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A SINDA '85 Nodal Heat Transfer Rate Calculation User Subroutine

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SYMBOLS

C_i thermal capacitance of node i
 G_{ij} linear conductance between nodes i and j
 \overline{G}_{ij} nonlinear conductance between nodes i and j
 Q_i impressed heat on node i
 $Q_{i,linear}$ linear energy transfer rate into node i
 $Q_{i,nonlinear}$ nonlinear energy transfer rate into node i
 $Q_{i,sum}$ total of all energy into node i
 T_i temperature of node i
 t time

SUMMARY

This paper describes a subroutine, GETQ, which was developed to compute the heat transfer rates through all conductors attached to a node within a SINDA '85 thermal submodel. The subroutine was written for version 2.3 of SINDA '85. Upon calling GETQ, the user supplies the submodel name and node number which the heat transfer rate computation is desired. The returned heat transfer rate values are broken down into linear, nonlinear, source and combined heat loads.

INTRODUCTION

SINDA '85 has many powerful subroutines and utilities which easily allow the user to access temperature, capacitance, conductance, and heat source values associated with thermal models. The ability to access these variables to affect the solution is an invaluable attribute of SINDA '85.

Often, however, a user needs the value of the heat transfer rate to a node through all conductors attached. The SINDA '85 Subroutine Library includes subroutines which perform "energy maps" for selected nodes. The usefulness is

limited by the fact the computed heat transfer rate information is output to a file, and thus is not accessible during execution. If a user wants to access the heat transfer rate values they must be calculated by logic input by the user. The user must calculate the temperature difference between nodes and multiply that value by the conductance between those nodes. An increasing

number of conductors attached required a disproportionate increase in logic required.

The user subroutine GETQ, described herein, automated the procedure described above. GETQ computes and returns the value of the sum of energy transfer rates into a node.

GETQ FUNCTIONAL DESCRIPTION

The subroutine GETQ was written to compute and return the value of the sum of the energy transfer rates to a given node. The finite difference form of the energy equation used by SINDA '85 is shown below:

$$C_i \frac{dT_i}{dt} = Q_i + \sum_{j=1}^N \{ G_{ij} [T_j - T_i] + \overline{G}_{ij} [T_j^4 - T_i^4] \} \quad (1)$$

The right hand side of Equation 1 consists of three terms which are described as source, linear, and nonlinear terms. The source term, Q_i represents the impressed heat load onto the node. The linear term, Q_{i_linear} represents the sum of the linear heat transfer rate into the node through all linear conductors. The term $Q_{i_nonlinear}$ represents the nonlinear heat transfer rate into the node through all radiation conductors. The expressions for the linear and nonlinear terms are shown below in equations (2) and (3) respectively:

$$Q_{i_linear} = \sum_{j=1}^N \{ G_{ij} [T_j - T_i] \} \quad (2)$$

$$Q_{i_nonlinear} = \sum_{j=1}^N \{ \overline{G}_{ij} [T_j^4 - T_i^4] \} \quad (3)$$

The GETQ subroutine returns the values of Q_i , Q_{i_linear} , $Q_{i_nonlinear}$ and the sum of these three values, Q_{i_sum} .

GETQ USAGE INSTRUCTIONS

The version of GETQ presented herein is written to be used as a user subroutine. It could, with proper modification, be included as a local library subroutine at the user's installation site. The person responsible for installing or maintaining SINDA'85 at the user's site should be contacted to perform this service.

Location of Subroutine

As a user subroutine, the GETQ subroutine should be included in the user's SINDA'85 model in the SUBROUTINE logic block. The user must enter the text of the subroutine. The GETQ Subroutine has been included as Appendix A. An example of a SINDA'85 model which utilizes GETQ has been included as Appendix B.

If this subroutine will be used often, the user may wish to use the SINDA'85 INCLUDE macroinstruction to simplify reuse.

Location of Call Statement

The GETQ subroutine can be called from any of the SINDA'85 logic blocks (OPERATIONS, VARIABLES 0, VARIABLES 1, VARIABLES 2, OUTPUT CALLS, SUBROUTINE DATA). However, since the temperature values and conductor values are potentially time and temperature dependent, it follows that the heat transfer rate values will represent more realistic values at the end of each solution timestep. Therefore, the most appropriate location for the call to GETQ is in VARIABLES 2 or OUTPUT logic blocks for either transient or steady state analysis.

