Table 9, p. 8 of 12

GENOPT user creates this part

```
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
C
      BUCKL(ILOADX) = EIGCRT
C
      RETURN
      END
C
C
C
C
C=DECK      BEHX2
      SUBROUTINE BEHX2
     1 (IFILE,NPRINX,IMODX,IFAST,ILOADX,JCOL,PHRASE)
C
C   PURPOSE: OBTAIN effective stress in shell segment
C
C   YOU MUST WRITE CODE THAT, USING
C   THE VARIABLES IN THE LABELLED
C   COMMON BLOCKS AS INPUT, ULTIMATELY
C   YIELDS THE RESPONSE VARIABLE FOR
C   THE ith LOAD CASE, ILOADX:
C
C     STRESS(ILOADX,JCOL)
C
C   AS OUTPUT. THE ith CASE REFERS
C   TO ith ENVIRONMENT (e.g. load com-
C   bination).
C   THE jth COLUMN  (JCOL)
C   INDEX IS DEFINED AS FOLLOWS:
C     shell segment number
C
C   DEFINITIONS OF INPUT DATA:
C    IMODX  = DESIGN CONTROL INTEGER:
C     IMODX = 0 MEANS BASELINE DESIGN
C     IMODX = 1 MEANS PERTURBED DESIGN
C     IFAST = 0 MEANS FEW  SHORTCUTS FOR PERTURBED DESIGNS
C     IFAST = 1 MEANS MORE SHORTCUTS FOR PERTURBED DESIGNS
C    IFILE = FILE FOR OUTPUT LIST:
C    NPRINX= OUTPUT CONTROL INTEGER:
C     NPRINX=0 MEANS SMALLEST AMOUNT
C     NPRINX=1 MEANS MEDIUM AMOUNT
C     NPRINX=2 MEANS LOTS OF OUTPUT
C
C     ILOADX = ith LOADING COMBINATION
C     JCOL   = jth column of STRESS
C     JCOL   = shell segment number
C     PHRASE = effective stress in shell segment
C
C   OUTPUT:
C
C     STRESS(ILOADX,JCOL)
C
       CHARACTER*80 PHRASE
C  INSERT ADDITIONAL COMMON BLOCKS:
      COMMON/FV06/ZSPH(15),IZSPH
      REAL ZSPH
      COMMON/FV07/ZCYL(15),IZCYL
      REAL ZCYL
      COMMON/FV08/ZREFSP(15),IZREFSP
      REAL ZREFSP
      COMMON/FV09/THKSPH(15)
      REAL THKSPH
      COMMON/FV10/ZREFCY(15),IZREFCY
      REAL ZREFCY
      COMMON/FV11/THKCYL(15)
      REAL THKCYL
      COMMON/FV12/PRESS(20)
      REAL PRESS
      COMMON/FV15/BUCKL(20),BUCKLA(20),BUCKLF(20)
      REAL BUCKL,BUCKLA,BUCKLF
      COMMON/FV18/STRESS(20,10),JSTRESS,STRESSA(20,10),STRESSF(20,10)
      REAL STRESS,STRESSA,STRESSF
      COMMON/IV01/NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      INTEGER NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      COMMON/FV01/RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
      REAL RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
C
C
```

stress analysis

GENTEXT creates this part

Table 9, p. 9 of 12

```
C  INSERT SUBROUTINE STATEMENTS HERE.
C
      COMMON/STRCON/STFMXS(295),STFMXR(295),SKNMAX(295)
      COMMON/IBIGX2/ISTFMS(295),ISTFMR(295),ISKNMX(295)
      COMMON/ENDUVX/ENDUV,STRMAX,ARCLEN
      COMMON/INSTAB/INDIC
      COMMON/PRMOUT/IFILE3,IFILE4,IFILE8,IFILE9,IFIL11
      COMMON/NUMPAR/IPARX,IVARX,IALLOW,ICONSX,NDECX,NLINKX,NESCAP,ITYPEX
      common/caseblock/CASE
      CHARACTER*28 CASE
      CHARACTER*35 CASA
C
      INDIC = 0
C
      CALL BOSDEC(2,24,ILOADX,INDIC)
C
      IF (ITYPEX.EQ.2) THEN
C      Get CASE.BEHX2 file for input for BIGBOSOR4...
C      CASE.BEHX2 is an input file for BIGBOSOR4 for behavior no. 2:
C      maximum effective stress
         I=INDEX(CASE,' ')
         IF(I.NE.0) THEN
            CASA=CASE(:I-1)//'.BEHX2'
         ELSE
            CASA=CASE//'.BEHX2'
         ENDIF
         OPEN(UNIT=61,FILE=CASA,STATUS='UNKNOWN')
         CALL BOSDEC(2,61,ILOADX,INDIC)
         CLOSE(UNIT=61)
         WRITE(IFILE,'(/,/,A,A,/,A)')
     1 ' BIGBOSOR4 input file for:',
     1 ' maximum effective stress (INDIC=0)',
     1   CASA
      ENDIF
C
      CALL B4READ
      CALL B4MAIN
      CALL GASP(DUM1,DUM2,-2,DUM3)
C
      IF (JCOL.EQ.1) THEN
       DO 9 I = 1,2
        WRITE(IFILE,'(A,1P,E12.4,/,A,I4)')
     1 ' Shell skin maximum effective stress,           SKNMAX=',
     1   SKNMAX(I),' at nodal point',ISKNMX(I)
    9  CONTINUE
       WRITE(IFILE,10) STRMAX
   10  FORMAT(/,
     1' ****** MAXIMUM EFFECTIVE STRESS IN ISOTROPIC WALL ******',/,
     1' STRMAX=',1P,E12.4,/,
     1' ******************************************************')
      ENDIF
C
      STRESS(ILOADX,JCOL) = SKNMAX(JCOL)
C
      RETURN
      END
C
C
C
C
C=DECK      USRCON
      SUBROUTINE USRCON(INUMTT,IMODX,CONMAX,ICONSX,IPOINC,CONSTX,
     1  WORDCX,WORDMX,PCWORD,CPLOTX,ICARX,IFILEX)
C   PURPOSE: GENERATE USER-WRITTEN
C   INEQUALITY CONSTRAINT CONDITION
C   USING ANY COMBINATION OF PROGRAM
C   VARIABLES.
C   YOU MUST WRITE CODE THAT, USING
C   THE VARIABLES IN THE LABELLED
C   COMMON BLOCKS AS INPUT, ULTIMATELY
C   YIELDS A CONSTRAINT CONDITION,
C   CALLED "CONX" IN THIS ROUTINE.
      DIMENSION WORDCX(*),WORDMX(*),IPOINC(*),CONSTX(*)
      DIMENSION PCWORD(*),CPLOTX(*)
      CHARACTER*80 WORDCX,WORDMX,PCWORD
C  INSERT ADDITIONAL COMMON BLOCKS:
      COMMON/FV06/ZSPH(15),IZSPH
      REAL ZSPH
```

BOSDEC generates an input file for BIGBOSOR4

means "stress analysis"

creates *.BEHX2

BIGBOSOR4 preprocessor

BIGBOSOR4 mainprocessor

GENOPT uses created this part

GENTEXT creates this part

Table 9, p. 10 of 12

```
      COMMON/FV07/ZCYL(15),IZCYL
      REAL ZCYL
      COMMON/FV08/ZREFSP(15),IZREFSP
      REAL ZREFSP
      COMMON/FV09/THKSPH(15)
      REAL THKSPH
      COMMON/FV10/ZREFCY(15),IZREFCY
      REAL ZREFCY
      COMMON/FV11/THKCYL(15)
      REAL THKCYL
      COMMON/FV12/PRESS(20)
      REAL PRESS
      COMMON/FV15/BUCKL(20),BUCKLA(20),BUCKLF(20)
      REAL BUCKL,BUCKLA,BUCKLF
      COMMON/FV18/STRESS(20,10),JSTRESS,STRESSA(20,10),STRESSF(20,10)
      REAL STRESS,STRESSA,STRESSF
      COMMON/IV01/NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      INTEGER NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      COMMON/FV01/RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
      REAL RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
C
      CONX = 0.0
C
C  INSERT USER-WRITTEN STATEMENTS
C  HERE. THE CONSTRAINT CONDITION
C  THAT YOU CALCULATE IS CALLED "CONX"
C
      IF (CONX.EQ.0.0) RETURN
      IF (CONX.LT.0.0) THEN
         WRITE(IFILEX,*)' CONX MUST BE GREATER THAN ZERO.'
         CALL EXIT
      ENDIF
C
C  DO NOT CHANGE THE FOLLOWING STATEMENTS, EXCEPT WORDC
C
      ICARX = ICARX + 1
      INUMTT = INUMTT + 1
      WORDCX(ICARX) = ' USER: PROVIDE THIS.'
      CPLOTX(ICARX) = CONX - 1.
      CALL BLANKX(WORDCX(ICARX),IENDP)
      PCWORD(ICARX)  = WORDCX(ICARX)(1:IENDP)//' -1'
      IF (IMODX.EQ.0.AND.CONX.GT.CONMAX) GO TO 200
      IF (IMODX.EQ.1.AND.IPOINC(INUMTT).EQ.0) GO TO 200
      ICONSX = ICONSX + 1
      IF (IMODX.EQ.0) IPOINC(INUMTT) = 1
      CONSTX(ICONSX) = CONX
      WORDMX(ICONSX)  = WORDCX(ICARX)(1:IENDP)//' -1'
  200 CONTINUE
C  END OF USRCON
C
C
      RETURN
      END
C
C
C
C=DECK      USRLNK
      SUBROUTINE USRLNK(VARI,I,VARIAB)
C Purpose: generate user-written
C linking conditions using any
C combination of decision variables.
C You must write conde that, using
C the variables in the subroutine
C argument VARIAB as input, ultimately
C yield a value for the linked variable
C VARI.
C
C VARI is the Ith entry of the array
C VARIAB.  You have decided that this
C is to be a linked variable with user
C defined linking.  It is linked to
C the decision variables in the array
C VARIAB.
C An example will provide the simplest
C explanation of this:
C Let"s say that the 5th decision
C variable candidate (I=5) is linked
C to the decision variable candidates
```

GENTEXT creates this part

Table 9, p. 11 of 12

```
C 2 and 7. (You used DECIDE to select
C these as decision variables.
C In this case VARI is equal to
C VARIAB(I).  You then write your
C linking equation in the form
C VARI=f(VARIAB(2),VARIAB(7)).
C Use the index I in an IF statement if
C you have more than one user-defined
C linked variable.
C
C
      REAL VARI,VARIAB(50)
      INTEGER I
C
C  INSERT USER-WRITTEN DECLARATION
C  STATEMENTS HERE.
C
C  INSERT USER-WRITTEN
C  STATEMENTS HERE.
C
C
C  END OF USRLNK
      RETURN
      END
C=DECK       OBJECT
      SUBROUTINE OBJECT(IFILE,NPRINX,IMODX,OBJGEN,PHRASE)
C   PURPOSE:weight of the BIGBOSOR4 model
C
C   YOU MUST WRITE CODE THAT, USING
C   THE VARIABLES IN THE LABELLED
C   COMMON BLOCKS AS INPUT, ULTIMATELY
C   YIELDS THE OBJECTIVE FUNCTION
C         WEIGHT
C   AS OUTPUT. MAKE SURE TO INCLUDE AT
C   THE END OF THE SUBROUTINE, THE
C   STATEMENT: OBJGEN = WEIGHT
C
C
C   DEFINITIONS OF INPUT DATA:
C    IMODX  = DESIGN CONTROL INTEGER:
C     IMODX = 0 MEANS BASELINE DESIGN
C     IMODX = 1 MEANS PERTURBED DESIGN
C     IFAST = 0 MEANS FEW  SHORTCUTS FOR PERTURBED DESIGNS
C     IFAST = 1 MEANS MORE SHORTCUTS FOR PERTURBED DESIGNS
C    IFILE = FILE FOR OUTPUT LIST:
C    NPRINX= OUTPUT CONTROL INTEGER:
C     NPRINX=0 MEANS SMALLEST AMOUNT
C     NPRINX=1 MEANS MEDIUM AMOUNT
C     NPRINX=2 MEANS LOTS OF OUTPUT
C
C   DEFINITION OF PHRASE:
C     PHRASE = weight of the BIGBOSOR4 model
C
      CHARACTER*80 PHRASE
C  INSERT ADDITIONAL COMMON BLOCKS:
      COMMON/FV06/ZSPH(15),IZSPH
      REAL ZSPH
      COMMON/FV07/ZCYL(15),IZCYL
      REAL ZCYL
      COMMON/FV08/ZREFSP(15),IZREFSP
      REAL ZREFSP
      COMMON/FV09/THKSPH(15)
      REAL THKSPH
      COMMON/FV10/ZREFCY(15),IZREFCY
      REAL ZREFCY
      COMMON/FV11/THKCYL(15)
      REAL THKCYL
      COMMON/FV12/PRESS(20)
      REAL PRESS
      COMMON/FV15/BUCKL(20),BUCKLA(20),BUCKLF(20)
      REAL BUCKL,BUCKLA,BUCKLF
      COMMON/FV18/STRESS(20,10),JSTRESS,STRESSA(20,10),STRESSF(20,10)
      REAL STRESS,STRESSA,STRESSF
      COMMON/IV01/NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      INTEGER NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      COMMON/FV01/RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
      REAL RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
C
```

the objective is computed

GENTEX creates this part

Table 9, p. 12 of 12

```
C
C  INSERT SUBROUTINE STATEMENTS HERE.
C
      COMMON/TOTMAX/TOTMAS
C
      WEIGHT = TOTMAS
C
      OBJGEN =WEIGHT
C
C
      RETURN
      END
C
C
C
```

GENOPT user creates this

end of "fleshed out" version of the library, behavior.new

in BIGBOSOR4 "TOTMAS" is the total mass of the multi-segment model. I used weight density rather than mass density. Therefore, in this application TOTMAS is the total weight.

Table 10 (4 pages) bosdec, submarine

```
C=DECK       BOSDEC
C
C  PURPOSE IS TO SET UP BIGBOSOR4 INPUT FILE FOR "trusscomp"
C
      SUBROUTINE BOSDEC(INDX,IFIL14,ILOADX,INDIC)
C  Insert labelled common blocks: submarine.COM
      COMMON/FV06/ZSPH(15),IZSPH
      REAL ZSPH
      COMMON/FV07/ZCYL(15),IZCYL
      REAL ZCYL
      COMMON/FV08/ZREFSP(15),IZREFSP
      REAL ZREFSP
      COMMON/FV09/THKSPH(15)
      REAL THKSPH
      COMMON/FV10/ZREFCY(15),IZREFCY
      REAL ZREFCY
      COMMON/FV11/THKCYL(15)
      REAL THKCYL
      COMMON/FV12/PRESS(20)
      REAL PRESS
      COMMON/FV15/BUCKL(20),BUCKLA(20),BUCKLF(20)
      REAL BUCKL,BUCKLA,BUCKLF
      COMMON/FV18/STRESS(20,10),JSTRESS,STRESSA(20,10),STRESSF(20,10)
      REAL STRESS,STRESSA,STRESSF
      COMMON/IV01/NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      INTEGER NODSPH,NODCYL,NPTSPH,NPTCYL,NBUKLO,NBUKHI
      COMMON/FV01/RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
      REAL RADIUS,LENGTH,EMOD,NU,DENSTY,WEIGHT
C  end of submarine.COM
      COMMON/PRMOUT/IFILE3,IFILE4,IFILE8,IFILE9,IFIL11
      DIMENSION NSHAPE(2),NNODES(2),IHVALU(4,2),HVALU(4,2)
      DIMENSION R1(2),Z1(2),R2(2),Z2(2),RC(2),ZC(2)
      DIMENSION NZVALU(2),Z(15,2),ZVAL(15,2),TVAL(15,2)
      DIMENSION IDISP(2,4)
C
      REWIND IFIL14
C
      WRITE(IFILE4,3)
    3 FORMAT(//'  ***************  BOSDEC  ******************'/
     1'  The purpose of BOSDEC is to set up an input file, NAME.ALL,'/
     1'  for a cylindrical shell. NAME is your name for'/
     1'  the case. The file NAME.ALL is a BOSOR4 input "deck" used'/
     1'  by SUBROUTINE B4READ.'/
     1'  ***********************************************'/)
C
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
C
C  Generate a valid input data file, *.ALL, for BIGBOSOR4
C
C  Global input before segment data...
        NPRT = 1
        NSEG = 2
        ISTRES = 0
        IF (INDX.EQ.2) ISTRES = 1
        IF (INDX.EQ.1) WRITE(IFIL14,'(A)')
     1' buckling of tank (INDIC=1)'
        IF (INDX.EQ.2) WRITE(IFIL14,'(A)')
     1' effective stress (INDIC=0)'
        WRITE(IFIL14,'(4I3,A)') INDIC,NPRT,ISTRES,NSEG,
     1' $ INDIC,NPRT,ISTRES,NSEG'
C
        NTYPEH = 1
        NHVALU = 4
        NSHAPE(1) = 2
        NSHAPE(2) = 1
        NNODES(1) = NODSPH
        NNODES(2) = NODCYL
C
        IHVALU(1,1) = 1
        IHVALU(2,1) = NODSPH/2
        IHVALU(3,1) = NODSPH/2 + 1
        IHVALU(4,1) = NODSPH - 1
        IHVALU(1,2) = 1
        IHVALU(2,2) = NODCYL/2
        IHVALU(3,2) = NODCYL/2 + 1
        IHVALU(4,2) = NODCYL - 1
C
        HVALU(1,1) = 1.
```

BOSDEC generates input files for BIGBOSOR4

Tabla 10 (p. 2 of 4)

```
        HVALU(2,1) = 1.
        HVALU(3,1) = 0.5
        HVALU(4,1) = 0.5
        HVALU(1,2) = 0.5
        HVALU(2,2) = 0.5
        HVALU(3,2) = 1.
        HVALU(4,2) = 1.
C
        R1(1) = 0.
        Z1(1) = 0.
        R2(1) = RADIUS
        Z2(1) = RADIUS
        RC(1) = 0.
        SROT  = -1.
        ZC(1) = RADIUS
        R1(2) = RADIUS
        Z1(2) = RADIUS
        R2(2) = RADIUS
        Z2(2) = RADIUS + LENGTH/2.
C
        NTYPEZ = 1
        NTYPE  = 2
        NZVALU(1) = NPTSPH
        NZVALU(2) = NPTCYL
        DO 10 I = 1,NPTSPH
        Z(I,1) = ZSPH(I)
        ZVAL(I,1) = ZREFSP(I)
        TVAL(I,1) = THKSPH(I)
   10   CONTINUE
        DO 20 I = 1,NPTCYL
        Z(I,2) = ZCYL(I)
        ZVAL(I,2) = ZREFCY(I)
        TVAL(I,2) = THKCYL(I)
   20   CONTINUE
C
C
        DO 100 ISEG = 1,NSEG
         I = ISEG
         WRITE(IFIL14,'(A,4I6)')' H   $ Segment number ',I,I,I,I
         WRITE(IFIL14,'(3I4,A)') NNODES(ISEG),NTYPEH,NHVALU,
     1 ' $ NMESH,NTYPEH,NHVALU'
         WRITE(IFIL14,'(4I4,A)') (IHVALU(K,ISEG),K=1,NHVALU),
     1 ' $ (IHVALU(K,ISEG), K=1,NHVALU)'
         WRITE(IFIL14,'(1P,4E14.6,A)') (HVALU(K,ISEG),K=1,NHVALU),
     1 ' $ (HVALU(K,ISEG), K=1,NHVALU)'
         WRITE(IFIL14,'(I4,A)') NSHAPE(ISEG),
     1 ' $ indicator for meridian geometry'
         WRITE(IFIL14,'(1P,4E14.6,A)') R1(I),Z1(I),R2(I),Z2(I),
     1 ' $ R1,Z1,R2,Z2'
         IF (NSHAPE(ISEG).EQ.2) THEN
          WRITE(IFIL14,'(1P,3E14.6,A)') RC(ISEG),ZC(ISEG),SROT,
     1 ' $ RC,ZC,SROT'
         ENDIF
         WRITE(IFIL14,'(A)')' 0  $ indicator for imperfection'
         WRITE(IFIL14,'(3I4,A)') NTYPEZ,NZVALU(ISEG),NTYPE,
     1 ' $ NTYPEZ,NZVALU,NTYPE'
         NZVAL = NZVALU(ISEG)
         WRITE(IFIL14,'(1P,(4E14.6))') (Z(K,ISEG),K=1,NZVAL)
         WRITE(IFIL14,'(1P,(4E14.6))') (ZVAL(K,ISEG),K=1,NZVAL)
         WRITE(IFIL14,'(A)')' N  $ do you want to print r(s), etc.?'
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
         WRITE(IFIL14,'(A)')' 0, 0, 0, 1  $ NRINGS,K,LINTYP,IDISAB'
         WRITE(IFIL14,'(A)')
     1                   ' 1, 2, 0, 0  $ NLTYPE,NPSTAT,NLOAD(1),NLOAD(2)'
         WRITE(IFIL14,'(A)')
     1                   ' 1, -1., -1., 2  $ NLOAD(3),PN(1),PN(2),NTYPE'
         WRITE(IFIL14,'(1P,2E14.6,A)') Z1(ISEG),Z2(ISEG),
     1 ' $ Z(1),Z(2) callouts'
         WRITE(IFIL14,'(A)')' 2  $ NWALL = 2 for isotropic'
         WRITE(IFIL14,'(1P,3E14.6,A)') EMOD,NU,DENSTY,
     1 ' $ E, U, SM'
         WRITE(IFIL14,'(A)')' 0., 0, -1, 1  $ ALPHA,NRS,NSUR,NTYPET'
         WRITE(IFIL14,'(2I4,A)') NZVALU(ISEG),NTYPE,
     1 ' $ NTVALU, NTYPE'
         NZVAL = NZVALU(ISEG)
         WRITE(IFIL14,'(1P,(4E14.6))') (Z(K,ISEG),K=1,NZVAL)
         WRITE(IFIL14,'(1P,(4E14.6))') (TVAL(K,ISEG),K=1,NZVAL)
         WRITE(IFIL14,'(A)')' N  $ do you want to print refsurf etc.?'
```

