Table 74 allen.inp (abridged)

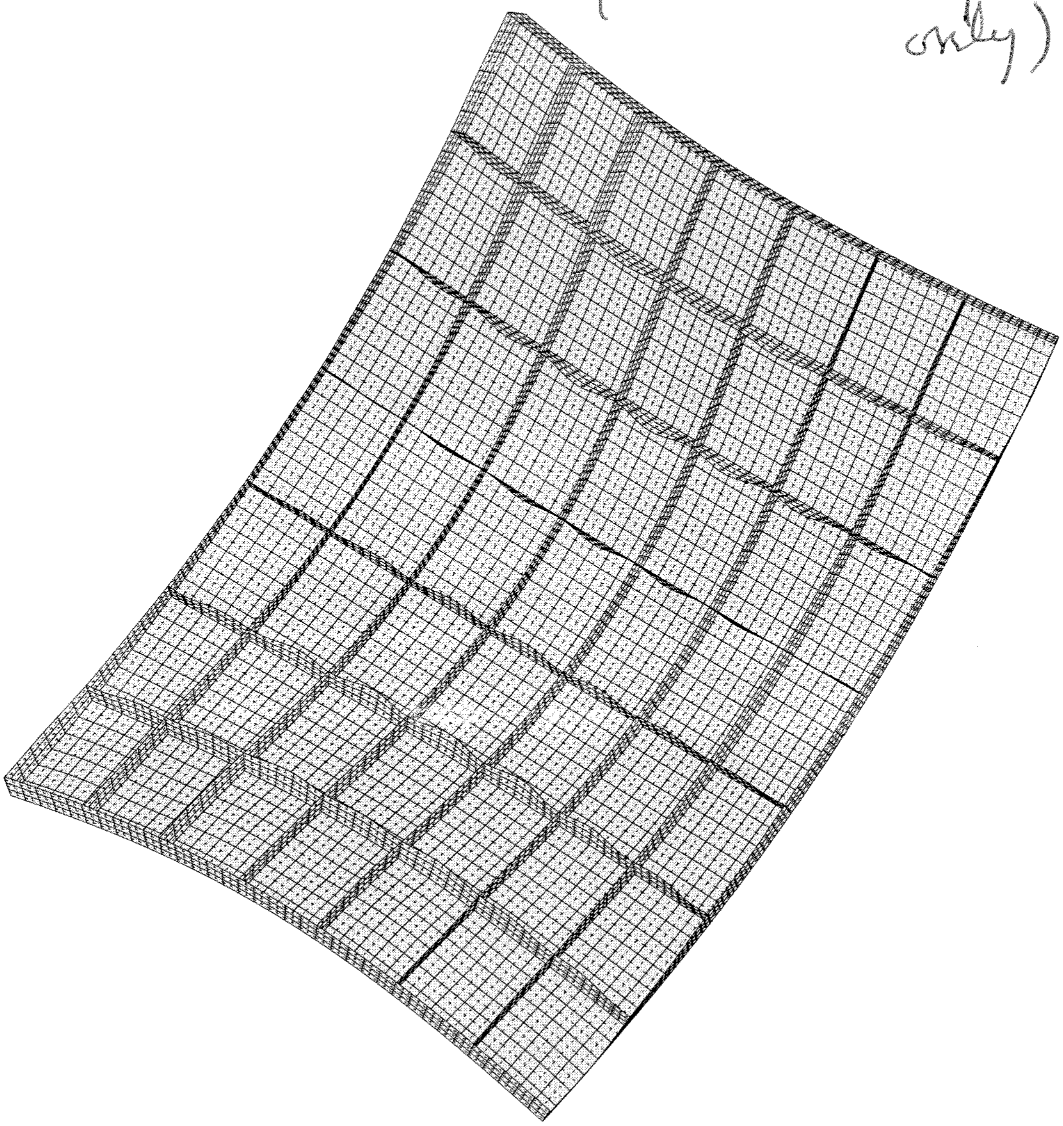
Abridged allen.inp file, showing the NEGATIVE
general buckling modal imperfection with amplitude,
Wimp = -0.5 inch.

```
 1, $ NIMPFS=number of bucklng modal imperfections.
 0, $ INERT = 0 means no inertial load records
 0  $ NINSR = 0 means no crack tip element sets. END B-2 rec.
C
C Begin B-3 input data...
 7, $ NTAM = number of entries in material tabl.BEGIN B-3 rec.
 5, $ NTAB = number of beam cross section entries
 6, $ NTAW = number of entries in shell wall table.
 0, $ NTAP = 0 means user parameters not included.
 2, $ NTAMT = 2 means two fastener element tables.
 1    $ NGCP = 1 means the GCP system will be used. END B-3 rec.
C
C Begin B-4, B-5 input data, if any...
 -0.500   0  1  1    $B-5 WIMPFA, IMSTEP, IMMODE, IMRUN (1st imperf.)
C
C
C Begin F-1 input data (discretization)...
  71  85, $ F-1 NROWS( 1),  NCOLS( 1) unit 1 = cyl. shell
  71   7, $ f-1 strng.web NROWS(  2),NCOLS(  2) Unit   2 stringer no.   1
  71   7, $ f-1 strng.web NROWS(  3),NCOLS(  3) Unit   3 stringer no.   2
```

one imperfection shape

NEGATIVE imperfection amplitude

Overall deformation with NEGATIVE imperfection (one modal imperfection only)



solution scale = 0.1291E+02

PA= 1.30000E+00 PB= 0.00000E+00 PX= 0.00000E+00

step 17 displacement deformed geometry

STAGS model: nonlinear deformation, same view as linear buckling modes

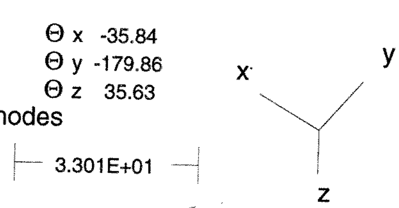
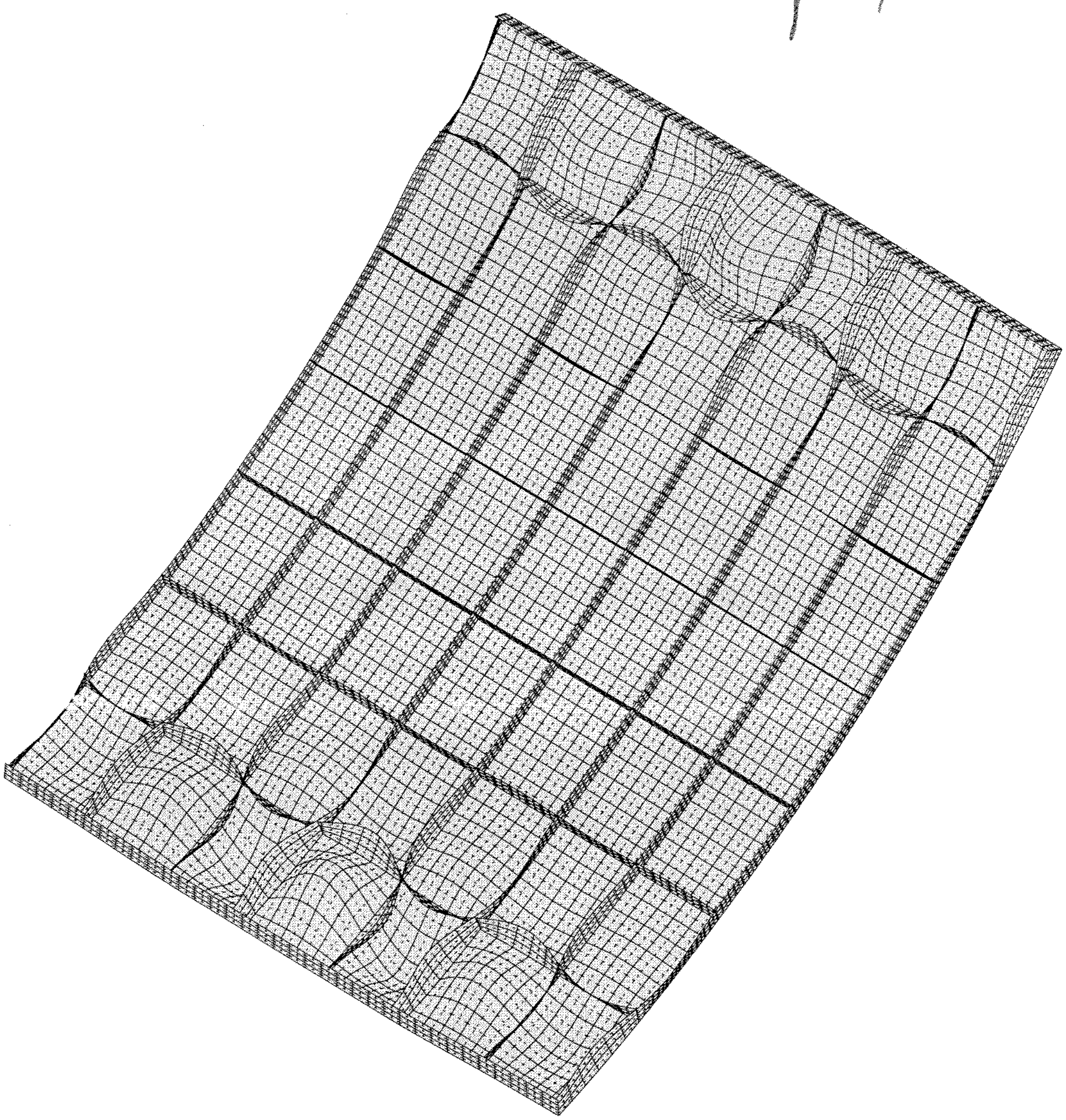


