)=-270.00  ( 335)=-270.00
( 336)=-270.00  ( 337)=-270.00  ( 338)=-270.00  ( 339)=-270.00  ( 401)=-270.00  ( 402)=-270.00  ( 403)=-270.00  ( 404)=-270.00
( 405)=-270.00  ( 406)=-270.00  ( 407)=-270.00  ( 408)=-270.00  ( 409)=-270.00  ( 411)=-270.00  ( 412)=-270.00  ( 413)=-270.00
( 414)=-270.00  ( 415)=-270.00  ( 416)=-270.00  ( 417)=-270.00  ( 418)=-270.00  ( 419)=-270.00  ( 421)=-270.00  ( 422)=-270.00
( 423)=-270.00  ( 424)=-270.00  ( 425)=-270.00  ( 426)=-270.00  ( 427)=-270.00  ( 428)=-270.00  ( 429)=-270.00  ( 431)=-270.00
( 432)=-270.00  ( 433)=-270.00  (  19)=-270.00  ( 435)=-270.00  ( 436)=-270.00  ( 437)=-270.00  ( 438)=-270.00  ( 439)=-270.00
( 501)=-270.00  ( 502)=-270.00  ( 503)=-270.00  ( 504)=-270.00  ( 505)=-270.00  ( 506)=-270.00  ( 507)=-270.00  ( 508)=-270.00
( 509)=-270.00  ( 511)=-270.00  ( 512)=-270.00  ( 513)=-270.00  ( 514)=-270.00  ( 515)=-270.00  ( 516)=-270.00  ( 517)=-270.00
( 518)=-270.00  ( 519)=-270.00  ( 521)=-270.00  ( 522)=-270.00  ( 523)=-270.00  ( 524)=-270.00  ( 525)=-270.00  ( 526)=-270.00
( 527)=-270.00  ( 528)=-270.00  ( 529)=-270.00  ( 531)=-270.00  ( 532)=-270.00  ( 533)=-270.00  ( 534)=-270.00  ( 535)=-270.00
( 536)=-270.00  ( 537)=-270.00  ( 538)=-270.00  ( 539)=-270.00  ( 601)=-270.00  ( 602)=-270.00  ( 603)=-270.00  ( 604)=-270.00
( 605)=-270.00  ( 606)=-270.00  ( 607)=-270.00  ( 608)=-270.00  ( 609)=-270.00  ( 611)=-270.00  ( 612)=-270.00  ( 613)=-270.00
( 614)=-270.00  ( 615)=-270.00  ( 616)=-270.00  ( 617)=-270.00  ( 618)=-270.00  ( 619)=-270.00  ( 621)=-270.00  ( 622)=-270.00
( 623)=-270.00  ( 624)=-270.00  ( 625)=-270.00  ( 626)=-270.00  ( 627)=-270.00  ( 628)=-270.00  ( 629)=-270.00  ( 631)=-270.00
( 632)=-270.00  ( 633)=-270.00  ( 634)=-270.00  ( 635)=-270.00  ( 636)=-270.00  ( 637)=-270.00  ( 638)=-270.00  ( 639)=-270.00

                              MINIMUM NODE TEMPERATURES REACHED
(   1)=  57.70  (   2)=  89.30  (   3)= 113.83  (   4)= 121.47  (   5)= 110.15  (   6)= 118.25  (   7)= 139.16  (   8)= 143.09
(   9)= 143.40  (  11)=  93.33  (  12)= 122.84  (  13)= 145.82  (  14)= 161.11  (  15)= 142.74  (  16)= 149.89  (  17)= 151.10
(  18)= 173.12  ( 434)= 535.20  (  21)= 123.24  (  22)= 150.90  (  23)= 172.55  (  24)= 191.35  (  25)= 170.01  (  26)= 175.72
(  27)= 167.14  (  28)= 139.43  (  29)= 139.54  (  31)= 123.26  (  32)= 150.91  (  33)= 172.56  (  34)= 191.37  (  35)= 173.03
(  36)= 175.33  (  37)= 167.15  (  38)= 138.45  (  39)= 198.62  ( 101)=  51.91  ( 102)=  83.66  ( 103)= 108.32  ( 104)= 113.22
( 105)= 164.31  ( 106)= 112.73  ( 107)= 124.71  ( 108)= 137.72  ( 109)= 135.28  ( 111)=  45.92  ( 112)=  77.75  ( 113)= 102.51
( 114)= 135.65  ( 115)=  99.70  ( 116)= 107.37  ( 117)= 119.44  ( 118)= 132.59  ( 119)= 133.25  ( 200)=   -.00  ( 201)=  17.35
( 202)=  33.93  ( 203)=  49.92  ( 204)=  65.32  ( 205)=  80.22  ( 206)=  94.38  ( 207)= 109.34  ( 208)= 123.81  ( 209)= 123.91
( 301)= 215.65  ( 302)= 237.64  ( 303)= 255.04  ( 304)= 270.28  ( 305)= 251.42  ( 306)= 257.98  ( 307)= 257.08  ( 308)= 276.39
( 309)= 275.46  ( 311)= 238.87  ( 312)= 259.80  ( 313)= 276.34  ( 314)= 290.97  ( 315)= 273.39  ( 316)= 279.18  ( 317)= 298.01
( 318)= 295.81  ( 319)= 255.65  ( 321)= 260.08  ( 322)= 280.02  ( 323)= 295.80  ( 324)= 309.99  ( 325)= 293.40  ( 326)= 239.59
( 327)= 307.13  ( 328)= 315.59  ( 329)= 275.96  ( 331)= 260.10  ( 332)= 290.03  ( 333)= 295.81  ( 334)= 310.00  ( 335)= 233.41
( 336)= 248.69  ( 337)= 307.14  ( 338)= 315.60  ( 339)= 198.69  ( 401)= 461.66  ( 402)= 472.14  ( 403)= 480.48  ( 404)= 438.82
( 405)= 478.14  ( 406)= 482.59  ( 407)= 486.95  ( 408)= 431.52  ( 409)= 491.72  ( 411)= 471.14  ( 412)= 481.11  ( 413)= 489.39
( 414)= 495.97  ( 415)= 485.92  ( 416)= 491.47  ( 417)= 495.67  ( 418)= 500.45  ( 419)= 501.42  ( 421)= 480.94  ( 422)= 430.67
( 423)= 438.71  ( 424)= 506.20  ( 425)= 496.31  ( 426)= 500.77  ( 427)= 504.98  ( 428)= 509.53  ( 429)= 510.55  ( 431)= 490.95
( 432)= 490.67  ( 433)= 499.71  (  19)= 173.24  ( 435)= 496.32  ( 436)= 500.77  ( 437)= 504.99  ( 438)= 509.54  ( 439)= 510.60
( 501)= 641.36  ( 502)= 645.69  ( 503)= 649.17  ( 504)= 653.77  ( 505)= 648.55  ( 506)= 650.44  ( 507)= 651.77  ( 508)= 654.83
( 509)= 654.60  ( 511)= 644.49  ( 512)= 648.68  ( 513)= 652.15  ( 514)= 656.93  ( 515)= 651.47  ( 516)= 653.35  ( 517)= 654.74
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 30)

```
HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JP INSUL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE    4        CASE=   MP7  SEQ= 1
 ( 518)= 656.97  ( 519)= 682.44  ( 521)= 648.50  ( 522)= 652.63  ( 523)= 656.06  ( 524)= 660.68  ( 525)= 655.33  ( 526)= 657.19
 ( 527)= 654.65  ( 528)= 660.85  ( 529)= 645.63  ( 531)= 648.50  ( 532)= 652.63  ( 533)= 656.06  ( 534)= 650.68  ( 535)= 655.33
 ( 536)= 657.13  ( 537)= 658.65  ( 538)= 660.85  ( 539)= 726.71  ( 601)= 722.40  ( 602)= 724.37  ( 603)= 725.98  ( 604)= 729.19
 ( 605)= 725.82  ( 606)= 725.58  ( 607)= 727.15  ( 608)= 728.19  ( 609)= 727.89  ( 611)= 723.21  ( 612)= 725.16  ( 613)= 726.77
 ( 614)= 724.33  ( 615)= 725.59  ( 616)= 727.44  ( 617)= 727.94  ( 618)= 728.98  ( 619)= 726.59  ( 621)= 724.36  ( 622)= 725.80
 ( 623)= 723.49  ( 624)= 731.65  ( 625)= 728.26  ( 626)= 729.11  ( 627)= 729.66  ( 628)= 730.69  ( 629)= 728.31  ( 631)= 724.96
 ( 632)= 725.88  ( 633)= 729.49  ( 634)= 731.65  ( 635)= 728.26  ( 636)= 729.11  ( 637)= 729.66  ( 638)= 730.69  ( 639)= 726.74
                 TIMES MINIMUM NODE TEMPERATURES REACHED
 (   1)=-180.00  (   2)=-150.00  (   3)=-150.00  (   4)=-240.00  (   5)=-210.00  (   6)=-180.00  (   7)=-150.00  (   8)=-150.00
 (   9)=-150.00  (  11)=-180.00  (  12)=-150.00  (  13)=-150.00  (  14)=-240.00  (  15)=-210.00  (  16)=-150.00  (  17)=-150.00
 (  18)=-150.00  ( 434)=-180.00  (  21)=-140.00  (  22)=-180.00  (  23)=-190.00  (  24)=-150.00  (  25)=-210.00  (  26)=-180.00
 (  27)=-150.00  (  28)=-150.00  (  29)=-150.00  (  31)=-180.00  (  32)=-190.00  (  33)=-180.00  (  34)=-130.00  (  35)=-210.00
 (  36)=-140.00  (  37)=-150.00  (  38)=-150.00  (  39)=-150.00  ( 101)=-180.00  ( 102)=-150.00  ( 103)=-150.00  ( 104)=-240.00
 ( 105)=-210.00  ( 106)=-180.00  ( 107)=-150.00  ( 108)=-150.00  ( 109)=-150.00  ( 111)=-180.00  ( 112)=-150.00  ( 113)=-150.00
 ( 114)=-240.00  ( 115)=-210.00  ( 116)=-180.00  ( 117)=-150.00  ( 118)=-150.00  ( 119)=-150.00  ( 200)= -15.00  ( 201)=-150.00
 ( 202)=-150.00  ( 203)= -30.00  ( 204)= -30.00  ( 205)= -15.00  ( 206)=-150.00  ( 207)=-150.00  ( 208)= -60.00  ( 209)= -60.00
 ( 301)=-180.00  ( 302)=-180.00  ( 303)=-180.00  ( 304)=-180.00  ( 305)=-210.00  ( 306)=-180.00  ( 307)=-150.00  ( 308)=-150.00
 ( 309)=-150.00  ( 311)=-150.00  ( 312)=-180.00  ( 313)=-180.00  ( 314)=-180.00  ( 315)=-210.00  ( 316)=-180.00  ( 317)=-150.00
 ( 318)=-150.00  ( 319)=-150.00  ( 321)=-180.00  ( 322)=-180.00  ( 323)=-180.00  ( 324)=-180.00  ( 325)=-210.00  ( 326)=-180.00
 ( 327)=-180.00  ( 328)=-150.00  ( 329)=-150.00  ( 331)=-180.00  ( 332)=-180.00  ( 333)=-180.00  ( 334)=-180.00  ( 335)=-210.00
 ( 336)=-180.00  ( 337)=-180.00  ( 338)=-150.00  ( 339)=-150.00  ( 401)=-210.00  ( 402)=-210.00  ( 403)=-210.00  ( 404)=-180.00
 ( 405)=-210.00  ( 406)=-180.00  ( 407)=-210.00  ( 408)=-180.00  ( 409)=-180.00  ( 411)=-210.00  ( 412)=-210.00  ( 413)=-210.00
 ( 414)=-180.00  ( 415)=-210.00  ( 416)=-210.00  ( 417)=-210.00  ( 418)=-180.00  ( 419)=-180.00  ( 421)=-210.00  ( 422)=-210.00
 ( 423)=-210.00  ( 424)=-180.00  ( 425)=-210.00  ( 426)=-210.00  ( 427)=-210.00  ( 428)=-180.00  ( 429)=-180.00  ( 431)=-210.00
 ( 432)=-210.00  ( 433)=-210.00  (  19)=-150.00  ( 435)=-210.00  ( 436)=-210.00  ( 437)=-210.00  ( 438)=-180.00  ( 439)=-180.00
 ( 501)=-210.00  ( 502)=-210.00  ( 503)=-210.00  ( 504)=-180.00  ( 505)=-210.00  ( 506)=-210.00  ( 507)=-210.00  ( 508)=-210.00
 ( 509)=-210.00  ( 511)=-210.00  ( 512)=-210.00  ( 513)=-210.00  ( 514)=-180.00  ( 515)=-210.00  ( 516)=-210.00  ( 517)=-210.00
 ( 518)=-210.00  ( 519)=-210.00  ( 521)=-210.00  ( 522)=-210.00  ( 523)=-210.00  ( 524)=-180.00  ( 525)=-210.00  ( 526)=-210.00
 ( 527)=-210.00  ( 528)=-210.00  ( 529)=-210.00  ( 531)=-210.00  ( 532)=-210.00  ( 533)=-210.00  ( 534)=-180.00  ( 535)=-210.00
 ( 536)=-210.00  ( 537)=-210.00  ( 538)=-210.00  ( 539)=-210.00  ( 601)=-210.00  ( 602)=-210.00  ( 603)=-210.00  ( 604)=-180.00
 ( 605)=-210.00  ( 606)=-210.00  ( 607)=-210.00  ( 608)=-210.00  ( 609)=-210.00  ( 611)=-210.00  ( 612)=-210.00  ( 613)=-210.00
 ( 614)=-180.00  ( 615)=-210.00  ( 616)=-210.00  ( 617)=-210.00  ( 618)=-210.00  ( 619)=-210.00  ( 621)=-210.00  ( 622)=-210.00
 ( 623)=-210.00  ( 624)=-180.00  ( 625)=-210.00  ( 626)=-210.00  ( 627)=-210.00  ( 628)=-210.00  ( 629)=-210.00  ( 631)=-210.00
 ( 632)=-210.00  ( 633)=-210.00  ( 634)=-180.00  ( 635)=-210.00  ( 636)=-210.00  ( 637)=-210.00  ( 638)=-210.00  ( 639)=-210.00
TEMPERATURE CHANGE DUE TO  END CASE  OPRIT=  .1
 (   1)=-192.23  (   2)=-163.68  (   3)=-135.14  (   4)=-114.94  (   5)= -95.76  (   6)= -77.89  (   7)=-119.52  (   8)=-106.67
 (   9)=-135.34  (  11)=-155.49  (  12)=-125.99  (  13)=-104.13  (  14)= -84.32  (  15)= -66.35  (  16)= -49.64  (  17)= -33.55
 (  18)= -73.51  ( 434)=-392.34  (  21)=-126.43  (  22)= -98.76  (  23)= -77.25  (  24)= -58.54  (  25)= -41.55  (  26)= -25.76
 (  27)= -62.44  (  28)= -51.25  (  29)= -51.14  (  31)=-126.42  (  32)= -98.75  (  33)= -77.23  (  34)= -58.53  (  35)= -41.53
 (  36)= -23.75  (  37)= -62.48  (  38)= -51.23  (  39)= -51.06  ( 101)= -88.02  ( 102)= -56.32  ( 103)= -31.66  ( 104)= -10.35
 ( 105)=   8.92  ( 106)=  26.83  ( 107)= -14.97  ( 108)=  -2.05  ( 109)=  -1.50  ( 111)= -29.03  ( 112)= -12.23  ( 113)=  -2.47
 ( 114)=  13.96  ( 115)=  28.34  ( 116)=  41.43  ( 117)=  -5.25  ( 118)=   2.81  ( 119)=   3.46  ( 200)=   -.00  ( 201)=   2.35
 ( 202)=   3.95  ( 203)=   4.92  ( 204)=   5.32  ( 205)=   5.22  ( 206)=   4.60  ( 207)=   4.42  ( 208)=   3.81  ( 209)=   3.21
 ( 301)=-284.90  ( 302)=-261.94  ( 303)=-244.53  ( 304)=-229.31  ( 305)=-215.42  ( 306)=-202.36  ( 307)=-232.62  ( 308)=-223.34
 ( 309)=-224.27  ( 311)=-260.56  ( 312)=-239.59  ( 313)=-223.06  ( 314)=-208.59  ( 315)=-195.31  ( 316)=-182.83  ( 317)=-211.59
 ( 318)=-202.91  ( 319)=-244.04  ( 321)=-239.29  ( 322)=-219.23  ( 323)=-203.46  ( 324)=-189.56  ( 325)=-175.83  ( 326)=-164.34
 ( 327)=-192.51  ( 328)=-184.11  ( 329)=-223.72  ( 331)=-239.27  ( 332)=-219.22  ( 333)=-203.45  ( 334)=-189.55  ( 335)=-175.82
 ( 336)=-164.32  ( 337)=-192.50  ( 338)=-184.09  ( 339)=-300.99  ( 401)=-436.92  ( 402)=-426.51  ( 403)=-418.12  ( 404)=-410.66
 ( 405)=-403.77  ( 406)=-397.23  ( 407)=-412.23  ( 408)=-407.70  ( 409)=-407.61  ( 411)=-427.31  ( 412)=-417.08  ( 413)=-408.91
 ( 414)=-401.64  ( 415)=-395.04  ( 416)=-388.89  ( 417)=-403.21  ( 418)=-398.76  ( 419)=-397.81  ( 421)=-417.07  ( 422)=-407.13
 ( 423)=-393.17  ( 424)=-392.34  ( 425)=-385.03  ( 426)=-380.05  ( 427)=-393.79  ( 428)=-389.65  ( 429)=-388.65  ( 431)=-417.06
 ( 432)=-407.12  ( 433)=-399.17  (  19)= -76.47  ( 435)=-396.02  ( 436)=-380.04  ( 437)=-393.78  ( 438)=-399.64  ( 439)=-380.58
 ( 501)=-705.17  ( 502)=-701.85  ( 503)=-698.35  ( 504)=-695.21  ( 505)=-692.31  ( 506)=-689.55  ( 507)=-695.89  ( 508)=-693.96
 ( 509)=-693.31  ( 511)=-702.99  ( 512)=-698.71  ( 513)=-695.25  ( 514)=-692.17  ( 515)=-689.35  ( 516)=-686.70  ( 517)=-692.03
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 31)