Table 10 (p. 3 of 4)

```
          WRITE(IFIL14,'(A)')' N  $ do you want to print C(i,j?'
          WRITE(IFIL14,'(A)')' N  $ do you want to print loads?'
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
C
  100   CONTINUE
C
C  Next, do global data after all the segments...
C
          WRITE(IFIL14,'(A)')' H  $ GLOBAL DATA BEGINS...'
          NLAST = 0
          IF (INDX.EQ.2) NLAST = 1
          WRITE(IFIL14,'(I4A)') NLAST,'  $ NLAST'
          WRITE(IFIL14,'(A)')' N  $ any expanded plots?'
          IF (INDX.EQ.1) THEN
            NMINB = NBUKLO
            NMAXB = NBUKHI
            INCRB = 1
            NVEC  = 1
            WRITE(IFIL14,'(5I6,A)') NMINB,NMINB,NMAXB,INCRB,NVEC,
     1 '  $ N0B,NMINB,NMAXB,INCRB,NVEC'
          ENDIF
          IF (INDX.EQ.1) THEN
             P = 0.
             DP = ABS(PRESS(ILOADX))
          ENDIF
          IF (INDX.EQ.2) THEN
             P = ABS(PRESS(ILOADX))
          ENDIF
          DP = ABS(PRESS(ILOADX))
          WRITE(IFIL14,'(1P,2E14.6,A)') P,DP,'  $ P,DP'
          IF (INDX.EQ.1)
     1    WRITE(IFIL14,'(A)')' 0., 0., 0., 0. $ TEMP,DTEMP,OMEGA,DOMEGA'
          IF (INDX.EQ.2)
     1    WRITE(IFIL14,'(A)')' 0., 0., 1,  0., 0. $ TEMP,DTEMP,NSTEPS,..'
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
          WRITE(IFIL14,'(A)')' H  $ CONSTRAINT CONDITIONS FOLLOW....'
          WRITE(IFIL14,'(I6,A)') NSEG,'  $ how many segments?'
C
C   Next, generate the BIGBOSOR4 input for all the constraint
C   conditions (connections to ground and segment junctions)
C   in the multi-segment model.
C
C   The connections to ground are governed by the array,
C   IDISP(i,j), in which i is the shell segment number,
C   and j is the index for which displacement component is
C   constrained or not constrained.
C
C   IDISP(i,j) = 1 means that the jth displacement component is
C                  constrained to be zero.
C   IDISP(i,j) = 0 means that the jth displacement component is
C                  free
C
C   In BIGBOSOR4 [10] there are 4 displacement components:
C
C   IDISP(i,1) refers to USTAR, the radial (horizontal) displacement
C   IDISP(i,2) refers to VSTAR, the circumferential displacement
C   IDISP(i,3) refers to WSTAR, the axial (vertical) displacement
C   IDISP(i,4) refers to CHI, the meridional rotation
C
C   constraints to grouund  at the midlength of the cylindrical
C   are symmetry conditions:
C
          IDISP(2,1) = 1
          IDISP(2,2) = 0
          IDISP(2,3) = 0
          IDISP(2,4) = 1
C
          WRITE(IFIL14,'(A)')
     1 ' H  $ CONSTRAINT CONDITIONS FOR SEGMENT 1  1  1  1'
           WRITE(IFIL14,'(A)') ' 1, 1, 0  $ one pole, IPOLE, to ground'
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
          WRITE(IFIL14,'(A)')' N  $ joined to other lower segments?'
          WRITE(IFIL14,'(A)')
     1 ' H  $ CONSTRAINT CONDITIONS FOR SEGMENT 2  2  2  2'
          WRITE(IFIL14,'(A)')' 0, 1  $ number of poles, numb. to ground'
          WRITE(IFIL14,'(I6,A)') NODCYL,'  $ node connected to ground'
          WRITE(IFIL14,'(4I4,A)') (IDISP(2,K),K=1,4),
     1 ' $ IUSTAR,IVSTAR,IWSTAR,ICHI'
```

Table 10 (p. 9 of 14)

```
      WRITE(IFIL14,'(A)')' 0., 0.  $ D1,D2'
      WRITE(IFIL14,'(A)')' Y  $ constraint same for prebuck & buck?'
      WRITE(IFIL14,'(A)')' Y  $ joined to lower segments?'
      WRITE(IFIL14,'(A)')' 1, 1, 1  $ how many?, INODE, JSEG'
      WRITE(IFIL14,'(I6,A)') NODSPH,'  $ jseg node of the junction'
      WRITE(IFIL14,'(A)')' 1, 1, 1, 1, 0., 0.  $ connection cond.'
      WRITE(IFIL14,'(A)')' Y  $ constraint same for prebuck & buck?'
      WRITE(IFIL14,'(A)')' H  $ RIGID BODY CONSTRAINT CONDITIONS'
      WRITE(IFIL14,'(A)')' Y  $ is rigid body motion possible?'
      WRITE(IFIL14,'(A)')' Y  $ want to prevent rigid body motion?'
      WRITE(IFIL14,'(A)')' 2  $ Segment no. to prevent rigid body'
      WRITE(IFIL14,'(I6,A)') NODCYL,'  $ node to prevent rigid body'
      WRITE(IFIL14,'(A)')' 1, 1, 0, 1  $ rigid body for n=0 waves'
      WRITE(IFIL14,'(A)')' 1, 1, 0, 1  $ rigid body for n=1 waves'
      WRITE(IFIL14,'(A)')' Y  $ list output for segment 1?'
      WRITE(IFIL14,'(A)')' Y  $ list output for segment 2?'
      WRITE(IFIL14,'(A)')' Y  $ list output for discrete rings?'
C
      RETURN
      END
```

end of BOSDEC

Table II (4 pages) doer. ALL (input for BIGBOSOR4)

```
buckling of tank (INDIC=1)
         1       $ INDIC = analysis type indicator
         1       $ NPRT = output options (1=minimum, 2=medium, 3=maximum)
         0       $ ISTRES= output control (0=resultants, 1=sigma, 2=epsilon)
         2       $ NSEG  = number of shell segments (less than 295)
      H          $
      H          $ SEGMENT NUMBER    1    1    1    1    1    1    1    1
      H          $ NODAL POINT DISTRIBUTION FOLLOWS...
        91       $ NMESH = number of node points (5 = min.; 98 = max.)( 1)
         1       $ NTYPEH= control integer (1 or 3) for nodal point spacing
         4       $ NHVALU= number of callouts for nodal point spacing
         1       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 1)
        45       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 2)
        46       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 3)
        90       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 4)
  1.000000       $ HVALU=meridional arc length between nodal points,HVALU( 1)
  1.000000       $ HVALU=meridional arc length between nodal points,HVALU( 2)
 0.5000000       $ HVALU=meridional arc length between nodal points,HVALU( 3)
 0.5000000       $ HVALU=meridional arc length between nodal points,HVALU( 4)
      H          $ REFERENCE SURFACE GEOMETRY FOLLOWS...
         2       $ NSHAPE= indicator (1,2 or 4) for geometry of meridian
  0.000000       $ R1      = radius at beginning of segment (see p. 66)
  0.000000       $ Z1      = global axial coordinate at beginning of segment
  20.00000       $ R2      = radius at end of segment
  20.00000       $ Z2      = global axial coordinate at end of segment
  0.000000       $ RC      = radius from axis of rev. to center of curvature
  20.00000       $ ZC      = axial coordinate of center of curvature
 -1.000000       $ SROT=indicator for direction of increasing arc (-1. or +1.)
      H          $ IMPERFECTION SHAPE FOLLOWS...
         0       $ IMP   = indicator for imperfection (0=none, 1=some)
      H          $ REFERENCE SURFACE LOCATION RELATIVE TO WALL
         1       $ NTYPEZ= control (1 or 3) for reference surface location
         5       $ NZVALU= number of meridional callouts for ref. surf.
         2       $ NTYPE = control for meaning of callout (2=z, 3=r)
  0.000000       $ Z(I)  = axial coordinate of Ith callout, z( 1)
  10.00000       $ Z(I)  = axial coordinate of Ith callout, z( 2)
  13.00000       $ Z(I)  = axial coordinate of Ith callout, z( 3)
  16.00000       $ Z(I)  = axial coordinate of Ith callout, z( 4)
  20.00000       $ Z(I)  = axial coordinate of Ith callout, z( 5)
 0.6250000       $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 1)
 0.6250000       $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 2)
 0.7250000       $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 3)
 0.8250000       $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 4)
  1.000000       $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 5)
      N          $ Do you want to print out r(s), r'(s), etc. for this segment?
      H          $ DISCRETE RING INPUT FOLLOWS...
         0       $ NRINGS= number (max=20) of discrete rings in this segment
         0       $ K=elastic foundation modulus (e.g. lb/in**3)in this seg.
      H          $ LINE LOAD INPUT FOLLOWS...
         0       $ LINTYP= indicator (0, 1, 2 or 3) for type of line loads
      H          $ DISTRIBUTED LOAD INPUT FOLLOWS...
         1       $ IDISAB= indicator (0, 1, 2 or 3) for load set A and B
      H          $ SURFACE LOAD INPUT FOR LOAD SET "A" FOLLOWS
         1       $ NLTYPE=control (0,1,2,3) for type of surface loading
         2       $ NPSTAT= number of meridional callouts for surface loading
         0       $ NLOAD(1)=indicator for meridional traction (0=none, 1=some)
         0       $ NLOAD(2)=indicator for circumferential traction
         1       $ NLOAD(3)=indicator for normal pressure     (0=none, 1=some)
 -1.000000       $ PN(i)   = normal pressure (p.74) at ith callout, PN( 1)
 -1.000000       $ PN(i)   = normal pressure (p.74) at ith callout, PN( 2)
         2       $ NTYPE = control for meaning of loading callout (2=z, 3=r)
  0.000000       $ Z(I)  = axial coordinate of Ith loading callout, z( 1)
  20.00000       $ Z(I)  = axial coordinate of Ith loading callout, z( 2)
      H          $ SHELL WALL CONSTRUCTION FOLLOWS...
         2       $ NWALL=index (1, 2, 4, 5, 6, 7, 8, 9, 10) for wall construction
0.1600000E+08    $ E     = Young's modulus for skin
0.2500000        $ U     = Poisson's ratio for skin
0.1600000        $ SM =mass density of skin (e.g. alum.=.00025 lb-sec**2/in**4)
  0.000000       $ ALPHA = coefficient of thermal expansion
         0       $ NRS  = control (0 or 1) for addition of smeared stiffeners
        -1       $ NSUR   = control for thickness input (0 or 1 or -1)
         1       $ NTYPET= index (1 or 3) for type of input for thickness
         5       $ NTVALU= number of callouts along segment for thickness
         2       $ NTYPE = control for meaning of thickness callout (2=z, 3=r)
  0.000000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 1)
  10.00000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 2)
  13.00000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 3)
  16.00000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 4)
```

see Fig. 9

This is the properly annotated Version of a BIGBOSOR4 input file.

Table II (p. 2 of 4)

```
  20.00000      $ Z(I)  = axial coordinate of Ith thickness callout, z( 5)
  1.250000      $ TVAL(i) = thickness at Ith callout, TVAL( 1)
  1.250000      $ TVAL(i) = thickness at Ith callout, TVAL( 2)
  1.450000      $ TVAL(i) = thickness at Ith callout, TVAL( 3)
  1.650000      $ TVAL(i) = thickness at Ith callout, TVAL( 4)
  2.000000      $ TVAL(i) = thickness at Ith callout, TVAL( 5)
     N          $ Do you want to print out ref. surf. location and thickness?
     N          $ Do you want to print out the C(i,j) at meridional stations?
     N          $ Do you want to print out distributed loads along meridian?
     H          $
     H          $ SEGMENT NUMBER    2    2    2    2    2    2    2    2
     H          $ NODAL POINT DISTRIBUTION FOLLOWS...
       51       $ NMESH = number of node points (5 = min.; 98 = max.)( 2)
        1       $ NTYPEH= control integer (1 or 3) for nodal point spacing
        4       $ NHVALU= number of callouts for nodal point spacing
        1       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 1)
       25       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 2)
       26       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 3)
       50       $ IHVALU(I)= Ith callout for nodal point spacing, IHVALU( 4)
 0.5000000      $ HVALU=meridional arc length between nodal points,HVALU( 1)
 0.5000000      $ HVALU=meridional arc length between nodal points,HVALU( 2)
  1.000000      $ HVALU=meridional arc length between nodal points,HVALU( 3)
  1.000000      $ HVALU=meridional arc length between nodal points,HVALU( 4)
     H          $ REFERENCE SURFACE GEOMETRY FOLLOWS...
        1       $ NSHAPE= indicator (1,2 or 4) for geometry of meridian
  20.00000      $ R1      = radius at beginning of segment (see p. 66)
  20.00000      $ Z1      = global axial coordinate at beginning of segment
  20.00000      $ R2      = radius at end of segment
  40.00000      $ Z2      = global axial coordinate at end of segment
     H          $ IMPERFECTION SHAPE FOLLOWS...
        0       $ IMP   = indicator for imperfection (0=none, 1=some)
     H          $ REFERENCE SURFACE LOCATION RELATIVE TO WALL
        1       $ NTYPEZ= control (1 or 3) for reference surface location
        5       $ NZVALU= number of meridional callouts for ref. surf.
        2       $ NTYPE = control for meaning of callout (2=z, 3=r)
  20.00000      $ Z(I)  = axial coordinate of Ith callout, z( 1)
  22.00000      $ Z(I)  = axial coordinate of Ith callout, z( 2)
  25.00000      $ Z(I)  = axial coordinate of Ith callout, z( 3)
  30.00000      $ Z(I)  = axial coordinate of Ith callout, z( 4)
  40.00000      $ Z(I)  = axial coordinate of Ith callout, z( 5)
  1.000000      $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 1)
  1.100000      $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 2)
  1.200000      $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 3)
  1.250000      $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 4)
  1.250000      $ ZVAL  = distance from leftmost surf. to ref. surf.,ZVAL( 5)
     N          $ Do you want to print out r(s), r'(s), etc. for this segment?
     H          $ DISCRETE RING INPUT FOLLOWS...
        0       $ NRINGS= number (max=20) of discrete rings in this segment
        0       $ K=elastic foundation modulus (e.g. lb/in**3)in this seg.
     H          $ LINE LOAD INPUT FOLLOWS...
        0       $ LINTYP= indicator (0, 1, 2 or 3) for type of line loads
     H          $ DISTRIBUTED LOAD INPUT FOLLOWS...
        1       $ IDISAB= indicator (0, 1, 2 or 3) for load set A and B
     H          $ SURFACE LOAD INPUT FOR LOAD SET "A" FOLLOWS
        1       $ NLTYPE=control (0,1,2,3) for type of surface loading
        2       $ NPSTAT= number of meridional callouts for surface loading
        0       $ NLOAD(1)=indicator for meridional traction (0=none, 1=some)
        0       $ NLOAD(2)=indicator for circumferential traction
        1       $ NLOAD(3)=indicator for normal pressure     (0=none, 1=some)
-1.000000       $ PN(i)   = normal pressure (p.74) at ith callout, PN( 1)
-1.000000       $ PN(i)   = normal pressure (p.74) at ith callout, PN( 2)
        2       $ NTYPE = control for meaning of loading callout (2=z, 3=r)
 20.00000       $ Z(I)  = axial coordinate of Ith loading callout, z( 1)
 40.00000       $ Z(I)  = axial coordinate of Ith loading callout, z( 2)
     H          $ SHELL WALL CONSTRUCTION FOLLOWS...
        2       $ NWALL=index (1, 2, 4, 5, 6, 7, 8, 9, 10) for wall construction
0.1600000E+08   $ E     = Young's modulus for skin
0.2500000       $ U     = Poisson's ratio for skin
0.1600000       $ SM =mass density of skin (e.g. alum.=.00025 lb-sec**2/in**4)
 0.000000       $ ALPHA = coefficient of thermal expansion
        0       $ NRS  = control (0 or 1) for addition of smeared stiffeners
       -1       $ NSUR   = control for thickness input (0 or 1 or -1)
        1       $ NTYPET= index (1 or 3) for type of input for thickness
        5       $ NTVALU= number of callouts along segment for thickness
        2       $ NTYPE = control for meaning of thickness callout (2=z, 3=r)
 20.00000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 1)
 22.00000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 2)
 25.00000       $ Z(I)  = axial coordinate of Ith thickness callout, z( 3)
```

see Fig. 9

see Fig. 9

Table II (p. 3 of 9)

```
30.00000      $ Z(I)  = axial coordinate of Ith thickness callout, z( 4)
40.00000      $ Z(I)  = axial coordinate of Ith thickness callout, z( 5)
2.000000      $ TVAL(i) = thickness at Ith callout, TVAL( 1)
2.200000      $ TVAL(i) = thickness at Ith callout, TVAL( 2)
2.400000      $ TVAL(i) = thickness at Ith callout, TVAL( 3)
2.500000      $ TVAL(i) = thickness at Ith callout, TVAL( 4)
2.500000      $ TVAL(i) = thickness at Ith callout, TVAL( 5)
   N          $ Do you want to print out ref. surf. location and thickness?
   N          $ Do you want to print out the C(i,j) at meridional stations?
   N          $ Do you want to print out distributed loads along meridian?
   H          $
   H          $ GLOBAL DATA BEGINS...
      0       $ NLAST = plot options  (-1=none, 0=geometry, 1=u,v,w)
   N          $ Are there any regions for which you want expanded plots?
      0       $ N0B   = starting number of circ. waves (buckling analysis)
      0       $ NMINB = minimum number of circ. waves  (buckling analysis)
     10       $ NMAXB = maximum number of circ. waves  (buckling analysis)
      1       $ INCRB = increment in number of circ. waves (buckling)
      1       $ NVEC  = number of eigenvalues for each wave number
0.000000      $ P      = pressure or surface traction multiplier
15000.00      $ DP     = pressure or surface traction multiplier increment
0.000000      $ TEMP   = temperature rise multiplier
0.000000      $ DTEMP  = temperature rise multiplier increment
0.000000      $ OMEGA  = angular vel. about axis of revolution (rad/sec)
0.000000      $ DOMEGA = angular velocity increment (rad/sec)
   H          $ CONSTRAINT CONDITIONS FOLLOW....
      2       $ How many segments in the structure?
   H          $
   H          $ CONSTRAINT CONDITIONS FOR SEGMENT NO.    1    1    1    1
   H          $ POLES INPUT FOLLOWS...
      1       $ Number of poles (places where r=0) in SEGMENT( 1)
      1       $ IPOLE = nodal point number of pole, IPOLE( 1)
   H          $ INPUT FOR CONSTRAINTS TO GROUND FOLLOWS...
      0       $ At how many stations is this segment constrained to ground?
   H          $ JUNCTION CONDITION INPUT FOLLOWS...
   N          $ Is this segment joined to any lower-numbered segments?
   H          $
   H          $ CONSTRAINT CONDITIONS FOR SEGMENT NO.    2    2    2    2
   H          $ POLES INPUT FOLLOWS...
      0       $ Number of poles (places where r=0) in SEGMENT( 2)
   H          $ INPUT FOR CONSTRAINTS TO GROUND FOLLOWS...
      1       $ At how many stations is this segment constrained to ground?
     51       $ INODE = nodal point number of constraint to ground, INODE( 1)
      1       $ IUSTAR=axial displacement constraint (0 or 1 or 2)
      0       $ IVSTAR=circumferential displacement(0=free,1=0,2=imposed)
      0       $ IWSTAR=radial displacement(0=free,1=constrained,2=imposed)
      1       $ ICHI=meridional rotation (0=free,1=constrained,2=imposed)
0.000000      $ D1    = radial component of offset of ground support
0.000000      $ D2    = axial component of offset of ground support
   Y          $ Is this constraint the same for both prebuckling and buckling?
   H          $ JUNCTION CONDITION INPUT FOLLOWS...
   Y          $ Is this segment joined to any lower-numbered segments?
      1       $ At how may stations is this segment joined to previous segs.?
      1       $ INODE = node in current segment (ISEG) of junction, INODE( 1)
      1       $ JSEG  = segment no. of lowest segment involved in junction
     91       $ JNODE = node in lowest segmnt (JSEG) of junction
      1       $ IUSTAR= axial displacement (0=not slaved, 1=slaved)
      1       $ IVSTAR= circumferential displacement (0=not slaved, 1=slaved)
      1       $ IWSTAR= radial displacement (0=not slaved, 1=slaved)
      1       $ ICHI  = meridional rotation (0=not slaved, 1=slaved)
0.000000      $ D1    = radial component of juncture gap
0.000000      $ D2    = axial component of juncture gap
   Y          $ Is this constraint the same for both prebuckling and buckling?
   H          $ RIGID BODY CONSTRAINT INPUT FOLLOWS...
   Y          $ Given existing constraints, are rigid body modes possible?
   Y          $ Do you wish to prevent rigid body motion?
      2       $ ISEG  = segment no. at which to prevent rigid body motion
     51       $ INODE = node no. at which to prevent rigid body motion
      1       $ IUSTAR= axial n=0 rigid body constraint (0=none, 1=some)
      1       $ IVSTAR= circ. n=0 rigid body constraint (usually equals 1)
      0       $ IWSTAR= radial n=0 rigid body constraint (usually equals 0)
      1       $ ICHI  = meridional rot. rigid body constraint
      1       $ IUSTAR= axial n=1 rigid body constraint (usually equals 1)
      1       $ IVSTAR= circ. n=1 rigid body constraint (usually equals 1)
      0       $ IWSTAR= radial n=1 rigid body constraint (usually equals 0)
      1       $ ICHI  = meridional rot. rigid body constraint
   H          $ "GLOBAL3" QUESTIONS (AT END OF CASE)...
   Y          $ Do you want to list output for segment( 1)
```

see Fig. 9

Table 11 (p. 4 of 4)

```
Y       $ Do you want to list output for segment( 2)
Y       $ Do you want to list forces in the discrete rings, if any?
```

end of doer. ALL file.

Table 12 (2 pages) doer.ALL

```
buckling of tank (INDIC=1)
 1  1  0  2 $ INDIC,NPRT,ISTRES,NSEG
H   $ Segment number      1     1     1     1
 91   1   4 $ NMESH,NTYPEH,NHVALU
  1  45  46  90 $ (IHVALU(K,ISEG), K=1,NHVALU)
 1.000000E+00  1.000000E+00  5.000000E-01  5.000000E-01 $ (HVALU(K,ISEG), K=1,NHVALU)
  2 $ indicator for meridian geometry
 0.000000E+00  0.000000E+00  2.000000E+01  2.000000E+01 $ R1,Z1,R2,Z2
 0.000000E+00  2.000000E+01 -1.000000E+00 $ RC,ZC,SROT
0  $ indicator for imperfection
  1   5   2 $ NTYPEZ,NZVALU,NTYPE
 0.000000E+00  1.000000E+01  1.300000E+01  1.600000E+01
 2.000000E+01
 6.250000E-01  6.250000E-01  7.250000E-01  8.250000E-01
 1.000000E+00
N  $ do you want to print r(s), etc.?
0, 0, 0, 1  $ NRINGS,K,LINTYP,IDISAB
1, 2, 0, 0  $ NLTYPE,NPSTAT,NLOAD(1),NLOAD(2)
1, -1., -1., 2  $ NLOAD(3),PN(1),PN(2),NTYPE
 0.000000E+00  2.000000E+01 $ Z(1),Z(2) callouts
2  $ NWALL = 2 for isotropic
 1.600000E+07  2.500000E-01  1.600000E-01 $ E, U, SM
0., 0, -1, 1  $ ALPHA,NRS,NSUR,NTYPET
  5   2 $ NTVALU, NTYPE
 0.000000E+00  1.000000E+01  1.300000E+01  1.600000E+01
 2.000000E+01
 1.250000E+00  1.250000E+00  1.450000E+00  1.650000E+00
 2.000000E+00
N  $ do you want to print refsurf etc.?
N  $ do you want to print C(i,j?
N  $ do you want to print loads?
H   $ Segment number      2     2     2     2
 51   1   4 $ NMESH,NTYPEH,NHVALU
  1  25  26  50 $ (IHVALU(K,ISEG), K=1,NHVALU)
 5.000000E-01  5.000000E-01  1.000000E+00  1.000000E+00 $ (HVALU(K,ISEG), K=1,NHVALU)
  1 $ indicator for meridian geometry
 2.000000E+01  2.000000E+01  2.000000E+01  4.000000E+01 $ R1,Z1,R2,Z2
0  $ indicator for imperfection
  1   5   2 $ NTYPEZ,NZVALU,NTYPE
 2.000000E+01  2.200000E+01  2.500000E+01  3.000000E+01
 4.000000E+01
 1.000000E+00  1.100000E+00  1.200000E+00  1.250000E+00
 1.250000E+00
N  $ do you want to print r(s), etc.?
0, 0, 0, 1  $ NRINGS,K,LINTYP,IDISAB
1, 2, 0, 0  $ NLTYPE,NPSTAT,NLOAD(1),NLOAD(2)
1, -1., -1., 2  $ NLOAD(3),PN(1),PN(2),NTYPE
 2.000000E+01  4.000000E+01 $ Z(1),Z(2) callouts
2  $ NWALL = 2 for isotropic
 1.600000E+07  2.500000E-01  1.600000E-01 $ E, U, SM
0., 0, -1, 1  $ ALPHA,NRS,NSUR,NTYPET
  5   2 $ NTVALU, NTYPE
 2.000000E+01  2.200000E+01  2.500000E+01  3.000000E+01
 4.000000E+01
 2.000000E+00  2.200000E+00  2.400000E+00  2.500000E+00
 2.500000E+00
N  $ do you want to print refsurf etc.?
N  $ do you want to print C(i,j?
N  $ do you want to print loads?
H  $ GLOBAL DATA BEGINS...
  0  $ NLAST
N  $ any expanded plots?
    0     0    10     1     1  $ N0B,NMINB,NMAXB,INCRB,NVEC
 0.000000E+00  1.500000E+04  $ P,DP
0., 0., 0., 0. $ TEMP,DTEMP,OMEGA,DOMEGA
H  $ CONSTRAINT CONDITIONS FOLLOW....
    2  $ how many segments?
H  $ CONSTRAINT CONDITIONS FOR SEGMENT 1  1  1  1
1, 1, 0  $ one pole, IPOLE, to ground
N  $ joined to other lower segments?
H  $ CONSTRAINT CONDITIONS FOR SEGMENT 2  2  2  2
0, 1  $ number of poles, numb. to ground
   51  $ node connected to ground
  1   0   0   1 $ IUSTAR,IVSTAR,IWSTAR,ICHI
0., 0.  $ D1,D2
Y  $ constraint same for prebuck & buck?
Y  $ joined to lower segments?
1, 1, 1  $ how many?, INODE, JSEG
```

This is the version of doer.ALL as produced by BOSDEC.