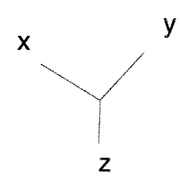
Fig. 38

nonlinear buckling at load step 17



solution scale = 0.1112E+02
mode 1, pcr = 0.13477E+01
step 17 eigenvector deformed geometry
nonlinear buckling of imperfect shell from STAGS

Θ x -35.84
Θ y -179.86
Θ z 35.63

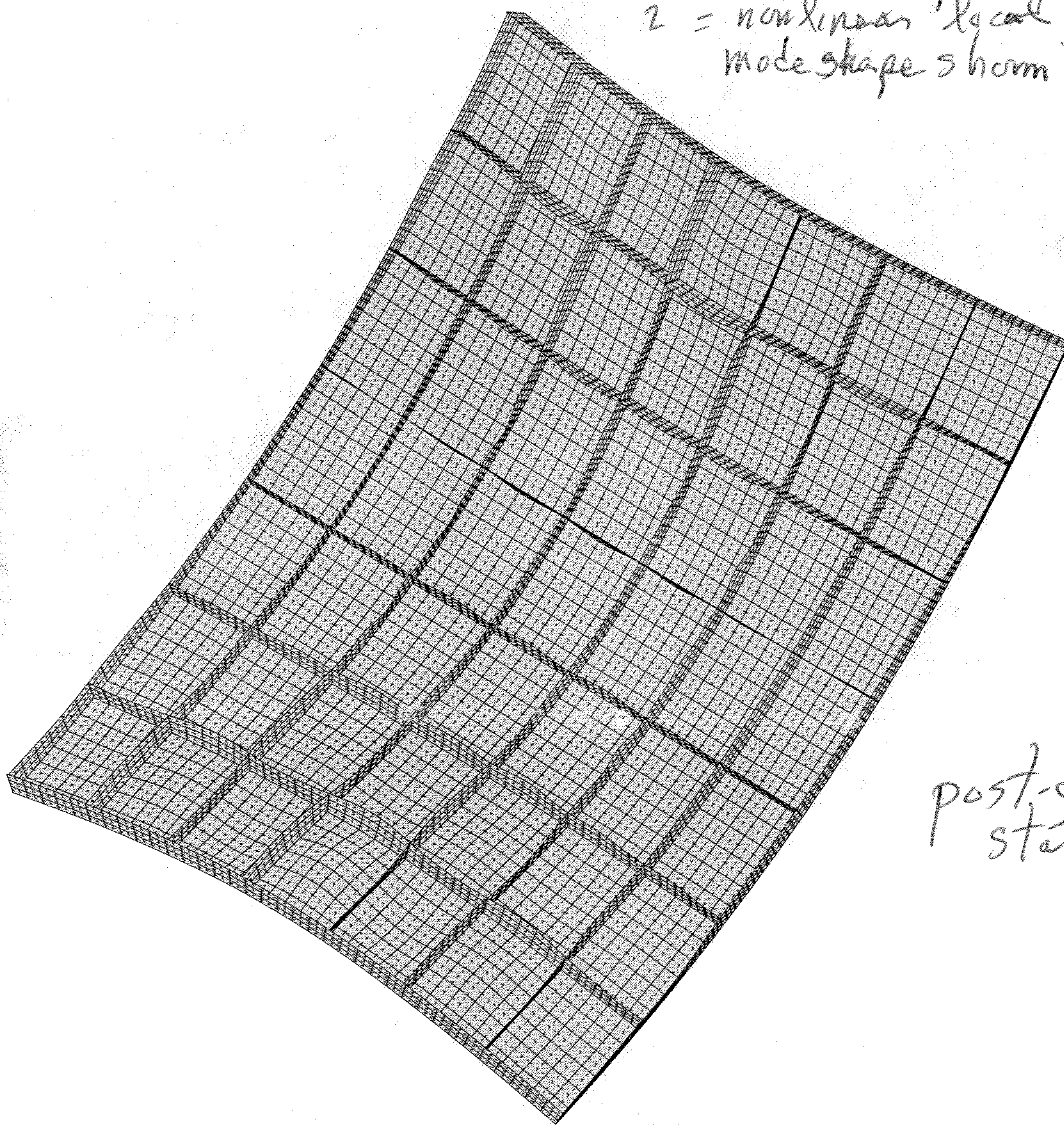


3.301E+01

178

Fig. 39

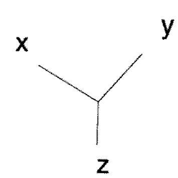
2 modal imperfections:
1 = general linear buckling mode with Wimp = −0.5 inch (Fig. 28)
2 = nonlinear local with Wimp = 0.01 mode shape shown in Fig. 39.



post-collapse state

solution scale = 0.5813E+01
PA= 1.27160E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 20 displacement deformed geometry
STAGS model: nonlinear deformation, same view as linear buckling modes

