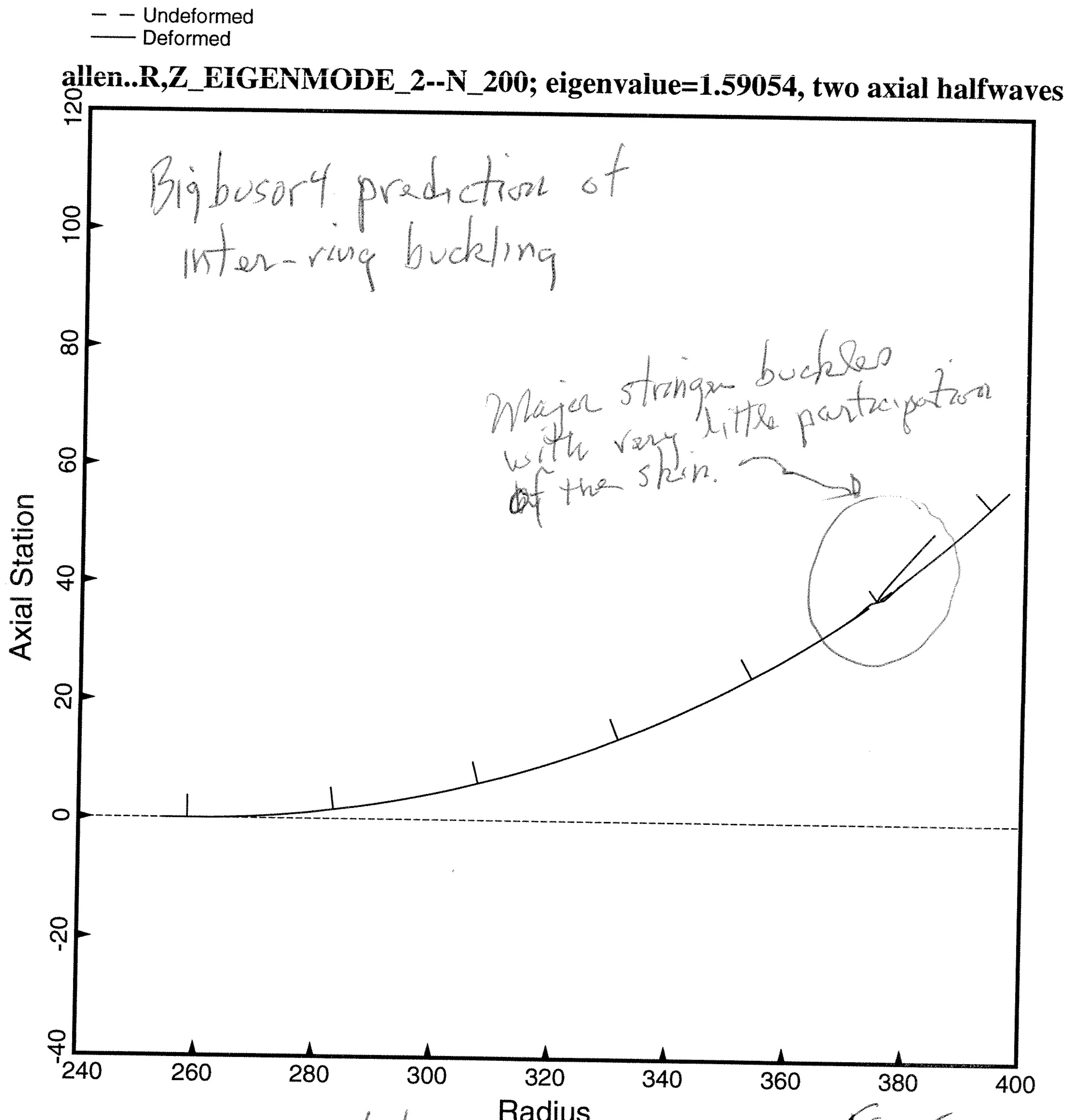
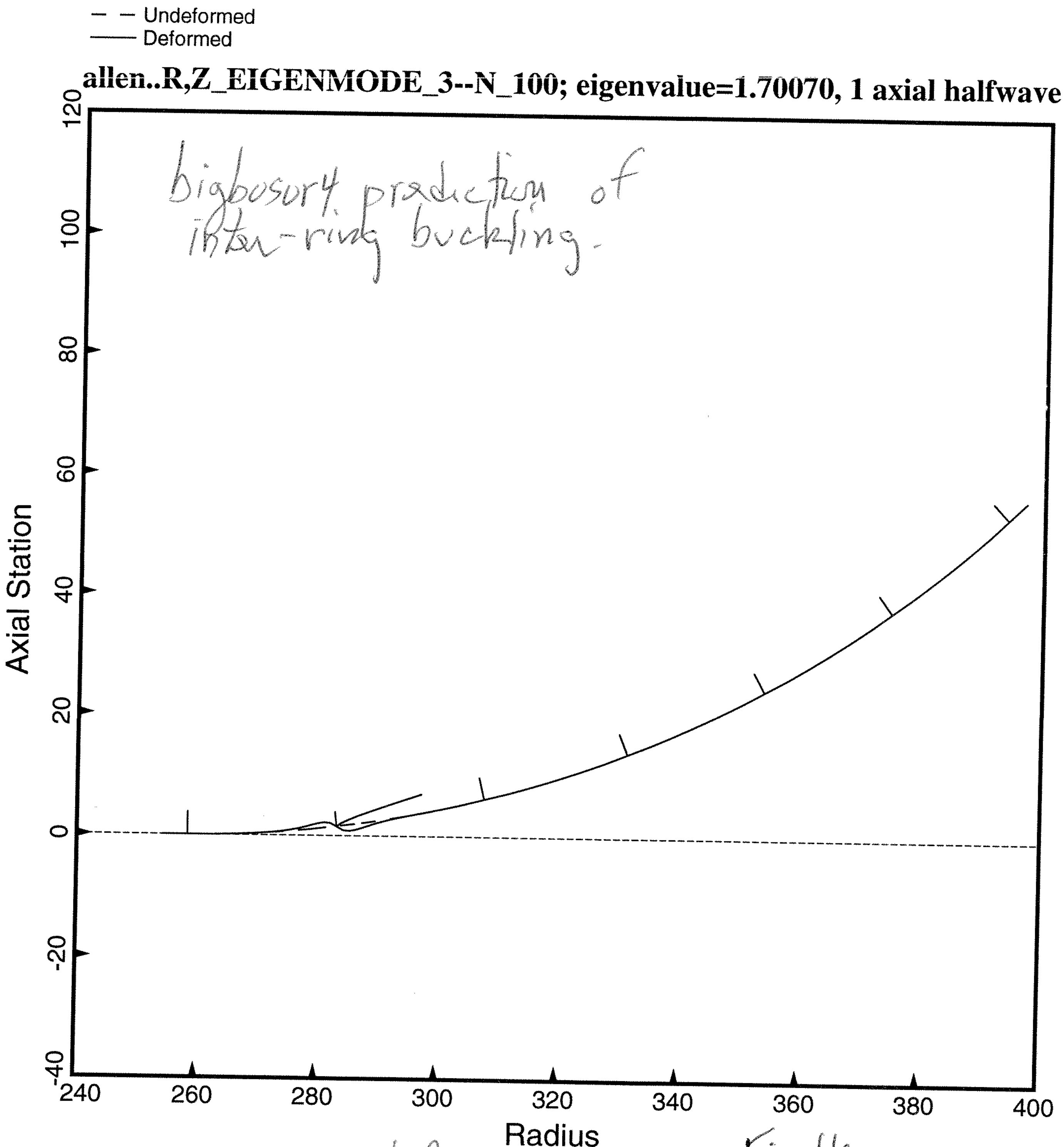


– – Undeformed
—— Deformed
allen..R,Z_EIGENMODE_2--N_200; eigenvalue=1.59054, two axial halfwaves
Bigbosor4 prediction of inter-ring buckling
Major stringer buckles with very little participation of the skin.
Axial Station
Radius

101

Fig. 15



Undeformed
Deformed
allen..R,Z_EIGENMODE_3--N_100; eigenvalue=1.70070, 1 axial halfwave
bigbosor4 prediction of
inter-ring buckling.
Axial Station
120
100
80
60
40
20
0
-20
-40
240
260
280
300
320
340
360
380
400
Radius

102

Fig. 16

Table 43 allen.PAN & allen.OUT

abridged allen.OUT file

allen bigbosor4 buckling. The input data
were generated via the PANDA2 processor, PANEL2

The input data for PANEL2 are:

```
    n        $ Do you want a tutorial session and tutorial output?
  124        $ Length of the ring-stiffened cylindrical shell, L1
    1        $ Choose BOSOR4 model: INDIC=1 or INDIC=4; INDIC
-8025        $ Axial resultant Nx in Load Set A, Nx
    0        $ Axial resultant Nxo in Load Set B, Nxo
    0        $ Normal pressure p
    1        $ IABP = 1 if pressure in Load Set A; IABP=0 otherwise. IABP
```

~~0 $ Enter control (0 or 1) for rings at the cylinder ends~~

```
    2        $ Enter control (1=sym; 2=s.s.; 3=clamp) for buckling b.c.
    2        $ Starting number of circumferential waves [see H(elp)],N0B
   12        $ Ending number of circumferential waves [see H(elp)],NMAXB
    1        $ Increment in number of circumferential waves, INCRB
    1        $ Number of eigenvalues for each circ. wavenumber, NVEC
```

See ITEM 769 in panda2.news

Output in the allen.OUT file (search for the string, "EIGENVALUE("

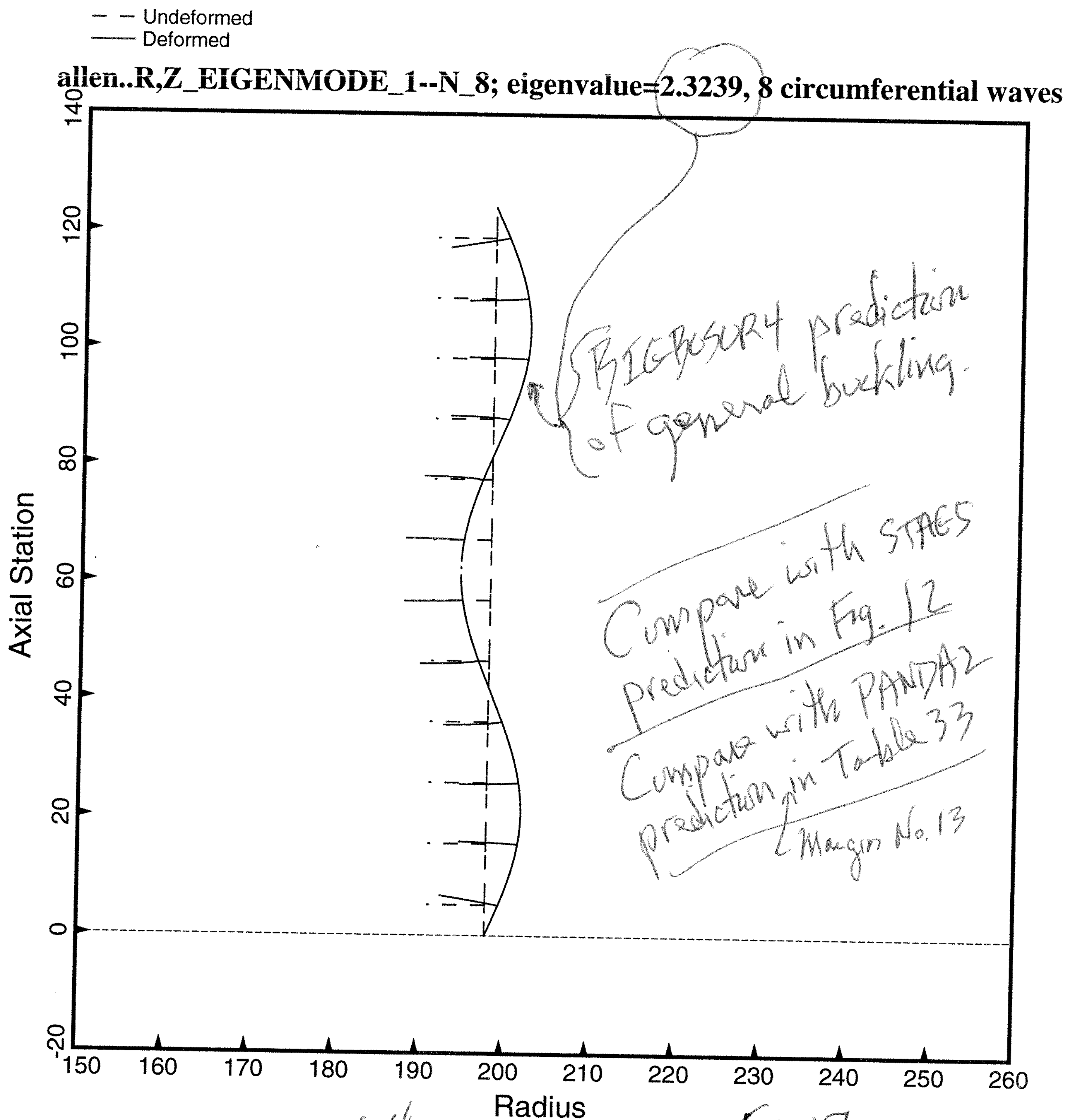
```
***** EIGENVALUES AND MODE SHAPES *****
 EIGENVALUE(CIRC. WAVES)
=======================================
   3.1694E+00(   2)
   3.0088E+00(   3)
   2.8210E+00(   4)
   2.6335E+00(   5)
   2.4726E+00(   6)
   2.3492E+00(   7)
   2.3239E+00(   8) <--critical (lowest) value
   2.3701E+00(   9)
   2.5138E+00(  10)
   2.7645E+00(  11)
   3.1291E+00(  12)
=======================================
```

(general buckling - Fig. 17)

BIGBOSOR4 prediction of general buckling

compare with STAGS in Fig. 12
compare with PANDA2 in ~~Fig~~ Table 33

Margin No. 13



BIGBOSOR4 prediction of general buckling.

Compare with STAGS prediction in Fig. 12

Compare with PANDA2 prediction in Table 33

Margin No. 13

104

Fig. 17

Table 44 allen.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)
   0.1          $ 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")?
     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)?
     2          $ 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?
     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
     2          $ 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
```

Note the small general buckling modal imperfection amplitude. Otherwise, this table is the same as Table 32.

Table 45 allen.OPM (1st load set only)

Abridged allen.OPM file corresponding to the optimum design listed in Table 28.

A small general buckling modal imperfection amplitude has been introduced, especially to see what happens with those very slender rings.

Wimp = 0.1 inch, as in the previous table.

Compare the margins in this table with those in Load set no. 1 of Table 28.