```
HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JM INSUL .25 IN. TUBE   **75/12/08.*20.57.(1.* PAGE   5          CASE=   MP7  SEQ= 1
     ( 518)=-693.94  ( 519)=-665.27  ( 521)=-698.84  ( 522)=-694.63  ( 523)=-691.24  ( 524)=-688.31  ( 525)=-695.59  ( 526)=-683.01
     ( 527)=-683.94  ( 528)=-687.15  ( 529)=-662.12  ( 531)=-698.84  ( 532)=-694.63  ( 533)=-691.24  ( 534)=-698.31  ( 535)=-685.59
     ( 536)=-683.00  ( 537)=-688.94  ( 538)=-627.15  ( 539)=-621.09  ( 601)=-825.12  ( 602)=-823.18  ( 603)=-821.60  ( 604)=-820.19
     ( 605)=-813.89  ( 606)=-817.64  ( 607)=-820.49  ( 609)=-819.62  ( 609)=-819.91  ( 611)=-824.31  ( 612)=-822.38  ( 613)=-820.81
     ( 614)=-813.40  ( 615)=-818.11  ( 616)=-816.90  ( 617)=-819.71  ( 618)=-818.84  ( 619)=-821.17  ( 621)=-822.56  ( 622)=-820.65
     ( 623)=-819.10  ( 624)=-817.75  ( 625)=-816.50  ( 626)=-815.31  ( 627)=-818.04  ( 628)=-817.22  ( 629)=-819.52  ( 631)=-822.56
     ( 632)=-820.64  ( 633)=-819.10  ( 634)=-817.75  ( 635)=-816.50  ( 636)=-815.31  ( 637)=-818.04  ( 638)=-817.22  ( 639)=-821.06
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 32)

```
HEATRAN*INS HT SHIELD MACH 4.5L .25 IN JP INSL .25 IN. TUBE  **75/12/08.*20.57.01.* PAGE   6         CASE=   MP7  SEQ= 1

HEATRAN CASE      MP7   WITH   208 ELEMENTS USING METHOD =   6
                        WAS CLOCKED ON AT  20.57.34.  AND TOOK    48.441 SEC. CP TIME, COMPUTED    10   TIME STEP(S).
                        ERRORS DETECTED =       0
TIME =     -15.0000            DEGREE FAHRENHEIT    K2 =     10      FINAL
   (   1)=  57.77  (   2)=  83.32  (   3)= 113.86  (   4)= 135.06  (   5)= 154.24  (   6)= 172.11  (   7)= 130.48  (   8)= 143.33
   (   9)= 143.62  (  11)=  93.51  (  12)= 123.02  (  13)= 145.87  (  14)= 165.68  (  15)= 183.65  (  16)= 200.36  (  17)= 161.45
   (  18)= 173.41  ( 434)= 507.66  (  21)= 123.57  (  22)= 151.24  (  23)= 172.75  (  24)= 191.46  (  25)= 209.45  (  25)= 224.24
   (  27)= 137.51  (  28)= 198.75  (  29)= 198.86  (  31)= 123.58  (  32)= 151.25  (  33)= 172.77  (  34)= 191.47  (  35)= 209.47
   (  36)= 224.25  (  37)= 187.52  (  38)= 198.77  (  39)= 198.94  ( 101)=  51.98  ( 102)=  83.68  ( 103)= 109.34  ( 104)= 123.65
   ( 105)= 143.32  ( 106)= 165.49  ( 107)= 125.03  ( 108)= 137.95  ( 109)= 138.50  ( 111)=  45.97  ( 112)=  77.77  ( 113)= 102.53
   ( 114)= 123.96  ( 115)= 143.34  ( 116)= 161.43  ( 117)= 119.75  ( 118)= 132.81  ( 119)= 133.46  ( 200)=   -.00  ( 201)=  17.36
   ( 202)=  33.35  ( 203)=  49.92  ( 204)=  65.32  ( 205)=  80.22  ( 206)=  94.60  ( 207)= 109.42  ( 208)= 123.81  ( 209)= 123.81
   ( 301)= 214.00  ( 302)= 233.06  ( 303)= 255.47  ( 304)= 270.69  ( 305)= 284.58  ( 306)= 297.64  ( 307)= 257.38  ( 308)= 275.66
   ( 309)= 275.73  ( 311)= 237.34  ( 312)= 260.41  ( 313)= 276.94  ( 314)= 291.41  ( 315)= 304.69  ( 316)= 317.17  ( 317)= 299.31
   ( 318)= 297.03  ( 319)= 255.95  ( 321)= 260.72  ( 322)= 290.77  ( 323)= 276.54  ( 324)= 310.44  ( 325)= 323.17  ( 326)= 335.06
   ( 327)= 307.43  ( 328)= 315.59  ( 329)= 275.29  ( 331)= 260.73  ( 332)= 280.78  ( 333)= 296.55  ( 334)= 310.45  ( 335)= 323.18
   ( 336)= 335.09  ( 337)= 337.50  ( 338)= 315.91  ( 339)= 199.01  ( 401)= 463.98  ( 402)= 473.49  ( 403)= 481.88  ( 404)= 499.34
   ( 405)= 435.23  ( 406)= 502.77  ( 407)= 437.71  ( 408)= 492.30  ( 409)= 432.39  ( 411)= 472.69  ( 412)= 482.32  ( 413)= 491.09
   ( 414)= 493.36  ( 415)= 504.96  ( 416)= 511.11  ( 417)= 436.79  ( 418)= 501.24  ( 419)= 502.19  ( 421)= 492.93  ( 422)= 492.87
   ( 423)= 500.83  ( 424)= 507.56  ( 425)= 513.97  ( 426)= 519.95  ( 427)= 506.21  ( 428)= 510.39  ( 429)= 511.39  ( 431)= 489.94
   ( 432)= 602.88  ( 433)= 500.83  (  19)= 173.53  ( 435)= 513.98  ( 436)= 519.35  ( 437)= 506.22  ( 438)= 510.36  ( 439)= 511.42
   ( 501)= 643.83  ( 502)= 649.15  ( 503)= 651.65  ( 504)= 654.79  ( 505)= 657.59  ( 506)= 660.45  ( 507)= 654.11  ( 508)= 655.04
   ( 509)= 655.64  ( 511)= 547.01  ( 512)= 651.29  ( 513)= 654.75  ( 514)= 657.83  ( 515)= 660.65  ( 516)= 663.30  ( 517)= 657.17
   ( 518)= 653.06  ( 519)= 664.73  ( 521)= 651.15  ( 522)= 655.37  ( 523)= 658.75  ( 524)= 661.69  ( 525)= 654.41  ( 526)= 655.99
   ( 527)= 651.05  ( 528)= 662.85  ( 529)= 597.86  ( 531)= 651.16  ( 532)= 655.37  ( 533)= 658.76  ( 534)= 661.69  ( 535)= 664.41
   ( 536)= 667.03  ( 537)= 661.06  ( 538)= 652.85  ( 539)= 728.91  ( 601)= 724.88  ( 602)= 726.82  ( 603)= 728.40  ( 504)= 729.81
   ( 605)= 731.12  ( 606)= 732.36  ( 607)= 729.51  ( 608)= 730.38  ( 609)= 730.09  ( 611)= 725.69  ( 612)= 727.62  ( 613)= 729.19
   ( 614)= 730.60  ( 615)= 731.89  ( 616)= 733.10  ( 617)= 730.29  ( 618)= 731.16  ( 619)= 728.83  ( 621)= 727.44  ( 622)= 729.35
   ( 623)= 730.90  ( 624)= 732.25  ( 625)= 733.50  ( 626)= 734.69  ( 627)= 731.96  ( 628)= 732.78  ( 629)= 730.48  ( 631)= 727.44
   ( 632)= 729.36  ( 633)= 730.90  ( 634)= 732.25  ( 635)= 733.50  ( 636)= 734.69  ( 637)= 731.96  ( 638)= 732.78  ( 639)= 728.94
                                                     LOCATIONS USED = 17690     LOCATIONS AVAILABLE =  390E
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 33)

```
HEATRAN*                    GENERAL HEAT TRANSFER PROGRAM.**75/12/08.*20.58.28.* PAGE    1           CASE=CHNGBS  SEQ= 2
                          TIME EXPENDED=  77.143 CP(SEC)
THE FOLLOWING ROUTINES ARE CALLED IN ORDER.

              ORA
              ORB
              ORC
              SFA
              VRA
              VCA
              FLUIDB
              RRA
CHANGE DATA $CASEA      TRANSIENT
CHANGE DATA $CASEC    -15.      600.      2000.      100.      -1.
CHANGE DATA $FLUID3   X    0
CHANGE DATA $END CASE
                          END OF CASE REACHED ON INPUT. CARDS READ =     4
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 34)

HEATRAN* TRANSIENT **75/12/08.*20.58.28.* PAGE 2 CASE=CHNGBS SEC= 2

CASE = MP7 ELEMENTS = 199 METHOD = 6

K-DIAGONAL MATRIX..K = 198

BEGIN TIME = -15.0000 ENDING TIME = 600.0000

TMAX = 2000.00 TMIN = 100.00

TEMPERATURES ARE LAST T ADD -0.000 NCA = 199

INITIAL TEMPERATURES DEGREE FAHRENHEIT

TIME= -15.000)

(1)	123.5635	151.2541	260.7327	290.7797	482.9375	492.8793	651.1509	655.3562	727.4439	729.3558	(10)
(11)	172.7545	246.5473	500.6346	658.7369	730.9133	191.4749	310.4527	507.6644	661.6963	732.2477	(20)
(21)	225.4552	323.1777	513.9752	664.4167	733.4943	224.2595	335.0760	519.9562	666.9956	734.5[illegible]	(30)
(31)	167.3225	337.5[illegible]	506.2153	661.0632	731.3514	198.7673	315.9052	510.3572	662.8450	732.7806	(40)
(41)	198.9315	159.3109	511.4164	728.9051	728.9385	123.5677	151.2393	260.7189	280.7666	482.9321	(50)
(51)	492.6741	651.1512	655.3555	727.4428	729.3548	172.7544	296.5352	500.8295	658.7553	730.9023	(60)
(61)	131.4514	310.4405	507.6595	661.6356	732.2467	208.4521	323.1679	513.9704	664.4061	733.4974	(70)
(71)	224.2331	335.2545	519.9515	666.9950	734.6695	187.5089	307.4915	506.2103	661.0525	731.9605	(80)
(81)	193.7[illegible]	315.6[illegible]32	510.3524	662.8454	732.7797	198.8623	276.2832	511.3515	697.8813	730.4763	(90)
(91)	53.5125	123.0215	233.3427	280.4055	477.6946	482.9160	647.0081	651.2920	725.6393	727.6250	(100)
(101)	145.5725	276.9331	491.0334	654.7467	729.1937	165.5830	291.4098	498.3597	657.8326	730.5976	(110)
(111)	193.6457	324.5554	524.9595	660.6535	731.0558	200.3635	317.1697	511.1058	663.2354	733.0993	(120)
(121)	[illegible]	255.3360	495.7335	657.1602	730.2943	173.4059	297.0975	501.2365	659.0592	731.1565	(130)
(131)	173.3252	255.3629	502.1927	684.7271	728.8313	57.7695	89.3207	216.0042	238.0567	463.0757	(140)
(141)	473.4833	643.4276	648.1486	724.9804	725.8223	113.9577	255.4652	481.8797	651.6535	728.4002	(150)
(151)	133.3624	273.3473	489.3393	654.7582	729.8146	154.2492	284.5842	496.2320	657.6926	731.1223	(160)
(161)	172.1106	297.5307	502.7571	660.4513	732.3613	130.4761	267.3844	487.7140	654.1053	729.5075	(170)
(171)	143.3256	276.6621	492.2974	656.6359	730.3783	143.6247	275.7330	492.3911	656.6937	730.0887	(180)
(181)	91.9731	83.6922	108.3367	129.6457	148.9202	166.8937	125.0265	137.9536	138.5000	45.9747	(190)
(191)	77.7677	102.5313	123.9562	143.3387	161.4290	119.7503	132.8108	133.4582	-.0000	(199)	

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 35)

```
HEATRAN*      TRANSIENT                                  **75/12/08.*20.58.28.* PAGE  20          CASE=   HP7  SEQ= 2

THE FOLLOWING DATA BELONGS TO ROUTINE FLUID8

1----6 -10 -14 -18 -22 -26 -30  -34  -38  -42  -46  -50  -54  -58  -62  -66  -70 71-80
FLUID8   X    0   -0  -0   -0  -0   -0   -0   -0   -0   -0   -0   -0   -0   -0   -0  -0-0
ROUTINE  FLUID9 LOADED. NCFOL =  -0 NCFOL ACTUAL =  0
                                                   LOCATIONS USED =   833    LOCATIONS AVAILABLE = 20278
                                                                  LOADING INFORMATION  -11292 -11287 -10817
```


FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 36)

HEATRAN* TRANSIENT **75/12/31.*20.59.24.* PAGE 3 CASE= HP7 SEQ= 2

TIME = 130.0000 DEGREE FAHRENHEIT K2 = 24

(1)= 255.27	(2)= 369.05	(3)= 320.03	(4)= 333.10	(5)= 344.99	(6)= 355.48	(7)= 330.98	(8)= 334.17
(9)= [illegible]	(11)= 2[illegible].92	(12)= 305.55	(13)= 325.59	(14)= 373.59	(15)= 345.37	(16)= 355.92	(17)= 331.32
(18)= [illegible]	(19)= 333.[illegible]	(21)= 297.52	(634)= 404.45	(23)= 321.05	(24)= 334.01	(25)= 345.75	(26)= 355.15
(27)= 331.75	(28)= 333.9[illegible]	(29)= 359.00	(31)= 287.53	(32)= 306.13	(33)= 321.05	(34)= 334.01	(35)= 345.75
(36)= [illegible]	(37)= 331.75	(38)= 338.93	(39)= 339.00	(101)= 285.14	(102)= 304.99	(103)= 319.98	(638)= 405.27
(1[illegible])= 344.[illegible]	(1[illegible])= 355.41	(107)= 330.78	(108)= 338.08	(109)= 338.08	(111)= 285.99	(112)= 304.85	(113)= 319.87
(11[illegible])= 332.95	(115)= 344.81	(116)= 355.33	(117)= 330.68	(118)= 337.99	(119)= 337.99	(200)= -.00	(301)= 307.68
(302)= 323.52	(303)= 333.17	(304)= 347.24	(305)= 357.28	(306)= 366.22	(307)= 345.30	(308)= 351.49	(309)= 351.32
(311)= 333.19	(312)= 323.36	(313)= 336.57	(314)= 347.59	(315)= 357.60	(316)= 366.50	(317)= 345.66	(318)= 351.83
(319)= [illegible]	(321)= 309.73	(322)= 324.44	(323)= 336.99	(324)= 347.97	(325)= 357.94	(326)= 366.81	(327)= 346.05
(328)= 352.[illegible]	(329)= 347.17	(331)= 303.73	(332)= 324.44	(333)= 336.99	(334)= 347.97	(335)= 357.34	(336)= 365.81
(337)= [illegible]	(338)= 352.20	(339)= 339.01	(401)= 347.43	(402)= 357.72	(403)= 366.61	(404)= 373.31	(405)= 379.97
(406)= 365.[illegible]	(407)= 377.01	(611)= 395.9[illegible]	(409)= 376.04	(411)= 347.73	(412)= 357.98	(413)= 366.25	(414)= 373.52
(415)= [illegible]	(416)= 355.12	(417)= 372.23	(418)= 376.33	(419)= 375.49	(421)= 348.10	(422)= 358.32	(423)= 355.55
(424)= 373.[illegible]	([illegible])= 330.42	(426)= 336.35	(427)= 372.51	(428)= 376.60	(429)= 375.74	(431)= 348.10	(432)= 358.32
(433)= [illegible]	(434)= 373.40	(435)= 380.42	(436)= 386.35	(437)= 372.51	(438)= 376.60	(439)= 375.58	(501)= 382.3[illegible]
(502)= [illegible]	(503)= 391.94	(504)= 395.74	(505)= 399.22	(506)= 402.37	(507)= 395.06	(508)= 397.21	(509)= 397.25
(511)= 332.45	(512)= 367.76	(513)= 392.04	(514)= 395.93	(515)= 339.30	(516)= 402.44	(517)= 395.15	(518)= 397.30
(519)= 399.93	(521)= 332.68	(522)= 387.95	(523)= 392.21	(524)= 395.99	(525)= 399.45	(526)= 402.58	(527)= 395.31
(528)= 397.[illegible]	(529)= 400.08	(531)= 382.63	(532)= 387.95	(533)= 392.21	(534)= 395.99	(535)= 393.45	(536)= 402.55
(537)= 3[illegible].31	(538)= 397.46	(539)= 404.05	(601)= 396.96	(606)= 408.02	(603)= 402.22	(604)= 404.32	(605)= 406.26
([illegible])= 399.[illegible]	(607)= 403.94	(608)= 405.14	(609)= 405.10	(408)= 376.13	(612)= 399.89	(613)= 402.25	(614)= 404.35
(6[illegible])= [illegible]	(616)= 409.34	(617)= 403.97	(618)= 405.17	(619)= 404.91	(621)= 397.11	(622)= 400.01	(623)= 402.36
(6[illegible])= [illegible].49	(625)= 405.38	(626)= 403.13	(627)= 404.07	(628)= 405.27	(629)= 405.00	(631)= 397.11	(632)= 400.01
([illegible]3)= [illegible]	(22)= [illegible]6.19	(635)= 406.34	(636)= 408.13	(637)= 404.07	(104)= 333.06	(639)= 404.86	

ROUTINE SR[illegible] EXTRAPOLATED CURVE 10100 14.0000000E+01
ROUTINE SR[illegible] EXTRAPOLATED CURVE 20100 14.0000000E+01
ROUTINE SR[illegible] EXTRAPOLATED CURVE 40100 14.0000000E+01
ROUTINE SR[illegible] EXTRAPOLATED CURVE 50100 14.0000000E+01

TIME = 14[illegible] DEGREE FAHRENHEIT K2 = 27

(1)= 231.24	(2)= 307.34	(3)= 323.77	(4)= 336.36	(5)= 347.74	(6)= 357.78	(7)= 334.21	(8)= 341.17
(9)= 341.17	(11)= 291.74	(12)= 309.75	(13)= 324.13	(14)= 336.66	(15)= 347.99	(16)= 359.[illegible]	(17)= 334.52
(18)= 341.49	(19)= 341.46	(21)= 292.21	(634)= 392.16	(23)= 324.48	(24)= 336.96	(25)= 349.25	(26)= 359.22
(27)= 334.83	(28)= 341.74	(29)= 341.74	(31)= 292.21	(32)= 310.16	(33)= 324.48	(34)= 336.96	(35)= 349.25
(36)= 359.22	(37)= 334.83	(38)= 341.74	(39)= 341.75	(101)= 231.14	(102)= 309.25	(103)= 323.70	(638)= 392.55
(1[illegible])= [illegible]	(1[illegible])= 357.74	(107)= 334.15	(108)= 341.11	(109)= 341.11	(111)= 291.03	(112)= 309.15	(113)= 323.62
(11[illegible])= 329.22	(115)= 347.62	(116)= 357.69	(117)= 334.07	(118)= 341.05	(119)= 341.05	(200)= -.00	(301)= 307.65
(302)= 322.97	(303)= 333.22	(304)= 345.93	(305)= 355.64	(306)= 364.23	(307)= 344.09	(308)= 357.03	(309)= 349.99
(311)= 323.[illegible]	(312)= 323.30	(313)= 335.51	(314)= 345.18	(315)= 355.35	(316)= 364.42	(317)= 344.35	(318)= 350.27
(319)= 345.85	(321)= 308.47	(322)= 323.67	(323)= 335.83	(324)= 346.45	(325)= 356.09	(326)= 364.62	(327)= 344.63
(328)= 355.53	(329)= 347.10	(331)= 308.47	(332)= 323.67	(333)= 335.83	(334)= 346.45	(335)= 355.09	(336)= 364.62
(337)= 344.63	(338)= 350.53	(339)= 341.75	(401)= 338.10	(402)= 348.17	(403)= 356.28	(404)= 363.42	(405)= 369.93
(406)= 375.73	(407)= 367.15	(511)= 374.86	(409)= 366.09	(411)= 338.34	(412)= 348.37	(413)= 356.46	(414)= 363.58
(415)= 370.[illegible]	(416)= 371.65	(417)= 362.34	(418)= 366.32	(419)= 365.48	(421)= 338.63	(422)= 348.63	(423)= 356.69
(424)= 363.73	(425)= 372.25	(426)= 376.01	(427)= 362.55	(428)= 365.51	(429)= 355.66	(431)= 339.63	(432)= 348.63
(433)= 3[illegible].69	(434)= 363.76	(435)= 370.25	(436)= 376.01	(437)= 362.55	(438)= 366.51	(439)= 365.50	(501)= 364.45
(502)= 369.65	(503)= 373.08	(504)= 377.61	(505)= 381.03	(506)= 384.10	(507)= 376.95	(508)= 379.06	(509)= 379.06
(511)= 364.55	(512)= 369.74	(513)= 373.96	(514)= 377.68	(515)= 381.09	(516)= 384.15	(517)= 377.02	(518)= 379.12
(519)= 3[illegible].33	(521)= 364.71	(522)= 369.83	(523)= 374.09	(524)= 377.80	(525)= 381.20	(526)= 384.26	(527)= 377.15
(528)= 379.24	(529)= 380.43	(531)= 364.71	(532)= 369.89	(533)= 374.09	(534)= 377.80	(535)= 381.20	(536)= 384.26
(537)= 377.15	(538)= 379.24	(539)= 382.75	(601)= 374.63	(606)= 385.68	(603)= 380.00	(604)= 382.07	(605)= 383.96
(602)= 377.69	(607)= 381.70	(608)= 382.87	(609)= 387.85	(408)= 366.17	(612)= 377.71	(613)= 380.03	(614)= 382.03
(615)= 383.98	(616)= 385.70	(617)= 381.72	(618)= 382.89	(619)= 382.75	(621)= 374.95	(622)= 377.79	(623)= 380.11

