# CNS Type B Casks

# HAC Fire Analyses of the 8-120B and 10-160B Casks with Ruptured Impact Limiter Ends

Project Number: 12CV01.1001-01

**IDV: Not Required**

| | |
|---|---|
| Print Name | |
| Sign / Date | |

Contract Number: None

DRCM reference: None

| REV. | DATE | REVISION STATUS | ORIGINATOR | CHECKER | APPROVER |
|---|---|---|---|---|---|
| 0 | | Original Issue | M. Baig | C. Hendrix | J.D. Sohl |
| 1 | 5/23/12 | Revised to Calculate the Average Bulk-Air Temperature | M. Baig | C. Hendrix | M. Baig |
| | | | | | |

# HISTORY SHEET

| Rev | Reason for revision | Originator |
|---|---|---|
| 0 | Initial Issue | Mirza Baig |
| 1 | Revised to calculate the average bulk-air temperature. | Mirza Baig |

# Calculation Summary and Control Sheet

**Quality Level / Category:** ☒ **QL-1** ☐ **QL-2** ☐ **QL-3** ☐ **QL-4**

| | |
|---|---|
| **Calculation results rely on a COMPUTER PROGRAM:**<br>☒ Yes ☐ No<br>If "Yes," complete Verification and Validation Information section | **Verification and Validation Information**<br>Program Used: ANSYS<br>Revision: 13.0<br>Desktop Computer tag #: 28254-D<br>V&V report (number and rev): SW-072 Rev.1 & SW-073 Rev.1 |
| **Results generated using a SOFTWARE TOOL are reported and checked by hand for applications that are not validated and verified:**<br>☐ Yes ☒ No<br>("No" to be checked only if a software tool is not used) | **Note: All calculations, including those generated using a software tool, shall be hand checked unless a computer program was used to perform the calculation AND proper documentation exists confirming that the computer program has been verified and validated in accordance with ES-QA-PR-019, Computer Software Management, and that modeling conditions are within the scope of the verification and validation of the program.** |
| **Calculation contains Unverified Assumptions:**<br>☐ Yes ☒ No | **Note: If calculation contains unverified assumptions identify them in the box below.** |

**Identify and Number Unverified Assumptions:**

None

**Identify Design Inputs (may reference appropriate calculation section):**

Energy*Solutions* Document TH-028.

**Results and Conclusions:**

The average bulk air temperature in the 8-120B cask with punctured lower end of the impact limiter is calculated to be 266°F.

## TABLE OF CONTENTS

1. INTRODUCTION AND SCOPE ..... 6
2. ASSUMPTIONS ..... 6
3. INPUTS ..... 7
4. CALCULATION METHODOLOGY ..... 7
5. CALCULATIONS ..... 7
6. RESULTS AND CONCLUSIONS ..... 8
7. ELECTRONIC FILES ..... 8
8. REFERENCES ..... 10

## LIST OF FIGURES

Figure 1 – 8-120B Cask with the Impact Limiter ..... Fig.1

Figure 2 – 8-120B Cask Temperature Profile at the Time When the Secondary Lid Seals Attain the Peak Temperature ..... Fig.2

Figure 3 – 8-120B Cask Secondary Lid Seal's Temperature Time-History Plot ..... Fig.3

Figure 4 – 8-120B Cask with Damaged Bottom Impact Limiter Cover – Temperature Profile at the End of the Fire..... Fig.4

Figure 5 – 8-120B Cask Baseplate Inside and Outside Temperature Time-History Plot ..... Fig.5

Figure 6 – 8-120B Cask Temperature Profile at the Time When the Secondary lid Seals Attain the Peak Temperature ..... Fig.6

Figure 7 – 8-120B Cask Secondary Lid Seal's Temperature Time-History Plot ..... Fig.7

## 1. INTRODUCTION AND SCOPE

The finite element model analyses of the 8-120B Cask for the hypothetical fire test, performed in the N.R.C. approved Safety Analysis Report (SAR) (Reference 1), uses thermally insulated boundary conditions on the surfaces that are covered by the impact limiters. During the RSI (Request for Supplemental Information) response to the N.R.C. for the renewal of the Certificate of Compliance (CofC) application, it was noticed that the SAR did not address the scenario in which the puncture bar makes contact with the package at the top or bottom central location. At these locations the impact limiters contain a void, which is covered by sheet-metal (see Figure 1). In a puncture bar drop test scenario if the package is dropped at these locations, the sheet metal may rupture. In the subsequent fire test the outside surface of the secondary lid that has been ruptured during the puncture drop test, will be exposed to the fire after a top end drop scenario. In the bottom end drop scenario the portion of the baseplate will be exposed to the fire. Since the temperatures of the secondary lid seals and that of the cask cavity are a concern in these scenarios, thermal evaluations of the package is performed in this document to obtain these temperatures.

The finite element model described in Energy*Solutions* document TH-028 (Reference 2), which was used as a reference document for the CofC renewal, is utilized in the analyses of this document.

Based on the results of the analyses presented in Section 6 of this report it is concluded that, with the conservative assumptions on the heat transfer mode, the secondary lid seal's temperature could reach 581.2°F. This temperature will exceed the seal material temperature limit of 450°F specified in the currently approved SAR, and 235°F proposed in the CofC renewal application (Reference 2). The maximum cask cavity temperature is calculated to be approximately 500°F.

The 10-160B casks also use similar impact limiter and secondary lid seal design. In fact, the 10-160B cask's seals are located on a more vulnerable position than the 8-120B casks. The N.R.C. approved SAR of this cask also did not address the rupture of the impact limiter's ends after the puncture drop tests. Therefore, it is concluded that the 10-160B cask seals temperature will also exceed the maximum working limit of the material.

## 2. ASSUMPTIONS

The assumptions mentioned in Reference 2 have been followed throughout in the analyses performed in this document. In addition, the following assumptions are also made.

1. The heat transfer between the primary and secondary lid by conduction through the

bolts have been neglected. This assumption is conservative for the evaluation of the secondary lid seal's temperature because it eliminates the heat flow through this path. This in turn increases the heat flow towards the secondary lid seals.

2. The heat transfer by radiation between the secondary and primary lid surfaces facing each other has been neglected. As described in 1 above, this is conservative due to eliminating the heat flow away from the secondary lid seals.
3. The secondary lid comprises of two circular plates that are welded only along the circumference. The unwelded interface between the two plates has been examined in two extreme conditions – (1) when they are totally connected, and (2) they are totally disconnected. The larger of the two temperatures is reported as the seal's temperature during the fire event.

## 3. INPUTS

The dimensional and design input are listed in Reference 2.

## 4. CALCULATION METHODOLOGY

The methodology used in the finite element modeling of the cask is described in detail in Reference 2.

## 5. CALCULATIONS

The finite element model described in Reference 2 was modified to include the boundary conditions corresponding to the puncture drop test damage to the package. It was solved for three conditions listed below.

a. Undamaged impact limiter – This case corresponds to the original analysis of Reference 2. It is referred to as the SAR Analysis.
b. Damaged Lower Impact Limiter Skin – The sheet-metal covering of the hollow portion of the lower impact limiter is assumed to be totally ruptured. The exposed portion of the outside surface of the baseplate is subjected to the same boundary conditions during the entire thermal transient (fire and cool-down) as the fire-shield on the body of the cask.
c. Damaged Upper Impact Limiter Skin – The sheet-metal covering of the hollow portion of the upper impact limiter is assumed to be totally ruptured. The exposed portion of the outside surface of the secondary lid is subjected to the same boundary conditions during the entire thermal transient (fire and cool-down) as the fire-shield on the body of the cask.

ANSYS Version 13.0 (Reference 3) was used to construct and analyze the finite element models used in the analyses presented in this document. The printout of the finite

element model data for the undamaged impact limiter scenario is included in Appendix 1. The temperature time-history data of the secondary lid seals for the damaged upper impact limiter skin scenario is included in Appendix 2.

All the data files used in the analyses presented in this document are included on a media disk in Appendix 3.

## 6. RESULTS AND CONCLUSIONS

Figure 2 shows the temperature profile in the cask under the conditions addressed in the SAR at the time when the secondary lid seals attain the maximum temperature. Figure 3 is the maximum temperature attained by the seals under this scenario. The maximum temperature attained by the secondary lid seals is less than 210°F.

With the assumption that the bottom end impact limiter skin is ruptured during the puncture drop, the temperature profile in the cask, at the end of the 30 minute fire is shown in Figure 4. Figure 5 shows the temperature time-history plot of the inside and outside surfaces of the baseplate. The bulk air temperature is volume-averaged for every load step. The maximum average temperature of the bulk air is calculated to be 266°F (see Appendix 2).

With the assumption that the top end impact limiter skin is ruptured during the puncture drop, the temperature profile in the cask at the time when the seal's temperature reaches a peak value is shown in Figure 6. Figure 7 shows the time-history plot of the seal's temperature during the HAC fire event. The maximum temperature attained by the secondary lid seals during this test is 581.2°F (see Figure 7 and Appendix 2).

The secondary lid seal's temperature predicted by the analyses in this document 581.2°F exceeds the 450°F specified in the currently approved SAR (Reference 1) and 235°F specified in the CofC application renewal (Reference 2).

The maximum cask cavity temperature is calculated to be 495°F (see Figure 5).