```
 *********** 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 -3.60E-01 Local buckling from discrete model-1.,M=2   axial halfwaves;FS=1.55
 2 -3.60E-01 Bending-torsion buckling; M=2  ;FS=1.5556
 3 -3.41E-01 Bending-torsion buckling: Koiter theory,M=2   axial halfwav;FS=1.55
 4  3.96E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.1044; MID.;FS=1.
 5  2.04E+02 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 6  1.69E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
 7 -3.59E-01 (m=2   lateral-torsional buckling load factor)/(FS)-1;FS=1.5556
 8 -1.93E-01 skin-substringer discrete model-1.,M=5   axial halfwaves;FS=1.5556
 9 -7.35E-01 Ring sidesway buk., discrete model, n=56  circ.halfwaves;FS=1.5556
10  1.01E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
11  4.71E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
12  1.56E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=1.5556
13 -1.50E-01 buck.(DONL);simp-support general buck;M=3;N=8;slope=0.;FS=2.1538
14  7.42E-03 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=1.5556
15 -1.38E-01 buck.(DONL);rolling only of stringers;M=20;N=0;slope=0.;FS=1.4
16  6.62E+00 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
17  7.94E-03 buckling:simp-support altsoln4  intermajorpatch; FS=1.5556
18  4.56E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
19  1.15E+00 1.-V(1)^1+5.V(9)^1-1
20  2.03E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=1.5556
21 -1.52E-01 buck.(SAND);simp-support general buck;M=3;N=8;slope=0.;FS=2.1538
22  4.31E-02 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=1.5556
```

especially note this.

The design is the same as that listed in Table 28, that is, the optimum design from PANDA2 (not the "STAGSworthy" design listed in Table 33)

Table 46 allen.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?
note { 0.999     $ Factor of safety for general instability, FSGEN( 1)
       0.999     $ Factor of safety for panel (between rings) instability, FSPAN( 1)
       0.999     $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
       1.000     $ 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)
note --> 0.5     $ 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( 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?
note { 0.999     $ Factor of safety for general instability, FSGEN( 1)
       0.999     $ Factor of safety for panel (between rings) instability, FSPAN( 1)
       0.999     $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
       1.000     $ 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)
note --> -0.5    $ 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)
```

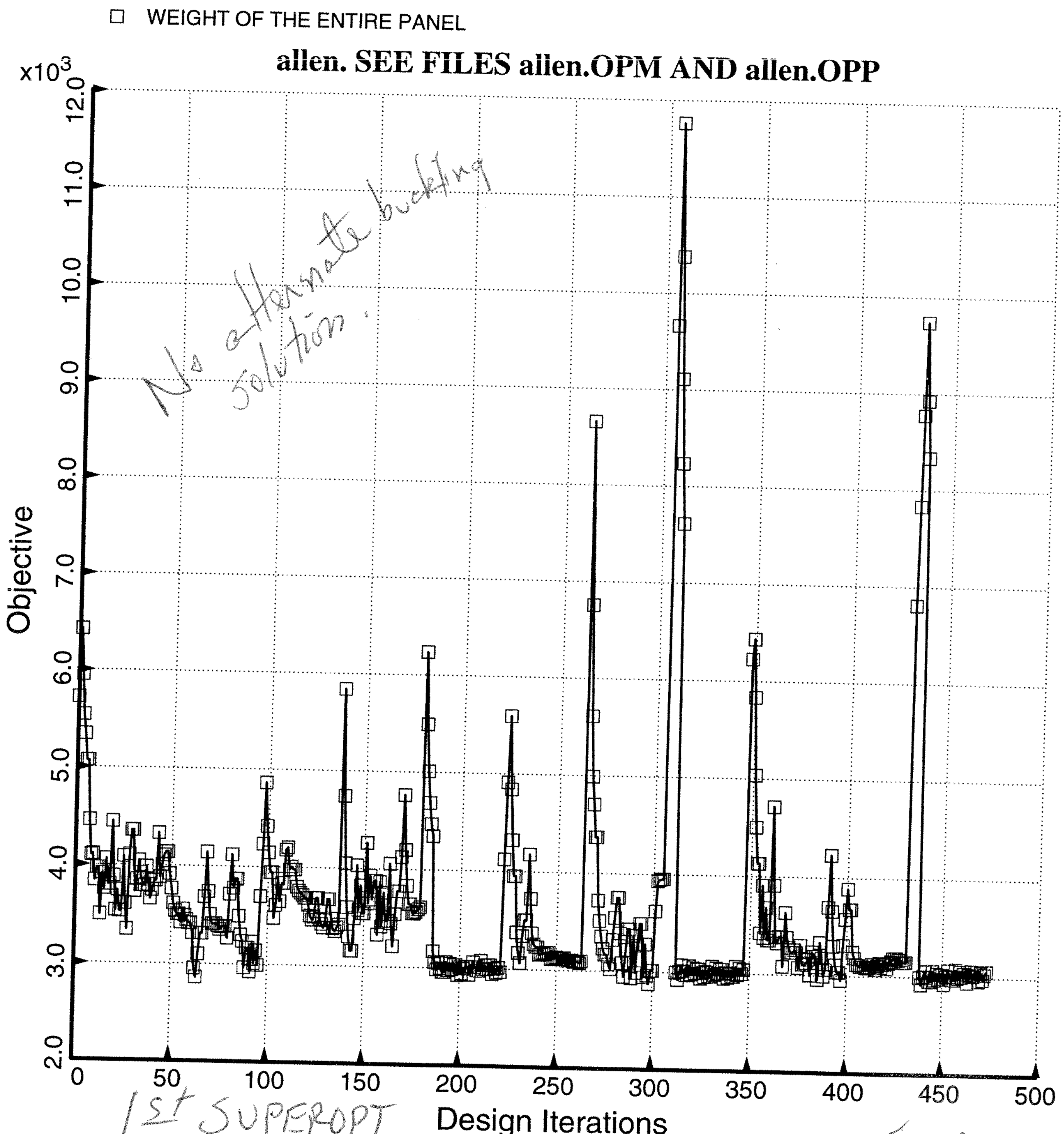
Table 46 (p. 2 of 2)

```
       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?
   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)?
note   n          $ Do you want to use the "alternative" buckling solution?
       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)
```

no alternate buckling solution at first in order to get a reasonably good optimum design with use of a small amount of computer time.

Note that the factors of safety for buckling have all been set equal to 0.999, since there exists an imperfection and therefore we do not need higher factors of safety.

Optimizing the imperfect shell



1st SUPEROPT

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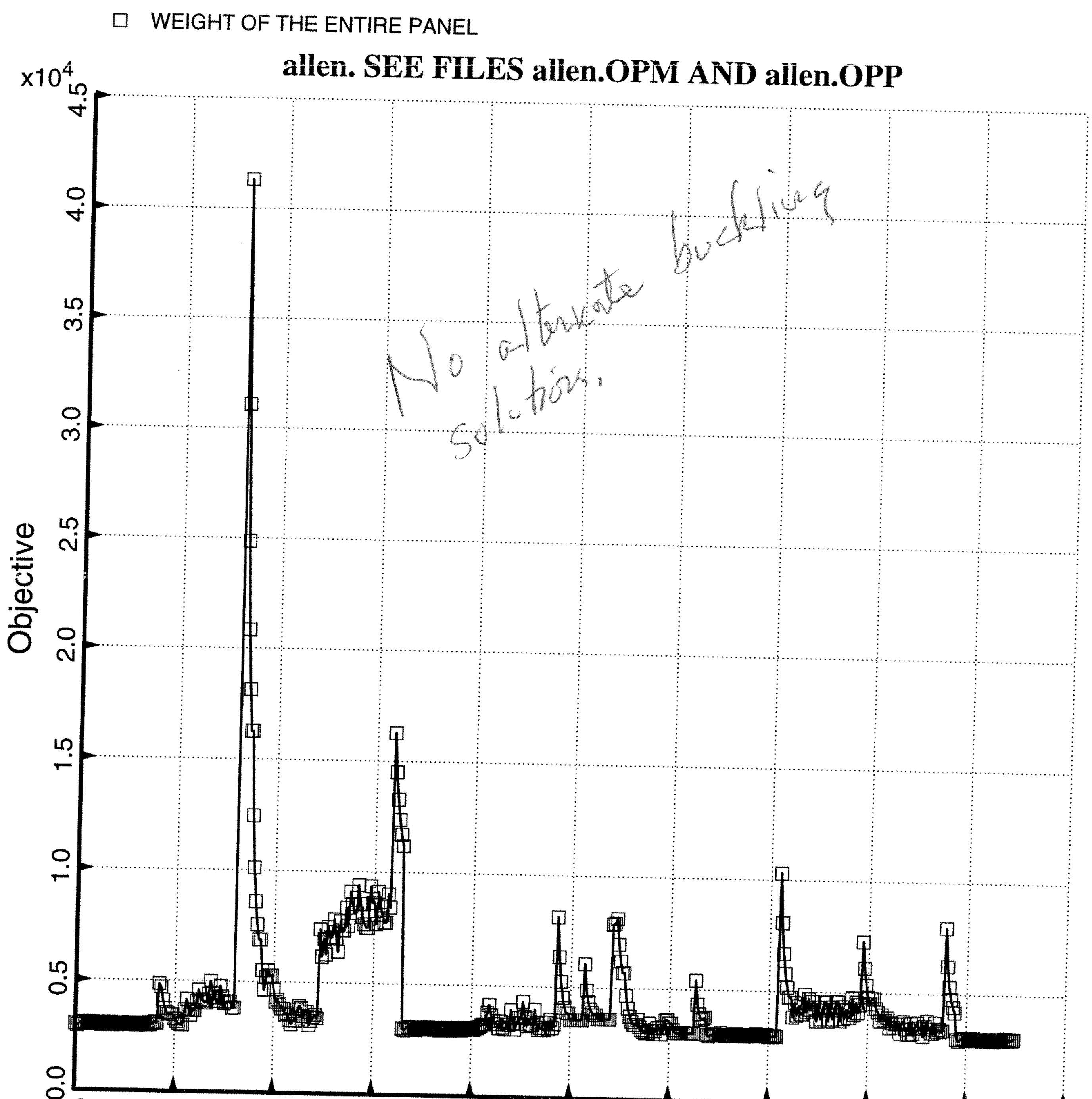
Fig. 18



2nd SUPEROPT

110

Fig. 19

Table 47 allen.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?
 0.999      $ Factor of safety for general instability, FSGEN( 1)
 0.999      $ Factor of safety for panel (between rings) instability, FSPAN( 1)
 0.999      $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.000      $ 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)
   0.5      $ 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( 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?
 0.999      $ Factor of safety for general instability, FSGEN( 1)
 0.999      $ Factor of safety for panel (between rings) instability, FSPAN( 1)
 0.999      $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.000      $ 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)
  -0.5      $ 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)
```

Table 47 (p. 2 of 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?
    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
       2        $ 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?
   1.0
       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)
```

This time include the alternate buckling solution.

Table 48(4pp) allen.OPM after one execution of SUPEROPT

Abridged allen.OPM file after one SUPEROPT
with no alternate buckling solution (to save computer time).

The shell was optimized with three load sets:

1. axial compression and positive general buckling modal
imperfection shape with amplitude = +0.5 inch.

2. axial compression and negative general buckling modal
imperfection shape with amplitude = -0.5 inch.

3. axial compression with internal pressure, perfect shell.

The following corresponds to the optimum design determined
without use of the alternate buckling solution but with
the alternate buckling solution re-introduced for this
"fixed" design analysis.

(lines skipped to save space)

```
 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 1;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  1.1435E+00 (flat skin)
  Local buckling load factor from BOSOR4 theory =  1.1075E+00 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  5.32E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  1.45E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  9.31E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.2285; MID.;FS=1.
 4  1.98E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5  1.87E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
 6  4.19E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  1.24E+00 skin-substringer discrete model-1.,M=3   axial halfwaves;FS=0.999
 8  3.73E+00 Ring sidesway buk., discrete model, n=79  circ.halfwaves;FS=0.999
 9  1.50E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
10  9.46E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
11  2.46E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999
note→12  1.35E+00 buck.(DONL);simp-support general buck;M=1;N=6;slope=0.;FS=0.999
13  2.22E-01 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999
14  1.11E+02 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
15  1.43E-01 buckling:simp-support altsoln4  intermajorpatch; FS=0.999
16  4.86E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
17  2.36E+00 1.-V(1)^1+5.V(9)^1-1
18  3.49E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
19  1.30E+00 buck.(SAND);simp-support general buck;M=1;N=6;slope=0.;FS=0.999
20  2.83E-01 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999


 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 1;  SUBCASE 2:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  1.1390E+00 (flat skin)
  Local buckling load factor from BOSOR4 theory =  1.1068E+00 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  5.25E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  1.40E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  9.73E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.2285; RNGS;FS=1.
 4  1.86E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 5  1.85E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
 6  4.14E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  1.23E+00 skin-substringer discrete model-1.,M=3   axial halfwaves;FS=0.999
 8  1.00E+01 Inter-ring bucklng, discrete model, n=117 circ.halfwaves;FS=0.999
 9  1.52E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
10  9.93E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-RNGS;FS=1.
11  8.97E-01 buckling margin   ring   Iseg.3 . Local halfwaves=1  .RNGS;FS=1.
12  2.18E-01 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999
13  1.11E+02 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
14  4.84E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
```

Table 48 (p. 2 of 4)

```
15  2.78E-01 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999


 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 2;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  1.0191E+00 (flat skin)
  Local buckling load factor from BOSOR4 theory =  1.0209E+00 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1 -2.92E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  2.01E-02 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  1.65E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1149; MID.;FS=1.
 4  1.71E+03 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5  1.57E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
 6  1.81E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  9.91E-01 skin-substringer discrete model-1.,M=3   axial halfwaves;FS=0.999
 8  9.90E+00 Inter-ring bucklng, discrete model, n=117 circ.halfwaves;FS=0.999
 9  2.24E+01 Hi-n Inter-ring buck.,discrete model,n=314 circ.halfwaves;FS=0.999
10  1.51E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
11  9.54E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
12  9.06E-01 buckling margin   ring   Iseg.3 . Local halfwaves=1  .MID.;FS=1.
13  9.06E-01 buckling margin   ring   Iseg.3 . Local halfwaves=1  .NOPO;FS=1.
14  4.46E-02 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999
15  1.24E+00 buck.(DONL);simp-support general buck;M=1;N=6;slope=0.;FS=0.999
16  8.70E-02 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999
17  1.11E+02 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
18 -2.43E-01 buckling:simp-support altsoln4  intermajorpatch; FS=0.999
19  4.50E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
20  1.14E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
21  1.20E+00 buck.(SAND);simp-support general buck;M=1;N=6;slope=0.;FS=0.999
22  1.32E-01 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999
```

note → (at margin 18)

we will have to optimize with the alt. soln turned on

```
 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 2;  SUBCASE 2:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  1.0152E+00 (flat skin)
  Local buckling load factor from BOSOR4 theory =  1.0202E+00 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1 -2.99E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  1.62E-02 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  1.64E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1149; RNGS;FS=1.
 4  1.36E+03 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 5  1.55E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
 6  1.71E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  9.88E-01 skin-substringer discrete model-1.,M=3   axial halfwaves;FS=0.999
 8  3.79E+00 Ring sidesway buk., discrete model, n=79  circ.halfwaves;FS=0.999
 9  1.55E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
10  1.01E+00 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-RNGS;FS=1.
11  8.70E-02 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999
12  1.12E+02 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
13  4.48E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  1.28E-01 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=0.999


 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 3;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  1.13E+04 -5.69E+01
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  1.7788E+00 (flat skin)
  Local buckling load factor from BOSOR4 theory =  1.7413E+00 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 3, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
```