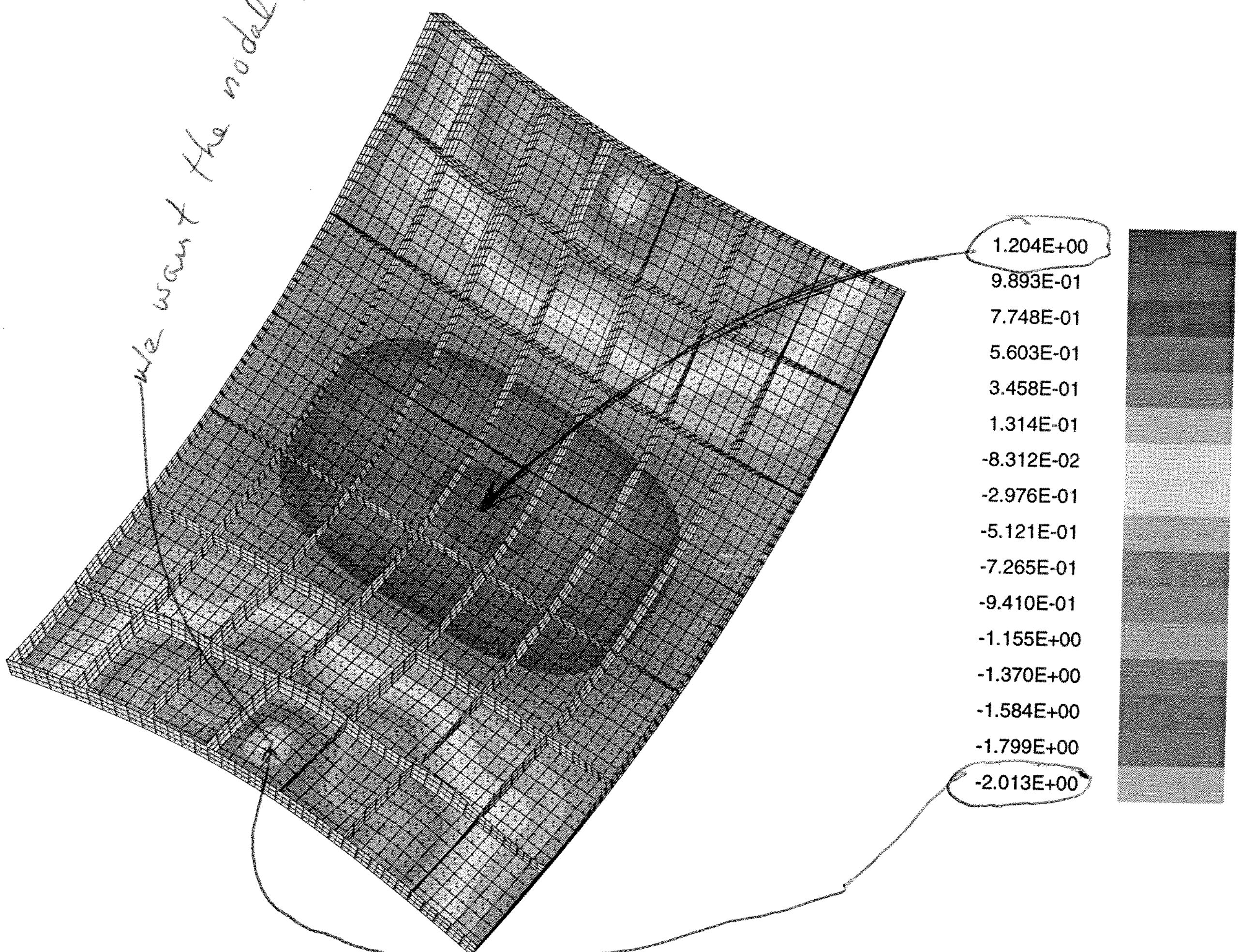
Θ x -35.84
Θ y -179.86
Θ z 35.63



3.301E+01

Fig. 40

We want the nodal point corresponding to this location. (See Fig. 42)



solution scale = 0.5813E+01
PA= 1.27160E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 20 displacement w contours
nonlinear w same view as linear buckling mode
Minimum value = -2.01339E+00, Maximum value = 1.20373E+00

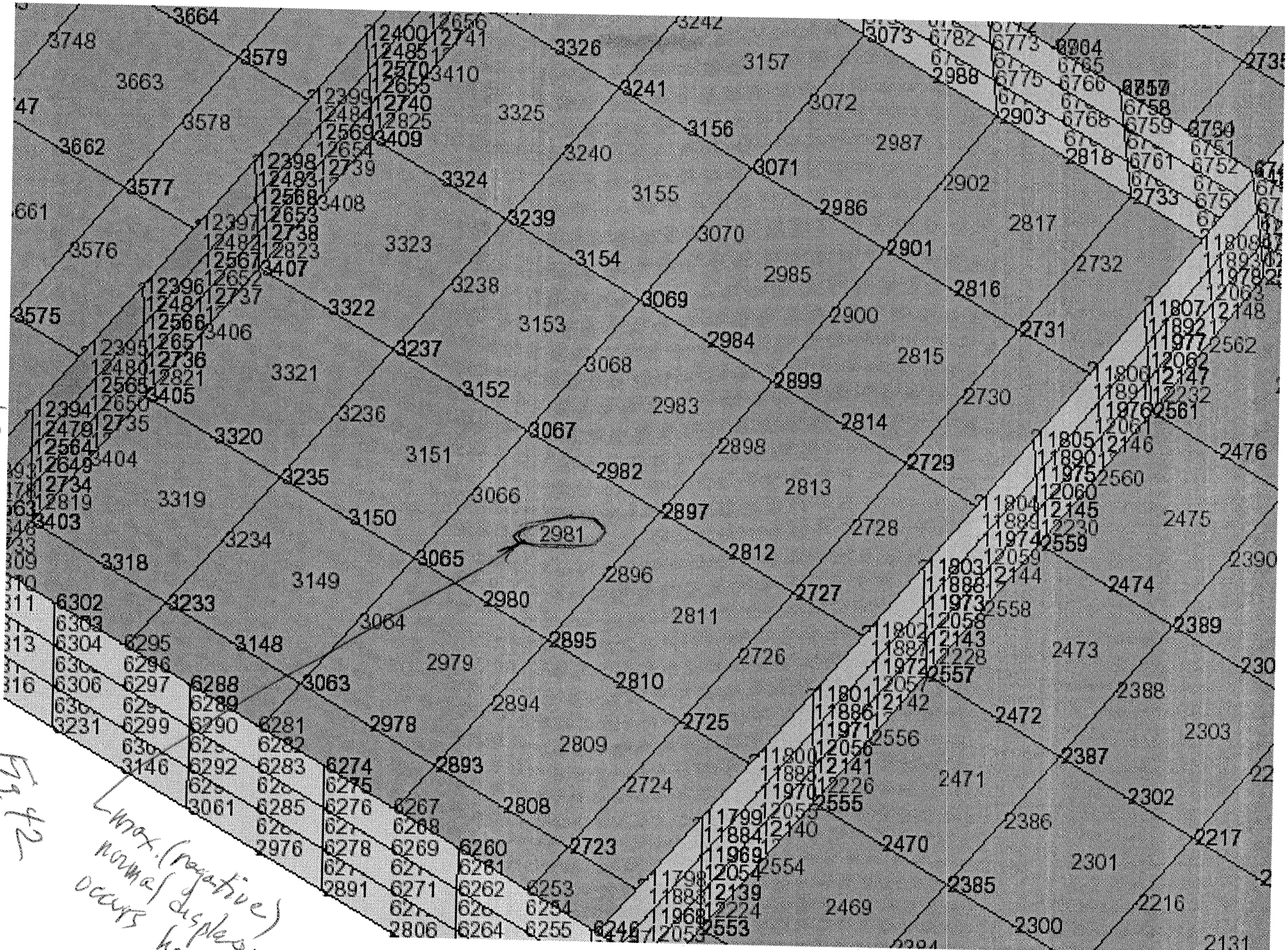
Θ x -35.84
Θ y -179.86
Θ z 35.63

3.770E+01

x y z

180

Fig. 41



Lmax. (negative) normal displacement occurs here.