How to Call GETQ

The call statement to GETQ requires six arguments. The first two arguments are inputs, the remaining four are returned computed heat transfer rate values.

In order, the arguments to GETQ are 1) a character string representing the submodel name for the node of interest; 2) an integer value representing the actual (user assigned) node number; 3) a real variable for storing Q_{i_linear} ; 4) a variable for storing $Q_{i_nonlinear}$; 5) a variable for storing Q_i ; 6) a variable for storing $QLIN+QRAD+QSRC$.

The user may use any properly defined variable names as arguments in the call statement.

DEMONSTRATION OF USE

The GETQ subroutine is very helpful in isolating heat loss from a system into the environment. An illustration of that capability is shown in the following problem description.

Sample Problem Description

A 1 kilogram mass aluminum is heated at a rate of 100 Watts. The exterior surface of the mass has an area of $.01 \text{ m}^2$, an emissivity of $.5$ and a convection coefficient of $10 \text{ W/m}^2\text{-K}$. Assuming a specific heat of 900 J/kg-K , find the heat loss to the environment via radiation and convection separately during the first 30 minutes of heating. Assume the temperature is uniform throughout the mass and that the initial temperature is 100 C . See Figure 1.

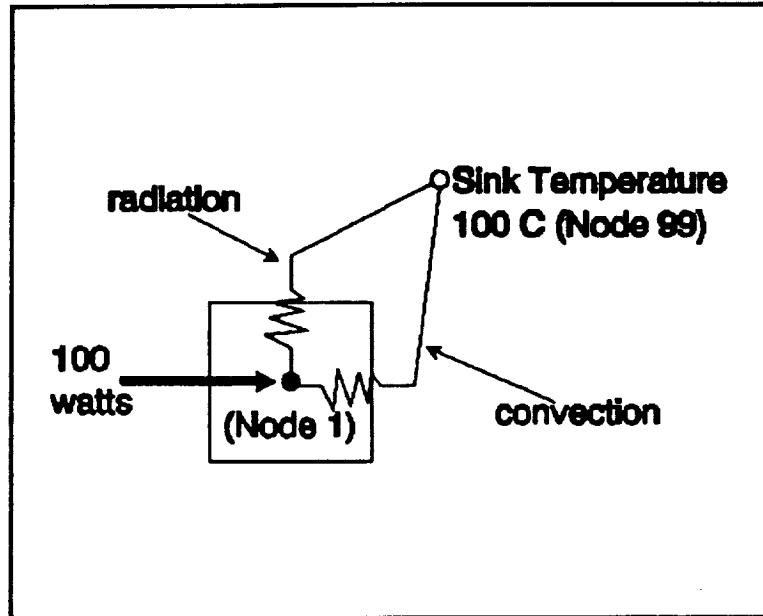


Figure 1. Schematic of Sample Problem

Sample Problem Input File

A SINDA '85 model of the above problem has been included as Appendix B.

The model has a call statement to GETQ in the OUTPUT logic block. Since the desired output is the heat loss to the environment via convection and radiation, the boundary node was chosen as the argument to pass to the GETQ subroutine. For this example, either of the two nodes would be suitable candidates. If, however, the mass were composed of N nodes attached to the boundary node, the boundary node would be the obvious choice of arguments to GETQ. The other option would be to make N calls to GETQ to get the same information.

Once the values of Q_{i_linear} , $Q_{i_nonlinear}$, Q_i , and Q_{i_sum} are returned, the user can use them as desired. In this case, the values are printed to a user file. The user file has been included as Appendix C.

To further illustrate the benefits of this subroutine over the SINDA'85 Library Subroutines, NODMAP was also called from the OUTPUT logic block. NODMAP is one of the many Library Subroutines supplied with SINDA'85. The output from the NODMAP subroutine has been included as Appendix D.

USAGE CAUTIONS

One Way Conductors

One-way conductors in SINDA '85 models are often causes of "ENERGY STABLE BUT UNBALANCED" caution messages generated by the processor. These messages indicate an inability of SINDA '85 to account for the energy flowing out of a node that has a one-way conductor attached. The GETQ Subroutine has the same limitation. Therefore, the Q_{i_linear} term only accounts for the energy through the one-way conductors which have node i as the downstream node.