Table 48 (p.3 of 4)

```
 1  5.04E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2  6.17E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=1.1
 3  1.87E-02 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.1149; MID.;FS=1.26
 4  1.21E+06 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.2658
 5  6.45E-01 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.2658
 6  7.53E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 7  2.01E+00 skin-substringer discrete model-1.,M=4   axial halfwaves;FS=1.1
 8  1.20E+01 Inter-ring bucklng, discrete model, n=23  circ.halfwaves;FS=1.1
 9  6.11E-01 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.2658
10  1.86E-02 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.1149;-MID.;FS=1.26
11  7.62E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=1.1
12  2.20E+00 buck.(DONL);simp-support general buck;M=2;N=7;slope=0.;FS=1.1
13  2.57E-01 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=1.1
14  7.97E-01 buckling:simp-support altsoln4  intermajorpatch; FS=1.1
15  3.52E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
16  7.61E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=1.1
17  2.17E+00 buck.(SAND);simp-support general buck;M=2;N=7;slope=0.;FS=1.1
18  2.57E-01 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=1.1


 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 3;  SUBCASE 2:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  1.13E+04 -5.69E+01
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  1.7554E+00 (flat skin)
  Local buckling load factor from BOSOR4 theory =  1.7426E+00 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 3, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  5.05E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2  5.96E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=1.1
 3  2.41E-02 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1149; RNGS;FS=1.26
 4  6.95E+05 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.2658
 5  5.96E-01 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.2658
 6  7.14E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 7  2.00E+00 skin-substringer discrete model-1.,M=4   axial halfwaves;FS=1.1
 8  1.20E+01 Inter-ring bucklng, discrete model, n=23  circ.halfwaves;FS=1.1
 9  6.38E-01 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.2658
10  3.20E-02 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.1149;-RNGS;FS=1.265
11  2.21E-01 buck.(DONL);rolling with smear rings; M=21;N=1;slope=0.;FS=1.1
12  3.44E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  2.21E-01 buck.(SAND);rolling with smear rings; M=21;N=1;slope=0.;FS=1.1
 ***********  ALL 3 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 2.6932E+01  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 8.9685E+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 4.3434E+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 2.2988E-01  2.00E+00   T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     N     N      0    0.00E+00  7.68E-04 1.1859E-01  5.00E+00  TSUB,substr:Thickness, »
TSUB, of substiffener set(1 ): SK
   6   Y     N     N      0    0.00E+00  1.35E-02 1.3329E+00  1.05E+01  HSUB,substr:Height, HSU»
B, of substiffener set(1 ): SKN s
   7   Y     N     N      0    0.00E+00  6.77E-02 5.9066E+00  9.00E+00  BSUB,substr:Spacing, BS»
UB, of substiffener set(1 ): SKN
   8   Y     Y     N      0    0.00E+00  6.50E-02 4.5704E-01  3.00E+00   T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
   9   Y     N     N      0    0.00E+00  2.00E+00 1.8124E+01  5.00E+01        B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
  10   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
  11   Y     N     N      0    0.00E+00  6.50E-02 4.7110E+00  1.05E+01        H(RNG):height of s»
tiffener (type H for sketch), h:
  12   Y     Y     N      0    0.00E+00  6.50E-02 2.5565E-01  3.00E+00   T(3 )(RNG):thickness f»
or layer index no.(3 ): RNG seg=3
0
  CURRENT VALUE OF THE OBJECTIVE FUNCTION:
```

optimum obtained without use of the alternate buckling soln.

Table 48 (p.4 of 4)

```
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE          DEFINITION
            0     0   2.999E+03  WEIGHT OF THE ENTIRE PANEL

 TOTAL WEIGHT OF SKIN                                  =    1.7377E+03
 TOTAL WEIGHT OF SUBSTIFFENERS                         =    2.0228E+02
 TOTAL WEIGHT OF STRINGERS                             =    5.5714E+02
 TOTAL WEIGHT OF RINGS                                 =    5.0232E+02
 SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=          3.8886E-02
IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
allen.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
RUN SUPEROPT.
********************* END OF allen.OPM FILE *****************
```

compare with the weight listed in Table 28.

Note: The optimum design is the same after the second SUPEROPT.

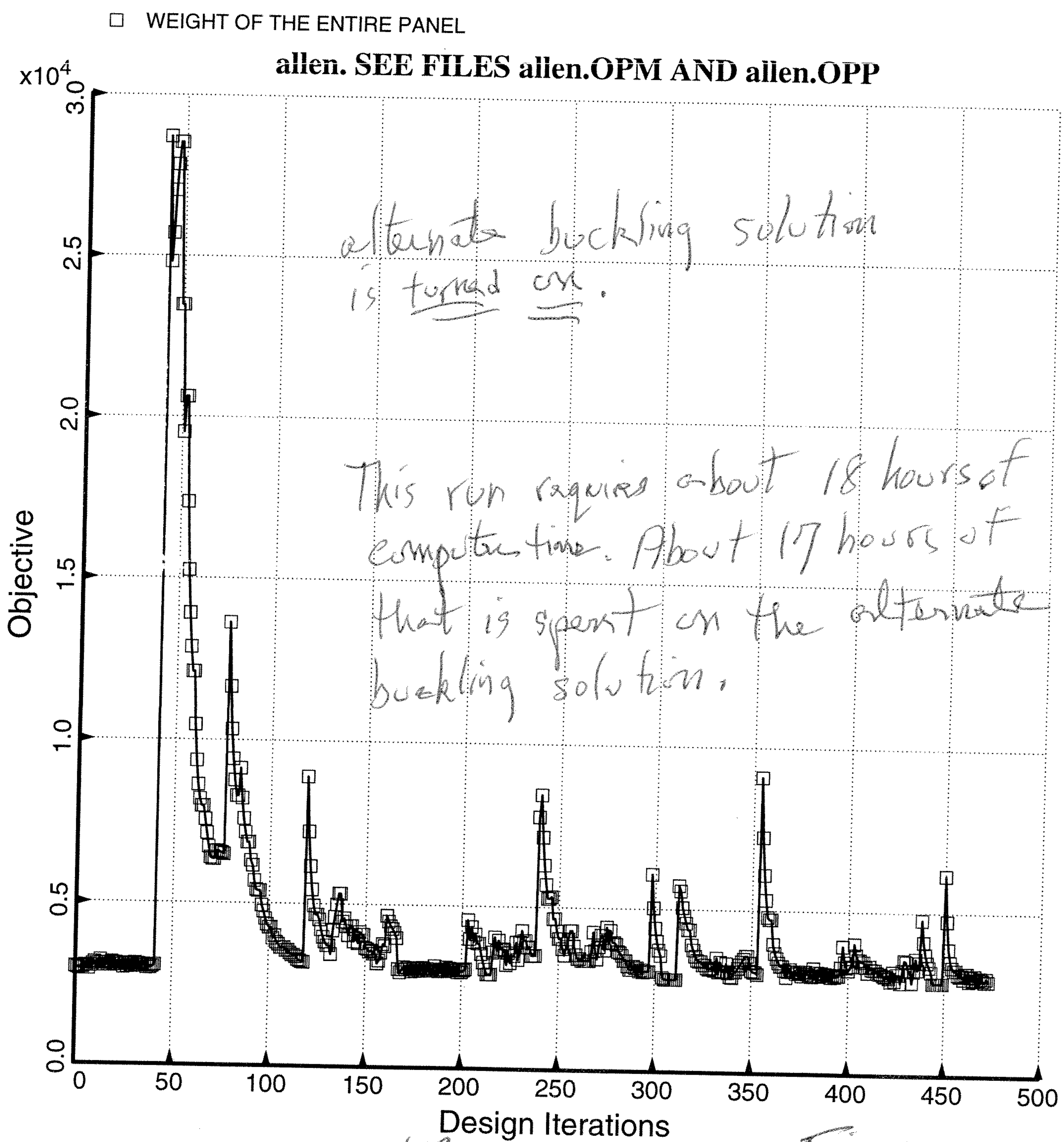

WEIGHT OF THE ENTIRE PANEL
allen. SEE FILES allen.OPM AND allen.OPP
x10^4
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Objective
0
50
100
150
200
250
300
350
400
450
500
Design Iterations
alternate buckling solution
is turned on.
This run requires about 18 hours of
computation time. About 17 hours of
that is spent on the alternate
buckling solution.

Fig. 20

Table 49 (5pp.) allen.OPM after SUPEROPT

```
Abridged allen.OPM file after one SUPEROPT
with yes alternate buckling solution.

The shell was optimized with three load sets:

1. axial compression and positive general buckling modal
imperfection shape with amplitude = +0.5 inch.

2. axial compression and negative general buckling modal
imperfection shape with amplitude = -0.5 inch.

3. axial compression with internal pressure, perfect shell.

The following corresponds to the optimum design determined
WITH use of the alternate buckling solution.

 (lines skipped to save space)

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

(positive imperfection)

```
   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   9.52E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2   1.82E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3   6.78E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.1784; MID.;FS=1.
 4   9.68E+03 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5   1.95E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
 6   4.03E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7   2.18E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 8   6.15E-01 Ring sidesway buk., discrete model, n=85  circ.halfwaves;FS=0.999
 9   1.29E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
10   6.90E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
11   2.72E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999
12   8.29E-01 buck.(DONL);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
13   1.73E-01 buck.(DONL);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999
14   3.95E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
15   4.99E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
16   2.90E+00 1.-V(1)^1+5.V(9)^1-1
17   4.25E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
18   7.96E-01 buck.(SAND);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
19   2.53E-01 buck.(SAND);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999


 *********** 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
```

Table 19 (p. 2 of 5)

```
   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  9.62E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
  2  1.81E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
  3  7.04E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.1784; RNGS;FS=1.
  4  1.02E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
  5  1.94E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
  6  4.05E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
  7  2.17E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
  8  9.24E+00 Inter-ring bucklng, discrete model, n=99  circ.halfwaves;FS=0.999
  9  1.31E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
 10  7.18E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-RNGS;FS=1.
 11  1.69E-01 buck.(DONL);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999
 12  3.95E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
 13  4.98E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 14  2.50E-01 buck.(SAND);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999

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

(Negative imperfection)

```
   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. 2, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                  DEFINITION
  1  7.68E-03 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
  2  5.44E-02 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
  3  1.63E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1244; MID.;FS=1.
  4  4.49E+03 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
  5  1.53E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
  6  1.93E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
  7  4.47E-02 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
  8  9.24E+00 Inter-ring bucklng, discrete model, n=99  circ.halfwaves;FS=0.999
  9  1.29E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
 10  6.90E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 11  3.40E-03 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999
 12  8.28E-01 buck.(DONL);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
 13  7.38E-04 buck.(DONL);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999
 14  3.95E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
 15  4.46E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 16  9.67E-02 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
 17  7.95E-01 buck.(SAND);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
 18  5.90E-02 buck.(SAND);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999

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

Table 49 (p.3 of 5)

```
          (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. 2, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1   7.49E-03 Local buckling from discrete model-1.,M=1    axial halfwaves;FS=0.99
 2   5.19E-02 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3   1.63E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1244; RNGS;FS=1.
 4   4.18E+03 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 5   1.52E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
 6   1.91E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7   4.38E-02 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 8   6.15E-01 Ring sidesway buk., discrete model, n=85  circ.halfwaves;FS=0.999
 9   1.31E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
10   7.18E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-RNGS;FS=1.
11  -1.50E-03 buck.(DONL);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999
12   3.95E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
13   4.44E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14   5.65E-02 buck.(SAND);rolling with smear rings; M=18;N=1;slope=0.;FS=0.999

 *********** LOAD SET NO. 3  **************
 ICASE =  1  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS AT RINGS
```

(Perfect shell with internal pressure)

```
   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. 3, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1   6.65E-01 Local buckling from discrete model-1.,M=1    axial halfwaves;FS=1.1
 2   6.65E-01 Bending-torsion buckling; M=1   ;FS=1.1
 3   8.09E-01 Bending-torsion buckling: Koiter theory,M=1   axial halfwav;FS=1.1
 4   7.77E-03 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.1244; MID.;FS=1.26
 5   7.13E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.2658
 6   6.17E-01 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.2658
 7   9.05E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 8   4.94E-01 skin-substringer discrete model-1.,M=7   axial halfwaves;FS=1.1
 9   1.06E+01 Inter-ring bucklng, discrete model, n=20  circ.halfwaves;FS=1.1
10   5.87E-01 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.2658
11   7.76E-03 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.1244;-MID.;FS=1.26
12   9.67E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=1.1
```

Table 49 (p.4 of 5)

```
 13  2.18E+00 buck.(DONL);simp-support general buck;M=2;N=7;slope=0.;FS=1.1
 14  2.33E-01 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=1.1
 15  3.46E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 16  9.66E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=1.1
 17  2.16E+00 buck.(SAND);simp-support general buck;M=2;N=7;slope=0.;FS=1.1
 18  2.33E-01 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=1.1


