Table 5 Output data from the PANDA2 processor PANDAOPT with NPRINT = 2 and ITYPE = 2 (allenrngs.OPM), in this case corresponding to the optimum design. This table is long because NPRINT = 2, which calls for lots of output data. Most of the output corresponding to SUBCASE 2 has been deleted to save space. This file, named allenrngs.OPM after PANDAOPT has been executed, is stored here as the file, allenrngs.opm.table5. This file contains the optimum design found after the bug in SUBROUTINE MODE was discovered and eliminated (see Item No. 804 in …/panda2/doc/panda2.news), and the panel was re-optimized with stringer spacing and ring spacing not used as decision variables but maintained at their old optimized dimensions, stringer spacing = 2.4705 inches, ring spacing = 9.7793 inches.

```
=============================================================================
      n         $ Do you want a tutorial session and tutorial output?
   -1000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
   0.000000     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
   0.000000     $ In-plane shear in load set A,                  Nxy( 1)
      N         $ Does the axial load vary in the L2 direction?
   0.000000     $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
   0.000000     $ 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?
   0.999000     $ Factor of safety for general instability, FSGEN( 1)
   0.999000     $ Factor of safety for panel (between rings) instability, FSPAN( 1)
  0.1000000     $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
   1.000000     $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
   1.000000     $ Factor of safety for stress, FSSTR( 1)
      n         $ Do you want "flat skin" discretized module for local buckling?
      n         $ Do you want to skip the KOITER local postbuckling analysis?
      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)
         0      $ Axial load applied along the (0=neutral plane), (1=panel skin)
   0.000000     $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
   0.000000     $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
   0.000000     $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
   0.000000     $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
  0.1000000E-06 $ Initial local imperfection amplitude (must be positive), Wloc( 1)
      Y         $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
       130      $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
      Y         $ Do you want PANDA2 to find the general imperfection shape?( 1)
   1.000000     $ 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)
         1      $ Index for type of shell theory (0 or 1 or 2), ISAND
      Y         $ Does the postbuckling axial wavelength of local buckles change?
      Y         $ 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)
         1      $ 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)?
    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)

************ END OF THE  allenrngs.OPT  FILE ***********
************ NOVEMBER, 2009 VERSION OF PANDA2   ************
******** BEGINNING OF THE  allenrngs.OPM  FILE *********
```

NOTE: The references called out in the following text are
listed in the section following the headings,
"PANDA2 REFERENCES", "ABOUT BOSOR4", and "ABOUT STAGS"

DESCRIPTION OF PANDA2

PANDA2 is a computer program for the minimum weight design of stiffened, composite, flat or cylindrical, perfect/imperfect panels and shells subjected to multiple sets of combined in-plane loads, normal pressure, and temperature. For most configurations the panels can be locally postbuckled. Previous work on PANDA2 is documented in [1]. PANDA2 incorporates the theories of earlier codes PANDA [2] and BOSOR4 [1B - 7B]. The optimizer used in PANDA2 is called ADS [20, 21]. Panels are optimized subject primarily to buckling and stress constraints.

PANDA2 Processors and Types of Analysis:

As described in [1],[16,17], the PANDA2 system consists of several processors, BEGIN, SETUP, DECIDE, MAINSETUP, PANDAOPT, CHOOSEPLOT, CHANGE, STAGSUNIT, PANEL, PANEL2, etc. The functions of these processors are as follows:

```
BEGIN   User establishes starting design, material properties,
        prebuckling and buckling boundary conditions.
SETUP   System sets up BOSOR4-type templates for stiffness and
        load-geometric matrices.
DECIDE  User chooses decision variables and bounds and sets up
        equality (linking) and inequality constraints.
MAINSETUP  User chooses analysis type, loading, solution
           strategies, imperfection amplitudes, factors of
           safety, etc.
PANDAOPT   Analysis type is performed (e.g. optimization).
CHOOSEPLOT User chooses what to plot.
DIPLOT     The system obtains plots (postscript files).
CHANGE     User changes selected variables and constants.
AUTOCHANGE A new starting design is automatically generated
           in a random manner.
SUPEROPT   An attempt is made to find a global optimum design.
PANEL      A BOSOR4 input file is generated for inter-ring
           buckling of panel skin and stringers, with
           stringers modelled as flexible shell branches.
PANEL2     A BOSOR4 input file is generated for inter-ring
```

```
           buckling of panel skin+smeared stringers with rings
           modelled as flexible shell branches.
STAGSMODEL An input file for STAGS [1S - 4S] is generated (one
           finite element unit, only stringers are permitted).
STAGSUNIT  An input file for STAGS is generated (multiple
           shell units, both stringers and rings are permitted)
CLEANPAN   Delete all files except files containing the user-
           provided input data for BEGIN, DECIDE, MAINSETUP,
           CHANGE, PANEL, PANEL2, STAGSMODEL, STAGSUNIT,
           CHOOSEPLOT
```

PANDA2 can be run in five modes:

1. optimization
2. simple analysis of a fixed design
3. test simulation (monotonically increasing loading)
4. design sensitivity (margins computed for a user-selected range of one decision variable, all others held constant)
5. load-interaction curves (Nx,Ny) or (Nx,Nxy) or (Ny,Nxy)

Overview of models used in PANDA2

PANDA2 computes stress and buckling loads from several different models as follows:

1. Discretized single-module skin-stringer (Figs.20,22 of [1])
   The cross section of a stringer and panel skin of width equal to the stringer spacing is discretized as shown in [1]. Variation of unknowns u,v,w in the axial direction is trigonometric with m axial halfwaves. This one-dimensional discretization is analogous to that used in BOSOR4 [1B,3B] for shells of revolution.
   (a) This model is for the axial length of shell between rings.
   (b) This model can be used for local postbuckling analysis as shown in Figs. 23 of [1] and Fig. 10 of [11]. The local postbuckling theory [3] is an extension of that of Koiter described in Ref. [22].
   (c) Buckling load factors can be checked by a BOSOR4 model [1B - 7B] generated by the PANDA2 processor, PANEL. (See Items 112c,d, 270, 319 in .../doc/panda2.news and Fig. 21 in [1] and Figs. 33 and 34 of [18]).

2. Discretized single-module "skin"-ring (Fig.30 of [6]):
   The cross section of a ring and panel skin with "smeared" stringers of axial length equal to the ring spacing is discretized. Variation of unknowns u,v,w, in the circumferential direction is trigonometric with n circumferential halfwaves. This one-dimensional discretization is the same as that used in BOSOR4 [1B,3B] for shells of revolution.

   (a) This model involves discretized skin-with-smeared-stringers combined with discretized ring cross section.
   (b) Buckling load factors can be checked by a BOSOR4 model [1B - 7B] generated by the PANDA2 processor, PANEL2. (See Item 463 in ...panda2/doc/panda2.news and Fig.33 of [6] and Figs. 35 and 36 of [18])
   (c) This model is used to determine a knockdown factor

that compensates for the inherent unconservativeness of models with "smeared" rings. (See Items 509, 511, 522, 532, 605, 617, 619, 632, 633, and 676 in the file, ...panda2/doc/panda2.news).

3. PANDA-type closed form buckling formulas [2] for shell skin and segments of stringers and segments of rings:
   (a) This model involves an elaborate search over (m,n,s) space, in which m = number of axial halfwaves, n =number of circumferential halfwaves and s =slope of the buckling nodal lines (assumed straight)
   (b) Either Donnell theory or Sanders theory or Marlowe theory is used for the shell analysis. (User chooses).
   (c) This model is used to compute knockdown factors for stiffened or unstiffened cylindrical panels and shells with local, inter-ring, and general buckling modal imperfection shapes with user-specified amplitudes [4].
   (d) This model is used to get a knockdown factor to compensate for the fact that the in-plane shear load Nxy equals zero in all BOSOR4-type (discretized) models
   (e) This model is used for buckling of stiffener segments such as shown in Figs. 5 and 6 of [2].
   (f) This model is used for the buckling of sandwich wall face sheets attached to an elastic foundation that represents the core of the sandwich wall [10].
   (g) This model is used for many of the buckling modes that exist in panels with major stiffeners and substiffeners between the major stiffeners [16].

4. Sandwich wall failure modes unique to sandwich walls [10]:
   (a) face sheet wrinkling
   (b) face sheet dimpling
   (c) core crimping
   (d) stiffener-web-bending-induced face sheet pull-off
   (e) stiffener-web-bending-induced core crushing
   (f) amplification-of-initial-face-sheet-waviness-induced face sheet pull-off
   (f) amplification-of-initial-face-sheet-waviness-induced core crushing
   (g) hexagonal core face sheet pull-off
   (h) transverse shear core failure
   (i) core tension failure.

5. Models involving solution by double trigonometric series expansions [6]:
   (a) local buckling between adjacent major stiffeners
   (b) general buckling of a "patch" involving N x M major stiffener bays
   (c) inter-ring buckling of a "patch" involving N major stringer bays
   (d) local, "general", and inter-subring models in shells with substringers and subrings between major stiffners. The "general" buckling domain is a "patch" involving N x M substiffener bays lying between adjacent major stringers and major rings.

6. Optimum designs obtained by PANDA2 may be checked by running a general-purpose finite element program. The

```
   PANDA2 processor called STAGSUNIT generates input files,
   <casename>.inp and <casename>.bin for STAGS [1S - 4S].
   STAGSUNIT [7] generates valid STAGS input files for any
   subdomain of a shell or panel, as seen in Refs. [7, 16, 17].


   Stress and buckling margins and other facts about PANDA2
==============================================================
PART 1.1: stress constraints from discretized and
          non-discretized models.

PART 1.2: buckling constraints from discretized single module
          skin-stringer model (Example: Fig. 22 of [1]).

PART 1.3: buckling constraints from discretized single module
          skin-with-smeared-stringers/discretized ring model
          (Example: Fig. 30 of [6]).

PART 1.4: buckling constraints from PANDA-type models [2] and
          alternative models involving double trigonometric
          series expansions ("altsol" models, [6])

          Part 1.4.1 Various types of buckling/models included
                     in SUBROUTINE BUCPAN
          Part 1.4.2 Special cases in SUBROUTINE BUCPAN
          Part 1.4.3 Types of "knockdown" used in PANDA2
          Part 1.4.4 Imperfections cause stress redistribution
          Part 1.4.5 Buckling margins

PART 1.5: buckling constraints from PANDA-type models of
          buckling of stiffener segments (Fig. 5 of [2])

PART 1.6: Conservativeness of PANDA2 analyses

PART 1.7: How the effect of imperfections is handled in PANDA2
--------------------------------------------------------------


PART 1.1

PANDA2 computes the following types of margins relating to
stress constraints:

-------------------- typical margin names ---------------------
eff.stress:matl=1,STR,Dseg=5,node=11,layer=1,z=.281; MID.;FS=1
eff.stress:matl=1,RNG,Iseg=3,at:TIP,layer=1,z=0.363;-MID.;FS=1
fibertensn:matl=1,STR,Dseg=4,node=6,layer=1,z=-0.11; ENDS;FS=1
fibercompr:matl=1,SKN,Dseg=2,node=6,layer=2,z=0.11; ENDS;FS=1
transtensn:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.11; ENDS;FS=1
transcompr:matl=1,SKN,Dseg=2,node=6,layer=2,z=0.11; ENDS;FS=1
inplnshear:matl=1,STR,Dseg=3,node=1,layer=1,z=0.083; ENDS;FS=1
fibertensn:matl=1,STR,Iseg=4,allnode,layer=1,z=-.11;-ENDS;FS=1
fibercompr:matl=1,SKN,Iseg=1,at:n=11,layer=2,z=0.11;-ENDS;FS=1
transtensn:matl=1,SKN,Iseg=2,at:n=11,layer=1,z=-.11;-ENDS;FS=1
transcompr:matl=1,STR,Iseg=4,allnode,layer=1,z=0.11;-ENDS;FS=1
inplnshear:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-ENDS;FS=1
---------------------------------------------------------------
```

```
in which the following definitions apply:
"STR" = "stringer"; "RNG" = "ring"; "SKN" = "skin";
"MID" = midway between rings (midbay); "ENDS" = "at rings"
"TIP" = at the tip of a stiffener web
"Dseg" = segment numbering for discretized single module model
"Iseg" = segment numbering from "BEGIN" (See *.BEG file)
"z" = distance from reference surface (thickness coordinate)
"node" = nodal point in discretized single module model
"allnode" = "at all nodes" [IQUICK=1 (non-discretized) model]
"layer" = layer number in the segment wall
"FS" = factor of safety
"eff.stress" = von Mises effective stress
"fibertensn" = tensile stress in the direction of the fibers
"fibercompr" = compressive stress along the fibers
"transtensn" = tension stress normal to the fibers
"transcompr" = compressive stress normal to the fibers
"inplnshear" = in-plane shear stress

Stresses in the category denoted "Iseg"(non-discretized model)
are computed in SUBROUTINE STRCON for both positive and
negative amplitudes of buckling modal imperfection.
Stresses in the category denoted "Dseg"(discretized model)
are computed in SUBROUTINE STRTHK and include the effect of
local postbuckling of the panel skin between adjacent
stringers.

In computing the various stress constraints, SUB.STRCON/STRTHK
include the effect of redistribution of stress resultants
between panel skin and stiffener segments caused by bending of
an initially imperfect shell subjected to its design load. For
example, in one case (not this case), this prebuckling bending
gives rise to additional compressive stress resultants as
follows:

Additional resultants (Nx,Ny) in panel skin from
global and inter-ring bending of imperfect panel:
             Additional axial resultant, DNX = -1.4357E+03
             Additional  hoop resultant, DNY = -2.3231E+04
    Additional in-plane shear resultant, DNXY=  0.0000E+00

Additional axial resultants DNX along webs and flanges of
stringers from global and inter-ring bending of imperfect panel:
    Additional Nx in  base  of stringer, DNX = -1.4357E+03
    Additional Nx at webtip of stringer, DNX = -2.5133E+03
    Additional Nx in flange of stringer, DNX = -1.8180E+03

Additional axial resultants DNX along webs and flanges of
rings from global and inter-ring bending of imperfect panel:
    Additional Nx in  base  of   ring,   DNX = -2.5529E+04
    Additional Nx at webtip of   ring,   DNX = -9.7624E+04
    Additional Nx in flange of   ring,   DNX = -6.4280E+04
----------------------------------------------------------------
```

PART 1.2

Buckling load factors may be computed with use of the single discretized skin-stringer module model [1]. Examples of this model appear in Figs. 22, 46, 98, and 99 of Ref.[1]. This one-dimensionally-discretized model is analogous to the model used in BOSOR4 [1B,3B] for analysis of axisymmetric shells. This model is used only for inter-ring buckling phenomena (no rings!). The types of buckling margins obtained with this model are as follows:

```
------------------- typical margin names ---------------------
Local buckling from discrete model-1.,M=5 axial halfwaves;FS=1
long-wave local buckling, discrete model(m=1 axial halfwav);FS
Local buckling from Koiter theory,M=5 axial halfwaves;FS=1.0
Bending-torsion buckling; M=1  ;FS=1.0
(m=1 lateral-torsional buckling load factor)/(FS)-1;FS=1.0
local wide-column bucking, discrete model(m=1 axial halfwave)
stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
stringer popoff margin:(allowable/actual)-1, web 2  MID.;FS=1.
(Wide column panel buckling load factor)/(F.S.) - 1; FS=1.0
(Funny hat buckling load factor)/(F.S.) -1; FS=1.0
-.05+(eig(high-axial-m) -eig(low-axial-m))/eig(high-m);FS=1.0
---------------------------------------------------------------
```

A typical local buckling mode is shown in Fig.22a of [1].
A typical wide column panel buckling mode is in [1], Fig. 22c.
Stringer popoff is explained in the discussion associated with Figs. 5 - 8 of [1].
Bending-torsion buckling and lateral-torsional buckling modes are modes in which the tip of the stringer deforms more than the panel skin midway between adjacent stringers. Fig. 20b in [18] shows an example.
The "Funny hat" buckling mode applies only to hat-stiffened panels and is discussed in Item 123(u) of ..doc/panda2.news.
The last margin listed above attempts to keep buckling modes with high numbers of axial halfwaves m non-critical compared to those with low numbers of axial halfwaves.

In computing the various buckling load factors, SUB. LOCAL includes the effect of redistribution of stress resultants between panel skin and stiffener segments caused by bending of an initially imperfect shell subjected to its design load. For example, see the list of DNX, DNY, DNXY printed above.

PART 1.3

Computations with "SKIN"-RING discrete single module model[6]:
See Item No. 463 of the file, ../doc/panda2.news and Ref.[6]:
Bushnell, D., et al, "Additional buckling solutions in PANDA2" AIAA Paper 99-1233, Proc. 40th AIAA Structures and Materials Conference, pp 302-345 (1999) [6]. See especially pp 318-323 and Figs. 30-33. Also, read ITEMs 509, 511, 522, 605 of the file, ..panda2/doc/panda2.news, about how PANDA2 develops a knockdown factor to compensate for the unconservativeness of buckling models in which the rings are smeared out.