Table 12 (p. 2 of 2)

```
   91  $ jseg node of the junction
1, 1, 1, 1, 0., 0.  $ connection cond.
Y  $ constraint same for prebuck & buck?
H  $ RIGID BODY CONSTRAINT CONDITIONS
Y  $ is rigid body motion possible?
Y  $ want to prevent rigid body motion?
2  $ Segment no. to prevent rigid body
   51  $ node to prevent rigid body
1, 1, 0, 1  $ rigid body for n=0 waves
1, 1, 0, 1  $ rigid body for n=1 waves
Y  $ list output for segment 1?
Y  $ list output for segment 2?
Y  $ list output for discrete rings?
```

end of doer. ALL

Table 13 doer. BEG

```
n              $ Do you want a tutorial session and tutorial output?
 20.00000      $ radius of the tank: RADIUS
 40.00000      $ total length of the cylinder: LENGTH
0.1600000E+08  $ elastic modulus of the shell wall: EMOD
0.2500000      $ Poisson ratio of the shell wall: NU
0.1600000      $ weight density of the shell wall: DENSTY
      91       $ number of nodal points in the dome: NODSPH
      51       $ number of nodal points in the cylinder: NODCYL
       5       $ number of axial callouts in the dome: NPTSPH
       5       $ Number IZSPH   of rows in the array  ZSPH: IZSPH
 0.000000      $ axial location of callout in the dome: ZSPH( 1)
 10.00000      $ axial location of callout in the dome: ZSPH( 2)
 13.00000      $ axial location of callout in the dome: ZSPH( 3)
 16.00000      $ axial location of callout in the dome: ZSPH( 4)
 20.00000      $ axial location of callout in the dome: ZSPH( 5)
       5       $ Number of axial callouts in the cylinder: NPTCYL
       5       $ Number IZCYL   of rows in the array  ZCYL: IZCYL
 20.00000      $ axial location of callout in the cylinder: ZCYL( 1)
 22.00000      $ axial location of callout in the cylinder: ZCYL( 2)
 25.00000      $ axial location of callout in the cylinder: ZCYL( 3)
 30.00000      $ axial location of callout in the cylinder: ZCYL( 4)
 40.00000      $ axial location of callout in the cylinder: ZCYL( 5)
       5       $ Number IZREFSP of rows in the array  ZREFSP: IZREFSP
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 1)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 2)
0.7250000      $ location of ref. surf. in the dome: ZREFSP( 3)
0.8250000      $ location of ref. surf. in the dome: ZREFSP( 4)
 1.000000      $ location of ref. surf. in the dome: ZREFSP( 5)
 1.250000      $ wall thickness in the dome: THKSPH( 1)
 1.250000      $ wall thickness in the dome: THKSPH( 2)
 1.450000      $ wall thickness in the dome: THKSPH( 3)
 1.650000      $ wall thickness in the dome: THKSPH( 4)
 2.000000      $ wall thickness in the dome: THKSPH( 5)
       5       $ Number IZREFCY of rows in the array  ZREFCY: IZREFCY
 1.000000      $ location of the ref. surf. in the cylinder: ZREFCY( 1)
 1.100000      $ location of the ref. surf. in the cylinder: ZREFCY( 2)
 1.200000      $ location of the ref. surf. in the cylinder: ZREFCY( 3)
 1.250000      $ location of the ref. surf. in the cylinder: ZREFCY( 4)
 1.250000      $ location of the ref. surf. in the cylinder: ZREFCY( 5)
 2.000000      $ thickness of the cylindrical shell: THKCYL( 1)
 2.200000      $ thickness of the cylindrical shell: THKCYL( 2)
 2.400000      $ thickness of the cylindrical shell: THKCYL( 3)
 2.500000      $ thickness of the cylindrical shell: THKCYL( 4)
 2.500000      $ thickness of the cylindrical shell: THKCYL( 5)
       0       $ low end of range of buckling circ. waves: NBUKLO
      10       $ high end of range of buckling circ. waves: NBUKHI
       1       $ Number NCASES  of load cases (environments): NCASES
 15000.00      $ uniform external pressure: PRESS( 1)
 1.000000      $ allowable buckling load (Use 1.0): BUCKLA( 1)
 1.300000      $ factor of safety for buckling: BUCKLF( 1)
       2       $ Number JSTRESS of columns in the array, STRESS: JSTRESS
  120000       $ maximum allowable effective stress: STRESSA( 1, 1)
  120000       $ maximum allowable effective stress: STRESSA( 1, 2)
 1.000000      $ factor of safety for stress: STRESSF( 1, 1)
 1.000000      $ factor of safety for stress: STRESSF( 1, 2)
```

input for BEGIN

Table 14 (2 pages) done, DEC

```
       n          $ Do you want a tutorial session and tutorial output?
       3          $ Choose a decision variable (1,2,3,...)
 0.6250000        $ Lower bound of variable no.( 3)
  1.500000        $ Upper bound of variable no.( 3)
       y          $ Any more decision variables (Y or N) ?
       4          $ Choose a decision variable (1,2,3,...)
 0.6250000        $ Lower bound of variable no.( 4)
  2.500000        $ Upper bound of variable no.( 4)
       y          $ Any more decision variables (Y or N) ?
       5          $ Choose a decision variable (1,2,3,...)
 0.6250000        $ Lower bound of variable no.( 5)
  2.500000        $ Upper bound of variable no.( 5)
       y          $ Any more decision variables (Y or N) ?
       8          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.( 8)
  2.500000        $ Upper bound of variable no.( 8)
       y          $ Any more decision variables (Y or N) ?
       9          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.( 9)
  2.500000        $ Upper bound of variable no.( 9)
       y          $ Any more decision variables (Y or N) ?
      10          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.(10)
  2.500000        $ Upper bound of variable no.(10)
       y          $ Any more decision variables (Y or N) ?
      11          $ Choose a decision variable (1,2,3,...)
 0.6250000        $ Lower bound of variable no.(11)
  1.500000        $ Upper bound of variable no.(11)
       y          $ Any more decision variables (Y or N) ?
      12          $ Choose a decision variable (1,2,3,...)
 0.6250000        $ Lower bound of variable no.(12)
  1.500000        $ Upper bound of variable no.(12)
       y          $ Any more decision variables (Y or N) ?
      13          $ Choose a decision variable (1,2,3,...)
 0.6250000        $ Lower bound of variable no.(13)
  1.500000        $ Upper bound of variable no.(13)
       y          $ Any more decision variables (Y or N) ?
      16          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.(16)
  3.000000        $ Upper bound of variable no.(16)
       y          $ Any more decision variables (Y or N) ?
      17          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.(17)
  3.000000        $ Upper bound of variable no.(17)
       y          $ Any more decision variables (Y or N) ?
      18          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.(18)
  2.500000        $ Upper bound of variable no.(18)
       y          $ Any more decision variables (Y or N) ?
      19          $ Choose a decision variable (1,2,3,...)
  1.250000        $ Lower bound of variable no.(19)
  2.500000        $ Upper bound of variable no.(19)
       n          $ Any more decision variables (Y or N) ?
       y          $ Any linked variables (Y or N) ?
      14          $ Choose a linked variable (1,2,3,...)
       1          $ Choose type of linking (1=polynomial; 2=user-defined)
      19          $ To which variable is this variable linked?
 0.5000000        $ Assign a value to the linking coefficient, C(j)
       1          $ To what power is the decision variable raised?
       n          $ Any other decision variables in the linking expression?
       n          $ Any constant C0 in the linking expression?
       y          $ Any more linked variables (Y or N) ?
      15          $ Choose a linked variable (1,2,3,...)
       1          $ Choose type of linking (1=polynomial; 2=user-defined)
      19          $ To which variable is this variable linked?
 0.5000000        $ Assign a value to the linking coefficient, C(j)
       1          $ To what power is the decision variable raised?
       n          $ Any other decision variables in the linking expression?
       n          $ Any constant C0 in the linking expression?
       y          $ Any more linked variables (Y or N) ?
      20          $ Choose a linked variable (1,2,3,...)
       1          $ Choose type of linking (1=polynomial; 2=user-defined)
      19          $ To which variable is this variable linked?
 1.000000         $ Assign a value to the linking coefficient, C(j)
       1          $ To what power is the decision variable raised?
       n          $ Any other decision variables in the linking expression?
       n          $ Any constant C0 in the linking expression?
       n          $ Any more linked variables (Y or N) ?
```

Input for DECIDE

See Table 16

ZREFCY(4) = $\frac{1}{2}$ THKCYL(4)

ZREFCY(5) = $\frac{1}{2}$ THKCYL(4)

THKCYL(5) = THKCYL(4)

The reference surface is the middle surface in the upper 10 inches of the cyl. segment

The upper 10 inches of the cyl. segment has constant thickness

Table 14 (p. 242)

```
n       $ Any inequality relations among variables? (type H)
y       $ Any escape variables (Y or N) ?
y       $ Want to have escape variables chosen by default?
```

Input for DECIDE

Table 15 doer.OPT

```
n       $ Do you want a tutorial session and tutorial output?
  0     $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
  2     $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
  2     $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
  5     $ How many design iterations in this run (3 to 25)?
n       $ Take "shortcuts" for perturbed designs (Y or N)?
  2     $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
  1     $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
y       $ Do you want default (RATIO=10) for initial move limit jump?
y       $ Do you want the default perturbation (dx/x = 0.05)?
n       $ Do you want to have dx/x modified by GENOPT?
n       $ Do you want to reset total iterations to zero (Type H)?
```

Note → 2

Input for MAINSETUP
for analysis of a fixed design

Table 16 (Bpp.) doer.OPM (output from "OPTIMIZE"

```
      n          $ Do you want a tutorial session and tutorial output?
         0       $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
         2       $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
         2       $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
         5       $ How many design iterations in this run (3 to 25)?
      n          $ Take "shortcuts" for perturbed designs (Y or N)?
         3       $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
         4       $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
      y          $ Do you want default (RATIO=10) for initial move limit jump?
      y          $ Do you want the default perturbation (dx/x = 0.05)?
      n          $ Do you want to have dx/x modified by GENOPT?
      n          $ Do you want to reset total iterations to zero (Type H)?

 ************ END OF THE  doer.OPT  FILE ***********
 ************ JUNE, 2009 VERSION OF GENOPT ****************
 ******** BEGINNING OF THE  doer.OPM  FILE *********


 ********************** MAIN PROCESSOR **********************
 The purpose of the mainprocessor, OPTIMIZE, is to perform,
 in a batch mode, the work specified by MAINSETUP for the case
 called doer.  Results are stored in the file  doer.OPM.
 Please inspect doer.OPM before doing more design iterations.
 ************************************************************


 STRUCTURAL ANALYSIS FOR DESIGN ITERATION NO.    0
0
  STRUCTURAL ANALYSIS WITH UNPERTURBED DECISION VARIABLES
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER       CURRENT     UPPER       DEFINITION
  NO. VAR.  VAR.  VAR.    TO   CONSTANT    BOUND       VALUE       BOUND
   1   N     N     N      0    0.00E+00  0.00E+00  6.2500E-01  0.00E+00  location of ref. surf. i»
n the dome: ZREFSP(1 )
   2   N     N     N      0    0.00E+00  0.00E+00  6.2500E-01  0.00E+00  location of ref. surf. i»
n the dome: ZREFSP(2 )
   3   Y     N     N      0    0.00E+00  6.25E-01  7.2500E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(3 )
   4   Y     N     N      0    0.00E+00  6.25E-01  8.2500E-01  2.50E+00  location of ref. surf. i»
n the dome: ZREFSP(4 )
   5   Y     N     N      0    0.00E+00  6.25E-01  1.0000E+00  2.50E+00  location of ref. surf. i»
n the dome: ZREFSP(5 )
   6   N     N     N      0    0.00E+00  0.00E+00  1.2500E+00  0.00E+00  wall thickness in the do»
me: THKSPH(1 )
   7   N     N     N      0    0.00E+00  0.00E+00  1.2500E+00  0.00E+00  wall thickness in the do»
me: THKSPH(2 )
   8   Y     Y     N      0    0.00E+00  1.25E+00  1.4500E+00  2.50E+00  wall thickness in the do»
me: THKSPH(3 )
   9   Y     Y     N      0    0.00E+00  1.25E+00  1.6500E+00  2.50E+00  wall thickness in the do»
me: THKSPH(4 )
  10   Y     Y     N      0    0.00E+00  1.25E+00  2.0000E+00  2.50E+00  wall thickness in the do»
me: THKSPH(5 )
  11   Y     N     N      0    0.00E+00  6.25E-01  1.0000E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(1 )
  12   Y     N     N      0    0.00E+00  6.25E-01  1.1000E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(2 )
  13   Y     N     N      0    0.00E+00  6.25E-01  1.2000E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(3 )
  14   N     N     Y     19    5.00E-01  0.00E+00  1.2500E+00  0.00E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(4 )
  15   N     N     Y     19    5.00E-01  0.00E+00  1.2500E+00  0.00E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(5 )
  16   Y     Y     N      0    0.00E+00  1.25E+00  2.0000E+00  3.00E+00  thickness of the cylindr»
ical shell: THKCYL(1 )
  17   Y     Y     N      0    0.00E+00  1.25E+00  2.2000E+00  3.00E+00  thickness of the cylindr»
ical shell: THKCYL(2 )
  18   Y     Y     N      0    0.00E+00  1.25E+00  2.4000E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(3 )
  19   Y     Y     N      0    0.00E+00  1.25E+00  2.5000E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(4 )
  20   N     N     Y     19    1.00E+00  0.00E+00  2.5000E+00  0.00E+00  thickness of the cylindr»
ical shell: THKCYL(5 )
  BEHAVIOR FOR  1 ENVIRONMENT (LOAD SET)

 CONSTRAINT  BEHAVIOR              DEFINITION
   NUMBER     VALUE
```

↖ The starting design. See Table 16 of [13].

Table 16, p. 2 of 3

```
 BEHAVIOR FOR LOAD SET NUMBER, ILOADX= 1


 BIGBOSOR4 input file for: buckling load (INDIC=1)
doer.BEHX1

 WEIGHT OF THE BIGBOSOR4 MODEL OF THE TANK
 TOTMAS =  1.5458E+03
 ******************************************************

 BUCKLING LOAD FACTORS AND MODES (BEHX1)
        5.1170E+00(   0)
        5.0881E+00(   1)
        2.3019E+00(   2)
        1.8904E+00(   3)
        2.9298E+00(   4)
        4.4143E+00(   5)
        5.6151E+00(   6)
        6.1995E+00(   7)
        7.0420E+00(   8)
        8.1151E+00(   9)
        9.3925E+00(  10)
 Critical buckling load factor, BUCKL=  1.8904E+00
 Critical number of circumferential waves, NWVCRT=     3
    1        1.890413      tank buckling eigenvalue: BUCKL(1 )

  BEHAVIOR OVER J =  shell segment number


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
 Shell skin maximum effective stress,           SKNMAX=  1.2234E+05
 at nodal point  38
 Shell skin maximum effective stress,           SKNMAX=  1.0877E+05
 at nodal point  18

 ****** MAXIMUM EFFECTIVE STRESS IN ISOTROPIC WALL ******
 STRMAX=  1.2234E+05
 ******************************************************
    2        122343.1      effective stress in shell segment: STRESS(1 ,1 )


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
    3        108771.6      effective stress in shell segment: STRESS(1 ,2 )

 ***** RESULTS FOR LOAD SET NO.  1  ******
 PARAMETERS WHICH DESCRIBE BEHAVIOR (e.g. stress, buckling load)

 BEH.   CURRENT
 NO.     VALUE            DEFINITION
  1    1.890E+00    tank buckling eigenvalue: BUCKL(1 )
  2    1.223E+05    effective stress in shell segment: STRESS(1 ,1 )
  3    1.088E+05    effective stress in shell segment: STRESS(1 ,2 )

 ******* NOTE ******* NOTE ******* NOTE ****** NOTE ******
 The phrase, "NOT APPLY", for MARGIN VALUE means that that
 particular margin value is exactly zero.
 *** END NOTE *** END NOTE *** END NOTE *** END NOTE *****


 ***** RESULTS FOR LOAD SET NO.  1  ******
 MARGINS CORRESPONDING TO CURRENT DESIGN (F.S.= FACTOR OF SAFETY)

 MARGIN CURRENT
 NO.     VALUE            DEFINITION
  1    4.542E-01  (BUCKL(1 )/BUCKLA(1 )) / BUCKLF(1 )-1; F.S.=  1.30
  2   -1.083E-01  (STRESSA(1 ,1 )/STRESS(1 ,1 )) / STRESSF(1 ,1 )-1; F.S.=  1.10
  3    2.935E-03  (STRESSA(1 ,2 )/STRESS(1 ,2 )) / STRESSF(1 ,2 )-1; F.S.=  1.10

 ************************************************
 ******************** DESIGN OBJECTIVE ********************
 *************                                  ************
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:

 VAR.   CURRENT
 NO.     VALUE            DEFINITION
  1    1.546E+03  weight of the BIGBOSOR4 model: WEIGHT
```

critical eigenvalue & mode

shell segment ① (fig. 1)

shell segment ② (fig. 1)

(16)

Table 16 (p. 343)

```
**********                                          **********
******************** DESIGN OBJECTIVE ********************
*****************************************************
***********  ALL 1 LOAD CASES PROCESSED ***********
*****************************************************


PARAMETERS WHICH ARE ALWAYS FIXED.  NONE CAN BE DECISION VARIAB.

VAR.    CURRENT
NO.      VALUE            DEFINITION
 1    2.000E+01  radius of the tank: RADIUS
 2    4.000E+01  total length of the cylinder: LENGTH
 3    1.600E+07  elastic modulus of the shell wall: EMOD
 4    2.500E-01  Poisson ratio of the shell wall: NU
 5    1.600E-01  weight density of the shell wall: DENSTY
 6    0.000E+00  axial location of callout in the dome: ZSPH(1 )
 7    1.000E+01  axial location of callout in the dome: ZSPH(2 )
 8    1.300E+01  axial location of callout in the dome: ZSPH(3 )
 9    1.600E+01  axial location of callout in the dome: ZSPH(4 )
10    2.000E+01  axial location of callout in the dome: ZSPH(5 )
11    2.000E+01  axial location of callout in the cylinder: ZCYL(1 )
12    2.200E+01  axial location of callout in the cylinder: ZCYL(2 )
13    2.500E+01  axial location of callout in the cylinder: ZCYL(3 )
14    3.000E+01  axial location of callout in the cylinder: ZCYL(4 )
15    4.000E+01  axial location of callout in the cylinder: ZCYL(5 )
PARAMETERS WHICH ARE ENVIRONMENTAL FACTORS (e.g. loads, temps.)

VAR.    CURRENT
NO.      VALUE            DEFINITION
 1    1.500E+04  uniform external pressure: PRESS(1 )
PARAMETERS WHICH ARE CLASSIFIED AS ALLOWABLES (e.g. max. stress)

VAR.    CURRENT
NO.      VALUE            DEFINITION
 1    1.000E+00  allowable buckling load (Use 1.0): BUCKLA(1 )
 2    1.200E+05  maximum allowable effective stress: STRESSA(1 ,1 )
 3    1.200E+05  maximum allowable effective stress: STRESSA(1 ,2 )
PARAMETERS WHICH ARE FACTORS OF SAFETY

VAR.    CURRENT
NO.      VALUE            DEFINITION
 1    1.300E+00  factor of safety for buckling: BUCKLF(1 )
 2    1.100E+00  factor of safety for stress: STRESSF(1 ,1 )
 3    1.100E+00  factor of safety for stress: STRESSF(1 ,2 )

   0 INEQUALITY CONSTRAINTS WHICH MUST BE SATISFIED


DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

doer.NAM = This file contains only the name of the case.
doer.OPM = Output data. Please list this file and inspect
           carefully before proceeding.
doer.OPP = Output file containing evolution of design and
           margins since the beginning of optimization cycles.
doer.CBL = Labelled common blocks for analysis.
           (This is an unformatted sequential file.)
doer.OPT = This file contains the input data for MAINSETUP
            as well as OPTIMIZE. The batch command OPTIMIZE
            can be given over and over again without having
            to return to MAINSETUP because doer.OPT exists.
URPROMPT.DAT= Prompt file for interactive input.

For further information about files used and generated
during operation of GENOPT, give the command HELPG FILES.

Menu of commands: CHOOSEPLOT, OPTIMIZE, MAINSETUP, CHANGE,
                  DECIDE, SUPEROPT

IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
RUN  "OPTIMIZE"  MANY TIMES DURING AN OPTIMIZATION AND/OR USE
THE "GLOBAL" OPTIMIZING SCRIPT, "SUPEROPT".
********************* END OF doer.OPM FILE *****************
```

Output from BIGBOSOR4 (bosorplot)

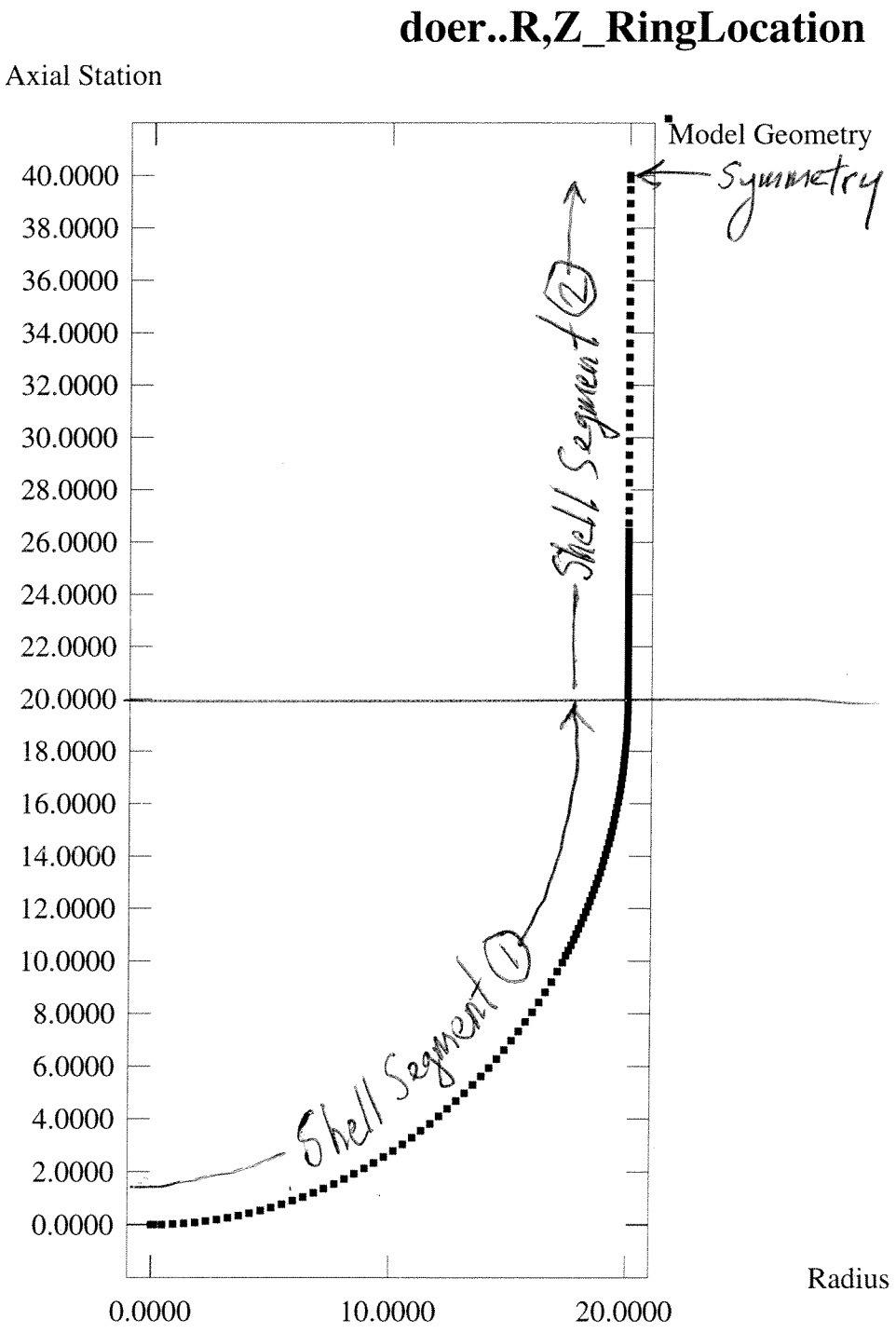

Fig. 1

Output from BIGBOSOR4 (bosorplot)