## 7. ELECTRONIC FILES

Below is the directory of the files used in the analyses presented in this document. The electronic files are included on a media disk in Appendix 3.

```
 Volume in drive E is TH-0001 Rev.1
 Volume Serial Number is A8E9-334E

 Directory of E:\

05/23/2012  01:26 PM    <DIR>          Bottom End Impact Limiter Skin
Damaged
```

```
               0 File(s)              0 bytes

 Directory of E:\Bottom End Impact Limiter Skin Damaged

05/23/2012  01:26 PM    <DIR>          .
05/23/2012  01:39 PM    <DIR>          ..
04/27/2012  06:24 PM    <DIR>          TH-0001
               0 File(s)              0 bytes

 Directory of E:\Bottom End Impact Limiter Skin Damaged\TH-0001

04/27/2012  06:24 PM    <DIR>          .
05/23/2012  01:26 PM    <DIR>          ..
05/23/2012  01:26 PM    <DIR>          Bottom End Impact Limiter Skin
Damaged
04/27/2012  06:24 PM    <DIR>          Top End Impact Limiter Skin
Damaged
04/27/2012  06:25 PM    <DIR>          Undamaged Impact Limiter
               0 File(s)              0 bytes

 Directory of E:\Bottom End Impact Limiter Skin Damaged\TH-0001\Bottom
End Impact Limiter Skin Damaged

05/23/2012  01:26 PM    <DIR>          .
04/27/2012  06:24 PM    <DIR>          ..
05/23/2012  11:12 AM             1,211 AirTemp.in
05/23/2012  01:26 PM             6,633 AirTemp.out
10/31/2011  01:16 PM            65,536 annulus-sub.sub
10/31/2011  04:06 PM           131,072 cavity-sub.sub
04/24/2012  11:49 AM         5,308,416 file.db
03/14/2012  03:06 PM            24,586 file000.png
04/25/2012  01:49 PM           179,481 model.out
               7 File(s)      5,716,935 bytes

 Directory of E:\Bottom End Impact Limiter Skin Damaged\TH-0001\Top End
Impact Limiter Skin Damaged

04/27/2012  06:24 PM    <DIR>          .
04/27/2012  06:24 PM    <DIR>          ..
10/31/2011  01:16 PM            65,536 annulus-sub.sub
04/24/2012  12:05 PM         4,325,376 file.db
03/19/2012  09:15 AM       106,692,608 file.rth
03/20/2012  05:17 PM            21,488 file000.png
04/24/2012  12:04 PM            26,944 file002.png
04/25/2012  01:50 PM           130,380 model.out
03/19/2012  09:20 AM            12,451 Seal Temp.lis
               7 File(s)    111,274,783 bytes

 Directory of E:\Bottom End Impact Limiter Skin Damaged\TH-
0001\Undamaged Impact Limiter

04/27/2012  06:25 PM    <DIR>          .
04/27/2012  06:24 PM    <DIR>          ..
10/31/2011  01:16 PM            65,536 annulus-sub.sub
10/31/2011  01:16 PM            59,964 ansub.out
```

```
10/31/2011  04:06 PM           131,072 cavity-sub.sub
10/31/2011  04:06 PM           337,229 cavsub.out
04/25/2012  01:19 PM         4,390,912 file.db
03/16/2012  11:59 AM        98,631,680 file.rth
03/14/2012  03:37 PM            22,566 file000.png
03/14/2012  03:47 PM            27,818 file002.png
04/25/2012  01:18 PM           149,534 model.out
               9 File(s)    103,816,311 bytes

     Total Files Listed:
              23 File(s)    220,808,029 bytes
              15 Dir(s)               0 bytes free
```

## 8. REFERENCES

1. Safety Analysis Report for Model 8-120B Type B Shipping Packaging, Revision 7, January 2010.
2. Energy*Solutions* Document TH-028, Revision 2, Fire Transient Analyses of the 8-120B Cask Using Finite Element Models.
3. ANSYS Version 13.0, ANSYS Inc., Canonsburg, PA, 2010.

Figures

(7 pages)

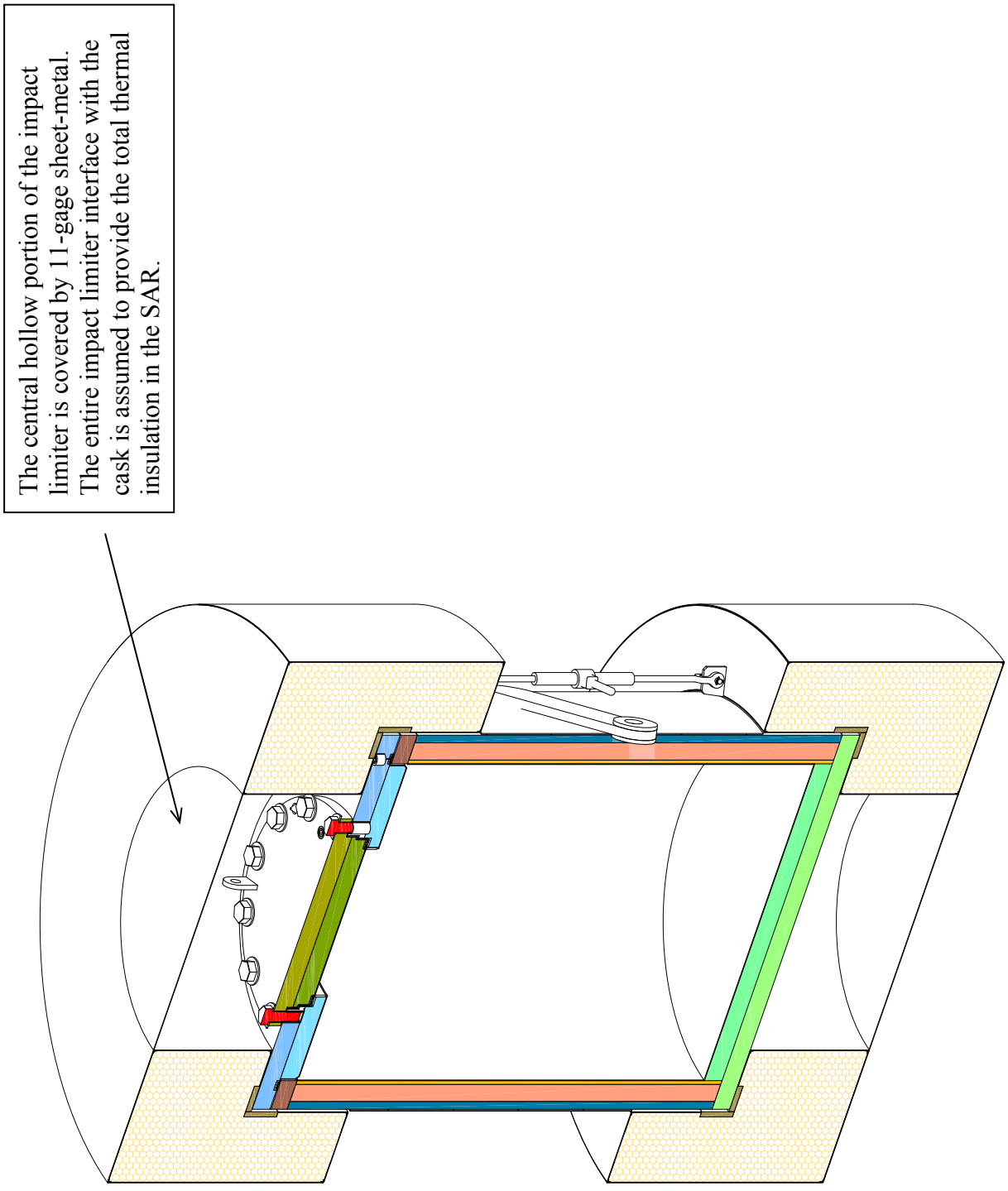


Figure 1 – 8-120B Cask with the Impact Limiter

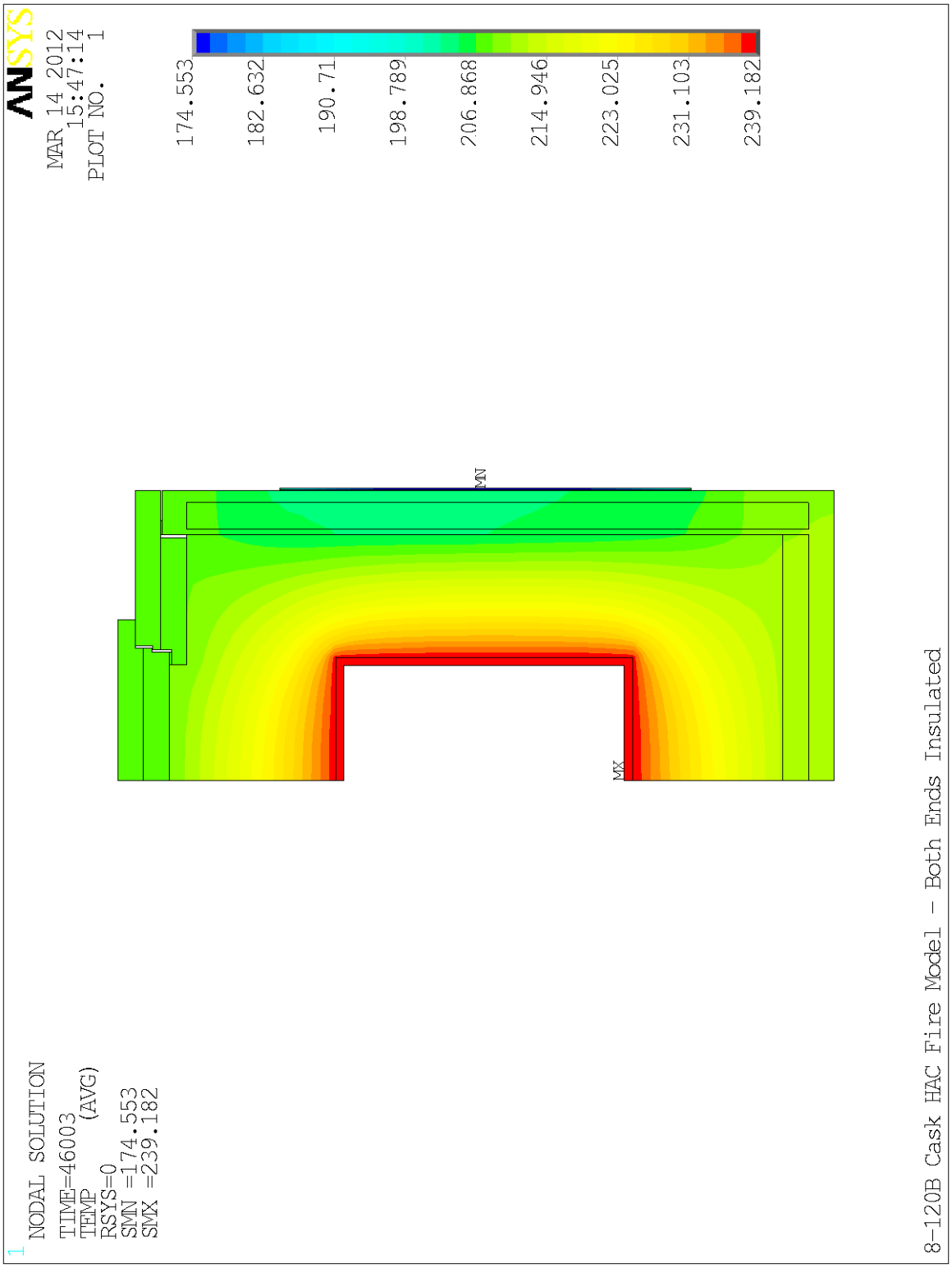


Figure 2 – 8-120B Cask Temperature Profile at the Time When the Secondary Lid Seals Attain the Peak Temperature (SAR Analysis)

