A1755

See pocket 2A for enclosure

PDR-1
LPDR- Wm-10 (2)
Wm-11 (2)
Wm-16 (2)

Sandia National Laboratories
Albuquerque, New Mexico 87185

WM DOCKET CONTROL CENTER

'87 JUL 16 P12:12

July 15, 1987

Mr. John Peshel
Engineering Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Dear Mr. Peshel:

The enclosed monthly report summarizes the activities during the month of June for FIN A-1755.

If you have any questions, please feel free to contact me at FTS 844-8368 or L. R. Shipers at FTS 846-3051.

Sincerely,

Robert M. Cranwell

Robert M. Cranwell
Supervisor
Waste Management Systems
Division 6416

RMC:6416

Enclosure

Copy to:
Office of the Director, NMSS
Attn: Program Support Branch
6400 R. C. Cochrell
6410 N. R. Ortiz
6416 R. M. Cranwell
6416 L. R. Shipers

87225731
WM Project: WM-10, 11, 16
PDR w/encl
(Return to WM, 623-SS)

WM Record File: A1755
LPDR w/encl

Wm-Res
WM Record File A1755
SNL

WM Project 10,11,16
Docket No.
PDR ✓
LPDR ✓ (B,N,S)

Distribution:
Peshel
Joan-ticket
Sac
(Return to WM, 623-SS)

8709080142 870715
PDR WMRES EXISANL
A-1755 PDR

3901

See ltr to Peshel fm Cranwell 7-15-87

PROGRAM: Coupled Thermal-Hydrological-Mechanical Assessments and Site Characterization Activities for Geologic Repositories

FIN#: A-1755

CONTRACTOR: Sandia National Laboratories

BUDGET PERIOD: 10/86 - 9/87

DRA PROGRAM MANAGER: J. Peshel

BUDGET AMOUNT: 250K

CONTRACT PROGRAM MANAGER: R. M. Cranwell

FTS PHONE: 844-8368

PRINCIPAL INVESTIGATOR: L. R. Shipers

FTS PHONE: 846-9777

PROJECT OBJECTIVES

To provide technical assistance to NRC in the assessment of coupled thermal-hydrological-mechanical phenomena and site characterization activities for high-level waste repositories.

ACTIVITIES DURING JUNE 1987

Activities and Accomplishments

Progress was made in two areas during the month of June. In the first, four different cases of the vertical cross-section model of the BWIP Exploratory shaft were simulated. The computer runs were made on Sandia's CRAY-CTSS System using the Waste Isolation version of STEALTH 2D. In Cases 1, 2, and 3 a variable thickness for the grout and the liner as a function of depth was considered. For Case 1, the damping factor (i.e., relaxation frequency parameter) was set equal to zero to determine the fundamental frequency of the modelled system. This was necessary in order to critically damp out the lowest frequency and obtain an equilibrium solution with a dynamic technique. By examining the time histories of stress at certain monitored locations, a damping factor between 0.1 and 0.2 was indicated by this analysis. In Case 2 a damping factor of 0.1 was used while all other input remained unchanged from Case 1. The Case 2 results appeared satisfactory but slightly underdamped. Therefore, another simulation (Case 3) was run with a damping factor of 0.2 (again, the other input remained unchanged). In Case 3 the relaxation to the equilibrium stresses occurred more quickly than in Case 2. Only very slight differences in results occurred between these two cases. The Case 3 results also provided confidence that a proper range of damping had been utilized. In order to estimate the rock movement in the absence of grout or a liner, Case 4 was run with the variable hole diameter, but the liner and the grout were not included in the model. The results of these four cases are currently being analyzed. Attachments to this monthly report include input data files and update files for Cases 1, 2, 3, and 4, microfiche output for Cases 2, 3, and 4, and selected plots of stress distribution as a function of radial distance. Note that in the

results presented the principal horizontal stress components TXX and TZZ are, respectively, the radial and tangential components. The ratio of initial horizontal to vertical stress in the rock mass was chosen as two. One major difference between the results of the previous horizontal cross-section model and the present model is the lack of failure (i.e., plastic flow) in the present model response. This difference was not expected and is contrary to our intuition given the physics of the problem. Efforts are currently underway to examine and resolve this issue.

In the second area, the conversion of the Waste Isolation (W.I.) version of the STEALTH 2D computer code for use on the Open NOS (CDC) operating system was completed. A sample problem, "BWIP Horizontal X-Section of Shaft, Cohasset, w=0.25," was executed to benchmark this version of the code. Results form the CDC-Open NOS and the CRAY-CTSS versions of STEALTH 2D W.I. computer code for this problem were identical. For the purposes of comparison, computer time required for the 300 cycle run in each case was:

CRAY-CTSS	81 CP seconds
CDC-Open NOS	286 CP seconds

so that run time is approximately 3.5 times longer on the Open NOS operating system. Note that actual computer costs are system dependent and must include any input/output charges as well as CP time charges.

Travel

None.

Problems Encountered

None.