Using GETQ with DRPMOD

If a user desires to drop a submodel from the current model build, a Library Subroutine, DRPMOD, may be called. The user must be aware that although DRPMOD causes the submodel to be dropped, any conductors which were attached between the remaining built submodels and the dropped submodels will remain active. The temperatures of the dropped submodel will be held constant at the values prior to the DRPMOD call. For such cases, the energy flow calculations performed by GETQ will reflect the temperature and conductance values of the dormant model.

Appendix A - GETQ User Subroutine

```

-----C
C SUBROUTINE GETQ(SUBMDL,NODEA,QLIN,QRAD,QSRC,SUMQ) C
C C C
C AUTHOR: DERRICK CHESTON C
C VERSION: 1.0 C
C CREATED: OCTOBER 3, 1991 C
C UPDATED: AUGUST 15, 1992 C
C C
C FUNCTION: THE SUBROUTINE COMPUTES THE HEAT TRANSFERRED TO A SPECIFIED NODE C
C FROM ALL ATTACHED NODES IN THE CURRENTLY BUILT MODEL, THROUGH C
C ALL CURRENTLY BUILT CONDUCTORS. IT IS TYPICALLY USED TO COMPUTE C
C THE DISTRIBUTION OF HEAT FLOW INTO BOUNDARY NODES. C
C C
C ARGUMENTS: SUBMDL - THE NAME OF THE SUBMODEL (CHARACTER) C
C NODEA - THE ACTUAL NODE NUMBER FOR WHICH HEAT FLOW IS TO BE C
C COMPUTED (INTEGER) C
C QLIN - RETURNED VALUE OF LINEAR HEAT TRANSFER INTO NODE (REAL) C
C QRAD - RETURNED VALUE OF NONLINEAR HEAT TRANSFER INTO NODE C
C (REAL) C
C QSRC - RETURNED VALUE OF IMPRESSED HEAT LOAD INTO NODE (REAL) C
C SUMQ - SUM OF ABOVE THREE VALUES (REAL) C
C C
C CALLING: THIS ROUTINE SHOULD BE CALLED FROM VARIABLES 2 OR OUTPUT CALLS C
-----C
F SUBROUTINE GETQ(SUBMDL,NODEA,QLIN,QRAD,QSRC,SUMQ)
  CALL COMMON
  CHARACTER SUBMDL*(*)
  REAL*8 QRAD,QLIN,QSRC,SUMQ
  INTEGER NODEA,GOFFST

C*****C
C FIND RELATIVE NODE NUMBER, NREL FOR NODEA C
C*****C
F CALL MODTRN(SUBMDL,NODEA,NREL)

C*****C
C FIND LOCATION OF FIRST LINEAR CONDUCTOR C
C ATTACHED TO NODEA C
C*****C
F GOFFST=0
F DO 10 I=1, NREL-1
F GOFFST=GOFFST+NLIN(I)+NRAD(I)
F 10 CONTINUE

C*****C
C INITIALIZE RETURN VARIABLES TO ZERO C
C*****C
F QLIN=0.0
F QRAD=0.0
F SUMQ=0.0

C*****C
C FOR EACH LINEAR CONDUCTOR ATTACHED TO NODEA C
C FIND THE CONDUCTANCE VALUE, GAB C
C FIND THE TEMPERATURE AT THE END, TB C
C COMPUTE THE HEAT FLOW THROUGH CONDUCTOR, DQ C
C INCREASE THE QLIN BY DQ C
C NEXT CONDUCTOR C
C*****C
F DO 20 I=1,NLIN(NREL)
F GAB=G(PG(GOFFST+I))
F TB=T(PT(GOFFST+I))
F DQ=GAB*(TB-T(NREL))
F QLIN=QLIN+DQ
F 20 CONTINUE

C*****C
C FIND LOCATION OF FIRST NONLINEAR CONDUCTOR C
C ATTACHED TO NODEA C
C*****C
F GOFFST=GOFFST+NLIN(NREL)