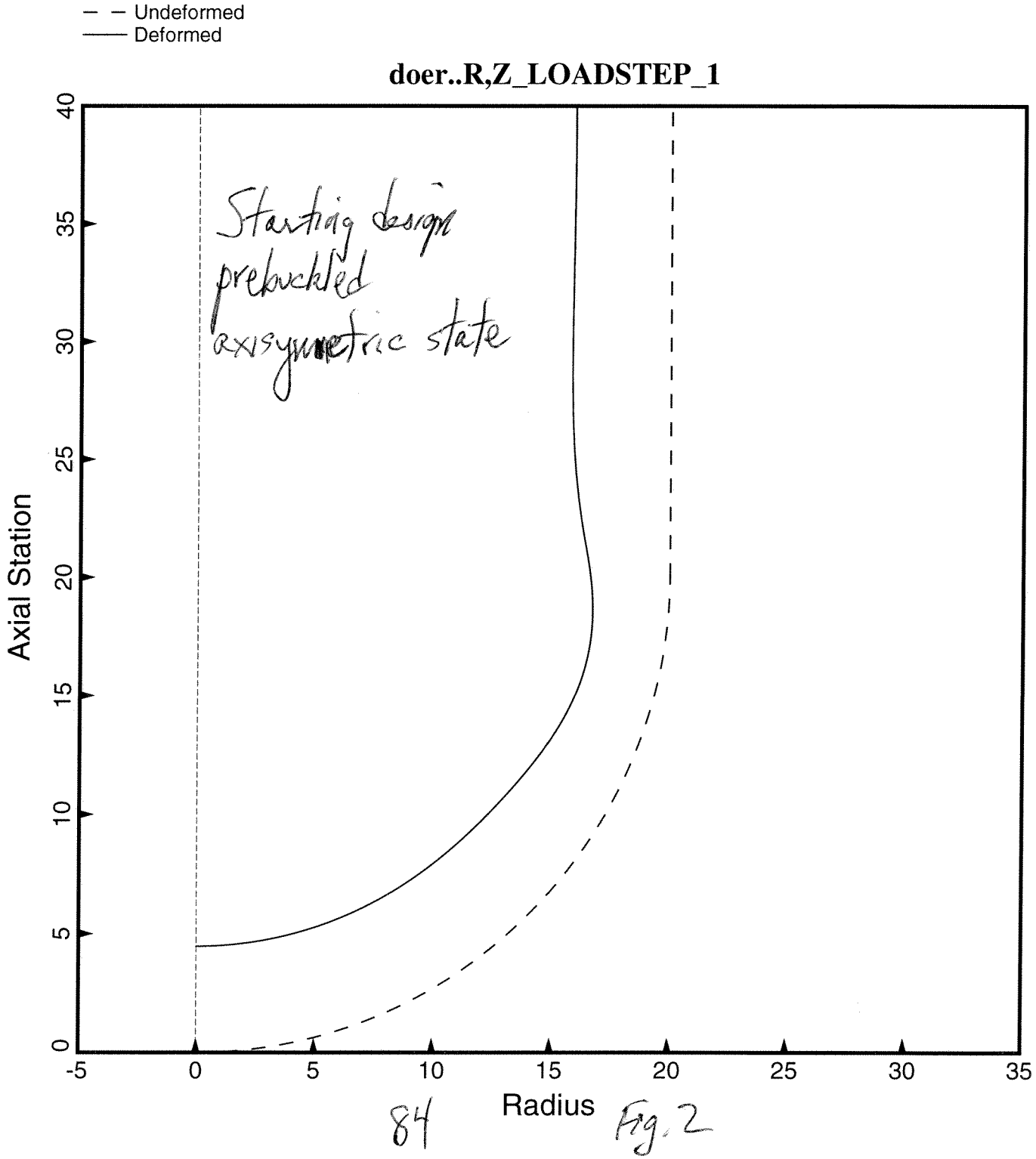

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Fig. 2

Output from BIGBOSOR4 (bosorplot)

Starting design

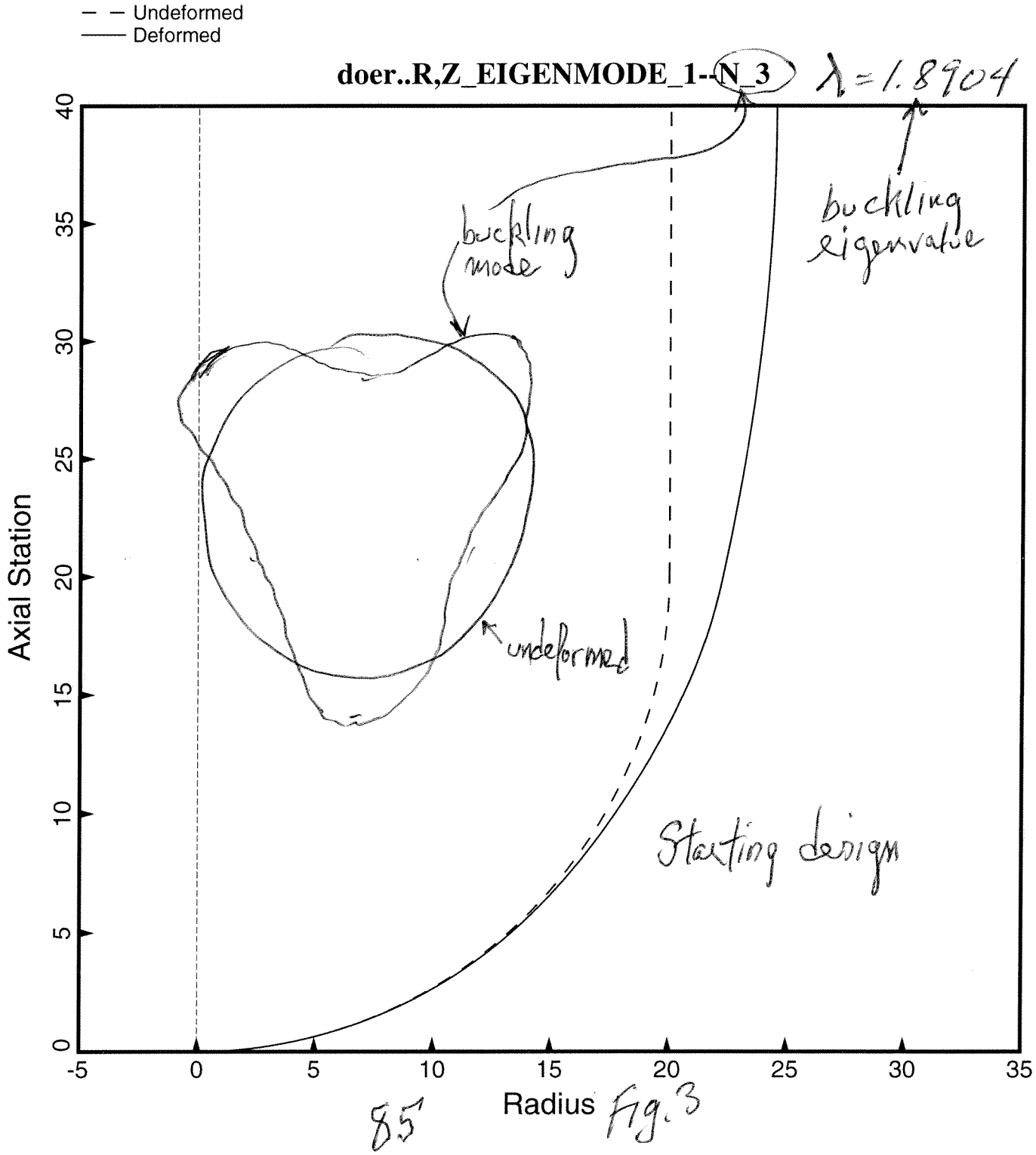
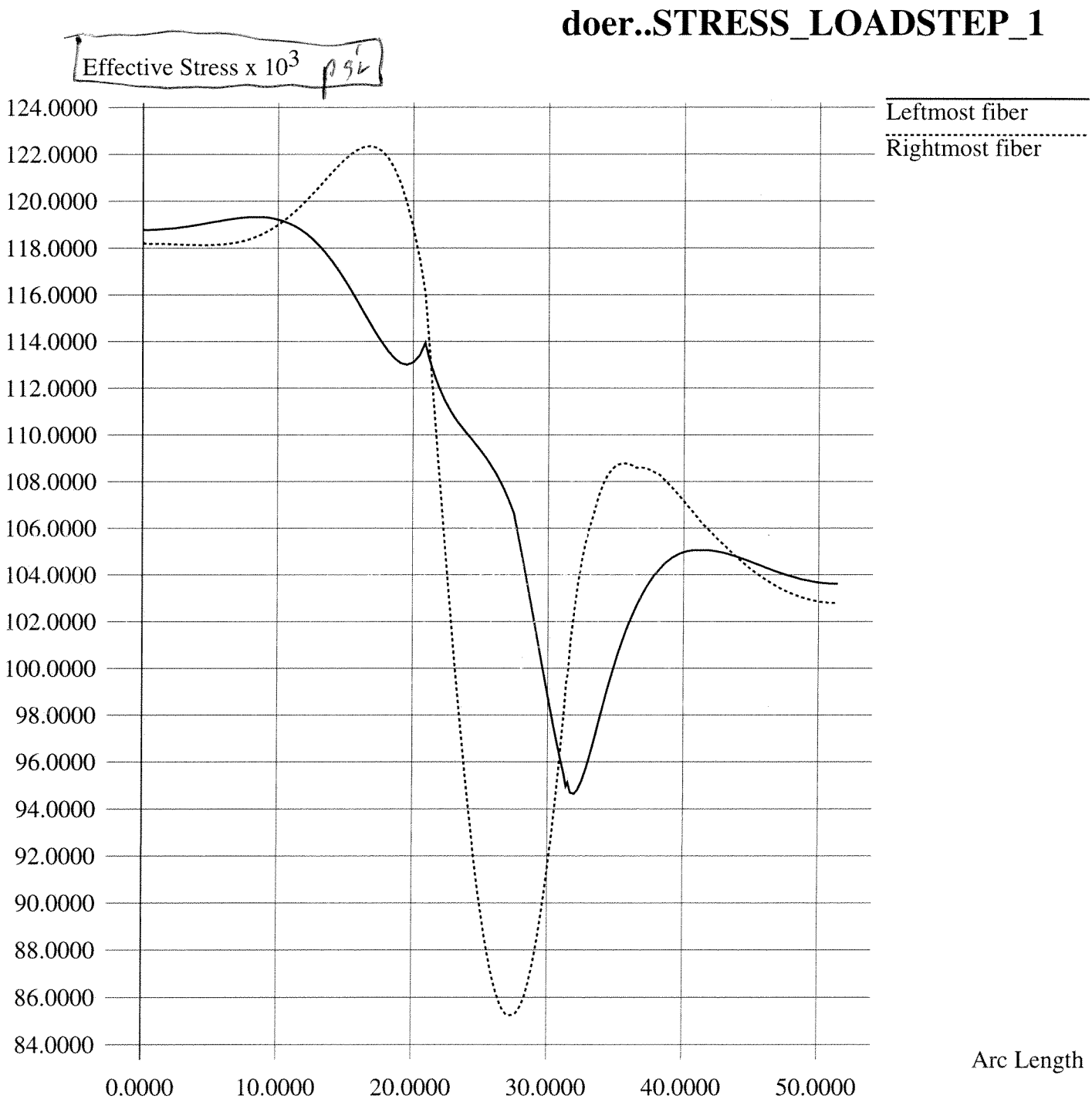


Fig. 3

Output from BIGBOSOR4 (starting design)



Starting design Fig. 4

Table 17 doer.OPT

```
n          $ Do you want a tutorial session and tutorial output?
   0       $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
   0       $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
   1       $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
   5       $ How many design iterations in this run (3 to 25)?
n          $ Take "shortcuts" for perturbed designs (Y or N)?
   2       $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
   1       $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
y          $ Do you want default (RATIO=10) for initial move limit jump?
y          $ Do you want the default perturbation (dx/x = 0.05)?
n          $ Do you want to have dx/x modified by GENOPT?
n          $ Do you want to reset total iterations to zero (Type H)?
```

Note →

input to mainsetup for optimization

Output from SUPEROPT/CHOOSEPLOT/DIPLOT

doer.5.ps

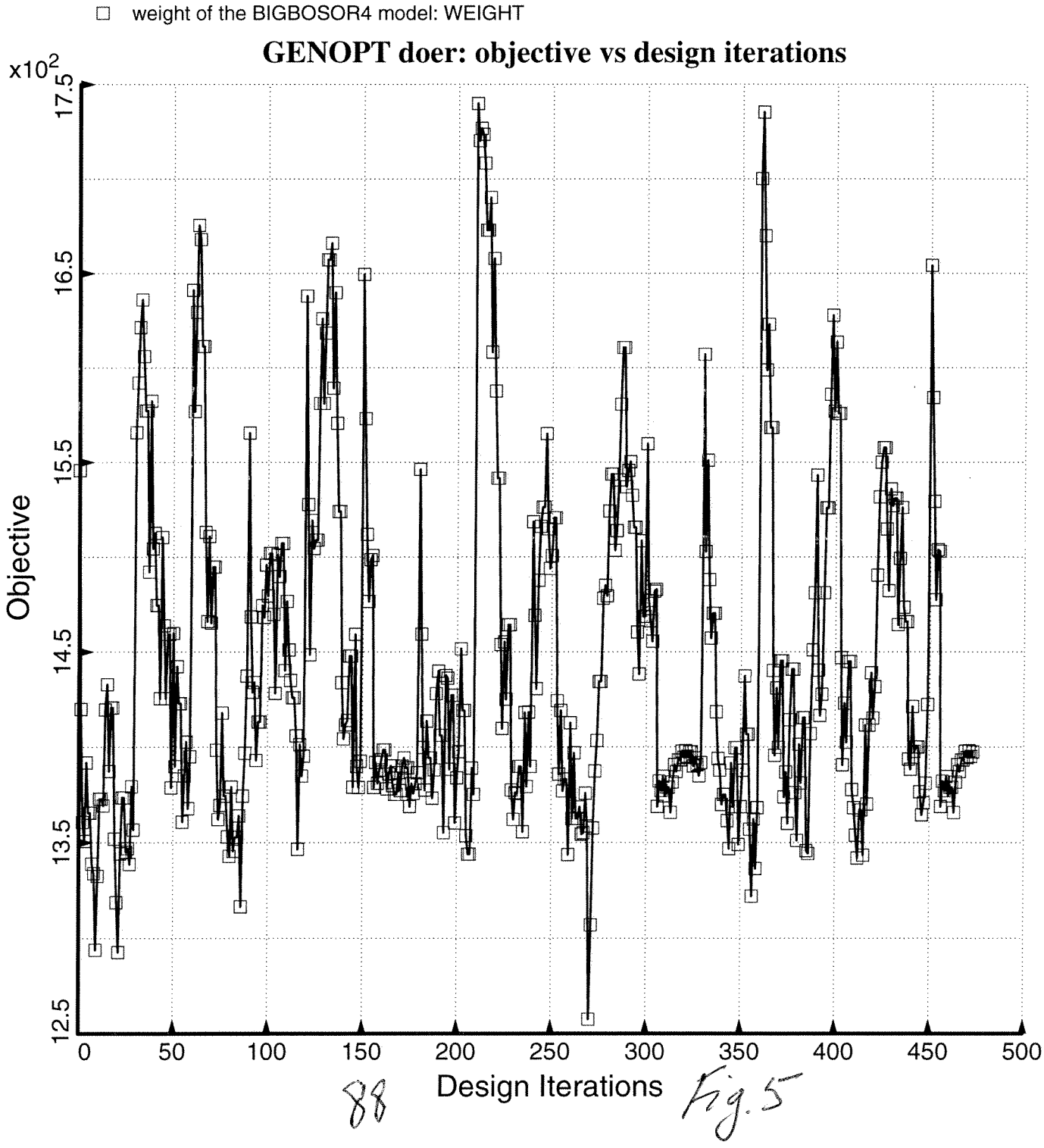


Fig. 5

Table 18 (3 ~~to~~ pages) doer.OPM

```
     n          $ Do you want a tutorial session and tutorial output?
        0       $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
        2       $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
        2       $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
        5       $ How many design iterations in this run (3 to 25)?
     n          $ Take "shortcuts" for perturbed designs (Y or N)?
        2       $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
        1       $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
     y          $ Do you want default (RATIO=10) for initial move limit jump?
     y          $ Do you want the default perturbation (dx/x = 0.05)?
     n          $ Do you want to have dx/x modified by GENOPT?
     n          $ Do you want to reset total iterations to zero (Type H)?

************ END OF THE  doer.OPT  FILE ***********
************ JUNE, 2009 VERSION OF GENOPT ***************
******** BEGINNING OF THE  doer.OPM  FILE *********
```

Output from "OPTIMIZE"

```
********************** MAIN PROCESSOR **********************
The purpose of the mainprocessor, OPTIMIZE, is to perform,
in a batch mode, the work specified by MAINSETUP for the case
called doer.  Results are stored in the file  doer.OPM.
Please inspect doer.OPM before doing more design iterations.
************************************************************
```

Optimum design after one execution of SUPEROPT

```
 STRUCTURAL ANALYSIS FOR DESIGN ITERATION NO.   0:
0
  STRUCTURAL ANALYSIS WITH UNPERTURBED DECISION VARIABLES
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER      CURRENT     UPPER       DEFINITION
  NO. VAR.  VAR.  VAR.    TO   CONSTANT    BOUND       VALUE      BOUND
   1   N     N     N      0    0.00E+00  0.00E+00  6.2500E-01  0.00E+00  location of ref. surf. i»
n the dome: ZREFSP(1 )
   2   N     N     N      0    0.00E+00  0.00E+00  6.2500E-01  0.00E+00  location of ref. surf. i»
n the dome: ZREFSP(2 )
   3   Y     N     N      0    0.00E+00  6.25E-01  6.6694E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(3 )
   4   Y     N     N      0    0.00E+00  6.25E-01  6.4444E-01  2.50E+00  location of ref. surf. i»
n the dome: ZREFSP(4 )
   5   Y     N     N      0    0.00E+00  6.25E-01  7.7483E-01  2.50E+00  location of ref. surf. i»
n the dome: ZREFSP(5 )
   6   N     N     N      0    0.00E+00  0.00E+00  1.2500E+00  0.00E+00  wall thickness in the do»
me: THKSPH(1 )
   7   N     N     N      0    0.00E+00  0.00E+00  1.2500E+00  0.00E+00  wall thickness in the do»
me: THKSPH(2 )
   8   Y     N     N      0    0.00E+00  1.25E+00  1.3091E+00  2.50E+00  wall thickness in the do»
me: THKSPH(3 )
   9   Y     N     N      0    0.00E+00  1.25E+00  1.2500E+00  2.50E+00  wall thickness in the do»
me: THKSPH(4 )
  10   Y     N     N      0    0.00E+00  1.25E+00  1.5676E+00  2.50E+00  wall thickness in the do»
me: THKSPH(5 )
  11   Y     N     N      0    0.00E+00  6.25E-01  9.9422E-01  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(1 )
  12   Y     N     N      0    0.00E+00  6.25E-01  1.0948E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(2 )
  13   Y     N     N      0    0.00E+00  6.25E-01  8.3843E-01  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(3 )
  14   N     N     Y     19    5.00E-01  0.00E+00  1.0898E+00  0.00E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(4 )
  15   N     N     Y     19    5.00E-01  0.00E+00  1.0898E+00  0.00E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(5 )
  16   Y     Y     N      0    0.00E+00  1.25E+00  1.9048E+00  3.00E+00  thickness of the cylindr»
ical shell: THKCYL(1 )
  17   Y     Y     N      0    0.00E+00  1.25E+00  2.1159E+00  3.00E+00  thickness of the cylindr»
ical shell: THKCYL(2 )
  18   Y     Y     N      0    0.00E+00  1.25E+00  1.9536E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(3 )
  19   Y     Y     N      0    0.00E+00  1.25E+00  2.1796E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(4 )
  20   N     N     Y     19    1.00E+00  0.00E+00  2.1796E+00  0.00E+00  thickness of the cylindr»
ical shell: THKCYL(5 )
  BEHAVIOR FOR  1 ENVIRONMENT (LOAD SET)

 CONSTRAINT  BEHAVIOR            DEFINITION
   NUMBER     VALUE
```

Table 18 (p. 2 of 3)

```
 BEHAVIOR FOR LOAD SET NUMBER, ILOADX= 1


 BIGBOSOR4 input file for: buckling load (INDIC=1)
doer.BEHX1

 WEIGHT OF THE BIGBOSOR4 MODEL OF THE TANK
 TOTMAS =  1.3688E+03
 *******************************************************

 BUCKLING LOAD FACTORS AND MODES (BEHX1)
       5.0503E+00(   0)
       5.0362E+00(   1)
       1.8694E+00(   2)
       1.3044E+00(   3)
       1.9491E+00(   4)
       2.9185E+00(   5)
       4.0596E+00(   6)
       5.1299E+00(   7)
       5.8542E+00(   8)
       6.6359E+00(   9)
       7.5675E+00(  10)
 Critical buckling load factor, BUCKL=  1.3044E+00
 Critical number of circumferential waves, NWVCRT=     3
    1        1.304394      tank buckling eigenvalue: BUCKL(1 )

  BEHAVIOR OVER J =  shell segment number


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
 Shell skin maximum effective stress,           SKNMAX=  1.2597E+05
 at nodal point  75
 Shell skin maximum effective stress,           SKNMAX=  1.2356E+05
 at nodal point  33

 ****** MAXIMUM EFFECTIVE STRESS IN ISOTROPIC WALL ******
 STRMAX=  1.2597E+05
 *******************************************************
    2        125968.0      effective stress in shell segment: STRESS(1 ,1 )


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
    3        123558.8      effective stress in shell segment: STRESS(1 ,2 )

 ***** RESULTS FOR LOAD SET NO.  1  ******
 PARAMETERS WHICH DESCRIBE BEHAVIOR (e.g. stress, buckling load)

 BEH.   CURRENT
 NO.     VALUE            DEFINITION
  1    1.304E+00    tank buckling eigenvalue: BUCKL(1 )
  2    1.260E+05    effective stress in shell segment: STRESS(1 ,1 )
  3    1.236E+05    effective stress in shell segment: STRESS(1 ,2 )

 ******* NOTE ******* NOTE ******* NOTE ****** NOTE ******
 The phrase, "NOT APPLY", for MARGIN VALUE means that that
 particular margin value is exactly zero.
 *** END NOTE *** END NOTE *** END NOTE *** END NOTE *****


 ***** RESULTS FOR LOAD SET NO.  1  ******
 MARGINS CORRESPONDING TO CURRENT DESIGN (F.S.= FACTOR OF SAFETY)

 MARGIN CURRENT
 NO.     VALUE            DEFINITION
  1    3.380E-03  (BUCKL(1 )/BUCKLA(1 )) / BUCKLF(1 )-1; F.S.=  1.30
  2   -4.738E-02  (STRESSA(1 ,1 )/STRESS(1 ,1 )) / STRESSF(1 ,1 )-1; F.S.=  1.00
  3   -2.880E-02  (STRESSA(1 ,2 )/STRESS(1 ,2 )) / STRESSF(1 ,2 )-1; F.S.=  1.00

 ************************************************
 ******************* DESIGN OBJECTIVE ***********
 *************                          ***********
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:

 VAR.   CURRENT
 NO.     VALUE            DEFINITION
  1    1.369E+03  weight of the BIGBOSOR4 model: WEIGHT
```

critical / eigenvalue & mode

A bit too high, perhaps

shell segment (1)

shell segment (2)