Attachment I

Update Files for Cases 1, 2, and 3

```
*ID BWIPSFT
*C STEALTH
*D ZONSDV2.105,106
C     ** DEFINE ESTIMATED TOAL STRESSES **
   70 SIGXX = SXXN - (PRHN+AVSH)
      SIGYY = SYYN - (PRHN+AVSH)
      SSUM = SIGXX + SIGYY
      SDIF = SIGXX - SIGYY
C      ** DEFINE UNADJUSTED PRINCIPAL STRESSES **
      SIG1 = SSUM/2. + SQRT(SDIF**2/4. + SXYN**2)
      SIG2 = SSUM/2. - SQRT(SDIF**2/4. + SXYN**2)
      PANG = 0.
      IF(SDIF .EQ. 0. .AND. SXYN .EQ. 0.)GO TO 71
C     ** PANG IS THE PRINCIPAL STRESS ORIENTATION IN DEG. **
      PANG = 28.6364 * ATAN2(2.*SXYN, SDIF)
   71 CONTINUE
      YSTN = SIG1 - SIG2
      EX1N = SIG1
      EX3N = SIG2
      EX4N = EX4O
      EX5N = PANG
      IF(YSTN .LE. SMLNUM) GO TO 990
*D ZONSDV2.119,120
   80 ADJN = YLDN/YSTN
C     ** EX4N IS A MEASURE OF PROXIMITY TO YIELD SURFACE **
C     ** WHEN EX4N IS GREATER THAN 1, NO PLASTIC FLOW OCCURS **
      EX4N = ADJN
*D ZONSDV2.128,131
C     ** ADJUST STRESSES ACCCORDING TO TRESCA CRITERION **
   90 SSUM = ADJN * SSUM
      SDIF = ADJN * SDIF
      SXYN = ADJN * SXYN
      SIG1 = ADJN * SIG1
      SIG2 = ADJN * SIG2
C     ** DEFINE ADJUSTED TOTAL STRESSES IN X-Y DIRECTIONS **
      SIGXX = 0.5 * (SSUM + SDIF)
      SIGYY = 0.5 * (SSUM - SDIF)
      SXXN = SIGXX + (PRHN+AVSH)
      SYYN = SIGYY + (PRHN+AVSH)
      SZZN = - (SXXN+SYYN)
C     ** EX1N IS THE MAJOR PRINCIPAL STRESS **
C     ** EX3N IS THE MINOR PRINCIPAL STRESS **
C     ** EX5N IS THE PRICIPAL STRESS ORIENTATION **
      EX1N = SIG1
      EX3N = SIG2
      EX5N = PANG
*D ZONPRH.54
      VAL = PRHO + EOS2*(1./RLVN - 1./RLVO)
*I GENCHK2.54
      DATA  SBOT2,   SBOT3,   SBOT4,   SBOT5,   SBOT7,   SBOT8  /
     1 -73.9056E6, -64.0441E6, -20.8056E6, -17.888E6,
     2  -24.9569E6, -25.1227E6  /
      DATA  FACHV / 2.0 /
*I GENCHK2.86
```

```
      IF(JN .EQ. JLNBOT) TYINC = 0.0
*I GENCHK2.269
      TYINC = - ARDN(MPNO) * GRVY * (YPNNTR-YPNNBR)
      IF(I .GE. 8) GO TO 321
      IF(I .EQ. 2) GO TO 322
      IF(I .EQ. 3) GO TO 323
      IF(I .EQ. 4) GO TO 324
      IF(I .EQ. 5 .OR. I .EQ. 6) GO TO 326
C
C        *** I = 7 ***
      TYINC7 = TYINC
      TYYN = SBOT7 + TYINC7/2.0
      TXXN = FACHV * TYYN
      IF(J .GT. 24) TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C        *** I IS GREATER THAN OR EQUAL TO 8 ***
  321 TYINC8 = TYINC
      TYYN = SBOT8 + TYINC8/2.0
      TXXN = FACHV * TYYN
      TZZN = TXXN
      GO TO 328
C
C       *** I = 2 ***
  322 TYINC2 = TYINC
      TYYN = SBOT2 + TYINC2/2.0
      TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C        *** I = 3 ***
  323 TYINC3 = TYINC
      TYYN = SBOT3 + TYINC3/2.0
      TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C        *** I = 4 ***
  324 TYINC4 = TYINC
      TYYN = SBOT4 + TYINC4/2.0
      TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C       *** I = 5 OR 6 ***
  326 TYINC5 = TYINC
      TYYN = SBOT5 + TYINC5/2.0
      TXXN = TYYN
      TZZN = TXXN
  328 CONTINUE
      PRHN = - (TXXN+TYYN+TZZN) / 3.
      TXX(I,JT) = TXXN
      TYY(I,JT) = TYYN
      TZZ(I,JT) = TZZN
```

```
      RLVO = RLVN
      PRHO = PRHN
*I GENCHK2.363
      SBOT2 = SBOT2 + TYINC2
      SBOT3 = SBOT3 + TYINC3
      SBOT4 = SBOT4 + TYINC4
      SBOT5 = SBOT5 + TYINC5
      SBOT7 = SBOT7 + TYINC7
      SBOT8 = SBOT8 + TYINC8
*D PLTTTL.53
   30 CALL PLTLBL(NPLT,MAXCDN,1,0,0.18,0.98,HGT,WID,0.0,CDN)
```

Attachment II

Update Files for Case 4

```
*ID BWIPSFT
*C STEALTH
*D ZONSDV2.105,106
C     ** DEFINE ESTIMATED TOAL STRESSES **
   70 SIGXX = SXXN - (PRHN+AVSH)
      SIGYY = SYYN - (PRHN+AVSH)
      SSUM = SIGXX + SIGYY
      SDIF = SIGXX - SIGYY
C      ** DEFINE UNADJUSTED PRINCIPAL STRESSES **
      SIG1 = SSUM/2. + SQRT(SDIF**2/4. + SXYN**2)
      SIG2 = SSUM/2. - SQRT(SDIF**2/4. + SXYN**2)
      PANG = 0.
      IF(SDIF .EQ. 0. .AND. SXYN .EQ. 0.)GO TO 71
C     ** PANG IS THE PRINCIPAL STRESS ORIENTATION IN DEG. **
      PANG = 28.6364 * ATAN2(2.*SXYN, SDIF)
   71 CONTINUE
      YSTN = SIG1 - SIG2
      EX1N = SIG1
      EX3N = SIG2
      EX4N = EX4O
      EX5N = PANG
      IF(YSTN .LE. SMLNUM) GO TO 990
*D ZONSDV2.119,120
   80 ADJN = YLDN/YSTN
C     ** EX4N IS A MEASURE OF PROXIMITY TO YIELD SURFACE **
C     ** WHEN EX4N IS GREATER THAN 1, NO PLASTIC FLOW OCCURS **
      EX4N = ADJN
*D ZONSDV2.128,131
C     ** ADJUST STRESSES ACCCORDING TO TRESCA CRITERION **
   90 SSUM = ADJN * SSUM
      SDIF = ADJN * SDIF
      SXYN = ADJN * SXYN
      SIG1 = ADJN * SIG1
      SIG2 = ADJN * SIG2
C     ** DEFINE ADJUSTED TOTAL STRESSES IN X-Y DIRECTIONS **
      SIGXX = 0.5 * (SSUM + SDIF)
      SIGYY = 0.5 * (SSUM - SDIF)
      SXXN = SIGXX + (PRHN+AVSH)
      SYYN = SIGYY + (PRHN+AVSH)
      SZZN = - (SXXN+SYYN)
C     ** EX1N IS THE MAJOR PRINCIPAL STRESS **
C     ** EX3N IS THE MINOR PRINCIPAL STRESS **
C     ** EX5N IS THE PRICIPAL STRESS ORIENTATION **
      EX1N = SIG1
      EX3N = SIG2
      EX5N = PANG
*D ZONPRH.54
      VAL = PRHO + EOS2*(1./RLVN - 1./RLVO)
*I GENCHK2.54
      DATA  SBOT2,   SBOT3,   SBOT4,   SBOT5,   SBOT7,   SBOT8  /
     1 -0.000E0, -0.000E0, -0.000E0, -0.000E0,
     2  -21.8079E6, -25.1227E6  /
      DATA  FACHV / 2.0 /
*I GENCHK2.86
```

```
      IF(JN .EQ. JLNBOT) TYINC = 0.0
*I GENCHK2.269
      TYINC = - ARDN(MPNO) * GRVY * (YPNNTR-YPNNBR)
      IF(I .GE. 8) GO TO 321
      IF(I .EQ. 2) GO TO 322
      IF(I .EQ. 3) GO TO 323
      IF(I .EQ. 4) GO TO 324
      IF(I .EQ. 5 .OR. I .EQ. 6) GO TO 326
C
C        *** I = 7 ***
      TYINC7 = TYINC
      TYYN = SBOT7 + TYINC7/2.0
      TXXN = FACHV * TYYN
      IF(J .GT. 24) TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C        *** I IS GREATER THAN OR EQUAL TO 8 ***
  321 TYINC8 = TYINC
      TYYN = SBOT8 + TYINC8/2.0
      TXXN = FACHV * TYYN
      TZZN = TXXN
      GO TO 328
C
C       *** I = 2 ***
  322 TYINC2 = 0.0
      TYYN = SBOT2 + TYINC2/2.0
      TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C        *** I = 3 ***
  323 TYINC3 = 0.0
      TYYN = SBOT3 + TYINC3/2.0
      TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C        *** I = 4 ***
  324 TYINC4 = 0.0
      TYYN = SBOT4 + TYINC4/2.0
      TXXN = TYYN
      TZZN = TXXN
      GO TO 328
C
C       *** I = 5 OR 6 ***
  326 TYINC5 = 0.0
      TYYN = SBOT5 + TYINC5/2.0
      TXXN = TYYN
      TZZN = TXXN
  328 CONTINUE
      PRHN = - (TXXN+TYYN+TZZN) / 3.
      TXX(I,JT) = TXXN
      TYY(I,JT) = TYYN
      TZZ(I,JT) = TZZN
```

```
      RLVO = RLVN
      PRHO = PRHN
*I GENCHK2.363
      SBOT2 = SBOT2 + TYINC2
      SBOT3 = SBOT3 + TYINC3
      SBOT4 = SBOT4 + TYINC4
      SBOT5 = SBOT5 + TYINC5
      SBOT7 = SBOT7 + TYINC7
      SBOT8 = SBOT8 + TYINC8
*I ZONMDL.44
      IF (MPNN .NE. 2) GO TO 10
      TXXN = TXXO
      TYYN = TYYO
      TZZN = TZZO
      TXYN = TXYO
      PRHN = PRHO
      ZIEN = ZIEO
      EX1N = EX1O
      EX3N = EX3O
      EX4N = EX4O
      EX5N = EX5O
      GO TO 20
   10 CONTINUE
*I ZONMDL.116
   20 CONTINUE
*D PLTTTL.53
   30 CALL PLTLBL(NPLT,MAXCDN,1,0,0.18,0.98,HGT,WID,0.0,CDN)
```