This model is used only for ring-stiffened cylindrical shells. The model is analogous to the discretized single module skin-stringer model described previously. It is a discretized single module "skin"-ring model of axial length equal to the ring spacing. The cylindrical "skin" part extends from midbay to midbay, with symmetry conditions applied at top and bottom. "Skin" is in quotes because it consists of the actual skin of the cylindrical shell plus smeared stringers, if any. The ring cross section is discretized (branched shell model), with the plane of the ring web lying in the horizontal plane of symmetry of the entire discretized "skin"-ring module.

```
------------------- typical margin names ---------------------
The types of buckling margins obtained with this model are:
Inter-ring bucklng, discrete model, n=37 circ.halfwaves;FS=1.0
Ring sidesway buk., discrete model, n=4  circ.halfwaves;FS=1.0
Ring web buckling,  discrete model, n=?? circ.halfwaves;FS=1.0
Ring flange buckling,discrete model,n=54 circ.halfwaves;FS=1.0
Hi-n Inter-ring buc.,discrete model,n=?? circ.halfwaves;FS=1.0
Hi-n Ring sidesway,  discrete model,n=?? circ.halfwaves;FS=1.0
Hi-n Ring web buckl.,discrete model,n=27 circ.halfwaves;FS=1.0
Hi-n Ring flang buckl.discret model,n=67 circ.halfwaves;FS=1.0
Lo-n Inter-ring buc.,discrete model,n=?? circ.halfwaves;FS=1.0
Lo-n Ring sidesway, discrete model, n=7  circ.halfwaves;FS=1.0
Lo-n Ring web buck., discrete model,n=?? circ.halfwaves;FS=1.0
Lo-n Ring flng buck.,discrete model,n=?? circ.halfwaves;FS=1.0
---------------------------------------------------------------
```

In computing the various buckling load factors, SUB. STRUCT includes the effect of redistribution of stress resultants between panel skin and stiffener segments caused by bending of an initially imperfect shell subjected to its design load. For example, see the list of DNX, DNY, DNXY printed above

----

PART 1.4

Computations that occur in SUBROUTINE BUCPAN...
Buckling load factors are computed from PANDA-type theory [2] and possibly also from the "alternative" buckling theory where the buckling mode is expanded in a double-trigonometric series as described in Ref.[6]. Stiffener rolling, referred to below, is shown in Fig.6 (a-c) on p. 546 of [2]. If the panel is of sandwich wall construction, then Ref.[10] applies. If the panel has both stiffeners and substiffeners, then Ref. [16] applies. A very large eigenvalue, such as 1.E+17, indicates that buckling does not occur, probably because the loading is tensile and there is no shear (positive Nx, Ny; no Nxy), or that PANDA2 did not compute a particular buckling mode.

Part 1.4.1 Various types of buckling/models included in SUBROUTINE BUCPAN:

If the panel is stiffened by both rings and stringers, then the following computations are performed:

1. Local buckling of the panel skin between adjacent stringers and rings:

(a) with the use of PANDA-type (closed form) theory [2]
(b) with the use of double-trig. series expansions [6] over a "patch" which spans the stringer spacing and may be shorter than the ring spacing.

2. Inter-ring buckling of panel skin and possibly smeared stringers between adjacent rings:

   (a) with the use of PANDA-type (closed form) theory [2] (stringers smeared; rings replaced by simple support)
   (b) with the use of PANDA-type theory and for a panel of the same geometry except that it is flat (huge R)
   (c) with the use of double-trig. series expansions [6] over a "patch" that spans the ring spacing and that includes up to 6 stringer spacings with discrete stringers.

   NOTE: Results from 2(a,b) may be superseded by results from a discretized module model in which there is one ring attached to a length of cylindrical skin-with-smeared-stringers equal to the ring spacing, with symmetry boundary conditions applied to the top and bottom of the cylindrical part of the model. See Fig. 30 of Ref.[6]. If 2(a,b) have been superseded, a message such as the following will appear in the *.OPM file:

   "Simple-support inter-ring buckling with smeared stringers is not recorded as a margin because this type of buckling has been superseded by the results from the discretized inter-ring module model, for which inter-ring buckling load factors have been computed in the range from n = 1 to n = 118 circumferential halfwaves.
   The critical simple-support inter-ring buckling model has 34 circ. half waves, which lies within this range."

3. General buckling of panel skin with possibly smeared stringers and possibly smeared rings:

   (a) with the use of PANDA-type (closed form) theory [2] (stringers and rings both smeared)
   (b) with the use of double-trig. series expansions [6] over a "patch" that may include up to six stringer spacings and up to five ring spacings with discrete. stringers and discrete rings.

4. Inter-ring buckling with ring rolling, smeared stringers; PANDA-type theory [2] only.(May be superseded as with 2a,b)

5. Buckling between stringers with smeared rings including stringer rolling; PANDA-type theory only.

6. Low-axial-wave stringer rolling without skin participation; PANDA-type theory only.

7. High-axial-wave stringer rolling without skin participation; PANDA-type theory only.

8. Low-circumferential-wave ring rolling without skin participation; PANDA-type theory. (May be superseded as with 2a,b).

9. High-circumferential-wave ring rolling without skin participation. (May be superseded as with 2a,b).

10. Axisymmetric rolling of ring without participation of skin.

11. Stringer web buckling from PANDA-type theory only.

12. Ring web buckling from PANDA-type theory only.

13. For hat or truss-core stiffened configurations:
    (a) hat base or truss core lower skin buckling
    (b) hat crown or truss core upper skin buckling

Part 1.4.2 Special cases in SUBROUTINE BUCPAN:

Special behavioral constraints for sandwich wall construction if applicable [10]. For each panel module segment:

1. Local buckling of sandwich segment (from VINSON 1986)

2. For both upper and lower face sheets of sandwich wall:
(a) Face sheet wrinkling from BUSHNELL theory (PANDA-type with the sandwich core represented by an elastic foundation)
(b) Face sheet wrinkling from VINSON theory
(c) Face sheet wrinkling from HOFF theory (Plantema book)
(d) Face sheet dimpling (local buckling of face sheet with wavelength equal to the honeycomb cell diameter).

3. Failure modes that involve the sandwich core and interaction of the core with face sheets:
(a) Core crimping (from VINSON)
(b) Stringer-web-bending-induced face sheet pull-off
(c) Stringer-web-bending-induced core crushing
(d) Ring-web-bending-induced face sheet pull-off
(e) Ring-web-bending-induced core crushing
(f) Amplification-of-initial-face-sheet-waviness induced face sheet pull-off
(g) Amplification-of-initial-face-sheet-waviness induced core crushing
(h) hexagonal-core face sheet pull-off, if applicable
(i) L-direction (x-z) transverse shear core failure
(j) W-direction (y-z) transverse shear core failure
(k) core tension failure.

Buckling modes involving substiffeners [16], if applicable:

1. For isogrid substiffening: buckling of triangular piece of subskin between adjacent substiffeners including rolling of the subisogrid members along the three edges [12, 16].

2. Buckling of subring as wide column with linearly varying width-wise web compression from subring tip to subring root

3. Local subskin buckling between adjacent substiffeners including substiffener rolling along the 4 edges of the domain (PANDA-type theory [2]). This calculation is analogous to that for local buckling; see 1(a) above.

4. Buckling of substringer simply supported along root, no participation of the panel skin (ENDBUK-like coding).

5. Buckling of subring simply supported along root, no participation of the panel skin (ENDBUK-like coding).

6. Buckling of "patch" with use of double-trigonometric series expansion [6] over domain including up to 6 substringer spacings and 6 subring spacings with discrete substringers and discrete subrings. (The margin contains the string "altsoln4"). This calculation is analogous to the model 3(b) for general instability listed above [6].

7. Buckling of "patch" with use of double-trigonometric series expansion [6] over domain between adjacent substringers and subrings, with rolling of substiffeners included along the four edges. (The margin contains the string "altsoln5"). This calculation is analogous to the model 1(b) for local buckling listed above.

8. buckling between subrings with smeared substringers, subring rolling included. This calculation is analogous to the models 2(a) and 4 for inter-ring buckling listed above [2].

9. Buckling of "patch" with use of double-trigonometric series expansion [6] over domain between adjacent subrings, with rolling of subrings included. The domain includes up to six substringer spacings and the substringers are discrete. (The margin contains the string "altsol6"). This calculation is analogous to the model 2(c) for inter-ring buckling listed above [6].

10. Buckling between substringers with smeared subrings from PANDA-type theory [2]. Substringer rolling is included. This calculation is analogous to model 5 listed above [2].

11. Models involving rolling of substringers and subrings without participation of the panel skin [2]:
    (a) low-m rolling of substringer
    (b) high-m rolling of substringer
    (c) low-m rolling of subring
    (d) high-m rolling of subring
    (e) axisymmetric rolling of subring.
    These models are analagous to Models 6 - 10 listed above for stringer and ring rolling [2].

Part 1.4.3 Types of "knockdown" used in PANDA2

The Local, Inter-ring, and General buckling load factors are knocked down by the following factors:

(a) Imperfection sensitivity factor
(b) Inherent unconservativeness of smearing stringers
    (if there are smeared stringers in the model)
(c) Inherent unconservativeness of smearing rings
    (if there are smeared rings in the model)
(d) Transverse shear deformation (t.s.d.) effects
(e) Ratio of buckling loads from ARBOCZ/PANDA2 theories, if
    that ratio is less than 1.0.

Part 1.4.4 Imperfections cause stress redistribution:

In computing the various buckling load factors, SUB. GENSTB includes the effect of redistribution of stress resultants between panel skin and stiffener segments caused by bending of an initially imperfect shell subjected to its design load. For example, see the listing for DNX, DNY, DNXY at the end of PART 1.1.

Part 1.4.5 Buckling margins

Buckling load factors corresponding to buckling margins of the following types are computed in SUBROUTINE GENSTB (called by SUBROUTINE BUCPAN):

```
------------------- typical margin names ---------------------
buck.(SAND);simp-support local buck.; M=1;N=1;slope=0.09;FS=1.
buck.(SAND);simp-support smear rings; M=272;N=1;slope=0.;FS=1.
buck.(SAND);simp-support general buck;M=1;N=3;slope=3.4427;FS=
buck.(SAND);rolling with local buck.; M=1;N=1;slope=6.57;FS=1.
buck.(SAND);rolling with smear rings;M=110;N=1;slope=0.01;FS=1
buck.(SAND);rolling only of stringers;M=12;N=0;slope=0.;FS=1.6
buck.(SAND);hiwave roll. of stringers;M=92;N=0;slope=0.;FS=1.2
buck.(SAND); STRINGERS:  web buckling;M=7;N=1;slope=0.;FS=1.0
buck.(SAND);   RINGS:    web buckling;M=1;N=1;slope=0.186;FS=1
---------------------------------------------------------------
```

in which "SAND" = "Sanders shell theory", (M,N,slope)=buckling mode (axial halfwaves,circ.halfwaves,slope of nodal lines) and "FS" = "factor of safety".

If the user seeks additional buckling solutions [6], the following additional buckling margins are computed:

```
------------------- typical margin names ---------------------
buck.(SAND);simp-support local buck.; (0.95*altsol);FS=0.999
buck.(SAND);simp-support inter-ring;  (1.00*altsol);FS=0.999
buck.(SAND);simp-support general buck;(0.85*altsol);FS=0.999
--------------------------------------------------------------
```

in which the string "altsol" indicates that the margins were computed with use of double trigonometric series expansions.

In the presence of substiffeners [16] SUBROUTINE BUCPAN computes the following additional buckling margins:

```
------------------- typical margin names ---------------------
buck.(SAND);rolling with skin buckl.;M=1;N=1;slope=0.175;FS=1.
buckling:simp-support of substring.M=1;FS=1.
buckling:simp-support of subrings  N=1;FS=1.
buckling:simp-support altsoln4  intermajorpatch; FS=0.999
buckling:simp-support altsoln5  skin+edgsubroll; FS=0.999
buck.(SAND);rolling with smear substr;M=1;N=1;slope=14.3;FS=1.
buckling:simp-support altsoln6  inter-subring  ; FS=0.999
buck.(SAND);rolling with smear subrng;M=43;N=1;slope=0.02;FS=1
buck.(SAND);rolling only of substring;M=29;N=0;slope=0.;FS=1.6
buck.(SAND);hiwave roll. of substring;M=31;N=0;slope=0.;FS=1.6
buck.(SAND);rolling only of subrings; M=0;N=3;slope=0.;FS=1.6
---------------------------------------------------------------
```

If one or more of the panel module segments is of sandwich wall construction [10], SUBROUTINE GENSTB computes the following additional margins (also see below for yet more behavioral constraints relating to sandwich walls):

```
------------------- typical margin names ---------------------
localbuck (VINSON);strng Iseg1 ;MID; local buck.; M=5;FS=1.1
Face1 wavelength/celldiam;STR;Iseg=1 ;Matl=2 ;MIDLENGTH;FS=1.
Core crushing margin;STR;Iseg=1 ;Matl 2 ;MIDLENGTH;FS=1.
L-dir. sandwich core shear;STR;Iseg=1 ;Matl 2 ;MIDLENGTH;FS=1.
W-dir. sandwich core shear;STR;Iseg=1 ;Matl 2 ;MIDLENGTH;FS=1.
---------------------------------------------------------------
```

If the stiffeners form an isogrid pattern (ISOGRD=1)[12], then there are additional margins pertaining to the isogrid members

```
------------------- typical margin names ---------------------
buck.(SAND);rolling only of isogrid3 ;M=1;N=0;slope=0.;FS=1.6
buck.(SAND);hiwave roll. of isogrid3 ;M=5;N=0;slope=0.;FS=1.2
buck.(SAND); ISOGRID  :  web buckling;M=4;N=1;slope=0.;FS=1.0
--------------------------------------------------------------
```

in which "isogrid3" means "the 3rd set of isogrid members". (There are three sets of equally spaced isogrid members, the three sets forming equilateral triangles).

If the panel is a truss-core sandwich, Ref.[5], Fig.9, there are additional margins, as follows:

```
------------------- typical margin names ---------------------
buck.(DONL); STRINGERS:lower skin; M=69;N=1;slope=0.723;FS=1.0
buck.(DONL); STRINGERS:webbuckling;M=35;N=1;slope=-0.356;FS=1.
buck.(DONL); STRINGERS:upper skin; M=19;N=1;slope=0.2281;FS=1.
0.45*(Stringer spacing, b)/(Stringer base width, b2) - 1;FS=1.
(Str. base width, b2)/(0.2*(Str. spacing, b)) - 1; FS=1.0
--------------------------------------------------------------
```

in which "DONL" means "Donnell shell theory" and "webbuckling" indicates the most critical truss core web.

If the panel is hat-stiffened, Ref.[1], Figs.19,20, there are additional margins, as follows:

```
-------------------- typical margin names ---------------------
buck.(DONL); STRINGERS: under hat; M=18;N=1;slope=0.01;FS=1.0
buck.(DONL); STRINGERS: crown of hat;M=23;N=1;slope=0.;FS=1.0
---------------------------------------------------------------
```

PART 1.5

Computations that occur in SUBROUTINE STFEIG...
The purpose of SUBROUTINE STFEIG is to compute buckling load factors for the various segments of the stiffeners. There is a double loop: outer loop over K = 1,2 (1=stringers; 2=rings); inner loop over I = ISTART,IEND, the segment number within the stiffener. The buckling modes are of the type shown in Fig.5 in Ref.[2]. Examples of corresponding buckling margins are:

```
-------------------- typical margin names ---------------------
buckling margin stringer Iseg.3. Local halfwaves=7. MID.;FS=1.
buckling margin stringer Iseg.4. Local halfwaves=7. MID.;FS=1.
buckling stringer Isegs.3+4 together.M=7  ;C=0.; MID.;FS=1.4
buckling stringer Iseg 4 as beam on foundation.M=221;MID.;FS=3
buckling margin   ring   Iseg.3. Local halfwaves=1. MID.;FS=1.
buckling   ring   Iseg 4 as beam on foundation.M=114;MID.;FS=3
---------------------------------------------------------------
```

in which "Iseg" is the stiffener segment number used in the prompts to the user during the interactive BEGIN execution, "MID" = "midway between rings" and "FS" ="factor of safety".

In computing the stiffener buckling load factors, SUB. STFEIG includes the effect of redistribution of stress resultants between panel skin and stiffener segments caused by bending of an initially imperfect shell subjected to its design load. For example, see the listing for DNX, DNY, DNXY at the end of PART 1.1.