Fig. 42

Table 75 allen.input

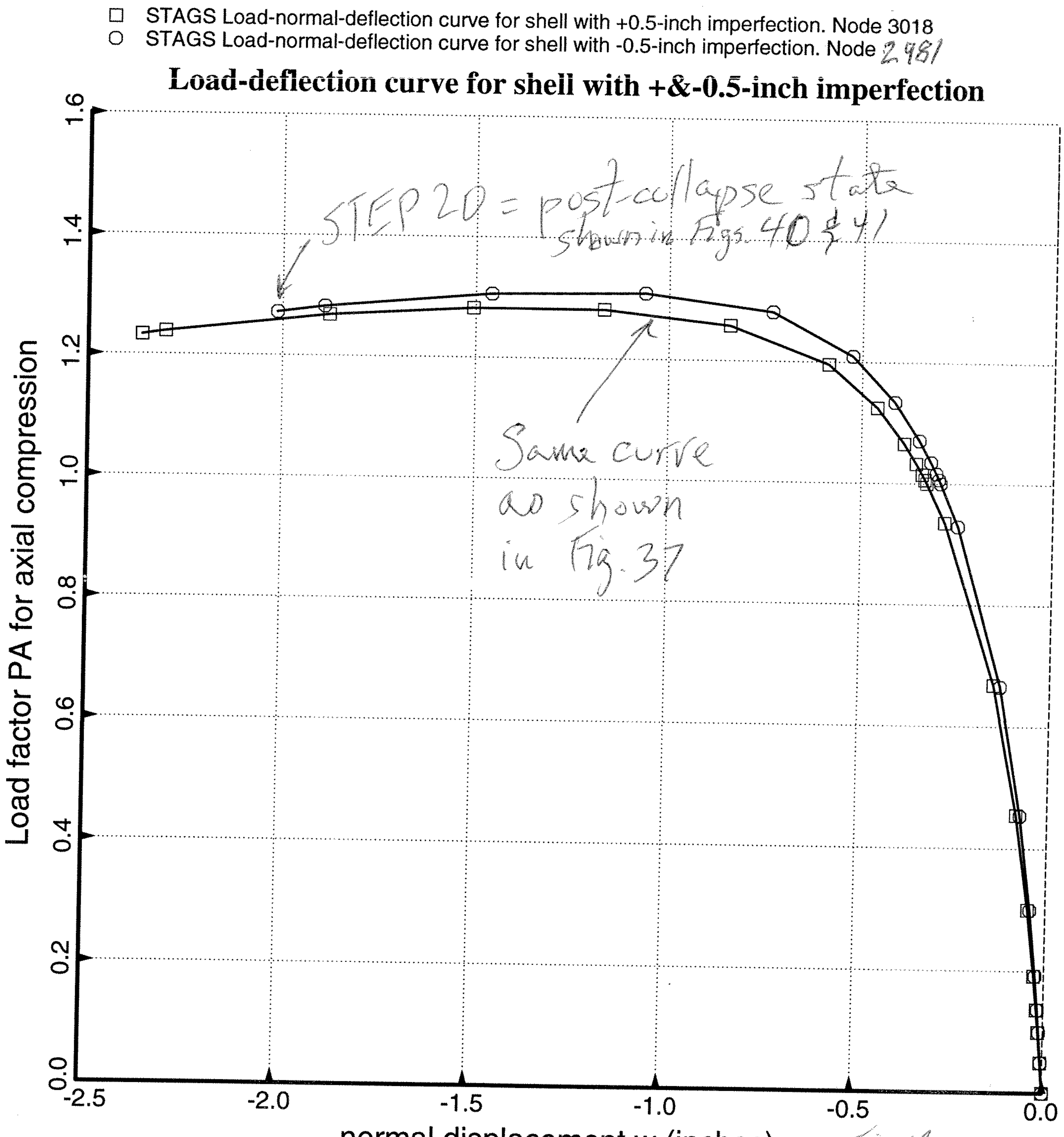
```
# Global directives, load-deflection curve for imperfect shell
=title(Load-deflection curve for shell with +&-0.5-inch imperfection)
=xlabel(normal displacement w (inches))
=ylabel(Load factor PA for axial compression)
# data set 1 Load-normal-deflection curve for shell with +0.5-inch imperfection.
+legend(STAGS Load-normal-deflection curve for shell with +0.5-inch imperfection. Node 3018)
+setmarker(0)
   0.000000E+00     0.000000E+00
  -6.062267E-03     5.000000E-02
  -1.267012E-02     1.000000E-01
  -1.795808E-02     1.371490E-01
  -2.644285E-02     1.922598E-01
  -4.551424E-02     3.000967E-01
  -7.981193E-02     4.549815E-01
  -1.454831E-01     6.683604E-01
  -2.799166E-01     9.351743E-01
  -3.285631E-01     1.000000E+00
  -3.336133E-01     1.006040E+00
  -3.412620E-01     1.014979E+00
  -3.568573E-01     1.032408E+00
  -3.893023E-01     1.065477E+00
  -4.599832E-01     1.124563E+00
  -5.866479E-01     1.195516E+00
  -8.418592E-01     1.257721E+00
  -1.168232E+00     1.281121E+00
  -1.505615E+00     1.281428E+00
  -1.878039E+00     1.267902E+00
  -2.299847E+00     1.238176E+00
  -2.361071E+00     1.232369E+00
```

Same as in Table 73

```
# data set 2 Load-normal-deflection curve for shell with -0.5-inch imperfection.
+legend(STAGS Load-normal-deflection curve for shell with -0.5-inch imperfection. Node )
+setmarker(1)
   0.000000E+00     0.000000E+00
  -5.217942E-03     5.000000E-02
  -1.093863E-02     1.000000E-01
  -1.553447E-02     1.371252E-01
  -2.293525E-02     1.921626E-01
  -3.965560E-02     2.997160E-01
  -6.988678E-02     4.538492E-01
  -1.278855E-01     6.655096E-01
  -2.454557E-01     9.293338E-01
  -2.919124E-01     1.000000E+00
  -2.967231E-01     1.006557E+00
  -3.040004E-01     1.016249E+00
  -3.188023E-01     1.035103E+00
  -3.494041E-01     1.070727E+00
   [illegible].147570E-01     1.133885E+00
  -5.247670E-01     1.209456E+00
  -7.324254E-01     1.281177E+00
  -1.061504E+00     1.309239E+00
  -1.458622E+00     1.305393E+00
  -1.890809E+00     1.281727E+00
  -2.013389E+00     1.271603E+00
```

2981

new data from xytrans



□ STAGS Load-normal-deflection curve for shell with +0.5-inch imperfection. Node 3018
○ STAGS Load-normal-deflection curve for shell with -0.5-inch imperfection. Node 2981
Load-deflection curve for shell with +&-0.5-inch imperfection
STEP 20 = post-collapse state shown in Figs. 40 & 41
Same curve as shown in Fig. 37
Load factor PA for axial compression
normal displacement w (inches)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0

Fig. 43

Begin results for

"allen2"

(no substrings)