Attachment III

Input File for Case 1

```
TTL       BWIP VERTICAL X-SECTION OF SHAFT, CASE 1, W=0.0
PRB                                                   2.
PRO       2.0
SYM       2.
GRV       0.0       -9.807
DTS       2.0       1.
GRD       1.0       1.0       26.0      28.0
END
MAT                                                   1.
111 COHAS 1.0       1.0
112       1.0       2.0       2.0       2.0
121       1.0       2830.0
122       1.0       1.        0.          4.96 E10
132       1.0          1.50 E8
134       1.0         2.97 E10
136       1.0          -2.9 E7
111 GROUT 2.0       1.0
112       2.0       2.0       2.0       2.0
121       2.0       1900.0
122       2.0       1.        0.         1.169 E10
132       2.0          1.50 E7
134       2.0          5.83 E9
136       2.0         -1.00 E7
111 LINER 3.0       1.0
112       3.0       2.0       2.0       2.0
121       3.0       7850.0
122       3.0       1.        0.         1.390 E11
132       3.0          2.07 E8
134       3.0         7.79 E10
136       3.0         -3.45 E8
111 SEDIM 4.0       1.0
112       4.0       2.0       2.0       2.0
121       4.0       2000.0
122       4.0       1.        0.          1.00 E09
132       4.0          1.00 E7
134       4.0         1.00 E09
136       4.0          -2.9 E7
111 BSLT2 5.0       1.0
112       5.0       2.0       2.0       2.0
121       5.0       2810.0
122       5.0       1.        0.          6.33 E10
132       5.0          1.50 E8
134       5.0         3.27 E10
136       5.0          -2.9 E7
END
GPT                                     1.0       1.0
211       1.0       1.0       1.0       0.9144    -960.
212       1.0       0.0       2.0       2.0
212       2.0       0.0       -960.     1.0
212       3.0       20.       -960.     1.0
212       4.        20.       2.        3.
221       1.        1.        3.        1.        5.
221       2.        1.        3.        5.        24.
221       3.        1.        3.        24.       28.
```

```
221        4.         3.         4.         1.         5.
221        5.         3.         4.         5.         24.
221        6.         3.         4.         24.        28.
221        7.         4.         7.         1.         5.
221        8.         4.         7.         5.         24.
221        9.         4.         7.         24.        28.
221        10.        7.         26.        1.         5.
221        11.        7.         26.        5.         24.
221        12.        7.         26.        24.        28.
247        1.         0.9144     0.0254     -960.      50.        1.         1.
247        2.         0.9144     0.0254     -910.      741.       1.         1.
247        3.         0.9144     0.0254     -169.      169.       1.         1.
247        4.         0.9398     0.01905    -960.      50.        1.         1.
247        5.         0.9398     0.01905    -910.      741.       1.         1.
247        6.         0.9398     0.01905    -169.      169.       1.         1.
247        7.         0.95885    0.4572     -960.      50.        1.         1.
247        8.         0.95885    0.4572     -910.      741.       1.         1.
247        9.         0.95885    0.4572     -169.      169.       1.         1.
247        10.        1.41605    18.584     -960.      50.        1.06       1.
247        11.        1.41605    18.584     -910.      741.       1.06       1.
247        12.        1.41605    18.584     -169.      169.       1.06       1.
END
ZON                                                    1.
311        1.         1.         4.         1.         5.
321        1.         3.
322        1.         1.
311        2.         4.         6.         1.         5.
321        2.         2.
322        2.         1.
322        3.         1.
322        4.         1.
322        5.         1.
322        6.         1.
322        7.         1.
322        8.         1.
322        9.         1.
311        3.         6.         26.        1.         5.
321        3.         1.
311        4.         1.         3.         5.         24.
321        4.         3.
311        5.         3.         6.         5.         24.
321        5.         2.
311        6.         6.         26.        5.         24.
321        6.         5.
311        7.         1.         2.         24.        28.
321        7.         3.
311        8.         2.         7.         24.        28.
321        8.         2.
311        9.         7.         26.        24.        28.
321        9.         4.
END
BDY                                                    1.0
411 BSEG1  1.         1.         28.        1.         1.
411 BSEG2  2.         1.         1.         26.        1.
411 BSEG3  3.0        26.0       1. 0       26.0       28.0
```

```
411 BSEG4 4.0       26.0      28.0      1.0       28.0
412       1.0       1.0       3.0       5.0
412 BSEG2 2.0       1.0       6.0       5.0       3.0
412 BSEG3 3.0       1.0       6.0       5.0       4.0
412       4.0       1.0       3.0       5.0
414       2.0                         1.1
414       3.0                         1.1
481       1.0       1.0       2.0
481       2.        2.        3.
481       3.0       3.0       4.0
482       1.0       1.0       5.0       5.                  0.05
482       2.        1.        5.        5.                  0.25
482       3.0       1.0       5.0       5.                  0.25
END
TIM                                                 1.
511       0.1
512       0.1       0.1
513       1.0       1.0
514       0.0
521       1000.0    500.
END
EDT                                                 1.
611       2.0
613       2.0
616       2.0
621       1.0       0.        500.0     100.0
622       1.0       26.0      1.0       28.0
623       11.0      14.0      71.0      72.0      73.0      81.0      82.0
623       83.       74.       64.       91.       93.       94.       95.
623       12.       15.
641       1.        0.        500.      250.
624       3.
671       1.        0.        500.      5.
674       1.        1.        71.       1.        2002.
674       2.        1.        71.       1.        4010.
674       3.        1.        71.       1.        26019.
674       4.        1.        71.       1.        16010.
674       5.        1.        5.        1.
674       6.        2.          71.               500.                15.
674       7.        2.          92.               500.                20.
674       8.        2.        72.                 500.                2000.
674       9.        1.        72.       1.        16010.
674       10.       1.        91.       1.        10010.
674       11.       1.        71.       1.        5002.
674       12.       1.        71.       1.        7002.
674       13.       1.        71.       1.        5012.
674       14.       1.        71.       1.        7012.
674       15.       1.        73.       1.        7002.
674       16.       2.        71.                 500.                2.
674       17.       2.        72.                 500.                2.
674       18.       1.        71.       1.        8025.
674       19.       1.        72.       1.        16016.
674       20.       1.        91.       1.        7002.
END
END
```