The various buckling margins listed above are computed as follows:

(a) buckling of "interior" stiffener segments (stiffener segments attached to other structure along both long edges): SUBROUTINE WEBBUK, called by SUBROUTINE CRIPPL. Linear variation of axial compression from web root to web tip is accounted for. See Items 120d and 121 in ../doc/panda2.news.
(b) buckling of "end" stiffener segments (stiffener segments attached to other structure along only one long edge): SUBROUTINE ENDBUK, called by SUBROUTINE CRIPPL. See Item 121 in ../doc/panda2.news.
(c) buckling of web and outstanding flange together: SUBROUTINE CRIPP2. The axial load in the stiffener web in this calculation is the average of that at the web root and that at the web tip. See panda2.news Items 30 and 516
(d) buckling of outstanding flange as beam on an elastic foundation. The elastic foundation is the web. (Item 383)

In addition, for truss-core sandwich walls the wide column width-wise buckling of segments of the truss core and face sheets are computed. In the case of isogrid stiffening, the rolling of isogrid members assumed to be hinged along their roots is computed in SUBROUTINE EIGISO. See [12],Item no. 122.

If the stiffeners form an isogrid pattern [12] there exist buckling margins of the following type:

```
------------------- typical margin names ---------------------
buckling margin isogrd1  web. Local halfwaves=4  .MID.;FS=1.0
buckling margin isogrd2  web. Local halfwaves=4  .MID.;FS=1.0
buckling margin isogrd3  web. Local halfwaves=4  .MID.;FS=1.0
buckling margin isogrd3  flange. Local halfwaves=3.MID.;FS=1.0
buckling isogrd3  Isegs.3+4 together.M=4  ;C=0.;  MID.;FS=1.4
buckling isogrd3  stiff.no.J=3 ;panel MID.;M=1 ;FS=1.2
--------------------------------------------------------------
```

in which "isogrd1", "isogrd2", "isogrd3" mean "isogrid members 1, 2, 3, respectively. (There are three sets of equally spaced isogrid stiffeners that form equilateral triangles).

If the panel is truss-core sandwich, Ref.[5],Fig.9, there are additional margins, as follows:

```
------------------- typical margin names ---------------------
buckling marg. stringer Iseg.(width-wise wide col.)MID.;FS=1.0
buckling marg. stringer Iseg.(width-wise wide col.)MID.;FS=1.0
buckling marg. stringer Iseg.(width-wise wide col.)NOPO;FS=1.0
buckling marg. stringer Iseg.(width-wise wide col.)NOPO;FS=1.0
--------------------------------------------------------------
```

in which Iseg = segment numbering as in "BEGIN"; "MID." = "midway between rings" (midbay); "NOPO" = "no postbuckling".

PART 1.6

Conservativeness of PANDA2 analyses

Designs generated by PANDA2 tend to be conservative because:

1. In several instances there is more than one model of a particular phenomenon. {Example: general buckling from PANDA-type (closed form) theory [2] and general buckling from double trigonometric series expansion [6].} PANDA2 retains the margins from both models so that the design that evolves during optimization cycles will be feasible with respect to both models.

2. For imperfect shells the imperfection sensitivity knockdown factors generated from the PANDA-type theory [4] are applied to the double-trigonometric series "patch" models [6] even if the "patch" models yield buckling modes that do not resemble the corresponding buckling modes (local, inter-ring, general) from PANDA-type (closed form) theory.

3. Knockdown factors are applied to the double-trig. series expansion models [6] to compensate for possible truncation error. For example, in the case of the general buckling

"patch" model, a rather conservative knockdown factor 0.85 is applied to the buckling load factor (in addition to the knockdown factor for imperfection sensitivity) in order to compensate for truncation of the double trigonometric series expansion.

4. For imperfect cylindrical panels and shells subjected to pure axial compression or predominantly axial compression, [specifically: SQRT(Nx^2 + Nxy^2)/ABS(Ny) > 10], a factor of 4.0 is applied to the initial amplitude of the imperfection specified by the user. This is done because hyperbolic growth of the imperfection amplitude is assumed to hold [6] as the applied load approaches the design load. This assumption is only valid if the buckling eigenvalues are well separated, as is true for axially compressed columns or externally pressurized cylindrical shells. For axially compressed, very thin cylindrical shells there exists a cluster of eigenvalues in the neighborhood of the "classical" buckling load, with the result that the initial imperfection grows more slowly than hyperbolically for low loads and more steeply than hyperbolically for high loads. The factor of 4.0 compensates for the approximation, of hyperbolic growth of the buckling modal imperfection amplitude; most likely it compensates conservatively.

5. In panels and shells with both stringers and rings, the stringers and rings are allowed to deform "through eachother" where they intersect. That is, they do not support eachother in any way where they intersect.

6. The knockdown factor to compensate for the unconservativeness of smearing rings is quite conservative, since it is computed with the use of a discretized "skin"-ring single module model with symmetry conditions applied at top and bottom, which simulates an infinitely long cylindrical shell. (See leftmost image, bottom row in Fig. 30 of [6]).

   The "smeared ring" knockdown factor is the ratio:

   (buckling load factor from the discretized module model)/
   (buckling load factor of a ring with the same cross-sect.)

   computed for the critical number of circumferential waves determined from a PANDA-type model with smeared rings and an axial length equal to the user-specified length. The knockdown factor is less than 1.0 primarily because the cross section of the discretized module model can deform whereas the ring cross section is assumed not to deform.

7. The knockdown factor for transverse shear deformation (t.s.d.) is on the conservative side. (See Fig. 25 on p.527 of [1]).

8. The buckling load factor for the outstanding flanges of stringers and rings, computed in SUBROUTINE ENDBUK (called by SUB.CRIPPL, which is called by SUB.STFEIG) is conservative because it is based on the assumption that the flange is simply supported where it joins the web tip.

9. The buckling load factor for the web and outstanding flange of a stringer (or ring) (stiffener segment 3+4 buckling) is conservative because it is assumed that the web root is simply supported where it joins the panel skin.

10. The buckling load factor of an outstanding flange acting as a beam on an elastic foundation is conservative because of the factor of safety of 3.0 applied to that kind of failure.

11. The buckling load factor of a stringer and/or ring rolling without participation of the panel skin is conservative because of the factor of safety, F.S.=1.6, applied to that kind of failure. (For a picture of this kind of buckling see Fig. 6b, p. 546 of [2]).

12. The knockdown factor to compensate for the unconservativeness of smearing stringers is felt to be conservative.

13. For panels stiffened by stringers and/or rings with cross sections that have outstanding flanges (not blades), the buckling load factors computed with use of the double trigonometric series expansions [6] will usually be conservative because the edges of the "altsol patch" are assumed to be simply supported rather than supported by a stiffener.

14. The "knockdown" factor for imperfection sensitivity (see PART 1.7) is often made smaller by multiplication by a ratio, (ARBOCZ/PANDA2), which is either unity or less than unity. In the ratio, (ARBOCZ/PANDA2):
    ARBOCZ = buckling load of perfect shell from ARBOCZ theory (see [5])
    PANDA2 = buckling load of perfect shell from PANDA-type (closed form) theory (see [2]).

15. PANDA2 computes a "knockdown" factor for imperfection sensitivity by iteratively computing an effective circumferential radius of curvature as described below and in Ref. [17]. The effective radius of the imperfect shell is larger than the nominal radius of the perfect shell because it corresponds to the local circumferential radius of curvature at the point on the shell surface where there is a maximum inward lobe of the general buckling modal imperfection pattern. Although this maximum circumferential radius of curvature is local, varying along the circumference because of the waviness of the general buckling modal imperfection shape, in PANDA2 it is assumed that the maximum circumferential radius of curvature of the imperfect shell is UNIFORM over the entire circumference of the panel. This is almost certainly a conservative model. See below and Ref. [17] for a more complete discussion of how imperfection sensitivity is handled in PANDA2. It is emphasized here that the theory used in PANDA2 is NOT the very conservative asymptotic "classical" imperfection sensitivity theory by Koiter.

****

**** 2006: A NEW "CONSERVATIVENESS" INDEX, "ICONSV" *****
****

In 2006 a new "conservativeness" index, ICONSV, was introduced as an input datum in the *.OPT file.
ICONSV= 1 generates the most conservative model.
ICONSV= 0 generates a model of intermediate conservativeness.
ICONSV=-1 generates the least conservative model.
Please see Section 9.0, Item No. 676 in [18] for details.

ICONSV = 1 (recommended model) means:

a. Include ARBOCZ theory when computing knockdown factors for local, inter-ring, general buckling.
b. Use more conservative knockdown factors for models in which the stringers are smeared.
c. Use computed knockdown factor for smearing rings
d. The Donnell shell theory is used in SUBROUTINE STRIMP, where imperfection sensitivity is being computed.

ICONSV = 0 (less conservative model) means:

a. Do NOT include ARBOCZ theory when computing knockdown factors for local, inter-ring, general buckling.
b. Use less conservative knockdown factors for models in which the stringers are smeared.
c. Use computed knockdown factor for smearing rings (Same as for ICONSV = 1).
d. The user-selected shell theory is used in SUBROUTINE STRIMP, where imperfection sensitivity is being computed.

ICONSV = -1 (still less conservative model) means:

a. Do NOT include ARBOCZ theory when computing knockdown factors for local, inter-ring, general buckling. (Same as for ICONSV = 0)
b. Use less conservative knockdown factors for models in which the stringers are smeared. (Same as for ICONSV = 0)
c. Do NOT use computed knockdown factor for smearing rings (Knockdown factor for smearing rings = 1.0).

d. Set the knockdown factor for truncated double-trig series expansion (altsol) models to RFACT = 0.95. (RFACT=0.85 for "altsol" models in which there are smeared stiffeners if ICONSV = 0 or 1).
e. The user-selected shell theory is used in SUBROUTINE STRIMP, where imperfection sensitivity is being computed.

PART 1.7

How the effect of imperfections is handled in PANDA2:

PANDA2 can optimize imperfect stiffened panels and shells [4]. Imperfections are assumed to be in the shapes of the general, inter-ring, and local buckling modes obtained from the "PANDA-type" model [2]. This section of PANDA2 applies to stiffened panels with a general buckling modal imperfection, that is, an imperfection shape that is determined from a model in which the stiffeners are smeared out. A general buckling modal imperfection in a stiffened shell has two major effects:

1. The imperfect stiffened panel or shell bends as soon as any loading is applied. This bending causes significant redistribution of stresses between the panel skin and the various stiffener parts, thus affecting significantly many local and inter-ring buckling and stress constraints.

2. The "effective" curvature of an imperfect cylindrical panel or shell depends on the amplitude of the initial imperfection, on the circumferential wavelength of the critical buckling mode of the perfect and of the imperfect shell, and on the amount that the initial imperfection grows as the loading increases from zero to the design load. The "effective" circumferential radius of curvature of the imperfect and loaded shell is larger than its nominal radius of curvature because this radius corresponds to the maximum local radius of a typical inward circumferential lobe of the initial and subsequently load-amplified buckling modal imperfection.

In PANDA2 this larger local radius of curvature is assumed to be the governing radius in the buckling equations pertaining to the imperfect shell. For each type of buckling modal imperfection (general, inter-ring, local) PANDA2 computes a "knockdown" factor based on the ratio:
(buckling load factor: panel with its "effective" radius)/
(buckling load factor: panel with its nominal radius)

In the following "imperfection sensitivity" calculations PANDA2 does the following (using Donnell shell theory if

ICONSV = 1 and using the user-selected shell theory if ICONSV = 0 or ICONSV = -1):

1. Computes the buckling load factor for a PERFECT panel from PANDA-type theory [2].
2 Computes the buckling load factor for a PERFECT panel from ARBOCZ theory. Equations are from "The effect of initial imperfections on shell stability - an updated review" by Johann Arbocz, Faculty of Aerospace Engineering, Delft University of Technology, Report LR-695, Sept.1992. in particular, see Equation No. (3.61) in that report. This ARBOCZ theory is also described briefly in [5].

3. Computes the buckling load factor for an IMPERFECT panel from ARBOCZ theory.

4. Computes the buckling load factor for an IMPERFECT panel from PANDA-type theory [2]. This is done iteratively since the "effective" circumferential radius of curvature of the imperfect panel depends on the buckling load factor that is being computed.

5. Decides (partly depending on user-provided input) on whether to use the buckling mode for the PERFECT shell or the buckling mode of the IMPERFECT shell as the

imperfection shape.

6. Computes the curvature changes and twist, Wxx, Wyy, Wxy, generated because of prebuckling bending of the imperfect shell as it is loaded by the design load.

7. Presents a summary of "knockdown" factors to be used in connection with local, inter-ring, and general buckling of the stiffened shell.

For more information on the behavior of imperfect stiffened shells, please see the following news items in the file, ..doc/panda2/news: 377, 456, 525, 553, 564, 594, and 596. Also, please read the papers [4], [5], and especially [17]. Study Sections 11 - 14 and Tables 9 and 10 of [17].

************* PANDA2 REFERENCES ***************
ABOUT PANDA2:

[1] Bushnell, D.,
"PANDA2 - Program for minimum weight design of stiffened, composite, locally buckled panels", COMPUTERS AND STRUCTURES, Vol. 25, No. 4, pp 469-605, 1987

[2] Bushnell, D.,
"Theoretical basis of the PANDA computer program for preliminary design of stiffened panels under combined in-plane loads", COMPUTERS AND STRUCTURES, v. 27, No. 4, pp 541-563 (1987).

[3] Bushnell, D.,
"Optimization of composite, stiffened, imperfect panels under combined loads for service in the postbuckling regime", Computer Methods in Applied Mechanics and Engineering, Vol. 103 (1993) 43-114

[4] Bushnell, D. and Bushnell, W. D.,
"Approximate method for the optimum design of ring and stringer stiffened cylindrical panels and shells with local, inter-ring, and general buckling modal imperfections" Computers and Structures, Vol. 59, No. 3, pp 489-527 (1996)

[5] Bushnell, D.,
"Recent enhancements to PANDA2" AIAA Paper 96-1337-CP, Proc. AIAA 37th Structures, Structural Dynamics and Materials Conference, pp 126-182, April, 1996.

[6] Bushnell, D., Jiang, H., and Knight, N.F.,
"Additional buckling solutions in PANDA2", Proceedings 40th AIAA SDM Conference, AIAA Paper 99-1233, pp 302-345 April 1999

[7] Bushnell, D. and Rankin, C.C.,
"Optimization of perfect and imperfect ring and stringer stiffened cylindrical shells with PANDA2 and evaluation the optimum designs with STAGS", AIAA Paper 2002-1408, Proc. AIAA 43rd SDM Meeting, pp 1562-1613, April 2002

[8] Bushnell, D. and Bushnell, W.D.,
"Minimum-weight design of a stiffened panel via PANDA2 and evaluation of the optimized panel via STAGS", Computers and Structures, Vol. 50, No. 4, pp 569-602 (1994)

[9] Bushnell, D. and Bushnell, W.D.,
"Optimum design of composite stiffened panels under combined loading", Computers and Structures,Vol. 55, pp 819-856 (1995)

[10] Bushnell, D.,
"Optimum design via PANDA2 of composite sandwich panels with honeycomb or foam cores", AIAA Paper 97-1142, Proc. 38th AIAA Structures, Structural Dynamics and Materials Conference, pp 2163-2202, April, 1997

[11] Bushnell, D., Rankin, C.C., and Riks, E.,
"Optimization of stiffened panels in which mode jumping is accounted for", AIAA Paper 97-1141, Proc. 38th AIAA SDM Conference, pp 2123-2162, April 1997

[12] Bushnell, D.,
"Global optimum design of externally pressurized isogrid stiffened cylindrical shells with added T-rings", Int. J. Non-Linear Mechanics, Vol. 37, Nos 4-5, pp 801-831 (2002)

[13] Bushnell, D.,
"Optimization of panels with riveted Z-shaped stiffeners via PANDA2", in Advances in the Mechanics of Plates and Shells, Durban, D, Givoli, D., and Simmonds, J.G., Eds, Kluwer Academic Publishers, pp 79-102 (2001)

[14] Bushnell, D.,
"Truss-core sandwich design via PANDA2", Computers and Structures, Vol. 44, No. 5, pp 1091-1119 (1992)

[15] Bushnell, D., Holmes, A.M.C., Flaggs, D.L., McCormick, P.J., "Optimum design, fabrication and test of graphite-epoxy curved, stiffened, locally buckled panels loaded in axial compression", in BUCKLING OF STRUCTURES, edited by I. Elishakoff, et al, Elsevier, Amsterdam, pp 61-131, 1988

[16] Bushnell, D. and Rankin, C.C.,
"Optimum design of stiffened panels with substiffeners", AIAA Paper 1932, 46th AIAA Structures, Structural Dynamics and Materials Meeting, Austin, TX, April 2005

[17] Bushnell, D. and Rankin, C.C.,
"Difficulties in optimization of imperfect stiffened cylindrical shells", AIAA Paper 1943, 47th AIAA Structures, Structural Dynamics and Materials Meeting, Newport RI, April 2006

[18] Bushnell, D.
"Optimization of an axially compressed ring and stringer stiffened cylindrical shell with a general buckling modal imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting, Honolulu, Hawaii, April 2007

[19] Bushnell, D., .../panda2/doc/panda2.news, a continually updated file distributed with PANDA2 that contains a log of all significant modifications to PANDA2 from 1987 on.