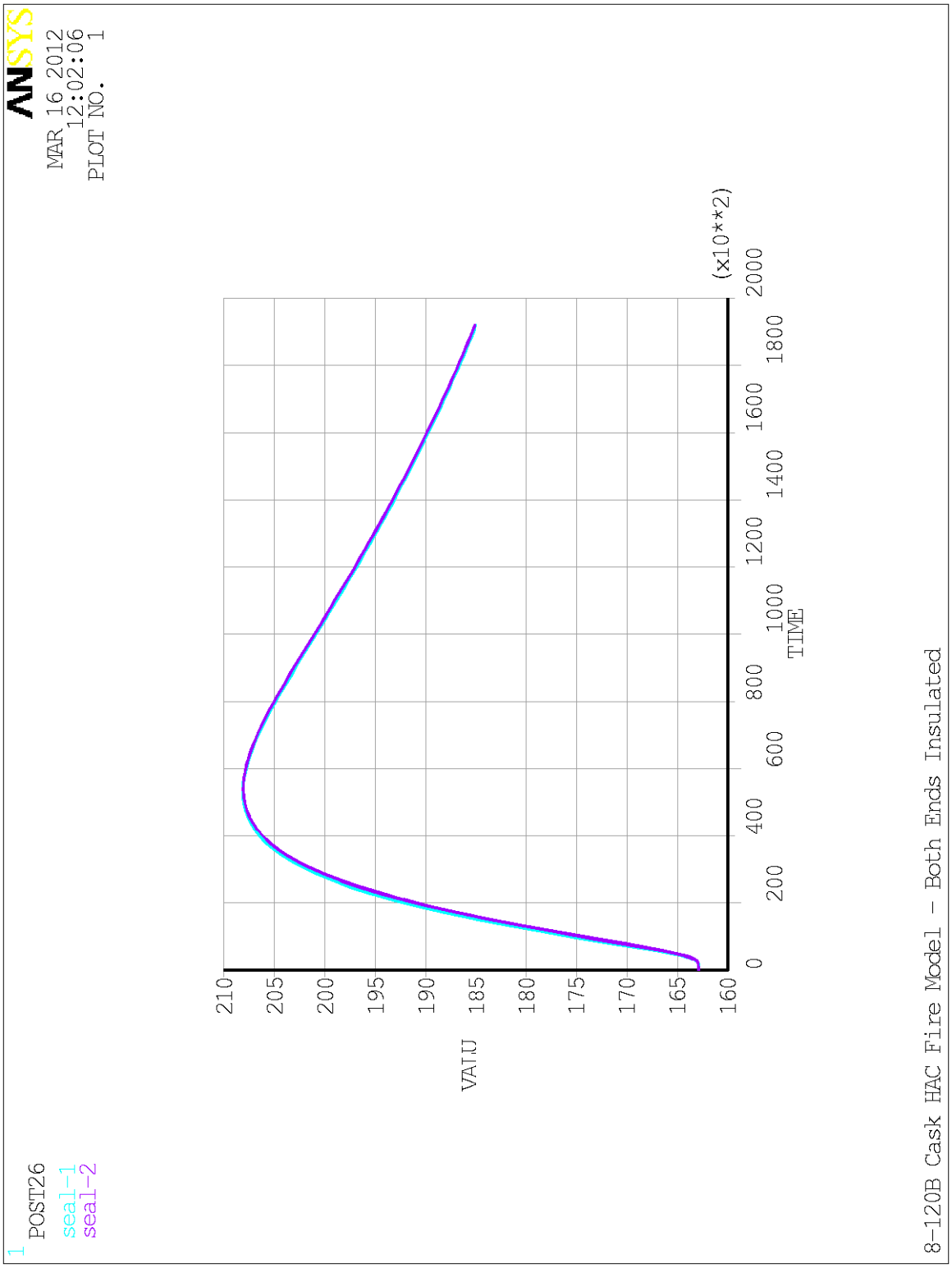


Figure 3 – 8-120B Cask Secondary Lid Seal's Temperature Time-History Plot
(SAR Analysis)

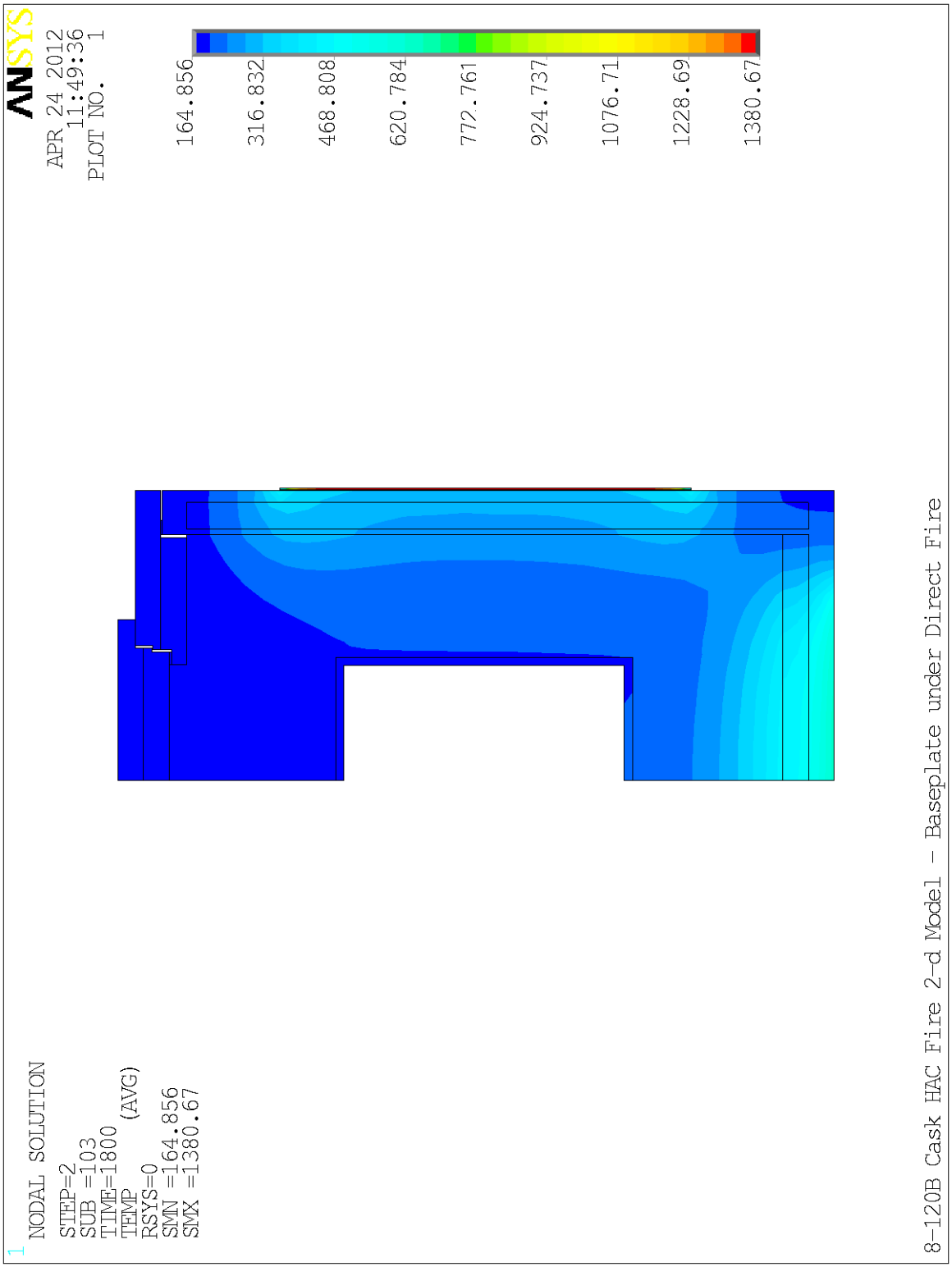


Figure 4 – 8-120B Cask with Damaged Bottom Impact Limiter Cover – Temperature Profile at the End of the Fire