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 37)

```
M"ATRAN"       TRANSIENT                                            **75/12/06.*20.58.23.* PAGE    4            CASE=    MP7   SEQ= 2
   ( 624)= 382.16  ( 625)= 384.05  ( 626)= 385.76  ( 627)= 381.79  ( 628)= 382.96  ( 629)= 382.82  ( 631)= 374.95  ( 632)= 377.79
   ( 633)= 380.11  (  22)= 310.16  ( 635)= 384.05  ( 636)= 385.76  ( 637)= 381.79  ( 104)= 336.29  ( 639)= 382.75

TIME =      150.0000                 DEGREE FAHRENHEIT     K2 =        30
   (   1)= 294.91  (   2)= 312.31  (   3)= 326.22  (   4)= 338.33  (   5)= 349.28  (   6)= 358.90  (   7)= 336.31  (   8)= 342.95
   (   9)= 342.95  (  11)= 295.26  (  12)= 312.59  (  13)= 326.44  (  14)= 338.50  (  15)= 349.41  (  16)= 358.99  (  17)= 335.49
   (  18)= 343.11  (  19)= 343.11  (  21)= 295.61  ( 634)= 358.01  (  23)= 326.68  (  24)= 338.69  (  25)= 349.56  (  26)= 359.10
   (  27)= 335.69  (  28)= 343.29  (  29)= 343.29  (  31)= 295.61  (  32)= 312.88  (  33)= 326.68  (  34)= 335.69  (  35)= 349.56
   (  36)= 359.10  (  37)= 335.69  (  38)= 343.29  (  39)= 343.29  ( 101)= 294.33  ( 102)= 312.25  ( 103)= 326.17  ( 638)= 358.79
   ( 105)= 340.25  ( 106)= 358.88  ( 107)= 336.27  ( 108)= 342.92  ( 109)= 342.92  ( 111)= 294.75  ( 112)= 312.19  ( 113)= 326.12
   ( 114)= 333.25  ( 115)= 349.22  ( 116)= 358.86  ( 117)= 336.23  ( 118)= 342.89  ( 119)= 342.89  ( 200)=    -.00  ( 301)= 305.50
   ( 302)= 321.30  ( 303)= 333.16  ( 304)= 343.52  ( 305)= 352.90  ( 306)= 351.17  ( 307)= 341.78  ( 308)= 347.48  ( 309)= 347.40
   ( 311)= 305.73  ( 312)= 321.54  ( 313)= 333.36  ( 314)= 343.67  ( 315)= 353.02  ( 316)= 361.26  ( 317)= 341.94  ( 318)= 347.62
   ( 319)= 345.74  ( 321)= 307.11  ( 322)= 321.80  ( 323)= 333.57  ( 324)= 343.85  ( 325)= 353.17  ( 326)= 361.38  ( 327)= 342.13
   ( 328)= 347.79  ( 329)= 345.93  ( 331)= 307.11  ( 332)= 321.80  ( 333)= 333.57  ( 334)= 343.85  ( 335)= 353.17  ( 336)= 361.38
   ( 337)= 342.13  ( 338)= 347.79  ( 339)= 343.29  ( 401)= 327.77  ( 402)= 337.60  ( 403)= 345.54  ( 404)= 352.51  ( 405)= 359.86
   ( 406)= 354.49  ( 407)= 351.33  ( 611)= 350.87  ( 409)= 355.11  ( 411)= 327.94  ( 412)= 337.75  ( 413)= 345.66  ( 414)= 352.61
   ( 415)= 358.94  ( 416)= 364.59  ( 417)= 351.43  ( 418)= 355.28  ( 419)= 354.39  ( 421)= 328.17  ( 422)= 337.95  ( 423)= 345.93
   ( 424)= 352.75  ( 425)= 359.36  ( 426)= 354.65  ( 427)= 351.58  ( 428)= 355.41  ( 429)= 354.51  ( 431)= 328.17  ( 432)= 337.95
   ( 433)= 345.93  ( 434)= 352.75  ( 435)= 359.06  ( 436)= 364.65  ( 437)= 351.58  ( 438)= 355.41  ( 439)= 354.33  ( 501)= 345.17
   ( 502)= 351.23  ( 503)= 354.43  ( 504)= 358.09  ( 505)= 361.44  ( 506)= 364.43  ( 507)= 357.46  ( 508)= 359.50  ( 509)= 359.47
   ( 511)= 345.25  ( 512)= 350.34  ( 513)= 354.48  ( 514)= 358.13  ( 515)= 361.48  ( 516)= 364.46  ( 517)= 357.50  ( 518)= 359.54
   ( 519)= 359.17  ( 521)= 345.37  ( 522)= 350.46  ( 523)= 354.58  ( 524)= 358.27  ( 525)= 361.55  ( 526)= 364.53  ( 527)= 357.59
   ( 528)= 354.63  ( 529)= 359.23  ( 531)= 345.37  ( 532)= 350.46  ( 533)= 354.58  ( 534)= 358.22  ( 535)= 361.55  ( 536)= 364.53
   ( 537)= 357.59  ( 538)= 359.53  ( 539)= 358.79  ( 601)= 350.84  ( 606)= 351.47  ( 603)= 355.92  ( 604)= 357.94  ( 605)= 359.80
   ( 602)= 353.64  ( 607)= 357.59  ( 608)= 358.73  ( 609)= 358.72  ( 408)= 355.19  ( 612)= 353.66  ( 613)= 355.94  ( 614)= 357.96
   ( 615)= 354.81  ( 616)= 351.48  ( 617)= 357.60  ( 618)= 358.74  ( 619)= 358.73  ( 621)= 350.94  ( 622)= 353.73  ( 623)= 355.00
   ( 624)= 355.01  ( 625)= 359.55  ( 626)= 361.53  ( 627)= 357.66  ( 628)= 358.79  ( 629)= 358.78  ( 631)= 350.94  ( 632)= 353.73
   ( 633)= 355.00  (  22)= 312.88  ( 635)= 359.86  ( 636)= 361.53  ( 637)= 357.66  ( 104)= 339.29  ( 639)= 358.79

TIME =      175.0000                 DEGREE FAHRENHEIT     K2 =        33
   (   1)= 297.25  (   2)= 314.06  (   3)= 327.40  (   4)= 339.06  (   5)= 349.60  (   6)= 358.81  (   7)= 337.16  (   8)= 343.50
   (   9)= 343.50  (  11)= 297.48  (  12)= 314.15  (  13)= 327.49  (  14)= 339.10  (  15)= 349.60  (  16)= 358.77  (  17)= 337.21
   (  18)= 343.53  (  19)= 343.53  (  21)= 297.70  ( 634)= 329.77  (  23)= 327.61  (  24)= 339.18  (  25)= 349.64  (  26)= 358.78
   (  27)= 337.30  (  28)= 343.59  (  29)= 343.59  (  31)= 297.70  (  32)= 314.31  (  33)= 327.61  (  34)= 339.18  (  35)= 349.64
   (  36)= 358.78  (  37)= 337.30  (  38)= 343.59  (  39)= 343.59  ( 101)= 297.22  ( 102)= 313.97  ( 103)= 327.38  ( 638)= 330.55
   ( 105)= 349.60  ( 106)= 358.82  ( 107)= 337.15  ( 108)= 343.50  ( 109)= 343.50  ( 111)= 297.17  ( 112)= 313.94  ( 113)= 327.36
   ( 114)= 339.04  ( 115)= 349.50  ( 116)= 358.83  ( 117)= 337.14  ( 118)= 343.49  ( 119)= 343.49  ( 200)=    -.00  ( 301)= 303.79
   ( 302)= 319.11  ( 303)= 329.60  ( 304)= 339.62  ( 305)= 348.70  ( 306)= 356.66  ( 307)= 337.98  ( 308)= 343.45  ( 309)= 343.42
   ( 311)= 303.95  ( 312)= 319.24  ( 313)= 329.69  ( 314)= 339.68  ( 315)= 348.72  ( 316)= 356.65  ( 317)= 338.04  ( 318)= 343.49
   ( 319)= 343.23  ( 321)= 304.19  ( 322)= 318.41  ( 323)= 329.81  ( 324)= 339.76  ( 325)= 348.78  ( 326)= 356.67  ( 327)= 338.13
   ( 328)= 343.56  ( 329)= 343.29  ( 331)= 304.19  ( 332)= 318.41  ( 333)= 329.81  ( 334)= 339.76  ( 335)= 348.78  ( 336)= 356.67
   ( 337)= 338.13  ( 338)= 343.56  ( 339)= 343.59  ( 401)= 315.16  ( 402)= 324.81  ( 403)= 332.60  ( 404)= 339.43  ( 405)= 345.64
   ( 406)= 351.12  ( 407)= 334.29  ( 611)= 322.57  ( 409)= 341.96  ( 411)= 315.28  ( 412)= 324.90  ( 413)= 332.66  ( 414)= 339.47
   ( 415)= 345.67  ( 416)= 351.13  ( 417)= 338.34  ( 418)= 342.08  ( 419)= 341.08  ( 421)= 315.45  ( 422)= 325.03  ( 423)= 332.76
   ( 424)= 339.55  ( 425)= 345.73  ( 426)= 351.17  ( 427)= 338.42  ( 428)= 342.15  ( 429)= 341.14  ( 431)= 315.45  ( 432)= 325.33
   ( 433)= 332.76  ( 434)= 333.55  ( 435)= 345.73  ( 436)= 351.17  ( 437)= 338.42  ( 438)= 342.15  ( 439)= 340.94  ( 501)= 322.42
   ( 502)= 327.43  ( 503)= 331.61  ( 504)= 335.25  ( 505)= 338.57  ( 506)= 341.53  ( 507)= 334.64  ( 508)= 336.65  ( 509)= 336.57
   ( 511)= 322.47  ( 512)= 327.53  ( 513)= 331.64  ( 514)= 335.27  ( 515)= 338.59  ( 516)= 341.53  ( 517)= 334.66  ( 518)= 336.67
   ( 519)= 334.43  ( 521)= 322.57  ( 522)= 327.62  ( 523)= 331.71  ( 524)= 335.33  ( 525)= 338.63  ( 526)= 341.57  ( 527)= 334.72
   ( 528)= 335.72  ( 529)= 334.46  ( 531)= 322.57  ( 532)= 327.62  ( 533)= 331.71  ( 534)= 335.33  ( 535)= 338.63  ( 536)= 341.57
   ( 537)= 334.72  ( 538)= 336.72  ( 539)= 330.79  ( 601)= 322.56  ( 606)= 333.26  ( 603)= 327.68  ( 604)= 329.72  ( 605)= 331.69
   ( 602)= 325.38  ( 607)= 329.37  ( 608)= 330.51  ( 609)= 330.52  ( 408)= 342.05  ( 612)= 325.39  ( 613)= 327.69  ( 614)= 329.73
```

FIGURE 5 - SAMPLE PROBLEM OUTPUT (SHEET 38)

7. PROGRAM USAGE

Section 4 has specified the data input for a case by discussing the several types of data required. This section includes several additional requirements and general suggestions for usage of the program. The section on data input also discusses errors in the input data as it is sorted and read. This section discusses additional errors which may occur and what the computer program does in response to these errors.

7.1 MISCELLANEOUS REQUIREMENTS FOR PROGRAM USE

The (1, 10, 1) curve (calculation interval) and the (1, 10, 2) curve (output interval) are required for every case. An error is counted if these curves are omitted from the data input. (See paragraph 7.2 for an explanation of the procedure the computer program takes when a case contains errors.)

Subroutine CURVES is used to perform table lookups on curves not specified on heat transfer method subroutine data input cards and to set up arguments which may be used for table lookups in curves specified in the heat transfer method subroutines. An example of this application is the altitude versus time and velocity versus time curves which are frequently used to analyze an aircraft mission. Neither of these curves are called for by the heat transfer method subroutines directly, however, the information may be needed for the computations. Subroutine CURVES must be called in Subroutine EQDAT prior to calling any subroutines which may need arguments setup. Failure to call Subroutine CURVES first will cause a value of zero to be used on the first time step and may cause a division by zero error. (All undefined argument values are zero). The curve arguments may also be setup one time step late for the remainder of the case depending on the argument used.

7.2 SOLUTION ACCURACY

Solution accuracy may be influenced by several factors which are under control of the user. The backward finite difference solution does not alter the time step input by the user. Increasing the time step tends to increase truncation errors for transient heat transfer problems. The higher the rate of change of temperature with time, the larger the error is in the computed temperature at the end of a time step. One of the causes for this is the evaluation of properties at the last known temperatures. The linearization used for T^4 in the internal radiation heat transfer subroutines also causes errors in the computed heat flux which become larger as the rate of change of temperature increases. The user should specify the time steps for a case to reflect the heating rates input for the model boundary conditions.

7.3 STEADY STATE SOLUTIONS

Cases may be set up for steady state only or a transient analysis with steady state temperatures, optionally computed at one or more problem times. Cases of the first type may be computed by omitting all heat storage subroutines and running the case for several computations (time steps). This is necessary to allow temperature dependent properties such as specified heat and conductivity, to be evaluated at the steady state temperatures since they are evaluated at the old known temperature. Some heat transfer methods (e.g. internal radiation) employ an approximation used to linearize the heat balances. These subroutines may require a few additional iterations (time steps) to reach a steady state solution. Ten time steps will produce a steady state solution in most cases with no heat storage.

Cases which combine steady state and transient portions obviously may not use the method discussed above. Heat storage terms must be included for the transient portion of the analysis and zeroed out for the steady state computations. This may be done by inputting a density curve as a function of time and specifying the density equal to zero for the time intervals when steady state temperatures are desired. The number of time steps required to reach steady state temperatures will vary as described above (size of step is immaterial).

7.4 USER ERRORS

There are two categories of user errors; those which occur before the P-phase and those which occur during the P-phase. Errors in the input data are detected and error messages output in the M and Z-phases of the program. The computer program continues to process cards, regardless of errors which are detected, until the completion of the Z-phase. The program will compute one time step in the P-phase if errors have been detected in previous data processing phases. This is done to check as much of the data input as possible and therefore minimize the number of runs which must be made to obtain a solution. There are situations where one error causes a number of other error messages to be output.

The computer program assumes values for missing or bad input data to allow one time step to be computed. A value of 1.0 is assumed for a specified curve that is missing. A value of 1.265×10^{322} is assumed for dimension table values that have not been input. The program assumes the following values if the CASEB card is not found:

NCA = 10
MPRNT = 0
NORBIT = 0
METHOD = 3

The program assumes the following values for the CASEC variables if the card is not found:

BTIME = 0.
FTIME = 2.0
TMAX = 1000
TMIN = 2.0
TEQAL = 560.
ADD2T = 0.

Additional case data values are assumed if the following errors are detected:

(1) The value of NCA must be greater than one for all methods.
(2) The method number must be valid; otherwise it is set to Method 3.
(3) FTIME must be greater than BTIME; otherwise they are reversed.
(4) TMAX must be greater than TMIN; otherwise they are reversed.
(5) TEQAL has three options. TEQAL = 0. causes initial temperatures to be read from CASET cards. Either too few or too many initial temperature values being input will cause an error. The additional values of initial temperature are set equal to 560°R when too few initial temperatures are input. If TEQAL is negative, final temperatures from the preceding case (if present) are used for initial temperatures for the present case. A value of 560°R is assumed for initial temperatures if there are less nodes in the previous case than in the present case. If TEQAL is greater than zero, no error checking is done.

The following user errors occur in the P-phase.

(1) Temperatures greater than TMAX or less than TMIN cause an error to be counted and the case is terminated.
(2) Divide checks occur when the computations result in a division by zero and may cause mode termination by the CDC computer. Input data should be checked for zero values.

A warning message is output each time a curve is extrapolated. A curve argument outside of the range of the input values for the independent variable causes a linear extrapolation using two points closest to the value desired. This message does not cause an error to be counted as the value may or may not represent an error. The user should check the extrapolated values to determine their suitability.

8. REFERENCES

1. C. E. Whitman, KBDR General Heat Transfer Program User's Manual, MDC A0613, Vol. 1, March 1973.
2. C. E. Whitman, KBDR General Heat Transfer Program User's Manual, MDC A0613, Vol. 2, September 1970.
3. G. M. Dusinberre, Heat Transfer Calculation by Finite Differences, International Textbook Company, 1961.

APPENDIX A

SUBROUTINE DESCRIPTION AND DATA SHEETS

Section		Page
A.1.0	Heat Storage Subroutines	A-3
A.2.0	Heat Conduction subroutines	A-14
A.3.0	Heat Convection Subroutines	A-43
A.4.0	Heat Radiation Subroutines	A-51
A.5.0	Heat Flux Subroutines	A-72
A.6.0	Fluid Flow Subroutines	A-80
A.7.0	Model Subroutine	A-90
A.8.0	Miscellaneous Subroutines	A-95

Curve Specification

Almost all FASTEMP subroutines require as part of their input, curves which describe material properties, source temperatures, coefficients, and other boundary conditions. Section 4.5 describes the input and use of these curves. Curves are designated using a three number system (NRELN, NTYPE, NCLAS). The following is a standard list of curve NTYPE and NCLAS.

LIST OF CURVE NTYPE & NCLAS

NTYPE	NCLAS	CURVE DESCRIPTION
1	0	Density (lb/ft^3)
2	0	Specific heat (BTU/lb°F)
3	0	Conductivity (BTU/hr-ft-°F)
4	0	Emissivity
5	0	Interface conductance (BTU/hr-ft^2-°F)
		TIME STEP CURVES
10	1	Delta Tau vs. Time (Seconds), NRELN = 1
10	2	Temperature printout, NRELN = 1
		ATMOSPHERIC PROPERTIES
11	1	Temperature (°R)
11	2	Pressure (psia)
		TRAJECTORY DATA
12	1	Altitude (ft)
12	2	Velocity (ft/sec)
12	3	Mach number
12	4	Angle of attack (degrees)
		TEMPERATURE CURVES
13	1	TAW - Adiabiatic wall temperature (°R)
13	2	TR - Radiation Source temperature (°R)
13	4	TP - Known temperature for conduction (°R)
		MISCELLANEOUS CURVES
15	0	h-convective film coefficients (BTU/hr-ft-°F)
17	0	Shape factor curves
19	1	Fluid flow rates (lb/hr)
99	0	Heating Rate curves (BTU/hr-ft^2)
99	0	Multiplier Curve

A.1.0 Heat Storage Subroutines

Section		Page
A.1.1	SRA, SCA, SKA, SKB, SKC, SSA	A-4

A.1.1 SRA, SCA, SKA, SKB, SKC, SSA

Purpose: These subroutines will compute the heat storage terms for thermal model elements of either rectangular, cylindrical, conical or spherical geometry. The subroutines are identical except for the element volume.

Equation: The heat storage term added to the heat balance is:

$$Q = \frac{3600}{1728} \rho \, C_p \, V \, B \, (T'_{NN} - T^{\circ}_{NN})/\Delta\tau$$

where V is the element volume ($in.^3$).

Data Cards:

Symbolic Name	Value
NN	node number
NM	material properties curve relative number
X, Y, Z, δ RØ, RI, RM Θ, ϕ_1, ϕ_2	element dimensions (in. or deg.), used to obtain V
B	arbitrary constant

Required Curves:

ρ - (NM, 1, 0) - density (lb_m/ft^3)

C_p - (NM, 2, 0) - specific heat at constant pressure (Btu/lb_m-°R)

Restrictions and Notes:

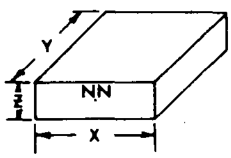
1) All subroutines are available in general format number 2. Subroutines SRA, SCA and SKA are also available in general format number 1.
2) Curve argument number 2 is available as the temperature of node NN.