[20] Vanderplaats, G. N., "ADS--a FORTRAN program for automated design synthesis, Version 2.01", Engineering Design Optimization, Inc, Santa Barbara, CA, January, 1987

[21] Vanderplaats, G. N. and Sugimoto, H., "A general-purpose optimization program for engineering design", Computers and Structures, Vol. 24, pp 13-21, 1986

[22] Koiter, W. T., "Het Schuifplooiveld by Grote Overshrijdingen van de Knikspanning", National Luchtvaart Laboratorium, The Netherlands, Report X295, November 1946 (in Dutch)

ABOUT BOSOR4:

[1B] Bushnell, D., "Stress, stability and vibration of complex, branched shells of revolution", Computers & Structures, vol. 4, pp 399-435 (1974)

[2B] Bushnell, D., "Buckling of Shells--Pitfall for Designers", AIAA Journal, Vol. 19, No. 9, September, 1981, pp. 1183-1226

[3B] Bushnell, D., "Computerized Analysis of Shells--Governing Equations", Computers & Structures, Vol. 18, pp.471-536, 1984

[4B] Bushnell, D., COMPUTERIZED BUCKLING ANALYSIS OF SHELLS, published by Nijhoff, The Netherlands, 1985, reprinted by Kluwer Academic Publishers, 1989

[5B] BOSOR4 Bushnell,D., "BOSOR4--Program for stress, buckling, and vibration of complex shells of revolution," in STRUCTURAL MECHANICS SOFTWARE SERIES, vol. 1, Univ. Press of Virginia, pp 11-143, 1977. Also, see also, STRUCTURAL ANALYSIS SYSTEMS, Vol. 2, Editor: A. Niku-Lari, Pergamon Press, 1986, pp 25-54

[6B] BOSOR4 Bushnell, D., "Stress, buckling and vibration of prismatic shells", AIAA Journal, Vol. 9, No. 10, pp 2004-2013, Oct. 1971

[7B] BOSOR4 Bushnell, D., "Automated optimum design of shells of revolution with application to ring-stiffened cylindrical shells with wavy walls", AIAA Paper 2000-1663, 41st AIAA Structures Meeting, Atlanta, GA, April 2000. Also see: Lockheed Rept LMMS P525674, November, 1999

ABOUT STAGS:

[1S] B. O. Almroth, F. A. Brogan, "The STAGS Computer Code",
 NASA CR-2950, NASA Langley Research Center, Hampton, Va.(1978)

[2S] C. C. Rankin, P. Stehlin and F. A. Brogan,
"Enhancements to the STAGS computer code", NASA CR 4000,
 NASA Langley Research Center, Hampton, Va, November 1986

[3S] Riks, E., Rankin C. C., Brogan F. A., "On the solution
of mode jumping phenomena in thin walled shell structures",
First ASCE/ASM/SES Mechanics Conference, Charlottesville, VA,
June 6-9, 1993, in: Computer Methods in Applied Mechanics and
Engineering, Vol.136, 1996.

[4S] G. A. Thurston, F. A. Brogan and P. Stehlin,
"Postbuckling analysis using a general purpose code",
 AIAA Journal, 24, (6) (1986) pp. 1013-1020.

```
*************** END PANDA2 LITERATURE ********************


****************************************
ITERATION NO., LOAD SET NO., SUBCASE NO. =   0   1   1     PANEL MIDLENGTH
****************************************
ILOADS,ICASES,NWAVES(ILOADS,ICASES)=     1     1     0

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

  APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
        Applied     axial       stress resultant, Nx= -1.0000E+03
        Applied circumferential stress resultant, Ny=  0.0000E+00
        Applied    in-plane     shear  resultant,Nxy=  5.0000E+00
        Applied     axial       moment resultant, Mx=  0.0000E+00
        Applied circumferential moment resultant, My=  0.0000E+00
        Applied pressure (positive for upward),   p =  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=  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
****************************************
ENTERING STRUCT. IMOD= 0
ITERATION NO., LOAD SET NO., SUBCASE NO. =   0   1   1       CURRENT DESIGN
****************************************
```

The numbers of the references [ ] given in the CHAPTER
headings correspond to those listed at the end of the paper:
Bushnell, D.
"Optimization of an axially compressed ring and stringer
stiffened cylindrical shell with a general buckling modal

imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting, Honolulu, Hawaii, April 2007

The overall structure of PANDA2 and its use are described in the first PANDA2 paper, Ref.[1A], cited in the April 2007 paper just identified. Ref.[1A] is the following paper:
Bushnell, D.,
"PANDA2 - Program for minimum weight design of stiffened, composite, locally buckled panels", COMPUTERS AND STRUCTURES, Vol. 25, No. 4, pp 469-605, 1987

Concepts such as "wide-column" buckling, "discretized module model", "stringer pop-off", "constitutive matrices" "reduction factor for transverse shear deformtion (t.s.d.)" "smeared stiffeners", "neutral surface", "overall and local static response to uniform pressure", "knockdown factors for anisotropy and in-plane shear loading", "crippling of stiffener parts", and "local postbuckling" are described there, with many early PANDA2 examples provided.

The string, "PANDA-type theory" often occurs. This refers to the theory presented in Ref. [1B] of the April 2007 citation listed first. Ref.[1B] contains the theory given in the paper:
Bushnell, D.,
"Theoretical basis of the PANDA computer program for preliminary design of stiffened panels under combined in-plane loads", COMPUTERS & STRUCTURES, v. 27, No. 4, pp 541-563 (1987).

The theory used for local postbuckling behavior appears in Ref. [1C] of the April 2007 paper cited first (above).
Ref. [1C] is the following paper:
Bushnell, D.,
"Optimization of composite, stiffened, imperfect panels under combined loads for service in the postbuckling regime", Computer Methods in Applied Mechanics and Engineering, Vol. 103 (1993) 43-114

The theory used for imperfection sensitivity appears in Refs. [1E] and [1D] of the first-cited paper above.
Refs. [1E] and [1D] are the following two papers:

Bushnell, D. and Bushnell, W. D.,
"Approximate method for the optimum design of ring and stringer stiffened cylindrical panels and shells with local, inter-ring, and general buckling modal imperfections" Computers and Structures, Vol. 59, No. 3, pp 489-527 (1996)

Bushnell, D.,
"Recent enhancements to PANDA2" AIAA Paper 96-1337-CP, Proc. of the AIAA 37th Structures, Structural Dynamics and Materials Conference, pp 126-182, April, 1996.

The last paper cited also describes the "global" optimizer, "SUPEROPT", implementation of Sanders shell equations into PANDA2, implementation of the Arbocz theory for imperfection sensitivity, implementation of isogrid geometry, and implementation of various truss-core geometries, with examples.

The theories used in PANDA2 for the analysis of sandwich walls are given in Ref.[1F] of the first-cited paper above. Ref. [1K] is the following paper:
Bushnell, D.,
"Optimum design via PANDA2 of composite sandwich panels with honeycomb or foam cores", AIAA Paper 97-1142, Proc. 38th AIAA Structures, Structural Dynamics and Materials Conference, pp 2163-2202, April, 1997

The "alternate" (double-trigonometric series expansion buckling theory) and the discretized "skin"-ring module model are described in Ref. [1G] of the first-cited paper. Ref. [1G] is the following paper:
Bushnell, D., Jiang, H., and Knight, N.F.,
"Additional buckling solutions in PANDA2", Proceedings of the 40th AIAA SDM Conference, AIAA Paper 99-1233, pp 302-345 April 1999

Details of the strategy used in PANDA2 for accounting for initial buckling modal imperfections are described and listed in a table in Ref. [1K]. Ref. [1K] is the following paper:
Bushnell, D. and Rankin, C.C.,
"Difficulties in optimization of imperfect stiffened cylindrical shells",
AIAA Paper 1943, 47th AIAA Structures, Structural Dynamics and Materials Meeting, Newport RI, April 2006

```
************************************************************
ENTERING SUBROUTINE STRUCT
****************    TABLE OF CONTENTS   ********************
CHAPTER 1  Compute the 6 x 6 constitutive matrices [C] for
           individual model segments and various combinations
           thereof (skin with smeared stiffener sets [1A]).
CHAPTER 2  Do PANDA-type [1B] general buckling analysis to
           get Donnell factors for later use, if appropriate.
CHAPTER 3  Do various PANDA-type [1B] general buckling
           analyses needed for later computation of effective
           length of the panel. Compute the effective length.

CHAPTER NEW Compute wide-column buckling from discretized
           skin-stringer module model (Figs. 20b,c & 22b,c in
           [1A]) with only Nx (Ny=0, Nxy=0). The purpose is to
           obtain a knockdown factor, WIDKNK, for smearing
           the stringers in an inter-ring buckling mode
CHAPTER 4  Compute axisymmetric prebuckling "hungry-horse"
           state of the curved panel or cylindrical shell.
           (See Ref.[1E]).
CHAPTER 5  Get static response of panel to normal pressure
           [1A].
CHAPTER 6  Do PANDA-type [1B] general and inter-ring buckling
           analyses to permit later computation of
           amplification of panel bowing.
CHAPTER 7  Compute distribution of loads in panel module
           skin-stringer segments, neglecting redistribution
           due to initial buckling modal imperfections
```