```

```

C*****C
C   FOR EACH NONLINEAR CONDUCTOR ATTACHED TO NODEA C
C   FIND THE CONDUCTANCE VALUE, GAB C
C   FIND THE TEMPERATURE AT THE END, TB C
C   COMPUTE THE HEAT FLOW THROUGH CONDUCTOR, DQ C
C   INCREASE THE QRAD BY DQ C
C   NEXT CONDUCTOR C
C*****C
F   DO 30 I=1,NRAD(NREL)
F   GAB=G(PG(GOFFST+I))
F   TB=T(PY(GOFFST+I))
F   DQ=GAB*SIGMA*((TB-ABSZRO)**4.0 - (T(NREL) -ABSZRO)**4.0)
F   QRAD=QRAD+DQ
F 30 CONTINUE

C*****C
C   COMPUTE IMPRESSED HEAT LOAD ON NODEA, QSRC C
C*****C
F   QSRC=Q(NREL)

C*****C
C   COMPUTE QSUM = QLIN + QSRC + QRAD C
C*****C
F   SUMQ=QLIN+QRAD+QSRC
F   END

```

Appendix B - SINDA '85 Model for Sample Problem

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HEADER OPTIONS DATA
TITLE SAMPLE PROBLEM DEMONSTRATING GETQ
  OUTPUT=QDOT.OUT
  QMAP=QDOT.MAP
HEADER NODE DATA, BLOCK
  1, 100., 1.*900.
  -99, 100., 1.0
HEADER SOURCE DATA, BLOCK
  1, 100.
HEADER CONDUCTOR DATA, BLOCK
  -1, 1, 99, .01*.5 $ RADIATION CONDUCTOR AREA*EMIS
  2, 1, 99, .01*10. $ CONVECTION CONDUCTOR AREA*CONVECTION COEFFICIENT
HEADER USER DATA, GLOBAL
  QAPPLY=1.0 $ VARIABLE FOR STORING IMPRESSED HEAT RATE
  QCONV=1.0 $ VARIABLE FOR STORING CONVECTION HEAT TRANSFER RATE
  QNLIN=1.0 $ VARIABLE FOR STORING RADIATION HEAT TRANSFER RATE
  QTOTL=1.0 $ VARIABLE FOR STORING TOTAL HEAT TRANSFER RATE
HEADER CONTROL DATA, GLOBAL
  SIGMA=5.6778E-8
  ABSZRO=-273.15
  TIMEND=60.*30. $ STOP SOLUTION AT 30 MINUTES
  OUTPUT=30. $ OUTPUT INTERVAL 30 SECONDS
HEADER OPERATIONS DATA
BUILD ASSBL, BLOCK
  CALL FLDLCK
HEADER OUTPUT CALLS, BLOCK
  CALL GETQ('BLOCK',99,QCONV,QNLIN,QAPPLY,QTOTL)
  WRITE(71,100) TIMEN/60., QCONV, QNLIN
  100 FORMAT('TIME (MINUTES) = ', F10.4,5X,
  + 'CONVECTION HEAT LOSS (WATTS)=', E12.5,5X,
  + 'RADIATION HEAT LOSS (WATTS)=', E12.5)
  CALL MODMAP('BLOCK',99,1)
  CALL TPRINT('ALL')
HEADER SUBROUTINE DATA
-----C
C SUBROUTINE GETQ(SUBMDL,NODEA,QLIN,GRAD,QSRC,SUMQ) C
C C C
C AUTHOR: DERRICK CHESTON C
C VERSION: 1.0 C
C CREATED: OCTOBER 3, 1991 C
C UPDATED: AUGUST 15, 1992 C
C C
C FUNCTION: THE SUBROUTINE COMPUTES THE HEAT TRANSFERRED TO A SPECIFIED NODE C
C FROM ALL ATTACHED NODES IN THE CURRENTLY BUILT MODEL, THROUGH C
C ALL CURRENTLY BUILT CONDUCTORS. IT IS TYPICALLY USED TO COMPUTE C
C THE DISTRIBUTION OF HEAT FLOW INTO BOUNDARY NODES. C
C C
C ARGUMENTS: SUBMDL - THE NAME OF THE SUBMODEL (CHARACTER) C
C NODEA - THE ACTUAL NODE NUMBER FOR WHICH HEAT FLOW IS TO BE C
C COMPUTED (INTEGER) C
C QLIN - RETURNED VALUE OF LINEAR HEAT TRANSFER INTO NODE (REAL) C
C GRAD - RETURNED VALUE OF NONLINEAR HEAT TRANSFER INTO NODE C
C (REAL) C
C QSRC - RETURNED VALUE OF IMPRESSED HEAT LOAD INTO NODE (REAL) C
C SUMQ - SUM OF ABOVE THREE VALUES (REAL) C
C C
C CALLING: THIS ROUTINE SHOULD BE CALLED FROM VARIABLES 2 OR OUTPUT CALLS C
-----C
F SUBROUTINE GETQ(SUBMDL,NODEA,QLIN,GRAD,QSRC,SUMQ)
  CALL COMMON
F CHARACTER SUBMDL*(*)
F REAL*8 GRAD,QLIN,QSRC,SUMQ
F INTEGER NODEA,GOFFST