  *********** LOAD SET NO. 3  **************
  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. 3, SUBCASE NO. 2
  MAR. MARGIN
  NO.  VALUE                 DEFINITION
  1  6.76E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
  2  8.07E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=1.1
→ 3  3.56E-03 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1244; RNGS;FS=1.26
  4  8.71E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.2658
  5  5.84E-01 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.2658
  6  8.92E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
  7  4.90E-01 skin-substringer discrete model-1.,M=7   axial halfwaves;FS=1.1
  8  1.06E+01 Inter-ring bucklng, discrete model, n=20  circ.halfwaves;FS=1.1
  9  6.13E-01 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.2658
→10  8.66E-03 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.1244;-RNGS;FS=1.265
 11  2.10E-01 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=1.1
 12  3.41E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 13  2.10E-01 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=1.1
 ***********  ALL 3 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 2.4368E+01 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 8.1146E+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 4.5035E+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 2.4872E-01 2.00E+00    T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     N     N      0    0.00E+00  7.68E-04 1.0570E-01 5.00E+00  TSUB,substr:Thickness, »
TSUB, of substiffener set(1 ): SK
   6   Y     N     N      0    0.00E+00  1.35E-02 1.6973E+00 1.05E+01  HSUB,substr:Height, HSU»
B, of substiffener set(1 ): SKN s
   7   Y     N     N      0    0.00E+00  6.77E-02 9.0000E+00 9.00E+00  BSUB,substr:Spacing, BS»
UB, of substiffener set(1 ): SKN
   8   Y     Y     N      0    0.00E+00  6.50E-02 3.5670E-01 3.00E+00    T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
   9   Y     N     N      0    0.00E+00  2.00E+00 1.9016E+01 5.00E+01       B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
  10   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
  11   Y     N     N      0    0.00E+00  6.50E-02 4.1637E+00 1.05E+01       H(RNG):height of s»
tiffener (type H for sketch), h:
  12   Y     Y     N      0    0.00E+00  6.50E-02 1.9382E-01 3.00E+00    T(3 )(RNG):thickness f»
or layer index no.(3 ): RNG seg=3
```

Optimum design.

Table 49 (p. 5 of 5)

```
**************************************************
******************** DESIGN OBJECTIVE *******************
*************                               ***********
0
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE           DEFINITION
            0     0    2.850E+03  WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                              =    1.8801E+03
  TOTAL WEIGHT OF SUBSTIFFENERS                     =    1.5067E+02
  TOTAL WEIGHT OF STRINGERS                         =    4.9831E+02
  TOTAL WEIGHT OF RINGS                             =    3.2078E+02
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL= 3.6947E-02

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

Compare with results in Tables 28 & 48

Table 50 allen.CHG (save the 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, . .)
 24.36800        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        2        $ Number of parameter to change (1, 2, 3, . .)
 8.114600        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        3        $ Number of parameter to change (1, 2, 3, . .)
 4.503500        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        4        $ Number of parameter to change (1, 2, 3, . .)
0.2487200        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        5        $ Number of parameter to change (1, 2, 3, . .)
0.1057000        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        6        $ Number of parameter to change (1, 2, 3, . .)
 1.697300        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        7        $ Number of parameter to change (1, 2, 3, . .)
 9.000000        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        8        $ Number of parameter to change (1, 2, 3, . .)
0.3567000        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        9        $ Number of parameter to change (1, 2, 3, . .)
19.016000        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
       10        $ 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?
       11        $ Number of parameter to change (1, 2, 3, . .)
 4.163700        $ New value of the parameter
      y          $ Want to change any other parameters in this set?
       12        $ Number of parameter to change (1, 2, 3, . .)
0.1938200        $ 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?
```

optimum design obtained by PANDA2
(see previous table)

Table 51 allow, CHG ("STAGS worthy" 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, . .)
24.39354    $ New value of the parameter
y           $ Want to change any other parameters in this set?
     2      $ Number of parameter to change (1, 2, 3, . .)
8.123050    $ New value of the parameter
y           $ Want to change any other parameters in this set?
     3      $ Number of parameter to change (1, 2, 3, . .)
4.503500    $ New value of the parameter
y           $ Want to change any other parameters in this set?
     4      $ Number of parameter to change (1, 2, 3, . .)
0.2487200   $ New value of the parameter
y           $ Want to change any other parameters in this set?
     5      $ Number of parameter to change (1, 2, 3, . .)
0.1057000   $ New value of the parameter
y           $ Want to change any other parameters in this set?
     6      $ Number of parameter to change (1, 2, 3, . .)
1.697300    $ New value of the parameter
y           $ Want to change any other parameters in this set?
     7      $ Number of parameter to change (1, 2, 3, . .)
8.131180    $ New value of the parameter
y           $ Want to change any other parameters in this set?
     8      $ Number of parameter to change (1, 2, 3, . .)
0.3567000   $ New value of the parameter
y           $ Want to change any other parameters in this set?
     9      $ Number of parameter to change (1, 2, 3, . .)
17.714290   $ New value of the parameter
y           $ Want to change any other parameters in this set?
    10      $ 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?
    11      $ Number of parameter to change (1, 2, 3, . .)
4.163700    $ New value of the parameter
y           $ Want to change any other parameters in this set?
    12      $ Number of parameter to change (1, 2, 3, . .)
0.1938200   $ 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?
```

7 ring spacings in axial length of 124"

3 substringers per major stringer spacing

0.333 x 24.3954"

51 stringers in 360-degree cyl. shell.

Table 52(sp) allen.OPM file for "STAGSworthy" design

Abridged allen.OPM file for optimum design after SUPEROPT, but with certain of the decision variables changed so that this is a "STAGSworthy" model: The major stringer spacing, B(STR), is changed from 24.368 to 24.39354; The stringer base width, B2(STR) is changed from 8.1146 to 8.12305; The substringer spacing, HSUB(substringer), is changed from 9.0000 to 8.13118; and the ring spacing, B(RNG), is changed from 19.016 to 17.71429 inches.

(lines skipped to save space)

```
 *********** 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   3.12E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99   1.312
  2   3.12E-01 Bending-torsion buckling; M=1  ;FS=0.999   1.312
  3   4.06E-01 Bending-torsion buckling: Koiter theory,M=1   axial halfwav;FS=0.99   1.406
  4   7.26E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.1784; MID.;FS=1.
  5   9.69E+03 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.   1.726
  6   1.96E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
  7   5.86E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999   1.586
  8   4.68E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999   1.468
  9   8.06E-01 Ring sidesway buk., discrete model, n=85  circ.halfwaves;FS=0.999   1.806
 10   1.33E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
 11   7.37E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.   1.737
 12   5.34E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999   1.534
 13   8.91E-01 buck.(DONL);simp-support general buck;M=1;N=7;slope=0.;FS=0.999   1.891
 14   2.08E-01 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999   1.208
 15   4.45E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
 16   3.49E-01 buckling:simp-support altsoln4  intermajorpatch; FS=0.999   1.349
 17   5.01E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 18   2.63E+00 1.-V(1)^1+5.V(9)^1-1
 19   6.99E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
 20   8.56E-01 buck.(SAND);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
 21   2.86E-01 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
```

load factors = (margin+1.) x f.s.

```
 *********** 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
```

Table 52 (p. 2 of 5)

```
 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  3.15E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  3.13E-01 Bending-torsion buckling; M=1  ;FS=1.
 3  4.07E-01 Bending-torsion buckling: Koiter theory,M=1   axial halfwav;FS=0.99
 4  7.50E-01 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.1784; RNGS;FS=1.
 5  9.98E+03 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 6  1.95E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
 7  5.93E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 8  4.67E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 9  1.05E+01 Inter-ring bucklng, discrete model, n=108 circ.halfwaves;FS=0.999
10  1.34E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
11  7.64E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-RNGS;FS=1.
12  2.05E-01 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
13  4.45E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
14  4.99E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
15  2.82E-01 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999


 *********** 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 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. 2, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                  DEFINITION
 1  2.42E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  3.00E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  1.67E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1244; MID.;FS=1.
 4  2.82E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5  1.57E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
 6  4.55E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  2.66E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 8  1.05E+01 Inter-ring bucklng, discrete model, n=108 circ.halfwaves;FS=0.999
 9  1.33E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
10  7.37E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
11  2.33E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999
12  8.91E-01 buck.(DONL);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
13  3.76E-02 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
14  4.45E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
15  2.10E-02 buckling:simp-support altsoln4  intermajorpatch; FS=0.999
16  4.50E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
17  3.37E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
18  8.56E-01 buck.(SAND);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
19  9.47E-02 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999


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

Table 52 (p,3of5)

```
  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. 2, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  2.42E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  2.98E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  1.67E+00 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1244; RNGS;FS=1.
 4  2.69E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 5  1.56E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
 6  4.52E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  2.65E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 8  8.06E-01 Ring sidesway buk., discrete model, n=85  circ.halfwaves;FS=0.999
 9  1.34E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
10  7.64E-01 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-RNGS;FS=1.
11  3.54E-02 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
12  4.45E+01 buck.(DONL);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
13  4.49E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  9.23E-02 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999


 *********** LOAD SET NO. 3  **************
 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. 3, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  7.67E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2  7.67E-01 Bending-torsion buckling; M=1  ;FS=1.1
 3  9.11E-01 Bending-torsion buckling: Koiter theory,M=1   axial halfwav;FS=1.1
 4  2.13E-02 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.1244; MID.;FS=1.26
 5  3.73E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.2658
 6  6.32E-01 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.2658
 7  1.01E+00 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 8  5.05E-01 skin-substringer discrete model-1.,M=6   axial halfwaves;FS=1.1
 9  1.20E+01 Inter-ring bucklng, discrete model, n=22  circ.halfwaves;FS=1.1
10  6.03E-01 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.2658
11  2.13E-02 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.1244;-MID.;FS=1.26
12  1.10E+00 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=1.1
13  2.20E+00 buck.(DONL);simp-support general buck;M=2;N=7;slope=0.;FS=1.1
14  2.60E-01 buck.(DONL);rolling with smear rings; M=20;N=1;slope=0.;FS=1.1
```

Table 52 (p.4 of 5)

```
 15  9.78E-01 buckling:simp-support altsoln4  intermajorpatch; FS=1.1
 16  3.49E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 17  1.10E+00 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=1.1
 18  2.18E+00 buck.(SAND);simp-support general buck;M=2;N=7;slope=0.;FS=1.1
 19  2.60E-01 buck.(SAND);rolling with smear rings; M=20;N=1;slope=0.;FS=1.1


  *********** LOAD SET NO. 3  **************
  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. 3, SUBCASE NO. 2
  MAR. MARGIN
  NO.  VALUE                 DEFINITION
  1   7.82E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
  2   9.60E-01 Bending-torsion buckling; M=1  ;FS=1.
  3   9.13E-01 Bending-torsion buckling: Koiter theory,M=1   axial halfwav;FS=1.1
  4   1.49E-02 eff.stress:matl=1,STR,Dseg=4,node=11,layer=1,z=0.1244; RNGS;FS=1.26
  5   4.42E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.2658
  6   6.00E-01 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.2658
  7   1.01E+00 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
  8   5.01E-01 skin-substringer discrete model-1.,M=6   axial halfwaves;FS=1.1
  9   1.20E+01 Inter-ring bucklng, discrete model, n=22  circ.halfwaves;FS=1.1
 10   6.28E-01 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.2658
 11   1.97E-02 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.1244;-RNGS;FS=1.265
 12   2.38E-01 buck.(DONL);rolling with smear rings; M=20;N=1;slope=0.;FS=1.1
 13   3.44E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 14   2.38E-01 buck.(SAND);rolling with smear rings; M=20;N=1;slope=0.;FS=1.1
 ***********  ALL 3 LOAD SETS PROCESSED  ***********
 ****************************************************
```

"STAGS worthy" optimum design

```
        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 2.4394E+01  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 8.1230E+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 4.5035E+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 2.4872E-01  2.00E+00    T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     N      N      0   0.00E+00  7.68E-04 1.0570E-01  5.00E+00   TSUB,substr:Thickness, »
TSUB, of substiffener set(1 ): SK
   6   Y     N      N      0   0.00E+00  1.35E-02 1.6973E+00  1.05E+01   HSUB,substr:Height, HSU»
B, of substiffener set(1 ): SKN s
   7   Y     N      N      0   0.00E+00  6.77E-02 8.1312E+00  9.00E+00   BSUB,substr:Spacing, BS»
UB, of substiffener set(1 ): SKN
   8   Y     Y      N      0   0.00E+00  6.50E-02 3.5670E-01  3.00E+00    T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
   9   Y     N      N      0   0.00E+00  2.00E+00 1.7714E+01  5.00E+01        B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
  10   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
  11   Y     N      N      0   0.00E+00  6.50E-02 4.1637E+00  1.05E+01        H(RNG):height of s»
tiffener (type H for sketch), h:
  12   Y     Y      N      0   0.00E+00  6.50E-02 1.9382E-01  3.00E+00    T(3 )(RNG):thickness f»
or layer index no.(3 ): RNG seg=3
```

Table 52 (p.5 of 5)

```
****************************************************
******************** DESIGN OBJECTIVE *******************
*************                          ***********
0
  CURRENT VALUE OF THE OBJECTIVE FUNCTION:
VAR. STR/ SEG. LAYER    CURRENT
NO.   RNG   NO.   NO.    VALUE          DEFINITION
            0      0   2.889E+03  WEIGHT OF THE ENTIRE PANEL

 TOTAL WEIGHT OF SKIN                                  =   1.8801E+03
 TOTAL WEIGHT OF SUBSTIFFENERS                         =   1.6678E+02
 TOTAL WEIGHT OF STRINGERS                             =   4.9778E+02
 TOTAL WEIGHT OF RINGS                                 =   3.4436E+02
 SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   3.7455E-02

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

"STAGS-worthy" optimum

Compare with Table 49

Table 53 allan.OPT (1st load set only)

```
    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?
 0.999         $ Factor of safety for general instability, FSGEN( 1)
 0.999         $ Factor of safety for panel (between rings) instability, FSPAN( 1)
 0.999         $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.000         $ 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)
   0.0         $ 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")?
    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)?
     2         $ 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?
    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
     2         $ 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?
 1.0
     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

PANDA2 run ("fixed" design) with zero imperfection amplitude.
1st load set only because that load set is the one we want to use with STAGS.

Table 54 (2pp.) allen.OPM for perfect shell ("STAGS worthy" optimum)

Abridged allen.OPM file.
1st load set only, but with the amplitude
of the general buckling modal imperfection
set equal to zero.

(lines skipped to save space)

```
 *********** 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   3.30E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2   4.15E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3   1.77E+00 eff.stress:matl=1,STR,Dseg=3,node=11,layer=1,z=0.1784; MID.;FS=1.
 4   4.92E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5   1.80E+00 matl=1 ; substiffener effective stressSTRTHK MID.;FS=1.
 6   5.83E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7   4.64E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 8   1.29E+01 Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=0.999
 9   1.79E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
10   1.78E+00 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
11   5.47E-01 buck.(DONL);simp-support inter-ring;  (1.00*altsol);FS=0.999
12   1.46E+00 buck.(DONL);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
13   1.95E-01 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
14   3.75E-01 buckling:simp-support altsoln4  intermajorpatch; FS=0.999
15   4.74E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
16   2.63E+00 1.-V(1)^1+5.V(9)^1-1
17   5.47E-01 buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
18   1.41E+00 buck.(SAND);simp-support general buck;M=1;N=7;slope=0.;FS=0.999
19   1.95E-01 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
```

note → (line 12)

Handwritten beside margins: 1.33 (line 1), 1.45 (line 2), 1.58 (line 6), 1.46 (line 7), 1.54 (line 11), 2.46 (line 12), 1.19 (line 13), 1.375 (line 14)

STAGS mode agrees with PANDA2 (Figs 25 & 26)

STAGS gets 1.3958 (Fig. 21)

STAGS gets 1.6891 (Fig. 24)

STAGS gets 2.46 (Fig. 22)

buckling load factors;

load factor = (margin + 1.) × f.s.

factor of safety.