Compare with p. 2 of Table 22

(lb)

Table 18 (p. 343)

```
**********                                  **********
********** DESIGN OBJECTIVE **********
**************************************************
***********  ALL 1 LOAD CASES PROCESSED ***********
**************************************************

PARAMETERS WHICH ARE ALWAYS FIXED.  NONE CAN BE DECISION VARIAB.

VAR.    CURRENT
NO.       VALUE             DEFINITION
 1     2.000E+01  radius of the tank: RADIUS
 2     4.000E+01  total length of the cylinder: LENGTH
 3     1.600E+07  elastic modulus of the shell wall: EMOD
 4     2.500E-01  Poisson ratio of the shell wall: NU
 5     1.600E-01  weight density of the shell wall: DENSTY
 6     0.000E+00  axial location of callout in the dome: ZSPH(1 )
 7     1.000E+01  axial location of callout in the dome: ZSPH(2 )
 8     1.300E+01  axial location of callout in the dome: ZSPH(3 )
 9     1.600E+01  axial location of callout in the dome: ZSPH(4 )
10     2.000E+01  axial location of callout in the dome: ZSPH(5 )
11     2.000E+01  axial location of callout in the cylinder: ZCYL(1 )
12     2.200E+01  axial location of callout in the cylinder: ZCYL(2 )
13     2.500E+01  axial location of callout in the cylinder: ZCYL(3 )
14     3.000E+01  axial location of callout in the cylinder: ZCYL(4 )
15     4.000E+01  axial location of callout in the cylinder: ZCYL(5 )
PARAMETERS WHICH ARE ENVIRONMENTAL FACTORS (e.g. loads, temps.)

VAR.    CURRENT
NO.       VALUE             DEFINITION
 1     1.500E+04  uniform external pressure: PRESS(1 )
PARAMETERS WHICH ARE CLASSIFIED AS ALLOWABLES (e.g. max. stress)

VAR.    CURRENT
NO.       VALUE             DEFINITION
 1     1.000E+00  allowable buckling load (Use 1.0): BUCKLA(1 )
 2     1.200E+05  maximum allowable effective stress: STRESSA(1 ,1 )
 3     1.200E+05  maximum allowable effective stress: STRESSA(1 ,2 )
PARAMETERS WHICH ARE FACTORS OF SAFETY

VAR.    CURRENT
NO.       VALUE             DEFINITION
 1     1.300E+00  factor of safety for buckling: BUCKLF(1 )
 2     1.000E+00  factor of safety for stress: STRESSF(1 ,1 )
 3     1.000E+00  factor of safety for stress: STRESSF(1 ,2 )

   0 INEQUALITY CONSTRAINTS WHICH MUST BE SATISFIED


DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

doer.NAM = This file contains only the name of the case.
doer.OPM = Output data. Please list this file and inspect
           carefully before proceeding.
doer.OPP = Output file containing evolution of design and
           margins since the beginning of optimization cycles.
doer.CBL = Labelled common blocks for analysis.
           (This is an unformatted sequential file.)
doer.OPT = This file contains the input data for MAINSETUP
            as well as OPTIMIZE. The batch command OPTIMIZE
            can be given over and over again without having
            to return to MAINSETUP because doer.OPT exists.
URPROMPT.DAT= Prompt file for interactive input.

For further information about files used and generated
during operation of GENOPT, give the command HELPG FILES.

Menu of commands: CHOOSEPLOT, OPTIMIZE, MAINSETUP, CHANGE,
                  DECIDE, SUPEROPT

IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
RUN  "OPTIMIZE"  MANY TIMES DURING AN OPTIMIZATION AND/OR USE
THE "GLOBAL" OPTIMIZING SCRIPT, "SUPEROPT".
********** END OF doer.OPM FILE **********
```

Table 19 doer.CHG

```
     n          $ Do you want a tutorial session and tutorial output?
     y          $ Do you want to change any values in Parameter Set No. 1?
       1        $ Number of parameter to change (1, 2, 3, . .)
 0.6250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       2        $ Number of parameter to change (1, 2, 3, . .)
 0.6250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       3        $ Number of parameter to change (1, 2, 3, . .)
 0.6669400      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       4        $ Number of parameter to change (1, 2, 3, . .)
 0.6444400      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       5        $ Number of parameter to change (1, 2, 3, . .)
 0.7748300      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       6        $ Number of parameter to change (1, 2, 3, . .)
  1.250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       7        $ Number of parameter to change (1, 2, 3, . .)
  1.250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       8        $ Number of parameter to change (1, 2, 3, . .)
  1.309100      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       9        $ Number of parameter to change (1, 2, 3, . .)
  1.250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      10        $ Number of parameter to change (1, 2, 3, . .)
  1.567600      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      11        $ Number of parameter to change (1, 2, 3, . .)
 0.9942200      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      12        $ Number of parameter to change (1, 2, 3, . .)
 1.0948000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      13        $ Number of parameter to change (1, 2, 3, . .)
 0.838430       $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      14        $ Number of parameter to change (1, 2, 3, . .)
  1.089800      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      15        $ Number of parameter to change (1, 2, 3, . .)
  1.089800      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      16        $ Number of parameter to change (1, 2, 3, . .)
  1.904800      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      17        $ Number of parameter to change (1, 2, 3, . .)
  2.115900      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      18        $ Number of parameter to change (1, 2, 3, . .)
  1.953600      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      19        $ Number of parameter to change (1, 2, 3, . .)
  2.179600      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      20        $ Number of parameter to change (1, 2, 3, . .)
  2.179600      $ New value of the parameter
     n          $ Want to change any other parameters in this set?
     n          $ Do you want to change values of any "fixed" parameters?
     n          $ Do you want to change any loads?
     n          $ Do you want to change values of allowables?
     n          $ Do you want to change any factors of safety?
```

Always use CHANGE to save optimum designs. The optimum design listed in Table 18 is preserved.

input for CHANGE for optimized design after one execution of SUPEROPT.

Table 20 doer.OPT

```
n          $ Do you want a tutorial session and tutorial output?
  0        $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
  0        $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
  1        $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
 15        $ How many design iterations in this run (3 to 25)?
n          $ Take "shortcuts" for perturbed designs (Y or N)?
  1        $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
  3        $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
y          $ Do you want default (RATIO=10) for initial move limit jump?
y          $ Do you want the default perturbation (dx/x = 0.05)?
n          $ Do you want to have dx/x modified by GENOPT?
n          $ Do you want to reset total iterations to zero (Type H)?
```

Note

input to mainsetup for more optimization

Table 21 doar.CPL

```
     n          $ Do you want a tutorial session and tutorial output?
     y          $ Any design variables to be plotted v. iterations (Y or N)?
       2        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
       3        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
       4        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
       5        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
       7        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
       8        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
       9        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      10        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      11        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      12        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      13        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      14        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      16        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      17        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      18        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     y          $ Any more design variables to be plotted (Y or N) ?
      19        $ Choose a variable to be plotted v. iterations (1,2,3,..)
     n          $ Any more design variables to be plotted (Y or N) ?
     y          $ Any design margins to be plotted v. iterations (Y or N)?
       1        $ Choose a margin to be plotted v. iterations (1,2,3,..)
     y          $ Any more margins to be plotted (Y or N) ?
       2        $ Choose a margin to be plotted v. iterations (1,2,3,..)
     y          $ Any more margins to be plotted (Y or N) ?
       3        $ Choose a margin to be plotted v. iterations (1,2,3,..)
     n          $ Any more margins to be plotted (Y or N) ?
0.3000000       $ Give maximum value (positive) to be included in plot frame.
```

input for CHOOSEPLOT for generating the next three figures via DIPLOT

doer.3.ps

□ (BUCKL(1)/BUCKLA(1)) / BUCKLF(1)-1; F.S.= 1.30
○ (STRESSA(1 ,1)/STRESS(1 ,1)) / STRESSF(1 ,1)-1; F.S.= 1.00
△ (STRESSA(1 ,2)/STRESS(1 ,2)) / STRESSF(1 ,2)-1; F.S.= 1.00

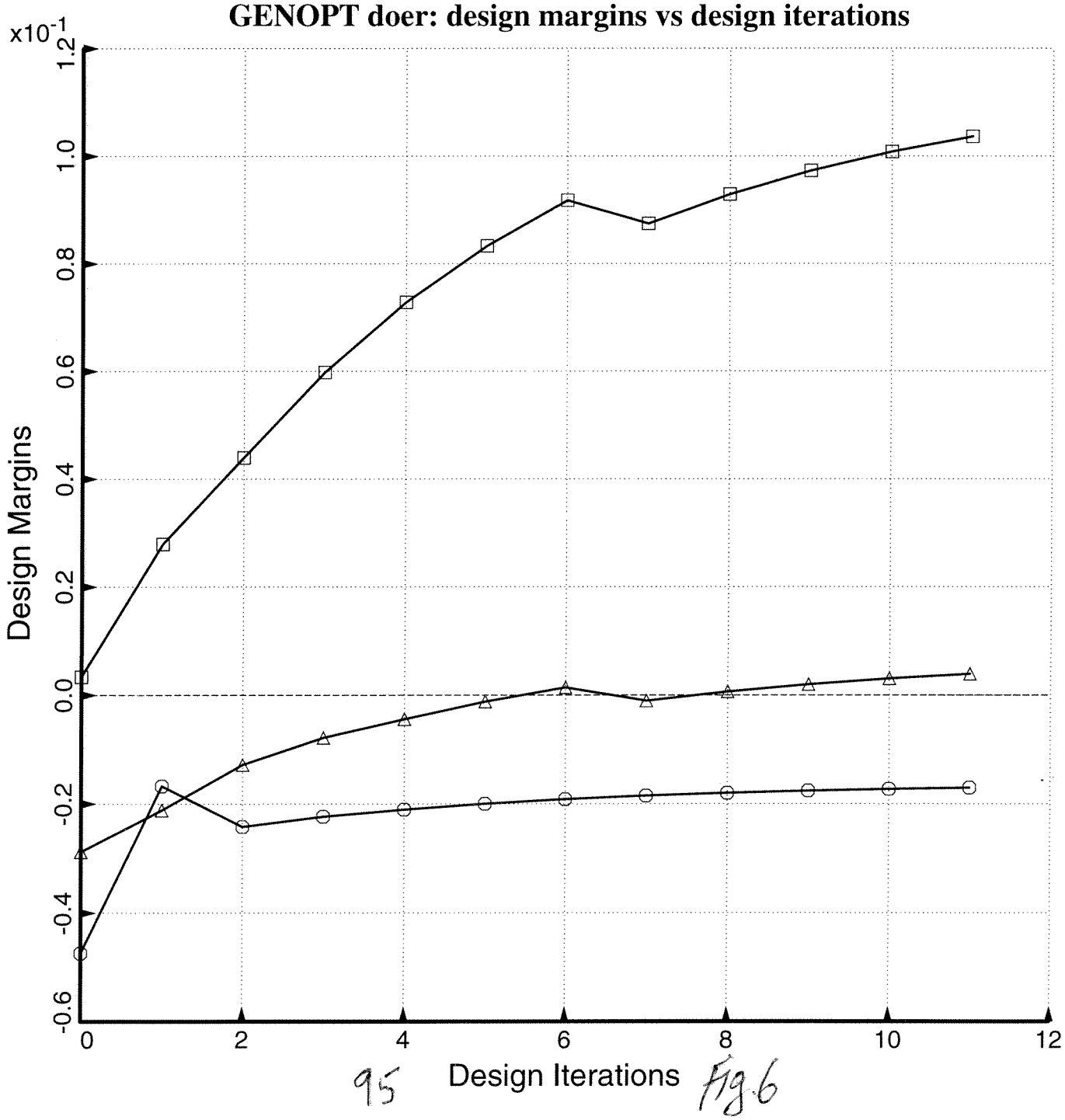


Fig. 6

□ location of ref. surf. in the dome: ZREFSP(2)
○ location of ref. surf. in the dome: ZREFSP(3)
△ location of ref. surf. in the dome: ZREFSP(4)
+ location of ref. surf. in the dome: ZREFSP(5)
× wall thickness in the dome: THKSPH(2)
◇ wall thickness in the dome: THKSPH(3)
▽ wall thickness in the dome: THKSPH(4)
⊠ wall thickness in the dome: THKSPH(5)
✕ location of the ref. surf. in the cylinder: ZREFCY(1)
⌖ location of the ref. surf. in the cylinder: ZREFCY(2)
⊕ location of the ref. surf. in the cylinder: ZREFCY(3)
⧖ location of the ref. surf. in the cylinder: ZREFCY(4)
⊞ thickness of the cylindrical shell: THKCYL(1)
⊠ thickness of the cylindrical shell: THKCYL(2)
⧄ thickness of the cylindrical shell: THKCYL(3)
● thickness of the cylindrical shell: THKCYL(4)

doer.4.ps

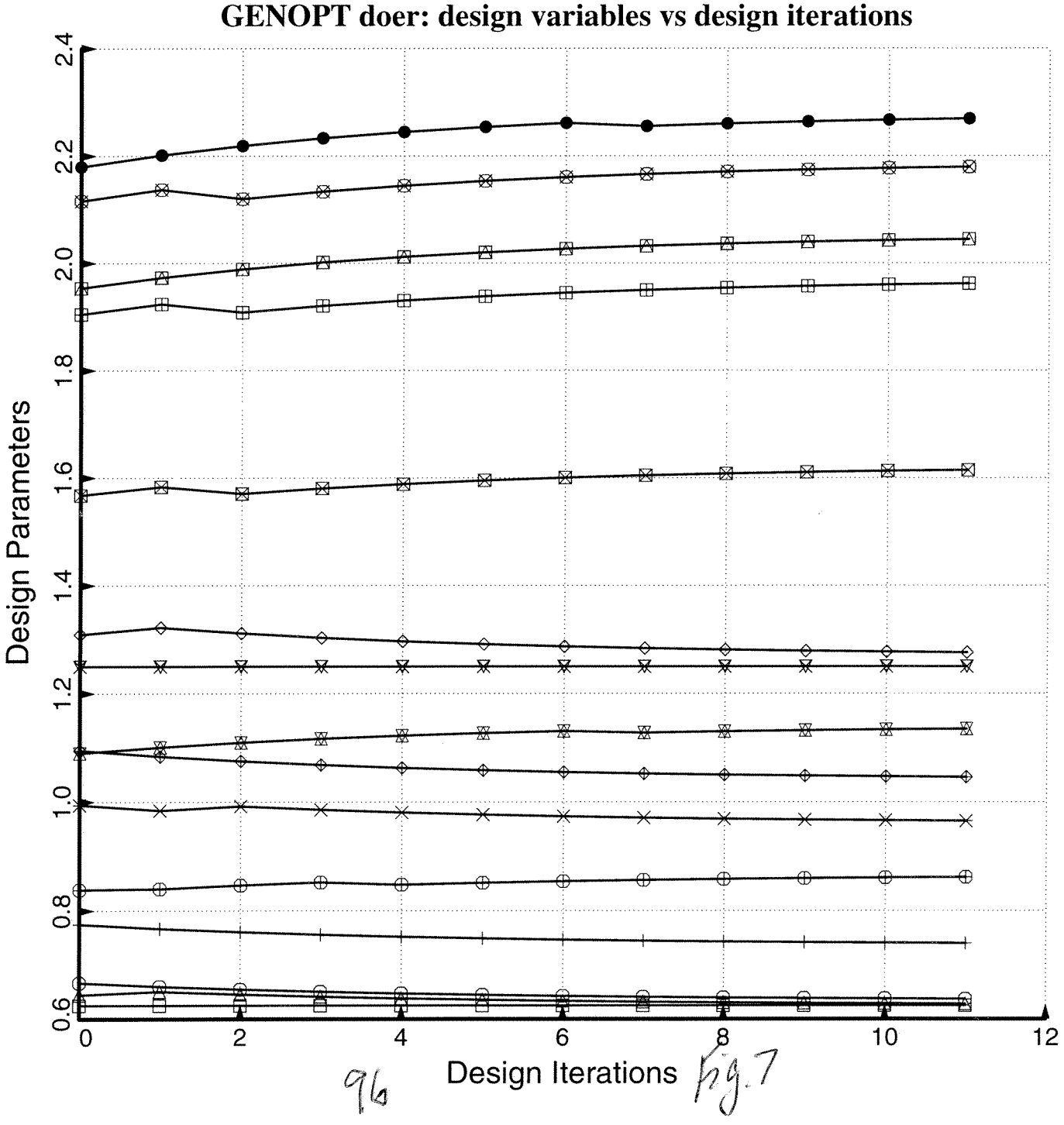
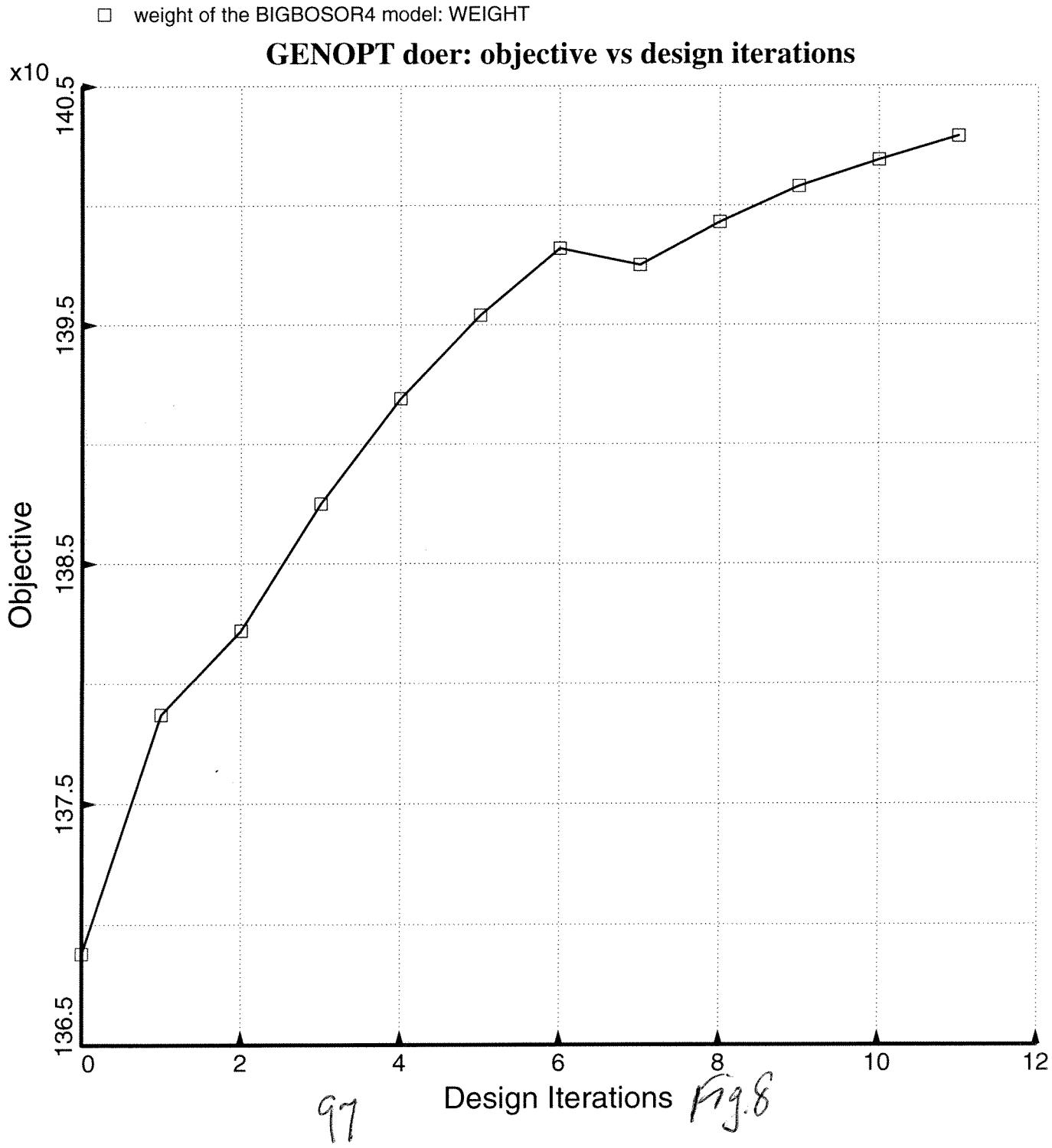


fig.7

doer.5.ps



97

Fig. 8

Table 22 (3pp.) doer.OPM

```
     n          $ Do you want a tutorial session and tutorial output?
        0       $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
        2       $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
        2       $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
       15       $ How many design iterations in this run (3 to 25)?
     n          $ Take "shortcuts" for perturbed designs (Y or N)?
        1       $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
        3       $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
     y          $ Do you want default (RATIO=10) for initial move limit jump?
     y          $ Do you want the default perturbation (dx/x = 0.05)?
     n          $ Do you want to have dx/x modified by GENOPT?
     n          $ Do you want to reset total iterations to zero (Type H)?

************ END OF THE  doer.OPT  FILE ***********
************ JUNE, 2009 VERSION OF GENOPT ****************
******** BEGINNING OF THE  doer.OPM  FILE *********

********************** MAIN PROCESSOR **********************
The purpose of the mainprocessor, OPTIMIZE, is to perform,
in a batch mode, the work specified by MAINSETUP for the case
called doer.  Results are stored in the file  doer.OPM.
Please inspect doer.OPM before doing more design iterations.
************************************************************

 STRUCTURAL ANALYSIS FOR DESIGN ITERATION NO.   0:
0
  STRUCTURAL ANALYSIS WITH UNPERTURBED DECISION VARIABLES
 VAR.  DEC.  ESCAPE  LINK.  LINKED   LINKING     LOWER        CURRENT      UPPER       DEFINITION
  NO.  VAR.   VAR.   VAR.     TO    CONSTANT     BOUND        VALUE       BOUND
   1    N      N      N       0    0.00E+00   0.00E+00   6.2500E-01   0.00E+00   location of ref. surf. i»
n the dome: ZREFSP(1 )
   2    N      N      N       0    0.00E+00   0.00E+00   6.2500E-01   0.00E+00   location of ref. surf. i»
n the dome: ZREFSP(2 )
   3    Y      N      N       0    0.00E+00   6.25E-01   6.3706E-01   1.50E+00   location of ref. surf. i»
n the dome: ZREFSP(3 )
   4    Y      N      N       0    0.00E+00   6.25E-01   6.2800E-01   2.50E+00   location of ref. surf. i»
n the dome: ZREFSP(4 )
   5    Y      N      N       0    0.00E+00   6.25E-01   7.4011E-01   2.50E+00   location of ref. surf. i»
n the dome: ZREFSP(5 )
   6    N      N      N       0    0.00E+00   0.00E+00   1.2500E+00   0.00E+00   wall thickness in the do»
me: THKSPH(1 )
   7    N      N      N       0    0.00E+00   0.00E+00   1.2500E+00   0.00E+00   wall thickness in the do»
me: THKSPH(2 )
   8    Y      Y      N       0    0.00E+00   1.25E+00   1.2758E+00   2.50E+00   wall thickness in the do»
me: THKSPH(3 )
   9    Y      Y      N       0    0.00E+00   1.25E+00   1.2500E+00   2.50E+00   wall thickness in the do»
me: THKSPH(4 )
  10    Y      Y      N       0    0.00E+00   1.25E+00   1.6144E+00   2.50E+00   wall thickness in the do»
me: THKSPH(5 )
  11    Y      N      N       0    0.00E+00   6.25E-01   9.6499E-01   1.50E+00   location of the ref. sur»
f. in the cylinder: ZREFCY(1 )
  12    Y      N      N       0    0.00E+00   6.25E-01   1.0457E+00   1.50E+00   location of the ref. sur»
f. in the cylinder: ZREFCY(2 )
  13    Y      N      N       0    0.00E+00   6.25E-01   8.6174E-01   1.50E+00   location of the ref. sur»
f. in the cylinder: ZREFCY(3 )
  14    N      N      Y      19    5.00E-01   0.00E+00   1.1346E+00   0.00E+00   location of the ref. sur»
f. in the cylinder: ZREFCY(4 )
  15    N      N      Y      19    5.00E-01   0.00E+00   1.1346E+00   0.00E+00   location of the ref. sur»
f. in the cylinder: ZREFCY(5 )
  16    Y      Y      N       0    0.00E+00   1.25E+00   1.9620E+00   3.00E+00   thickness of the cylindr»
ical shell: THKCYL(1 )
  17    Y      Y      N       0    0.00E+00   1.25E+00   2.1794E+00   3.00E+00   thickness of the cylindr»
ical shell: THKCYL(2 )
  18    Y      Y      N       0    0.00E+00   1.25E+00   2.0447E+00   2.50E+00   thickness of the cylindr»
ical shell: THKCYL(3 )
  19    Y      Y      N       0    0.00E+00   1.25E+00   2.2693E+00   2.50E+00   thickness of the cylindr»
ical shell: THKCYL(4 )
  20    N      N      Y      19    1.00E+00   0.00E+00   2.2693E+00   0.00E+00   thickness of the cylindr»
ical shell: THKCYL(5 )
  BEHAVIOR FOR  1 ENVIRONMENT (LOAD SET)

 CONSTRAINT  BEHAVIOR              DEFINITION
   NUMBER     VALUE
```