Subroutine Geometry:

Subroutine	Geometry Type
SRA	Rectangular
SCA	Cylindrical
SKA	Conical
SKB	Conical
SKC	Conical
SSA	Spherical

FASTEMP	General Heat Transfer Program	SRA - Heat Storage - Rect.

$$Q_{SRA} = \rho\ C_p\ \frac{X\ Y\ Z}{1728}\ B\ (T'_{NN} - T^{o}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
X, Y, Z - Element Dimensions
B - Constant

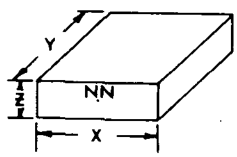
Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SRA		0			1														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	X 31–40	Y 41–50	Z 51–60	B 61–70	71–80
SRA											

FASTEMP	General Heat Transfer Program	SRA - Heat Storage - Rect.

$$Q_{SRA} = \rho\ C_p\ \frac{X\ Y\ Z}{1728}\ B\ (T'_{NN} - T^{o}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
X, Y, Z - Element Dimensions
B - Constant

Required curves:

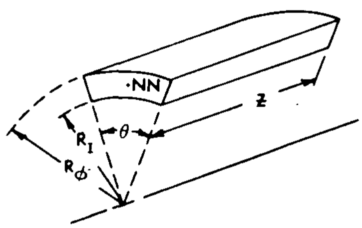
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SRA		0			2														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	[X] 34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
SRA																			

FASTEMP	General Heat Transfer Program	SCA - Heat Storage - Cyl.

$$Q_{SCA} = \rho\ C_p \frac{\pi\theta}{360.} \frac{(R\emptyset^2 - RI^2)Z}{1728} B\ (T'_{NN} - T^{\circ}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
θ - Angle
B - Constant

Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

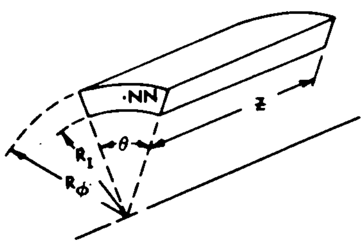
RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SCA		0			1														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	RØ 31 40	RI 41 50	Z 51 60	θ 61 70	B 71 80
SCA											

FASTEMP

FASTEMP	General Heat Transfer Program	SCA - Heat Storage - Cyl.

$$Q_{SCA} = \rho\ C_p \frac{\pi\theta}{360.} \frac{(R\emptyset^2 - RI^2)Z}{1728} B\ (T'_{NN} - T^{\circ}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
Θ - Angle
B - Constant

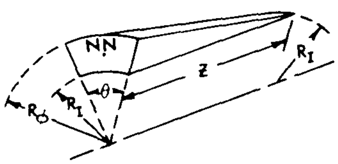
Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SCA		0			2														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	54	58	62	66	70	74	78	80
SCA																			

FASTEMP	General Heat Transfer Program	SKA - Heat Storage - Con.

$$Q_{SKA} = \rho\, C_p \frac{1}{3}\, \frac{\pi\theta}{360.}\, \frac{(R\emptyset^2 + R\emptyset\ RI - 2\ RI^2)Z}{1728}\, B\, (T'_{NN} - T^{\circ}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Section Height
θ - Angle
B - Constant

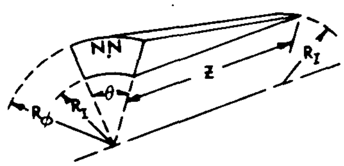
Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCODT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SKA		0			1														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	RØ 31–40	RI 41–50	Z 51–60	θ 61–70	B 71–80
SKA											

FASTEMP	General Heat Transfer Program	SKA - Heat Storage - Con.

$$Q_{SKA} = \rho\ C_p\ \frac{1}{3}\ \frac{\pi\theta}{360.}\ \frac{(R\emptyset^2 + R\emptyset\ RI - 2\ RI^2)Z}{1728}\ B\ (T'_{NN} - T^{o}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Section Height
θ - Angle
B - Constant

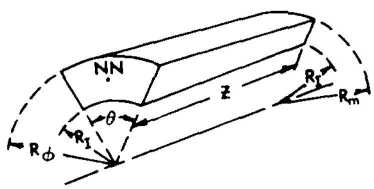
Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SKA		0			2														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	54	58	62	66	70	74	78	80
SKA																			

FASTEMP	General Heat Transfer Program	SKB - Heat Storage - Con.

$$Q_{SKB} = \rho\ C_p\ \frac{1}{3}\ \frac{\pi\theta}{360.}\ \frac{(RØ^2 + RØ\ RM + RM^2 - 3RI^2)Z}{1728}\ (T'_{NN} - T^{o}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
RM - Middle Radius
Z - Section Height
Θ - Angle
B - Constant

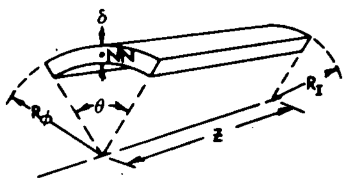
Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SKB		0			2														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	[RM] 54	58	62	66	70	74	78	80
SKB																			

FASTEMP	General Heat Transfer Program	SKC - Heat Storage - Con.

$$Q_{SKC} = \rho\, C_p \frac{\pi\theta}{360}\, \frac{\delta\sqrt{Z^2+(R\emptyset-RI)^2}\left[R\emptyset+RI-\delta\sqrt{Z^2+(R\emptyset-RI)^2}/Z\right]}{1728}\, B\,(T'_{NN}-T^{o}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Height of Cone
Θ - Angle
B - Constant
δ - Skin Thickness

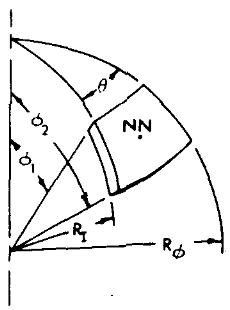
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SKC		0			2														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	[δ] 54	58	62	66	70	74	78	80
SKC																			

FASTEMP	General Heat Transfer Program	SSA - Heat Storage - Sph.

$$Q_{SSA} = \rho \; C_p \; \frac{1}{3} \; \frac{\pi\theta}{180} \; \frac{(R\emptyset^3 - RI^3)}{1728} \; (\text{Cos}\emptyset_1 - \text{Cos}\emptyset_2) \; B \; (T'_{NN} - T^{\circ}_{NN})/(\Delta\tau/3600)$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Θ - Longitudinal Angle
$\emptyset_1$ - Latitudinal Angle
$\emptyset_2$ - Latitudinal Angle
B -- Constant

Required Curves:
ρ - (NM, 1, 0) - Density
C_p - (NM, 2, 0) - Specific Heat

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
SSA		0			2														

RCØDT 1	10	NCARD 14	NN 18	22	NM 26	30	[RØ] 34	[RI] 38	[Θ] 42	[$\emptyset_1$] 46	[$\emptyset_2$] 50	[B] 54	58	62	66	70	74	78	80
SSA																			

A.2.0 Heat Conduction Subroutines

Section		Page
A.2.1	DRA, DCA, DCB, DCC, DKA, DKB, DKC, DKE, DSA, DSB, DSC (two nodes, same material)	A-15
A.2.2	DRB (two nodes or node-source/sink, two materials, interface conductance)	A-31
A.2.3	DRC, DCG, DCH, DCI (two nodes, interface conductance)	A-34

A.2.1 DRA, DCA, DCB, DCC, DKA, DKB, DKC, DKE, DSA, DSB, DSC

Purpose: These subroutines will compute the heat conduction terms between two elements of the same material. The thermal model elements may be of either rectangular, cylindrical, conical or spherical geometry. The subroutines are identical except for the conduction geometrical shape factor.

Equation: The heat conduction term added to the heat balance is:

$$Q = \frac{1}{12} k \ (A/L) \ B \ (T_{NP} - T_{NN})$$

where (A/L) is the element conduction geometrical shape factor (in.).

Data Cards:

Symbolic Name	Value
NN	node number of one element
NP	node number of other element
NM	thermal conductivity curve relative number
X, Y, Z, δ	
RØ, RI, RM	element dimensions (in. or deg.)
θ, ϕ_1, ϕ_2	used to obtain (A/L)
B	arbitrary constant

Required Curves:

k - (NM, 3, 0) - thermal conductivity (Btu/hr-ft-°R)

Restrictions and Notes:

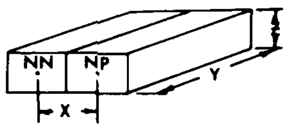
1) All subroutines are available in general format number 2. Subroutines DRA, DCA, DCB and DCC are also available in general format number 1.
2) Curve argument number 2 is available as the average temperature of the two nodes NN and NP.
3) The heat conduction terms are stored as two-way terms in the heat balance.
4) The subroutines are not valid for METHØD = 7.

Subroutine Geometry:

Subroutine	Geometry Type
DRA	Rectangular
DCA	Cylindrical
DCB	Cylindrical
DCC	Cylindrical
DKA	Conical
DKB	Conical
DKC	Conical
DKE	Conical
DSA	Spherical
DSB	Spherical
DSC	Spherical

FASTEMP	General Heat Transfer Program	DRA - Conduction, One Material - Rect.

$Q_{DRA} = k\ Y\ Z\ B\ (T_{NP} - T_{NN})/12\ X$



NN - Node Number
NP - Node Number
X, Y, Z - Element Dimensions
B - Constant

Required Curves:
k - (NM, 3, 0) - Thermal Conductivity

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DRA		0			1														

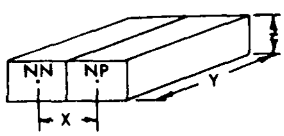
RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	X 31 40	Y 41 50	Z 51 60	B 61 70	71 80
DRA											

FASTEMP	General Heat Transfer Program	DRA - Conduction, One Material - Rect.

$$Q_{DRA} = k\ Y\ Z\ B\ (T_{NP} - T_{NN})/12\ X$$

NN - Node Number
NP - Node Number
X, Y, Z - Element Dimensions
B - Constant

Required Curves:
k - (NM,3,0) - Thermal Conductivity

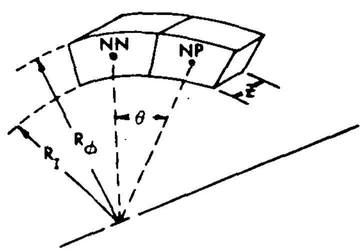


RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DRA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[X] 34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
DRA																			

FASTEMP	General Heat Transfer Program	DCA - Heat Conduction - Cyl., Angular

$$Q_{DCA} = k \frac{360}{\pi\theta} \frac{R\emptyset - RI}{R\emptyset + RI} \frac{Z}{12} B (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
Θ - Angle
B - Constant

Required Curves:
k - (NM,3,0) - Thermal conductivity

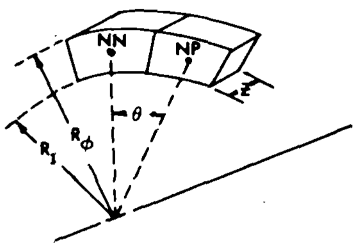
Notes:
RI, RØ, Θ ≠ 0
RI ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCA		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	RØ 31–40	RI 41–50	Z 51–60	Θ 61–70	B 71–80
DCA											

FASTEMP	General Heat Transfer Program	DCA, Heat Conduction - Cyl., Angular

$$Q_{DCA} = k \frac{360}{\pi\theta} \frac{R\O - RI}{R\O + RI} \frac{Z}{12} B (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
Θ - Angle
B - Constant

Required Curves:
k - (NM,3,0) - Thermal Conductivity

Notes:

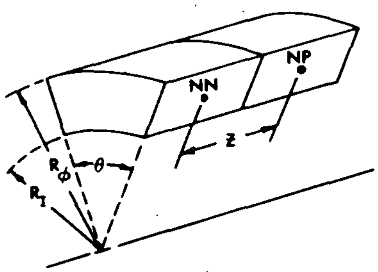
RI, RØ, Θ ≠ 0
RI ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	54	58	62	66	70	74	78	80
DCA																			

FASTEMP	General Heat Transfer Program	DCB - Heat Conduction - Cyl., Axial

$$Q_{DCB} = k \frac{\pi\theta}{360} (R\emptyset^2 - RI^2) B (T_{NP} - T_{NN})/12Z$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
θ - Angle
B - Constant

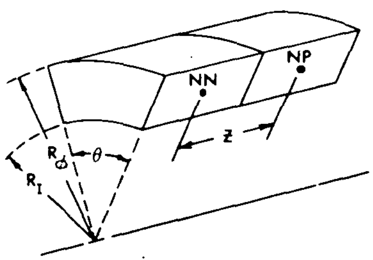
Required Curves:
k - (NM,3,0) - Thermal Conductivity

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCB		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	RØ 31–40	RI 41–50	Z 51–60	θ 61–70	B 71–80
DCB											

FASTEMP	General Heat Transfer Program	DCB · Heat Conduction - Cyl., Axial

$$Q_{DCB} = k\,\frac{\pi\theta}{360}\,(R\emptyset^2 - RI^2)\;B\;(T_{NP} - T_{NN})/12Z$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
θ - Angle
B - Constant

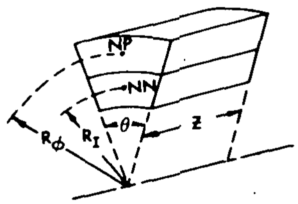
Required Curves:
k - (NM,3,0) - thermal conductivity

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCB		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	54	58	62	66	70	74	78	80
DCB																			

FASTEMP	General Heat Transfer Program	DCC - Heat Conduction - Cyl., Radial

$$Q_{DCC} = k \frac{\pi\theta}{180} \frac{Z}{12} B \, (T_{NP} - T_{NN})/\ln(R\emptyset/RI)$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
θ - Angle
B - Constant

Required Curves:
k - (NM,3,0) - Thermal conductivity

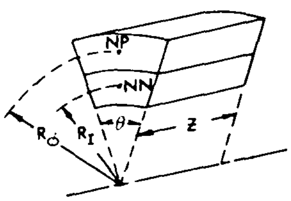
Note:
RI, RØ ≠ 0
RI ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCC		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	RØ 31–40	RI 41–50	Z 51–60	θ 61–70	B 71–80
DCC											

FASTEMP	General Heat Transfer Program	DCC - Heat Conduction - Cyl., Radial

$$Q_{DCC} = k \frac{\pi\theta}{180} \frac{Z}{12} B\,(T_{NP} - T_{NN})/\ln(RØ/RI)$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
θ - Angle
B - Constant

Required Curves:
k - (NM,3,0), thermal conductivity

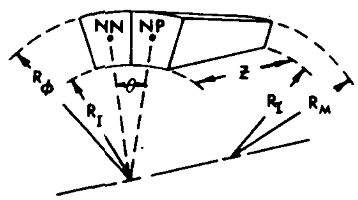
Note:
RI, RØ ≠ 0
RI ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	54	58	62	66	70	74	78	80
DCC																			

FASTEMP	General Heat Transfer Program	DKA - Heat Conduction, Con., Angular

$$Q_{DKA} = k \frac{180}{\pi \Theta} \frac{Z}{12} \left[RM \left(1 - \ln \frac{RM}{RI}\right) - R\emptyset \left(1 - \ln \frac{R\emptyset}{RI}\right)\right] B \left(T_{NP} - T_{NN}\right) / (R\emptyset - RM)$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
Θ - Angle
B - Constant
RM - Outer Radius (smaller)

Required Curves:

k - (NM,3,0) - *Thermal Conductivity*

Notes:

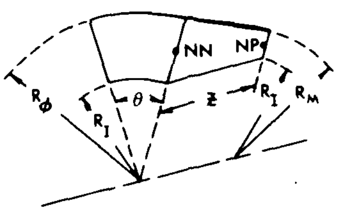
RI, RØ, RM, Θ ≠ 0
RØ ≠ RM ≠ RI

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DKA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	[RM] 54	58	62	66	70	74	78	80
DKA																			

FASTEMP	General Heat Transfer Program	DKB - Heat Conduction - Con., Axial

$$Q_{DKB} = k\,\frac{\pi\Theta}{180}\;\frac{RI\,(RØ - RM)}{\ln\left[\dfrac{RØ - RI}{RØ + RI}\cdot\dfrac{RM + RI}{RM - RI}\right]}\;B\,(T_{NP} - T_{NN})/12Z$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
Θ - Angle
B - Constant
RM - Outer Radius (smallest)

Required Curves:

k - (NM,3,0) - Thermal Conductivity

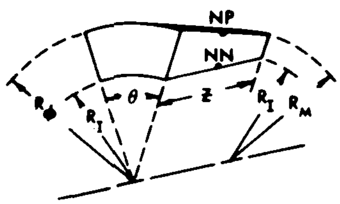
Note:
Z, RI, RM, RØ ≠ 0
RI ≠ RM ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DKB		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	[RM] 54	58	62	66	70	74	78	80
DKB																			

FASTEMP	General Heat Transfer Program	DKC - Heat Conduction - Con., Radial

$$Q_{DKC} = k \frac{\pi\Theta}{180} \frac{Z/12}{\ln[(RØ + RM)/(2\ RI)]} B \ (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
Θ - Angle
B - Constant
RM - Outer Radius (smallest)

Required Curves:

k - (NM,3,0) - Thermal Conductivity

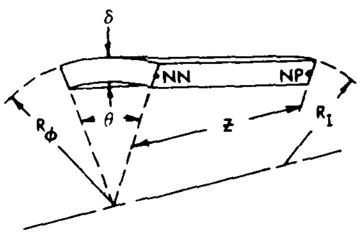
Note:
RI, RM, RØ ≠ 0
RI ≠ RM ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DKC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	[RM] 54	58	62	66	70	74	78	80
DKC																			

FASTEMP	General Heat Transfer Program	DKE - Heat Conduction - Con., Axial

$$Q_{DKE} = k \frac{\delta \frac{\pi\Theta}{180} (R\emptyset - RI)}{\cos\gamma \ln\left(\frac{2R\emptyset \cos\gamma - \delta}{2RI \cos\gamma - \delta}\right)} B \,(T_{NP} - T_{NN}) \,/\, 12Z$$



NN - Node Number
NP - Node Number
RØ - Larger Outside Radius
RI - Smaller Outside Radius
Z - Height
Θ - Angle
B - Constant
δ - Skin Thickness

γ - arctan [(RØ - RI)/Z]

Required Curves:

k - (NM,3,0) - Thermal Conductivity

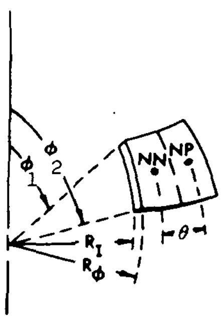
Note:
Z, RI, RØ ≠ 0
RI ≠ RM

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DKE		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	[δ] 54	58	62	66	70	74	78	80
DKE																			

FASTEMP	General Heat Transfer Program	DSA-Heat Conduction-Sph.,Latitude

$$Q_{DSA} = k\,\frac{180}{\pi\theta}\,\frac{(RØ-RI)}{12}\,\ln[\tan(\tfrac{1}{2}Ø_2)/\tan(\tfrac{1}{2}Ø_1)]\;B(T_{NP}-T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
θ - Longitudinal angle
$Ø_1$ - Latitudinal angle
$Ø_2$ - Latitudinal angle
B - Constant

Required Curves:
k-(NM,3,0) - Thermal conductivity

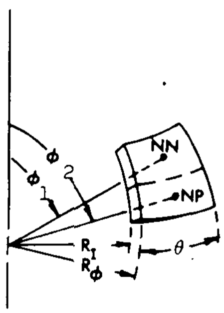
Note:
$Ø_1$, $Ø_2 \neq 0$ or 180
$\theta \neq 0$
$Ø_1 \neq Ø_2$

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DSA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Θ] 42	[$Ø_1$] 46	[$Ø_2$] 50	[B] 54	58	62	66	70	74	78	80
DSA																			

FASTEMP	General Heat Transfer Program	DSB-Heat Conduction - Sph., Longitude

$$Q_{DSB} = k\,\frac{\pi\theta}{180}\,\frac{(R\emptyset-RI)}{12}\,B\,(T_{NP}-T_{NN})/\ln[\tan(\tfrac{1}{2}\emptyset_2)/\tan(\tfrac{1}{2}\emptyset_1)]$$



NN - Node number
NP - Node number
RØ - Outer radius
RI - Inner radius
θ - Longitudinal angle
$\emptyset_1$ - Latitudinal angle
$\emptyset_2$ - Latitudinal angle
B - Constant

Required curves:

k-(NM,3,0) - Thermal conductivity

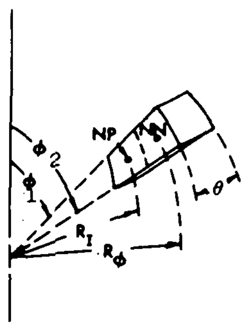
Note:
$\emptyset_1$, $\emptyset_2 \neq 0$ or 180
$\emptyset_1 \neq \emptyset_2$

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DSB		0			[illegible]														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[θ] 42	[Ø1] 46	[Ø2] 50	[B] 54	58	62	66	70	74	78	80
DSB																			

FASTEMP	General Heat Transfer Program	DSC-Heat Conduction-Sph., Radial

$$Q_{DSC} = k \frac{\pi\theta}{180} (\cos\text{Ø}_1 - \cos\text{Ø}_2) \frac{R\text{Ø}\ RI}{12(R\text{Ø}-RI)} B(T_{NP}-T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Θ - Longitudinal angle
Ø_1 - Latitudinal angle
Ø_2 - Latitudinal angle
B - Constant

Required Curves:

k-(NM,3,0) - Thermal conductivity

Note:
RI, RØ ≠ 0
RI ≠ RØ

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DSC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	30	[RØ] 34	[RI] 38	[Θ] 42	[Ø_1] 46	[Ø_2] 50	[B] 54	58	62	66	70	74	78	80
DSC																			

A.2.2 DRB

Purpose: This subroutine will compute the heat conduction terms between two elements or an element and a source/sink. Conduction is through two materials in a rectangular geometry with an optional interface conductance. Terms may be one-way or two-way in the heat balance.