```
 *********** 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
```

Table 54 (p.2 of 2)

```
MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
MAR. MARGIN
NO.  VALUE              DEFINITION
 1  3.31E-01 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=0.99
 2  4.13E-01 Local buckling from Koiter theory,M=1   axial halfwaves;FS=0.999
 3  1.79E+00 eff.stress:matl=1,STR,Dseg=3,node=1,layer=1,z=0.1784; RNGS;FS=1.
 4  5.65E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 5  1.79E+00 matl=1 ; substiffener effective stressSTRTHK RNGS;FS=1.
 6  5.82E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  4.63E-01 skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
 8  1.29E+01 Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=0.999
 9  1.80E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
10  1.80E+00 eff.stress:matl=1,STR,Iseg=3,at:ROOT,layer=1,z=0.;-RNGS;FS=1.
11  1.92E-01 buck.(DONL);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
12  4.73E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  1.92E-01 buck.(SAND);rolling with smear rings; M=19;N=1;slope=0.;FS=0.999
***********  ALL 1 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  2.4394E+01  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  8.1230E+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  4.5035E+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  2.4872E-01  2.00E+00   T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
  5   Y     N      N     0    0.00E+00  7.68E-04  1.0570E-01  5.00E+00  TSUB,substr:Thickness, »
TSUB, of substiffener set(1 ): SK
  6   Y     N      N     0    0.00E+00  1.35E-02  1.6973E+00  1.05E+01  HSUB,substr:Height, HSU»
B, of substiffener set(1 ): SKN s
  7   Y     N      N     0    0.00E+00  6.77E-02  8.1312E+00  9.00E+00  BSUB,substr:Spacing, BS»
UB, of substiffener set(1 ): SKN
  8   Y     Y      N     0    0.00E+00  6.50E-02  3.5670E-01  3.00E+00   T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
  9   Y     N      N     0    0.00E+00  2.00E+00  1.7714E+01  5.00E+01        B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
 10   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
 11   Y     N      N     0    0.00E+00  6.50E-02  4.1637E+00  1.05E+01       H(RNG):height of s»
tiffener (type H for sketch), h:
 12   Y     Y      N     0    0.00E+00  6.50E-02  1.9382E-01  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    2.889E+03   WEIGHT OF THE ENTIRE PANEL

 TOTAL WEIGHT OF SKIN                              =    1.8801E+03
 TOTAL WEIGHT OF SUBSTIFFENERS                     =    1.6678E+02
 TOTAL WEIGHT OF STRINGERS                         =    4.9778E+02
 TOTAL WEIGHT OF RINGS                             =    3.4436E+02
 SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=      3.7455E-02

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

"STAGS worthy" optimum

Table 55 allen.OPM with NPRINT = 2

Abridged allen.OPM file.
CHAPTER 14 (Buckling of skin-with-smeared-substringers/major stringer single discretized module model)

1st load set, subcase 1

```
*************************************************************
*************************************************************
*************************************************************
************          CHAPTER 14           *****************
*************************************************************
*************************************************************
*************************************************************
********* DESIGN PERTURBATION INDEX, IMOD=  0 *********

*************************************************************
CHAPTER 14 Compute local buckling from BOSOR4-type
           discretized skin-stringer single module model.
           See Section 12.2 (upper table on p. 511) and
           Figs. 46c and 98b in [1A], for examples.
```

skin + smeared substringers / major stringer

(lines skipped to save space)

BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
(skin-stringer discretized module of local buckling)

AXIAL HALF-WAVES	BUCKLING LOAD FACTOR BEFORE KNOCKDOWN	KNOCKDOWN FOR TRANSVERSE SHEAR DEFORMATION	KNOCKDOWN FOR IN-PLANE SHEAR LOADING AND/OR ANISOTROPY	BUCKLING LOAD FACTOR AFTER KNOCKDOWN
M	EIGOLD	KSTAR	KNOCK	EIGOLD*KSTAR*KNOCK
1	1.46209E+00	1.00000E+00	1.00000E+00	1.46209E+00
2	2.53475E+00	1.00000E+00	1.00000E+00	2.53475E+00

Buckling load factor before t.s.d.= 1.4621E+00 After t.s.d.= 1.3985E+00

1	1.46209E+00	9.56492E-01	1.00000E+00	$\boxed{1.39848E+00}$

(lines skipped to save space)

```
      Internal Stringer

    MODULE WITH RECTANGULAR STIFFENER...

                                   !   ^
         Segment No. 3 -----> !   !
                                   !   !
              Seg. No. 2-.         !   h
                             .     !   !
    Segment No. 1-.         .     !   !        .-Seg. No. 4
                  .          .     !   V        .(same as Seg. 1)
       ----------------==================-------------------
                       !<------ b2 ------->!
       !<--- Module width  =  stiffener spacing, b --->!


   EXPLODED VIEW, SHOWING LAYERS and (SEGMENT, NODE) NUMBERS

                                  (3,11)
                                    !
            Layer No. 1 -----> ! <---------- Layer No. k
                                    !
        Layer No. 1-.               !
                        .           !
  Layer No. 1-.            .        !               .-Layer No. 1
              .            .        !               .
              .         .    (3,1)                   .
   --------------    ====================     --------------
 (1,1)    .    (1,11)(2,1)    . (2,6)     (2,11)(4,1)   .     (4,11)
          .                   .                        .
          .                   .                       .
           Layer No. m        Layer No. n     Layer No. m
```

NORMAL MODAL DISPLACEMENTS IN THE PANEL MODULE SHOWN ABOVE
SKIN-STRINGER PANEL MODULE HAS 4 SEGMENTS
NUMBER OF HALF-WAVES IN THE AXIAL DIRECTION, M= 1

one axial halfwave,

NODE	Z	W	WD	WDD	U	V	WDDD
		MODAL DISPLACEMENTS FOR SEGMENT NO. 1					
1	0.00E+00	1.00E+00	0.00E+00	-1.46E-02	0.00E+00	-1.42E-02	1.46E-04
2	0.00E+00	9.95E-01	-1.18E-02	-1.45E-02	-8.37E-04	-1.41E-02	1.46E-04
3	0.00E+00	9.81E-01	-2.36E-02	-1.44E-02	-1.67E-03	-1.39E-02	1.46E-04

Table 55, (p.2 of 2)

4	0.00E+00	9.57E-01	-3.52E-02	-1.42E-02	-2.48E-03	-1.36E-02	2.37E-04
5	0.00E+00	9.23E-01	-4.67E-02	-1.39E-02	-3.28E-03	-1.31E-02	3.20E-04
6	0.00E+00	8.81E-01	-5.79E-02	-1.36E-02	-4.04E-03	-1.24E-02	3.92E-04
7	0.00E+00	8.29E-01	-6.88E-02	-1.33E-02	-4.77E-03	-1.17E-02	4.49E-04
8	0.00E+00	7.69E-01	-7.94E-02	-1.29E-02	-5.45E-03	-1.08E-02	4.86E-04
9	0.00E+00	7.00E-01	-8.97E-02	-1.25E-02	-6.09E-03	-9.78E-03	5.00E-04
10	0.00E+00	6.23E-01	-9.97E-02	-1.21E-02	-6.67E-03	-8.65E-03	4.87E-04
11	0.00E+00	5.38E-01	-1.09E-01	-1.17E-02	-7.18E-03	-7.42E-03	4.87E-04

MODAL DISPLACEMENTS FOR SEGMENT NO. 2

1	0.00E+00	5.38E-01	-1.09E-01	-1.16E-02	-7.18E-03	-7.42E-03	2.31E-04
2	0.00E+00	4.45E-01	-1.19E-01	-1.14E-02	-7.63E-03	-6.08E-03	2.31E-04
3	0.00E+00	3.45E-01	-1.28E-01	-1.12E-02	-8.00E-03	-4.66E-03	2.31E-04
4	0.00E+00	2.37E-01	-1.37E-01	-1.12E-02	-8.29E-03	-3.16E-03	5.46E-05
5	0.00E+00	1.22E-01	-1.46E-01	-1.13E-02	-8.50E-03	-1.60E-03	-1.77E-04
6	0.00E+00	5.65E-09	-1.51E-01	1.67E-08	-8.58E-03	-1.89E-09	1.39E-02
7	0.00E+00	-1.22E-01	-1.46E-01	1.13E-02	-8.50E-03	1.60E-03	1.39E-02
8	0.00E+00	-2.37E-01	-1.37E-01	1.12E-02	-8.29E-03	3.16E-03	-1.77E-04
9	0.00E+00	-3.45E-01	-1.28E-01	1.12E-02	-8.00E-03	4.66E-03	5.45E-05
10	0.00E+00	-4.45E-01	-1.19E-01	1.14E-02	-7.63E-03	6.08E-03	2.31E-04
11	0.00E+00	-5.38E-01	-1.09E-01	1.16E-02	-7.18E-03	7.42E-03	2.31E-04

MODAL DISPLACEMENTS FOR SEGMENT NO. 3

1	-1.24E-01	-2.73E-02	-1.51E-01	-6.40E-03	-5.65E-09	-1.76E-09	3.94E-03
2	-5.75E-01	-9.60E-02	-1.54E-01	-4.62E-03	-5.68E-09	-1.35E-09	3.94E-03
3	-1.03E+00	-1.66E-01	-1.55E-01	-2.85E-03	-5.69E-09	-9.57E-10	3.94E-03
4	-1.48E+00	-2.36E-01	-1.56E-01	-1.36E-03	-5.69E-09	-5.77E-10	3.31E-03
5	-1.93E+00	-3.06E-01	-1.57E-01	-2.43E-04	-5.69E-09	-2.08E-10	2.49E-03
6	-2.38E+00	-3.77E-01	-1.57E-01	4.15E-04	-5.68E-09	1.56E-10	1.46E-03
7	-2.83E+00	-4.47E-01	-1.56E-01	5.16E-04	-5.67E-09	5.22E-10	2.24E-04
8	-3.28E+00	-5.18E-01	-1.56E-01	-4.58E-05	-5.65E-09	8.95E-10	-1.25E-03
9	-3.73E+00	-5.88E-01	-1.57E-01	-1.38E-03	-5.62E-09	1.28E-09	-2.97E-03
10	-4.18E+00	-6.59E-01	-1.58E-01	-3.62E-03	-5.58E-09	1.68E-09	-4.97E-03
11	-4.63E+00	-7.30E-01	-1.60E-01	-5.86E-03	-5.54E-09	2.10E-09	-4.97E-03

MODAL DISPLACEMENTS FOR SEGMENT NO. 4

1	0.00E+00	-5.38E-01	-1.09E-01	1.17E-02	-7.18E-03	7.42E-03	4.87E-04
2	0.00E+00	-6.23E-01	-9.97E-02	1.21E-02	-6.67E-03	8.65E-03	4.87E-04
3	0.00E+00	-7.00E-01	-8.97E-02	1.25E-02	-6.09E-03	9.78E-03	4.87E-04
4	0.00E+00	-7.69E-01	-7.94E-02	1.29E-02	-5.45E-03	1.08E-02	5.00E-04
5	0.00E+00	-8.29E-01	-6.88E-02	1.33E-02	-4.77E-03	1.17E-02	4.86E-04
6	0.00E+00	-8.81E-01	-5.79E-02	1.36E-02	-4.04E-03	1.24E-02	4.49E-04
7	0.00E+00	-9.23E-01	-4.67E-02	1.39E-02	-3.28E-03	1.31E-02	3.92E-04
8	0.00E+00	-9.57E-01	-3.52E-02	1.42E-02	-2.48E-03	1.36E-02	3.20E-04
9	0.00E+00	-9.81E-01	-2.36E-02	1.44E-02	-1.67E-03	1.39E-02	2.37E-04
10	0.00E+00	-9.95E-01	-1.18E-02	1.45E-02	-8.37E-04	1.41E-02	1.46E-04
11	0.00E+00	-1.00E+00	0.00E+00	1.46E-02	0.00E+00	1.42E-02	1.46E-04

**** END SUBROUTINE MODE (LOCAL BUCKLING MODE SHAPE) ******

compare with STAGS buckling mode in Fig. 21 and in Fig. 27

Table 56(3pp) allen.OPM (with NPRINT = 2)

```
Abridged allen.OPM file (with NPRINT = 2)

CHAPTER 20c: discretized single module skin-substringer
model

 (lines skipped to save space)

 ***********************************************************
 ***********************************************************
 ***********************************************************
 ************          CHAPTER 20c          ****************
 ***********************************************************
 ***********************************************************
 ***********************************************************
 ********* DESIGN PERTURBATION INDEX, IMOD=  0 *********

 ***********************************************************
 CHAPTER 20c Compute buckling of a single discretized
             skin-substringer module. See panda2.news Item 764.
             The axial length of the module is equal to the
             spacing of the subrings, and the width of the
             module is equal to the spacing of the substringers.

 Find the skin-substringer module buckling from m=   1 to   22 axial halfwaves.
 The spacing of the subrings,     BSUBX(2)=  1.7714E+01
 The height of the substringers, HSUBX(1)=  1.6973E+00
  LABEL NO. IN STRUCT= 9465
 Buckling load factor before t.s.d.=  2.2178E+00 After t.s.d.=  2.1433E+00
 Buckling load factor before t.s.d.=  1.4973E+00 After t.s.d.=  1.4630E+00 <--critical value
 Buckling load factor before t.s.d.=  1.6805E+00 After t.s.d.=  1.6374E+00
 Buckling load factor before t.s.d.=  2.0836E+00 After t.s.d.=  2.0177E+00
 Buckling load factor before t.s.d.=  2.1060E+00 After t.s.d.=  2.0387E+00
 Buckling load factor before t.s.d.=  2.0352E+00 After t.s.d.=  1.9723E+00
 Buckling load factor before t.s.d.=  2.0707E+00 After t.s.d.=  2.0056E+00
 Buckling load factor before t.s.d.=  2.1855E+00 After t.s.d.=  2.1132E+00
 Buckling load factor before t.s.d.=  2.3612E+00 After t.s.d.=  2.2769E+00
 Buckling load factor before t.s.d.=  2.5864E+00 After t.s.d.=  2.4857E+00
 Buckling load factor before t.s.d.=  2.8552E+00 After t.s.d.=  2.7329E+00
 Buckling load factor before t.s.d.=  3.1636E+00 After t.s.d.=  3.0142E+00
 Buckling load factor before t.s.d.=  3.5091E+00 After t.s.d.=  3.3262E+00
 Buckling load factor before t.s.d.=  3.8900E+00 After t.s.d.=  3.6665E+00
 Buckling load factor before t.s.d.=  4.3053E+00 After t.s.d.=  4.0332E+00
 Buckling load factor before t.s.d.=  5.2361E+00 After t.s.d.=  4.8390E+00
 Buckling load factor before t.s.d.=  6.2971E+00 After t.s.d.=  5.7315E+00
 Buckling load factor before t.s.d.=  7.4860E+00 After t.s.d.=  6.7000E+00
 Buckling load factor before t.s.d.=  8.8013E+00 After t.s.d.=  7.7346E+00

 Buckling of single module skin-substringer model. KOUNT=  19
 Axial halfwaves    Eigenvalue (buckling load factor)
        1   2.143298E+00
        2   1.463018E+00   <--critcal value (2 axial halfwaves between rings)
        3   1.637409E+00
        4   2.017680E+00
        5   2.038723E+00
        6   1.972298E+00
        7   2.005589E+00
        8   2.113161E+00
        9   2.276928E+00
       10   2.485688E+00
       11   2.732949E+00
       12   3.014182E+00
       13   3.326182E+00
       14   3.666534E+00
       15   4.033244E+00
       17   4.839021E+00
       19   5.731497E+00
       21   6.700008E+00
       23   7.734577E+00
  LABEL NO. IN STRUCT= 9466
 Buckling load factor before t.s.d.=  1.4973E+00 After t.s.d.=  1.4630E+00
        2          1.4630E+00

 ** BEGIN SUB. MODE (SKIN-SUBSTRINGER MODULE BUCKLNG MODE) **

       Internal Stringer

     MODULE WITH RECTANGULAR STIFFENER...
```