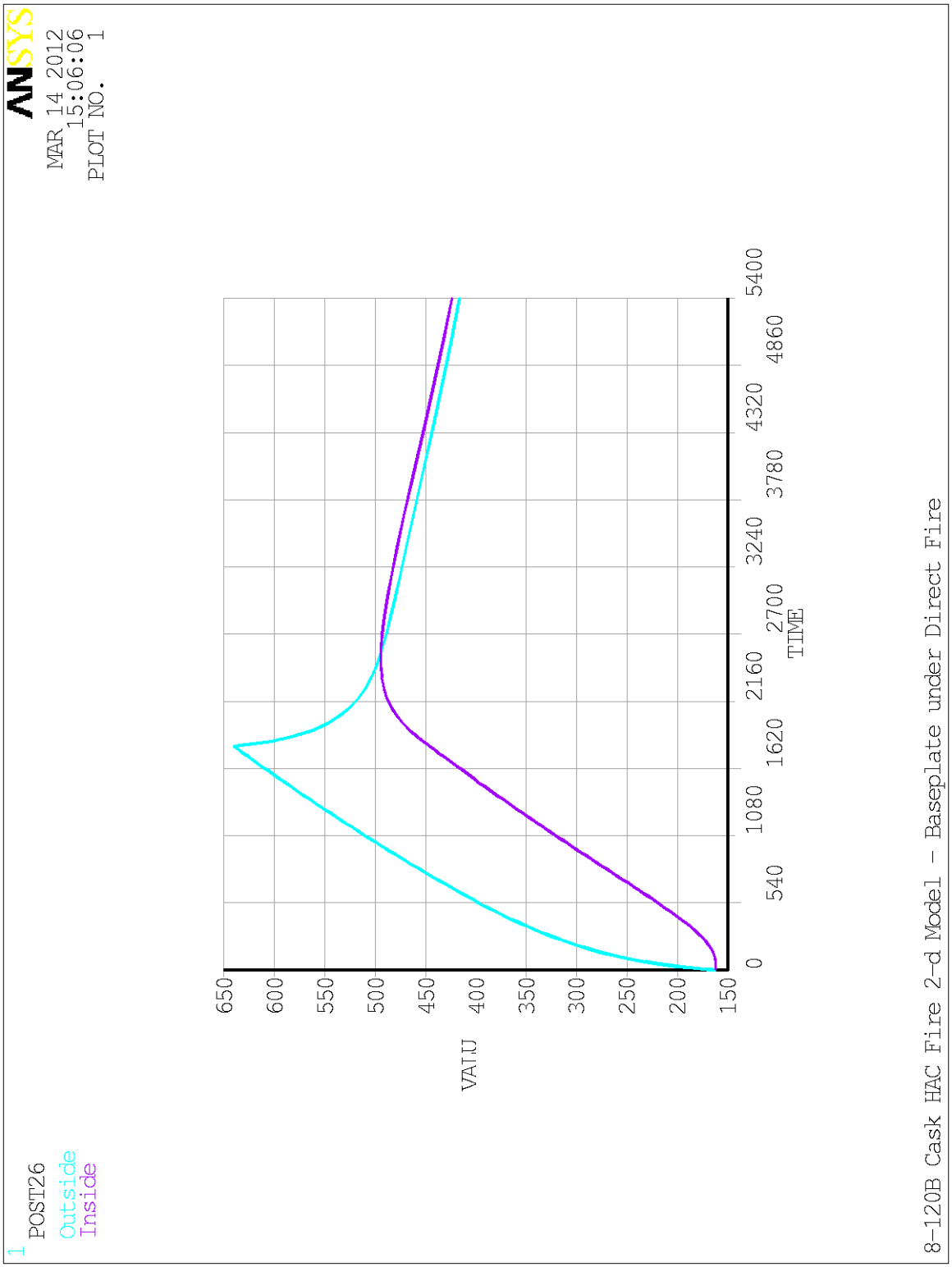


Figure 5 – 8-120B Cask Baseplate Inside and Outside Temperature Time-History Plot

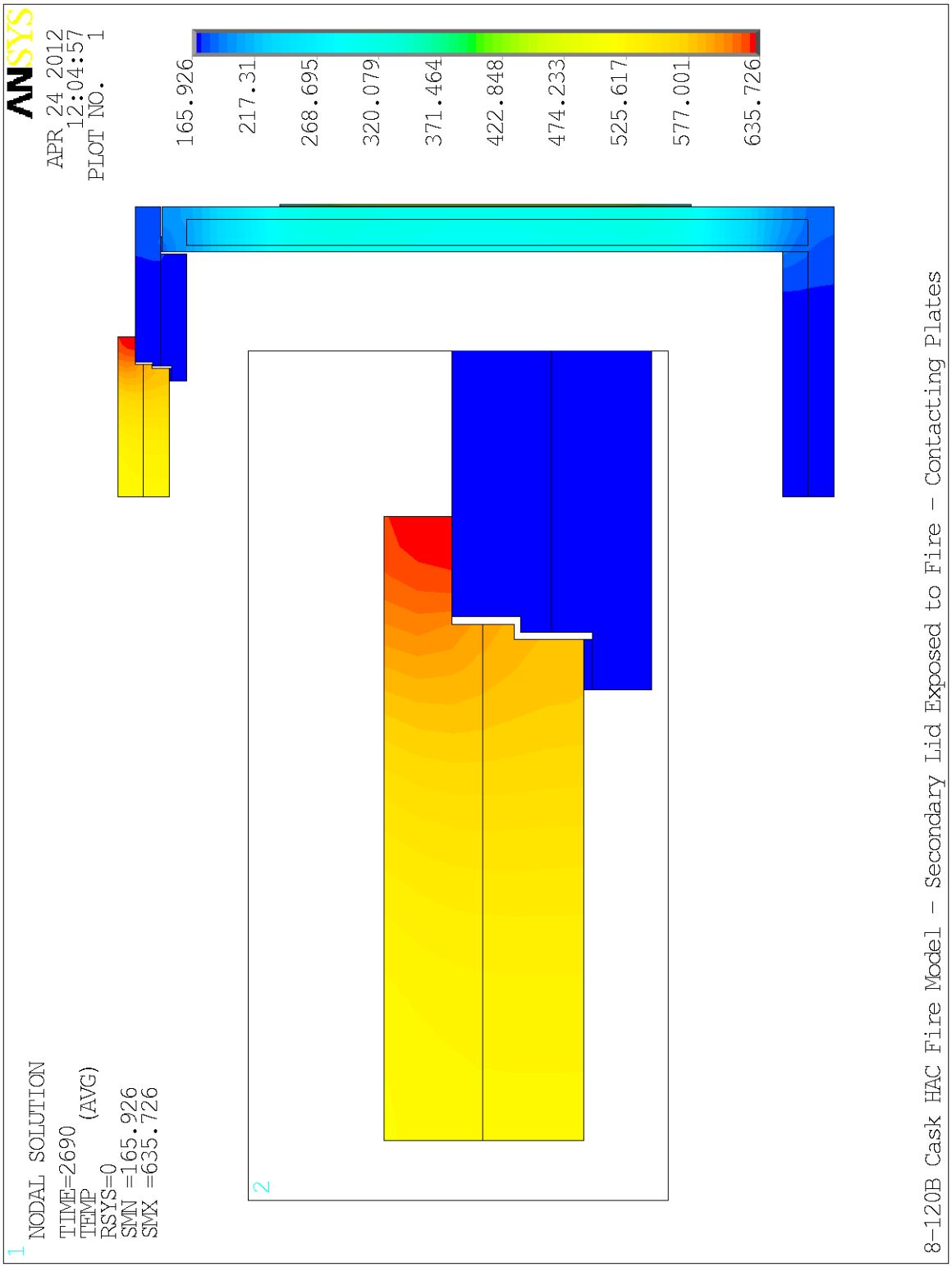


Figure 6 – 8-120B Cask Temperature Profile at the Time When the Secondary Lid Seals Attain the Peak Temperature Damaged Upper Impact Limiter Skin

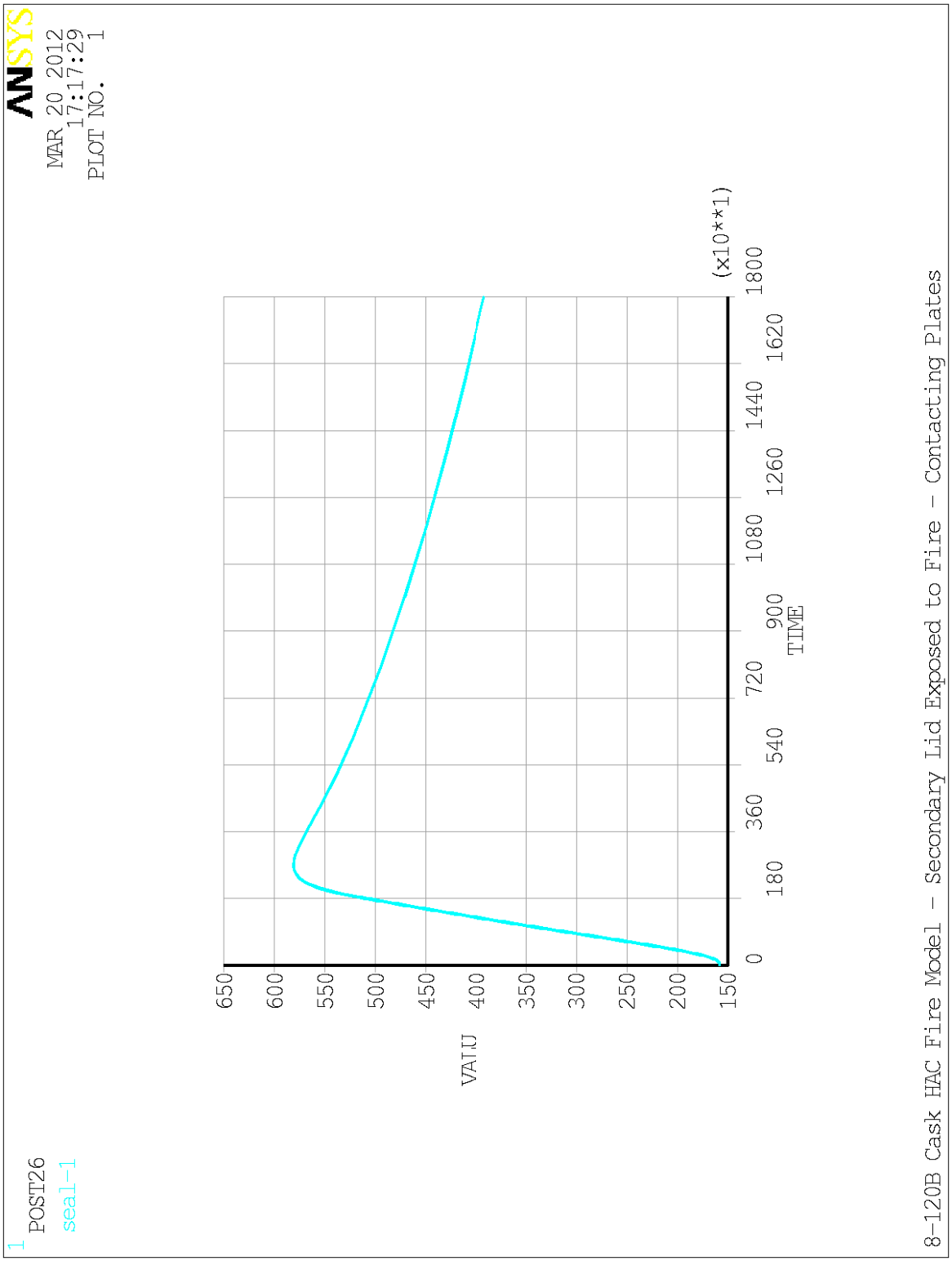


Figure 7 – 8-120B Cask Secondary Lid Seal's Temperature Time-History Plot

Damaged Upper Impact Limiter Skin

Appendix 1

FEM Data Print-Out

(18 Pages)