Equation: The heat conduction term added to the heat balance is:

$$Q = \frac{(B)(BB)(T_{NP}-T_{NN})}{\frac{12\ X_1}{k_1 A_1} + \frac{12\ X_2}{k_2 A_2} + \frac{144}{CA_{12}}}$$

Data Cards:

Symbolic Name	Value
NN	node number of one element (if connection is one-way, flow is from this node)
NP	node number of other element or source/sink curve relative number a) if $0 < NP \leq 4000$, NP is a node number with a two-way connection. b) if $4000 < NP \leq 5000$, (NP-4000) is the the curve relative number of the source/sink temperature. c) if $NP > 5000$, (NP-5000) is a node number with a one-way connection from node NN
NM1	thermal conductivity curve relative number for the element NN
NM2	thermal conductivity curve relative number for the element NP
X1	element length of node NN (in.)
A1	element cross-sectional area of node NN(in^2)
X2	element length of node NP (in.)
A2	element cross-sectional area of node NP (in^2)
A12	cross sectional area for interface conductance between node NN and NP (in^2)
NC	interface conductance curve relative number
B, BB	arbitrary constants

Required Curves:

k_1 - (NM_1, 3, 0) - thermal conductivity (Btu/hr-ft-°R)
k_2 - (NM_2, 3, 0) - thermal conductivity (Btu/hr-ft-°R)
C - (NC, 5, 0) - interface conductance (Btu/hr-ft^2-°R)if $NC > 0$
T_{NP} - ([NP-4000], 13, 4) - source/sink temperature (°R) if $4000 < NP \leq 5000$

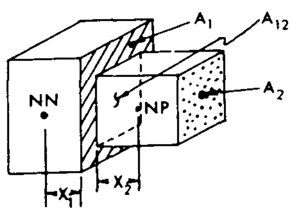
Restrictions and Notes:

1) This subroutine is available only in general format number 2.
2) Curve argument number 2 is available as:
   a) the temperature of node NN for the evaluation of k_1,
   b) the temperature of node NP (or source/sink) for the evaluation of k_2,
   c) the average temperature of the two nodes NN and NP (or source/sink) for the evaluation of C.
3) The terms B and BB may not be zero
4) The subroutine is not valid for METHØD = 7.

Subroutine Geometry: Rectangular

FASTEMP	General Heat Transfer Program	DRB - Conduction, Series with Interface Resistance - Rect.

$$Q_{DRB} = BB\ B\ (T_{NP} - T_{NN})/(12\ X_1/k_1A_1 + 12\ X_2/k_2A_2 + 144/C\ A_{12})$$



NN - Node Number
NP - ≤4000 Node Number
- >4000, Relative No. for Curve
X_1 - Path Length for Node NN
A_1 - Conduction Area for Node NN
X_2 - Path Length for Node NP
A_2 - Conduction Area for Node NP
A_{12}- Conductance area (if needed)
B - Constant
BB - Constant

Required Curves:
k_1 - (NM1,3,0)- Thermal conductivity for Node NN
k_2 - (NM2,3,0)- Thermal conductivity for Node NP
if NC > 0
C - (NC,5,0)- Interface conductance
if NP > 4000
T_{NP}- (NP-4000,13,4)- Source/sink temperature
Notes:
A_1, A_2, A_{12}, B, BB, k_1, k_2, C $\neq$ 0
X_1 and X_2 $\neq$ 0

RCODT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DRB		0			2														

RCODT 1	10	NCARD 14	NN 18	NP 22	NM1 26	NM2 30	[X1] 34	[A1] 38	[X2] 42	[A2] 46	[A12] 50	NC 54	[B] 58	[BB] 62	66	70	74	78	80
DRB																			

A.2.3 DRC, DCG, DCH, DCI

Purpose: These subroutines will compute the heat conduction terms for interface conductance between two elements. The thermal model elements may be of either rectangular or cylindrical geometry. The subroutines are identical except for the interface area.

Equation: The heat conduction term added to the heat balance is:

$$Q = \frac{1}{144} C A B (T_{NP} - T_{NN})$$

where A is the interface area (in^2).

Data Cards:

Symbolic Name	Value
NN	node number of one element
NP	node number of other element
NC	interface conductance curve relative number
Y, Z	element dimensions (in. or deg.)
RØ, RI, Θ	to obtain A
B	arbitrary constant

Required Curves:

C - (NC, 5, 0) - interface conductance (Btu/hr-ft^2-°R)

Restrictions and Notes:

1) All subroutines are available in general format numbers 1 and 2.
2) Curve argument number 2 is available as the average temperature of the two nodes NN and NP.
3) The heat conduction terms are stored as two-way terms in the heat balance
4) These subroutines are not valid for METHØD 7.

Subroutine Geometry:

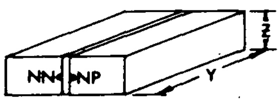
Subroutine	Geometry
DRC	Rectangular
DCG	Cylindrical
DCH	Cylindrical
DCI	Cylindrical

FASTEMP	General Heat Transfer Program	DRC - Interface Conductance - Rect.

$$Q_{DRC} = C \frac{Y\,Z}{144} B\,(T_{NP} - T_{NN})$$

NN - Node Number
NP - Node Number
Y, Z - Element Dimensions
B - Constant

Required Curves:
C - (NC, 5, 0)- Interface Conductance

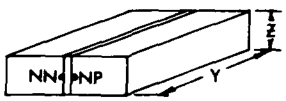


RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DRC		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NC 26	30	31 40	Y 41 50	Z 51 60	B 61 70	71 80
DRC											

FASTEMP	General Heat Transfer Program	DRC - Interface Conductance - Rect.

$$Q_{DRC} = C \frac{Y\ Z}{144} B (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
Y, Z - Element Dimensions
B - Constant

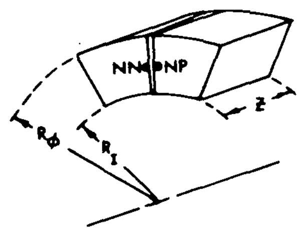
Required Curves:
C - (NC,5,0) - Interface Conductance

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DRC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NC 26	30	34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
DRC																			

FASTEMP	General Heat Transfer Program	DCG - Interface Conductance-Cyl., Angular

$$Q_{DCG} = C \ \frac{(R\emptyset - RI)Z}{144} \ B \ (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
B - Constant

Required Curves:

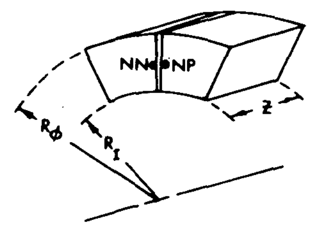
C - (NC, 5, 0) - Interface Conductance

RCØDT 1 10		NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCG		0			1														

RCØDT 1 10		NCARD 14	NN 18	NP 22	NC 26	30	RØ 31 40	RI 41 50	Z 51 60	61 70	B 71 80
DCG											

FASTEMP	General Heat Transfer Program	DCG - Interface Conductance-Cyl., Angular

$$Q_{DCG} = C \frac{(RØ-RI)\ Z}{144} B (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
B - Constant

Required Curves:

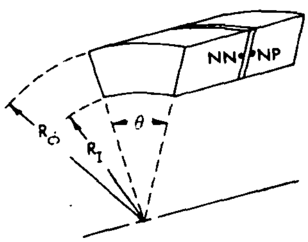
C - (NC, 5, 0) - Interface Conductance

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCG		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NC 26	30	[RØ] 34	[RI] 38	[Z] 42	46	[B] 50	54	58	62	66	70	74	78	80
DCG																			

FASTEMP	General Heat Transfer Program	DCH - Interface Conductance - Cyl, Axial

$$Q_{DCH} = C \frac{\pi(R\emptyset^2 - RI^2)}{144} \frac{\Theta}{360} B (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Θ - Angle
B - Constant

Required Curves:

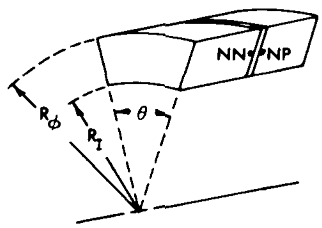
C-(NC,5,0) - Interface Conductance

RCØDT		NCARD		NPRNT	NFMT														
1	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCH		0			1														

RCØDT		NCARD	NN	NP	NC		RØ	RI		Θ	B
1	10	14	18	22	26	30	31 40	41 50	51 60	61 70	71 80
DCH											

FASTEMP	General Heat Transfer Program	DCH - Interface Conductance - Cyl, Axial

$$Q_{DCH} = C \frac{\pi(R\emptyset^2 - RI^2)}{144} \frac{\Theta}{360} B (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
RI - Inner Radius
Θ - Angle
B - Constant

Required Curves:

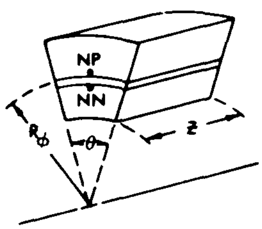
C-(NC,5,0) - Interface Conductance

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCH		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NC 26	30	[RØ] 34	[RI] 38	42	[Θ] 46	[B] 50	54	58	62	66	70	74	78	80
DCH																			

FASTEMP	General Heat Transfer Program	DCI - Interface Conductance - Cyl., Radial

$$Q_{DCI} = C \frac{2\pi\ R\emptyset\ Z}{144}\ \frac{\Theta}{360}\ B\ (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
Z - Axial Length
Θ - Angle
B - Constant

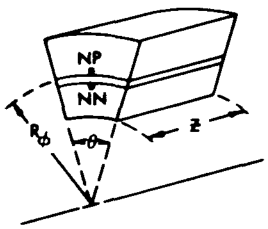
Required Curves:
C-(NC,5,0) - Interface Conductance)

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCI		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NC 26	30	RØ 31 40	41 50	Z 51 60	Θ 61 70	B 71 80
DCI											

FASTEMP	General Heat Transfer Program	DCI - Interface Conductance - Cyl., Radial

$$Q_{DCI} = C \frac{2\pi \; R\emptyset \; Z}{144} \; \frac{\Theta}{360} \; B \; (T_{NP} - T_{NN})$$



NN - Node Number
NP - Node Number
RØ - Outer Radius
Z - Axial Length
Θ - Angle
B - Constant

Required Curves:

C-(NC,5,0) - Interface Conductance

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
DCI		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NC 26	30	[RØ] 34	38	[Z] 42	[Θ] 46	[B] 50	54	58	62	66	70	74	78	80
DCI																			

A.3.0 Heat Convection Subroutines

Section		Page
A.3.1	VRA, VCA, VKA, VSA (forced convection heat transfer coefficient, adiabatic wall temperature)	A-44

A.3.1 VRA, VCA, VKA, VSA

Purpose: These subroutines will compute the heat convection terms for thermal model elements of either rectangular, cylindrical, conical or spherical geometry from a source/sink. The subroutines are identical except for the element surface area. Heat transfer coefficient is provided as known function.

Equation: The heat convection term added to the heat balance is:

$$Q = \frac{1}{144} h \; A \; B \; (T_{aw} - T_{NN})$$

where A is the element surface area (in^2)

Data Cards:

Symbolic Name	Value
NN	node number
NH	heat transfer coefficient curve relative number
NTAW	adiabatic wall temperature curve relative number
Y, Z; RØ, RI; Θ, ϕ_1, ϕ_2	element dimensions (in. or deg.)
I	area option (VCA only)
B	arbitrary constant

Required Curves:

h - (NH, 15, 0) - heat transfer coefficient (Btu/hr-ft^2-°R)

T_{aw} - (NTAW, 13, 1) - adiabatic wall temperature (°R)

Restrictions and Notes:

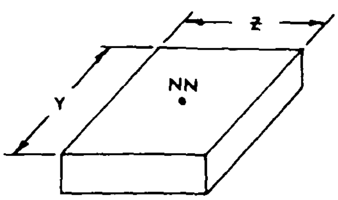
1) All subroutines are available in general format number 2. Subroutines VRA and VKA are also available in general format number 1.
2) Curve argument number 2 is available as the temperature of node NN.
3) These subroutines can be used to force a node to follow a prescribed temperature by letting the T_{aw} curve be the prescribed value and making the heat transfer coefficient a large number (e.g. 10^6).

Subroutine Geometry:

Subroutine	Geometry
VRA	Rectangular
VCA	Cylindrical
VKA	Conical
VSA	Spherical

FASTEMP	General Heat Transfer Program	VRA - Convection Using h and Taw Curves - Rect.

$$Q_{VRA} = h \frac{Y\ Z}{144} B\ (T_{AW} - T_{NN})$$



NN - Node Number
Y, Z - Element Dimensions
B - Constant

Required Curves:

h - (NH,15,0) - Heat transfer coefficient

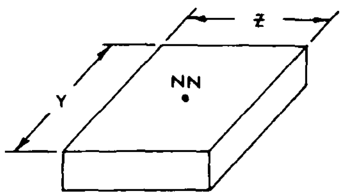
T_{AW} - (NTAW,13,1) - Adiabatic wall temperature

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
VRA		0			1														

RCØDT 1	10	NCARD 14	NN 18	NH 22	NTAW 26	30	31 40	Y 41 50	Z 51 60	B 61 70	71 80
VRA											

FASTEMP	General Heat Transfer Program	VRA - Convection Using h and Taw Curves - Rect.

$$Q_{VRA} = h \frac{Y Z}{144} B (T_{AW}-T_{NN})$$



NN - Node Number
Y, Z - Element Dimensions
B - Constant

Required Curves:

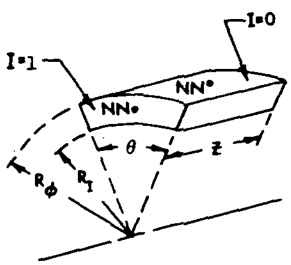
h - (NH,15,0) - Heat transfer coefficient
T_{AW} - (NTAW,13,1) - Adiabatic wall temperature

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
VRA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NH 22	NTAW 26	30	34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
VRA																			

FASTEMP	General Heat Transfer Program	VCA - Convection Using h and Taw Curves - Cyl.

$$Q_{VCA} = h \frac{Area}{144} B (T_{AW}-T_{NN})$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Axial Length
θ - Angle
B - Constant
I - 0, use Area = $\frac{\pi\theta}{180}$ RØZ

1, use Area = $\frac{\pi\theta}{360}$ (RØ^2-RI^2)

Required Curves:

h - (NH,15,0) - Heat transfer coefficient

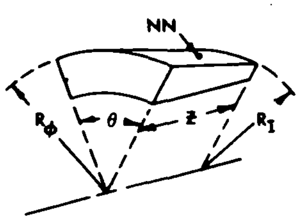
T_{AW} - (NTAW,13,1) - Adiabatic wall temperature

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
VCA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NH 22	NTAW 26	30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	I 54	58	62	66	70	74	78	80
VCA																			

FASTEMP	General Heat Transfer Program	VKA - Convection Using h and Taw Curves - Con.

$$Q_{VKA} = h \frac{\pi\theta}{360} \frac{(R\emptyset - RI)\sqrt{Z^2 + (R\emptyset - RI)^2}}{144} B (T_{AW} - T_{NN})$$



NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Conic Section Height
Θ - Angle
B - Constant

Required Curves:
h - (NH,15,0) - Heat transfer coefficient
T_{AW} - (NTAW,13,1) - Adiabatic wall temperature

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
VKA		0			1														

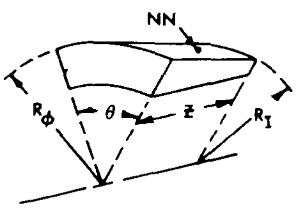
RCØDT 1	10	NCARD 14	NN 18	NH 22	NTAW 26	30	RØ 31 40	RI 41 50	Z 51 60	Θ 61 70	B 71 80
VKA											

FASTEMP	General Heat Transfer Program	VKA - Convection Using h and Taw Curves - Con.

$$Q_{VKA} = h \frac{\pi\Theta}{360} \frac{(R\emptyset-RI)\sqrt{Z^2 + (R\emptyset-RI)^2}}{144} B\,(T_{AW} - T_{NN})$$

NN - Node Number
RØ - Outer Radius
RI - Inner Radius
Z - Conic Section Height
Θ - Angle
B - Constant

Required Curves:
h - (NH,15,0) - Heat transfer coefficient
T_{AW} - (NTAW,13,1) - Adiabatic wall temperature

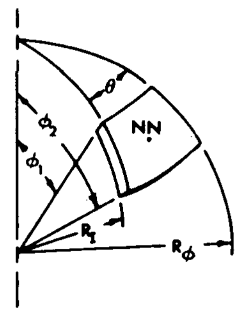


RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
VKA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NH 22	NTAW 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	54	58	62	66	70	74	78	80
VKA																			

FASTEMP	General Heat Transfer Program	VSA - Convection Using h and Taw Curves - Sph.

$$Q_{VSA} = h \frac{\pi\theta}{180} \frac{R\emptyset^2}{144} (\cos\emptyset_1 - \cos\emptyset_2)\ B\ (T_{AW}-T_{NN})$$



NN - Node Number
RØ - Outer Radius
θ - Longitudinal Angle
$\emptyset_1$ - Latitudinal Angle
$\emptyset_2$ - Latitudinal Angle
B - Constant

Required Curves:
h - (NH,15,0) - Heat transfer coefficient
Taw - (NTAW,13,1) - Adiabatic wall temperature

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
VSA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NH 22	NTAW 26	30	[RØ] 34	[RI] 38	[θ] 42	[$\emptyset_1$] 46	[$\emptyset_2$] 50	[B] 54	58	62	66	70	74	78	80
VSA																			

A.4.0 Heat Radiation Subroutines

Section		Page
A.4.1	RRA, RCA, RKA, RSA (external radiation, εF)	A-52
A.4.2	RRB (internal radiation, two gray plates)	A-59
A.4.3	RRC, RCC, RKC, RSC (internal radiation, εF)	A-62
A.4.4	RRD (internal radiation, enclosure)	A-69

A.4.1 RRA, RCA, RKA, RSA

Purpose: These subroutines will compute the heat radiation terms to thermal model elements of either rectangular, cylindrical, conical or spherical geometry from a source/sink. The subroutines are identical except for the element surface area.

Equation: The heat radiation term added to the heat balance is:

$$Q = \frac{1}{144} \sigma \varepsilon F A B (T_r^4 - T_{NN}^4)$$

where σ is the Stefan-Boltzmann constant (0.1714×10^{-8} Btu/hr-ft^2-$^\circ R^4$) and A is the element surface area (in^2).

Data Cards:

Symbolic Name	Value
NN	node number
NF	shape factor curve relative number from node NN to source/sink
NM	emissivity curve relative number
NTR	radiation source/sink temperature curve relative number
Y, Z	
RØ, RI	element dimensions (in. or deg.)
Θ, ϕ_1, ϕ_2	used to obtain A
I	area option (RCA only)
B	arbitrary constant

Required Curves:

F - (NF, 17. 0) - shape factor (-)
ε - (NM, 4, 0) - emissivity (-)
Tr - (NTR, 13, 2) - radiation source/sink temperature ($^\circ$R)

Restrictions and Notes:

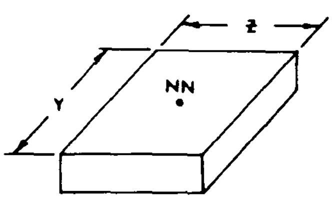
1) All subroutines are available in general format number 2. Subroutines RRA and RKA are also available in general format number 1.
2) Curve argument number 2 is available as the temperature of node NN.
3) These subroutines are not valid for METHØD = 5.
4) Approximations are made for T^4 in order to retain a linear set of equations. These approximations are given in Appendix B. These approximations require that the temperature change of the radiation nodes remain small over the transient time steps. For steady state solutions the approximation is exact.

Subroutine Geometry:

Subroutine	Geometry
RRA	Rectangular
RCA	Cylindrical
RKA	Conical
RSA	Spherical

FASTEMP	General Heat Transfer Program	RRA - External Radiation - Rect.

$$Q_{RRA} = \sigma\ \varepsilon\ F \frac{Y\ Z}{144} B\ (T_r^4 - T_{NN}^4)$$



NN - Node number
Y, Z - Element Dimensions
B - constant

Required curves:
F - (NF,17,0) - View factor
ε - (NM,4,0) - Emissivity
Tr- (NTR,13,2) Source/sink temp.