Attachment IV

Input File for Case 2

```
TTL       BWIP VERTICAL X-SECTION OF SHAFT, CASE 2, W=0.10
PRB                                                   2.
PRO       2.0
SYM       2.
GRV       0.0       -9.807
DTS       2.0       1.
GRD       1.0       1.0       26.0      28.0
END
MAT                                                   1.
111 COHAS 1.0       1.0
112       1.0       2.0       2.0       2.0
121       1.0       2830.0
122       1.0       1.        0.          4.96 E10
132       1.0          1.50 E8
134       1.0         2.97 E10
136       1.0          -2.9 E7
111 GROUT 2.0       1.0
112       2.0       2.0       2.0       2.0
121       2.0       1900.0
122       2.0       1.        0.         1.169 E10
132       2.0          1.50 E7
134       2.0          5.83 E9
136       2.0         -1.00 E7
111 LINER 3.0       1.0
112       3.0       2.0       2.0       2.0
121       3.0       7850.0
122       3.0       1.        0.         1.390 E11
132       3.0          2.07 E8
134       3.0         7.79 E10
136       3.0         -3.45 E8
111 SEDIM 4.0       1.0
112       4.0       2.0       2.0       2.0
121       4.0       2000.0
122       4.0       1.        0.          1.00 E09
132       4.0          1.00 E7
134       4.0         1.00 E09
136       4.0          -2.9 E7
111 BSLT2 5.0       1.0
112       5.0       2.0       2.0       2.0
121       5.0       2810.0
122       5.0       1.        0.          6.33 E10
132       5.0          1.50 E8
134       5.0         3.27 E10
136       5.0          -2.9 E7
END
GPT                                     1.0       1.0
211       1.0       1.0       1.0       0.9144    -960.
212       1.0       0.0       2.0       2.0
212       2.0       0.0       -960.     1.0
212       3.0       20.       -960.     1.0
212       4.        20.       2.        3.
221       1.        1.        3.        1.        5.
221       2.        1.        3.        5.        24.
221       3.        1.        3.        24.       28.
```

```
221        4.         3.         4.         1.         5.
221        5.         3.         4.         5.         24.
221        6.         3.         4.         24.        28.
221        7.         4.         7.         1.         5.
221        8.         4.         7.         5.         24.
221        9.         4.         7.         24.        28.
221        10.        7.         26.        1.         5.
221        11.        7.         26.        5.         24.
221        12.        7.         26.        24.        28.
247        1.         0.9144     0.0254     -960.      50.        1.         1.
247        2.         0.9144     0.0254     -910.      741.       1.         1.
247        3.         0.9144     0.0254     -169.      169.       1.         1.
247        4.         0.9398     0.01905    -960.      50.        1.         1.
247        5.         0.9398     0.01905    -910.      741.       1.         1.
247        6.         0.9398     0.01905    -169.      169.       1.         1.
247        7.         0.95885    0.4572     -960.      50.        1.         1.
247        8.         0.95885    0.4572     -910.      741.       1.         1.
247        9.         0.95885    0.4572     -169.      169.       1.         1.
247        10.        1.41605    18.584     -960.      50.        1.06       1.
247        11.        1.41605    18.584     -910.      741.       1.06       1.
247        12.        1.41605    18.584     -169.      169.       1.06       1.
END
ZON                                                    1.
311        1.         1.         4.         1.         5.
321        1.         3.
322        1.         1.
311        2.         4.         6.         1.         5.
321        2.         2.
322        2.         1.
322        3.         1.
322        4.         1.
322        5.         1.
322        6.         1.
322        7.         1.
322        8.         1.
322        9.         1.
311        3.         6.         26.        1.         5.
321        3.         1.
311        4.         1.         3.         5.         24.
321        4.         3.
311        5.         3.         6.         5.         24.
321        5.         2.
311        6.         6.         26.        5.         24.
321        6.         5.
311        7.         1.         2.         24.        28.
321        7.         3.
311        8.         2.         7.         24.        28.
321        8.         2.
311        9.         7.         26.        24.        28.
321        9.         4.
END
BDY                                                    1.0
411 BSEG1  1.         1.         28.        1.         1.
411 BSEG2  2.         1.         1.         26.        1.
411 BSEG3  3.0        26.0       1. 0       26.0       28.0
```

```
411 BSEG4 4.0       26.0      28.0      1.0       28.0
412       1.0       1.0       3.0       5.0
412 BSEG2 2.0       1.0       6.0       5.0       3.0
412 BSEG3 3.0       1.0       6.0       5.0       4.0
412       4.0       1.0       3.0       5.0
414       2.0                         1.1
414       3.0                         1.1
481       1.0       1.0       2.0
481       2.        2.        3.
481       3.0       3.0       4.0
482       1.0       1.0       5.0       5.0                 0.05
482       2.        1.        5.        5.                  0.25
482       3.0       1.0       5.0       5.0                 0.25
END
TIM                                                 1.
511       0.1
512       0.1       0.1
513       1.0       1.0
514       0.10
521       1000.0    500.
END
EDT                                                 1.
611       2.0
613       2.0
616       2.0
621       1.0       0.        500.0     100.0
622       1.0       26.0      1.0       28.0
623       11.0      14.0      71.0      72.0      73.0      81.0      82.0
623       83.       74.       64.       91.       93.       94.       95.
623       12.       15.
641       1.        0.        500.      250.
624       3.
671       1.        0.        500.      5.
674       1.        1.        71.       1.        2002.
674       2.        1.        71.       1.        4010.
674       3.        1.        71.       1.        26019.
674       4.        1.        71.       1.        16010.
674       5.        1.        5.        1.
674       6.        2.          71.               500.                15.
674       7.        2.          92.               500.                20.
674       8.        2.        72.                 500.                2000.
674       9.        1.        72.       1.        16010.
674       10.       1.        91.       1.        10010.
674       11.       1.        71.       1.        5002.
674       12.       1.        71.       1.        7002.
674       13.       1.        71.       1.        5012.
674       14.       1.        71.       1.        7012.
674       15.       1.        73.       1.        7002.
674       16.       2.        71.                 500.                2.
674       17.       2.        72.                 500.                2.
674       18.       1.        71.       1.        8025.
674       19.       1.        72.       1.        16016.
674       20.       1.        91.       1.        7002.
END
END
```