Output from "OPTIMIZE"

"refined" optimum design

Table 22 (p. 2 of 3)

```
  BEHAVIOR FOR LOAD SET NUMBER, ILOADX= 1


 BIGBOSOR4 input file for: buckling load (INDIC=1)
doer.BEHX1

 WEIGHT OF THE BIGBOSOR4 MODEL OF THE TANK
 TOTMAS =  1.4029E+03
 ****************************************************

 BUCKLING LOAD FACTORS AND MODES (BEHX1)
       5.0469E+00(   0)
       5.0282E+00(   1)
       1.9429E+00(   2)
       1.4347E+00(   3)
       2.1787E+00(   4)
       3.2639E+00(   5)
       4.4859E+00(   6)
       5.2346E+00(   7)
       5.7873E+00(   8)
       6.5147E+00(   9)
       7.4054E+00(  10)
 Critical buckling load factor, BUCKL=  1.4347E+00
 Critical number of circumferential waves, NWVCRT=    3
   1        1.434749      tank buckling eigenvalue: BUCKL(1 )

  BEHAVIOR OVER J =  shell segment number


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
 Shell skin maximum effective stress,          SKNMAX=  1.2208E+05
 at nodal point  73
 Shell skin maximum effective stress,          SKNMAX=  1.1953E+05
 at nodal point  33

 ****** MAXIMUM EFFECTIVE STRESS IN ISOTROPIC WALL ******
 STRMAX=  1.2208E+05
 ****************************************************
   2        122083.0      effective stress in shell segment: STRESS(1 ,1 )


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
   3        119530.0      effective stress in shell segment: STRESS(1 ,2 )

 ***** RESULTS FOR LOAD SET NO.  1  ******
 PARAMETERS WHICH DESCRIBE BEHAVIOR (e.g. stress, buckling load)

 BEH.   CURRENT
 NO.     VALUE            DEFINITION
  1    1.435E+00    tank buckling eigenvalue: BUCKL(1 )
  2    1.221E+05    effective stress in shell segment: STRESS(1 ,1 )
  3    1.195E+05    effective stress in shell segment: STRESS(1 ,2 )

 ******* NOTE ******* NOTE ******* NOTE ****** NOTE ******
 The phrase, "NOT APPLY", for MARGIN VALUE means that that
 particular margin value is exactly zero.
 *** END NOTE *** END NOTE *** END NOTE *** END NOTE *****


 ***** RESULTS FOR LOAD SET NO.  1  ******
 MARGINS CORRESPONDING TO CURRENT DESIGN (F.S.= FACTOR OF SAFETY)

 MARGIN CURRENT
 NO.     VALUE            DEFINITION
  1    1.037E-01   (BUCKL(1 )/BUCKLA(1 )) / BUCKLF(1 )-1; F.S.=  1.30
  2   -1.706E-02   (STRESSA(1 ,1 )/STRESS(1 ,1 )) / STRESSF(1 ,1 )-1; F.S.=  1.00
  3    3.932E-03   (STRESSA(1 ,2 )/STRESS(1 ,2 )) / STRESSF(1 ,2 )-1; F.S.=  1.00

 ****************************************************
 ******************* DESIGN OBJECTIVE ******************
 ************                                ***********
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:

 VAR.   CURRENT
 NO.     VALUE            DEFINITION
  1    1.403E+03   weight of the BIGBOSOR4 model: WEIGHT
```

critical eigenvalue & mode

This is acceptable now

Compare with p. 2 of Table 18

Table 22 (p. 3 of 3)

```
************                                        ************
******************** DESIGN OBJECTIVE ********************
*****************************************************
***********  ALL 1 LOAD CASES PROCESSED ***********
*****************************************************


 PARAMETERS WHICH ARE ALWAYS FIXED.  NONE CAN BE DECISION VARIAB.

 VAR.    CURRENT
 NO.       VALUE              DEFINITION
  1     2.000E+01  radius of the tank: RADIUS
  2     4.000E+01  total length of the cylinder: LENGTH
  3     1.600E+07  elastic modulus of the shell wall: EMOD
  4     2.500E-01  Poisson ratio of the shell wall: NU
  5     1.600E-01  weight density of the shell wall: DENSTY
  6     0.000E+00  axial location of callout in the dome: ZSPH(1 )
  7     1.000E+01  axial location of callout in the dome: ZSPH(2 )
  8     1.300E+01  axial location of callout in the dome: ZSPH(3 )
  9     1.600E+01  axial location of callout in the dome: ZSPH(4 )
 10     2.000E+01  axial location of callout in the dome: ZSPH(5 )
 11     2.000E+01  axial location of callout in the cylinder: ZCYL(1 )
 12     2.200E+01  axial location of callout in the cylinder: ZCYL(2 )
 13     2.500E+01  axial location of callout in the cylinder: ZCYL(3 )
 14     3.000E+01  axial location of callout in the cylinder: ZCYL(4 )
 15     4.000E+01  axial location of callout in the cylinder: ZCYL(5 )
 PARAMETERS WHICH ARE ENVIRONMENTAL FACTORS (e.g. loads, temps.)

 VAR.    CURRENT
 NO.       VALUE              DEFINITION
  1     1.500E+04  uniform external pressure: PRESS(1 )
 PARAMETERS WHICH ARE CLASSIFIED AS ALLOWABLES (e.g. max. stress)

 VAR.    CURRENT
 NO.       VALUE              DEFINITION
  1     1.000E+00  allowable buckling load (Use 1.0): BUCKLA(1 )
  2     1.200E+05  maximum allowable effective stress: STRESSA(1 ,1 )
  3     1.200E+05  maximum allowable effective stress: STRESSA(1 ,2 )
 PARAMETERS WHICH ARE FACTORS OF SAFETY

 VAR.    CURRENT
 NO.       VALUE              DEFINITION
  1     1.300E+00  factor of safety for buckling: BUCKLF(1 )
  2     1.000E+00  factor of safety for stress: STRESSF(1 ,1 )
  3     1.000E+00  factor of safety for stress: STRESSF(1 ,2 )

    0 INEQUALITY CONSTRAINTS WHICH MUST BE SATISFIED


 DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

 doer.NAM = This file contains only the name of the case.
 doer.OPM = Output data. Please list this file and inspect
            carefully before proceeding.
 doer.OPP = Output file containing evolution of design and
            margins since the beginning of optimization cycles.
 doer.CBL = Labelled common blocks for analysis.
            (This is an unformatted sequential file.)
 doer.OPT = This file contains the input data for MAINSETUP
             as well as OPTIMIZE. The batch command OPTIMIZE
             can be given over and over again without having
             to return to MAINSETUP because doer.OPT exists.
 URPROMPT.DAT= Prompt file for interactive input.

 For further information about files used and generated
 during operation of GENOPT, give the command HELPG FILES.

 Menu of commands: CHOOSEPLOT, OPTIMIZE, MAINSETUP, CHANGE,
                   DECIDE, SUPEROPT

 IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
 RUN  "OPTIMIZE"  MANY TIMES DURING AN OPTIMIZATION AND/OR USE
 THE "GLOBAL" OPTIMIZING SCRIPT, "SUPEROPT".
 ******************** END OF doer.OPM FILE *****************
```

Output from /home/progs/bin/plotps.linux

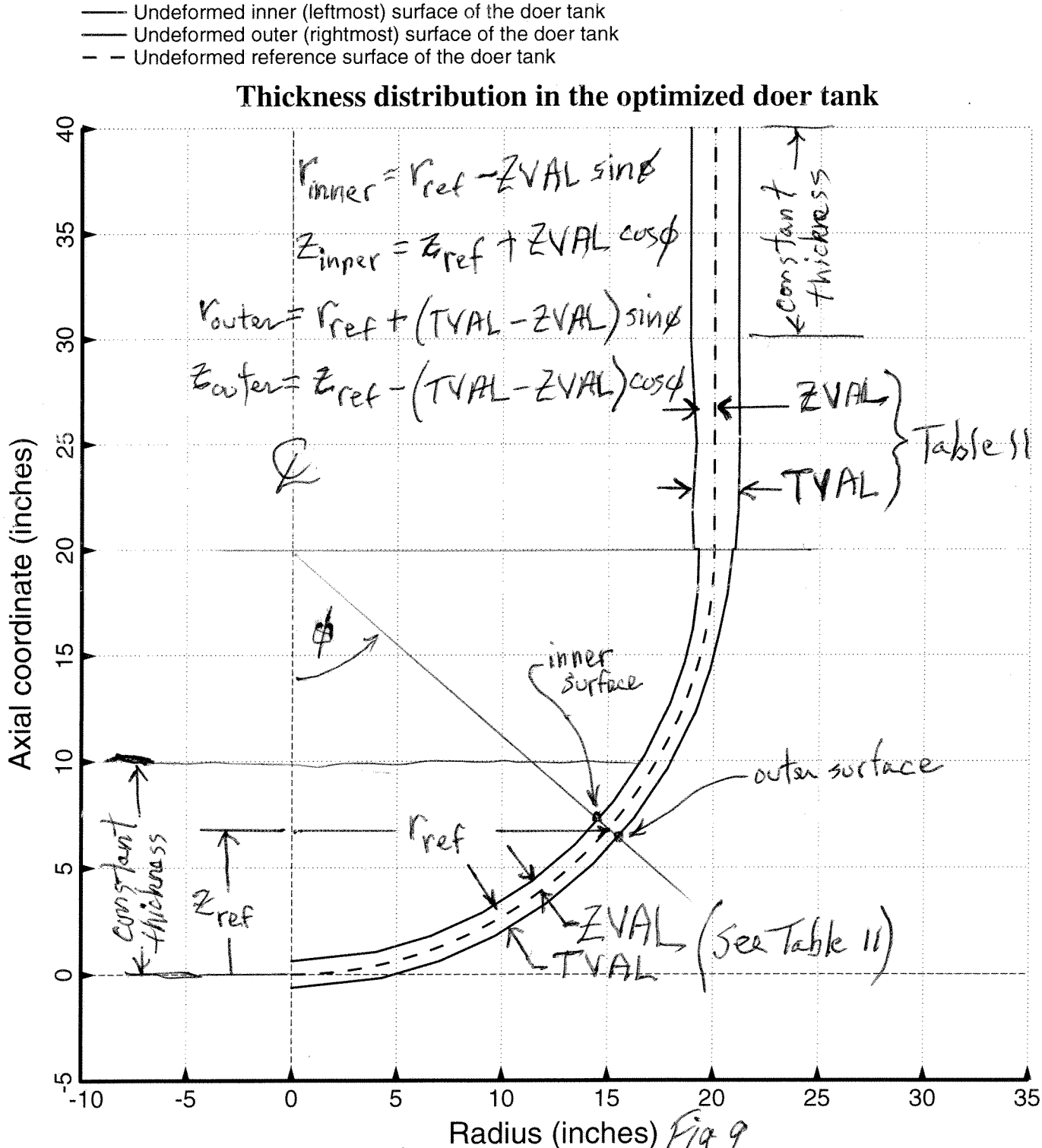


Fig. 9

Output from /home/progs/bin/plotps.linux

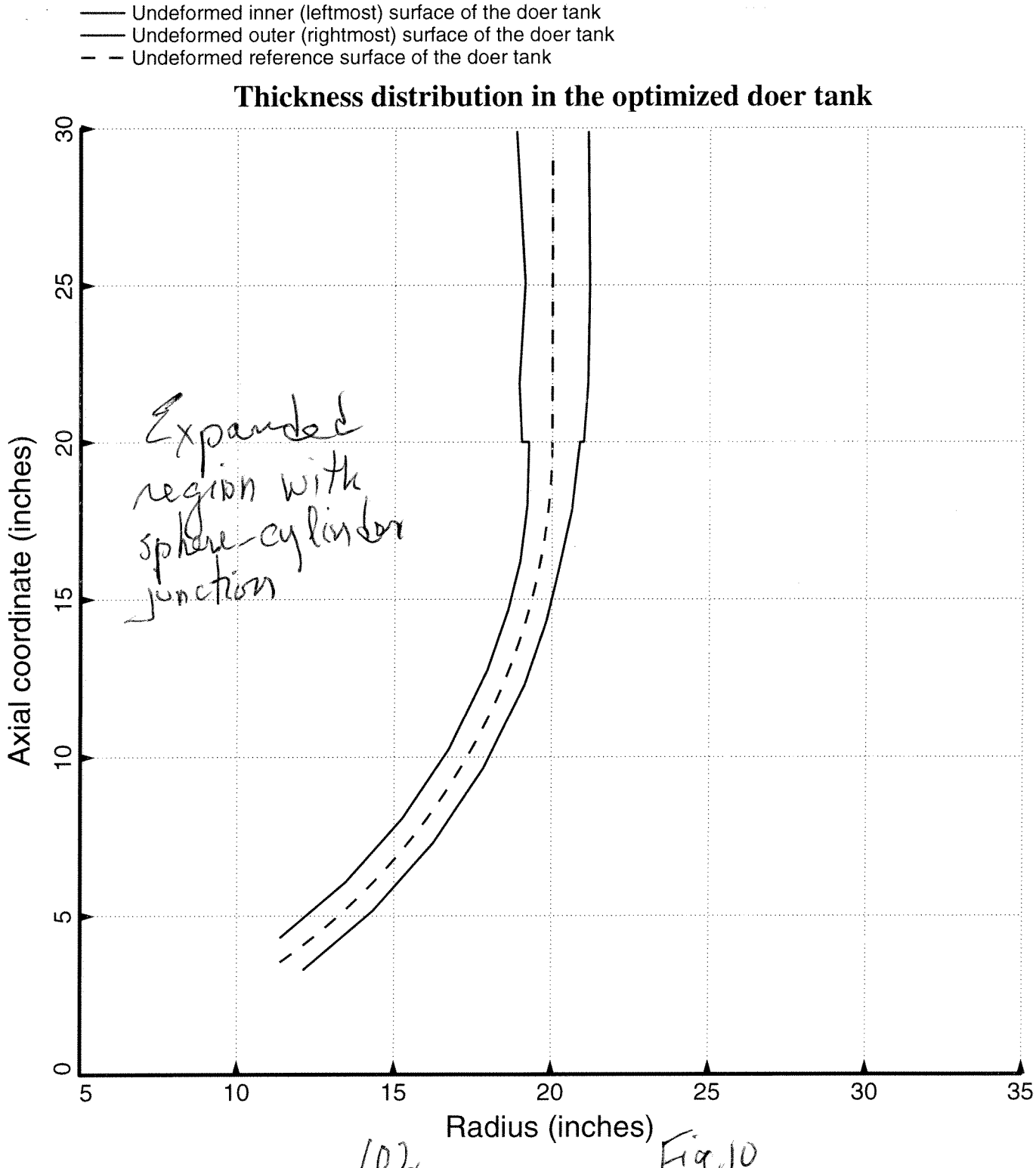


Fig. 10

Table 23 doer.CHG

```
     n          $ Do you want a tutorial session and tutorial output?
     y          $ Do you want to change any values in Parameter Set No. 1?
       1        $ Number of parameter to change (1, 2, 3, . .)
 0.6250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       2        $ Number of parameter to change (1, 2, 3, . .)
 0.6250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       3        $ Number of parameter to change (1, 2, 3, . .)
 0.6370600      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       4        $ Number of parameter to change (1, 2, 3, . .)
 0.6280000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       5        $ Number of parameter to change (1, 2, 3, . .)
 0.7401100      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       6        $ Number of parameter to change (1, 2, 3, . .)
  1.250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       7        $ Number of parameter to change (1, 2, 3, . .)
  1.250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       8        $ Number of parameter to change (1, 2, 3, . .)
  1.275800      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
       9        $ Number of parameter to change (1, 2, 3, . .)
  1.250000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      10        $ Number of parameter to change (1, 2, 3, . .)
  1.614400      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      11        $ Number of parameter to change (1, 2, 3, . .)
 0.9649900      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      12        $ Number of parameter to change (1, 2, 3, . .)
 1.0457000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      13        $ Number of parameter to change (1, 2, 3, . .)
  0.861740      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      14        $ Number of parameter to change (1, 2, 3, . .)
  1.134600      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      15        $ Number of parameter to change (1, 2, 3, . .)
  1.134600      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      16        $ Number of parameter to change (1, 2, 3, . .)
  1.962000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      17        $ Number of parameter to change (1, 2, 3, . .)
  2.179400      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      18        $ Number of parameter to change (1, 2, 3, . .)
  2.044700      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      19        $ Number of parameter to change (1, 2, 3, . .)
  2.269300      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
      20        $ Number of parameter to change (1, 2, 3, . .)
  2.269300      $ New value of the parameter
     n          $ Want to change any other parameters in this set?
     n          $ Do you want to change values of any "fixed" parameters?
     n          $ Do you want to change any loads?
     n          $ Do you want to change values of allowables?
     n          $ Do you want to change any factors of safety?
```

Always save optimum designs this way. The optimum design listed in Table 22 is preserved.