BEGIN STUDY OF THE STIFFENED CYLINDRICAL SHELL WITHOUT SUBSTIFFENERS

Next, optimize the shell without the substringers. This case is called "allen2". We start optimizing from the optimum design found with ICONSV = 1 (Table 19)

```
panda2log        (activate the panda2 command set)
begin            (Table 76)
change           (Table 77)
setup
decide           (Table 78)
mainsetup        (Table 79)
superopt
chooseplot
diplot
(Inspect the allen2.OPP file and see Fig.44)
(Edit the allen2.OPT file: set NPRINT=2, ITYPE=2)
mainsetup
pandaopt
(Inspect the allen2.OPM file. Abridged version in Table 80.)
change           (Table 81. Save the optimum design)
change           (Table 82. Establish "STAGSworthy" design)
setup
pandaopt
(Inspect the allen2.OPM file. Abridged version in Table 83.)

(Next, run "fixed" design for 1st load set only
because we want to use STAGS to check only the 1st load set).

mainsetup        (Table 84)
pandaopt
(Inspect the allen2.OPM file. Abridged version in Table 85.)

(Next, set up three STAGS models of the "STAGSworthy" optimum design)

(First, a 10-stringer-bay x 3-ring-bay STAGS model)

stagsunit        (Table 86; 10 major stringer bays x 3 ring bays)

(Go where you want to run STAGS and transfer the
 allen2.bin and allen2.inp files there. Execute STAGS).

stags -b allen2          (10 major stringer bays x 3 ring bays)
(Inspect the allen2.out2 file. Use STAPL.)
stapl allen2     (Table 87)
acroread allen2.pdf (Fig. 45; 10 major stringer bays x 3 ring bays)

stagsunit        (Table 88; Entire shell with smeared substringers and smeared stringers)
stags -b allen2          (Entire shell with smeared substringers and smeared stringers)
(Inspect the allen2.out2 file. Use STAPL.)
stapl allen2     (Table 89)
acroread allen2.pdf (Fig. 46; Entire shell with smeared substringers and smeared stringers)

stagsunit        (Table 90; Entire shell with all stiffeners and substiffeners smeared)
stags -b allen2          (Entire shell with all stiffeners and substiffeners smeared)
(Inspect the allen2.out2 file. Use STAPL.)
stapl allen2     (Table 89)
acroread allen2.pdf (Fig. 47; Entire shell with all stiffeners and substiffeners smeared)
stapl allen2     (Table 91)
acroread allen2.pdf (Fig. 48; Entire shell with all stiffeners and substiffeners smeared)
```

Table 76 allen2.BEG (no sub stringers)

```
     n          $ Do you want a tutorial session and tutorial output?
     124        $ Panel length normal to the plane of the screen, L1
  622.0353      $ Panel length in the plane of the screen, L2
     r          $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
       8        $ stiffener spacing, b
 0.6670000      $ width of stringer base, b2 (must be > 0, see Help)
 6.0000000      $ height of stiffener (type H for sketch), h
     n          $ Are the stringers cocured with the skin?
   10000        $ What force/(axial length) will cause web peel-off?
     n          $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 1)
     n          $ Can winding (layup) angles ever be decision variables?
       1        $ layer index (1,2,...), for layer no.( 1)
     y          $ Is this a new layer type?
 0.6500000E-01  $ thickness for layer index no.( 1)
       0        $ winding angle (deg.) for layer index no.( 1)
       1        $ material index (1,2,...) for layer index no.( 1)
     n          $ Any more layers or groups of layers in Segment no.( 1)
     n          $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 2)
     n          $ Can winding (layup) angles ever be decision variables?
       1        $ layer index (1,2,...), for layer no.( 1)
     n          $ Is this a new layer type?
     n          $ Any more layers or groups of layers in Segment no.( 2)
     n          $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 3)
     n          $ Can winding (layup) angles ever be decision variables?
       2        $ layer index (1,2,...), for layer no.( 1)
     y          $ Is this a new layer type?
 0.6500000      $ thickness for layer index no.( 2)
       0        $ winding angle (deg.) for layer index no.( 2)
       1        $ material index (1,2,...) for layer index no.( 2)
     n          $ Any more layers or groups of layers in Segment no.( 3)
       1        $ choose external (0) or internal (1) stringers
     r          $ Identify type of stiffener along L2  (N, T, J, Z, R, A)
       8        $ stiffener spacing, b
       0        $ width of ring base, b2 (zero is allowed)
 4.0000000      $ height of stiffener (type H for sketch), h
     n          $ Are the rings cocured with the skin?
     n          $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 3)
     n          $ Can winding (layup) angles ever be decision variables?
       3        $ layer index (1,2,...), for layer no.( 1)
     y          $ Is this a new layer type?
 0.6500000      $ thickness for layer index no.( 3)
       0        $ winding angle (deg.) for layer index no.( 3)
       1        $ material index (1,2,...) for layer index no.( 3)
     n          $ Any more layers or groups of layers in Segment no.( 3)
       1        $ choose external (0) or internal (1) rings
     y          $ Is the panel curved in the plane of the screen (Y for cyls.)?
    198         $ Radius of curvature (cyl. rad.) in the plane of screen, R
     n          $ Is panel curved normal to plane of screen? (answer N)
     y          $ Is this material isotropic (Y or N)?
 0.1120000E+08  $ Young's modulus,                E( 1)
 0.3000000      $ Poisson's ratio,               NU( 1)
  4307692.      $ transverse shear modulus,     G13( 1)
       0        $ Thermal expansion coeff.,    ALPHA( 1)
       0        $ residual stress temperature (positive),TEMPTUR( 1)
     n          $ Want to supply a stress-strain "curve" for this mat'l? (N)
     y          $ Want to specify  maximum effective stress ?
  66000.00      $ Maximum allowable effective stress in material type( 1)
     n          $ Do you want to take advantage of "bending overshoot"?
 0.9800000E-01  $ weight density (greater than 0!) of material type( 1)
     n          $ Is lamina cracking permitted along fibers (type H(elp))?
       0        $ Prebuckling: choose 0=bending included; 2=use membrane theory
       0        $ Buckling: choose 0=simple support or 1=clamping
```

Table 77 allen2.CHG (From p. 48 - Table 19)

```
     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, . .)
  8.790200      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        2       $ Number of parameter to change (1, 2, 3, . .)
  2.927100      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        3       $ Number of parameter to change (1, 2, 3, . .)
  2.495700      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        4       $ Number of parameter to change (1, 2, 3, . .)
 0.2769100      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        5       $ Number of parameter to change (1, 2, 3, . .)
 0.2258800      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        6       $ Number of parameter to change (1, 2, 3, . .)
  29.77500      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        7       $ Number of parameter to change (1, 2, 3, . .)
  0.000000      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        8       $ Number of parameter to change (1, 2, 3, . .)
  10.07400      $ New value of the parameter
     y          $ Want to change any other parameters in this set?
        9       $ Number of parameter to change (1, 2, 3, . .)
0.6500000E-01   $ New value of the parameter
     n          $ Want to change any other parameters in this set?
     n          $ Do you want to change values of "fixed" parameters?
     n          $ Do you want to change values of allowables?
```

Table 78 allen2.DEC

```
    n           $ Do you want a tutorial session and tutorial output?
    n           $ Want to use default for thickness decision variables (type H(elp)?
         1      $ Choose a decision variable (1,2,3,...)
         2      $ Lower bound of variable no.( 1)
        50      $ Upper bound of variable no.( 1)
    y           $ Any more decision variables (Y or N) ?
         3      $ Choose a decision variable (1,2,3,...)
0.6500000E-01   $ Lower bound of variable no.( 3)
 10.50000       $ Upper bound of variable no.( 3)
    y           $ Any more decision variables (Y or N) ?
         4      $ Choose a decision variable (1,2,3,...)
0.6500000E-01   $ Lower bound of variable no.( 4)
 2.000000       $ Upper bound of variable no.( 4)
    y           $ Any more decision variables (Y or N) ?
         5      $ Choose a decision variable (1,2,3,...)
0.6500000E-01   $ Lower bound of variable no.( 5)
 3.000000       $ Upper bound of variable no.( 5)
    y           $ Any more decision variables (Y or N) ?
         6      $ Choose a decision variable (1,2,3,...)
 2.000000       $ Lower bound of variable no.( 6)
 50.00000       $ Upper bound of variable no.( 6)
    y           $ Any more decision variables (Y or N) ?
         8      $ Choose a decision variable (1,2,3,...)
0.6500000E-01   $ Lower bound of variable no.( 8)
 10.50000       $ Upper bound of variable no.( 8)
    y           $ Any more decision variables (Y or N) ?
         9      $ Choose a decision variable (1,2,3,...)
0.6500000E-01   $ Lower bound of variable no.( 9)
 3.000000       $ Upper bound of variable no.( 9)
    n           $ Any more decision variables (Y or N) ?
    y           $ Any linked variables (Y or N) ?
         2      $ Choose a linked variable (1,2,3,...)
         1      $ To which variable is this variable linked?
0.3330000       $ Assign a value to the linking coefficient, C(j)
    n           $ Any other decision variables in the linking expression?
    n           $ Any constant C0 in the linking expression (Y or N)?
    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?
```