C*****C
C FIND RELATIVE NODE NUMBER, NREL FOR NODEA C
C*****C
F CALL MODTRN(SUBMDL,NODEA,NREL)

C*****C
C FIND LOCATION OF FIRST LINEAR CONDUCTOR C
C ATTACHED TO NODEA C

```



```

*****C
F      GOFFST=0
F      DO 10 I=1, NREL-1
F      GOFFST=GOFFST+NLIN(I)+NRAD(I)
F 10 CONTINUE

*****C
C      INITIALIZE RETURN VARIABLES TO ZERO      C
*****C
F      QLIN=0.0
F      GRAD=0.0
F      SUMQ=0.0

*****C
C      FOR EACH LINEAR CONDUCTOR ATTACHED TO NODEA      C
C      FIND THE CONDUCTANCE VALUE, GAB      C
C      FIND THE TEMPERATURE AT THE END, TB      C
C      COMPUTE THE HEAT FLOW THROUGH CONDUCTOR, DQ      C
C      INCREASE THE QLIN BY DQ      C
C      NEXT CONDUCTOR      C
*****C
F      DO 20 I=1, NLIN(NREL)
F      GAB=G(PG(GOFFST+I))
F      TB=T(PT(GOFFST+I))
F      DQ=GAB*(TB-T(NREL))
F      QLIN=QLIN+DQ
F 20 CONTINUE

*****C
C      FIND LOCATION OF FIRST NONLINEAR CONDUCTOR      C
C      ATTACHED TO NODEA      C
*****C
F      GOFFST=GOFFST+NLIN(NREL)

*****C
C      FOR EACH NONLINEAR CONDUCTOR ATTACHED TO NODEA      C
C      FIND THE CONDUCTANCE VALUE, GAB      C
C      FIND THE TEMPERATURE AT THE END, TB      C
C      COMPUTE THE HEAT FLOW THROUGH CONDUCTOR, DQ      C
C      INCREASE THE GRAD BY DQ      C
C      NEXT CONDUCTOR      C
*****C
F      DO 30 I=1, NRAD(NREL)
F      GAB=G(PG(GOFFST+I))
F      TB=T(PT(GOFFST+I))
F      DQ=GAB*SIGMA*((TB-ABSZRO)**4.0 - (T(NREL) -ABSZRO)**4.0)
F      GRAD=GRAD+DQ
F 30 CONTINUE