(See Section 10 of [1A]).
CHAPTER 8 Do PANDA-type local, inter-ring, general buckling analyses and PANDA-type stringer web and ring web buckling analyses to get knockdown factors to compensate for lack of in-plane shear Nxy loading and anisotropy in discretized BOSOR4-type models. (See Section 11 of [1A] and Item No. 81 in [1L]).
CHAPTER 9 Do BOSOR4-type "skin"-ring buckling analyses to compute knockdown factor to compensate for inherent unconservativeness of models with smeared rings. (See Items 509, 511, 522, and 605 in [1L]; "skin"=skin+smeared stringers).
CHAPTER 10 Compute knockdown factors and prebuckling bending associated with initial general, inter-ring, local buckling modal imperfections. (See Ref.[1E]).
CHAPTER 10.1 Compute knockdown factor and prebuckling bending associated with general buckling modal initial imperfection. (See Sectons 13 and 14 and Tables 9 and 10 of [1K] for a detailed example)
CHAPTER 10.2 Compute knockdown factor and prebuckling bending associated with inter-ring buckling modal initial imperfection.
CHAPTER 10.3 Compute knockdown factor and prebuckling bending associated with local buckling modal initial imperfection.
CHAPTER 10.4 Present a summary of imperfection sensitivity results. (See Section 13 and Table 9 of [1K])
CHAPTER 11 Get change in stress resultants, Nx, Ny, Nxy in various segments of the skin-stringer module during prebuckling bending of the imperfect shell. Also, do PANDA-type [1B] local, inter-ring, general buckling analyses and PANDA-type stringer web and ring web buckling analyses to get knockdown factors to compensate for the lack of in-plane shear Nxy loading and anisotropy in discretized BOSOR4-type models. (See Section 11 in [1A])
CHAPTER 12 List prebuckled state of the initially imperfect and loaded and bent panel or shell. This section includes the redistribution of Nx, Ny, Nxy in the various segments of the stiffened shell structure.
CHAPTER 13 List prebuckling stress resultants, Nx, Ny, needed for the discretized single-module skin-stringer model used for local buckling and bending-torsion buckling (BOSOR4-type model: see Figs. 18, 20, 22, 97, and 98 of [1A], for examples).
CHAPTER 14 Compute local buckling from BOSOR4-type discretized skin-stringer single module model. See Section 12.2 in [1A].
CHAPTER 15 Compute bending-torsion (low-m) buckling from BOSOR4-type discretized skin-stringer single module model. See Section 12.2 in [1A].
CHAPTER 16 Compute post-local buckling from the Koiter theory given in Ref.[1C]. (Figs. 23, 24 in [1A] and Fig. 6 in [1C]).
CHAPTER 17 Compute stresses in layers and at various locations in skin-stringer module model, including local post-buckling, if any. Compute stringer popoff constraints [1A].SUBROUTINE STRTHK is used.

```
CHAPTER 18 Present summary of state of loaded imperfect panel
           and give effective stiffnesses of possibly locally
           postbuckled skin-stringer module. These effective
           stiffnesses (Table 12 of Ref. [18]) are used later
           for overall buckling and inter-ring buckling.
CHAPTER 19 Do wide-column inter-ring buckling analysis with
           possibly locally postbuckled skin-stringer module
           model. (See Fig. 20c of [1A]).
CHAPTER 20 Compute width-wise wide column buckling and
           lateral-torsional buckling load factors from the
           possibly locally postbuckled skin-stringer module
           model (inter-ring buckling modes).
           See panda2.news Item Numbers 379 and 381 in [1L].
CHAPTER 20b Compute high-m buckling of single discretized
           skin-stringer module (same model as used in
           CHAPTER 14 except explored in the range of high
           numbers of axial halfwaves). See panda2.news
           Item Numbers 682 and 754.
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.
CHAPTER 21 Compute "skin"-ring buckling load factor for
           computing knockdown to compensate for inherent
           unconservativeness of smeared ring models.
           (See bottom row in Fig. 30 of Ref.[1G]. Also see
           panda2.news Items 509, 511, 522, 532, 605, 617
           619, 632, 633, 676.
CHAPTER 22 Compute "skin"-ring buckling load factors for:
           1. medium-n inter-ring buckling mode (See
              rightmost three mode shapes in top row of
              Fig. 30 of Ref.[1G]),
           2. high-n inter-ring buckling mode (See rightmost
              mode shape in middle row of Fig. 30, Ref.[1G]),
           3. low-n inter-ring buckling mode (See leftmost
              mode shape in top row of Fig. 30, Ref.[1G]).
CHAPTER 23 Compute stresses in layers and at various
           locations in modules for both positive and
           negative imperfection amplitudes from SUBROUTINE
           STRCON (local postbuckling neglected).
CHAPTER 24 Present short summary of redistribution of stress
           resultants, Nx, Ny, Nxy, caused by prebuckling
           bending of an initially imperfect shell.
           See Section 6.0 in [1K].
CHAPTER 25 Compute buckling load factors from PANDA-type
           theory for the various segments of a stringer and
           a ring. Typical buckling modes are displayed in
           Figs. 5 and 6 of Ref.[1B].
CHAPTER 26 Compute local, inter-ring, general buckling load
           factors from PANDA-type models [1B] and from
           "alternative" (double-trigonometric series
           expansion) models, Ref.[1G]. Also compute
           sandwich wall behavior [1F], if applicable.
           Also, compute buckling load factors appropriate
           when substiffeners are present.
CHAPTER 26b Compute the ring web buckling load factor and
           circumferential wavelength from cold-bending a
```

```
           flat "hogged out" plate into a cylindrical panel
           with cold-bending radius RCOLD from iterations.
           This analysis is performed only for cylindrical
           shells with INTERNAL rings with rectangular or
           Tee-shaped cross sections. The entire shell must
           be fabricated of the same isotropic material.
           See Item No.790 in ...panda2/doc/panda2.news .
 CHAPTER 27 Compute the objective function (e.g. WEIGHT).
 CHAPTER 28 Present design, loading, and margins for the
           current load set and subcase. (See Table 6 in [18])

 =============================================================
 Just before LTESTB: ITESTB,IABP,IABT,Pressure P=    0    1    0  0.0000E+00
 Just after  LTESTB: ITESTB,IABP,IABT,Pressure P=    0    1    0  0.0000E+00
 If ITESTB = 1 then PANDA2 computes some margins for
 Load Set B acting by itself. The purpose of this strategy is
 to make sure that Load Set B cannot cause buckling by itself.


 ********** IN SUBROUTINE STRUCT (after "2 CONTINUE)" *********
 Constraints higher than CONMAX are excluded: CONMAX =  1.0000E+07


 ***********************************************
 *****   DESIGN ITERATION NO.  0  ***********
 *****           LOAD SET NO.  1  ***********
 ***** STRESS AND BUCKLING STATE AT PANEL MIDLENGTH  ***
 ***** MATERIAL ITERATION NO.  0  ***********

0
 DIMENSIONS OF  CURRENT  DESIGN...
 VARIABLE   CURRENT
  NUMBER     VALUE            DEFINITION
    1    2.4705E+00        B(STR):stiffener spacing, b: STR seg=NA, layer=NA
    2    8.2342E-01       B2(STR):width of stringer base, b2 (must be > 0, see
    3    8.4714E-01        H(STR):height of stiffener (type H for sketch), h: S
    4    2.4141E-02    T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1
    5    8.0087E-02    T(2 )(STR):thickness for layer index no.(2 ): STR seg=3
    6    9.7793E+00        B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
    7    0.0000E+00       B2(RNG):width of ring base, b2 (zero is allowed): RNG
    8    8.4714E-01        H(RNG):height of stiffener (type H for sketch), h: R
    9    6.0060E-02    T(3 )(RNG):thickness for layer index no.(3 ): RNG seg=3

 Get new constitutive matrices, C(i,j), static response
 to uniform normal pressure, distributions of resultants
 Nx, Ny, Nxy, in the skin and stiffener parts for Load Set A,
 Load Set B, curing, and other thermal effects, and knockdown
 factors for buckling modal imperfections....




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 1             ****************
 **************************************************************
 **************************************************************
```

```
 ***************************************************************
 **** CHAPTER  1: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 **************************************************************
 CHAPTER 1  Compute the 6 x 6 constitutive matrices [C] for
            individual model segments and various combinations
            thereof (skin with smeared stiffener sets [1A]).
            See Section 8 in [1A], Eq.(8.1) on p.495 of [1A].

*** BEGIN SUBROUTINE GETCIJ (CONSTIT. LAW: SEGS AND SMEARED ***
 See Section 8, pp 494-503 of Reference [1A]. First the 6 x 6
 integrated constitutive coefficients Cij (Eq.8.1) and thermal
 loading are found for each segment in the skin-stringer module
 then for the skin-ring module, then for the skin with smeared
 stringers only, then for the skin with smeared rings only,
 and finally for the skin with both stringers and rings smeared.


 CONSTITUTIVE MATRIX C(i,j) FOR SKIN-STRINGER MODULE                         THERMAL {NT}
ETHERM {ET}

 UNIQUE SKIN-STRINGER MODULE iSEGMENT NO. 1:   PANEL  SKIN                   THERMAL {NT}
ETHERM {ET}
  2.6794E+05  8.0382E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  1.3013E+01  3.9038E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  4.5544E+00      0.0000E+00
0.0000E+00

 UNIQUE SKIN-STRINGER MODULE iSEGMENT NO. 2: STRINGER BASE                   THERMAL {NT}
ETHERM {ET}
  2.6794E+05  8.0382E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  1.3013E+01  3.9038E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  4.5544E+00      0.0000E+00
0.0000E+00

 UNIQUE SKIN-STRINGER MODULE iSEGMENT NO. 3: STRINGER WEB                    THERMAL {NT}
ETHERM {ET}
  8.8888E+05  2.6666E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  2.6666E+05  8.8888E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  3.1111E+05  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
```

```
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  4.7510E+02  1.4253E+02  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  1.4253E+02  4.7510E+02  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.6628E+02      0.0000E+00
0.0000E+00


 CONSTITUTIVE MATRIX C(i,j) FOR SKIN-RING MODULE                            THERMAL {NT}
ETHERM {ET}

 UNIQUE SKIN-RING MODULE iSEGMENT NO. 3:   RING   WEB                       THERMAL {NT}
ETHERM {ET}
  6.6660E+05  1.9998E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  1.9998E+05  6.6660E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  2.3331E+05  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  2.0038E+02  6.0114E+01  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  6.0114E+01  2.0038E+02  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  7.0133E+01      0.0000E+00
0.0000E+00

 Location of skin-stringer module centroid, ECCN=  2.3184E-01
 Effective skin-stringer module EI per length
 of circumferential arc of the panel, EIEFF=  4.9533E+04
 Inter-ring skin-stringer single module treated as an Euler
 column: buckling load/circ.arclength, FNCRIT=  5.1119E+03
 Compare FNCRIT to the wide-column buckling load. That gives
 you an idea what the combined knockdown factor should
 be for (1) smearing the stringers, + (2) the effect of t.s.d.
 The effective length of the Euler column is B(2)=  9.7793E+00


 C(i,j) with smeared stringers only...                                      THERMAL {NT}
ETHERM {ET}
 Reference surface is at the refer. surface of the skin midway between the
stringers.newsITEM 274
  5.4530E+05  8.0382E+04  0.0000E+00  1.2083E+05  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  1.2083E+05  0.0000E+00  0.0000E+00  6.9240E+04  3.9038E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.1574E+01      0.0000E+00
0.0000E+00


 C(i,j) with smeared stringers and reduced stiffness
 for Segment 1 of the panel skin.
```

```
 If FSLOC.LT.0.95 (post-local-buckling allowed) the following
 C(i,j) are used for the prediction of preliminary general
 instability, the purpose of which is to establish, for flat
 panels, how much any axial bowing amplitude grows under the
 applied axial load.
  5.4530E+05  8.0382E+04  0.0000E+00  1.2083E+05  0.0000E+00  0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00
  1.2083E+05  0.0000E+00  0.0000E+00  6.9240E+04  3.9038E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.1574E+01


 C(i,j) with smeared rings only...                                  THERMAL {NT}
ETHERM {ET}
 Reference surface is at the refer. surface of the panel skin.
  2.6794E+05  8.0382E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  8.0382E+04  3.2049E+05  0.0000E+00  0.0000E+00  2.2892E+04  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  1.3013E+01  3.9038E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  2.2892E+04  0.0000E+00  3.9038E+00  1.3128E+04  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.0630E+01      0.0000E+00
0.0000E+00
 IN SUB.CSTIF; STRINGERS; ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00
 IN SUB.CSTIF;   RINGS;   ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00


 C(i,j) with smeared stringers and rings...                         THERMAL {NT}
ETHERM {ET}
 Reference surface is at the refer. surface of the skin midway between the stringers.
  5.4530E+05  8.0382E+04  0.0000E+00  1.2083E+05  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  8.0382E+04  3.2049E+05  0.0000E+00  0.0000E+00  2.2892E+04  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00
0.0000E+00
  1.2083E+05  0.0000E+00  0.0000E+00  6.9240E+04  3.9038E+00  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  2.2892E+04  0.0000E+00  3.9038E+00  1.3128E+04  0.0000E+00      0.0000E+00
0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.7649E+01      0.0000E+00
0.0000E+00
 IN SUB.CSTIF; STRINGERS; ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00
 IN SUB.CSTIF;   RINGS;   ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00


 C(i,j) with smeared stringers and rings, with
```

```
 reduced stiffness for segment 1 of the panel skin.

 If FSLOC.LT.0.95 (post-local-buckling allowed) the following
 C(i,j) are also used for the prediction of preliminary
 general instability, the purpose of which is to establish,
 for a flat panel, how much any axial bowing amplitude grows
 under the applied axial load.
  5.4530E+05  8.0382E+04  0.0000E+00  1.2083E+05  0.0000E+00  0.0000E+00
  8.0382E+04  3.2049E+05  0.0000E+00  0.0000E+00  2.2892E+04  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00
  1.2083E+05  0.0000E+00  0.0000E+00  6.9240E+04  3.9038E+00  0.0000E+00
  0.0000E+00  2.2892E+04  0.0000E+00  3.9038E+00  1.3128E+04  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.7649E+01
 IN SUB.CSTIF; STRINGERS; ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00
 IN SUB.CSTIF;   RINGS;   ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00


 LOCATION OF THE NEUTRAL PLANE FOR AXIAL LOADING
 AND C(i,j) WITH SMEARED STIFFENERS. Reference surface for the
 following C(i,j) is the neutral plane for axial loading.
 Negative d corresponds to a neutral plane that lies above
 the plane of the reference surf. of the lowest panel skin.
 See Fig. 15a on page 502 of Reference [1].
 d =  -2.3136E-01

  5.4530E+05  8.0382E+04  0.0000E+00 -5.3299E+03 -1.8597E+04  0.0000E+00
  8.0382E+04  3.2049E+05  0.0000E+00 -1.8597E+04 -5.1256E+04  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00 -2.1697E+04
 -5.3299E+03 -1.8597E+04  0.0000E+00  4.2517E+04  4.3065E+03  0.0000E+00
 -1.8597E+04 -5.1256E+04  0.0000E+00  4.3065E+03  1.9691E+04  0.0000E+00
  0.0000E+00  0.0000E+00 -2.1697E+04  0.0000E+00  0.0000E+00  5.0874E+03
 **** END   SUBROUTINE GETCIJ (CONSTIT. LAW: SEGS AND SMEARED ***



 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 2             *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER  2: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 *************************************************************
 CHAPTER 2  Do PANDA-type [1B] general buckling analysis to
            get Donnell factors for later use, if appropriate.

 ** BEGIN SUBROUTINE BUCPAN (GENERAL PANDA-TYPE BUCKL.) ***
 PURPOSE IS TO GET DONNELL FACTORS FOR LATER USE IN SUB.DONELL.
 LABEL NO. IN STRUCT= 9010; ITUTOR= 0
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9010     1     0     0  1.0000E+07
```

```
general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7210    9010       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570796E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  0.0000E+00
Local buckling modal,               W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
n = 2,3,4 eigenvalues used in calc. of Donnell factors for
buckling with 2 circumferential halfwaves over 180 deg.:
 General buckling:  1.3602E+01(n=2);  4.5935E+00(n=3);  2.4395E+00(n=4)
 Inter-ring buckling:  0.0000E+00(n=2);  0.0000E+00(n=3);  0.0000E+00(n=4)
NOTE: The Donnell factor is NOT included in the above,
      but IS included in the following computations.

One or more of the n=2,3,4 eigenvalues above may be zero,
depending on the ratio of pi*r/(panel width).
Purpose of any non-zero n=2,3,4) eigenvalues is to help
later on in the computation of appropriate Donnell factors
for low-circ. wave buckling of models involving complete
cylindrical shells, such as are used for calculation of
imperfection sensitivity.
*** END  SUBROUTINE BUCPAN (EIGENVALUES. PANDA-TYPE BUCKL.) ***



***************************************************************
***************************************************************
***************************************************************
************          CHAPTER 3              *****************
***************************************************************
***************************************************************
***************************************************************
**** CHAPTER  3: DESIGN PERTURBATION INDEX, IMOD=  0 *****

**************************************************************
CHAPTER 3  Do various PANDA-type [1B] general buckling
           analyses needed for later computation of effective
           length of the panel. Compute the effective length.
```

```
**** BEGIN SUBROUTINE BUCPAN (FOR EFFECTIVE LENGTH CALCS) *****
 ****                     (KNOCKDOWN FOR SMEARED STRINGERS) ****
***** SEE ITEMS 106 and 107 in ...panda2/doc/panda2.news *****
 LABEL NO. IN STRUCT= 9020
******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
 9020     1     0     0  1.0000E+07

general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7210    9020       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  0.0000E+00
Local buckling modal,               W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.640E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.64E+00  1.64E+00  1.64E+00  1.00E+17  1.00E+17  1.64E+00  9.79E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         5
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  1.0000E+00
```

```
If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6396E+00  1.6396E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5674E+00  1.5674E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  1.5674E+00  1.5674E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********

GENERAL BUCKLING LOAD FACTOR USED FOR CALCULATION OF THE
GENERAL INSTABILITY LOAD FACTOR EIGGG1, WHICH IS USED IN
THE FORMULA, KNOCKDOWN = 1.O + 0.55*EIGGG1/EIGGG3, WHERE
"KNOCKDOWN" IS USED TO REDUCE GENERAL AND PANEL INSTABILITY
BUCKLING LOAD FACTORS TO ACCOUNT FOR INHERENT UNCONSERVA-
TIVENESS IN SMEARING OUT STIFFENERS IN MODELS OF BUCKLING.
EIGGG1(M,N)=  1.5674E+00(  4,  7)
 **** END SUBROUTINE BUCPAN (AXIAL WAVENUMBER; EFF.LNGTH) ******
 ****                   (KNOCKDOWN FOR SMEARED STRINGERS) ******

**** BEGIN SUBROUTINE BUCPAN (FOR EFFECTIVE LENGTH CALCS) ****
**** In this execution of BUCPAN, Axial load Nx is set to 0.0
 LABEL NO. IN STRUCT= 9040
******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
 9040     1     0     0  1.0000E+07

general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7210    9040       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy=  0.0000E+00 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    1    7  3.941E-01  1.019E+02  7.807E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00
```

```
EIGMNC=  1.02E+02  1.02E+02  1.02E+02  1.00E+17  1.70E+05  1.02E+02  1.00E+17
SLOPEX=  3.94E-01  3.94E-01  3.94E-01  0.00E+00  0.00E+00  3.94E-01  3.99E+00
MWAVEX=    1         1         1         0         1         1         1
NWAVEX=    7         7         7         0         5         7         0
TESTX =  7.81E-03  7.81E-03  7.81E-03  0.00E+00  7.81E-03  7.81E-03  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  1.0000E+00

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.0191E+02  1.0191E+02
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.0048E+02  1.0048E+02
EIGVAL,EIGVLX after knockdown for smearing stringers=  1.0048E+02  1.0048E+02
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********

GENERAL BUCKLING LOAD FACTOR USED FOR CALCULATION OF
LAMBDAY FOR EFFECTIVE LENGTH CALCULATION
LAMBDAY(M,N)=  1.0048E+02(  1,  7)
 **** END SUBROUTINE BUCPAN (LAMBDAY CALC.; EFF.LNGTH) *******

**** BEGIN SUBROUTINE BUCPAN (LAMBDAX; EFFECTIVE LENGTH) ****
**** In this execution of BUCPAN, Ny and Nxy are set to 0.0
 LABEL NO. IN STRUCT= 9050
******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
 9050     1     0     0  1.0000E+07

general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7210    9050       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03  0.0000E+00  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
```

```
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.640E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.64E+00  1.64E+00  1.64E+00  1.00E+17  1.00E+17  1.64E+00  9.79E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         5
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  1.0000E+00

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6396E+00  1.6396E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5674E+00  1.5674E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  1.5674E+00  1.5674E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********

GENERAL BUCKLING LOAD FACTOR USED FOR CALCULATION OF
LAMBDAX FOR EFFECTIVE LENGTH CALCULATION.
LAMBDAX(M,N)=  1.5674E+00(  4,  7)
 **** END SUBROUTINE BUCPAN (LAMBDAX CALC.; EFF.LNGTH) *******
 MINIMUM KNOCKDOWN FACTOR USED WITH SMEARED STIFFENER MODELS=  1.
 THIS KNOCKDOWN FACTOR WILL PROBABLY BE CHANGED LATER BY
 EITHER SUBOUTINE EIGKNK OR SUBROUTINE EIGMOD OR BY BOTH.

User-specified axial length of the panel, AXIAL=  1.3000E+02
Computed factor to modify the length, AXIAL: LENMOD=  1.0000E+00
Axial length of "equivalent" simply-supported panel, LENMOD*AXIAL=  1.3000E+02

*************************************************************
CHAPTER NEW Compute wide-column buckling from discretized
           skin-stringer module model (Figs. 20b,c & 22b,c in
           [1A]) with only Nx (Ny=0, Nxy=0). The purpose is to
           obtain a knockdown factor, WIDKNK, for smearing
           the stringers in an inter-ring buckling mode
** CHAPTER  NEW1: DESIGN PERTURBATION INDEX, IMOD=  0 ***



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

```
************************************************************
************          CHAPTER NEW1          ****************
************************************************************
************************************************************
************************************************************

 CHAPTER NEW1 Compute distribution of loads in panel module
           skin-stringer segments, neglecting redistribution
           due to initial buckling modal imperfections
           (See Section 10 of [1A]). These loads are for
           computing a preliminary value of wide column
           buckling, needed for smeared stringer knockdown.

 ******* Begin the section where WIDKNK is computed *********
 ******* See ..panda2/doc/panda2.news Items 724 & 725.*******
  LABEL NO. IN STRUCT= 9055

 ***** BEGIN SUB. FORCES (FOR SMEARED STRINGER KNOCKDOWN) *****
 Resultants in each segment of the skin-stringer and skin-ring
 modules are computed. The effect of prebuckling bending due to
 initial buckling modal imperfections is ignored at this time,
 but will be accounted for later when buckling load factors and
 stresses are computed. See Section 10, pp 506-509 of Ref.[1]


 POSITIONS OF STIFFENER SEGMENT CENTROIDS BELOW THE REFERENCE SURFACE OF THE PANEL
SKIN...