Input for CHANGE

Output from BIGBOSOR4
for the optimized design

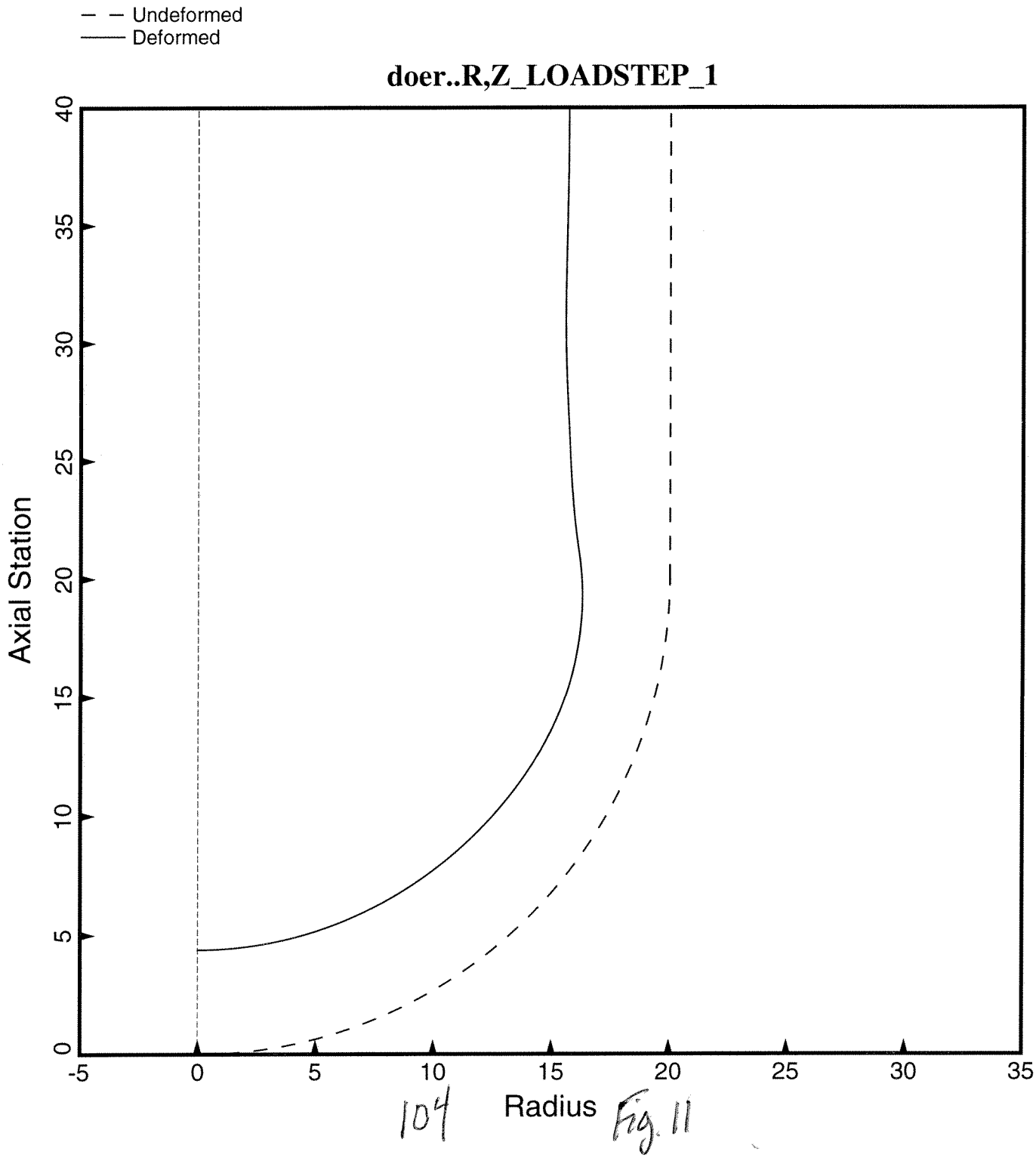


Fig. 11

Output from BIGBOSOR4 for the optimized design

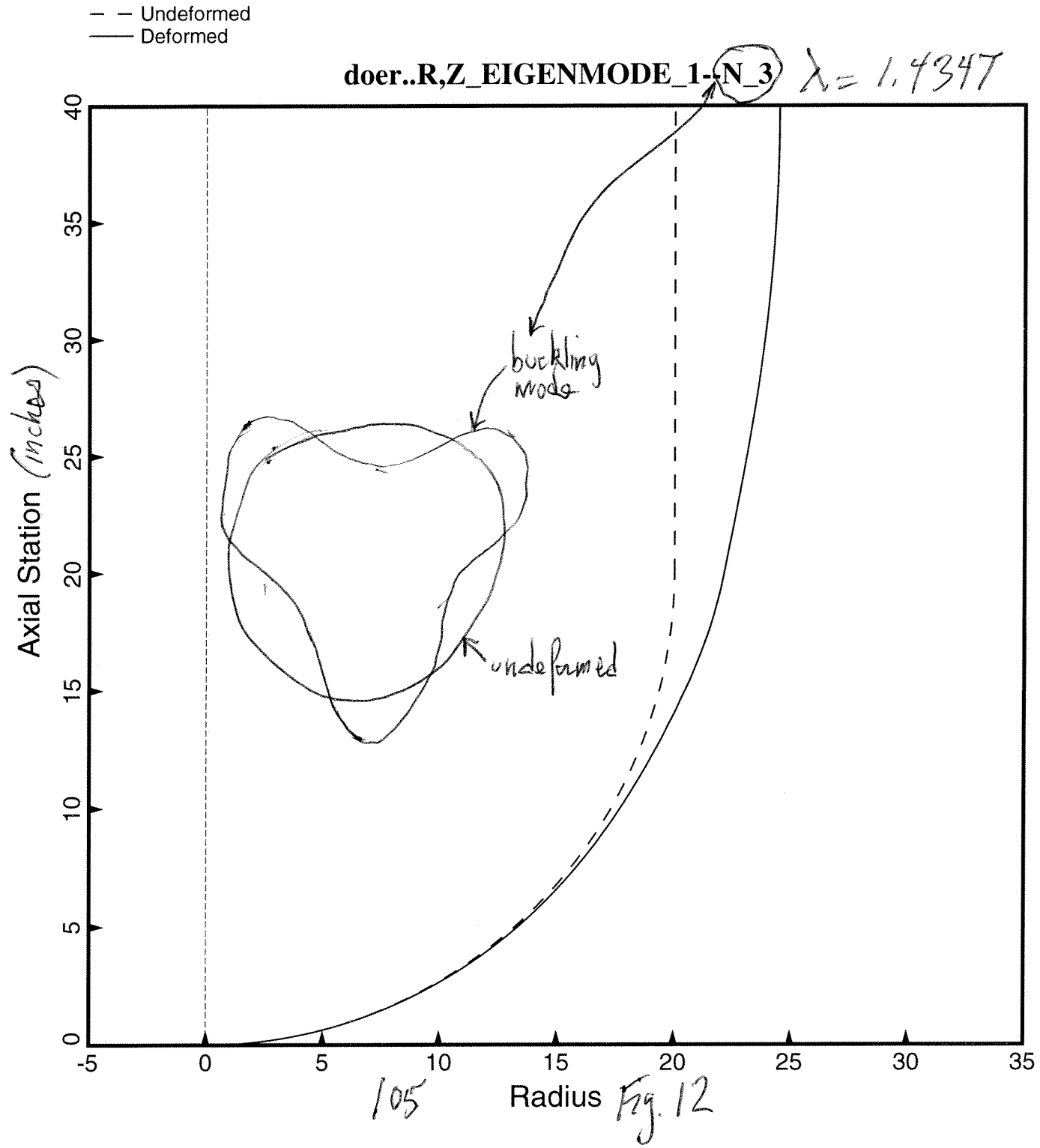


Fig. 12

Output from BIGBOSOR4 for the optimized design

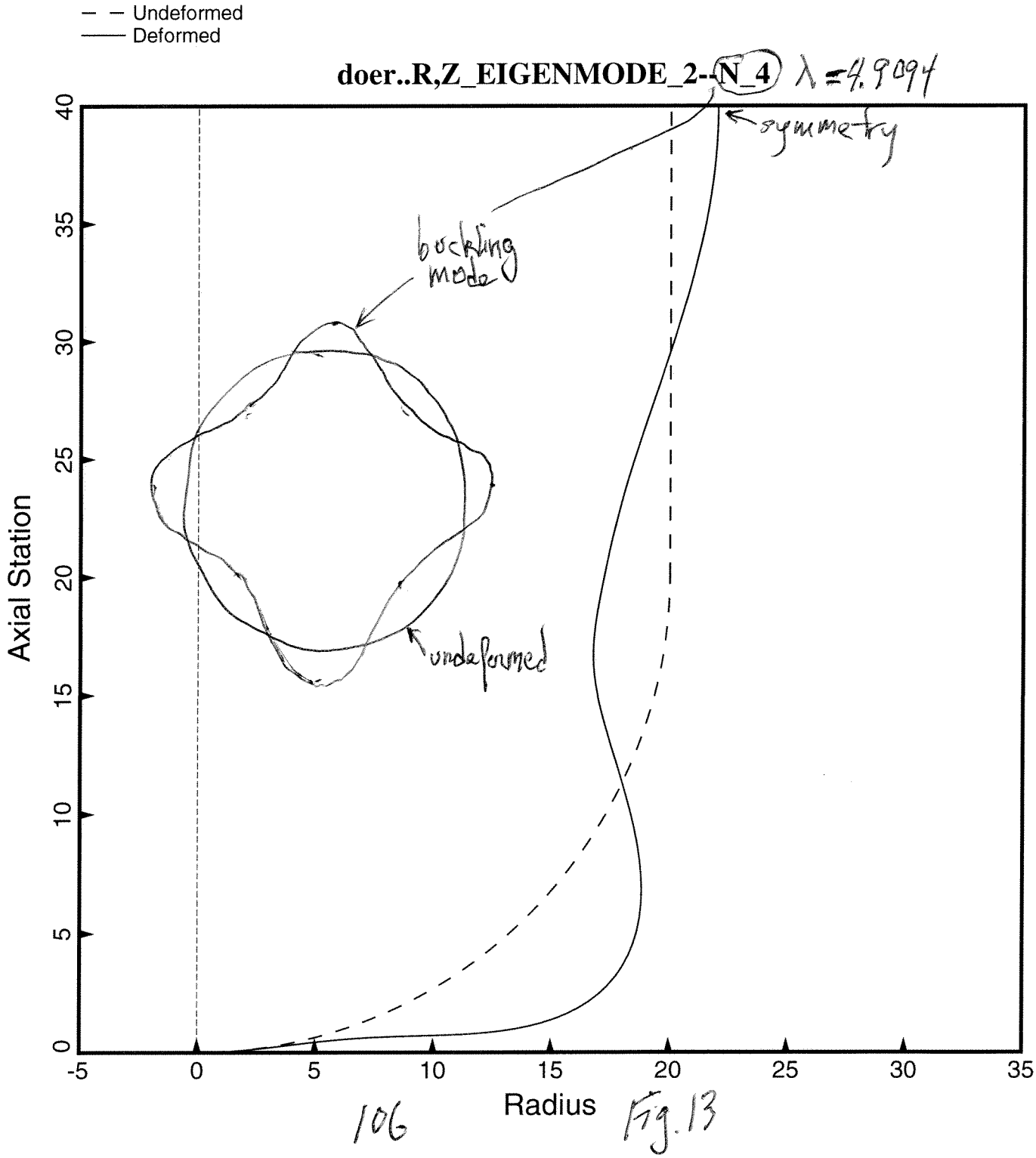


Fig. 13

Output from BIGBOSOR4 for the optimized design

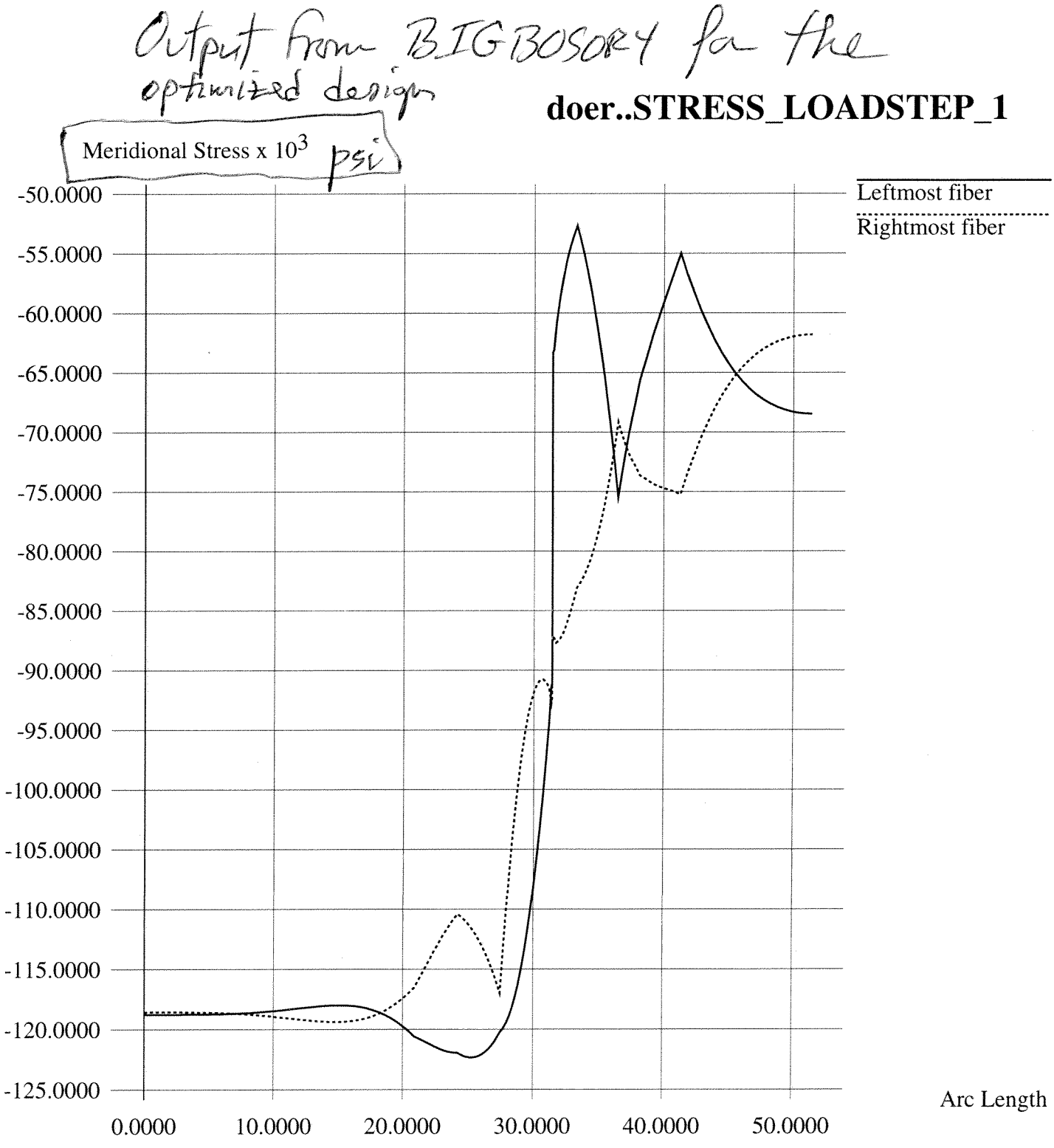


Fig. 14

Output from BIGBOSOR4 for the optimized design.

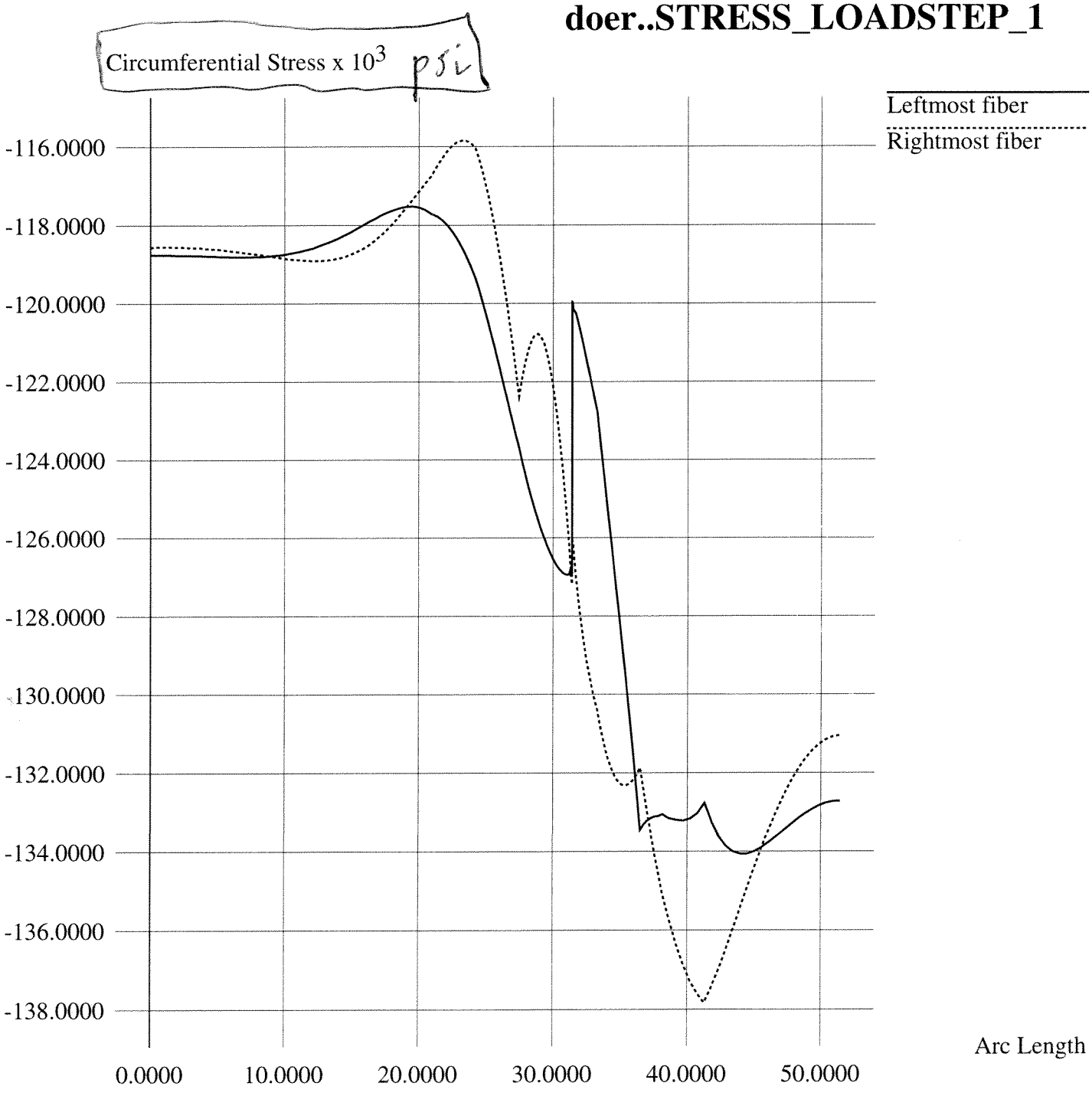


Fig. 15

Output from BIGBUSORY for the optimized design

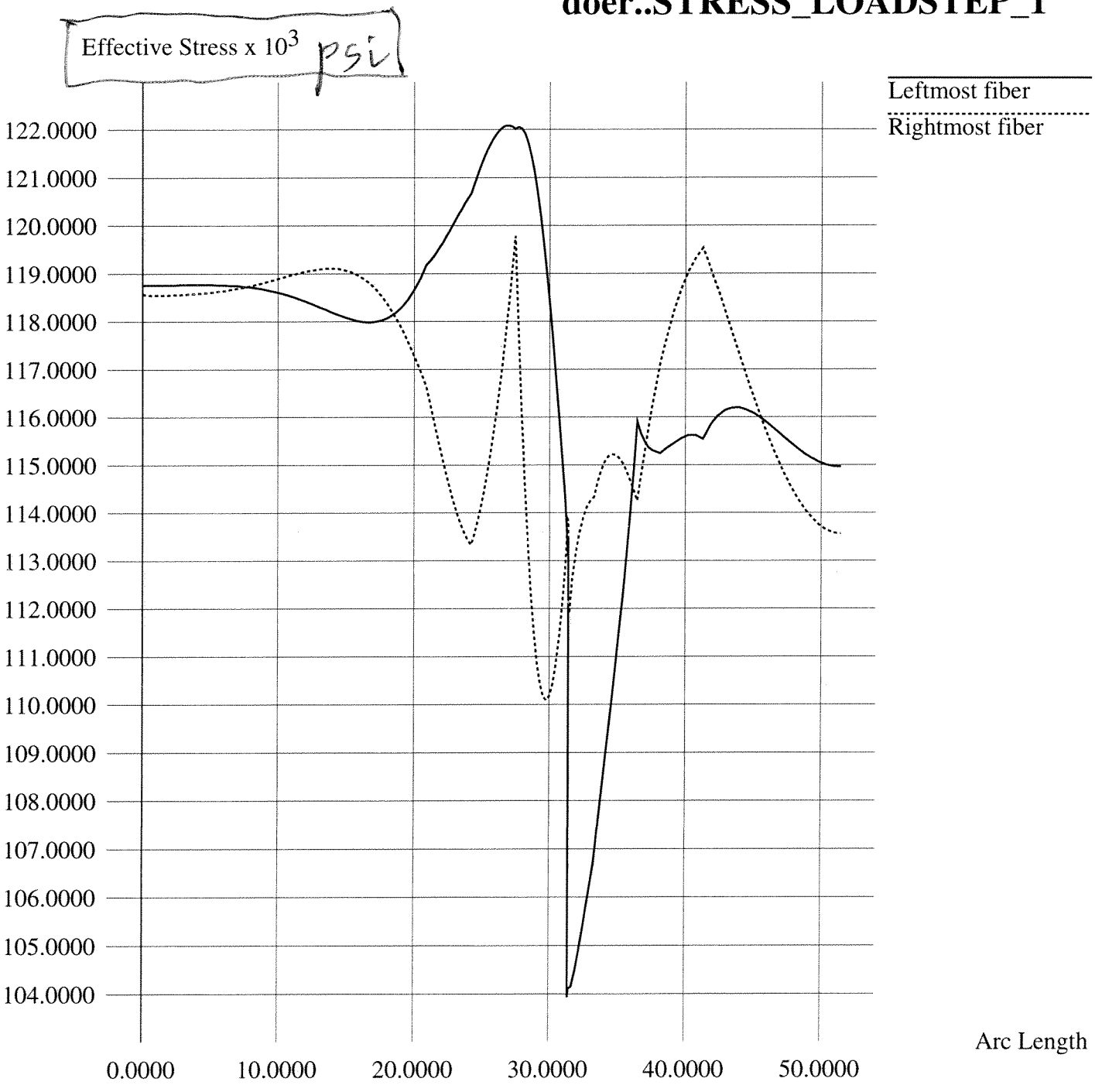


Fig. 16

Table 24 (2 pp) Doer, BEG (10 callouts for each shell segment)

```
n              $ Do you want a tutorial session and tutorial output?
20.00000       $ radius of the tank: RADIUS
40.00000       $ total length of the cylinder: LENGTH
0.1600000E+08  $ elastic modulus of the shell wall: EMOD
0.2500000      $ Poisson ratio of the shell wall: NU
0.1600000      $ weight density of the shell wall: DENSTY
91             $ number of nodal points in the dome: NODSPH
91             $ number of nodal points in the cylinder: NODCYL
10             $ number of axial callouts in the dome: NPTSPH
10             $ Number IZSPH   of rows in the array  ZSPH: IZSPH
0.000000       $ axial location of callout in the dome: ZSPH( 1)
10.00000       $ axial location of callout in the dome: ZSPH( 2)
12.00000       $ axial location of callout in the dome: ZSPH( 3)
14.00000       $ axial location of callout in the dome: ZSPH( 4)
15             $ axial location of callout in the dome: ZSPH( 5)
16             $ axial location of callout in the dome: ZSPH( 6)
17             $ axial location of callout in the dome: ZSPH( 7)
18             $ axial location of callout in the dome: ZSPH( 8)
19             $ axial location of callout in the dome: ZSPH( 9)
20.00000       $ axial location of callout in the dome: ZSPH(10)
10             $ Number of axial callouts in the cylinder: NPTCYL
10             $ Number IZCYL   of rows in the array  ZCYL: IZCYL
20.00000       $ axial location of callout in the cylinder: ZCYL( 1)
21             $ axial location of callout in the cylinder: ZCYL( 2)
22.00000       $ axial location of callout in the cylinder: ZCYL( 3)
23             $ axial location of callout in the cylinder: ZCYL( 4)
24             $ axial location of callout in the cylinder: ZCYL( 5)
25.00000       $ axial location of callout in the cylinder: ZCYL( 6)
26             $ axial location of callout in the cylinder: ZCYL( 7)
28             $ axial location of callout in the cylinder: ZCYL( 8)
30.00000       $ axial location of callout in the cylinder: ZCYL( 9)
40.00000       $ axial location of callout in the cylinder: ZCYL(10)
10             $ Number IZREFSP of rows in the array  ZREFSP: IZREFSP
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 1)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 2)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 3)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 4)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 5)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 6)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 7)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 8)
0.6250000      $ location of ref. surf. in the dome: ZREFSP( 9)
0.6250000      $ location of ref. surf. in the dome: ZREFSP(10)
1.250000       $ wall thickness in the dome: THKSPH( 1)
1.250000       $ wall thickness in the dome: THKSPH( 2)
1.250000       $ wall thickness in the dome: THKSPH( 3)
1.250000       $ wall thickness in the dome: THKSPH( 4)
1.250000       $ wall thickness in the dome: THKSPH( 5)
1.250000       $ wall thickness in the dome: THKSPH( 6)
1.250000       $ wall thickness in the dome: THKSPH( 7)
1.250000       $ wall thickness in the dome: THKSPH( 8)
1.250000       $ wall thickness in the dome: THKSPH( 9)
1.250000       $ wall thickness in the dome: THKSPH(10)
10             $ Number IZREFCY of rows in the array  ZREFCY: IZREFCY
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 1)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 2)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 3)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 4)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 5)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 6)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 7)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 8)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY( 9)
1.250000       $ location of the ref. surf. in the cylinder: ZREFCY(10)
2.500000       $ thickness of the cylindrical shell: THKCYL( 1)
2.500000       $ thickness of the cylindrical shell: THKCYL( 2)
2.500000       $ thickness of the cylindrical shell: THKCYL( 3)
2.500000       $ thickness of the cylindrical shell: THKCYL( 4)
2.500000       $ thickness of the cylindrical shell: THKCYL( 5)
2.500000       $ thickness of the cylindrical shell: THKCYL( 6)
2.500000       $ thickness of the cylindrical shell: THKCYL( 7)
2.500000       $ thickness of the cylindrical shell: THKCYL( 8)
2.500000       $ thickness of the cylindrical shell: THKCYL( 9)
2.500000       $ thickness of the cylindrical shell: THKCYL(10)
0              $ low end of range of buckling circ. waves: NBUKLO
5              $ high end of range of buckling circ. waves: NBUKHI
1              $ Number NCASES  of load cases (environments): NCASES
15000.00       $ uniform external pressure: PRESS( 1)
```

Table 24 (p. 2 of 2)

```
1.000000      $ allowable buckling load (Use 1.0): BUCKLA( 1)
1.300000      $ factor of safety for buckling: BUCKLF( 1)
       2      $ Number JSTRESS of columns in the array, STRESS: JSTRESS
  120000      $ maximum allowable effective stress: STRESSA( 1, 1)
  120000      $ maximum allowable effective stress: STRESSA( 1, 2)
1.000000      $ factor of safety for stress: STRESSF( 1, 1)
1.000000      $ factor of safety for stress: STRESSF( 1, 2)
```

input for BEGIN

Table 25 (3 pp) Doer. DEC (10 callouts for each shall segment)

```
n                $ Do you want a tutorial session and tutorial output?
     3           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 3)
 1.500000        $ Upper bound of variable no.( 3)
     y           $ Any more decision variables (Y or N) ?
     4           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 4)
 1.500000        $ Upper bound of variable no.( 4)
     y           $ Any more decision variables (Y or N) ?
     5           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 5)
 1.500000        $ Upper bound of variable no.( 5)
     y           $ Any more decision variables (Y or N) ?
     6           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 6)
 1.500000        $ Upper bound of variable no.( 6)
     y           $ Any more decision variables (Y or N) ?
     7           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 7)
 1.500000        $ Upper bound of variable no.( 7)
     y           $ Any more decision variables (Y or N) ?
     8           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 8)
 1.500000        $ Upper bound of variable no.( 8)
     y           $ Any more decision variables (Y or N) ?
     9           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.( 9)
 1.500000        $ Upper bound of variable no.( 9)
     y           $ Any more decision variables (Y or N) ?
    10           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.(10)
 1.500000        $ Upper bound of variable no.(10)
     y           $ Any more decision variables (Y or N) ?
    13           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(13)
 2.500000        $ Upper bound of variable no.(13)
     y           $ Any more decision variables (Y or N) ?
    14           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(14)
 2.500000        $ Upper bound of variable no.(14)
     y           $ Any more decision variables (Y or N) ?
    15           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(15)
 2.500000        $ Upper bound of variable no.(15)
     y           $ Any more decision variables (Y or N) ?
    16           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(16)
 2.500000        $ Upper bound of variable no.(16)
     y           $ Any more decision variables (Y or N) ?
    17           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(17)
 2.500000        $ Upper bound of variable no.(17)
     y           $ Any more decision variables (Y or N) ?
    18           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(18)
 2.500000        $ Upper bound of variable no.(18)
     y           $ Any more decision variables (Y or N) ?
    19           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(19)
 2.500000        $ Upper bound of variable no.(19)
     y           $ Any more decision variables (Y or N) ?
    20           $ Choose a decision variable (1,2,3,...)
 1.250000        $ Lower bound of variable no.(20)
 2.500000        $ Upper bound of variable no.(20)
     y           $ Any more decision variables (Y or N) ?
    21           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.(21)
 1.500000        $ Upper bound of variable no.(21)
     y           $ Any more decision variables (Y or N) ?
    22           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.(22)
 1.500000        $ Upper bound of variable no.(22)
     y           $ Any more decision variables (Y or N) ?
    23           $ Choose a decision variable (1,2,3,...)
0.6250000        $ Lower bound of variable no.(23)
 1.500000        $ Upper bound of variable no.(23)
     y           $ Any more decision variables (Y or N) ?
    24           $ Choose a decision variable (1,2,3,...)
```