*****C
C      COMPUTE IMPRESSED HEAT LOAD ON NODEA, QSRC      C
*****C
F      QSRC=Q(NREL)

*****C
C      COMPUTE QSUM = QLIN + QSRC + GRAD      C
*****C
F      SUMQ=QLIN+GRAD+QSRC
      END
END OF DATA

```

C-4

Appendix C - GETQ Output from Sample Problem

TIME (MINUTES) =	0.0000	CONVECTION HEAT LOSS (WATTS)=	0.00000E+00	RADIATION HEAT LOSS (WATTS)=	0.00000E+00
TIME (MINUTES) =	0.5000	CONVECTION HEAT LOSS (WATTS)=	0.33244E+00	RADIATION HEAT LOSS (WATTS)=	0.19878E+00
TIME (MINUTES) =	1.0000	CONVECTION HEAT LOSS (WATTS)=	0.66311E+00	RADIATION HEAT LOSS (WATTS)=	0.40180E+00
TIME (MINUTES) =	1.5000	CONVECTION HEAT LOSS (WATTS)=	0.99200E+00	RADIATION HEAT LOSS (WATTS)=	0.60905E+00
TIME (MINUTES) =	2.0000	CONVECTION HEAT LOSS (WATTS)=	0.13191E+01	RADIATION HEAT LOSS (WATTS)=	0.82053E+00
TIME (MINUTES) =	2.5000	CONVECTION HEAT LOSS (WATTS)=	0.16444E+01	RADIATION HEAT LOSS (WATTS)=	0.10363E+01
TIME (MINUTES) =	3.0000	CONVECTION HEAT LOSS (WATTS)=	0.19679E+01	RADIATION HEAT LOSS (WATTS)=	0.12562E+01
TIME (MINUTES) =	3.5000	CONVECTION HEAT LOSS (WATTS)=	0.22896E+01	RADIATION HEAT LOSS (WATTS)=	0.14804E+01
TIME (MINUTES) =	4.0000	CONVECTION HEAT LOSS (WATTS)=	0.26094E+01	RADIATION HEAT LOSS (WATTS)=	0.17087E+01
TIME (MINUTES) =	4.5000	CONVECTION HEAT LOSS (WATTS)=	0.29274E+01	RADIATION HEAT LOSS (WATTS)=	0.19413E+01
TIME (MINUTES) =	5.0000	CONVECTION HEAT LOSS (WATTS)=	0.32436E+01	RADIATION HEAT LOSS (WATTS)=	0.21781E+01
TIME (MINUTES) =	5.5000	CONVECTION HEAT LOSS (WATTS)=	0.35580E+01	RADIATION HEAT LOSS (WATTS)=	0.24190E+01
TIME (MINUTES) =	6.0000	CONVECTION HEAT LOSS (WATTS)=	0.38704E+01	RADIATION HEAT LOSS (WATTS)=	0.26641E+01
TIME (MINUTES) =	6.5000	CONVECTION HEAT LOSS (WATTS)=	0.41811E+01	RADIATION HEAT LOSS (WATTS)=	0.29133E+01
TIME (MINUTES) =	7.0000	CONVECTION HEAT LOSS (WATTS)=	0.44898E+01	RADIATION HEAT LOSS (WATTS)=	0.31666E+01
TIME (MINUTES) =	7.5000	CONVECTION HEAT LOSS (WATTS)=	0.47976E+01	RADIATION HEAT LOSS (WATTS)=	0.34241E+01
TIME (MINUTES) =	8.0000	CONVECTION HEAT LOSS (WATTS)=	0.51017E+01	RADIATION HEAT LOSS (WATTS)=	0.36855E+01
TIME (MINUTES) =	8.5000	CONVECTION HEAT LOSS (WATTS)=	0.54048E+01	RADIATION HEAT LOSS (WATTS)=	0.39510E+01
TIME (MINUTES) =	9.0000	CONVECTION HEAT LOSS (WATTS)=	0.57060E+01	RADIATION HEAT LOSS (WATTS)=	0.42205E+01
TIME (MINUTES) =	9.5000	CONVECTION HEAT LOSS (WATTS)=	0.60052E+01	RADIATION HEAT LOSS (WATTS)=	0.44939E+01
TIME (MINUTES) =	10.0000	CONVECTION HEAT LOSS (WATTS)=	0.63026E+01	RADIATION HEAT LOSS (WATTS)=	0.47713E+01
TIME (MINUTES) =	10.5000	CONVECTION HEAT LOSS (WATTS)=	0.65981E+01	RADIATION HEAT LOSS (WATTS)=	0.50526E+01