Attachment V

Input File for Case 3

```
TTL       BWIP VERTICAL X-SECTION OF SHAFT, CASE 3, W=0.20
PRB                                                   2.
PRO       2.0
SYM       2.
GRV       0.0       -9.807
DTS       2.0       1.
GRD       1.0       1.0       26.0      28.0
END
MAT                                                   1.
111 COHAS 1.0       1.0
112       1.0       2.0       2.0       2.0
121       1.0       2830.0
122       1.0       1.        0.          4.96 E10
132       1.0          1.50 E8
134       1.0         2.97 E10
136       1.0          -2.9 E7
111 GROUT 2.0       1.0
112       2.0       2.0       2.0       2.0
121       2.0       1900.0
122       2.0       1.        0.         1.169 E10
132       2.0          1.50 E7
134       2.0          5.83 E9
136       2.0         -1.00 E7
111 LINER 3.0       1.0
112       3.0       2.0       2.0       2.0
121       3.0       7850.0
122       3.0       1.        0.         1.390 E11
132       3.0          2.07 E8
134       3.0         7.79 E10
136       3.0         -3.45 E8
111 SEDIM 4.0       1.0
112       4.0       2.0       2.0       2.0
121       4.0       2000.0
122       4.0       1.        0.          1.00 E09
132       4.0          1.00 E7
134       4.0         1.00 E09
136       4.0          -2.9 E7
111 BSLT2 5.0       1.0
112       5.0       2.0       2.0       2.0
121       5.0       2810.0
122       5.0       1.        0.          6.33 E10
132       5.0          1.50 E8
134       5.0         3.27 E10
136       5.0          -2.9 E7
END
GPT                                     1.0       1.0
211       1.0       1.0       1.0       0.9144    -960.
212       1.0       0.0       2.0       2.0
212       2.0       0.0       -960.     1.0
212       3.0       20.       -960.     1.0
212       4.        20.       2.        3.
221       1.        1.        3.        1.        5.
221       2.        1.        3.        5.        24.
221       3.        1.        3.        24.       28.
```

```
221        4.         3.         4.         1.         5.
221        5.         3.         4.         5.         24.
221        6.         3.         4.         24.        28.
221        7.         4.         7.         1.         5.
221        8.         4.         7.         5.         24.
221        9.         4.         7.         24.        28.
221        10.        7.         26.        1.         5.
221        11.        7.         26.        5.         24.
221        12.        7.         26.        24.        28.
247        1.         0.9144     0.0254     -960.      50.        1.         1.
247        2.         0.9144     0.0254     -910.      741.       1.         1.
247        3.         0.9144     0.0254     -169.      169.       1.         1.
247        4.         0.9398     0.01905    -960.      50.        1.         1.
247        5.         0.9398     0.01905    -910.      741.       1.         1.
247        6.         0.9398     0.01905    -169.      169.       1.         1.
247        7.         0.95885    0.4572     -960.      50.        1.         1.
247        8.         0.95885    0.4572     -910.      741.       1.         1.
247        9.         0.95885    0.4572     -169.      169.       1.         1.
247        10.        1.41605    18.584     -960.      50.        1.06       1.
247        11.        1.41605    18.584     -910.      741.       1.06       1.
247        12.        1.41605    18.584     -169.      169.       1.06       1.
END
ZON                                                    1.
311        1.         1.         4.         1.         5.
321        1.         3.
322        1.         1.
311        2.         4.         6.         1.         5.
321        2.         2.
322        2.         1.
322        3.         1.
322        4.         1.
322        5.         1.
322        6.         1.
322        7.         1.
322        8.         1.
322        9.         1.
311        3.         6.         26.        1.         5.
321        3.         1.
311        4.         1.         3.         5.         24.
321        4.         3.
311        5.         3.         6.         5.         24.
321        5.         2.
311        6.         6.         26.        5.         24.
321        6.         5.
311        7.         1.         2.         24.        28.
321        7.         3.
311        8.         2.         7.         24.        28.
321        8.         2.
311        9.         7.         26.        24.        28.
321        9.         4.
END
BDY                                                    1.0
411 BSEG1  1.         1.         28.        1.         1.
411 BSEG2  2.         1.         1.         26.        1.
411 BSEG3  3.0        26.0       1. 0       26.0       28.0
```

```
411 BSEG4 4.0       26.0      28.0      1.0       28.0
412       1.0       1.0       3.0       5.0
412 BSEG2 2.0       1.0       6.0       5.0       3.0
412 BSEG3 3.0       1.0       6.0       5.0       4.0
412       4.0       1.0       3.0       5.0
414       2.0                         1.1
414       3.0                         1.1
481       1.0       1.0       2.0
481       2.        2.        3.
481       3.0       3.0       4.0
482       1.0       1.0       5.0       5.0                 0.05
482       2.        1.        5.        5.                  0.25
482       3.0       1.0       5.0       5.0                 0.25
END
TIM                                                 1.
511       0.1
512       0.1       0.1
513       1.0       1.0
514       0.20
521       1000.0    500.
END
EDT                                                 1.
611       2.0
613       2.0
616       2.0
621       1.0       0.        500.0     100.0
622       1.0       26.0      1.0       28.0
623       11.0      14.0      71.0      72.0      73.0      81.0      82.0
623       83.       74.       64.       91.       93.       94.       95.
623       12.       15.
641       1.        0.        500.      250.
624       3.
671       1.        0.        500.      5.
674       1.        1.        71.       1.        2002.
674       2.        1.        71.       1.        4010.
674       3.        1.        71.       1.        26019.
674       4.        1.        71.       1.        16010.
674       5.        1.        5.        1.
674       6.        2.          71.               500.                15.
674       7.        2.          92.               500.                20.
674       8.        2.        72.                 500.                2000.
674       9.        1.        72.       1.        16010.
674       10.       1.        91.       1.        10010.
674       11.       1.        71.       1.        5002.
674       12.       1.        71.       1.        7002.
674       13.       1.        71.       1.        5012.
674       14.       1.        71.       1.        7012.
674       15.       1.        73.       1.        7002.
674       16.       2.        71.                 500.                2.
674       17.       2.        72.                 500.                2.
674       18.       1.        71.       1.        8025.
674       19.       1.        72.       1.        16016.
674       20.       1.        91.       1.        7002.
END
END
```

Attachment VI

Input File for Case 4

```
TTL        BWIP VERTICAL X-SECTION OF SHAFT, CASE 4, W=0.20
PRB                                                   2.
PRO        2.0
SYM        2.
GRV        0.0       -9.807
DTS        2.0       1.
GRD        1.0       1.0       26.0      28.0
END
MAT                                                   1.
111 COHAS  1.0       1.0
112        1.0       2.0       2.0       2.0
121        1.0       2830.0
122        1.0       1.        0.          4.96 E10
132        1.0          1.50 E8
134        1.0         2.97 E10
136        1.0          -2.9 E7
111 AIR    2.0       1.0
112        2.0       2.0       2.0       2.0
121        2.0       1.0
122        2.0       1.        0.         1.000 E00
132        2.0          0.00 E0
134        2.0          0.00 E0
136        2.0         -1.00 E7
111 SEDIM  4.0       1.0
112        4.0       2.0       2.0       2.0
121        4.0       2000.0
122        4.0       1.        0.          1.00 E09
132        4.0          1.00 E7
134        4.0         1.00 E09
136        4.0          -2.9 E7
111 BSLT2  5.0       1.0
112        5.0       2.0       2.0       2.0
121        5.0       2810.0
122        5.0       1.        0.          6.33 E10
132        5.0          1.50 E8
134        5.0         3.27 E10
136        5.0          -2.9 E7
END
GPT                                      1.0       1.0
211        1.0       1.0       1.0       0.9144    -960.
212        1.0       0.0       2.0       2.0
212        2.0       0.0       -960.     1.0
212        3.0       20.       -960.     1.0
212        4.        20.       2.        3.
221        1.        1.        3.        1.        5.
221        2.        1.        3.        5.        24.
221        3.        1.        3.        24.       28.
221        4.        3.        4.        1.        5.
221        5.        3.        4.        5.        24.
221        6.        3.        4.        24.       28.
221        7.        4.        7.        1.        5.
221        8.        4.        7.        5.        24.
221        9.        4.        7.        24.       28.
221        10.       7.        26.       1.        5.
```

```
221        11.        7.         26.        5.         24.
221        12.        7.         26.        24.        28.
247        1.         0.9144     0.0254     -960.      50.        1.         1.
247        2.         0.9144     0.0254     -910.      741.       1.         1.
247        3.         0.9144     0.0254     -169.      169.       1.         1.
247        4.         0.9398     0.01905    -960.      50.        1.         1.
247        5.         0.9398     0.01905    -910.      741.       1.         1.
247        6.         0.9398     0.01905    -169.      169.       1.         1.
247        7.         0.95885    0.4572     -960.      50.        1.         1.
247        8.         0.95885    0.4572     -910.      741.       1.         1.
247        9.         0.95885    0.4572     -169.      169.       1.         1.
247        10.        1.41605    18.584     -960.      50.        1.06       1.
247        11.        1.41605    18.584     -910.      741.       1.06       1.
247        12.        1.41605    18.584     -169.      169.       1.06       1.
END
ZON                                                    1.
311        1.         1.         4.         1.         5.
321        1.         2.
322        1.         1.
311        2.         4.         6.         1.         5.
321        2.         2.
322        2.         1.
322        3.         1.
322        4.         1.
322        5.         1.
322        6.         1.
322        7.         1.
322        8.         1.
322        9.         1.
311        3.         6.         26.        1.         5.
321        3.         1.
311        4.         1.         3.         5.         24.
321        4.         2.
311        5.         3.         6.         5.         24.
321        5.         2.
311        6.         6.         26.        5.         24.
321        6.         5.
311        7.         1.         2.         24.        28.
321        7.         2.
311        8.         2.         7.         24.        28.
321        8.         2.
311        9.         7.         26.        24.        28.
321        9.         4.
END
BDY                                                    1.0
411 BSEG1  1.         1.         28.        1.         1.
411 BSEG2  2.         1.         1.         26.        1.
411 BSEG3  3.0        26.0       1. 0       26.0       28.0
411 BSEG4  4.0        26.0       28.0       1.0        28.0
412        1.0        1.0        3.0        5.0
412 BSEG2  2.0        1.0        6.0        5.0        3.0
412 BSEG3  3.0        1.0        6.0        5.0        4.0
412        4.0        1.0        3.0        5.0
414        2.0                              1.1
414        3.0                              1.1
```