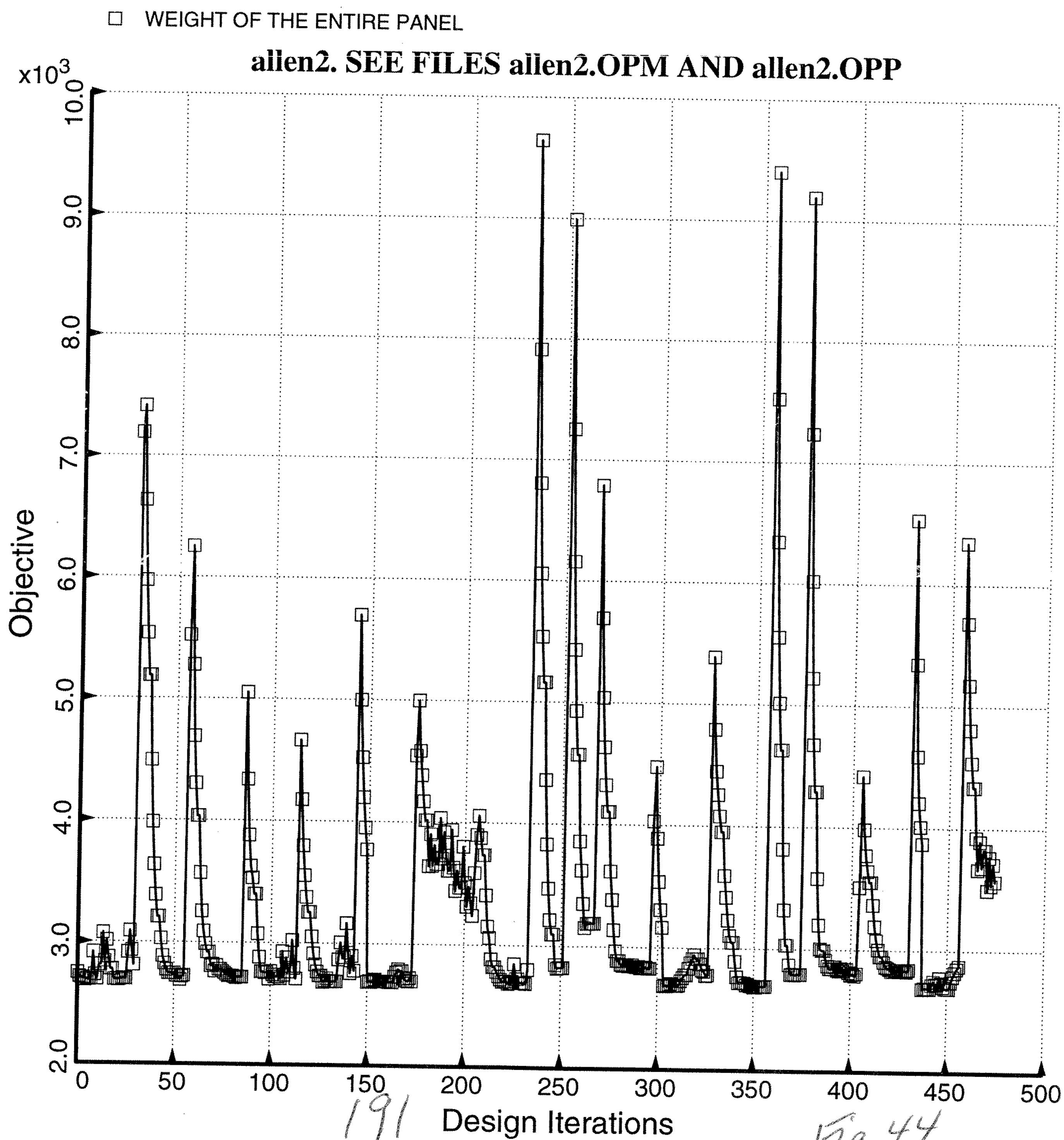
Table 79 allen2.OPT

```
     n         $ Do you want a tutorial session and tutorial output?
 -8025         $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
     0         $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
     0         $ In-plane shear in load set A,                        Nxy( 1)
     n         $ Does the axial load vary in the L2 direction?
     0         $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
     0         $ Applied hoop moment resultant (e.g. in-lb/in), My( 1)
     y         $ Want to include effect of transverse shear deformation?
     0         $ IQUICK = quick analysis indicator (0 or 1)
     y         $ Do you want to vary M for minimum local buckling load?
     n         $ Do you want to choose a starting M for local buckling?
     y         $ Do you want to perform a "low-axial-wavenumber" search?
  2.153846     $ Factor of safety for general instability, FSGEN( 1)
  1.555556     $ Factor of safety for panel (between rings) instability, FSPAN( 1)
  1.555556     $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
  1.555556     $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
     1         $ Factor of safety for stress, FSSTR( 1)
     y         $ Do you want "flat skin" discretized module for local buckling?
     n         $ Do you want wide-column buckling to constrain the design?
     0         $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
     0         $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
     1         $ Axial load applied along the (0=neutral plane), (1=panel skin)
     0         $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
     0         $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
     0         $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
     0         $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
     0         $ Initial local imperfection amplitude (must be positive), Wloc( 1)
     n         $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
     y         $ Do you want PANDA2 to find the general imperfection shape?( 1)
     0         $ Maximum allowable average axial strain (type H for HELP)( 1)
     n         $ Is there any thermal "loading" in this load set (Y/N)?
     y         $ Do you want a "complete" analysis (type H for "Help")?
     y         $ Want to provide another load set ?
 -8025         $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 2)
     0         $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 2)
     0         $ In-plane shear in load set A,                        Nxy( 2)
     n         $ Does the axial load vary in the L2 direction?
     0         $ Applied axial moment resultant (e.g. in-lb/in), Mx( 2)
     0         $ Applied hoop moment resultant (e.g. in-lb/in), My( 2)
     y         $ Want to include effect of transverse shear deformation?
     0         $ IQUICK = quick analysis indicator (0 or 1)
     y         $ Do you want to vary M for minimum local buckling load?
     n         $ Do you want to choose a starting M for local buckling?
     y         $ Do you want to perform a "low-axial-wavenumber" search?
     1         $ Factor of safety for general instability, FSGEN( 2)
     1         $ Factor of safety for panel (between rings) instability, FSPAN( 2)
     1         $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 2)
     1         $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 2)
  1.265753     $ Factor of safety for stress, FSSTR( 2)
     y         $ Do you want "flat skin" discretized module for local buckling?
     n         $ Do you want wide-column buckling to constrain the design?
     0         $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 2)
 11266.20      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 2)
     1         $ Axial load applied along the (0=neutral plane), (1=panel skin)
-56.90000      $ Uniform applied pressure [positive upward. See H(elp)], p( 2)
     n         $ Is the pressure part of Load Set A?
     n         $ Is the pressure hydrostatic (Type H for "HELP")?
     0         $ Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 2)
     y         $ Are you feeling well today (type H)?
     n         $ Is there a maximum allowable deflection due to pressure?
     0         $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 2)
     0         $ Initial buckling modal general imperfection amplitude, Wimpg2( 2)
     0         $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 2)
     0         $ Initial local imperfection amplitude (must be positive), Wloc( 2)
     n         $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 2)
     y         $ Do you want PANDA2 to find the general imperfection shape?( 2)
     0         $ Maximum allowable average axial strain (type H for HELP)( 2)
     n         $ Is there any thermal "loading" in this load set (Y/N)?
     y         $ Do you want a "complete" analysis (type H for "Help")?
     n         $ Want to provide another load set ?
     n         $ Do you want to impose minimum TOTAL thickness of any segment?
     n         $ Do you want to impose maximum TOTAL thickness of any segment?
     n         $ Do you want to impose minimum TOTAL thickness of any segment?
     n         $ Do you want to impose maximum TOTAL thickness of any segment?
     n         $ Use reduced effective stiffness in panel skin (H(elp), Y or N)?
     0         $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
     0         $ Index for type of shell theory (0 or 1 or 2), ISAND
     n         $ Does the postbuckling axial wavelength of local buckles change?
```