TIME (MINUTES) =	11.0000	CONVECTION HEAT LOSS (WATTS)=	0.68916E+01	RADIATION HEAT LOSS (WATTS)=	0.53377E+01
TIME (MINUTES) =	11.5000	CONVECTION HEAT LOSS (WATTS)=	0.71832E+01	RADIATION HEAT LOSS (WATTS)=	0.56266E+01
TIME (MINUTES) =	12.0000	CONVECTION HEAT LOSS (WATTS)=	0.74729E+01	RADIATION HEAT LOSS (WATTS)=	0.59193E+01
TIME (MINUTES) =	12.5000	CONVECTION HEAT LOSS (WATTS)=	0.77606E+01	RADIATION HEAT LOSS (WATTS)=	0.62156E+01
TIME (MINUTES) =	13.0000	CONVECTION HEAT LOSS (WATTS)=	0.80464E+01	RADIATION HEAT LOSS (WATTS)=	0.65157E+01
TIME (MINUTES) =	13.5000	CONVECTION HEAT LOSS (WATTS)=	0.83302E+01	RADIATION HEAT LOSS (WATTS)=	0.68193E+01
TIME (MINUTES) =	14.0000	CONVECTION HEAT LOSS (WATTS)=	0.86120E+01	RADIATION HEAT LOSS (WATTS)=	0.71265E+01
TIME (MINUTES) =	14.5000	CONVECTION HEAT LOSS (WATTS)=	0.88919E+01	RADIATION HEAT LOSS (WATTS)=	0.74372E+01
TIME (MINUTES) =	15.0000	CONVECTION HEAT LOSS (WATTS)=	0.91698E+01	RADIATION HEAT LOSS (WATTS)=	0.77514E+01
TIME (MINUTES) =	15.5000	CONVECTION HEAT LOSS (WATTS)=	0.94458E+01	RADIATION HEAT LOSS (WATTS)=	0.80690E+01
TIME (MINUTES) =	16.0000	CONVECTION HEAT LOSS (WATTS)=	0.97197E+01	RADIATION HEAT LOSS (WATTS)=	0.83999E+01
TIME (MINUTES) =	16.5000	CONVECTION HEAT LOSS (WATTS)=	0.99917E+01	RADIATION HEAT LOSS (WATTS)=	0.87140E+01
TIME (MINUTES) =	17.0000	CONVECTION HEAT LOSS (WATTS)=	0.10262E+02	RADIATION HEAT LOSS (WATTS)=	0.90414E+01
TIME (MINUTES) =	17.5000	CONVECTION HEAT LOSS (WATTS)=	0.10530E+02	RADIATION HEAT LOSS (WATTS)=	0.93719E+01
TIME (MINUTES) =	18.0000	CONVECTION HEAT LOSS (WATTS)=	0.10796E+02	RADIATION HEAT LOSS (WATTS)=	0.97055E+01
TIME (MINUTES) =	18.5000	CONVECTION HEAT LOSS (WATTS)=	0.11060E+02	RADIATION HEAT LOSS (WATTS)=	0.10042E+02
TIME (MINUTES) =	19.0000	CONVECTION HEAT LOSS (WATTS)=	0.11322E+02	RADIATION HEAT LOSS (WATTS)=	0.10382E+02
TIME (MINUTES) =	19.5000	CONVECTION HEAT LOSS (WATTS)=	0.11582E+02	RADIATION HEAT LOSS (WATTS)=	0.10724E+02
TIME (MINUTES) =	20.0000	CONVECTION HEAT LOSS (WATTS)=	0.11840E+02	RADIATION HEAT LOSS (WATTS)=	0.11069E+02
TIME (MINUTES) =	20.5000	CONVECTION HEAT LOSS (WATTS)=	0.12096E+02	RADIATION HEAT LOSS (WATTS)=	0.11417E+02
TIME (MINUTES) =	21.0000	CONVECTION HEAT LOSS (WATTS)=	0.12350E+02	RADIATION HEAT LOSS (WATTS)=	0.11768E+02
TIME (MINUTES) =	21.5000	CONVECTION HEAT LOSS (WATTS)=	0.12601E+02	RADIATION HEAT LOSS (WATTS)=	0.12121E+02
TIME (MINUTES) =	22.0000	CONVECTION HEAT LOSS (WATTS)=	0.12851E+02	RADIATION HEAT LOSS (WATTS)=	0.12476E+02
TIME (MINUTES) =	22.5000	CONVECTION HEAT LOSS (WATTS)=	0.13099E+02	RADIATION HEAT LOSS (WATTS)=	0.12834E+02