Table 25 (p. 243)

```
0.6250000      $ Lower bound of variable no.(24)
 1.500000      $ Upper bound of variable no.(24)
    y          $ Any more decision variables (Y or N) ?
      25       $ Choose a decision variable (1,2,3,...)
0.6250000      $ Lower bound of variable no.(25)
 1.500000      $ Upper bound of variable no.(25)
    y          $ Any more decision variables (Y or N) ?
      26       $ Choose a decision variable (1,2,3,...)
0.6250000      $ Lower bound of variable no.(26)
 1.500000      $ Upper bound of variable no.(26)
    y          $ Any more decision variables (Y or N) ?
      27       $ Choose a decision variable (1,2,3,...)
0.6250000      $ Lower bound of variable no.(27)
 1.500000      $ Upper bound of variable no.(27)
    y          $ Any more decision variables (Y or N) ?
      28       $ Choose a decision variable (1,2,3,...)
0.6250000      $ Lower bound of variable no.(28)
 1.500000      $ Upper bound of variable no.(28)
    y          $ Any more decision variables (Y or N) ?
      31       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(31)
 3.000000      $ Upper bound of variable no.(31)
    y          $ Any more decision variables (Y or N) ?
      32       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(32)
 3.000000      $ Upper bound of variable no.(32)
    y          $ Any more decision variables (Y or N) ?
      33       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(33)
 2.500000      $ Upper bound of variable no.(33)
    y          $ Any more decision variables (Y or N) ?
      34       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(34)
 2.500000      $ Upper bound of variable no.(34)
    y          $ Any more decision variables (Y or N) ?
      35       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(35)
 2.500000      $ Upper bound of variable no.(35)
    y          $ Any more decision variables (Y or N) ?
      36       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(36)
 2.500000      $ Upper bound of variable no.(36)
    y          $ Any more decision variables (Y or N) ?
      37       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(37)
 2.500000      $ Upper bound of variable no.(37)
    y          $ Any more decision variables (Y or N) ?
      38       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(38)
 2.500000      $ Upper bound of variable no.(38)
    y          $ Any more decision variables (Y or N) ?
      39       $ Choose a decision variable (1,2,3,...)
 1.250000      $ Lower bound of variable no.(39)
 2.500000      $ Upper bound of variable no.(39)
    n          $ Any more decision variables (Y or N) ?
    y          $ Any linked variables (Y or N) ?
      29       $ Choose a linked variable (1,2,3,...)
       1       $ Choose type of linking (1=polynomial; 2=user-defined)
      39       $ To which variable is this variable linked?
0.5000000      $ Assign a value to the linking coefficient, C(j)
       1       $ To what power is the decision variable raised?
    n          $ Any other decision variables in the linking expression?
    n          $ Any constant C0 in the linking expression?
    y          $ Any more linked variables (Y or N) ?
      30       $ Choose a linked variable (1,2,3,...)
       1       $ Choose type of linking (1=polynomial; 2=user-defined)
      39       $ To which variable is this variable linked?
0.5000000      $ Assign a value to the linking coefficient, C(j)
       1       $ To what power is the decision variable raised?
    n          $ Any other decision variables in the linking expression?
    n          $ Any constant C0 in the linking expression?
    y          $ Any more linked variables (Y or N) ?
      40       $ Choose a linked variable (1,2,3,...)
       1       $ Choose type of linking (1=polynomial; 2=user-defined)
      39       $ To which variable is this variable linked?
 1.000000      $ Assign a value to the linking coefficient, C(j)
       1       $ To what power is the decision variable raised?
    n          $ Any other decision variables in the linking expression?
```

↑ See Table 14 for an explanation of this input.

Table 25 (p. 343)

```
n       $ Any constant C0 in the linking expression?
n       $ Any more linked variables (Y or N) ?
n       $ Any inequality relations among variables? (type H)
y       $ Any escape variables (Y or N) ?
y       $ Want to have escape variables chosen by default?
```

input for DECIDE

Output from SUPEROPT/CHOOSEPLOT/DIPLOT
10 callouts for each shell segment

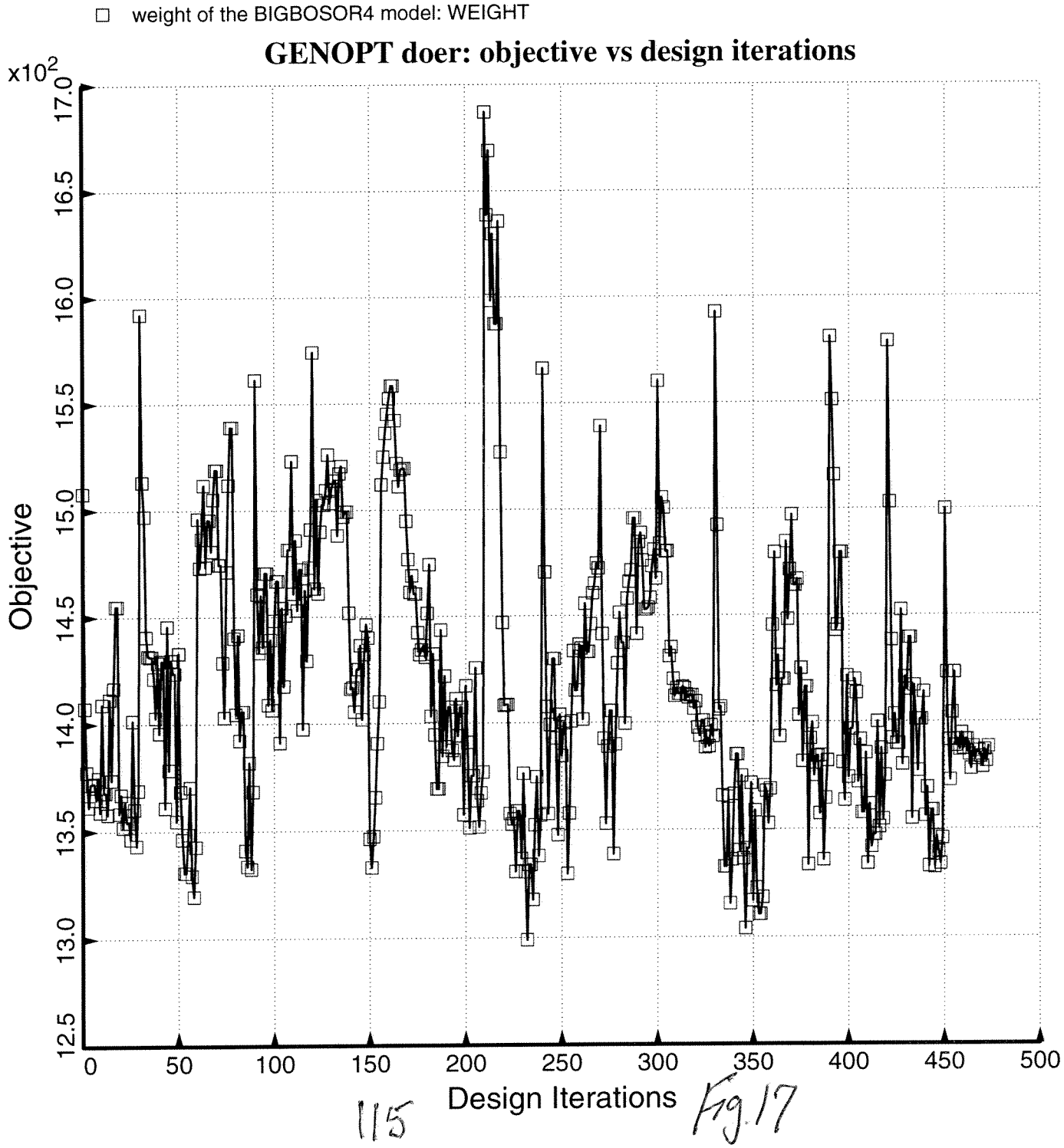


Fig. 17

Table 26 (4 pages) doer.OPM (output from OPTIMIZE)

```
     n          $ Do you want a tutorial session and tutorial output?
        0       $ Choose an analysis you DON'T want (1, 2,..), IBEHAV
        2       $ NPRINT= output index (0=GOOD, 1=ok, 2=debug, 3=too much)
        2       $ Choose type of analysis (1=opt., 2=fixed, 3=sensit.) ITYPE
        5       $ How many design iterations in this run (3 to 25)?
     n          $ Take "shortcuts" for perturbed designs (Y or N)?
        2       $ Choose 1 or 2 or 3 or 4 or 5 for IDESIGN
        1       $ Choose 1 or 2 or 3 or 4 or 5 for move limits, IMOVE
     y          $ Do you want default (RATIO=10) for initial move limit jump?
     y          $ Do you want the default perturbation (dx/x = 0.05)?
     n          $ Do you want to have dx/x modified by GENOPT?
     n          $ Do you want to reset total iterations to zero (Type H)?

************ END OF THE  doer.OPT  FILE ***********
************ JUNE, 2009 VERSION OF GENOPT ****************
******** BEGINNING OF THE  doer.OPM  FILE *********


********************** MAIN PROCESSOR **********************
The purpose of the mainprocessor, OPTIMIZE, is to perform,
in a batch mode, the work specified by MAINSETUP for the case
called doer.  Results are stored in the file  doer.OPM.
Please inspect doer.OPM before doing more design iterations.
************************************************************
```

optimum design.

```
 STRUCTURAL ANALYSIS FOR DESIGN ITERATION NO.   0:
0
  STRUCTURAL ANALYSIS WITH UNPERTURBED DECISION VARIABLES
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER      CURRENT     UPPER       DEFINITION
  NO. VAR.  VAR.  VAR.    TO  CONSTANT    BOUND       VALUE     BOUND
   1   N     N     N       0   0.00E+00  0.00E+00  6.2500E-01  0.00E+00  location of ref. surf. i»
n the dome: ZREFSP(1 )
   2   N     N     N       0   0.00E+00  0.00E+00  6.2500E-01  0.00E+00  location of ref. surf. i»
n the dome: ZREFSP(2 )
   3   Y     N     N       0   0.00E+00  6.25E-01  6.2501E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(3 )
   4   Y     N     N       0   0.00E+00  6.25E-01  6.3533E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(4 )
   5   Y     N     N       0   0.00E+00  6.25E-01  6.6382E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(5 )
   6   Y     N     N       0   0.00E+00  6.25E-01  7.9746E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(6 )
   7   Y     N     N       0   0.00E+00  6.25E-01  8.5627E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(7 )
   8   Y     N     N       0   0.00E+00  6.25E-01  8.5121E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(8 )
   9   Y     N     N       0   0.00E+00  6.25E-01  9.2385E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(9 )
  10   Y     N     N       0   0.00E+00  6.25E-01  9.5028E-01  1.50E+00  location of ref. surf. i»
n the dome: ZREFSP(10)
  11   N     N     N       0   0.00E+00  0.00E+00  1.2500E+00  0.00E+00  wall thickness in the do»
me: THKSPH(1 )
  12   N     N     N       0   0.00E+00  0.00E+00  1.2500E+00  0.00E+00  wall thickness in the do»
me: THKSPH(2 )
  13   Y     N     N       0   0.00E+00  1.25E+00  1.2611E+00  2.50E+00  wall thickness in the do»
me: THKSPH(3 )
  14   Y     N     N       0   0.00E+00  1.25E+00  1.2500E+00  2.50E+00  wall thickness in the do»
me: THKSPH(4 )
  15   Y     N     N       0   0.00E+00  1.25E+00  1.2936E+00  2.50E+00  wall thickness in the do»
me: THKSPH(5 )
  16   Y     N     N       0   0.00E+00  1.25E+00  1.6258E+00  2.50E+00  wall thickness in the do»
me: THKSPH(6 )
  17   Y     N     N       0   0.00E+00  1.25E+00  1.6748E+00  2.50E+00  wall thickness in the do»
me: THKSPH(7 )
  18   Y     N     N       0   0.00E+00  1.25E+00  1.5124E+00  2.50E+00  wall thickness in the do»
me: THKSPH(8 )
  19   Y     N     N       0   0.00E+00  1.25E+00  1.6510E+00  2.50E+00  wall thickness in the do»
me: THKSPH(9 )
  20   Y     N     N       0   0.00E+00  1.25E+00  1.9692E+00  2.50E+00  wall thickness in the do»
me: THKSPH(10)
  21   Y     N     N       0   0.00E+00  6.25E-01  1.2681E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(1 )
  22   Y     N     N       0   0.00E+00  6.25E-01  7.3318E-01  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(2 )
  23   Y     N     N       0   0.00E+00  6.25E-01  1.0341E+00  1.50E+00  location of the ref. sur»
```

Table 26 (p. 2 of 4)

← optimum design

```
f. in the cylinder: ZREFCY(3 )
  24   Y     N     N      0    0.00E+00  6.25E-01 6.2500E-01  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(4 )
  25   Y     N     N      0    0.00E+00  6.25E-01 9.5432E-01  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(5 )
  26   Y     N     N      0    0.00E+00  6.25E-01 1.2219E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(6 )
  27   Y     N     N      0    0.00E+00  6.25E-01 1.3482E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(7 )
  28   Y     N     N      0    0.00E+00  6.25E-01 1.0119E+00  1.50E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(8 )
  29   N     N     Y     39    5.00E-01  0.00E+00 1.0661E+00  0.00E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(9 )
  30   N     N     Y     39    5.00E-01  0.00E+00 1.0661E+00  0.00E+00  location of the ref. sur»
f. in the cylinder: ZREFCY(10)
  31   Y     N     N      0    0.00E+00  1.25E+00 2.3681E+00  3.00E+00  thickness of the cylindr»
ical shell: THKCYL(1 )
  32   Y     N     N      0    0.00E+00  1.25E+00 1.5889E+00  3.00E+00  thickness of the cylindr»
ical shell: THKCYL(2 )
  33   Y     N     N      0    0.00E+00  1.25E+00 2.1644E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(3 )
  34   Y     Y     N      0    0.00E+00  1.25E+00 1.4285E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(4 )
  35   Y     Y     N      0    0.00E+00  1.25E+00 2.2717E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(5 )
  36   Y     Y     N      0    0.00E+00  1.25E+00 2.5000E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(6 )
  37   Y     Y     N      0    0.00E+00  1.25E+00 2.4991E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(7 )
  38   Y     Y     N      0    0.00E+00  1.25E+00 1.9986E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(8 )
  39   Y     Y     N      0    0.00E+00  1.25E+00 2.1322E+00  2.50E+00  thickness of the cylindr»
ical shell: THKCYL(9 )
  40   N     N     Y     39    1.00E+00  0.00E+00 2.1322E+00  0.00E+00  thickness of the cylindr»
ical shell: THKCYL(10)
  BEHAVIOR FOR  1 ENVIRONMENT (LOAD SET)

 CONSTRAINT  BEHAVIOR              DEFINITION
   NUMBER     VALUE

  BEHAVIOR FOR LOAD SET NUMBER, ILOADX= 1


 BIGBOSOR4 input file for: buckling load (INDIC=1)
doer.BEHX1

 WEIGHT OF THE BIGBOSOR4 MODEL OF THE TANK
 TOTMAS =  1.3923E+03
 ************************************************

 BUCKLING LOAD FACTORS AND MODES (BEHX1)
        5.0683E+00(    0)
        5.0412E+00(    1)
        1.9042E+00(    2)
        1.3301E+00(    3)  ← critical
        1.9886E+00(    4)
        2.9995E+00(    5)
 Critical buckling load factor, BUCKL=  1.3301E+00
 Critical number of circumferential waves, NWVCRT=     3
    1        1.330093      tank buckling eigenvalue: BUCKL(1)

  BEHAVIOR OVER J =  shell segment number


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
doer.BEHX2
 Shell skin maximum effective stress,          SKNMAX=  1.2528E+05
 at nodal point  66
 Shell skin maximum effective stress,          SKNMAX=  1.2468E+05
 at nodal point  52

 ****** MAXIMUM EFFECTIVE STRESS IN ISOTROPIC WALL ******
 STRMAX=  1.2528E+05
 ************************************************
    2        125277.0      effective stress in shell segment: STRESS(1 ,1 )


 BIGBOSOR4 input file for: maximum effective stress (INDIC=0)
```

"oscillatory" optimum thicknesses probably not good. We are using shell theory, (thin) and the cylinder is very thick. In this model the callouts corresponding to these four values are spaced at 1-inch intervals. The variation in thickness from callout to callout is approximately the same as the callout spacing. Thin shell theory not appropriate

Table 26 (p. 314)

```
doer.BEHX2
    3        124684.9      effective stress in shell segment: STRESS(1 ,2 )

***** RESULTS FOR LOAD SET NO.  1  ******
PARAMETERS WHICH DESCRIBE BEHAVIOR (e.g. stress, buckling load)

BEH.   CURRENT
NO.      VALUE            DEFINITION
 1    1.330E+00    tank buckling eigenvalue: BUCKL(1 )
 2    1.253E+05    effective stress in shell segment: STRESS(1 ,1 )
 3    1.247E+05    effective stress in shell segment: STRESS(1 ,2 )

******* NOTE ******* NOTE ******* NOTE ****** NOTE ******
The phrase, "NOT APPLY", for MARGIN VALUE means that that
particular margin value is exactly zero.
*** END NOTE *** END NOTE *** END NOTE *** END NOTE *****


***** RESULTS FOR LOAD SET NO.  1  ******
MARGINS CORRESPONDING TO CURRENT DESIGN (F.S.= FACTOR OF SAFETY)

MARGIN CURRENT
NO.      VALUE            DEFINITION
 1    2.315E-02  (BUCKL(1 )/BUCKLA(1 )) / BUCKLF(1 )-1; F.S.=  1.30
 2   -4.212E-02  (STRESSA(1 ,1 )/STRESS(1 ,1 )) / STRESSF(1 ,1 )-1; F.S.=  1.00
 3   -3.757E-02  (STRESSA(1 ,2 )/STRESS(1 ,2 )) / STRESSF(1 ,2 )-1; F.S.=  1.00

************************************************
******************* DESIGN OBJECTIVE ******************
************                              ***********
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:

VAR.   CURRENT
NO.      VALUE            DEFINITION
 1    1.392E+03  weight of the BIGBOSOR4 model: WEIGHT

************                              ***********
******************* DESIGN OBJECTIVE ******************
************************************************
***********  ALL 1 LOAD CASES PROCESSED ***********
************************************************


PARAMETERS WHICH ARE ALWAYS FIXED.  NONE CAN BE DECISION VARIAB.

VAR.   CURRENT
NO.      VALUE            DEFINITION
 1    2.000E+01  radius of the tank: RADIUS
 2    4.000E+01  total length of the cylinder: LENGTH
 3    1.600E+07  elastic modulus of the shell wall: EMOD
 4    2.500E-01  Poisson ratio of the shell wall: NU
 5    1.600E-01  weight density of the shell wall: DENSTY
 6    0.000E+00  axial location of callout in the dome: ZSPH(1 )
 7    1.000E+01  axial location of callout in the dome: ZSPH(2 )
 8    1.200E+01  axial location of callout in the dome: ZSPH(3 )
 9    1.400E+01  axial location of callout in the dome: ZSPH(4 )
10    1.500E+01  axial location of callout in the dome: ZSPH(5 )
11    1.600E+01  axial location of callout in the dome: ZSPH(6 )
12    1.700E+01  axial location of callout in the dome: ZSPH(7 )
13    1.800E+01  axial location of callout in the dome: ZSPH(8 )
14    1.900E+01  axial location of callout in the dome: ZSPH(9 )
15    2.000E+01  axial location of callout in the dome: ZSPH(10)
16    2.000E+01  axial location of callout in the cylinder: ZCYL(1 )
17    2.100E+01  axial location of callout in the cylinder: ZCYL(2 )
18    2.200E+01  axial location of callout in the cylinder: ZCYL(3 )
19    2.300E+01  axial location of callout in the cylinder: ZCYL(4 )
20    2.400E+01  axial location of callout in the cylinder: ZCYL(5 )
21    2.500E+01  axial location of callout in the cylinder: ZCYL(6 )
22    2.600E+01  axial location of callout in the cylinder: ZCYL(7 )
23    2.800E+01  axial location of callout in the cylinder: ZCYL(8 )
24    3.000E+01  axial location of callout in the cylinder: ZCYL(9 )
25    4.000E+01  axial location of callout in the cylinder: ZCYL(10)
PARAMETERS WHICH ARE ENVIRONMENTAL FACTORS (e.g. loads, temps.)

VAR.   CURRENT
NO.      VALUE            DEFINITION
 1    1.500E+04  uniform external pressure: PRESS(1 )
PARAMETERS WHICH ARE CLASSIFIED AS ALLOWABLES (e.g. max. stress)
```

Table 26 (p. 4 of 4)

```
VAR.    CURRENT
NO.       VALUE                DEFINITION
 1     1.000E+00  allowable buckling load (Use 1.0): BUCKLA(1 )
 2     1.200E+05  maximum allowable effective stress: STRESSA(1 ,1 )
 3     1.200E+05  maximum allowable effective stress: STRESSA(1 ,2 )
PARAMETERS WHICH ARE FACTORS OF SAFETY

VAR.    CURRENT
NO.       VALUE                DEFINITION
 1     1.300E+00  factor of safety for buckling: BUCKLF(1 )
 2     1.000E+00  factor of safety for stress: STRESSF(1 ,1 )
 3     1.000E+00  factor of safety for stress: STRESSF(1 ,2 )

   0 INEQUALITY CONSTRAINTS WHICH MUST BE SATISFIED


DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

doer.NAM = This file contains only the name of the case.
doer.OPM = Output data. Please list this file and inspect
           carefully before proceeding.
doer.OPP = Output file containing evolution of design and
           margins since the beginning of optimization cycles.
doer.CBL = Labelled common blocks for analysis.
           (This is an unformatted sequential file.)
doer.OPT = This file contains the input data for MAINSETUP
           as well as OPTIMIZE. The batch command OPTIMIZE
           can be given over and over again without having
           to return to MAINSETUP because doer.OPT exists.
URPROMPT.DAT= Prompt file for interactive input.

For further information about files used and generated
during operation of GENOPT, give the command HELPG FILES.

Menu of commands: CHOOSEPLOT, OPTIMIZE, MAINSETUP, CHANGE,
                  DECIDE, SUPEROPT

IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
RUN  "OPTIMIZE"  MANY TIMES DURING AN OPTIMIZATION AND/OR USE
THE "GLOBAL" OPTIMIZING SCRIPT, "SUPEROPT".
********************* END OF doer.OPM FILE *****************
```

end of doer.OPM