Table 79 (p. 2 of 2)

```
       n          $ Want to suppress general buckling mode with many axial waves?
       n          $ Do you want to double-check PANDA-type eigenvalues [type (H)elp]?
          1       $ Choose (0=transverse inextensional; 1=transverse extensional)
          0       $ Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV
          1       $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
       Y          $ Do you want to prevent secondary buckling (mode jumping)?
       Y          $ Do you want to use the "alternative" buckling solution?
  1.000000        $ Factor of safety for "alternative" model of general buckling
          5       $ How many design iterations permitted in this run (5 to 25)?
  1.000000        $ MAXMAR. Plot only those margins less than MAXMAR (Type H)
       N          $ Do you want to reset total iterations to zero (Type H)?
          1       $ Index for objective (1=min. weight, 2=min. distortion)
  1.000000        $ FMARG (Skip load case with min. margin greater than FMARG)
```

note ICONSV=0



WEIGHT OF THE ENTIRE PANEL
allen2. SEE FILES allen2.OPM AND allen2.OPP
x10^3
Objective
Design Iterations

191

Fig. 44

Table 80 (3 pages) abridged allen.OPM file

```
Abridged allen2.OPM file for optimum design
with ICONSV = 0 and IQUICK = 0

 *********** LOAD SET NO. 1   **************
 ICASE =  1  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS AT RINGS                           )

   APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
         Applied    axial        stress resultant, Nx= -8.0250E+03
         Applied circumferential stress resultant, Ny= -8.0250E-03
         Applied    in-plane     shear  resultant,Nxy=  4.0125E+01
         Applied    axial        moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00
         Applied pressure (positive for upward),    p =  4.0530E-05

   APPLIED LOADS IN LOAD SET B ( fixed uniform loads):
         Applied    axial        stress resultant,Nx0=  0.0000E+00
         Applied circumferential stress resultant,Ny0=  0.0000E+00
         Applied    in-plane    shear  resultant,Nxy0=  0.0000E+00

 NOTE: "F.S." means "Factor of Safety";
 "DONL" means "Donnell shell theory used.";
 "SAND" means "Sanders shell theory used." panda2.news ITEM 128
 "Dseg" means "Segment numbering used in discretized model"
 "Iseg" means "Segment numbering used for input data." ITEM 272
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1 -1.07E-03 Local buckling from discrete model-1.,M=5   axial halfwaves;FS=1.55
 2 -1.07E-03 Bending-torsion buckling; M=5  ;FS=1.5556
 3 -5.44E-03 Bending-torsion buckling: Koiter theory,M=5   axial halfwav;FS=1.55
 4  1.71E+00 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.0788; MID.;FS=1.
 5  3.81E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 6  9.87E-03 (m=5   lateral-torsional buckling load factor)/(FS)-1;FS=1.5556
 7  1.10E-01 Inter-ring bucklng, discrete model, n=23  circ.halfwaves;FS=1.5556
 8  1.71E+00 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 9  2.54E-02 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=1.5556
10 -2.85E-02 buck.(DONL);simp-support general buck;M=3;N=8;slope=0.;FS=2.1538
11  8.52E+00 buck.(DONL);rolling with smear rings; M=60;N=1;slope=0.;FS=1.5556
12  4.72E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  2.39E-02 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=1.5556
14 -3.15E-02 buck.(SAND);simp-support general buck;M=3;N=8;slope=0.;FS=2.1538
15  8.52E+00 buck.(SAND);rolling with smear rings; M=60;N=1;slope=0.;FS=1.5556


 *********** LOAD SET NO. 1   **************
 ICASE =  2  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS AT RINGS                           )

   APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
         Applied    axial        stress resultant, Nx= -8.0250E+03
         Applied circumferential stress resultant, Ny= -8.0250E-03
         Applied    in-plane     shear  resultant,Nxy=  4.0125E+01
         Applied    axial        moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00
         Applied pressure (positive for upward),    p =  4.0530E-05

   APPLIED LOADS IN LOAD SET B ( fixed uniform loads):
         Applied    axial        stress resultant,Nx0=  0.0000E+00
         Applied circumferential stress resultant,Ny0=  0.0000E+00
         Applied    in-plane    shear  resultant,Nxy0=  0.0000E+00

 NOTE: "F.S." means "Factor of Safety";
 "DONL" means "Donnell shell theory used.";
 "SAND" means "Sanders shell theory used." panda2.news ITEM 128
 "Dseg" means "Segment numbering used in discretized model"
 "Iseg" means "Segment numbering used for input data." ITEM 272
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1  2.57E-02 Local buckling from discrete model-1.,M=4   axial halfwaves;FS=1.55
 2  2.44E-02 Bending-torsion buckling; M=4  ;FS=1.5556
 3  2.28E-02 Bending-torsion buckling: Koiter theory,M=4   axial halfwav;FS=1.55
 4  1.77E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1427; RNGS;FS=1.
 5  5.51E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
```

Table 80, (p. 2 of 3)

```
  6  3.66E-02 (m=4   lateral-torsional buckling load factor)/(FS)-1;FS=1.5556
  7  1.10E-01 Inter-ring bucklng, discrete model, n=23  circ.halfwaves;FS=1.5556
  8  1.78E+00 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.1427;-RNGS;FS=1.
  9  8.48E+00 buck.(DONL);rolling with smear rings; M=60;N=1;slope=0.;FS=1.5556
 10  4.69E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 11  8.48E+00 buck.(SAND);rolling with smear rings; M=60;N=1;slope=0.;FS=1.5556


 *********** LOAD SET NO. 2  **************
 ICASE =  1  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS AT RINGS                               )

   APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
         Applied     axial        stress resultant, Nx= -8.0250E+03
         Applied circumferential stress resultant, Ny= -8.0250E-03
         Applied    in-plane      shear  resultant,Nxy=  4.0125E+01
         Applied     axial        moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00

   APPLIED LOADS IN LOAD SET B ( fixed uniform loads):
         Applied     axial        stress resultant,Nx0=  0.0000E+00
         Applied circumferential stress resultant,Ny0=  1.1266E+04
         Applied    in-plane    shear  resultant,Nxy0=  0.0000E+00
         Applied pressure (positive for upward),    p = -5.6900E+01

 NOTE: "F.S." means "Factor of Safety";
 "DONL" means "Donnell shell theory used.";
 "SAND" means "Sanders shell theory used." panda2.news ITEM 128
 "Dseg" means "Segment numbering used in discretized model"
 "Iseg" means "Segment numbering used for input data." ITEM 272
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1  2.06E-02 Local buckling from discrete model-1.,M=7   axial halfwaves;FS=1.1
 2  2.05E-02 Bending-torsion buckling; M=7  ;FS=1.1
 3 -1.24E-03 Bending-torsion buckling: Koiter theory,M=7   axial halfwav;FS=1.1
 4  9.81E-03 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.1427; MID.;FS=1.26
 5  2.51E+03 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.2658
 6  3.05E-02 (m=7   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 7  1.35E+00 Inter-ring bucklng, discrete model, n=11  circ.halfwaves;FS=1.1
 8  1.03E-02 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.1427;-MID.;FS=1.26
 9  1.26E+00 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=1.1
10  1.21E+00 buck.(DONL);simp-support general buck;M=3;N=7;slope=0.;FS=1.1
11  1.81E+00 buck.(DONL);simp-support general buck;(0.85*altsol);FS=1.
12  1.26E+01 buck.(DONL);rolling with smear rings; M=60;N=1;slope=0.;FS=1.1
13  3.40E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  1.25E+00 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=1.1
15  1.20E+00 buck.(SAND);simp-support general buck;M=3;N=7;slope=0.;FS=1.1
16  1.80E+00 buck.(SAND);simp-support general buck;(0.85*altsol);FS=1.
17  1.26E+01 buck.(SAND);rolling with smear rings; M=60;N=1;slope=0.;FS=1.1


 *********** LOAD SET NO. 2  **************
 ICASE =  2  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS AT RINGS                               )

   APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
         Applied     axial        stress resultant, Nx= -8.0250E+03
         Applied circumferential stress resultant, Ny= -8.0250E-03
         Applied    in-plane      shear  resultant,Nxy=  4.0125E+01
         Applied     axial        moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00

   APPLIED LOADS IN LOAD SET B ( fixed uniform loads):
         Applied     axial        stress resultant,Nx0=  0.0000E+00
         Applied circumferential stress resultant,Ny0=  1.1266E+04
         Applied    in-plane    shear  resultant,Nxy0=  0.0000E+00
         Applied pressure (positive for upward),    p = -5.6900E+01

 NOTE: "F.S." means "Factor of Safety";
 "DONL" means "Donnell shell theory used.";
 "SAND" means "Sanders shell theory used." panda2.news ITEM 128
 "Dseg" means "Segment numbering used in discretized model"
 "Iseg" means "Segment numbering used for input data." ITEM 272
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 2
 MAR. MARGIN
```