## ANSYS Finite Element Model Print-Out

```
                          G L O B A L   S T A T U S

 ANSYS - Engineering Analysis System           Apr 25, 2012          13:18
 Release 13.0                 00222442                 WINDOWS x64  Version

 Current working directory: D:\ANSYS Analyses\8-120B Fire After Puncture Drop\Both
Ends Insulated


 MENULIST File: C:\Program Files\ANSYS Inc\v130\ANSYS\gui\en-us\UIDL\menulist130.ans

 Product(s) enabled: ANSYS Mechanical


 Total connect time. . . . .   0 hours  1 minutes
 Total CP usage. . . . . . .   0 hours  0 minutes  2.1 seconds

 J O B   I N F O R M A T I O N ------------------------------------------------

8-120B Cask HAC Fire Model - Both Ends Insulated

 Current jobname . . . . . .file
 Initial jobname . . . . . .file

 Units . . . . . .unknown

                                Available              Used
 Scratch Memory Space. . . .    9600.000 mb         517.787 mb (  5.4%)
 Database space  . . . . . .   65535.750 mb           2.173 mb (  0.0%)

 User menu file in use . . .%ANSYS130_DIR%\gui\en-us\UIDL\UIMENU.GRN
 User menu file in use . . .%ANSYS130_DIR%\gui\en-us\UIDL\UIFUNC1.GRN
 User menu file in use . . .%ANSYS130_DIR%\gui\en-us\UIDL\UIFUNC2.GRN
 User menu file in use . . .%ANSYS130_DIR%\gui\en-us\UIDL\MECHTOOL.AUI
 Beta features . . . . . .are not shown in the user interface

 M O D E L   I N F O R M A T I O N --------------------------------------------

 Solid model summary:

                             Largest         Number        Number
                              Number        Defined      Selected
 Keypoints . . . . . .          85            83             0
 Lines . . . . . .             115           113             0
 Areas . . . . . .              37            37             0
 Volumes . . . . . .             0             0             0

 Finite element model summary:

                             Largest         Number        Number
                              Number        Defined      Selected
 Nodes . . . . . .            2002           633           633
 Elements. . . . . .         1465           696           696

 Element types . . . . . .      69            48          n.a.
 Real constant sets. . . . .    61            25          n.a.
 Material property sets. . .    14            10          n.a.
```

```
Coupling. . . . . .        2              2          n.a.
Constraint equations. . . .        0              0          n.a.
Master DOFs . . . . . .        0              0          n.a.
Dynamic gap conditions. . .        0              0          n.a.

B O U N D A R Y   C O N D I T I O N   I N F O R M A T I O N ------------------

                                      Number
                                     Defined
Constraints on nodes. . . . . .          4
Constraints on keypoints. . . . . .          0
Constraints on lines. . . . . .          0
Constraints on areas. . . . . .          0

Forces on nodes . . . . . .          0
Forces on keypoints . . . . . .          0

Surface loads on elements . . . . . .        126
Number of element flagged surfaces  . . .          0
Surface loads on lines. . . . . .          0
Surface loads on areas. . . . . .          0

Body loads on elements. . . . . .          0
Body loads on areas . . . . . .          0
Body loads on lines . . . . . .          0
Body loads on nodes . . . . . .          0
Body loads on keypoints . . . . . .          0

Temperatures
   Uniform temperature. . . . . .      70.000
   Offset from absolute scale . . . . . .     460.000

                                          X            Y            Z
Linear acceleration . . . . . .    0.0000       0.0000       0.0000
Angular velocity (about global CS). . . .    0.0000       0.0000       0.0000
Angular acceleration (about global CS). .    0.0000       0.0000       0.0000
Location of reference CS. . . . . .    0.0000       0.0000       0.0000
Angular velocity (about reference CS) . .    0.0000       0.0000       0.0000
Angular acceleration (about reference CS)    0.0000       0.0000       0.0000

R O U T I N E   I N F O R M A T I O N ----------------------------------------

Current routine. . . . . .Preprocessing (PREP7)

Active coordinate system . . . . . .   0 (Cartesian)

Display coordinate system. . . . . .   0 (Cartesian)

Current element attributes:
   Type number . . . . . .    69  (CONTA172)
   Real number . . . . . .    61
   Material number . . . . . .     1
   Element coordinate system number. .     0

Current mesher type. . . . . .free mesher

Current element meshing shape 2D . . .use default element shape.

Current element meshing shape 3D . . .use default element shape.

SmrtSize Level  . . . . . . OFF
```

```
Global element size. . . . . .     0 divisions per line

Active coordinate system . . . . . .   0 (Cartesian)

Display coordinate system. . . . . .   0 (Cartesian)

Analysis type. . . . . .Transient

Active options for this analysis type:
   Solution method . . . . . .Full
   Equation solver to use. . . . . .Sparse

Results file . . . . . .file.rth

Load step number . . . . . .     5

Number of substeps:
   Starting number of substeps . . . .  40000
   Maximum number of substeps. . . . .  40000
   Minimum number of substeps. . . . .    100
   Step change boundary conditions . .Yes


                        Analysis Options


   New, Restart, or Expansion Pass:  NEW ANALYSIS
  Discipline (based on active DOF):  THERMAL
                      Analysis type:  TRANSIENT
                    Analysis method:  FULL


               Newton-Raphson option     PROGRAM CHOOSES
     Newton-Raphson adaptive descent     DO NOT USE ADAPT DESCENT

        Equation solver to be used  SPARSE DIRECT SOLVER

Difference (in degrees) between absolute zero and
   the temperature system being used   460.00

LIST ELEMENT TYPES FROM      1 TO     69 BY      1

ELEMENT TYPE      1 IS PLANE55      AXI. THERMAL SOLID
 KEYOPT( 1- 6)=        0      0      1        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE      2 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE      3 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        2      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE      4 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
```

```
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE      5 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      0       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE      6 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE      7 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        2      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE      8 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE      9 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     10 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     11 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     12 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     13 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     14 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     15 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     16 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0
```

```
ELEMENT TYPE     17 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      0      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     18 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     19 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     20 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     21 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     22 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     23 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     24 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     25 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     26 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     27 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     28 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0
```

```
ELEMENT TYPE     29 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     49 IS LINK33       3-D CONDUCTION BAR
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     50 IS MATRIX50     SUPERELEMENT (SUBSTRUCTURE)
 KEYOPT( 1- 6)=        1      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     51 IS SURF151      2-D THERMAL SURFACE
 KEYOPT( 1- 6)=        0      0       1        1      1      0
 KEYOPT( 7-12)=        1      4       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     52 IS SURF151      2-D THERMAL SURFACE
 KEYOPT( 1- 6)=        0      0       1        1      1      0
 KEYOPT( 7-12)=        0      0       1        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     53 IS SURF151      2-D THERMAL SURFACE
 KEYOPT( 1- 6)=        0      0       1        1      1      0
 KEYOPT( 7-12)=        0      4       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     54 IS SURF151      2-D THERMAL SURFACE
 KEYOPT( 1- 6)=        0      0       1        1      1      0
 KEYOPT( 7-12)=        0      0       1        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     55 IS SURF151      2-D THERMAL SURFACE
 KEYOPT( 1- 6)=        0      0       1        1      0      0
 KEYOPT( 7-12)=        0      1       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     56 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     57 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      0       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     58 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0       0        0      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      0
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     59 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      0       0        2      0      0
 KEYOPT( 7-12)=        0      0       0        0      0      5
 KEYOPT(13-18)=        0      0       0        0      0      0

ELEMENT TYPE     60 IS TARGE169     2-D TARGET SEGMENT
```

```
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     61 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      0      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     62 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     63 IS CONTA171     2D 2-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      0      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     66 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     67 IS CONTA172     2D 3-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        2      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     68 IS TARGE169     2-D TARGET SEGMENT
 KEYOPT( 1- 6)=        0      0      0        0      0      0
 KEYOPT( 7-12)=        0      0      0        0      0      0
 KEYOPT(13-18)=        0      0      0        0      0      0

ELEMENT TYPE     69 IS CONTA172     2D 3-NODE THERMAL CONTACT
 KEYOPT( 1- 6)=        2      2      0        2      0      0
 KEYOPT( 7-12)=        0      0      0        2      0      5
 KEYOPT(13-18)=        0      0      0        0      0      0

CURRENT NODAL DOF SET IS  TEMP
 THREE-DIMENSIONAL MODEL

LIST REAL SETS       1 TO      61 BY       1

REAL CONSTANT SET       3  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       3  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21   0.0000       1.0000       0.0000

REAL CONSTANT SET       3  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000      0.50000

REAL CONSTANT SET       3  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET       4  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       4  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21   0.0000       1.0000       0.0000
```

```
REAL CONSTANT SET       4  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET       4  ITEMS  19 TO  24
   0.0000       0.0000       1.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET       5  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       5  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET       5  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET       5  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET       6  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       6  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET       6  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET       6  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET       7  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       7  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET       7  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET       7  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET       8  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       8  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET       8  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET       8  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET       9  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET       9  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000
```

```
REAL CONSTANT SET       9  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET       9  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      10  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      10  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      10  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      10  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      11  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      11  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET      11  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET      11  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      12  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      12  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET      12  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET      12  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      13  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      13  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET      13  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET      13  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      14  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      14  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET      14  ITEMS  13 TO  18
```

```
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET      14  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      15  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      15  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21   0.0000       1.0000       0.0000

REAL CONSTANT SET      15  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000       0.50000

REAL CONSTANT SET      15  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      16  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      16  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      16  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      16  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      51  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      51  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      51  ITEMS  13 TO  18
  0.33330       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      52  ITEMS   1 TO   6
   1.0000      0.33056E-14   0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      52  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      52  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      53  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      53  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      53  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      54  ITEMS   1 TO   6
   1.0000      0.33056E-14   0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      54  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
```

```
REAL CONSTANT SET      54  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      55  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      55  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      55  ITEMS  13 TO  18
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      55  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      56  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      56  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      56  ITEMS  13 TO  18
   0.0000       1.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      56  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      57  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      57  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      57  ITEMS  13 TO  18
   0.0000       1.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      57  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      58  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      58  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      58  ITEMS  13 TO  18
   0.0000       1.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      58  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      59  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      59  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET      59  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000      0.50000
```

```
REAL CONSTANT SET      59  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

REAL CONSTANT SET      60  ITEMS   1 TO   6
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      60  ITEMS   7 TO  12
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      60  ITEMS  13 TO  18
   0.0000       1.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      60  ITEMS  19 TO  24
   0.0000       0.0000       0.0000       0.0000       0.0000       0.0000

REAL CONSTANT SET      61  ITEMS   1 TO   6
   0.0000       0.0000       1.0000      0.10000       0.0000       0.0000

REAL CONSTANT SET      61  ITEMS   7 TO  12
   0.0000       0.0000     0.10000E+21    0.0000       1.0000       0.0000

REAL CONSTANT SET      61  ITEMS  13 TO  18
   0.0000       0.0000       1.0000       0.0000       1.0000      0.50000

REAL CONSTANT SET      61  ITEMS  19 TO  24
   0.0000       1.0000       1.0000       0.0000       0.0000       1.0000

LIST MATERIALS       1 TO      14 BY       1
 PROPERTY= ALL

MATERIAL NUMBER       1

     TEMP         DENS
    70.000      0.28180
    100.00      0.28180
    150.00      0.28180
    200.00      0.28180
    250.00      0.28180
    300.00      0.28180
    350.00      0.28180
    400.00      0.28180
    450.00      0.28180
    500.00      0.28180
    550.00      0.28180
    600.00      0.28180
    650.00      0.28180
    700.00      0.28180
    750.00      0.28180
    800.00      0.28180
    900.00      0.28180
    1000.0      0.28180
    1100.0      0.28180
    1200.0      0.28180
    1300.0      0.28180
    1400.0      0.28180
    1500.0      0.28180

     TEMP         MU
                0.000000

     TEMP         KXX
```