   STRINGER PARTS...ZPARTX(I), I=1,4=       0.0000E+00  0.0000E+00 -4.3564E-01 -8.5921E-
01
   RING     PARTS...ZPARTY(I), I=1,4=       0.0000E+00  0.0000E+00 -4.3564E-01 -8.5921E-
01



 BOWING AMPLITUDES DUE TO INITIAL IMPERFECTION,
 CURING, OTHER TEMPERATURE LOADING, MOMENTS, AND PRESSURE...
   AXIAL BOWING DUE TO INITIAL IMPERFECTION  =   0.0000E+00
   AXIAL BOWING BETWEEN RINGS,THERMAL EFFECTS=   0.0000E+00
   OVERALL AXIAL      BOWING, THERMAL EFFECTS=   0.0000E+00
   OVERALL CIRCUMFER. BOWING, THERMAL EFFECTS=   0.0000E+00
   BOWING, ENTIRE PANEL UNDER PRESSURE       =   0.0000E+00
   BOWING, PANEL MODULE UNDER PRESSURE       =   0.0000E+00
   APPLIED AXIAL,HOOP MOMENTS,    MX, MY     =   0.0000E+00  0.0000E+00
   AXIAL,HOOP BOWING CAUSED BY MOMENTS MX, MY=   0.0000E+00  0.0000E+00
 INITIAL LOCAL IMPERFECTION IN SKIN...
   LOCAL IMPERFECTION, WIMP(local)           =   1.0000E-07
 STRATEGY PARAMETERS, IBLL, FMULTX, FMULTY...
   "BOUNDARY LAYER" INDEX, IBLL              =    0
   MULTIPLIER FOR AXIAL BOWING AMPLITUDES    =   1.0000E+00
   MULTIPLIER FOR CIRC. BOWING AMPLITUDES    =   6.8493E-01


 BOWING AMPLIFICATION FACTORS:
   Amplification factor for global axial bowing
    from global imperfection           =  0.0000E+00
   Amplification factor for global axial bowing
    from normal pressure               =  1.0000E+00
```

```
   Amplification factor for axial bowing from
    thermal residual deformation or edge moments
                                     =  1.0000E+00
   Amplification factor for inter-ring axial
    bowing                           =  1.0000E+00

 SHEAR RESULTANT IN WEB AT STRINGER ENDS...
 Shear resultant due to axial load/bowing effect=     4.3687E-07
 Axial coordinate corresponding to lowest buckling=   1.3000E+02
 Total shear resultant from pressure + bowing     =   4.3687E-07
 Axial coordinate corresponding to pressure part  =   1.3000E+02

 SHEAR RESULTANT IN WEB AT RING ENDS...
 Shear resultant due to circ. load/bowing effect=     0.0000E+00
 Axial coordinate corresponding to lowest buckling=   0.0000E+00
 Total shear resultant from pressure + bowing     =   0.0000E+00
 Axial coordinate corresponding to pressure part  =   0.0000E+00

==========================================================================================
================================

 APPLIED RESULTANTS: AXIAL, Nx = -1.0000E+03, CIRC., Ny = -1.0000E-03,  IN-PLANE SHEAR,
Nxy =  5.0000E+00 (LOAD SET A)
 APPLIED RESULTANTS: AXIAL, Nxo=  0.0000E+00, CIRC., Nyo=          0.0000E+00,  IN-PLANE
SHEAR, Nxyo=  0.0000E+00 (LOAD SET B)
 REDUCTION FACTOR NUMBER 1 FOR THE AXIAL LENGTH OF THE PANEL:
  (USED IN THE DETERMINATION OF THE AMPLITUDE FACTOR FOR
  BOWING.  LESS THAN 1.0 ONLY IF THE PANEL IS CLAMPED IN THE
  PREBUCKLING PHASE) =  1.0000E+00
 REDUCTION FACTOR NUMBER 2 FOR THE AXIAL LENGTH OF THE PANEL:
  (USED IN THE DETERMINATION OF THE BIFURCATION BUCKLING LOAD.
  LESS THAN 1.0 ONLY IF THE PANEL IS CLAMPED IN THE BUCKLING
  PHASE)             =  1.0000E+00
 DISTANCE FROM REFER. SURFACE OF PANEL MODULE SEGMENT 1 (SKIN) TO NEUTRAL SURFACES
(positive as for z in Fig. 9):
        X-DIRECTION :     DNEUTX = -2.3136E-01
        Y-DIRECTION :     DNEUTY = -7.6016E-02

 ECCENTRICITY OF AXIAL LOAD (DISTANCE FROM X-DIRECTION NEUTRAL SURFACE TO WHERE Nx AND
Nxo ARE APPLIED (pos. as for z in Fig.9):
    AXIAL LOAD ECCENTRICITY, ECC =  0.0000E+00

 AVERAGE REFERENCE SURFACE STRAINS AND CHANGES IN CURVATURE
 FOR PANEL WITH SMEARED STRINGERS AND RINGS:

  REFERENCE    Due to Nx, Ny, Nxy    Due to Nxo, Nyo        Due to      Due to
               Mx, My applied to     applied to panel as    pressure   temperature
   SURFACE     panel as bowed by     bowed by global im-
               global imperfection   perfection and all
 QUANTITIES    and all loadings.     loadings.
                    EPSLOD                EPSLD0              EAVEP      ETHERM
 AXIAL STRAIN     -1.9042E-03           0.0000E+00          0.0000E+00    0.0000E+00
 TRAN. STRAIN      4.7760E-04           0.0000E+00          0.0000E+00    0.0000E+00
 SHEAR STRAIN      5.3317E-05           0.0000E+00          0.0000E+00    0.0000E+00
 AXIAL KAPPA       5.6859E-13           0.0000E+00          0.0000E+00    0.0000E+00
 TRAN. KAPPA       4.8211E-11           0.0000E+00          0.0000E+00    0.0000E+00
    TWIST          0.0000E+00           0.0000E+00          0.0000E+00    0.0000E+00
```

```
 INTERNAL FORCES AND MOMENTS IN SKIN, STRINGER BASE,
 AND RING BASE FOR FOUR TYPES OF LOADING:
 1(Nx,Ny,Nxy,Mx,My), 2(Nxo,Nyo), 3(pressure), 4(temperature)

 PART OF          I N T E R N A L   F O R C E S   A N D   M O M E N T S
  PANEL       Nx         Ny          Nxy          Mx          My         Mt

 Internal forces and moments from Nx,Ny,Nxy,Mx,My:
  SKIN   -4.7183E+02 -2.5098E+01  5.0000E+00  1.9560E-10  6.2957E-10  0.0000E+00
 STRBASE -4.7183E+02 -2.5098E+01  5.0000E+00  1.9560E-10  6.2957E-10  0.0000E+00
 RNGBASE -2.5098E+01 -4.7183E+02  5.0000E+00  6.2957E-10  1.9560E-10  0.0000E+00

 Internal forces and moments from Nxo, Nyo:
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Internal forces and moments from overall
 response of the panel to pressure, p (Load Set A):
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Internal forces and moments from overall
 response of the panel to pressure, p (Load Set B):
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 Internal forces and moments from thermal loads:
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 ======================================================================

 REFERENCE SURFACE (SKIN REFER. SURFACE) STRAINS, CHANGES IN CURVATURE, AND TWIST CAUSED
BY APPLIED IN-PLANE LOADS, Nx, Ny, Nxy
 AND Nxo, Nyo, Nxyo AND CAUSED BY THERMAL LOADING

 REFERENCE       CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
  SURFACE                  (LOAD SET A)                        (LOAD SET B)
(LOAD SET B)
 QUANTITIES          SKIN  STRINGER BASE RING BASE         SKIN   STRINGER BASE RING BASE
SKIN  STRINGER BASE RING BASE
 AXIAL STRAIN    -1.904E-03 -1.904E-03  4.776E-04       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 TRAN. STRAIN     4.776E-04  4.776E-04 -1.904E-03       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 SHEAR STRAIN     5.332E-05  5.332E-05  5.332E-05       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 AXIAL KAPPA      5.686E-13  5.686E-13  4.821E-11       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 TRAN. KAPPA      4.821E-11  4.821E-11  5.686E-13       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
    TWIST         0.000E+00  0.000E+00  0.000E+00       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00

==========================================================================================
================================
```

```
                        CAUSED BY ALL LOADS
        S T R A I N S    I N   V A R I O U S   P A R T S  O F   T H E   P A N E L  S K
I N  A N D  S T I F F E N E R S
     ITEM        CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
                           (LOAD SET A)                         (LOAD SET B)
(LOAD SET B)
                    SKIN     STRINGER     RING            SKIN     STRINGER     RING
SKIN     STRINGER     RING
  SKIN AXIAL     -1.904E-03     -           -           0.000E+00     -           -
0.000E+00     -           -
  SKIN CIRC.      4.776E-04     -           -           0.000E+00     -           -
0.000E+00     -           -
  SKIN SHEAR      5.332E-05     -           -           0.000E+00     -           -
0.000E+00     -           -
                             STRINGER     RING                     STRINGER     RING
STRINGER     RING
 STIFFENER BASE ALONG AXIS -1.904E-03  4.776E-04                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE TRANSVERSE  4.776E-04 -1.904E-03                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE   SHEAR     5.332E-05 -5.332E-05                  0.000E+00  0.000E+00
0.000E+00  0.000E+00

 ALONG STIFFENER WEB AXIS  -1.904E-03  0.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 TRANSVERSE  TO  WEB AXIS   5.713E-04  0.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 IN-PLANE SHEARING OF WEB   1.404E-12  0.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00


==========================================================================================
===============================
                        CAUSED BY ALL LOADS
    R E S U L T A N T S  I N   V A R I O U S   P A R T S  O F   T H E   P A N E L  S K
I N  A N D  S T I F F E N E R S
     ITEM        CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
                           (LOAD SET A)                         (LOAD SET B)
(LOAD SET B)
                    SKIN     STRINGER     RING            SKIN     STRINGER     RING
SKIN     STRINGER     RING
  SKIN AXIAL     -4.718E+02     -           -           0.000E+00     -           -
0.000E+00     -           -
  SKIN CIRC.     -2.510E+01     -           -           0.000E+00     -           -
0.000E+00     -           -
  SKIN SHEAR      5.000E+00     -           -           0.000E+00     -           -
0.000E+00     -           -
                             STRINGER     RING                     STRINGER     RING
STRINGER     RING
 STIFFENER BASE ALONG AXIS -4.718E+02 -2.510E+01                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE TRANSVERSE -2.510E+01 -4.718E+02                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE   SHEAR     5.000E+00  5.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
```

```
 ALONG STIFFENER WEB AXIS  -1.540E+03  0.000E+00                 0.000E+00  0.000E+00
0.000E+00  0.000E+00
 TRANSVERSE  TO  WEB AXIS   0.000E+00  0.000E+00                 0.000E+00  0.000E+00
0.000E+00  0.000E+00
 IN-PLANE SHEARING OF WEB   4.369E-07  0.000E+00                 0.000E+00  0.000E+00
0.000E+00  0.000E+00

 AXIAL RESULTANTS AT THE ROOT AND TIP OF WEBS:
 AT THE ROOT OF THE WEBS   -1.540E+03  0.000E+00                 0.000E+00  0.000E+00
0.000E+00  0.000E+00
 AT THE TIP  OF THE WEBS   -1.540E+03  0.000E+00                 0.000E+00  0.000E+00
0.000E+00  0.000E+00


==========================================================================================
===============================
                        CAUSED BY ALL LOADS
       E Q U I L I B R I U M   O F   R E S U L T A N T S   F R O M   A P P L I E D   A N
D   T H E R M A L   L O A D S
    ITEM        CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
                             (LOAD SET A)                        (LOAD SET B)
(LOAD SET B)
                     Nx         Ny         Nxy              Nx          Ny         Nxy
Nx         Ny         Nxy

   DERIVED       -1.000E+03 -2.510E+01  5.000E+00      0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
   APPLIED       -1.000E+03 -1.000E-03  5.000E+00      0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 DIFFERENCE       0.000E+00 -2.510E+01  0.000E+00      0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00

==========================================================================================
================================

==========================================================================================
================================

 BOUNDARY CONDITIONS AND BOWING AMPLITUDE FACTORS:
   AXIAL BOUNDARY CONDITIONS FOR PREBUCKLING PHASE    =BENDING THEORY
   AXIAL BOUNDARY CONDITIONS FOR BIFURCATION BUCKLING =SIMPLE SUPPORT
   AMPLITUDE FACTOR FOR BOWING DUE TO PRESSURE, THERMAL
   THRU-THICKNESS GRADIENT, EDGE MOMENTS,       AMPLT2=  1.0000E+00
   AMPLITUDE FACTOR FOR DEFORMATION FROM GLOBAL IMPERFECTION
                                                AMPLIT=  0.0000E+00
 THE CONSTITUTIVE C(i,j) MATRIX WITH REDUCED SKIN STIFFNESS
 IS USED BECAUSE  LOCAL BUCKLING OF THE SKIN IS PERMITTED.

  ****** END SUB. FORCES (FOR SMEARED STRINGER KNOCKDOWN) ******

 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER NEW2          *****************
 **************************************************************
 **************************************************************
 **************************************************************
```

```
CHAPTER NEW2 List prebuckling stress resultants, Nx, Ny,
       needed for the discretized single-module skin-stringer
       model used for a preliminary value of wide column
       buckling (BOSOR4-type model: see Figs. 18, 20,
       22, 97, and 98 of [1A], for examples of the
       discretized single skin-stringer BOSOR4-type
       module model.). This distribution of Nx is used in
       the wide column model used to obtain the smeared
       stringer knockdown factor, WIDKNK. Ny and Nxy and the
       fixed (non-eigenvalue) loads, Nxo, Nyo, Nxyo are set
       to zero for this computation of wide column buckling.
 LABEL NO. IN STRUCT= 9056

==============================================
BEGIN: PREBUCKLING STRESS RESULTANTS USED IN THE
DISCRETIZED SINGLE MODULE MODEL FOR WIDE COLUMN BUCKLING...
----------------------------------------------------------
PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 1
 "Total." loads, Nx(var),Ny(var),Nxy(var)= -4.7183E+02  0.0000E+00  0.0000E+00
 "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 2
 "Total." loads, Nx(var),Ny(var),Nxy(var)= -4.7183E+02  0.0000E+00  0.0000E+00
 "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 3
 "Total." loads, Nx(var),Ny(var),Nxy(var)= -1.5403E+03  0.0000E+00  0.0000E+00
 "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00

PREBUCKLING AXIAL RESULTANTS IN STRINGER WEB: SEGMENT NO. 3
 "Eigenvalue" axial resultant, Nx(var)=
-1.5403E+03 -1.5403E+03 -1.5403E+03 -1.5403E+03 -1.5403E+03 -1.5403E+03
-1.5403E+03 -1.5403E+03 -1.5403E+03 -1.5403E+03 -1.5403E+03
 "  fixed   " axial resultant, Nx(fix)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 4
 "Total." loads, Nx(var),Ny(var),Nxy(var)= -4.7183E+02  0.0000E+00  0.0000E+00
 "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------
END:  PREBUCKLING STRESS RESULTANTS USED IN THE
DISCRETIZED SINGLE MODULE MODEL FOR WIDE COL. BUCKLING.
========================================================

***** END OF OUTPUT FOR UNIFORMLY LOADED PREBUCKLED STATE*****

EXPLANATION OF FOLLOWING CALCULATION (LOAD SET NO. 1):
    Next, the load factor for wide column panel buckling is
    computed from the discretized panel module model. The
    analysis neglects local deformation of the skin between
    stringers and local deformation of the stringers.
    Clamping of the L2 edges (edges that lie in the plane of
    the screen and parallel to it) is accounted for by doing
    the wide column calculation for a panel that is shorter in
    the axial direction by a factor, LENMOD =  1.0000E+00 than the
```

```
    axial dimension that you gave in your input.



 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER NEW3          *****************
 **************************************************************
 **************************************************************
 **************************************************************
 *** CHAPTER  NEW3: DESIGN PERTURBATION INDEX, IMOD=  0 ***

 CHAPTER NEW3 Do wide-column inter-ring buckling analysis.
            (See Figs. 20c, 22c, 46d, and 67 of [1A],
            for examples.). The purpose of this computation
            is to obtain a smeared stringer knockdown factor.
  LABEL NO. IN STRUCT= 9057

*** BEGIN SUBROUTINE BUCKLE (WIDE-COLUMN BUCKLING - MODULE ***
***                         FOR SMEARED STRINGER KNOCKDOWN ***
***  END  SUBROUTINE BUCKLE (WIDE-COLUMN BUCKLING - MODULE ***
***                         FOR SMEARED STRINGER KNOCKDOWN ***

*** BEGIN SUBROUTINE MODE (WIDE-COLUMN BUCKLING MODE SHAPE ***
***                         FOR SMEARED STRINGER KNOCKDOWN ***

 WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR =
 pi**2*EI/[abs(local hoop load)*WIDTH**2]=  8.3841E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  4.7189E-03
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  6.6665E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  6.3088E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  6.3088E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  3.4362E-18
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  3.8106E-18
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  6.6666E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  4.7189E-03

 NUMBER OF AXIAL HALFWAVES =      1
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR  =  3.5513E-01
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,  WSTR/WSKIN =  3.5513E-01
 NOTE: THERE IS SIGNIFICANT DEFORMATION OF THE CROSS SECTION
       OF THE PANEL MODULE IN THIS BUCKLING MODE. THIS
       DEFORMATION MAY WELL CAUSE THE WIDE COLUMN BUCKLING
       LOAD FACTOR TO BE CONSIDERABLY LESS THAN THE GENERAL
       OR PANEL (BETWEEN RINGS) INSTABILITY LOAD FACTORS.