Table 56 (p. 2 of 3)

```
                                       !    ^
          Segment No. 3 -----> !    !
                                       !    !
               Seg. No. 2-.            !    h
                           .           !    !
      Segment No. 1-.          .       !    !        .-Seg. No. 4
                    .             .    !    V       .(same as Seg. 1)
   ------------------==================------------------
                  !<------ b2 ------->!
   !<--- Module width  =  stiffener spacing, b --->!


 EXPLODED VIEW, SHOWING LAYERS and (SEGMENT, NODE) NUMBERS

                              (3,11)
                                 !
        Layer No. 1 -----> ! <---------- Layer No. k
                                 !
     Layer No. 1-.               !
                     .           !
 Layer No. 1-.          .        !            .-Layer No. 1
              .            .     !           .
             .              .  (3,1)          .
 --------------      ===================    --------------
(1,1)    .    (1,11)(2,1)   . (2,6)    (2,11)(4,1)   .    (4,11)
       .                  .                       .
      .                  .                       .
        Layer No. m       Layer No. n    Layer No. m
```

2 axial halfwaves between rings.

NORMAL MODAL DISPLACEMENTS IN THE PANEL MODULE SHOWN ABOVE
SKIN-STRINGER PANEL MODULE HAS 4 SEGMENTS
NUMBER OF HALF-WAVES IN THE AXIAL DIRECTION, M= 2

NODE	Z	W	WD	WDD	U	V	WDDD
			MODAL DISPLACEMENTS FOR SEGMENT NO. 1				
1	0.00E+00	1.00E+00	0.00E+00	-1.50E-01	0.00E+00	-2.73E-03	1.15E-02
2	0.00E+00	9.90E-01	-5.38E-02	-1.46E-01	-1.62E-03	-2.74E-03	1.15E-02
3	0.00E+00	9.61E-01	-1.07E-01	-1.42E-01	-3.21E-03	-2.66E-03	1.15E-02
4	0.00E+00	9.12E-01	-1.57E-01	-1.35E-01	-4.73E-03	-2.53E-03	1.89E-02
5	0.00E+00	8.46E-01	-2.05E-01	-1.26E-01	-6.17E-03	-2.34E-03	2.59E-02
6	0.00E+00	7.62E-01	-2.49E-01	-1.14E-01	-7.48E-03	-2.11E-03	3.23E-02
7	0.00E+00	6.64E-01	-2.88E-01	-9.99E-02	-8.65E-03	-1.84E-03	3.81E-02
8	0.00E+00	5.52E-01	-3.21E-01	-8.41E-02	-9.65E-03	-1.54E-03	4.31E-02
9	0.00E+00	4.28E-01	-3.49E-01	-6.68E-02	-1.05E-02	-1.20E-03	4.71E-02
10	0.00E+00	2.96E-01	-3.70E-01	-4.85E-02	-1.11E-02	-8.30E-04	5.02E-02
11	0.00E+00	1.57E-01	-3.83E-01	-3.01E-02	-1.14E-02	-4.40E-04	5.02E-02
			MODAL DISPLACEMENTS FOR SEGMENT NO. 2				
1	0.00E+00	1.57E-01	-3.83E-01	-2.94E-02	-1.14E-02	-4.40E-04	5.27E-02
2	0.00E+00	1.26E-01	-3.85E-01	-2.51E-02	-1.15E-02	-3.53E-04	5.27E-02
3	0.00E+00	9.48E-02	-3.87E-01	-2.08E-02	-1.15E-02	-2.65E-04	5.27E-02
4	0.00E+00	6.33E-02	-3.88E-01	-1.65E-02	-1.16E-02	-1.77E-04	5.28E-02
5	0.00E+00	3.17E-02	-3.89E-01	-1.22E-02	-1.16E-02	-8.87E-05	5.28E-02
6	0.00E+00	7.42E-12	-3.90E-01	-2.24E-09	-1.16E-02	-1.82E-12	1.51E-01
7	0.00E+00	-3.17E-02	-3.89E-01	1.22E-02	-1.16E-02	8.87E-05	1.51E-01
8	0.00E+00	-6.33E-02	-3.88E-01	1.65E-02	-1.16E-02	1.77E-04	5.28E-02
9	0.00E+00	-9.48E-02	-3.87E-01	2.08E-02	-1.15E-02	2.65E-04	5.28E-02
10	0.00E+00	-1.26E-01	-3.85E-01	2.51E-02	-1.15E-02	3.53E-04	5.27E-02
11	0.00E+00	-1.57E-01	-3.83E-01	2.94E-02	-1.14E-02	4.40E-04	5.27E-02
			MODAL DISPLACEMENTS FOR SEGMENT NO. 3				
1	-1.24E-01	-6.01E-02	-3.90E-01	-1.72E-01	-3.05E-12	1.45E-14	1.80E-01
2	-2.94E-01	-1.29E-01	-4.17E-01	-1.42E-01	-3.04E-12	1.37E-13	1.80E-01
3	-4.64E-01	-2.02E-01	-4.39E-01	-1.11E-01	-3.03E-12	2.60E-13	1.80E-01
4	-6.34E-01	-2.78E-01	-4.55E-01	-8.36E-02	-3.02E-12	3.85E-13	1.62E-01
5	-8.03E-01	-3.56E-01	-4.67E-01	-5.96E-02	-3.01E-12	5.12E-13	1.41E-01
6	-9.73E-01	-4.36E-01	-4.76E-01	-3.99E-02	-3.00E-12	6.44E-13	1.16E-01
7	-1.14E+00	-5.18E-01	-4.81E-01	-2.52E-02	-2.98E-12	7.80E-13	8.68E-02
8	-1.31E+00	-6.00E-01	-4.85E-01	-1.62E-02	-2.96E-12	9.22E-13	5.30E-02
9	-1.48E+00	-6.82E-01	-4.87E-01	-1.38E-02	-2.94E-12	1.07E-12	1.44E-02
10	-1.65E+00	-7.65E-01	-4.90E-01	-1.87E-02	-2.92E-12	1.23E-12	-2.93E-02
11	-1.82E+00	-8.49E-01	-4.94E-01	-2.37E-02	-2.90E-12	1.40E-12	-2.93E-02
			MODAL DISPLACEMENTS FOR SEGMENT NO. 4				
1	0.00E+00	-1.57E-01	-3.83E-01	3.01E-02	-1.14E-02	4.40E-04	5.02E-02
2	0.00E+00	-2.96E-01	-3.70E-01	4.85E-02	-1.11E-02	8.30E-04	5.02E-02

Table 56 (p.3 of 3)

```
 3  0.00E+00 -4.28E-01 -3.49E-01  6.68E-02 -1.05E-02  1.20E-03  5.02E-02
 4  0.00E+00 -5.52E-01 -3.21E-01  8.41E-02 -9.65E-03  1.54E-03  4.71E-02
 5  0.00E+00 -6.64E-01 -2.88E-01  9.99E-02 -8.65E-03  1.84E-03  4.31E-02
 6  0.00E+00 -7.62E-01 -2.49E-01  1.14E-01 -7.48E-03  2.11E-03  3.81E-02
 7  0.00E+00 -8.46E-01 -2.05E-01  1.26E-01 -6.17E-03  2.34E-03  3.23E-02
 8  0.00E+00 -9.12E-01 -1.57E-01  1.35E-01 -4.73E-03  2.53E-03  2.59E-02
 9  0.00E+00 -9.61E-01 -1.07E-01  1.42E-01 -3.21E-03  2.66E-03  1.89E-02
10  0.00E+00 -9.90E-01 -5.38E-02  1.46E-01 -1.62E-03  2.74E-03  1.15E-02
11  0.00E+00 -1.00E+00  0.00E+00  1.50E-01  0.00E+00  2.73E-03  1.15E-02
 **** END SUB. MODE (SKIN-SUBSTRINGER MODULE BUCKLNG MODE) **

******* NOTE ********** NOTE ******** NOTE *********
Discretized skin-substringer module buckling mode
involves significant deformation of the panel skin.
***** END NOTE ****** END NOTE ***** END NOTE *********
Margin=  4.6448E-01  skin-substringer discrete model-1.,M=2   axial halfwaves;FS=0.999
********* DESIGN PERTURBATION INDEX, IMOD=  0 *********
```

Compare with STAGS in Fig. 24

Table 57 allen.STG

```
     n         $ Do you want a tutorial session and tutorial output?
     1         $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
     0         $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
 1.700000      $ Local buckling load factor from PANDA2, EIGLOC
     y         $ Are the dimensions in this case in inches?
     0         $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
     0         $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
 53.142        $ X-direction length of the STAGS model of the panel: XSTAGS
 73.1820       $ Panel length in the plane of the screen, L2
     y         $ Is the nodal point spacing uniform along the stringer axis?
   101         $ Number of nodes in the X-direction: NODEX
 -8025         $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
     0         $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
     0         $ In-plane shear in load set A,                         Nxy
     0         $ Normal pressure in STAGS model in Load Set A, p
     0         $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
     0         $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
     0         $ Normal pressure in STAGS model in Load Set B, p0
     1         $ Starting load factor for Load System A, STLD(1)
     0         $ Load factor increment for Load System A, STEP(1)
     1         $ Maximum load factor for Load System A, FACM(1)
     0         $ Starting load factor for Load System B, STLD(2)
     0         $ Load factor increment for Load System B, STEP(2)
     0         $ Maximum load factor for Load System B, FACM(2)
     5         $ How many eigenvalues do you want? NEIGS
   480         $ Choose element type (410 or 411 or 480) for panel skin
     n         $ Have you obtained buckling modes from STAGS for this case?
    51         $ Number of stringers in STAGS model of 360-deg. cylinder
     4         $ Number of rings in the STAGS model of the panel
     y         $ Are there rings at the ends of the panel?
note→ 3        $ Sub-stringer model, ISTRSB = 1 or 2 or 3 (Type H(elp))
     7         $ Number of nodes over height of sub-stringer web, NPSUBS
     4         $ Number of finite elements between adjacent sub-stringers
    11         $ Number of finite elements between adjacent rings
     3         $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
     3         $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
    -1         $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
     n         $ Do you want to use fasteners (they are like rigid links)?
     n         $ Are the stringers to be "smeared out"?
     n         $ Are the rings to be "smeared out"?
     7         $ Number of nodes over height of stiffener webs, NODWEB
     7         $ Number of nodes over width of stringer flange, NDFLGS
     7         $ Number of nodes over width of ring flange, NDFLGR
     n         $ Do you want stringer(s) with a high nodal point density?
     n         $ Do you want ring(s) with a high nodal point density?
     n         $ Is there plasticity in this STAGS model?
     n         $ Do you want to use the "least-squares" model for torque?
     n         $ Is stiffener sidesway permitted at the panel edges?
     y         $ Do you want symmetry conditions along the straight edges?
```

3 bay x 3 bay STAGS model

3 stringer bays = 3 x 24.394 inches

3 ring bays = 3 x 17.714 inches

Table 58 allen.out2 (abridged)

Abridged allen.out2 file (STAGS prediction)

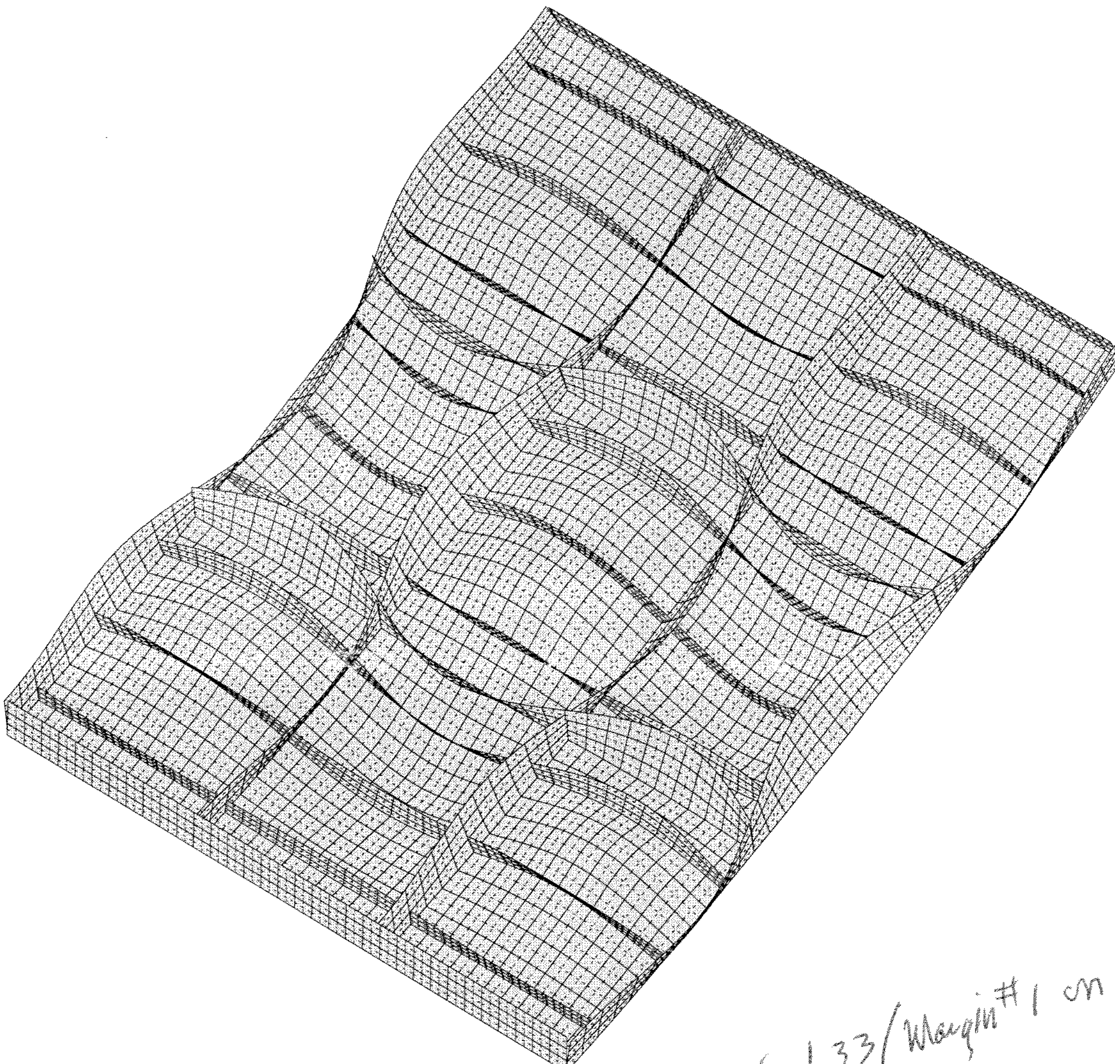
MAXIMUM NUMBER OF ITERATIONS
CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES 1 THROUGH 6
CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES 7 THROUGH 8