| | |
|---|---|
| 70.000 | 0.81300E-03 |
| 100.00 | 0.80300E-03 |
| 150.00 | 0.78900E-03 |
| 200.00 | 0.77800E-03 |
| 250.00 | 0.76200E-03 |
| 300.00 | 0.74800E-03 |
| 350.00 | 0.73100E-03 |
| 400.00 | 0.71500E-03 |
| 450.00 | 0.70100E-03 |
| 500.00 | 0.68300E-03 |
| 550.00 | 0.66700E-03 |
| 600.00 | 0.64800E-03 |
| 650.00 | 0.63200E-03 |
| 700.00 | 0.61600E-03 |
| 750.00 | 0.60000E-03 |
| 800.00 | 0.58300E-03 |
| 900.00 | 0.55100E-03 |
| 1000.0 | 0.51900E-03 |
| 1100.0 | 0.48400E-03 |
| 1200.0 | 0.45100E-03 |
| 1300.0 | 0.41700E-03 |
| 1400.0 | 0.38000E-03 |
| 1500.0 | 0.36300E-03 |

| TEMP | C |
|---|---|
| 70.000 | 0.10400 |
| 100.00 | 0.10600 |
| 150.00 | 0.10900 |
| 200.00 | 0.11300 |
| 250.00 | 0.11500 |
| 300.00 | 0.11800 |
| 350.00 | 0.12200 |
| 400.00 | 0.12400 |
| 450.00 | 0.12600 |
| 500.00 | 0.12800 |
| 550.00 | 0.13100 |
| 600.00 | 0.13300 |
| 650.00 | 0.13500 |
| 700.00 | 0.13900 |
| 750.00 | 0.14200 |
| 800.00 | 0.14600 |
| 900.00 | 0.15400 |
| 1000.0 | 0.16300 |
| 1100.0 | 0.17200 |
| 1200.0 | 0.18400 |
| 1300.0 | 0.20500 |
| 1400.0 | 0.41100 |
| 1500.0 | 0.19900 |

| TEMP | EMIS |
|---|---|
| | 0.000000 |

MATERIAL NUMBER 2

| TEMP | DENS |
|---|---|
| 70.000 | 0.28240 |
| 100.00 | 0.28240 |
| 150.00 | 0.28240 |
| 200.00 | 0.28240 |
| 250.00 | 0.28240 |
| 300.00 | 0.28240 |

| | |
|---|---|
| 350.00 | 0.28240 |
| 400.00 | 0.28240 |
| 450.00 | 0.28240 |
| 500.00 | 0.28240 |
| 550.00 | 0.28240 |
| 600.00 | 0.28240 |
| 650.00 | 0.28240 |
| 700.00 | 0.28240 |
| 750.00 | 0.28240 |
| 800.00 | 0.28240 |
| 900.00 | 0.28240 |
| 1000.0 | 0.28240 |
| 1100.0 | 0.28240 |
| 1200.0 | 0.28240 |
| 1300.0 | 0.28240 |
| 1400.0 | 0.28240 |
| 1500.0 | 0.28240 |

| TEMP | MU |
|---|---|
| | 0.000000 |

| TEMP | KXX |
|---|---|
| 70.000 | 0.19900E-03 |
| 100.00 | 0.20100E-03 |
| 150.00 | 0.20800E-03 |
| 200.00 | 0.21500E-03 |
| 250.00 | 0.22200E-03 |
| 300.00 | 0.22700E-03 |
| 350.00 | 0.23400E-03 |
| 400.00 | 0.24100E-03 |
| 450.00 | 0.24500E-03 |
| 500.00 | 0.25200E-03 |
| 550.00 | 0.25700E-03 |
| 600.00 | 0.26200E-03 |
| 650.00 | 0.26900E-03 |
| 700.00 | 0.27300E-03 |
| 750.00 | 0.27800E-03 |
| 800.00 | 0.28200E-03 |
| 900.00 | 0.29400E-03 |
| 1000.0 | 0.30600E-03 |
| 1100.0 | 0.31500E-03 |
| 1200.0 | 0.32400E-03 |
| 1300.0 | 0.33600E-03 |
| 1400.0 | 0.34500E-03 |
| 1500.0 | 0.35400E-03 |

| TEMP | C |
|---|---|
| 70.000 | 0.11700 |
| 100.00 | 0.11700 |
| 150.00 | 0.12000 |
| 200.00 | 0.12200 |
| 250.00 | 0.12500 |
| 300.00 | 0.12600 |
| 350.00 | 0.12800 |
| 400.00 | 0.12900 |
| 450.00 | 0.13000 |
| 500.00 | 0.13100 |
| 550.00 | 0.13200 |
| 600.00 | 0.13300 |
| 650.00 | 0.13400 |
| 700.00 | 0.13500 |

| | |
|---|---|
| 750.00 | 0.13600 |
| 800.00 | 0.13600 |
| 900.00 | 0.13800 |
| 1000.0 | 0.13900 |
| 1100.0 | 0.14100 |
| 1200.0 | 0.14100 |
| 1300.0 | 0.14300 |
| 1400.0 | 0.14400 |
| 1500.0 | 0.14500 |

MATERIAL NUMBER 3

| TEMP | DENS |
|---|---|
| 70.000 | 0.41090 |
| 100.00 | 0.41090 |
| 150.00 | 0.41090 |
| 200.00 | 0.41090 |
| 250.00 | 0.41090 |
| 300.00 | 0.41090 |
| 350.00 | 0.41090 |
| 400.00 | 0.41090 |
| 450.00 | 0.41090 |
| 500.00 | 0.41090 |
| 550.00 | 0.41090 |
| 600.00 | 0.41090 |
| 650.00 | 0.41090 |
| 700.00 | 0.41090 |
| 750.00 | 0.41090 |
| 800.00 | 0.41090 |
| 900.00 | 0.41090 |
| 1000.0 | 0.41090 |
| 1100.0 | 0.41090 |
| 1200.0 | 0.41090 |
| 1300.0 | 0.41090 |
| 1400.0 | 0.41090 |
| 1500.0 | 0.41090 |

| TEMP | KXX |
|---|---|
| 70.000 | 0.46500E-03 |
| 100.00 | 0.46100E-03 |
| 150.00 | 0.45500E-03 |
| 200.00 | 0.44800E-03 |
| 250.00 | 0.44100E-03 |
| 300.00 | 0.43500E-03 |
| 350.00 | 0.42800E-03 |
| 400.00 | 0.42200E-03 |
| 450.00 | 0.41500E-03 |
| 500.00 | 0.40900E-03 |
| 550.00 | 0.40200E-03 |
| 600.00 | 0.39500E-03 |
| 650.00 | 0.38900E-03 |
| 700.00 | 0.38900E-03 |
| 750.00 | 0.38900E-03 |
| 800.00 | 0.38900E-03 |
| 900.00 | 0.38900E-03 |
| 1000.0 | 0.38900E-03 |
| 1100.0 | 0.38900E-03 |
| 1200.0 | 0.38900E-03 |
| 1300.0 | 0.38900E-03 |
| 1400.0 | 0.38900E-03 |
| 1500.0 | 0.38900E-03 |

| TEMP | C |
|---|---|
| 70.000 | 0.31050E-01 |
| 100.00 | 0.31050E-01 |
| 150.00 | 0.31050E-01 |
| 200.00 | 0.31050E-01 |
| 250.00 | 0.31050E-01 |
| 300.00 | 0.31050E-01 |
| 350.00 | 0.31050E-01 |
| 400.00 | 0.31050E-01 |
| 450.00 | 0.31050E-01 |
| 500.00 | 0.31050E-01 |
| 550.00 | 0.31050E-01 |
| 600.00 | 0.31050E-01 |
| 650.00 | 0.31050E-01 |
| 700.00 | 0.31050E-01 |
| 750.00 | 0.31050E-01 |
| 800.00 | 0.31050E-01 |
| 900.00 | 0.31050E-01 |
| 1000.0 | 0.31050E-01 |
| 1100.0 | 0.31050E-01 |
| 1200.0 | 0.31050E-01 |
| 1300.0 | 0.31050E-01 |
| 1400.0 | 0.31050E-01 |
| 1500.0 | 0.31050E-01 |

MATERIAL NUMBER 4

| TEMP | DENS |
|---|---|
| 70.000 | 0.43510E-04 |
| 100.00 | 0.41120E-04 |
| 150.00 | 0.37520E-04 |
| 200.00 | 0.34680E-04 |
| 250.00 | 0.32360E-04 |
| 300.00 | 0.30310E-04 |
| 350.00 | 0.28310E-04 |
| 400.00 | 0.26730E-04 |
| 450.00 | 0.25220E-04 |
| 500.00 | 0.23960E-04 |
| 550.00 | 0.22780E-04 |
| 600.00 | 0.21680E-04 |
| 650.00 | 0.20710E-04 |
| 700.00 | 0.19800E-04 |
| 750.00 | 0.18980E-04 |
| 800.00 | 0.18180E-04 |
| 900.00 | 0.16900E-04 |
| 1000.0 | 0.15710E-04 |
| 1100.0 | 0.14720E-04 |
| 1200.0 | 0.13850E-04 |
| 1300.0 | 0.13040E-04 |
| 1400.0 | 0.12350E-04 |
| 1500.0 | 0.11710E-04 |

| TEMP | KXX |
|---|---|
| 70.000 | 0.34490E-06 |
| 100.00 | 0.36210E-06 |
| 150.00 | 0.39030E-06 |
| 200.00 | 0.41770E-06 |
| 250.00 | 0.44460E-06 |
| 300.00 | 0.47040E-06 |
| 350.00 | 0.49570E-06 |

| | |
|---|---|
| 400.00 | 0.52040E-06 |
| 450.00 | 0.54480E-06 |
| 500.00 | 0.56880E-06 |
| 550.00 | 0.59210E-06 |
| 600.00 | 0.61430E-06 |
| 650.00 | 0.63630E-06 |
| 700.00 | 0.65810E-06 |
| 750.00 | 0.67900E-06 |
| 800.00 | 0.69960E-06 |
| 900.00 | 0.74090E-06 |
| 1000.0 | 0.78040E-06 |
| 1100.0 | 0.81750E-06 |
| 1200.0 | 0.85450E-06 |
| 1300.0 | 0.88970E-06 |
| 1400.0 | 0.92850E-06 |
| 1500.0 | 0.97070E-06 |

| TEMP | C |
|---|---|
| 70.000 | 0.24020 |
| 100.00 | 0.24040 |
| 150.00 | 0.24080 |
| 200.00 | 0.24140 |
| 250.00 | 0.24210 |
| 300.00 | 0.24290 |
| 350.00 | 0.24380 |
| 400.00 | 0.24500 |
| 450.00 | 0.24610 |
| 500.00 | 0.24740 |
| 550.00 | 0.24900 |
| 600.00 | 0.25110 |
| 650.00 | 0.25270 |
| 700.00 | 0.25380 |
| 750.00 | 0.25520 |
| 800.00 | 0.25680 |
| 900.00 | 0.25960 |
| 1000.0 | 0.26280 |
| 1100.0 | 0.26590 |
| 1200.0 | 0.26890 |
| 1300.0 | 0.27170 |
| 1400.0 | 0.27420 |
| 1500.0 | 0.27660 |