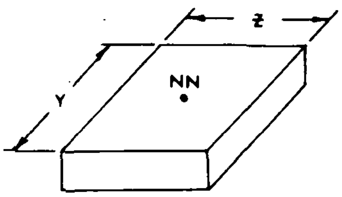
Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRA		0			1														

RCØDT 1	10	NCARD 14	NN 18	NF 22	NM 26	NTR 30	31 40	Y 41 50	Z 51 60	B 61 70	71 80
RRA											

FASTEMP	General Heat Transfer Program	RRA - External Radiation - Rect.

$$Q_{RRA} = \sigma \; \varepsilon \; F \; \frac{Y \; Z}{144} \; B \; (T_r^4 - T_{NN}^4)$$



NN - Node number
$\left.\begin{matrix} Y \\ Z \end{matrix}\right\}$ - Element Dimensions
B - Constant

Required curves:
F - (NF,17,0) - view factor
ε - (NM,4,0) - emissivity
Tr - (NTR,13,2) source/sink temperature

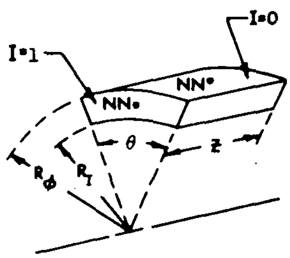
Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NF 22	NM 26	NTR 30	34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
RRA																			

FASTEMP	General Heat Transfer Program	RCA - External Radiation - Cyl.

$$Q_{RCA} = \sigma \ \varepsilon \ F \ \frac{Area}{144} \ B \ (T_r^4 - T_{NN}^4)$$



NN - Node number
RØ - Outer radius
RI - Inner radius
Z - Axial length
θ - Angle
B - Constant
I - 0, use Area = $\frac{\pi\theta}{180} R_Ø Z$
1, use Area = $\frac{\pi\theta}{360} (R_Ø^2 - R_I^2)$

Required curves:
F - (NF,17,0) - view factor
ε - (NM,4,0) - emissivity
T_r - (NTR,13,2) - source/sink temperature

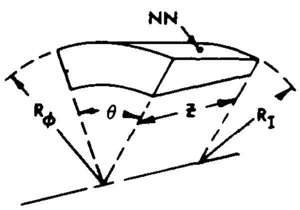
Note: Approximation used for T^4

RCØDT		NCARD		NPRNT	NFMT														
1	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RCA		0			2														

RCØDT		NCARD	NN	NF	NM	NTR	[RØ]	[RI]	[Z]	[Θ]	[B]	I							
1	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RCA																			

FASTEMP	General Heat Transfer Program	RKA - External Radiation - Con.

$$Q_{RKA} = \sigma \; \epsilon \; F \frac{\pi\theta}{360} \; \frac{(R\emptyset + RI)\sqrt{Z^2 + (R\emptyset - RI)^2}}{144} \; B \; (T_r^4 - T_{NN}^4)$$



NN - Node number
RØ - Outer radius
RI - Inner Radius
Z - Conic section height
Θ - Angle
B - Constant

Required curves:
F - (NF,17,0) - View factor
ε - (NM,4,0) - Emissivity
T_r - (NTR,13,2) - Radiation source temperature

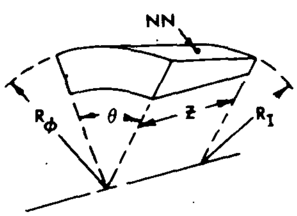
Note: Approximation ued for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RKA		0			1														

RCØDT 1	10	NCARD 14	NN 18	NF 22	NM 26	NTR 30	RØ 31 - 40	RI 41 - 50	Z 51 - 60	Θ 61 - 70	B 71 - 80
RKA											

FASTEMP	General Heat Transfer Program	RKA - External Radiation - Con.

$$Q_{RKA} = \sigma\ \varepsilon\ F\ \frac{\pi\theta}{360}\ \frac{(RØ + RI)\sqrt{Z^2 + (RØ - RI)^2}}{144}\ B\ (T_r^4 - T_{NN}^4)$$



NN - Node number
RØ - Outer Radius
RI - Inner Radius
Z - Conic section height
Θ - Angle
B - Constant

Required curves:
F - (NF,17,0) - View factor
ε - (NM,4,0) - Emissivity
T_r - (NTR,13,2) - Source/sink temp.

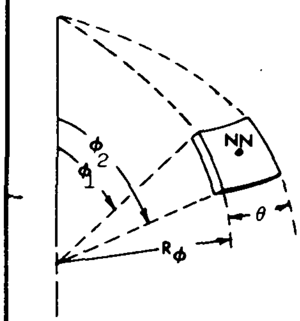
Note: Approximation used for T^4

RCØDT I	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RKA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NF 22	NM 26	NTR 30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	54	58	62	66	70	74	78	80
RKA																			

FASTEMP	General Heat Transfer Program	RSA - External Radiation - Sph.

$$Q_{RSA} = \sigma\ \varepsilon\ \frac{\pi\theta}{180}\ \frac{R\phi^2}{144}\ (\cos\phi_1 - \cos\phi_2)\ B\ (T_r^4 - T_{NN}^4)$$



NN - Node number
RØ - Outer radius
θ - Longitudinal angle
ϕ_1 - Latitudinal angle
ϕ_2 - Latitudinal angle
B - Constant

Required curves:
F - (NF,17,0) - View factor
ε - (NM,4,0) - Emissivity
T_r - (NTR,13,2) - Source/sink temp.

Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RSA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NF 22	NM 26	NTR 30	[RØ] 34	38	[θ] 42	[Ø1] 46	[Ø2] 50	[B] 54	58	62	66	70	74	78	80
RSA																			

A.4.2 RRB

Purpose: This subroutine will compute the heat radiation terms between two thermal model elements of rectangular geometry. The radiation shape factor is computed for two gray infinite parallel plates.

Equation: The heat radiation term added to the heat balance is:

$$Q = \frac{\frac{1}{144}\,\sigma\ Y\ Z\ B\ (T_{NP}^{\ 4} - T_{NN}^{\ 4})}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)}$$

where σ is the Stefan-Boltzmann constant (0.1714×10^{-8} Btu/hr-ft^2 - °R^4).

Data Cards:

Symbolic Name	Value
NN	node number of one node
NP	node number of other node
NM1	emissivity curve relative number of node NN
NM2	emissivity curve relative number of node NP
Y, Z	element dimensions (in.)
B	arbitrary constant

Required Curves:

ε_1 - (NM1, 4, 0) - emissivity (-)
ε_2 - (NM2, 4, 0) - emissivity (-)

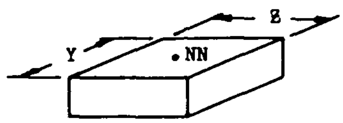
Restrictions and Notes:

1) This subroutine is available in general format numbers 1 and 2.
2) Curve argument number 2 is available as:
   a) the temperature of node NN for the evaluation of ε_1,
   b) the temperature of node NP for the evaluation of ε_2.
3) This subroutine is not valid for METHØD = 5, 7.
4) Approximations are made for T^4 in order to retain a linear set of equations. These approximations are given in Appendix B. These approximations require that the temperature change of the radiation nodes remain small over the transient time steps. For steady state solutions the approximations are exact.
5) The heat radiation terms are stored as two-way terms in the heat balance.

Subroutine Geometry: Rectangular

FASTEMP	General Heat Transfer Program	RRB - Internal Radiation - Rect.

$$Q_{RRB} = \sigma \left(\frac{1}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} \right) \frac{Y\,Z}{144}\, B \left(T_{NP}^4 - T_{NN}^4\right)$$



NN - Node number
NP - Node number
Y, Z - Element Dimensions
B - Constant

Required curves:
ϵ_1 - (NM1,4,0) emissivity for node surface NN
ϵ_2 - (NM2,4,0) - emissivity for node surface NP

Note: Approximation used for T^4

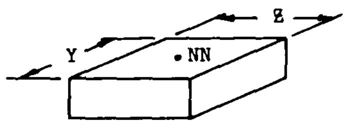
RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRB		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM1 26	NM2 30	31 40	Y 41 50	Z 51 60	B 61 70	71 80
RRB											

FASTEMP	General Heat Transfer Program	RRB - Internal Radiation - Rect.

$$Q_{RRB} = \sigma \left(\frac{1}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} \right) \frac{Y\ Z}{144}\ B\ (T_{NP}^4 - T_{NN}^4)$$

NN - Node number
NP - Node number
Y, Z - Element Dimensions
B - Constant



Required curves:
ϵ_1 - (NM1,4,0) - emissivity for node surface NN
ϵ_2 - (NM2,4,0) - emissivity for node surface NP

Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRB		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM1 26	NM2 30	34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
RRB																			

A.4.3 RRC, RCC, RKC, RSC

Purpose: These subroutines will compute the heat radiation terms between thermal model elements of either rectangular, cylindrical, conical or spherical geometry. The subroutines are identical except for the element surface area.

Equation: The heat radiation term added to the heat balance is:

$$Q = \frac{1}{144} \sigma \varepsilon F A B (T_{NP}^{4} - T_{NN}^{4})$$

where σ is the Stefan-Boltzmann constant (0.1714×10^{-8} Btu/hr - ft^2 - $°R^4$) and A is the element surface area (in^2).

Data Cards:

Symbolic Name	Value
NN	node number of one element
NP	node number of other element
NM	emissivity curve relative number
NFA	shape factor curve relative number from node NN to node NP
Y, Z; RØ, RI; Θ, ϕ_1, ϕ_2	element dimensions of node NN (in. or deg.)
I	area option (RCC only)
B	arbitrary constant

Required Curves:

ε - (NM, 4, 0) - emissivity (-)
F - (NFA, 17, 0) - shape factor (-)

Restrictions and Notes:

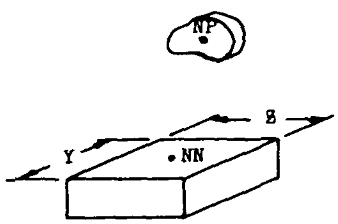
1) All subroutines are available in general format number 2. Subroutines RRC and RKC are also available in general format number 1.
2) Curve argument number 2 is available as:
   a) the temperature of node NN for the evaluation of ε,
   b) the temperature of node NP for the evaluation of F.
3) These subroutines are not valid for METHØD = 5, 7
4) Approximations are made for T^4 in order to retain a linear set of equations. These approximations are given in Appendix B. These approximations require that the temperature change of the radiation nodes remain small over the transient time steps. For steady state solutions the approximations are exact.
5) The heat radiation terms are stored as two-way terms in the heat balance.

Subroutine Geometry:

Subroutine	Geometry
RRC	Rectangular
RCC	Cylindrical
RKC	Conical
RSC	Spherical

FASTEMP	General Heat Transfer Program	RRC - Internal Radiation - Rectangular

$$Q_{RRC} = \sigma \varepsilon F \frac{Y\,Z}{144} B (T^4_{NP} - T^4_{NN})$$



NN - Node number
NP - Node number
Y, Z - Element Dimensions
B - Constant

Required curves:
F - (NFA,17,0) - View factor
ε - (NM,4,0) - Emissivity

Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRC		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	NFA 30	31 40	Y 41 50	Z 51 60	B 61 70	71 80
RRC											

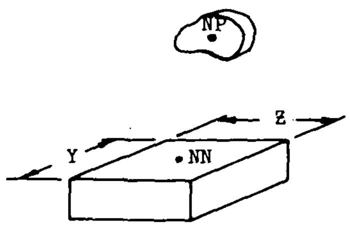
FASTEMP	General Heat Transfer Program	RRC - Internal Radiation - Rectangular

$$Q_{RRC} = \sigma \; \varepsilon \; F \frac{Y\,Z}{144} B \,(T_{NP}^4 - T_{NN}^4)$$

NN - Node number
NP - Node number
Y, Z - Element Dimensions
B - Constant

Required curves:
F - (NFA,17,0) - view factor
ε - (NM,4,0) - emissivity

Note: Approximation used for T^4

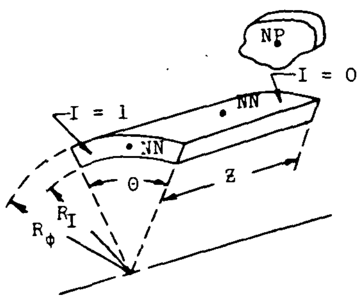


RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	NFA 30	34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
RRC																			

FASTEMP	General Heat Transfer Program	RCC - Internal Radiation-Cyl.

$$Q_{RCC} = \sigma \; \epsilon \; F \; \frac{Area}{144} \; B \; (T^4_{NP} - T^4_{NN})$$



NN - Node number
NP - Node number
RØ - Outer radius node NN
RI - Inner radius node NN
Z - Axial length
θ - Angle
B - Constant
I - 0, use area = $\frac{\pi\theta}{180} R_\emptyset Z$

1, use area = $\frac{\pi\theta}{360} (R^2_\emptyset - R^2_I)$

Required curves:
F - (NFA,17,0) - View factor
ε - (NM,4,0) - Emissivity

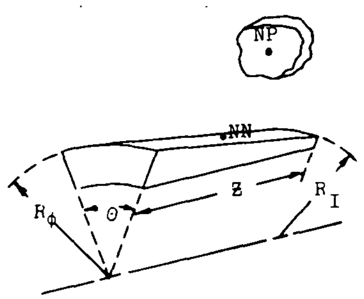
Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RCC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	NFA 30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	I 54	58	62	66	70	74	78	80
RCC																			

FASTEMP	General Heat Transfer Program	RKC - Internal Radiation - Con.

$$Q_{RKC} = \sigma \, \varepsilon \, F \, \frac{\pi\theta}{360} \, \frac{(R\emptyset + RI)\sqrt{Z^2 + (R\emptyset - RI)^2}}{144} \, B \, (T_{NP}^4 - T_{NN}^4)$$



NN - Node number
NP - Node number
RØ - Larger radius node NN
RI - Smaller radius node NN
Z - Conical section height
θ - Angle
B - Constant

Required curves:
F - (NFA,17,0) - View factor
ε - (NM,4,0) - Emissivity

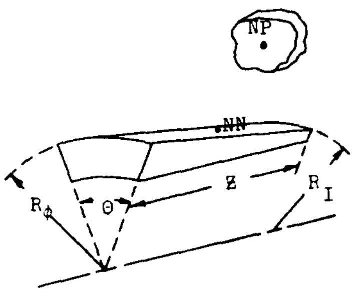
Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RKC		0			1														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	NFA 30	RØ 31–40	RI 41–50	Z 51–60	θ 61–70	B 71–80
RKC											

FASTEMP	General Heat Transfer Program	RKC - Internal Radiation - Con.

$$q_{RKC} = \sigma \, \epsilon \, F \, \frac{\pi\theta}{360} \, \frac{(R\emptyset + RI)\sqrt{Z^2 + (R\emptyset - RI)^2}}{144} \, B \, (T_{NP}^4 - T_{NN}^4)$$



NN - Node number
NP - Node number
RØ - Larger radius node NN
RI - Smaller radius node NN
Z - Conical section height
θ - Angle
B - Constant

Required curves:
F - (NFA,17,0) - view factor
ε - (NM,4,0) - emissivity

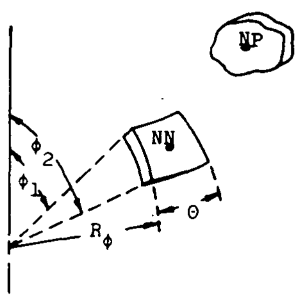
Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RKC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	NFA 30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	54	58	62	66	70	74	78	80
RKC																			

FASTEMP	General Heat Transfer Program	RSC - Internal Radiation - Sph.

$$Q_{RSC} = \sigma \ \varepsilon \ F \ \frac{\pi\theta}{180} \ \frac{R\phi^2}{144} \ (\cos\phi_1 - \cos\phi_2) \ B \ (T_{NP}^4 - T_{NN}^4)$$



NN - Node number
NP - Node number
RØ - Outer radius node NN
Θ - Longitudinal angle
ϕ_1 - Smallest latitudinal angle
ϕ_2 - Largest latitudinal angle
B - Constant

Required curves:
F - (NFA,17,0) - View factor
ε - (NM,4,0) - Emissivity

Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RSC		0			2														

RCØDT 1	10	NCARD 14	NN 18	NP 22	NM 26	NFA 30	[RØ] 34	38	[Θ] 42	[ϕ_1] 46	[ϕ_2] 50	[B] 54	58	62	66	70	74	78	80
RSC																			

A.4.4 RRD

Purpose: This subroutine will compute the heat radiation terms between a thermal model element and up to three other elements in an enclosure.

Equation: The heat radiation terms added to the heat balance are:

$$Q = \frac{1}{144} \sigma A \sum_{I=1}^{3} \mathcal{F}_{NI} (T_{NI}^{4} - T_{NN}^{4})$$

where σ is the Stefan-Boltzmann constant (0.1714×10^{-8} Btu/hr - ft^2 - $°R^4$).

Data Cards:

Symbolic Name	Value
NN	node number
N1, N2, N3	node numbers of other surfaces (up to three)
A	surface area of node NN (in^2)
FN1, FN2, FN3	shape factors from node NN to node N1, N2 and N3 respectively

Required Curves:
None

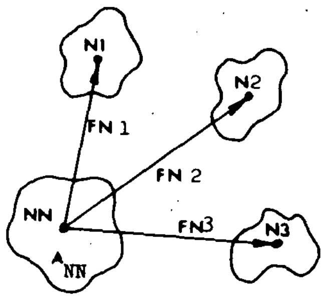
Restrictions and Notes:

1) This subroutine is available in general format numbers 1 and 2.
2) This subroutine is not valid for METHØD = 5,7.
3) Approximations are made for T^4 in order to retain a linear set of equations. These approximations are given in Appendix B. These approximations require that the temperature change of the radiation nodes remain small over the transient time steps. For steady state solutions the approximations are exact.
4) The heat radiation terms are stored as two-way terms in the heat balance.

Subroutine Geometry: Rectangular

FASTEMP	General Heat Transfer Program	RRD - Internal Radiation - Rect.

$$Q_{RRD} = \sigma \mathcal{F}_{NI} \frac{A_{NN}}{144} (T^4_{NI} - T^4_{NN})$$



NN - Node number
N1 - Node number
N2 - Node number
N3 - Node number
A_{NN} - Area of Node NN
FN1 - View factor node NN to N1
FN2 - View factor node NN to N2
FN3 - View factor node NN to N3

Required curves:
None

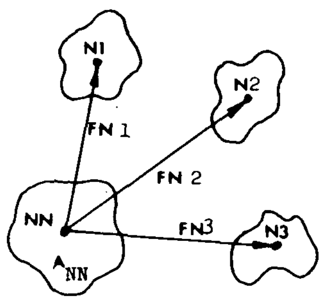
Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRD		0			1														

RCØDT 1	10	NCARD 14	NN 18	N1 22	N2 26	N3 30	ANN 31 40	FN1 41 50	FN2 51 60	FN3 61 70	71 80
RRD											

FASTEMP	General Heat Transfer Program	RRD - Internal Radiation - Rect.

$$Q_{RRD} = \sigma \mathcal{F}_{NI} \frac{A_{NN}}{144} (T_{NI}^4 - T_{NN}^4)$$



NN - Node number
N1 - Node number
N2 - Node number
N3 - Node Number
ANN- Area of Node NN
FN1- View factor from node NN to N1
FN2- View factor from node NN to N2
FN3- View factor from node NN to N3

Required curves:
None

Note: Approximation used for T^4

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
RRD		0			2														

RCØDT 1	10	NCARD 14	NN 18	N1 22	N2 26	N3 30	[ANN] 34	[FN1] 38	[FN2] 42	[FN3] 46	50	54	58	62	66	70	74	78	80
RRD																			

A.5.0 Heat Flux Subroutines

Section		Page
A.5.1	QCRA, QCCA, QCKA, QCSA (heat flux, one multiplier)	A-73

A.5.1 QCRA, QCCA, QCKA, QCSA

Purpose: These subroutines will compute the heat flux terms for thermal model elements of either rectangular, cylindrical, conical or spherical geometry with a prescribed heat flux imposed on its surface. The subroutines are identical except for the element surface area.

Equation: The heat flux term added to the heat balance is:

$$Q = \frac{1}{144} \; q \; A \; P \; B$$

where A is the element surface area (in^2).

Data Cards:

Symbolic Name	Value
NN	node number
NPER	multiplier curve relative number
NQ	heat flux curve relative number
Y, Z; RØ, RI; Θ, ϕ_1, ϕ_2	element dimensions (in. or deg.)
I	area option (QCCA only)
B	arbitrary constant

Required Curves:

P - (NPER, 99, 0) - multiplier (-)

q - (NQ, 99, 0) - heat flux (Btu/hr - Ft^2)

Restrictions and Notes:

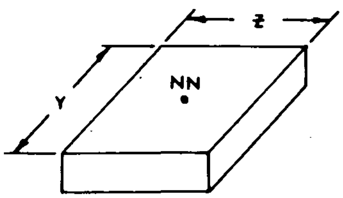
1) All subroutines are available in general format number 2. Subroutines QCRA and QCKA are also available in general format number 1.
2) Curve argument number 2 is available as the temperature of node NN.