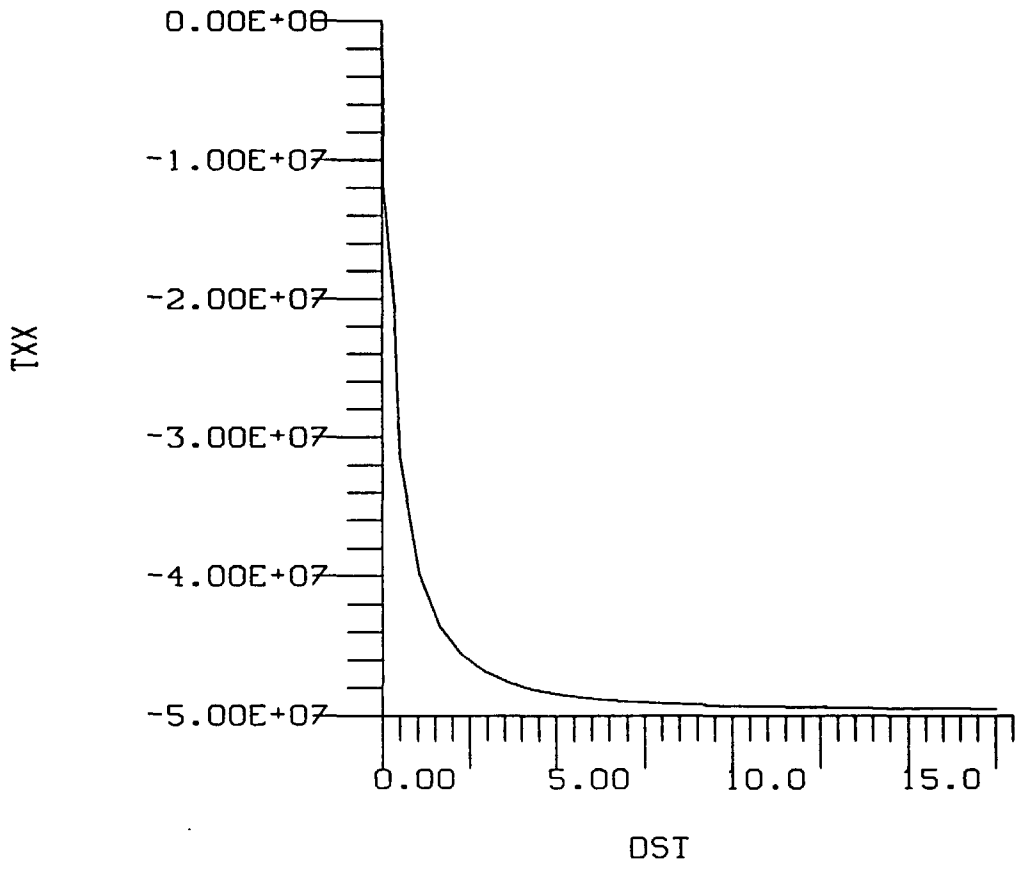
```
481     1.0     1.0     2.0
481     2.      2.      3.
481     3.0     3.0     4.0                             0.05
482     1.0     1.0     5.0     5.0                     0.25
482     2.      1.      5.      5.                      0.25
482     3.0     1.0     5.0     5.0
END                                             1.
TIM
511     0.1
512     0.1     0.1
513     1.0     1.0
514     0.20
521     1000.0  500.
END                                             1.
EDT
611     2.0
613     2.0
616     2.0
621     1.0     0.      500.0   100.0
622     1.0     10.0    1.0     28.0
623     11.0    14.0    71.0    72.0    73.0    81.0    82.0
623     83.     74.     64.     91.     93.     94.     95.
623     12.     15.
641     1.      0.      500.    250.
624     3.
671     1.      0.      500.    5.
674     1.      1.      71.     1.      7002.
674     2.      1.      71.     1.      7010.
674     3.      1.      71.     1.      26019.
674     4.      1.      71.     1.      16010.
674     5.      1.      5.      1.
674     6.      2.      71.             500.                    15.
674     7.      2.      91.             500.                    20.
674     8.      2.      72.             500.                    2000.
674     9.      1.      72.     1.      16010.
674     10.     1.      91.     1.      10010.
674     11.     1.      71.     1.      12002.
674     12.     1.      72.     1.      7002.
674     13.     1.      71.     1.      10012.
674     14.     1.      71.     1.      7012.
674     15.     1.      73.     1.      7004.
674     16.     2.      71.             500.                    2.
674     17.     2.      72.             500.                    2.
674     18.     1.      71.     1.      8025.
674     19.     1.      72.     1.      16016.
674     20.     1.      91.     1.      7002.
END
END
```