		CRITICAL LOAD FACTOR COMBINATION			
NO.	EIGENVALUE	LOAD SYSTEM A	LOAD SYSTEM B	@DOF	
1	1.395768E+00	1.395768E+00	0.000000E+00	24291	Fig 21
2	1.486006E+00	1.486006E+00	0.000000E+00	5157	Fig. 22
3	1.633013E+00	1.633013E+00	0.000000E+00	5193	Fig. 23
4	1.689094E+00	1.689094E+00	0.000000E+00	24765	Fig. 24
5	1.704807E+00	1.704807E+00	0.000000E+00	4869	
6	1.728542E+00	1.728542E+00	0.000000E+00	4041	
7	1.746772E+00	1.746772E+00	0.000000E+00	22143	
8	1.751870E+00	1.751870E+00	0.000000E+00	48423	

3bay X 3bay STAGS model

Table ~~58~~ 59 allen.pin

```
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1      0      4      0      1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0    3  $PL-5  DSCALE,NROTS
  1    -35.84    $PL-6  IROT,ROT
  2    180.14    $PL-6  IROT,ROT
  3     35.63    $PL-6  IROT,ROT
```



solution scale = 0.4794E+01

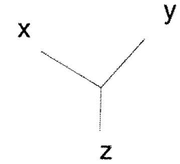
mode 1, pcr = 0.13958E+01

PANDA2 gets 1.33 (Margin #1 on p.1 of Table 54)

step 0 eigenvector deformed geometry

linear buckling of perfect shell from STAGS

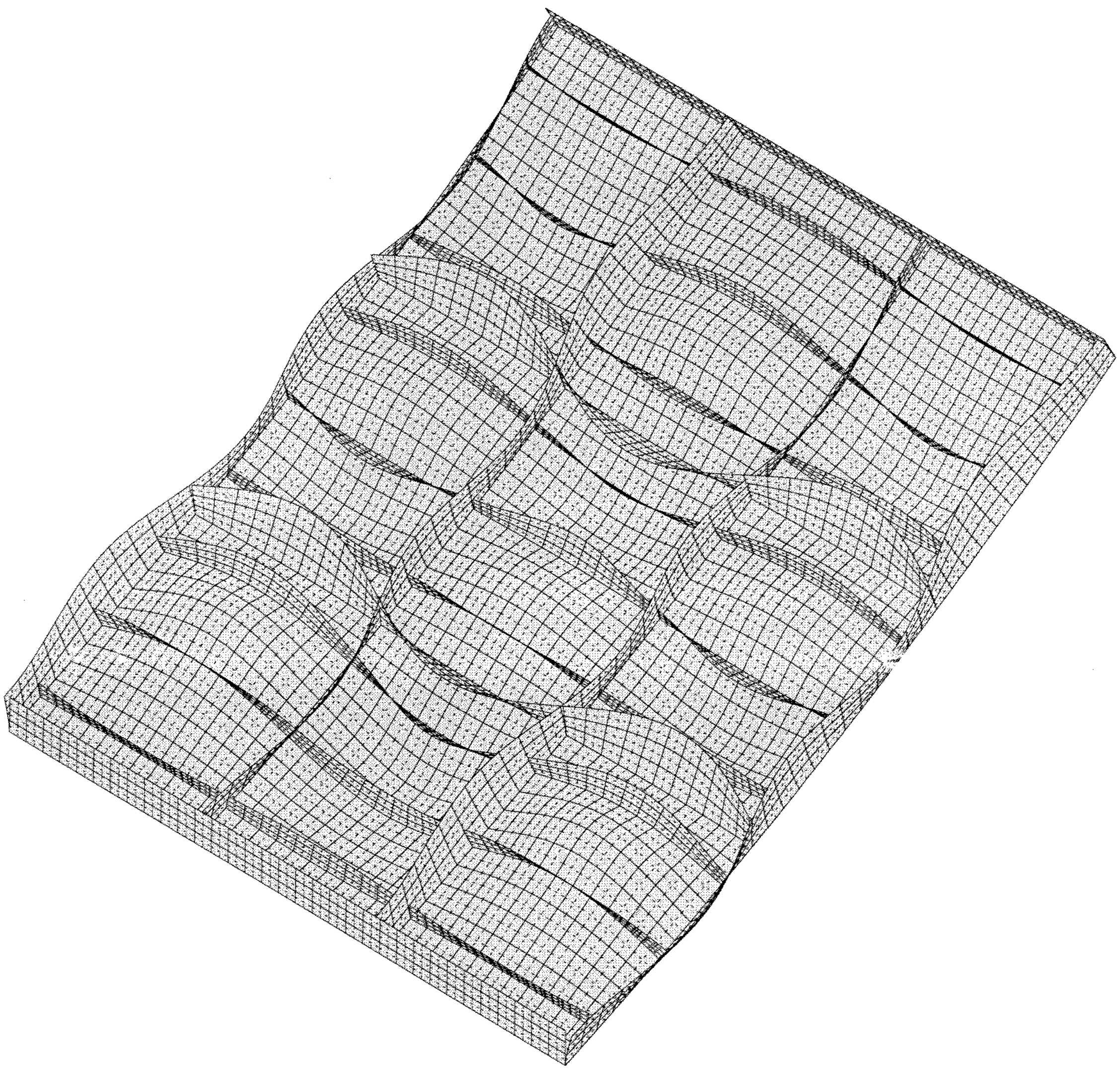
Θ x -35.84
Θ y -179.86
Θ z 35.63



1.414E+01

M1

Fig. 21



solution scale = 0.4641E+01
mode 2, pcr = 0.14860E+01
step 0 eigenvector deformed geometry
linear buckling of perfect shell from STAGS

Θ x -35.84
Θ y -179.86
Θ z 35.63

1.414E+01

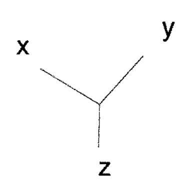
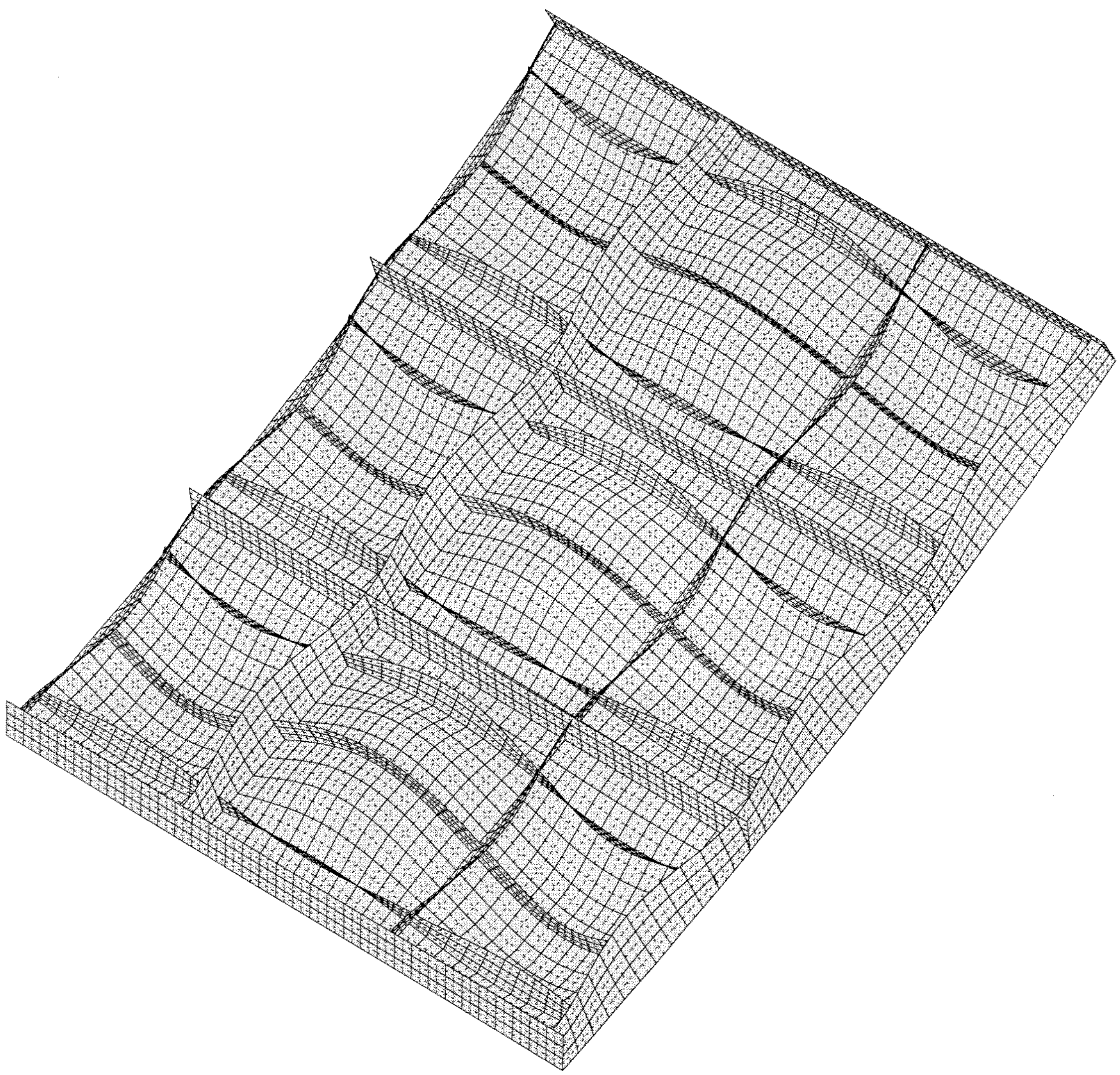


Fig. 22



solution scale = 0.4613E+01
mode 3, pcr = 0.16330E+01
step 0 eigenvector deformed geometry
linear buckling of perfect shell from STAGS

Θ x -35.84
Θ y -179.86
Θ z 35.63

1.414E+01

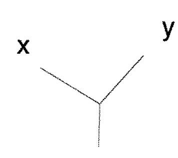
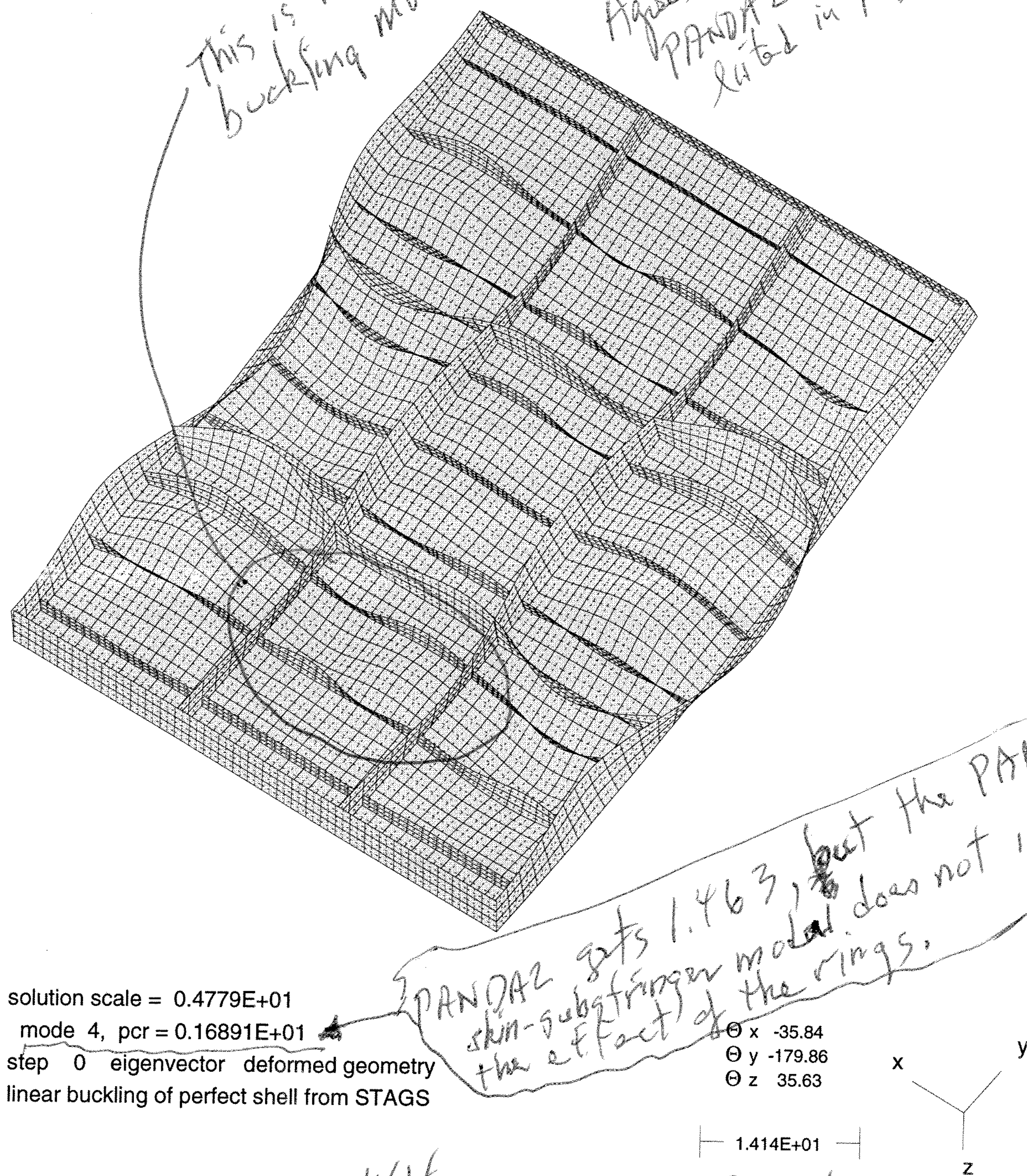


Fig. 23

This is the skin-substringer buckling mode: 2 axial halfwaves between rings. Agrees with the PANDA2 mode listed in Table 56.