Subroutine Geometry:

Subroutine	Geometry
QCRA	Rectangular
QCCA	Cylindrical
QCKA	Conical
QCSA	Spherical

FASTEMP	General Heat Transfer Program	QCRA - Q_{CURVE} - Rect.

$$Q_{QCRA} = q \frac{Y\,Z}{144} P\,B$$



NN - Node number
Y, Z - Element Dimensions
B - Constant

Required curves:

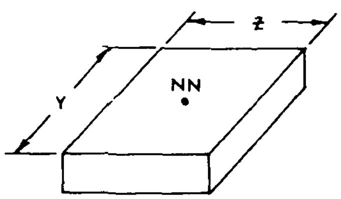
P - (NPER,99,0) - Multiplier
q - (NQ,99,0) - Heat flux

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
QCRA		0			1														

RCØDT 1	10	NCARD 14	NN 18	NPER 22	NQ 26	30	31 40	Y 41 50	Z 51 60	B 61 70	71 80
QCRA											

FASTEMP	General Heat Transfer Program	QCRA – Q_{CURVE} – Rect.

$$Q_{QCRA} = q \frac{Y\,Z}{144} P\,B$$



NN – Node number
Y, Z – Element Dimensions
B – Constant

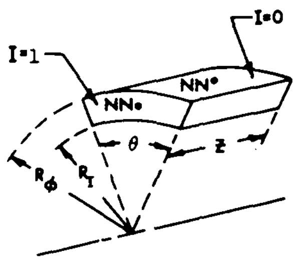
Required curves:
P – (NPER,99,0) – Multiplier
Q – (NQ,99,0) – Heat flux

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
QCRA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NPER 22	NQ 26	30	34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
QCRA																			

FASTEMP	General Heat Transfer Program	QCCA - Q Curve - Cyl.

$$Q_{QCCA} = q \frac{Area}{144} P B$$



NN - Node number
RØ - Outer Radius
RI - Inner Radius
Z - Axial length
Θ - Angle
B - Constant
I - 0 use Area = $\frac{\pi\theta}{180}$ RØ Z
    1 use Area = $\frac{\pi\theta}{360}$ $(RØ^2 - RI^2)$

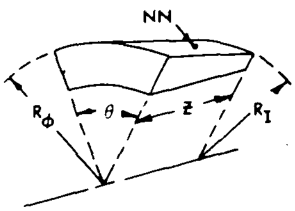
Required curves:
P - (NPER,99,0) - Multiplier
q - (NQ,99,0) - Heat flux

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
QCCA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NPER 22	NQ 26	30	[RØ] 34	[RI] 38	[Z] 42	[Θ] 46	[B] 50	I 54	58	62	66	70	74	78	80
QCCA																			

FASTEMP	General Heat Transfer Program	QCKA - Q Curve - Con.

$$Q_{QCKA} = q \frac{-\theta}{360} \frac{(R\emptyset+RI)\sqrt{Z^2 + (R\emptyset-RI)^2}}{144} \quad PB$$



NN - Node number
RØ - Larger outside radius
RI - Smaller outside radius
Z - Conic section height
Θ - Angle
B - Constant

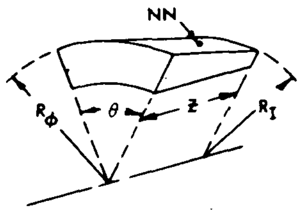
Required curves:
P - (NPER,99,0) - Multiplier
q - (NQ,99,0) - Heat flux

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
QCKA		0			1														

RCØDT 1	10	NCARD 14	NN 18	NPER 22	NQ 26	30	[RØ] 31–40	[RI] 41–50	[Z] 51–60	[Θ] 61–70	[B] 71–80
QCKA											

FASTEMP	General Heat Transfer Program	QCKA - Q CURVE - Con.

$$Q_{QCKA} = q\,\frac{\pi\theta}{360}\,\frac{(\text{RØ} + \text{RI})\sqrt{Z^2 + (\text{RØ} - \text{RI})^2}}{144}\;PB$$



NN - Node number
RØ - Larger outside radius
RI - smaller outside radius
Z - Conic section height
θ - Angle
B - Constant

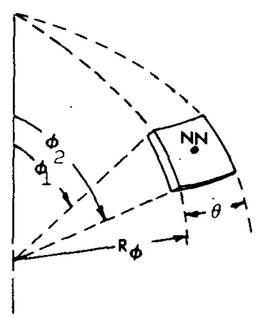
Required curves:
P - (NPER,99,0) - Multiplier
q - (NQ,99,0) - Heat flux

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
QCKA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NPER 22	NQ 26	30	[RØ] 34	[RI] 38	[Z] 42	[θ] 46	[B] 50	54	58	62	66	70	74	78	80
QCKA																			

FASTEMP	General Heat Transfer Program	QCSA - Q Curve - Sph.

$$Q_{QCSA} = q \frac{\pi\theta}{180} \frac{R\emptyset^2}{144} (\cos\emptyset_1 - \cos\emptyset_2) \; PB$$



NN - Node number
RØ - Outer radius
Θ - Incremental longitudinal angle
$\emptyset_1$ - Smallest latitude angle
$\emptyset_2$ - Largest latitude angle
B - Constant

Required curves:
P - (NPER,99,0) - Multiplier
q - (NQ,99,0) - Heat flux

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
QCSA		0			2														

RCØDT 1	10	NCARD 14	NN 18	NPER 22	NQ 26	30	[RØ] 34	38	[Θ] 42	[$\emptyset_1$] 46	[$\emptyset_2$] 50	[B] 54	58	62	66	70	74	78	80
QCSA																			

A.6.0 Fluid Flow Subroutine

Section		Page
A.6.1	FLUIDB (fluid convection with wall heat transfer)	A-81

A.6.1 FLUIDB

Purpose: This subroutine will compute the heat terms for a fluid flowing by one or more surfaces. The fluid to wall heat transfer coefficient h may be input by the user as curve data or may be computed by the subroutine. Options are provided in the subroutine for:

Option 0 - bulk temperature method

Option 1 - outlet temperature method

Option 2 - modified h method

Option 3 - modified $\dot{m}$ and h method

This subroutine can also be used to compute the pressure drop in the fluid control volume.

Equations: The heat terms added to the heat balance are:

$$\frac{3600}{1728} \frac{\rho C_p V B_1}{\Delta\tau} (T'_F - T_F^{\circ}) = Q_m + Q_w$$

where:

Option 0 - $Q_m = \dot{m} C_p B_3 (T'_{NI} - T'_{N\emptyset})$

$$Q_w = \frac{hA\ B_2}{144} (T'_{NW} - T'_F)$$

$$T_F = 1/2\ (T_{NI} + T_{N\emptyset})$$

Option 1 - $Q_m = \dot{m} C_p B_3 (T'_{NI} - T'_{N\emptyset})$

$$Q_w = \frac{hA\ B_2}{144} (T'_{NW} - T'_F)$$

$$T_F = T_{N\emptyset}$$

Option 2 - $\beta = (\Sigma \frac{hA\ B_2}{144})/\dot{m}\ C_p\ B_3$

$$Q_m = \dot{m}\ C_p\ B_3\ (T'_{NI} - T'_{N\emptyset})$$

$$Q_w = \frac{hA\ B_2}{144} [(e^{\beta} - 1)/\beta]\ (T'_{NW} - T'_F)$$

$$T_F = T_{N\emptyset}$$

Option 3 - $\beta = (\Sigma \frac{hA\ B_2}{144}) / \dot{m}\ C_p\ B_3$

$$C = \frac{e^{\beta} - \beta - 1}{\beta(e^{\beta} - 1)}$$

$$Q_m = \dot{m}\ C_p\ B_3\ (\beta\ [(1 - C)/(e^{\beta} - 1)])(T'_{NI} - T'_{N\emptyset})$$

$$Q_w = \frac{hA\ B_2}{144} [T'_{NW} - C\ T'_{NI} - (1 - C)\ T'_{N\emptyset}]$$

$$T_F = T_{N\emptyset}$$

The fluid element control volume equation options are:

user specified

$V = X1$

rectangular

$V = X1 \cdot X2 \cdot X3$

cylindrical

$V = \frac{\pi}{4} \cdot X2^2 \cdot X1$

If the fluid to wall heat transfer coefficient is computed by the subroutine, the equivalent diameter, D_e, and the cross sectional area, A_c, options are:

user specified

$D_e = X2$

$A_c = X3$

rectangular

$D_e = \frac{2 \cdot X2 \cdot X3}{X2 + X3}$

$A_c = X2 \cdot X3$

cylindrical

$D_e = X2$

$A_c = \frac{\pi}{4} \cdot X2^2$

The wall area equation options are:

user specified

$A = X4$

rectangular

$A = X4 \cdot X5$

cylindrical

$$A = \pi \cdot X4 \cdot X5$$

If the curve relative number IH is not zero, the heat transfer coefficient must be input by the user as curve data. If IH is zero, the heat transfer coefficient will be computed by the subroutine according to the relations

$$Nu = C_{LAM} \cdot Re^{EXL1} \cdot Pr^{EXL2} \cdot \left(\frac{D_e}{L_o}\right)^{EXL3} \cdot \left(\frac{\mu_b}{\mu_w}\right)^{EXL4}$$

for the laminar case when $Re \leq Re_{CL}$;

$$Nu = C_{TURB} \cdot Re^{EXT1} \cdot Pr^{EXT2} \cdot \left(\frac{D_e}{L_o}\right)^{EXT3} \cdot \left(\frac{\mu_b}{\mu_w}\right)^{EXT4}$$

for the turbulent case when $Re \geq Re_{CT}$;

Nu = logarithmic interpolation between the laminar Nusselt number evaluated at Re_{CL} and the turbulent Nusselt number evaluated at Re_{CT}.

when $Re_{CL} < Re < Re_{CT}$, where:

$$Nu = \text{Nusselt Number} = \frac{h\ D_e}{12\ k_b}$$

$$Re = \text{Reynolds number} = \frac{\rho_b V D_e}{\mu_b} = \frac{12\ \dot{m}\ D_e}{3600\ \mu_b\ A_c}$$

$$Pr = \text{Prandtl Number} = \frac{3600\ Cp_b\ \mu_b}{k_b}$$

b and w denote properties evaluated at the bulk fluid and wall temperatures, respectively.

If the user specifies a value for ILC in the subroutine zero card, the constant and exponents for the laminar Nusselt number equation are obtained from the dimension table as follows:

C_{LAM} = value in dimension table location ILC
EXL1 = value in dimension table location ILC+1
EXL2 = value in dimension table location ILC+2
EXL3 = value in dimension table location ILC+3
EXL4 = value in dimension table location ILC+4

If ILC is zero or is not specified, the following default values will be used in the laminar equation:

C_{LAM} = 1.86

EXL1 = 0.3333333

EXL2 = 0.3333333

EXL3 = 0.3333333

EXL4 = 0.140

If the user specifies a value for ITC in the subroutine zero card, the constant and exponents for the turbulent Nusselt number equation are obtained from the dimension table as follows:

C_{TURB} = value in dimension table location ITC

EXT1 = value in dimension table location ITC+1

EXT2 = value in dimension table location ITC+2

EXT3 = value in dimension table location ITC+3

EXT4 = value in dimension table location ITC+4

If ITC is zero or is not specified, the following default values will be used in the turbulent equation:

C_{TURB} = 0.0225

EXT1 = 0.80

EXT2 = 0.3333333

EXT3 = 0.0

EXT4 = 0.140

If the user specifies a value for IF in the subroutine zero card, the pressure drop in the fluid control volume will be computed. The equation is:

$$\Delta P = \frac{1}{144} \left(\frac{4fL}{D_e}\right) \frac{(\dot{m}/3600)^2}{2\ g_c\ \rho (A_c/144)^2} \quad \text{psi}$$

$$P_{out} = P_{in} - \Delta P$$

where:

f = friction factor input as a curve versus Reynolds number (curve argument 30)

L = X1 variable

The inlet pressure is optional and is obtained from the card 1 type. If the inlet pressure is specified, the outlet pressure replaces it allowing the pressure through a series of control volumes to be computed. The inlet pressure to the first control volume can be specified by the MØPA subroutine.

If the pressure drop option is specified, the following printout is obtained for each fluid control volume at the print times specified by curve 1, 10, 2.

FLUIDB NI NØ ΔP P_{out} Re Nu f

(The Nusselt number is without the viscosity factor, which is dependent on each wall section.)

Data Cards:	Symbolic Name	Value
	NCFØL	number of cards to follow
	IFM	fluid method
		= 0 bulk temperature method
		= 1 outlet temperature method
		= 2 modified h method
		= 3 modified $\dot{m}$ and h method
	RECL	critical Reynolds number for laminar flow
	RECT	critical Reynolds number for turbulent flow
	ILC	index for laminar Nusselt number constants or zero
	ITC	index for turbulent Nusselt number constants or zero
	IF	friction factor curve relative number or zero
Card 1	LC	last card in control volume
		= 0 no
		= 1 yes
	NI	fluid inlet node number
	NØ	fluid outlet node number
	IFP	fluid property curve relative number
	IMD	mass flow rate curve relative number
	IGV	control volume geometry option

		= -1 user specified
		= 0 rectangular
		= 1 cylindrical
	B1	volume term multiplier
	X1, X2, X3	element dimensions for volume
	XLØ	flow development length
	B3	flow term multiplier
	PIN	control volume inlet pressure if IF ≠ 0
Card 2	LC	last card in control volume
		= 0 no
		= 1 yes
	NW	wall node number
	IH	wall heat transfer coefficient curve relative number or zero
	IGA	area geometry option
		= -1 user specified = 0 rectangular = 1 cylindrical
	B2	area term multiplier
	X4, X5	element dimensions for area

Required Curves:

- f - (IF, 27, 0) - friction factor if IF ≠ 0
- ρ - (|IFP|, 1, 0) - fluid density (lb/ft^3) if IFP > 0
- R - (|IFP|, 1, 1) - gas constant ($ft\text{-}lb_f/lb_m$ - °R) if IFP < 0
- C_p - (|IFP|, 2, 0) - fluid specific heat (Btu/lb_m - °R)
- k - (|IFP|, 3, 0) - fluid thermal conductivity (Btu/hr-ft-°R) if IH = 0
- μ - (|IFP|, 8, 0) - fluid viscosity (lb_m/ft-sec) if IH = 0
- $\dot{m}$ - (IMD, 19, 1) - fluid mass flow rate (lb_m/hr)
- h - (IH, 15, 2) - wall heat transfer coefficient ($Btu/hr\text{-}ft^2$-°R) if IH ≠ 0

Restrictions and Notes:

1) This subroutine is only available in general format 2.
2) Curve argument number 2 is available as the bulk fluid temperature $T_B = 1/2\ (T_{NI} + T_{NØ})$. For evaluation of μ_w,

curve argument number 2 is available as the wall temperature T_{NW}.

3) If the presure drop option is used, curve argument number 30 is available as the Reynolds number for the fluid control volume.

4) For IFP < 0, fluid density is computed using the equation $\rho = P/RT_B$. Pressure is obtained from curve argument number 12.

5) This subroutine is not valid for METHØD = 1,2,5,7.

6) The finite difference method may be unstable if the bulk temperature method (IFM = 0) is used. The other methods (IFM = 1,2,3) are always stable.

7) Data cards are input in groups for each control volume. A fluid element card (Card 1) must be input as the first card for each control volume. These are followed by as many wall element cards (Card 2) as required. The last wall element card for a control volume must contain a 1 in column 18 to indicate the end of that control volume.

8) The C_p in the heat storage term is valid for a liquid flow or a constant pressure gas flow. For a variable pressure gas flow the C_p should be changed to C_V. This can be approximated by the input of B_1 as C_V/C_p. However, in many cases the heat storage term will be negligible compared to the other terms, and can be neglected, i.e., input B_1 as zero.

9) The expressions for fluid methods 2 and 3 are based on an analytical solution with negligible heat storage term. Fluid method 3 is for any number of wall nodes, fluid method 2 is for only one wall node per control volume. Fluid method 1 is valid when most of the fluid in the control is near the fluid outlet temperature, i.e., when $hA > \dot{m}\, C_p$. Fluid method 0 is valid when the fluid in the control volume is near an average between the fluid inlet and outlet, i.e., when $\dot{m}\, C_p > hA$. Fluid method 0 will be unstable if $hA > \dot{m}\, C_p$. Fluid method 1, 2, and 3 are always stable.

10) If no value is specified for the number of cards to follow, NCFØL, the subroutine assumes that 100 cards of card type 1 will be input. This value is used to allocate core storage. If multiple calls to this subroutine are made within a case, or if the number of data cards is less than the assumed number of 100, the user can reduce core storage requirements by specifying a value for NCFØL. For the purpose of this estimate, three cards of card type 2 are equivalent in data storage requirements to one card of card type 1. For example, if four cards of type 1 are input and twelve cards of type 2 are input, the value of NCFOL is equal to (4 + 12/3) and is input as 8.

FASTEMP	General Heat Transfer Program	FLUIDB - Fluid flow

$$\rho C_p \frac{V}{1728} B_1 \; (T_F' - T_F^o)/(\Delta\tau/3600) = Q_m + Q_w$$

NCFØL - number of cards to follow
IFM - fluid method
  =0 bulk temperature method
  =1 outlet temperature method
  =2 modified h method
  =3 modified $\dot{m}$ and h method
RECL - laminar critical Re
RECT - turbulent critical Re
ILC - index for laminar Nu constants
ITC - index for turbulent Nu constants
LC - last card in control volume
  =0 no
  =1 yes
NI - inlet fluid node
NØ - outlet fluid node
IGV - volume geometry option
  =-1 user specified V = X1
  = 0 rectangular V = X1·X2·X3
  = 1 cylindrical V = π/4·X2²·X1
B1 - volume term multiplier
X1, X2, X3 - element dimensions for volume

XLØ - flow development length
B3 - flow term multiplier
PIN - optional control volume inlet pressure
NW - wall node
IGA - area geometry option
  = -1 user specified A=X4
  = 0 rectangular A=X4·X5
  = 1 cylindrical A=π·X4·X5
B2 - area term multiplier
X4, X5 - element dimensions for area

Required curves:
if IF≠0
f - (IF,27,0) - friction factor
if IFP>0
ρ - (IFP,1,0) - fluid density
if IFP<0
R - (|IFP|,1,1) - gas constant
C_p - (|IFP|,2,0) - fluid specific heat
$\dot{m}$ - (IMD,19,1)- fluid mass flow rate
if IH=0
k - (|IFP|,3,0) - fluid thermal conductivity
μ - (|IFP|,8,0) - fluid viscosity
if IH≠0
h - (IH,15,2) - wall heat transfer coefficient
Note: Not valid for method - 1,2,5,7

RCØDT 1	10	NCARD 14	NCFØL 18	NPRNT 22	NFMT 26	30	IFM 34	[RECL] 38	[RECT] 42	ILC 46	ITC 50	54	58	62	66	70	74	78	IF 80
FLUIDB		0			2														
RCØDT 1 Card 1	10	NCARD 14	LC 18	NI 22	NØ 26	IFP 30	IMD 34	IGV 38	[B1] 42	[X1] 46	[X2] 50	[X3] 54	[XLØ] 58	[B3] 62	66	70	74	78	[PIN] 80
RCØDT 1 Card 2	10	NCARD 14	LC 18	NW 22	IH 26	30	34	IGA 38	[B2] 42	[X4] 46	[X5] 50	54	58	62	66	70	74	78	80
FLUIDB																			

A.7.0 Model Subroutine

Section		Page
A.7.1	ØNEDMR (one dimensional models)	A-91

A.7.1 ØNEDMR

Purpose: This subroutine will compute the heat storage terms and the heat conduction terms for a one-dimensional thermal model composed of rectangular elements.

Equation: The heat storage terms added to the heat balance are:

$$Q = \frac{3600}{1728} \rho \, C_p \, V_i \, B \, (T_i{}' - T_i{}^o)/\Delta\tau$$

where i = N1 to N2

For each rectangular element:

$$V_i = X\,Y\,Z \,/\, 2/(N2 - N1) \text{ for } i = N1 \text{ or } N2$$
$$= X\,Y\,Z \,/\, (N2 - N1) \text{ for } i \neq N1 \text{ or } N2$$
$$= X\,Y\,Z \text{ for } i \text{ when } N1 = N2$$

The heat conduction terms added to the heat balance, if N1 ≠ N2, are:

$$Q = K\,B\,(T_{i+1} - T_i)$$

where i = N1 to (N2 - 1).

For a rectangular model:

$$K = k\,Y\,Z \,/\, 12\,\Delta X_i$$

where $\Delta X_i = X / (N2 - N1)$

Data Cards:

Symbolic Name	Value
ID	directional option for ØNEDMC
N1	node number of first element
N2	node number of last element
NM	material properties curve relative numbers
X, Y, Z	element dimensions (in)
B	arbitrary constant

Required Curves:
ρ - (NM, 1, 0) - density (lbm/ft^3)
C_p - (NM, 2, 0) - specific heat at constant pressure (Btu/lbm - °R)
k - (NM, 3, 0) - thermal conductivity (Btu/hr-ft-°R) if N1 ≠ N2

FASTEMP

Restrictions and Notes:

1) This subroutine is available in general format numbers 1 and 2.

2) Curve argument number 2 is available as:

   a) the temperature of each node for the evaluation of the density and specific heat

   b) the average temperature of each connected node pair for the evaluation of the thermal conductivity.

3) The heat conduction terms are stored as two way terms in the heat balance.

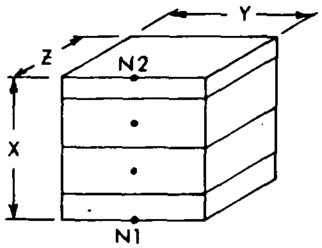
4) This subroutine is not valid for METHOD = 7 if N1 $\neq$ N2.