Attachment VII

Selected Plots of Stress Distribution as a Function of Radial Location

STEALTH 2D V4-1A WI-1C 87/06/11 17.09.12

BWIP VERTICAL X-SECTION OF SHAFT, EQUIL., W-0.10



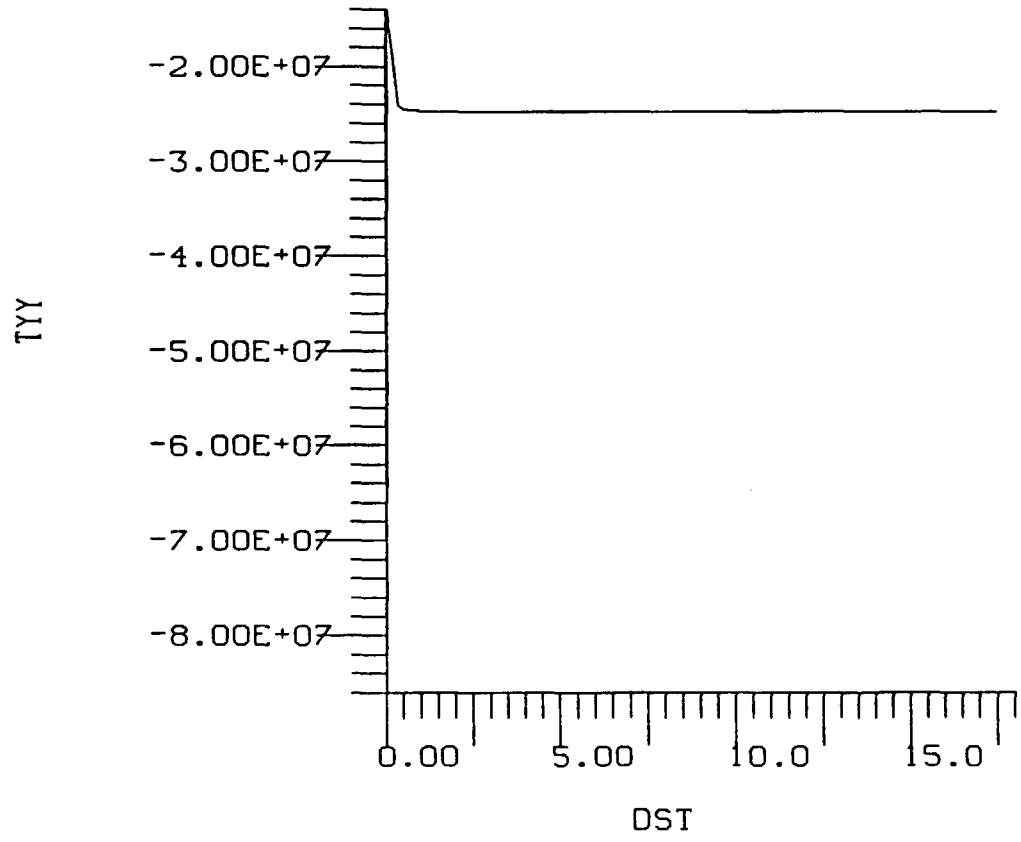
SNAPSHOT OF ROW 2

TIME - 50.000 CYCLE - 500

USER PLOT NUMBER - 16

STEALTH 2D V4-1A WI-1C 87/06/11 17.09.12

BWIP VERTICAL X-SECTION OF SHAFT, EQUIL., W-0.10



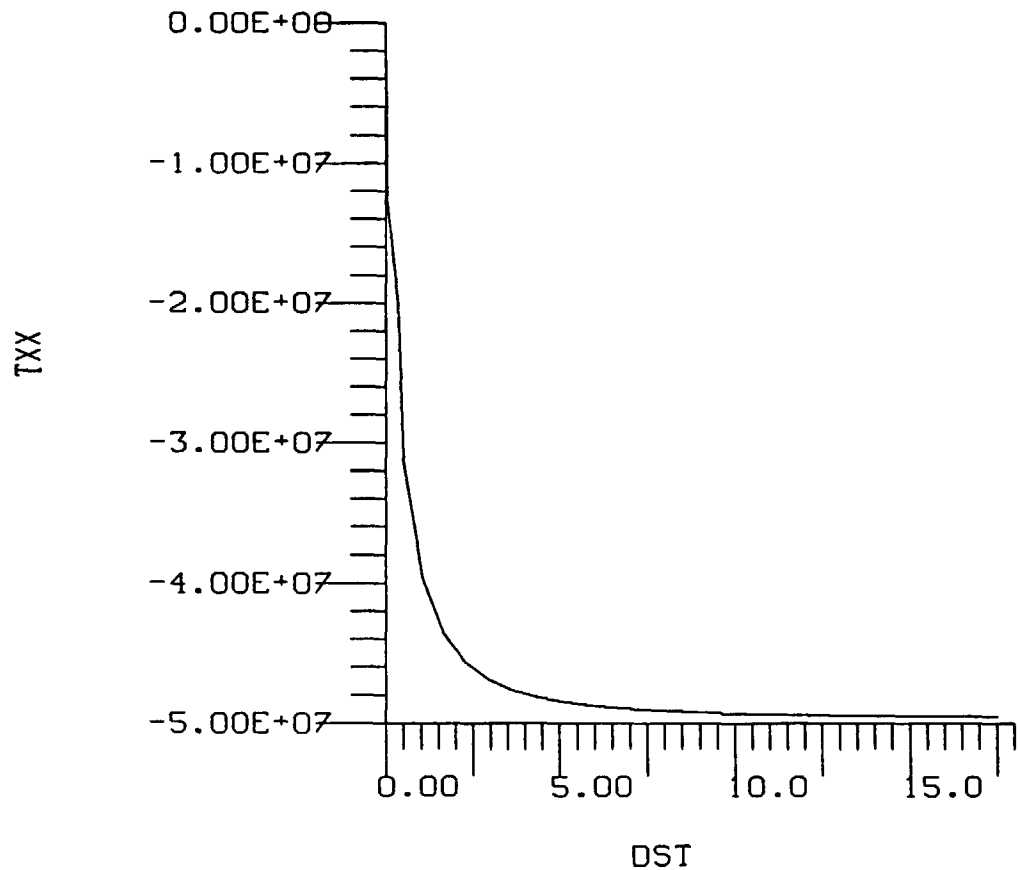
SNAPSHOT OF ROW 2

TIME - 50.000 CYCLE - 500

USER PLOT NUMBER - 17

STEALTH 2D V4-1A WI-1C 87/06/18 14.24.53

BWIP VERTICAL X-SECTION OF SHAFT, EQUIL., W=0.20



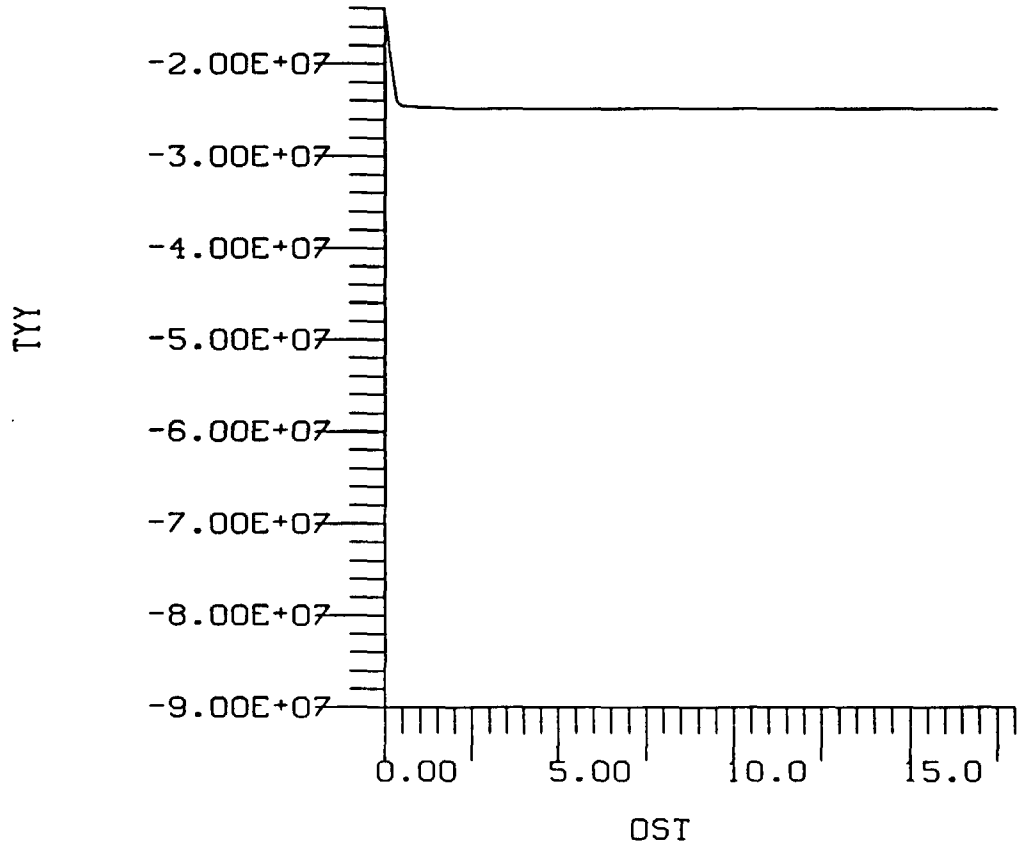
SNAPSHOT OF ROW 2

TIME - 50.000 CYCLE - 500

USER PLOT NUMBER - 16

STEALTH 2D V4-1A WI-1C 87/06/18 14.24.53

BWIP VERTICAL X-SECTION OF SHAFT, EQUIL., W-0.20



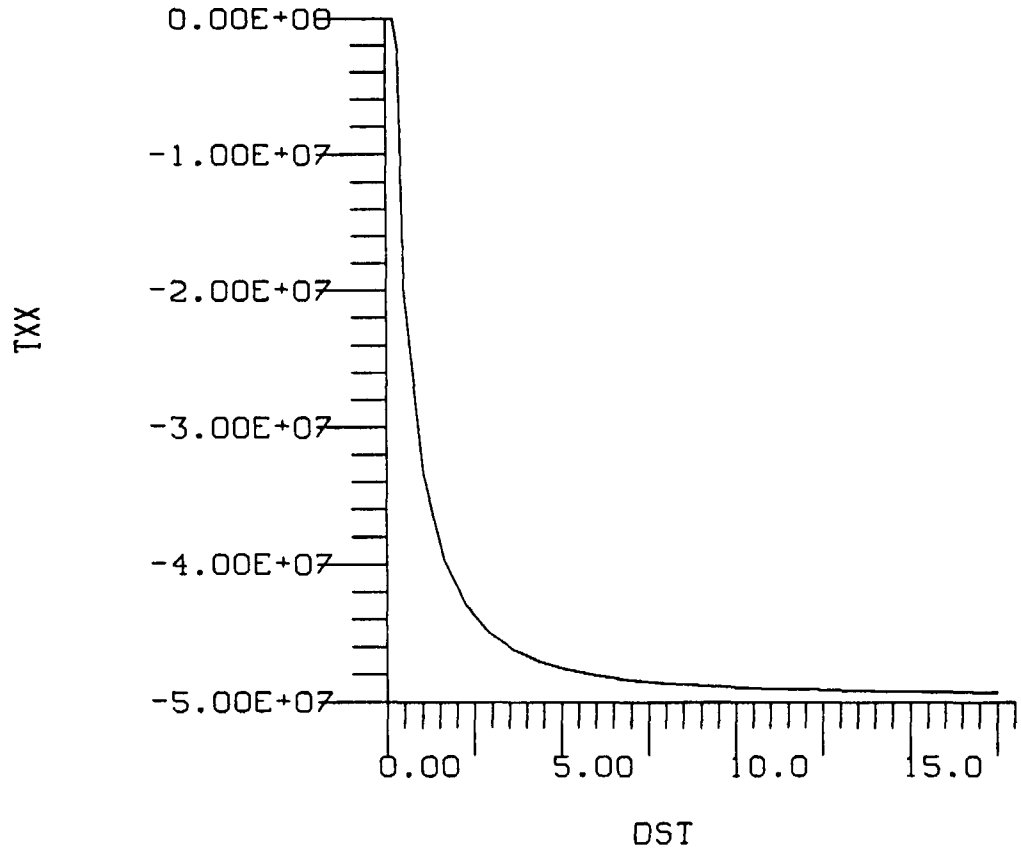
SNAPSHOT OF ROW 2