 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP  =  7.8720E-17
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,  WMID  =  5.9827E-17

***  END  SUBROUTINE MODE (WIDE-COLUMN BUCKLING MODE SHAPE ***
***                         FOR SMEARED STRINGER KNOCKDOWN ***
 Eigenvalues for  1 roots:  EIGPRD=   2.5300E+00

  WIDE COLUMN PANEL BUCKLING LOAD FACTOR =   2.5300E+00
 ISKINX = 0. MODE OF BUCKLING IS THE PANEL SKIN IF ISKINX = 1.
```

```
ITIPWX = 0. MODE OF BUCKLING IS STRINGER SIDESWAY IF ITIPWX=1
ICWBWX = 0. MODE OF BUCKLING IS THE STRINGER WEB IF ICWBWX=1
IFLGWX = 0. MODE OF BUCKLING IS STRINGER OUTSTANDING FLANGE IF IFLGWX=1
ICRWNX = 0. MODE OF BUCKLING IS THE CROWN OF THE HAT IF ICRWNX=1

Mode number  1 IS a wide column mode and is therefore acceptable.
*** END OF PRELIMINARY WIDE COLUMN BUCKLING CALCULATIONS ***

SMEARED STRINGER KNOCKDOWN FROM SKIN-STRINGER DISCRETE MODEL
(See ..panda2/doc/panda2.news Items 724 and 725):
Buckling axial resultant Nx from simple Euler model,   EULER =  5.1119E+03
Buckling axial resultant Nx from discretized  model,   EIGWID=  2.5300E+03
Knockdown factor for cross section rigidity & t.s.d., WIDKNK=  4.9493E-01
Effective axial length of the wide column model,       AXLEFF=  9.7793E+00

Axial resultant, Nx, in each of the segments of the
discretized skin-stringer cross-section before any deformation
-4.7183E+02 -4.7183E+02 -1.5403E+03 -4.7183E+02
******* End of the section where WIDKNK is computed ********
******* See ..panda2/doc/panda2.news Items 724 & 725.*******

* CHAPTERs 4 & 5a: DESIGN PERTURBATION INDEX, IMOD=  0 *



***************************************************************
***************************************************************
***************************************************************
************          CHAPTER 4              *****************
***************************************************************
***************************************************************
***************************************************************
**** CHAPTER  4: DESIGN PERTURBATION INDEX, IMOD=  0 *****

**************************************************************
CHAPTER 4  Compute axisymmetric prebuckling "hungry-horse"
           state of the curved panel or cylindrical shell.
           (See Ref.[1E], especially Fig. 1 and pp.495-498).

***** BEGIN COMPUTATIONS FOR AXISYMMETRIC PREBUCKLING
***** STATE OF THE PANEL. (See pp 495-498 of journal
***** article, COMPUTERS & STRUCTURES vol 59, no.3, 1996
***** Computations carried out in SUBROUTINE SKIN.
***** Axisymmetric response of the curved panel to the loads in Load Set A *****
Entering SUB. SKIN (get prebuckling behavior), IMOD= 0
 Normal pressure,                     P= -2.0000E-05
 Axial resultant,                    Nx= -1.0000E+03
 Hoop  resultant,                    Ny= -1.0000E-03
 Average hoop strain,               E0Y=  4.7760E-04
 Average hoop thermal strain, ETHERM(2)=  0.0000E+00
 Value of computation control,   WCALCS=  0.0000E+00
 Prebuckling b.c. indicator,     IBPRE =  0
 Ring stiffener indicator,     ISTIF(2)=  3
 Average Nyo, membrane theory,  FNYAVE = -2.5098E+01
 Average normal displacement,   WDPAVE =  2.3880E-02

PREBUCKLING STATE IN CYLINDRICAL PANEL. X=0 CORRESPONDS TO MIDBAY
```

I	AXIAL COORDINATE X	NORMAL DISPLACEMENT WDISP	MERIDIONAL CURVATURE WXXDSP	AXIAL RESULTANT FNXX	HOOP RESULTANT FNYY
1	0.0000E+00	2.4037E-02	-4.6945E-05	-1.0000E+03	-2.3460E+01
2	1.9559E-01	2.4036E-02	-4.6720E-05	-1.0000E+03	-2.3469E+01
3	3.9117E-01	2.4033E-02	-4.6046E-05	-1.0000E+03	-2.3495E+01
4	5.8676E-01	2.4029E-02	-4.4921E-05	-1.0000E+03	-2.3537E+01
5	7.8234E-01	2.4022E-02	-4.3346E-05	-1.0000E+03	-2.3597E+01
6	9.7793E-01	2.4015E-02	-4.1321E-05	-1.0000E+03	-2.3673E+01
7	1.1735E+00	2.4005E-02	-3.8845E-05	-1.0000E+03	-2.3765E+01
8	1.3691E+00	2.3994E-02	-3.5919E-05	-1.0000E+03	-2.3873E+01
9	1.5647E+00	2.3982E-02	-3.2541E-05	-1.0000E+03	-2.3996E+01
10	1.7603E+00	2.3969E-02	-2.8713E-05	-1.0000E+03	-2.4133E+01
11	1.9559E+00	2.3954E-02	-2.4433E-05	-1.0000E+03	-2.4284E+01
12	2.1514E+00	2.3938E-02	-1.9701E-05	-1.0000E+03	-2.4448E+01
13	2.3470E+00	2.3922E-02	-1.4518E-05	-1.0000E+03	-2.4624E+01
14	2.5426E+00	2.3905E-02	-8.8825E-06	-1.0000E+03	-2.4811E+01
15	2.7382E+00	2.3888E-02	-2.7950E-06	-1.0000E+03	-2.5007E+01
16	2.9338E+00	2.3871E-02	3.7448E-06	-1.0000E+03	-2.5212E+01
17	3.1294E+00	2.3854E-02	1.0737E-05	-1.0000E+03	-2.5424E+01
18	3.3250E+00	2.3837E-02	1.8180E-05	-1.0000E+03	-2.5642E+01
19	3.5205E+00	2.3821E-02	2.6075E-05	-1.0000E+03	-2.5865E+01
20	3.7161E+00	2.3806E-02	3.4421E-05	-1.0000E+03	-2.6091E+01
21	3.9117E+00	2.3792E-02	4.3217E-05	-1.0000E+03	-2.6318E+01
22	4.1073E+00	2.3780E-02	5.2462E-05	-1.0000E+03	-2.6544E+01
23	4.3029E+00	2.3770E-02	6.2154E-05	-1.0000E+03	-2.6768E+01
24	4.4985E+00	2.3762E-02	7.2293E-05	-1.0000E+03	-2.6988E+01
25	4.6941E+00	2.3758E-02	8.2876E-05	-1.0000E+03	-2.7201E+01
26	4.8897E+00	2.3756E-02	9.3901E-05	-1.0000E+03	-2.7407E+01

```
Average Ny over x-integration interval (XL=  4.8896E+00): Ny(ave)= -2.4986E+01
Average normal displacement over x-integration interval=  2.3905E-02
Average axial curvature change over x-integration int. =  9.3904E-07
 Value of computation control,   WCALCS=  0.0000E+00
 Hoop resultant in web of ring,            FCEWEB =  2.9067E+02
 Hoop resultant in flange of ring,         FCEFLG =  0.0000E+00
 Hoop strain in web and flange of ring,    EPSRNG =  4.7512E-04
 Hoop resultant at each node in ring web, (FCXWEB(i),i=1,11)=
 2.8821E+02  2.8870E+02  2.8919E+02  2.8968E+02  2.9018E+02  2.9067E+02
 2.9117E+02  2.9167E+02  2.9217E+02  2.9267E+02  2.9318E+02
 Meridional resultant at each node in ring web, (FCYWEB(i),i=1,11)=
 4.9248E+00  4.4323E+00  3.9398E+00  3.4473E+00  2.9549E+00  2.4624E+00
 1.9699E+00  1.4774E+00  9.8496E-01  4.9248E-01  0.0000E+00

PREBUCKLING DEFORMATION OF CYLINDRICAL SHELL BETWEEN RINGS:
 Subcase number                                ICASE =    1
 Radius of cylindrical shell                       R = -5.0000E+01
 Ring spacing,                                  B(2) =  9.7793E+00
 Axial resultant,                     Nx(Loadset A) = -1.0000E+03
 Hoop  resultant,                     Ny(Loadset A) = -1.0000E-03
 Normal displacement at midbay,                 WMID =  2.4037E-02
 Normal displacement at rings,                 WRING =  2.3756E-02
 Average normal displacement, Wave =-EPSILON(y)*R =  2.3880E-02
 Meridional curvature change at midbay,     WXXMID = -4.6945E-05
 Meridional curvature change at rings,      WXXRNG =  9.3901E-05
 Axial boundary layer length,                   BLL =  2.2670E+01
 Hoop stiffness EA of ring,               EA(ring) =  5.1388E+05
 Applied normal pressure,            P(Loadset A) =  2.0000E-05
```

```
 Shear in web of stringer,                 SHEARX =  0.0000E+00
 Correction to hoop resultant,             DFNYP0 =  9.6487E-01
 Transverse resultant in isogrid web,      POPISO =  0.0000E+00

***** Axisymmetric response of the curved panel to the loads in Load Set B *****
Entering SUB. SKIN (get prebuckling behavior), IMOD= 0
 Normal pressure,                     P=  0.0000E+00
 Axial resultant,                    Nx=  0.0000E+00
 Hoop  resultant,                    Ny=  0.0000E+00
 Average hoop strain,               E0Y=  0.0000E+00
 Average hoop thermal strain, ETHERM(2)=  0.0000E+00
 Value of computation control,   WCALCS=  0.0000E+00
 Prebuckling b.c. indicator,     IBPRE =  0
 Ring stiffener indicator,     ISTIF(2)=  3
 Average Nyo, membrane theory,  FNYAVE =  0.0000E+00
 Average normal displacement,   WDPAVE =  0.0000E+00

OVERALL AVERAGE HOOP STRAIN, E0Y = 0.
NO CALCULATION OF WMID,WRING,WXXMID,WXXRNG
WMID,WRING,WXXMID,WXXRNG=  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Value of computation control,   WCALCS=  1.0000E+00
 Hoop resultant in web of ring,            FCEWEB =  0.0000E+00
 Hoop resultant in flange of ring,         FCEFLG =  0.0000E+00
 Hoop strain in web and flange of ring,    EPSRNG =  0.0000E+00
 Hoop resultant at each node in ring web, (FCXWEB(i),i=1,11)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Meridional resultant at each node in ring web, (FCYWEB(i),i=1,11)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

PREBUCKLING DEFORMATION OF CYLINDRICAL SHELL BETWEEN RINGS:
 Subcase number                              ICASE =    1
 Radius of cylindrical shell                     R = -5.0000E+01
 Ring spacing,                                B(2) =  9.7793E+00
 Axial resultant,                    Nx(Loadset B) =  0.0000E+00
 Hoop  resultant,                    Ny(Loadset B) =  0.0000E+00
 Normal displacement at midbay,               WMID =  0.0000E+00
 Normal displacement at rings,               WRING =  0.0000E+00
 Average normal displacement, Wave =-EPSILON(y)*R =  0.0000E+00
 Meridional curvature change at midbay,    WXXMID =  0.0000E+00
 Meridional curvature change at rings,     WXXRNG =  0.0000E+00
 Axial boundary layer length,                 BLL =  2.2670E+01
 Hoop stiffness EA of ring,              EA(ring) =  5.1388E+05
 Applied normal pressure,             P(Loadset B) =  0.0000E+00
 Shear in web of stringer,                 SHEARX =  0.0000E+00
 Correction to hoop resultant,             DFNYP0 =  0.0000E+00
 Transverse resultant in isogrid web,      POPISO =  0.0000E+00
```

```
**************************************************************
**************************************************************
**************************************************************
************          CHAPTER 5             *****************
**************************************************************
**************************************************************
```

```
 ***************************************************************
 **** CHAPTER  5: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 **************************************************************
 CHAPTER 5  Get static response of panel to normal pressure
            [1A], especially Section 9 and Section 20.5 and
            Figs. 55 - 60 in [1A].

 Begin static response of entire panel to normal pressure:
 Axial length of panel, AXLEN=  1.3000E+02

 ** NOTE ** If the panel is curved it is treated as a complete
 (360-degree) cylindrical shell. The axisymmetric
 "hungry-horse" deformed state is computed for a single ring
 spacing in Chapter 4. For curved panels, therefore, no
 computations are performed for the entire panel here.
  PEDG= T
 IBPREL=  0
 End of equilibrium calculations for entire panel
 with smeared stiffeners under uniform normal pressure,
 p =  2.0000E-05
 ***** NOTE ****** See Chapter 4 for static response of a
 single "skin"-ring module of the curved panel, which is
 modelled as a complete (360-degree) cylindrical shell there.
 **** CHAPTER 5b: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 **** CHAPTER 5b ****:
 Next, find bending of a single skin-stringer panel
 module under uniform normal pressure, p=  2.0000E-05, See
 Section 9 of Ref.[1A].The panel skin is assumed to be flat
 Also see Fig. 56 on p. 555 of [1A] for an example.

***** BEGIN SUBROUTINE BUCPAN (MODULE PRESSURE RESPONSE) *****
***** This execution of BUCPAN is needed to get buckling load
***** factor that is used to determine axial "softening" due
***** to prebuckling destabilizing loads.
  LABEL NO. IN STRUCT= 9100
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9100     1     0     0  1.0000E+07

 general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7210    9100       0       1       2       1       0       0
  Radius  R,   Axial length, A,   Width  B
 -5.000000E+01  1.300000E+02  1.570800E+02
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
 Out-of-roundness,                    WG1  =  0.0000E+00
 General buckling modal,              WG2  =  0.0000E+00
 Inter-ring buckling modal,         W0PAN =  0.0000E+00
```

```
 Local buckling modal,               W0LOC =  1.0000E-07
 ***** Sanders theory is used in this section (ISAND=1)
 Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
  5.4530E+05  8.0382E+04  0.0000E+00
  8.0382E+04  3.2049E+05  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04

 The following section is entered only if TEST < 1.0 and the
 number of axial halfwaves is at least 3. (TEST < 1.0 means
 that the buckling mode from PANDA-type theory is of the
 type shown in Fig.9(b),p.554 of the "Theoretical basis..."
 paper. TEST > 1.0 means that Fig.9(a) applies.)
 In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
 obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                   EIGTS2 = eigenvalue with TEST < 1.0.
 The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
 High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
 ***(low-n)***
 (high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.640E+00  1.100E+00
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 EIGMNC=  1.64E+00  1.64E+00  1.64E+00  1.00E+17  1.00E+17  1.64E+00  9.79E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    4         4         4         0         0         4         5
 NWAVEX=    7         7         7         0         0         7         0
 TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  1.00E+01
 Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
 EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
 and/or rings, that is, before knockdown by the factor,  1.0000E+00

 If EIGVAL and EIGVLX are different:
 EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
 EIGVLX = original eigenvalue: no "fractional" refinement
 EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6396E+00  1.6396E+00
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5674E+00  1.5674E+00
 EIGVAL,EIGVLX after knockdown for smearing stringers=  1.5674E+00  1.5674E+00
              but before knockdown for smearing rings.
 EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
 ******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********

 ***** BEGIN SUBROUTINE FORCES (MODULE PRESSURE RESPONSE) *****
 Purpose is to obtain resultants in each segment of the skin-
 stringer single module model for input to the nonlinear static
 response of single skin-stringer module to normal pressure.
 See Section 10, pp 506-509, of Reference [1A].
 ****** END SUBROUTINE FORCES (MODULE PRESSURE RESPONSE) *******

 WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR
 WIDLAM =4*pi**2*EI/[abs(local hoop load)*WIDTH**2]=  3.4877E+00
 See ITEM 118(b) of .../panda2/doc/panda2.news for a
 discussion of width-wise wide column buckling constraint.