5) Care must be taken if this subroutine is used with the nonsequential node number option.

Subroutine Geometry:

Subroutine	Geometry Type
ØNEDMR	Rectangular

FASTEMP	General Heat Transfer Program	ØNEDMR - One Dimensional Model - Rect.



N1 - First Node
N2 - Last Node
X - Material thickness between nodes N1 and N2
Y, Z - Element Dimensions
B - Constant

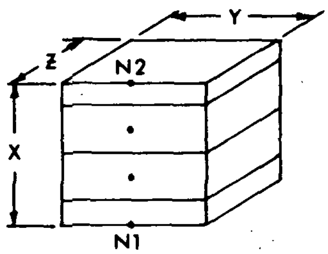
Required Curves:
ρ - (NM,1,0) - Density
Cp- (NM,2,0) - Specific Heat
k - (NM,3,0) - Thermal Conductivity

Note: May cause node number/equation number conflict if using nonsequential node number option.

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
ØNEDMR		0			1														

RCØDT 1	10	NCARD 14	18	N1 22	N2 26	NM 30	X 31–40	Y 41–50	Z 51–60	B 61–70	71–80
ØNEDMR											

FASTEMP	General Heat Transfer Program	ØNEDMR - One Dimensional Model - Rect.



N1 - First Node
N2 - Last Node
X - Material thickness between nodes N1 and N2
Y, Z - Element Dimensions
B - Constant

Required Curves:
ρ - (NM,1,0) - Density
Cp- (NM,2,0) - Specific Heat
k - (NM,3,0) - Thermal Conductivity

Note: May cause node number/equation number conflict if using nonsequential node number option.

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
ØNEDMR		0			2														

RCØDT 1	10	NCARD 14	18	N1 22	N2 26	NM 30	[X] 34	[Y] 38	[Z] 42	[B] 46	50	54	58	62	66	70	74	78	80
ØNEDMR																			

A.8.0 Miscellaneous Subroutines

Section		Page
A.8.1	CURVES (curve argument)	A-96
A.8.2	MOPA (miscellaneous operations, subroutine)	A-98

A.8.1 CURVES

Purpose: This subroutine allows the user to store curve argument values from the result of a table lookup from a curve.

Data Cards:

Symbolic Name	Value
NREL	Curve relative number, type and class
NTYPE	to be searched
NCLAS	
NARG	Curve argument number to store result

Required Curves: As specified by NREL, NTYPE and NCLAS

Restrictions and Notes:

1) The subroutine CURVE is designed for general use.
2) This subroutine must be called before any other subroutine which expects to use its results.
3) The value of NARG is ignored if the type and class of the curve matches the atmosphere/trajectory identifications shown on the data sheets.
4) If a velocity curve is specified (__, 12, 2), the subroutines will also compute and store the Mach number. If a Mach number curve is specified (__, 12, 3), the subroutines will also compute and store the velocity.

FASTEMP	General Heat Transfer Program	CURVES - Curve Argument Loading

-,12,1 - Altitude (arg. 3)
-,11,1 - Freestream temp. (arg.8)
-,11,2 - Freestream pres. (arg.7)
-,12,2 - Velocity (arg.4)
-,12,3 - Mach number (arg.5)
-,12,4 - Angle of attack (arg.6)
-,11,3 - Freestream den. (arg.9)

NARG - Curve argument location to store value obtained from curve.

If velocity specified, Mach no. will be computed $M_\infty = V_\infty/49.1\sqrt{T_\infty}$
If Mach no. specified velocity will be computed $V_\infty = 49.1\sqrt{T_\infty}\,M_\infty$

Required curves:
- (NREL,NTYPE,NCLAS) as specified

Note: Curve order may be important
The curves shown will be automatically stored in their proper curve argument.

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
CURVES		0			2														

RCØDT 1	10	NCARD 14	NREL 18	NTYPE 22	NCLAS 26	NARG 30	34	38	42	46	50	54	58	62	66	70	74	78	80
CURVES		1		12	1														
		2		11	1														
		3		11	2														
		4		12	2														
		5		12	3														
		6		12	4														
		7		11	3														

A.8.2 MØPA

Purpose: This subroutine allows the user to perform miscellaneous operations for the computation and modification of dimension table values, curve argument values, and curve values.

Equation: The result of the miscellaneous operation, R, is computed from one or two variables (V1 and V2)

$$R = f\ (V1,\ V2)$$

depending on the operation code, IØPR. The options are:

IØPR	Result
0	$R = V1$
+1	$R = V1 + V2$
+2	$R = V1 - V2$
+3	$R = V1 \times V2$
+4	$R = V1 \div V2$
+5	$R = \text{minimum}\ (V1,\ V2)$
+6	$R = \text{maximum}\ (V1,\ V2)$
+7	$R = V1^{V2}$
+8	$R = \text{average}\ (V1,\ V2)$
+9	$R = \begin{cases} -1.0 \text{ if } V1 < V2 \\ 0.0 \text{ if } V1 = V2 \\ +1.0 \text{ if } V1 > V2 \end{cases}$
-1	$R = \lvert V1 \rvert$
-2	$R = \sqrt{V1}$
-3	$R = \log V1$
-4	$R = \ln V1$
-5	$R = 10^{V1}$
-6	$R = e^{V1}$

Note that when the operation code is positive two variables are used to compute the result, otherwise only one variable is used. The two variables can be either dimension table values, curve argument values, or the result of a curve lookup. The result can be either a dimension table value, a curve argument value, or can be stored as a one dimensional curve value for later lookup.

An option code, IØPT, is also provided to specify when the operation is performed. When the option code is zero, the operation is performed on all time steps. When the option code is +1, the operation is performed only during the first time step.

Data Cards:

Symbolic Name	Value
IRT	result type = +1 dimension table value = 0 curve argument value = -1 one dimensional curve value
IRN	result number if IRT = +1, dimension table index if IRT = 0, curve argument number if IRT = -1, curve relative number
IRC	additional result number for curve (IRT = -1 only) four digit code, ttcc, giving the curve type (tt) and class (cc)
IVIT	variable one type = +1 dimension table value = 0 curve argument value = -1 curve lookup value
IVIN	variable one number if IRT = +1, dimension table index if IRT = 0, curve argument number if IRT = -1, curve relative number
IVIC	additional result number for curve (IVIT = -1 only) four digit code, ttcc, giving the curve type (tt) and class (cc)
IØPR	operation code
IV2T	variable two type (see IVIT)
IV2N	variable two number (see IVIN)
IV2C	additional variable two number (see IVIC)
IØPT	option code

Required Curves:

As required by the result and variable type codes.

Restrictions and Notes:

1) This subroutine is available only in general format number 2.
2) This subroutine must be called before any subroutine which expects to use its results.
3) This subroutines dynamically uses the dimension table for all variables and results, i.e., the required dimension table values are obtained from or stored in the dimension table every time step.
4) Although this subroutine may store dimension table values, these values may only be referenced by this subroutine or other subroutines which dynamically use the dimension table.

FASTEMP	General Heat Transfer Program	MØPA - Miscellaneous Operations

R = f (V1, V2)

IRT - result type
IRN - result number
IRC - additional result number (IRT = -1 only)
IV1T - variable one type
IV1N - variable one number
IV1C - additional variable one number (IV1T = -1 only)
IV2T - variable two type
IV2N - variable two number
IV2C - additional variable two number (IV2T = -1 only)
IØPR - operation code
IØPT - option code

Type	Value
+1	dimension table value
0	curve argument value
-1	curve value

Number	Value
if type =+1	dimension table index
if type = 0	curve argument number
if type =-1	curve relative number (also additional code gives 4 digit code, ttcc, for curve type and class)

Option	Value
0	performed for all time steps
+1	performed only during first time step

Operation	Value
0	$R = V1$
1	$R = V1 + V2$
2	$R = V1 - V2$
3	$R = V1 \times V2$
4	$R = V1 \div V2$
5	$R = \min (V1, V2)$
6	$R = \max (V1, V2)$
7	$R = V1^{V2}$
8	$R = \mathrm{av}\ (V1, V2)$
9	$R = \begin{cases} -1 & \text{if } V1 < V2 \\ 0 & \text{if } V1 = V2 \\ +1 & \text{if } V1 > V2 \end{cases}$
-1	$R = \lvert V1 \rvert$
-2	$R = \sqrt{V1}$
-3	$R = \log V1$
-4	$R = \ln V1$
-5	$R = 10^{V1}$
-6	$R = e^{V1}$

RCØDT 1	10	NCARD 14	18	NPRNT 22	NFMT 26	30	34	38	42	46	50	54	58	62	66	70	74	78	80
MØPA		0			2														

RCØDT 1	10	NCARD 14	IRT 18	IRN 22	IRC 26	IVIT 30	IVIN 34	IVIC 38	IØPR 42	IV2T 46	IV2N 50	IV2C 54	IØPT 58	62	66	70	74	78	80
MØPA																			

SUBROUTINE INDEX

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DCB	A.2.1	RKC	A.4.3
DCC	A.2.1	RRA	A.4.1
DCG	A.2.3	RRE	A.4.2
DCH	A.2.3		
DCI	A.2.3	RRC	A.4.3
DKA	A.2.1	RRD	A.4.4
DKB	A.2.1	RSA	A.4.1
DKC	A.2.1	RSC	A.4.3
DKE	A.2.1		
DRA	A.2.1	SCA	A.1.1
DRB	A.2.2	SKA	A.1.1
DRC	A.2.3	SKB	A.1.1
DRD	A.2.4	SKC	A.1.1
DSA	A.2.1	SRA	A.1.1
DSB	A.2.1	SSA	A.1.1
DSC	A.2.1		
		VCA	A.3.1
FLUIDB	A.6.1	VKA	A.3.1
		VRA	A.3.1
MOPA	A.8.2	VSA	A.3.1
ONEDMR	A.7.1		
QCCA	A.5.1		
QCKA	A.5.1		
QCRA	A.5.1		
QCSA	A.5.1		

APPENDIX B

Linearization Methods

The solution of a general set of nonlinear simultaneous equations is a difficult and time consuming problem. In a thermal analyzer program the heat balance equations must be setup and solved every time step. This is not practical even for a model consisting of only a few nodes. All nonlinear terms in the heat balance are, therefore, replaced by approximate linearized terms. These approximations are given below.

(1) Radiation Approximation (all radiation subroutines)

The radiation heat flux error may be written as

$$\text{error} = \frac{q_{approx.} - q_{actual}}{q_{actual}}$$

where

$$q_{actual} \propto T^4$$

For the forward finite difference method the temperature used is that at the start of a time step

$$T = T^o$$

resulting in

$$q_{actual} \propto T^{o4}$$

which is a known value and requires no approximation. For the mid finite difference method the temperature used is that at average time

$$T = \frac{1}{2} (T^o + T')$$

resulting in

$$q_{actual} \propto (T^o + T')^4$$

If the expression is expanded in a Taylor series about the point T^o, evaluated at the point T', and only the linear terms in T^o retained, the approximate radiation heat flux is given by

$$q_{approx.} \propto 3T^{o3} T' - 2T^{o4}$$

The radiation heat flux error may then be written as

$$\text{error} = 3 \left(\frac{T'}{T^o} - 1 \right)$$

For the backward finite difference method the temperature used is that at the end of time step

$$T = T'$$

resulting in

$$q_{actual} \propto T'^4$$

If this expression is expanded in a Taylor series about the point T^o, evaluated at the point T', and only the linear terms in T^o retained, the approximate radiation heat flux is given by

$$q_{approx.} \propto 4T^{o3}\,T' - 3T^{o4}$$

The radiation heat flux error may then be written as

$$\text{error} = 4\left(\frac{T'}{T^o} - 1\right)$$

Figure (B-1) shows the radiation heat flux error. It is seen that the error is small only when the temperature change over a time step is small.

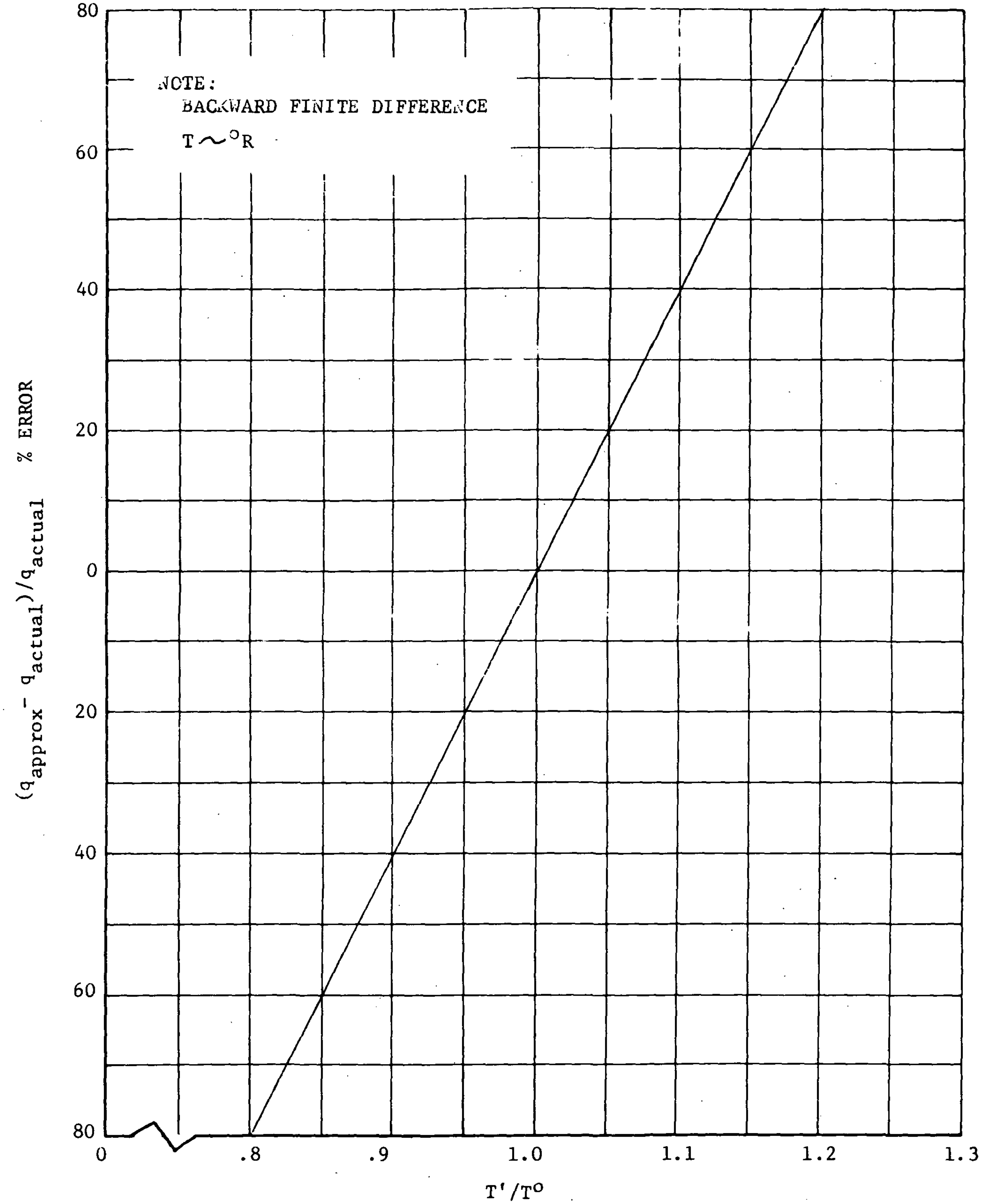

FIGURE B-1 - RADIATION APPROXIMATION ERROR

APPENDIX C

DATA INPUT FORMS

Form Description	Page
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Case Data Input	C-3
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Case Control Cards	C-12

FASTEMP	GENERAL HEAT TRANSFER	PROGRAM SPECIFICATION

```
1     7
      SUBRØUTINE b EQDAT
      RETURN
      END
```

FASTEMP	GENERAL HEAT TRANSFER	CASE DATA INPUT

NCASE – case name
NCA – number of nodes
MPRNT – master print control
NØRBIT – number of orbits
METHØD – *finite difference method*

3 – backward (full matrix)
4 – backward (tridiagonal matrix)
6 – backward (K diagonal matrix)
8 – backward (Gauss-Seidel iteration)

NSN – nonsequential node option
0 – sequential nodes
1 – nonsequential nodes

BTIME – beginning time
FTIME – final time
TMAX – maximum temperature (absolute)
TMIN – minimum temperature (absolute)
ADD2T – value added to initial temperatures
TEQAL – initial temperature option
TEQAL > 0 set all to TEQAL
TEQAL = 0 read in (CASET cards)
TEQAL < 0 use last case answers

1 6	7 Title 80
CASEA b	

1 6		8 NCASE 15	NCA 20	MPRNT 25	NØRBIT 30	METHØD 35	IMP 40	45	NSN 50	ITØ 55	60					
CASEB b																

1 6		11 BTIME 20	21 FTIME 30	31 TMAX 40	41 TMIN 50	51 TEQAL 60	61 ADD2T 70	71 80
CASEC b								
CASET b								

FASTEMP	GENERAL HEAT TRANSFER	DIMENSION TABLE INPUT 1

1 6	NPTS 10	
DIMENS		

1 6	No. 9–10	11 25	26 40	41 55	56 70
VALUES	01				
	05				
	09				
	13				
	17				
	21				
	25				
	29				
	33				
	37				
	41				
	45				
	49				
	53				
	57				
	61				
	65				
	69				
	73				
	77				
	81				
	85				

FASTEMP		GENERAL HEAT TRANSFER		DIMENSION TABLE INPUT 2	
1 6	No. 8–10	11 25	26 40	41 55	56 70
VALUES	089				
	093				
	097				
	101				
	105				
	109				
	113				
	117				
	121				
	125				
	129				
	133				
	137				
	141				
	145				
	149				
	153				
	157				
	161				
	165				
	169				
	173				
	177				
	181				
↓	185				

FASTEMP		GENERAL HEAT TRANSFER		DIMENSION TABLE INPUT 3	
1 6	NO. 8–10	11 25	26 40	41 55	56 70
VALUES	189				
	193				
	197				
	201				
	205				
	209				
	213				
	217				
	221				
	225				
	229				
	233				
	237				
	241				
	245				
	249				
	253				
	257				
	261				
	265				
	269				
	273				
	277				
	281				
	285				

FASTEMP			GENERAL HEAT TRANSFER PROGRAM					GENERAL FORMAT NUMBER 1			
RCØDT 1 6	10	NCARD 14	NX1 18	NX2 22	NX3 26	NX4 30	31 X1 40	41 X2 50	51 X3 60	61 X4 70	71 X5 80

FASTEMP	GENERAL HEAT TRANSFER PROGRAM	GENERAL FORMAT NUMBER 2

RCØDT 1 6	10	NCARD 14	NX1 18	NX2 22	NX3 26	NX4 30	NX5 34	NX6 38	NX7 42	NX8 46	NX9 50	NX10 54	NX11 58	NX12 62	NX13 66	NX14 70	NX15 74	NX16 78	NX17 80

FASTEMP	GENERAL HEAT TRANSFER	TEMPORARY CURVE INPUT 1

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS 1 34	NARG 1 38	
TCIDNT									

1 6	7 80
TCTITL	

	11 25	26 40	41 55	56 70

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS 1 34	NARG 1 38	
TCIDNT									

1 6	7 80
TCTITL	

	11 25	26 40	41 55	56 70

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS 1 34	NARG 1 38	
TCIDNT									

1 6	7 80
TCTITL	

	11 25	26 40	41 55	56 70

FASTEMP	GENERAL HEAT TRANSFER	TEMPORARY CURVE INPUT 2

1 6	NRELN 10	NTYPE 14	NCLAS 18	22	NPRNT 26	NDIMN 30	NPTS1 34	NARG1 38	NPTS2 42	NARG2 46	NPTS3 50	NARG3 54	NPTS4 58	NARG4 62	NPTS5 66	NARG5 70	
TCIDNT																	

1 6	7 80
TCTITL	

	11 25	26 40	41 55	56 70	

FASTEMP				GENERAL HEAT TRANSFER				SAME CURVE INPUT
1 6	NRELN 10	NTYPE 14	NCLAS 18		NRELN2 30	NTYPE2 34	NCLAS2 38	
SAMECR								

FASTEMP	GENERAL HEAT TRANSFER	CASE CONTROL CARDS
1	Cross out unnecessary cards	
END ^{b} CASE	Last card of each case	
BASIC	First card of each basic case (except first)	
CHANG ^{b} BASIC	First card of each change basic case	
CHANG ^{b} CHANG	First card of each change change case	
END JØB	Last card of each main subprogram data pack	