Table 80 (p. 3 of 3)

```
NO.  VALUE                 DEFINITION
 1   3.78E-01 Local buckling from discrete model-1.,M=7    axial halfwaves;FS=1.1
 2   5.16E-01 Bending-torsion buckling; M=7  ;FS=1.
 3   3.18E-01 Bending-torsion buckling: Koiter theory,M=7   axial halfwav;FS=1.1
 4   3.37E-05 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1427; RNGS;FS=1.26
 5   1.51E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.2658
 6   3.56E-01 (m=7   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 7   1.35E+00 Inter-ring bucklng, discrete model, n=11  circ.halfwaves;FS=1.1
 8   9.55E-03 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.1427;-RNGS;FS=1.265
 9   1.22E+01 buck.(DONL);rolling with smear rings; M=60;N=1;slope=0.;FS=1.1
10   3.30E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
11   1.22E+01 buck.(SAND);rolling with smear rings; M=60;N=1;slope=0.;FS=1.1
 ***********  ALL 2 LOAD SETS PROCESSED  ***********
 ****************************************************

           SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER     CURRENT     UPPER        DEFINITION
  NO. VAR.  VAR.  VAR.   TO    CONSTANT    BOUND      VALUE      BOUND
   1   Y     N     N     0     0.00E+00   2.00E+00  8.5529E+00  5.00E+01       B(STR):stiffener s»
pacing, b: STR seg=NA, layer=NA
   2   N     N     Y     1     3.33E-01   0.00E+00  2.8481E+00  0.00E+00       B2(STR):width of st»
ringer base, b2 (must be > 0, see
   3   Y     N     N     0     0.00E+00   6.50E-02  2.7722E+00  1.05E+01       H(STR):height of s»
tiffener (type H for sketch), h:
   4   Y     Y     N     0     0.00E+00   6.50E-02  2.8549E-01  2.00E+00       T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     Y     N     0     0.00E+00   6.50E-02  1.5755E-01  3.00E+00       T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
   6   Y     N     N     0     0.00E+00   2.00E+00  3.3892E+01  5.00E+01       B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
   7   N     N     N     0     0.00E+00   0.00E+00  0.0000E+00  0.00E+00       B2(RNG):width of ri»
ng base, b2 (zero is allowed): RN
   8   Y     N     N     0     0.00E+00   6.50E-02  9.8591E+00  1.05E+01       H(RNG):height of s»
tiffener (type H for sketch), h:
   9   Y     Y     N     0     0.00E+00   6.50E-02  6.5000E-02  3.00E+00       T(3 )(RNG):thickness f»
or layer index no.(3 ): RNG seg=3

 ****************************************************
 ******************* DESIGN OBJECTIVE ******************
 *************                              ***********
0
  CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER    CURRENT
 NO.  RNG   NO.   NO.     VALUE           DEFINITION
             0     0    2.687E+03  WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                                =   2.1580E+03
  TOTAL WEIGHT OF SUBSTIFFENERS                       =   0.0000E+00
  TOTAL WEIGHT OF STRINGERS                           =   3.8600E+02
  TOTAL WEIGHT OF RINGS                               =   1.4293E+02
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   3.4835E-02

 *************                            ************
 ******************* DESIGN OBJECTIVE ******************
 ****************************************************
```

Optimum design from PANDA2 after one execution of SUPEROPT

Table 81 allen.CHG (PANDA2 optimum design)

```
          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, . .)
   8.552900         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             2      $ Number of parameter to change (1, 2, 3, . .)
   2.848100         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             3      $ Number of parameter to change (1, 2, 3, . .)
   2.772200         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             4      $ Number of parameter to change (1, 2, 3, . .)
  0.2854900         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             5      $ Number of parameter to change (1, 2, 3, . .)
  0.1575500         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             6      $ Number of parameter to change (1, 2, 3, . .)
   33.89200         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             7      $ Number of parameter to change (1, 2, 3, . .)
   0.000000         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             8      $ Number of parameter to change (1, 2, 3, . .)
    9.85910         $ New value of the parameter
          y         $ Want to change any other parameters in this set?
             9      $ Number of parameter to change (1, 2, 3, . .)
0.6500000E-01       $ New value of the parameter
          n         $ Want to change any other parameters in this set?
          n         $ Do you want to change values of "fixed" parameters?
          n         $ Do you want to change values of allowables?
```

save the optimum design

Table 82 allen.CHG ("STAGSworthy" optimum designs)

```
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, . .)
8.521030     $ New value of the parameter
y            $ Want to change any other parameters in this set?
2            $ Number of parameter to change (1, 2, 3, . .)
2.837500     $ New value of the parameter
y            $ Want to change any other parameters in this set?
3            $ Number of parameter to change (1, 2, 3, . .)
2.772200     $ New value of the parameter
y            $ Want to change any other parameters in this set?
4            $ Number of parameter to change (1, 2, 3, . .)
0.2854900    $ New value of the parameter
y            $ Want to change any other parameters in this set?
5            $ Number of parameter to change (1, 2, 3, . .)
0.1575500    $ New value of the parameter
y            $ Want to change any other parameters in this set?
6            $ Number of parameter to change (1, 2, 3, . .)
31.00000     $ New value of the parameter
y            $ Want to change any other parameters in this set?
7            $ Number of parameter to change (1, 2, 3, . .)
0.000000     $ New value of the parameter
y            $ Want to change any other parameters in this set?
8            $ Number of parameter to change (1, 2, 3, . .)
9.85910      $ New value of the parameter
y            $ Want to change any other parameters in this set?
9            $ Number of parameter to change (1, 2, 3, . .)
0.6500000E-01 $ New value of the parameter
n            $ Want to change any other parameters in this set?
n            $ Do you want to change values of "fixed" parameters?
n            $ Do you want to change values of allowables?
```

4 ring bays in 124-inch axial length of the cylindrical shell.

0.333 x 8.52103 inches.

exactly 146 stringers in the 360-degree cyl. shell