PANDA2 gets 1.463, but the PANDA2 skin-substringer model does not include the effect of the rings.

Fig. 24

Table 60

allen.STG (general buckling)

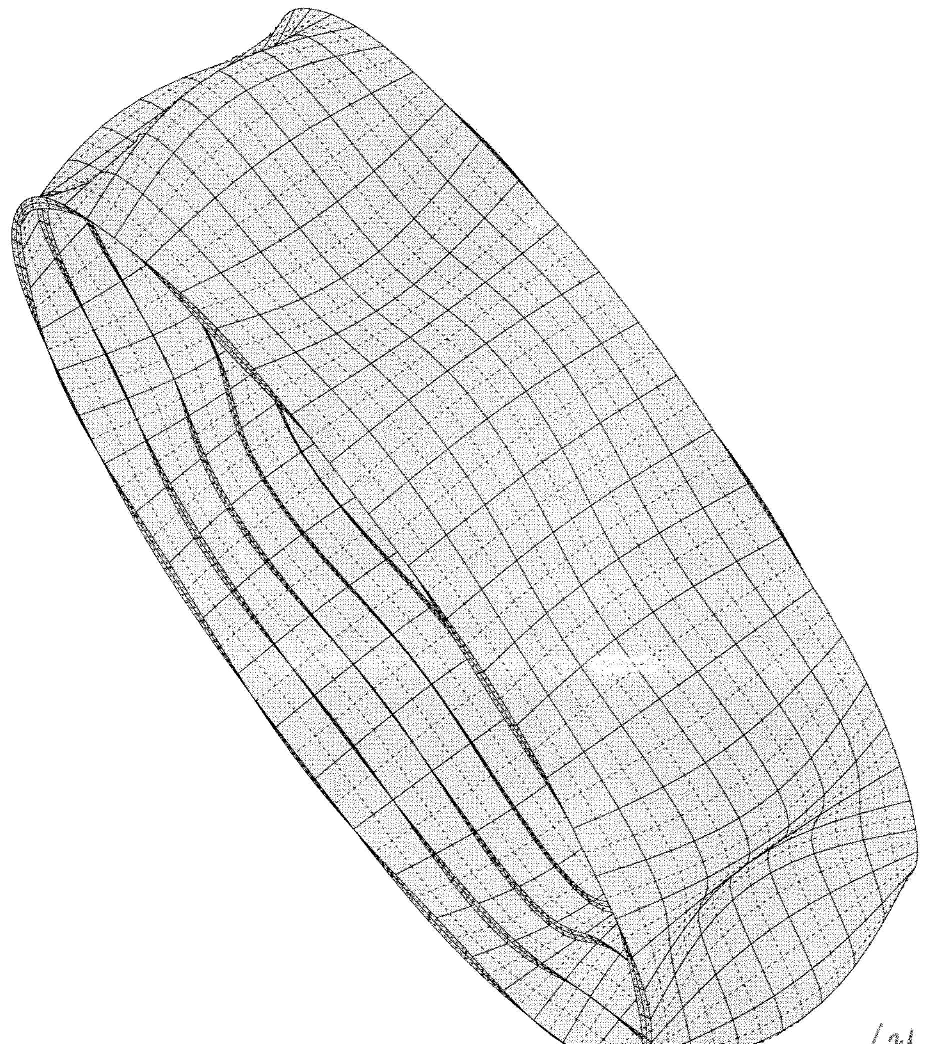
```
 n          $ Do you want a tutorial session and tutorial output?
     1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
     0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
 1.700000   $ Local buckling load factor from PANDA2, EIGLOC
 y          $ Are the dimensions in this case in inches?
     0      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
     0      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
 124.       $ X-direction length of the STAGS model of the panel: XSTAGS
 1244.0710  $ Panel length in the plane of the screen, L2
 y          $ Is the nodal point spacing uniform along the stringer axis?
   101      $ Number of nodes in the X-direction: NODEX
  -8025     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
     0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
     0      $ In-plane shear in load set A,                        Nxy
     0      $ Normal pressure in STAGS model in Load Set A, p
     0      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
     0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
     0      $ Normal pressure in STAGS model in Load Set B, p0
     1      $ Starting load factor for Load System A, STLD(1)
     0      $ Load factor increment for Load System A, STEP(1)
     1      $ Maximum load factor for Load System A, FACM(1)
     0      $ Starting load factor for Load System B, STLD(2)
     0      $ Load factor increment for Load System B, STEP(2)
     0      $ Maximum load factor for Load System B, FACM(2)
     2      $ How many eigenvalues do you want? NEIGS
   480      $ Choose element type (410 or 411 or 480) for panel skin
 n          $ Have you obtained buckling modes from STAGS for this case?
    51      $ Number of stringers in STAGS model of 360-deg. cylinder
     8      $ Number of rings in the STAGS model of the panel
 y          $ Are there rings at the ends of the panel?
     1      $ Sub-stringer model, ISTRSB = 1 or 2 or 3 (Type H(elp))
     7      $ Number of nodes over height of sub-stringer web, NPSUBS
     1      $ Number of finite elements between adjacent stringers
     1      $ Number of finite elements between adjacent rings
     3      $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
     3      $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
    -1      $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
 n          $ Do you want to use fasteners (they are like rigid links)?
 y          $ Are the stringers to be "smeared out"?
 n          $ Are the rings to be "smeared out"?
     5      $ Number of nodes over height of stiffener webs, NODWEB
     5      $ Number of nodes over width of stringer flange, NDFLGS
     5      $ Number of nodes over width of ring flange, NDFLGR
 n          $ Do you want stringer(s) with a high nodal point density?
 n          $ Do you want ring(s) with a high nodal point density?
 n          $ Is there plasticity in this STAGS model?
 n          $ Do you want to use the "least-squares" model for torque?
 n          $ Is stiffener sidesway permitted at the panel edges?
 n          $ Do you want symmetry conditions along the straight edges?
     0      $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

smeared substringers & smeared stringers

entire cylindrical shell

Table 61 allen.pin

```
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1      0      4      0      1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0    3  $PL-5  DSCALE,NROTS
  1    -35.84    $PL-6  IROT,ROT
  2    -13.14    $PL-6  IROT,ROT
  3     35.63    $PL-6  IROT,ROT
```



solution scale = 0.2079E+02

mode 1, pcr = 0.24602E+01 ← PANDA2 gets 2.46 (Margin no 12 in Table 54)

step 0 eigenvector deformed geometry

linear buckling of perfect shell from STAGS

Θ x -35.84
Θ y -13.14
Θ z 35.63

y z x

6.868E+01

Fig. 25

Table 62 allen.pin

```
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1      0      4      0      1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   3  $PL-5  DSCALE,NROTS
  1      0.0    $PL-6  IROT,ROT
  2     90.0    $PL-6  IROT,ROT
  3      0.0    $PL-6  IROT,ROT
```

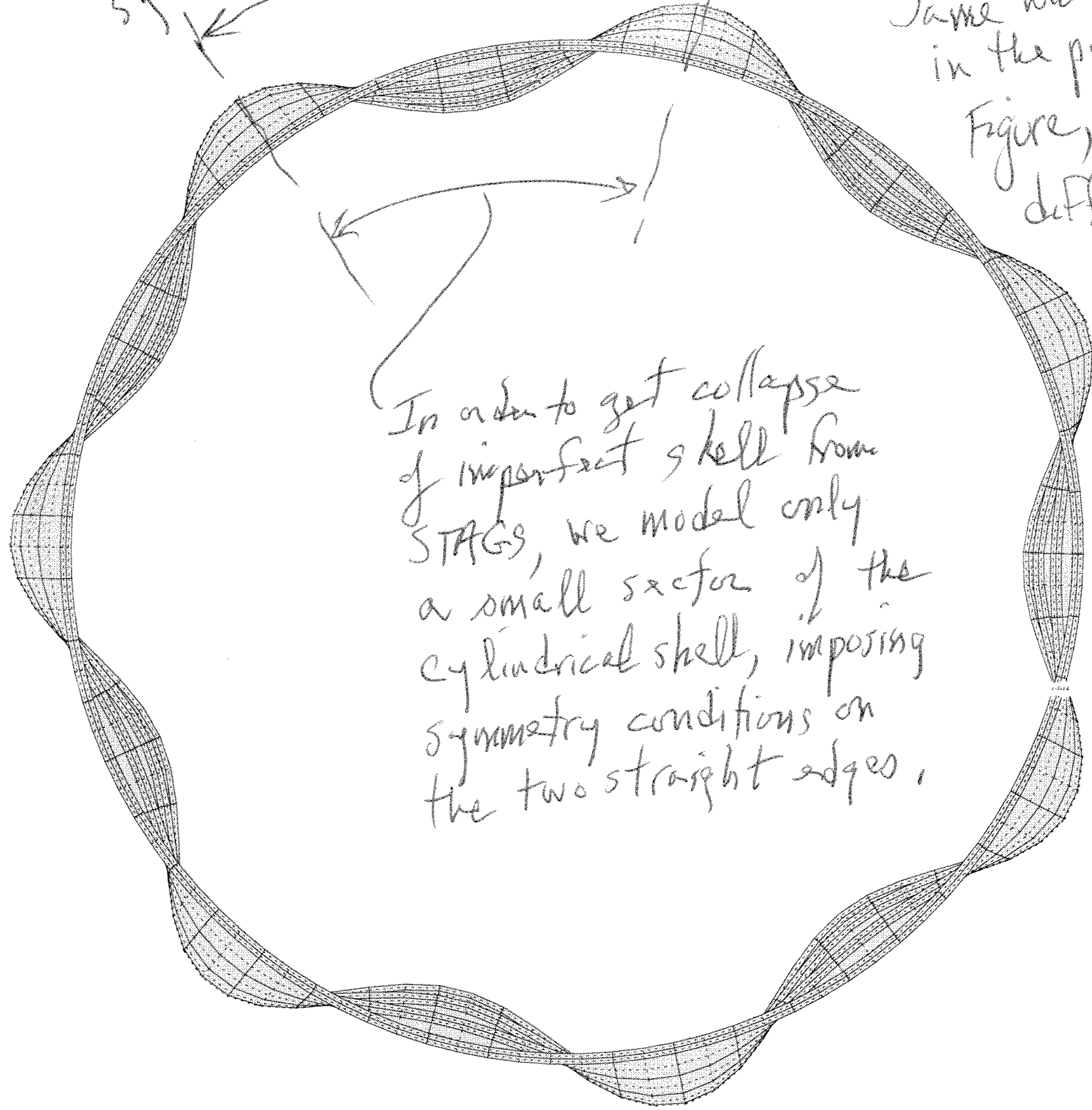
See Table 63

symmetry

about 177.7"

symmetry

Same mode as in the previous Figure, just a different view of it.



In order to get collapse of imperfect shell from STAGS, we model only a small sector of the cylindrical shell, imposing symmetry conditions on the two straight edges.

solution scale = 0.1987E+02
mode 1, pcr = 0.24602E+01
step 0 eigenvector deformed geometry
linear buckling of perfect shell from STAGS

Θ x 0.00
Θ y 90.00
Θ z 0.00

y
x z

6.596E+01

Fig. 26

Table 63 allen.STG

```
n          $ Do you want a tutorial session and tutorial output?
   1       $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
   0       $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
1.700000   $ Local buckling load factor from PANDA2, EIGLOC
  y        $ Are the dimensions in this case in inches?
   0       $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
   0       $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
124.0      $ X-direction length of the STAGS model of the panel: XSTAGS
170.758    $ Panel length in the plane of the screen, L2
  y        $ Is the nodal point spacing uniform along the stringer axis?
  101      $ Number of nodes in the X-direction: NODEX
-8025      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
   0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0       $ In-plane shear in load set A,                     Nxy
   0       $ Normal pressure in STAGS model in Load Set A, p
   0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
   0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
   0       $ Normal pressure in STAGS model in Load Set B, p0
   1       $ Starting load factor for Load System A, STLD(1)
   0       $ Load factor increment for Load System A, STEP(1)
   1       $ Maximum load factor for Load System A, FACM(1)
   0       $ Starting load factor for Load System B, STLD(2)
   0       $ Load factor increment for Load System B, STEP(2)
   0       $ Maximum load factor for Load System B, FACM(2)
   5       $ How many eigenvalues do you want? NEIGS
  480      $ Choose element type (410 or 411 or 480) for panel skin
  n        $ Have you obtained buckling modes from STAGS for this case?
  51       $ Number of stringers in STAGS model of 360-deg. cylinder
   8       $ Number of rings in the STAGS model of the panel
  y        $ Are there rings at the ends of the panel?
   1       $ Sub-stringer model, ISTRSB = 1 or 2 or 3 (Type H(elp))
   7       $ Number of nodes over height of sub-stringer web, NPSUBS
   6       $ Number of finite elements between adjacent stringers
   5       $ Number of finite elements between adjacent rings
   3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
   3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
  -1       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
  n        $ Do you want to use fasteners (they are like rigid links)?
  n        $ Are the stringers to be "smeared out"?
  n        $ Are the rings to be "smeared out"?
   7       $ Number of nodes over height of stiffener webs, NODWEB
   7       $ Number of nodes over width of stringer flange, NDFLGS
   7       $ Number of nodes over width of ring flange, NDFLGR
  n        $ Do you want stringer(s) with a high nodal point density?
  n        $ Do you want ring(s) with a high nodal point density?
  n        $ Is there plasticity in this STAGS model?
  n        $ Do you want to use the "least-squares" model for torque?
  n        $ Is stiffener sidesway permitted at the panel edges?
  y        $ Do you want symmetry conditions along the straight edges?
```

note

substringers are smeared out

{This width permits almost one full wave of the general buckling mode (see Fig. 26)}

entire length of the cylindrical shell

{For the collapse analysis with STAGS we choose a sector width that permits general buckling with approximately the correct critical circumferential wavelength.}

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