MATERIAL NUMBER 5

| TEMP | EMIS |
|---|---|
| | 0.1500000 |

MATERIAL NUMBER 6

| TEMP | EMIS |
|---|---|
| | 0.1500000 |

MATERIAL NUMBER 7

| TEMP | EMIS |
|---|---|
| | 0.2000000 |

MATERIAL NUMBER 8

| TEMP | EMIS |
|---|---|
| | 0.2000000 |

```
MATERIAL NUMBER      12

     TEMP         EMIS
              0.7347000

MATERIAL NUMBER      14

     TEMP         EMIS
              0.9000000
```

The nodal point coordinates, element connectivity, and boundary conditions print-out are listed in the file:

**TH-0001\Undamaged impact limiter\model.out**

This file is provided in Appendix 3.

Appendix 2

ANSYS Result Print-Out

(9 Pages)

# Damaged Upper Impact Limiter Skin – Seal Temperature Tim-History

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 1.0000 | 158.418 | 158.431 |
| 4.5980 | 158.418 | 158.431 |
| 8.1960 | 158.418 | 158.431 |
| 18.990 | 158.420 | 158.433 |
| 36.980 | 158.455 | 158.467 |
| 54.970 | 158.561 | 158.568 |
| 72.960 | 158.780 | 158.777 |
| 90.950 | 159.155 | 159.135 |
| 108.94 | 159.718 | 159.674 |
| 126.93 | 160.495 | 160.417 |
| 144.92 | 161.501 | 161.379 |
| 162.91 | 162.742 | 162.568 |
| 180.90 | 164.219 | 163.983 |
| 198.89 | 165.926 | 165.621 |
| 216.88 | 167.854 | 167.474 |
| 234.87 | 169.993 | 169.529 |
| 252.86 | 172.328 | 171.776 |
| 270.85 | 174.846 | 174.202 |
| 288.84 | 177.533 | 176.793 |
| 306.83 | 180.376 | 179.537 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 324.82 | 183.362 | 182.420 |
| 342.81 | 186.477 | 185.432 |
| 360.80 | 189.711 | 188.562 |
| 378.79 | 193.052 | 191.797 |
| 396.78 | 196.490 | 195.130 |
| 414.77 | 200.018 | 198.552 |
| 432.76 | 203.628 | 202.056 |
| 450.75 | 207.313 | 205.635 |
| 468.74 | 211.077 | 209.294 |
| 486.73 | 214.903 | 213.015 |
| 504.72 | 218.783 | 216.792 |
| 522.71 | 222.714 | 220.620 |
| 540.70 | 226.688 | 224.493 |
| 558.69 | 230.701 | 228.407 |
| 576.68 | 234.749 | 232.357 |
| 594.67 | 238.827 | 236.339 |
| 612.66 | 242.932 | 240.349 |
| 630.65 | 247.060 | 244.384 |
| 648.64 | 251.209 | 248.441 |
| 666.63 | 255.373 | 252.516 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 684.62 | 259.550 | 256.606 |
| 702.61 | 263.737 | 260.708 |
| 720.60 | 267.933 | 264.820 |
| 738.59 | 272.135 | 268.940 |
| 756.58 | 276.342 | 273.066 |
| 774.57 | 280.552 | 277.198 |
| 792.56 | 284.764 | 281.332 |
| 810.55 | 288.977 | 285.469 |
| 828.54 | 293.188 | 289.606 |

| | | |
|---|---|---|
| 846.53 | 297.397 | 293.742 |
| 864.52 | 301.602 | 297.877 |
| 882.51 | 305.801 | 302.007 |
| 900.50 | 309.992 | 306.132 |
| 918.49 | 314.176 | 310.250 |
| 936.48 | 318.353 | 314.362 |
| 954.47 | 322.523 | 318.468 |
| 972.46 | 326.685 | 322.567 |
| 990.45 | 330.839 | 326.659 |
| 1008.4 | 334.986 | 330.744 |
| 1026.4 | 339.124 | 334.822 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 1044.4 | 343.255 | 338.893 |
| 1062.4 | 347.378 | 342.956 |
| 1080.4 | 351.493 | 347.013 |
| 1098.4 | 355.604 | 351.064 |
| 1116.4 | 359.710 | 355.111 |
| 1134.4 | 363.811 | 359.154 |
| 1152.4 | 367.906 | 363.192 |
| 1170.4 | 371.993 | 367.225 |
| 1188.3 | 376.073 | 371.252 |
| 1206.3 | 380.146 | 375.272 |
| 1224.3 | 384.209 | 379.285 |
| 1242.3 | 388.265 | 383.291 |
| 1260.3 | 392.311 | 387.290 |
| 1278.3 | 396.348 | 391.280 |
| 1296.3 | 400.376 | 395.262 |
| 1314.3 | 404.394 | 399.235 |
| 1332.3 | 408.403 | 403.200 |
| 1350.3 | 412.401 | 407.156 |
| 1368.2 | 416.389 | 411.103 |
| 1386.2 | 420.366 | 415.040 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 1404.2 | 424.331 | 418.967 |
| 1422.2 | 428.286 | 422.883 |
| 1440.2 | 432.229 | 426.789 |
| 1458.2 | 436.160 | 430.685 |
| 1476.2 | 440.079 | 434.569 |
| 1494.2 | 443.985 | 438.442 |
| 1512.2 | 447.879 | 442.303 |
| 1530.2 | 451.761 | 446.153 |
| 1548.1 | 455.629 | 449.990 |
| 1566.1 | 459.484 | 453.816 |
| 1584.1 | 463.326 | 457.629 |
| 1602.1 | 467.156 | 461.429 |
| 1620.1 | 470.973 | 465.218 |
| 1638.1 | 474.777 | 468.995 |
| 1656.1 | 478.569 | 472.760 |
| 1674.1 | 482.349 | 476.513 |
| 1692.1 | 486.116 | 480.254 |
| 1710.1 | 489.870 | 483.983 |
| 1728.0 | 493.611 | 487.701 |
| 1746.0 | 497.340 | 491.406 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|

| | | |
|---|---|---|
| 1764.0 | 501.056 | 495.099 |
| 1782.0 | 504.758 | 498.780 |
| 1800.0 | 508.447 | 502.448 |
| 1800.0 | 508.451 | 502.452 |
| 1800.0 | 508.455 | 502.456 |
| 1800.1 | 508.467 | 502.468 |
| 1800.2 | 508.488 | 502.489 |
| 1800.3 | 508.508 | 502.509 |
| 1800.4 | 508.529 | 502.529 |
| 1800.5 | 508.549 | 502.550 |
| 1800.6 | 508.569 | 502.570 |
| 1800.7 | 508.590 | 502.590 |
| 1800.8 | 508.610 | 502.611 |
| 1800.9 | 508.631 | 502.631 |
| 1801.0 | 508.651 | 502.651 |
| 1805.8 | 509.621 | 503.616 |
| 1810.5 | 510.591 | 504.581 |
| 1824.8 | 513.489 | 507.463 |
| 1839.0 | 516.373 | 510.333 |
| 1881.2 | 524.620 | 518.543 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 1927.3 | 533.081 | 526.976 |
| 1978.9 | 541.648 | 535.537 |
| 2037.0 | 550.003 | 543.921 |
| 2102.3 | 557.791 | 551.785 |
| 2175.4 | 564.714 | 558.846 |
| 2257.5 | 570.552 | 564.891 |
| 2349.0 | 575.145 | 569.762 |
| 2451.4 | 578.446 | 573.406 |
| 2564.7 | 580.430 | 575.790 |
| 2689.7 | 581.162 | 576.966 |
| 2826.9 | 580.744 | 577.021 |
| 2977.2 | 579.299 | 576.061 |
| 3142.1 | 576.947 | 574.194 |
| 3323.4 | 573.796 | 571.518 |
| 3526.3 | 569.880 | 568.062 |
| 3761.6 | 565.110 | 563.736 |
| 4049.9 | 559.209 | 558.268 |
| 4435.6 | 551.506 | 550.993 |
| 5029.4 | 540.382 | 540.290 |
| 6132.1 | 521.993 | 522.272 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 8034.1 | 494.830 | 495.300 |
| 9936.1 | 470.896 | 471.399 |
| 11838. | 449.423 | 449.904 |
| 13740. | 429.960 | 430.404 |
| 15642. | 412.203 | 412.609 |
| 17544. | 395.936 | 396.306 |
| 19446. | 380.987 | 381.325 |
| 21348. | 367.214 | 367.524 |
| 23250. | 354.495 | 354.779 |
| 25152. | 342.695 | 342.957 |
| 27054. | 331.723 | 331.965 |
| 28956. | 321.508 | 321.731 |
| 30858. | 311.986 | 312.193 |
| 32760. | 303.101 | 303.293 |
| 34662. | 294.797 | 294.977 |
| 36564. | 287.027 | 287.195 |
| 38466. | 279.762 | 279.919 |