TIME - 50.000 CYCLE - 500

USER PLOT NUMBER - 17

STEALTH 2D V4-1A WI-1C 87/06/25 15.29.36

BWIP VERTICAL X-SECTION OF SHAFT, NO LINER, W-0.20



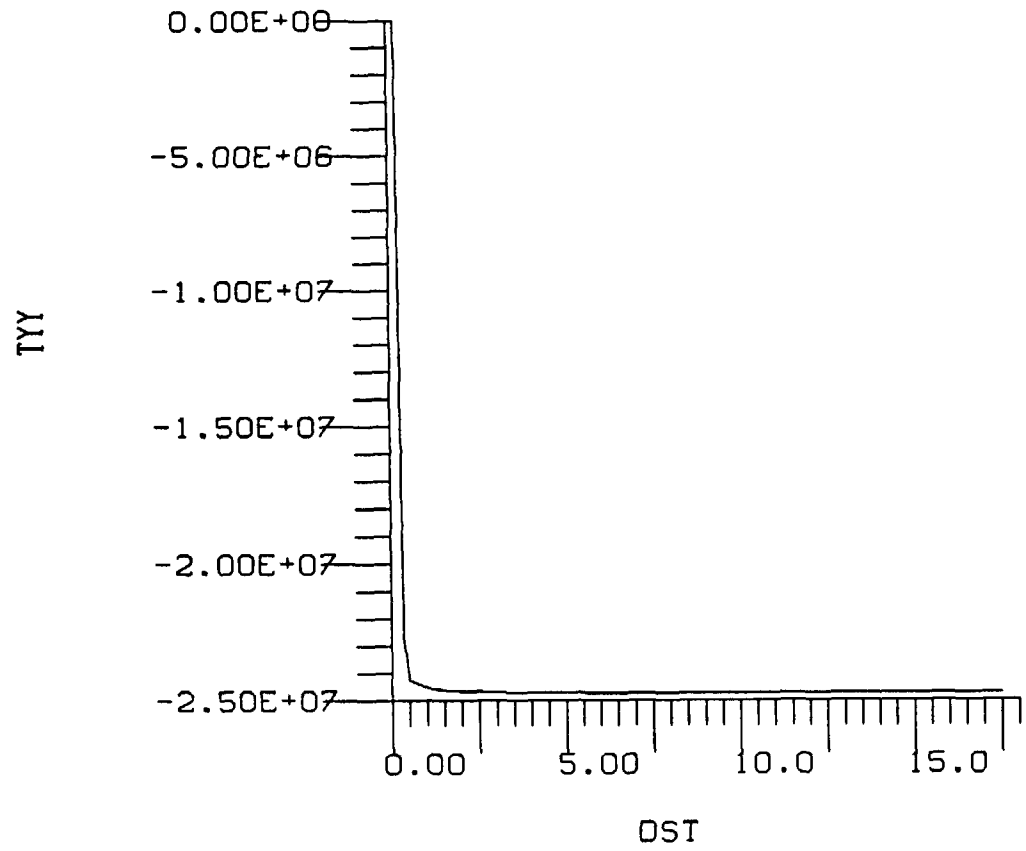
SNAPSHOT OF ROW 2

TIME - 50.000 CYCLE - 500

USER PLOT NUMBER - 16

STEALTH 2D V4-1A WI-1C 87/06/25 15.29.36

BWIP VERTICAL X-SECTION OF SHAFT, NO LINER, W-0.20



SNAPSHOT OF ROW 2

TIME - 50.000 CYCLE - 500

USER PLOT NUMBER - 17

A-1755
1628.010
June 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year -to- Date
I.	Direct Manpower (man-months of charged effort)	1.3	5.2
II.	Direct Loaded Labor Costs	8.0	33.0
	Materials and Services	0.0	0.0
	ADP Support (computer)	3.0	12.0
	Subcontracts	2.0	62.0
	Travel	0.0	2.0
	G & A	1.0	9.0
	Other (computer roundoff)	0.0	0.0
	TOTAL COSTS	14.0	118.0

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
None	250K	250K	None