TIME (MINUTES) =	23.0000	CONVECTION HEAT LOSS (WATTS)=	0.13345E+02	RADIATION HEAT LOSS (WATTS)=	0.13195E+02
TIME (MINUTES) =	23.5000	CONVECTION HEAT LOSS (WATTS)=	0.13589E+02	RADIATION HEAT LOSS (WATTS)=	0.13558E+02
TIME (MINUTES) =	24.0000	CONVECTION HEAT LOSS (WATTS)=	0.13831E+02	RADIATION HEAT LOSS (WATTS)=	0.13922E+02
TIME (MINUTES) =	24.5000	CONVECTION HEAT LOSS (WATTS)=	0.14071E+02	RADIATION HEAT LOSS (WATTS)=	0.14289E+02
TIME (MINUTES) =	25.0000	CONVECTION HEAT LOSS (WATTS)=	0.14308E+02	RADIATION HEAT LOSS (WATTS)=	0.14658E+02
TIME (MINUTES) =	25.5000	CONVECTION HEAT LOSS (WATTS)=	0.14544E+02	RADIATION HEAT LOSS (WATTS)=	0.15029E+02
TIME (MINUTES) =	26.0000	CONVECTION HEAT LOSS (WATTS)=	0.14778E+02	RADIATION HEAT LOSS (WATTS)=	0.15402E+02
TIME (MINUTES) =	26.5000	CONVECTION HEAT LOSS (WATTS)=	0.15010E+02	RADIATION HEAT LOSS (WATTS)=	0.15776E+02
TIME (MINUTES) =	27.0000	CONVECTION HEAT LOSS (WATTS)=	0.15239E+02	RADIATION HEAT LOSS (WATTS)=	0.16152E+02
TIME (MINUTES) =	27.5000	CONVECTION HEAT LOSS (WATTS)=	0.15467E+02	RADIATION HEAT LOSS (WATTS)=	0.16530E+02
TIME (MINUTES) =	28.0000	CONVECTION HEAT LOSS (WATTS)=	0.15693E+02	RADIATION HEAT LOSS (WATTS)=	0.16909E+02
TIME (MINUTES) =	28.5000	CONVECTION HEAT LOSS (WATTS)=	0.15916E+02	RADIATION HEAT LOSS (WATTS)=	0.17290E+02
TIME (MINUTES) =	29.0000	CONVECTION HEAT LOSS (WATTS)=	0.16138E+02	RADIATION HEAT LOSS (WATTS)=	0.17672E+02
TIME (MINUTES) =	29.5000	CONVECTION HEAT LOSS (WATTS)=	0.16358E+02	RADIATION HEAT LOSS (WATTS)=	0.18055E+02
TIME (MINUTES) =	30.0000	CONVECTION HEAT LOSS (WATTS)=	0.16575E+02	RADIATION HEAT LOSS (WATTS)=	0.18440E+02

Appendix D - NODMAP Output from Sample Problem

A QMAP OF INPUT BOUND MODE BLOCK 99 (INTERNAL 2)

THE PARAMETERS OF MODE BLOCK 99 ARE:

TEMPERATURE	=	100.000	(DEG.)
CAPACITANCE	=	1.00000	(ENERGY/DEG)
NET SOURCE/SINK	=	0.000000E+00	(ENERGY/TIME, INCLUDES TIES)
CAP./SUM OF COND.	=	4.73377	(TIME, INCLUDES TIES)

THE ADJOINING NODES TO MODE BLOCK 99 ARE:

MODE INPUT	(INTERNAL)	CONDUCTOR INPUT (INTERNAL)	TYPE	CONDUCTOR VALUE	% OF TYPE	% OF TOTAL	HEAT TRANSFER RATE (ENERGY/TIME)	TEMPERATURE OF ADJOINING NODE
BLOCK	1 (1)	2 (1)	LINEAR	0.100000	100.0	47.3	16.5753	265.753
BLOCK	1 (1)	1 (2)	RADIAT	5.000000E-03	100.0	52.7	18.4397	265.753

THE TOTALS ON MODE BLOCK 99 ARE:

LINEAR HEAT TRANSFER (CONDUCTION/CONVECTION)...	16.5753
RADIATION HEAT TRANSFER.....	18.4397
HEAT SOURCE/SINKS APPLIED.....	0.000000E+00
	35.0150
EFFECTIVE ERN TEMPERATURE.....	265.753 (ENERGY/TIME)

REPORT DOCUMENTATION PAGE

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