| | | |
|---|---|---|
| 40368. | 272.964 | 273.111 |
| 42270. | 266.597 | 266.735 |
| 44172. | 260.628 | 260.758 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 46074. | 255.029 | 255.150 |
| 47976. | 249.772 | 249.886 |
| 49878. | 244.833 | 244.940 |
| 51780. | 240.193 | 240.294 |
| 53682. | 235.830 | 235.926 |
| 55584. | 231.726 | 231.817 |
| 57486. | 227.863 | 227.949 |
| 59388. | 224.223 | 224.305 |
| 61290. | 220.793 | 220.870 |
| 63192. | 217.557 | 217.631 |
| 65094. | 214.505 | 214.575 |
| 66996. | 211.623 | 211.689 |
| 68898. | 208.901 | 208.964 |
| 70800. | 206.329 | 206.389 |
| 72702. | 203.897 | 203.955 |
| 74604. | 201.597 | 201.653 |
| 76506. | 199.422 | 199.475 |
| 78408. | 197.362 | 197.413 |
| 80310. | 195.411 | 195.460 |
| 82212. | 193.562 | 193.609 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 84114. | 191.809 | 191.854 |
| 86016. | 190.147 | 190.190 |
| 87918. | 188.571 | 188.613 |
| 89820. | 187.076 | 187.116 |
| 91722. | 185.658 | 185.696 |
| 93624. | 184.312 | 184.349 |
| 95526. | 183.034 | 183.071 |
| 97428. | 181.822 | 181.857 |
| 99330. | 180.671 | 180.704 |
| 0.10123E+06 | 179.577 | 179.610 |
| 0.10313E+06 | 178.539 | 178.571 |
| 0.10504E+06 | 177.553 | 177.584 |
| 0.10694E+06 | 176.616 | 176.646 |
| 0.10884E+06 | 175.726 | 175.754 |
| 0.11074E+06 | 174.879 | 174.908 |
| 0.11264E+06 | 174.075 | 174.103 |
| 0.11455E+06 | 173.311 | 173.338 |
| 0.11645E+06 | 172.585 | 172.611 |
| 0.11835E+06 | 171.894 | 171.919 |
| 0.12025E+06 | 171.237 | 171.262 |

***** ANSYS POST26 VARIABLE LISTING *****

| TIME | 214 TEMP seal-1 | 221 TEMP seal-2 |
|---|---|---|
| 0.12215E+06 | 170.613 | 170.637 |
| 0.12406E+06 | 170.019 | 170.042 |
| 0.12596E+06 | 169.454 | 169.477 |
| 0.12786E+06 | 168.916 | 168.939 |
| 0.12976E+06 | 168.405 | 168.427 |
| 0.13166E+06 | 167.919 | 167.941 |
| 0.13357E+06 | 167.456 | 167.477 |
| 0.13547E+06 | 167.016 | 167.037 |

```
 0.13737E+06     166.597       166.618
 0.13927E+06     166.199       166.219
 0.14117E+06     165.819       165.839
 0.14308E+06     165.458       165.478
 0.14498E+06     165.115       165.134
 0.14688E+06     164.788       164.807
 0.14878E+06     164.476       164.495
 0.15068E+06     164.180       164.198
 0.15259E+06     163.898       163.916
 0.15449E+06     163.629       163.647
 0.15639E+06     163.374       163.391
 0.15829E+06     163.130       163.148

        ***** ANSYS POST26 VARIABLE LISTING *****


   TIME         214 TEMP      221 TEMP
                  seal-1        seal-2
 0.16019E+06     162.899       162.916
 0.16210E+06     162.678       162.695
 0.16400E+06     162.468       162.484
 0.16590E+06     162.268       162.284
 0.16780E+06     162.077       162.093
 0.16970E+06     161.896       161.912
 0.17161E+06     161.723       161.739
 0.17351E+06     161.558       161.574
 0.17541E+06     161.402       161.417
 0.17731E+06     161.252       161.268
 0.17921E+06     161.110       161.126
 0.18112E+06     160.975       160.990
 0.18302E+06     160.846       160.861
 0.18492E+06     160.723       160.738
 0.18682E+06     160.606       160.621
 0.18872E+06     160.495       160.509
 0.19063E+06     160.388       160.403
 0.19200E+06     160.314       160.329
```

8-120B cask Bulk Air Average Temperature with the Damaged Lower Impact Limiter

The input file for post processing of the data (AirTemp.in) is listed in the data disk included in Appendix 3. The output file (AirTemp.out) is listed below.

```
Cavity Air Bulk Average Temperature Time-History

          Time     Avrg.Temp.

             1.      174.
             5.      174.
             8.      174.
            19.      174.
            30.      174.
            48.      174.
            66.      174.
            84.      174.
           102.      174.
           120.      174.
           138.      174.
           156.      174.
           174.      174.
           192.      174.
           210.      174.
           228.      174.
           246.      174.
           264.      174.
           282.      174.
           300.      175.
```

| | |
|---|---|
| 318. | 175. |
| 336. | 175. |
| 354. | 175. |
| 372. | 176. |
| 390. | 176. |
| 408. | 176. |
| 426. | 176. |
| 444. | 177. |
| 462. | 177. |
| 480. | 177. |
| 498. | 178. |
| 516. | 178. |
| 534. | 178. |
| 551. | 179. |
| 569. | 179. |
| 587. | 180. |
| 605. | 180. |
| 623. | 181. |
| 641. | 181. |
| 659. | 182. |
| 677. | 182. |
| 695. | 183. |
| 713. | 183. |
| 731. | 184. |
| 749. | 184. |
| 767. | 185. |
| 785. | 186. |
| 803. | 186. |
| 821. | 187. |
| 839. | 187. |
| 857. | 188. |
| 875. | 189. |
| 893. | 189. |
| 911. | 190. |
| 929. | 191. |
| 947. | 191. |
| 965. | 192. |
| 983. | 193. |
| 1001. | 193. |
| 1019. | 194. |
| 1037. | 195. |
| 1055. | 196. |
| 1073. | 196. |
| 1091. | 197. |
| 1109. | 198. |
| 1127. | 199. |
| 1145. | 199. |
| 1163. | 200. |
| 1181. | 201. |
| 1199. | 202. |
| 1217. | 202. |
| 1235. | 203. |
| 1253. | 204. |
| 1271. | 205. |
| 1289. | 206. |
| 1307. | 206. |
| 1325. | 207. |
| 1343. | 208. |
| 1361. | 209. |
| 1379. | 210. |
| 1397. | 211. |
| 1415. | 211. |
| 1433. | 212. |
| 1451. | 213. |
| 1469. | 214. |
| 1487. | 215. |
| 1505. | 216. |
| 1523. | 216. |
| 1541. | 217. |

| | |
|---|---|
| 1559. | 218. |
| 1577. | 219. |
| 1595. | 220. |
| 1613. | 221. |
| 1631. | 222. |
| 1649. | 223. |
| 1667. | 223. |
| 1685. | 224. |
| 1703. | 225. |
| 1721. | 226. |
| 1739. | 227. |
| 1757. | 228. |
| 1775. | 229. |
| 1793. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1800. | 230. |
| 1801. | 230. |
| 1801. | 230. |
| 1801. | 230. |
| 1801. | 230. |
| 1801. | 230. |
| 1806. | 230. |
| 1811. | 230. |
| 1825. | 231. |
| 1839. | 232. |
| 1882. | 234. |
| 1928. | 236. |
| 1980. | 239. |
| 2038. | 241. |
| 2104. | 244. |
| 2177. | 247. |
| 2259. | 250. |
| 2352. | 252. |
| 2455. | 255. |
| 2570. | 257. |
| 2699. | 260. |
| 2842. | 261. |
| 3003. | 263. |
| 3186. | 264. |
| 3396. | 265. |
| 3648. | 266. |
| 3967. | 266. |
| 4405. | 265. |
| 5070. | 264. |
| 6137. | 263. |
| 7750. | 261. |
| 9652. | 259. |
| 11554. | 258. |
| 13456. | 256. |
| 15358. | 255. |
| 17260. | 254. |
| 19162. | 253. |
| 21064. | 252. |
| 22966. | 250. |
| 24868. | 249. |
| 26770. | 248. |
| 28672. | 247. |
| 30574. | 246. |
| 32476. | 245. |
| 34378. | 244. |
| 36280. | 242. |
| 38182. | 241. |
| 40084. | 240. |

| | |
|---|---|
| 41986. | 239. |
| 43888. | 238. |
| 45790. | 237. |
| 47692. | 236. |
| 49594. | 235. |
| 51496. | 234. |
| 53398. | 233. |
| 55300. | 232. |
| 57202. | 231. |
| 59104. | 230. |
| 61006. | 229. |
| 62908. | 228. |
| 64810. | 227. |
| 66712. | 226. |
| 68614. | 225. |
| 70516. | 224. |
| 72418. | 223. |
| 74320. | 223. |
| 76222. | 222. |
| 78123. | 221. |
| 80025. | 220. |
| 81927. | 219. |
| 83829. | 219. |
| 85731. | 218. |
| 87633. | 217. |
| 89535. | 216. |
| 91437. | 216. |
| 93339. | 215. |
| 95241. | 214. |
| 97143. | 214. |
| 99045. | 213. |
| 100947. | 212. |
| 102849. | 212. |
| 104751. | 211. |
| 106653. | 210. |
| 108555. | 210. |
| 110457. | 209. |
| 112359. | 209. |
| 114261. | 208. |
| 116163. | 207. |
| 118065. | 207. |
| 119967. | 206. |
| 121869. | 206. |
| 123771. | 205. |
| 125673. | 205. |
| 127575. | 204. |
| 129477. | 204. |
| 131379. | 203. |
| 133281. | 203. |
| 135183. | 202. |
| 137085. | 202. |
| 138987. | 201. |
| 140889. | 201. |
| 142791. | 201. |
| 144693. | 200. |
| 146595. | 200. |
| 148497. | 199. |
| 150399. | 199. |
| 152301. | 198. |
| 154203. | 198. |
| 156105. | 198. |
| 158007. | 197. |
| 159909. | 197. |
| 161811. | 197. |
| 163713. | 196. |
| 165615. | 196. |
| 167517. | 195. |
| 169419. | 195. |
| 171321. | 195. |

```
       173223.      194.
       175125.      194.
       177027.      194.
       178929.      194.
       180831.      193.
       182733.      193.
       184635.      193.
       186537.      192.
       188439.      192.
       190341.      192.
       192000.      192.

Maximum Average Temperature    265.64  at Time   3966.89
```

Appendix 3

Media Disk (CD-ROM)

(1 Disk)