****** BEGIN SUBROUTINE BUCKLE (MODULE PRESSURE RESPONSE) *****
  LABEL NO. IN STRUCT= 9430
 PANEL DEFORMATION UNDER PRESSURE NOT YET CONVERGED.  Newton iteration no.  1; DW=
```

```
5.05E-03; W=  5.05E-03
 PANEL DEFORMATION UNDER PRESSURE NOT YET CONVERGED.  Newton iteration no.  2; DW= -
7.10E-10; W=  5.05E-03
 PANEL DEFORMATION UNDER NORMAL PRESSURE HAS CONVERGED.
  Newton iterations required =   3
  Last Increment in normal displacement between stiffeners, DW=  8.0072E-10
  Final  value  for normal displacement between stiffeners,  W=  5.0496E-03

 Local "pillowing" between stringers, WLPRES=  5.0496E-03
 before possible reduction by factor, PLOCF (ITEM 117(g)).
 ****** END SUBROUTINE BUCKLE (MODULE PRESSURE RESPONSE) *******

 *** NOTE ****** NOTE ****** NOTE ****** NOTE ****** NOTE ***
 Because the stringers are relatively weak, the local
 amplitude of "pillowing" between stringers is being reduced
 by the factor, PLOCF =   1.0000E+00. See news ITEM 117(g).
 *** END NOTE ***** END NOTE ***** END NOTE ***** END NOTE ***


****** BEGIN SUBROUTINE BUCKLE (MODULE PRESSURE RESPONSE) *****
 See Fig. 56 in Ref.[1A] for the model and its behavior.
  LABEL NO. IN STRUCT= 9440
 ****** END SUBROUTINE BUCKLE (MODULE PRESSURE RESPONSE) *******

****** BEGIN SUBROUTINE MODE (MODULE PRESSURE RESPONSE) *****
 ****** END SUBROUTINE MODE (MODULE PRESSURE RESPONSE) *******

****** BEGIN SUBROUTINE OUTPRS (MODULE PRESSURE RESPONSE) *****


 STATE OF PANEL AS DEFORMED BY PRESSURE, p=  2.0000E-05
  NORMAL DEFLECTION AT CENTER, WPRES=  0.0000E+00 AXIAL CURVATURE CHANGE=  0.0000E+00

  BOSOR   NODAL     NORMAL    CIRCUMFER.    AXIAL STRESS   CIRC. STRESS    AXIAL REF.
CIRC. REF.     CIRC. MOMENT
 TYPE OF  POINT   DEFLECTION  CURVATURE      RESULTANT      RESULTANT    SURFACE STRAIN
SURFACE STRAIN     RESULTANT
 SEGMENT   NO.        W      CHANGE W,yy    Nx(pressure)   Ny(pressure)  ex(ref.surface)
ey(ref.surface)  My(ref.surface)

    1       1     5.0496E-03 -1.3838E-02    -7.8213E-04     5.7988E-07    -3.2085E-09
9.6470E-10     -1.8007E-01
    1       2     5.0027E-03 -1.3626E-02    -7.7486E-04     5.7987E-07    -3.1786E-09
9.5576E-10     -1.7731E-01
    1       3     4.8633E-03 -1.2993E-02    -7.5327E-04     5.7989E-07    -3.0901E-09
9.2920E-10     -1.6907E-01
    1       4     4.6359E-03 -1.1946E-02    -7.1803E-04     5.7989E-07    -2.9456E-09
8.8584E-10     -1.5544E-01
    1       5     4.3274E-03 -1.0498E-02    -6.7024E-04     5.7989E-07    -2.7496E-09
8.2704E-10     -1.3661E-01
    1       6     3.9477E-03 -8.6684E-03    -6.1142E-04     5.7989E-07    -2.5083E-09
7.5467E-10     -1.1280E-01
    1       7     3.5093E-03 -6.4795E-03    -5.4349E-04     5.7990E-07    -2.2297E-09
6.7109E-10     -8.4315E-02
    1       8     3.0269E-03 -3.9586E-03    -4.6875E-04     5.7988E-07    -1.9232E-09
5.7913E-10     -5.1512E-02
    1       9     2.5176E-03 -1.1376E-03    -3.8986E-04     5.7988E-07    -1.5996E-09
4.8206E-10     -1.4803E-02
```

1	10	2.0006E-03	1.9484E-03	-3.0977E-04	5.7989E-07	-1.2712E-09	3.8351E-10	2.5353E-02
1	11	1.4969E-03	5.2604E-03	-2.3172E-04	5.7989E-07	-9.5108E-10	2.8749E-10	6.8452E-02
2	1	1.4969E-03	5.2604E-03	-2.3176E-04	4.4540E-07	-9.5108E-10	2.8699E-10	6.8452E-02
2	2	1.0288E-03	8.7567E-03	-1.5926E-04	4.4540E-07	-6.5371E-10	1.9778E-10	1.1395E-01
2	3	6.2019E-04	1.2394E-02	-9.5949E-05	4.4540E-07	-3.9406E-10	1.1988E-10	1.6128E-01
2	4	2.9558E-04	1.6126E-02	-4.5659E-05	4.4540E-07	-1.8781E-10	5.8005E-11	2.0984E-01
2	5	8.0305E-05	1.9907E-02	-1.2308E-05	4.4540E-07	-5.1025E-11	1.6970E-11	2.5904E-01
2	6	7.9096E-13	2.3688E-02	1.3543E-07	4.5144E-07	-5.0257E-19	1.6848E-12	3.0825E-01
2	7	8.0305E-05	1.9907E-02	-1.2304E-05	4.5747E-07	-5.1025E-11	1.7015E-11	2.5904E-01
2	8	2.9558E-04	1.6126E-02	-4.5655E-05	4.5747E-07	-1.8781E-10	5.8050E-11	2.0984E-01
2	9	6.2020E-04	1.2394E-02	-9.5945E-05	4.5747E-07	-3.9406E-10	1.1993E-10	1.6128E-01
2	10	1.0288E-03	8.7568E-03	-1.5925E-04	4.5747E-07	-6.5371E-10	1.9782E-10	1.1395E-01
2	11	1.4969E-03	5.2605E-03	-2.3176E-04	4.5747E-07	-9.5109E-10	2.8703E-10	6.8453E-02
3	1	-7.8060E-05	-1.8880E-18	-7.5775E-29	-2.5258E-28	0.0000E+00	-2.8416E-34	-8.9701E-16
3	2	-7.8060E-05	-1.8889E-18	-7.5782E-29	-2.5261E-28	0.0000E+00	-2.8418E-34	-8.9741E-16
3	3	-7.8060E-05	0.0000E+00	-3.7891E-29	-1.2630E-28	0.0000E+00	-1.4209E-34	0.0000E+00
3	4	-7.8060E-05	-1.8889E-18	8.5314E-34	2.8438E-33	0.0000E+00	3.1993E-39	-8.9741E-16
3	5	-7.8060E-05	-1.8880E-18	7.6783E-33	2.5594E-32	0.0000E+00	2.8794E-38	-8.9701E-16
3	6	-7.8060E-05	1.8889E-18	7.6783E-33	2.5594E-32	0.0000E+00	2.8794E-38	8.9741E-16
3	7	-7.8060E-05	-1.8889E-18	-1.8938E-29	-6.3126E-29	0.0000E+00	-7.1018E-35	-8.9741E-16
3	8	-7.8060E-05	0.0000E+00	1.3648E-32	4.5494E-32	0.0000E+00	5.1181E-38	0.0000E+00
3	9	-7.8060E-05	-1.8889E-18	2.1326E-32	7.1086E-32	0.0000E+00	7.9973E-38	-8.9741E-16
3	10	-7.8060E-05	1.8889E-18	1.8967E-29	6.3223E-29	0.0000E+00	7.1127E-35	8.9741E-16
3	11	-7.8060E-05	0.0000E+00	1.3650E-32	4.5501E-32	0.0000E+00	5.1189E-38	0.0000E+00
4	1	1.4969E-03	5.2605E-03	-2.3181E-04	2.7914E-07	-9.5109E-10	2.8637E-10	6.8453E-02
4	2	2.0006E-03	1.9484E-03	-3.0986E-04	2.7914E-07	-1.2712E-09	3.8239E-10	2.5354E-02
4	3	2.5176E-03	-1.1375E-03	-3.8995E-04	2.7914E-07	-1.5997E-09	4.8094E-10	-1.4802E-02
4	4	3.0269E-03	-3.9586E-03	-4.6885E-04	2.7913E-07	-1.9232E-09		

```
5.7801E-10     -5.1512E-02
    4      5     3.5093E-03 -6.4795E-03    -5.4358E-04     2.7914E-07    -2.2298E-09
6.6997E-10     -8.4315E-02
    4      6     3.9478E-03 -8.6685E-03    -6.1151E-04     2.7914E-07    -2.5084E-09
7.5355E-10     -1.1280E-01
    4      7     4.3274E-03 -1.0498E-02    -6.7033E-04     2.7913E-07    -2.7496E-09
8.2592E-10     -1.3661E-01
    4      8     4.6359E-03 -1.1946E-02    -7.1813E-04     2.7914E-07    -2.9456E-09
8.8472E-10     -1.5544E-01
    4      9     4.8634E-03 -1.2993E-02    -7.5336E-04     2.7913E-07    -3.0901E-09
9.2808E-10     -1.6907E-01
    4     10     5.0027E-03 -1.3626E-02    -7.7495E-04     2.7914E-07    -3.1787E-09
9.5464E-10     -1.7731E-01
    4     11     5.0496E-03 -1.3838E-02    -7.8222E-04     2.7915E-07    -3.2085E-09
9.6359E-10     -1.8007E-01

 ****** END SUBROUTINE OUTPRS (MODULE PRESSURE RESPONSE) *******
 End of nonlinear equilibrium calculations for
 panel module with uniform normal pressure, p=  2.0000E-05


 *************************************************************
 CHAPTER 5c (prebuckling bending between rings with beam
 model) is not executed because:
 (PEDG.OR.P.EQ.0.0.OR.ISKIPL.NE.0.OR.ISTIF(2).EQ.0
 .OR.ISOGRD.NE.0.OR.ISTIF(1).EQ.5.OR.AXIAL.LT.2.5*B(2))
 **** CHAPTER 5c: DESIGN PERTURBATION INDEX, IMOD=  0 *****




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 6              ****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER  6: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 *************************************************************
 CHAPTER 6  Do PANDA-type [1B] general and inter-ring buckling
           analyses to permit later computation of
           amplification of panel bowing.

**** BEGIN SUBROUTINE BUCPAN (PRELIM. PANDA-TYPE BUCKLING) ****
**** This execution of BUCPAN is used to find the general
**** buckling load factor that is used to compute the
**** amplification of bowing from all sources except pressure.
  LABEL NO. IN STRUCT= 9110
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9110     1     0     0  1.0000E+07

 general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
```

```
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7210    9110       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.640E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.64E+00  1.64E+00  1.64E+00  1.00E+17  1.00E+17  1.64E+00  9.79E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         5
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  1.0000E+00

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6396E+00  1.6396E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5674E+00  1.5674E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  1.5674E+00  1.5674E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
(m,n)=(1,1): GLOBAL MWAVE,EIGAMG,SLOPE,FACAMG=     4  2.0908E+01  0.0000E+00  1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********

GENERAL BUCKLING LOAD FACTOR USED FOR CALCULATION OF THE
```

```
 AMPLIFICATION OF BOWING FROM ALL SOURCES EXCEPT PRESSURE.
 EIGBOW(M,N)=  1.4699E+00(  4,  7)
 **** END SUBROUTINE BUCPAN (PRELIM. PANDA-TYPE BUCKLING) *******

*** BEGIN BUCPAN (INTER-RING BUCKLING, SMEARED STRINGERS) ***
*** This execution of BUCPAN is used to get amplification
*** factors for inter-ring axial bowing and inter-ring local
*** prebuckling deformations (pillowing).
  LABEL NO. IN STRUCT= 9120
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9120     5     0     0  1.0000E+07
 IPRELM=    5  ILOWSS(IPRELM+1,16)=    0

 inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7130    9120       0       1       3       1       0       0
  Radius  R,   Axial length, A,   Width  B
 -5.000000E+01  9.779300E+00  1.570800E+02
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
 Out-of-roundness,                   WG1  =  0.0000E+00
 General buckling modal,             WG2  =  0.0000E+00
 Inter-ring buckling modal,         W0PAN =  0.0000E+00
 Local buckling modal,              W0LOC =  1.0000E-07
 ***** Sanders theory is used in this section (ISAND=1)
 Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
  5.4530E+05  8.0382E+04  0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04
 ***(low-n)***
 (high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                  0     1    1   18  0.000E+00  4.142E+00  1.090E-03
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 EIGMNC=  4.14E+00  4.95E+00  4.14E+00  1.00E+17  1.00E+17  4.14E+00  8.18E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    1         1         1         0         0         1         1
 NWAVEX=   18        83        18         0         0        18         0
 TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  1.00E+01
 Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

 If EIGVAL and EIGVLX are different:
 EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
 EIGVLX = original eigenvalue: no "fractional" refinement
 EIGVAL,EIGVLX before knockdown for t.s.d.=  4.1420E+00  4.1420E+00
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.9335E+00  3.9335E+00
 EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
 (m,n)=(1,1): INTER-RING EIGAMS,SLOPE,FACAMS=  3.0340E+00  0.0000E+00  1.0000E+00
```

```
inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R=  1.5738E+06
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7145    9120       0       1       3       1       0       1
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s       EIGENVALUE  TEST
                0     0    1   10  0.000E+00  4.231E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.38E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0         1         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2308E+00  4.2308E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0135E+00  4.0135E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

INTER-RING BUCKLING load factors and (axial, circumfer.) halfwaves:
Sanders theory is used for these buckling calculations in this case.
INTER-RING BUCKLING FROM PANDA-TYPE THEORY [1B]
   AFTER KNOCKDOWN FOR t.s.d. AND FOR SMEARED STRINGERS:
EIGSS =   2.0255E+00(m=   1,n=  18)
Inter-ring eigenvalue with panel as flat:
EIGSS2=   2.0939E+00(m=   1,n=  10)
IPRELM=    5  ILOWSS(IPRELM+1,16)=    1
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
EIGPAN(M,N)=  2.0939E+00(  1, 10,  0.00E+00)
AMPLIFICATION OF INTER-RING BOWING,       AMPLT3=  1.4916E+00
AMPLIFICATION OF INTER-RING PREB.DEFORM., AMPLT4=  1.0898E+00
```

```
 *** END BUCPAN  (INTER-RING BUCKLING, SMEARED STRINGERS) ***



 ***********************************************************
 ***********************************************************
 ***********************************************************
 ************          CHAPTER 7            ****************
 ***********************************************************
 ***********************************************************
 ***********************************************************
 **** CHAPTER  7: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 **********************************************************
 CHAPTER 7  Compute distribution of loads in panel module
            skin-stringer segments, neglecting redistribution
            due to initial buckling modal imperfections
            (See Section 10 of [1A]).

 *** BEGIN SUBROUTINE FORCES (LOAD DISTRIB. IN SEGMENTS) *****
 Resultants in each segment of the skin-stringer and skin-ring
 modules are computed. The effect of prebuckling bending due to
 initial buckling modal imperfections is ignored at this time,
 but will be accounted for later when buckling load factors and
 stresses are computed. See Section 10, pp 506-509 of Ref.[1A]


 POSITIONS OF STIFFENER SEGMENT CENTROIDS BELOW THE REFERENCE SURFACE OF THE PANEL
SKIN...

   STRINGER PARTS...ZPARTX(I), I=1,4=        0.0000E+00  0.0000E+00 -4.3564E-01 -8.5921E-
01
   RING     PARTS...ZPARTY(I), I=1,4=        0.0000E+00  0.0000E+00 -4.3564E-01 -8.5921E-
01



 BOWING AMPLITUDES DUE TO INITIAL IMPERFECTION,
 CURING, OTHER TEMPERATURE LOADING, MOMENTS, AND PRESSURE...
   AXIAL BOWING DUE TO INITIAL IMPERFECTION  =   0.0000E+00
   AXIAL BOWING BETWEEN RINGS,THERMAL EFFECTS=   0.0000E+00
   OVERALL AXIAL      BOWING, THERMAL EFFECTS=   0.0000E+00
   OVERALL CIRCUMFER. BOWING, THERMAL EFFECTS=   0.0000E+00
   BOWING, ENTIRE PANEL UNDER PRESSURE       =   2.8069E-04
   BOWING, PANEL MODULE UNDER PRESSURE       =   0.0000E+00
   APPLIED AXIAL,HOOP MOMENTS,    MX, MY     =   0.0000E+00  0.0000E+00
   AXIAL,HOOP BOWING CAUSED BY MOMENTS MX, MY=   0.0000E+00  0.0000E+00
 INITIAL LOCAL IMPERFECTION IN SKIN...
   LOCAL IMPERFECTION, WIMP(local)           =   1.0000E-07
 STRATEGY PARAMETERS, IBLL, FMULTX, FMULTY...
   "BOUNDARY LAYER" INDEX, IBLL              =    0
   MULTIPLIER FOR AXIAL BOWING AMPLITUDES    =   1.0000E+00
   MULTIPLIER FOR CIRC. BOWING AMPLITUDES    =   6.8493E-01


 BOWING AMPLIFICATION FACTORS:
   Amplification factor for global axial bowing
```

```
    from global imperfection           =  3.1279E+00
   Amplification factor for global axial bowing
    from normal pressure               =  1.0502E+00
   Amplification factor for axial bowing from
    thermal residual deformation or edge moments
                                       =  1.0502E+00
   Amplification factor for inter-ring axial
    bowing                             =  1.4916E+00

 SHEAR RESULTANT IN WEB AT STRINGER ENDS...
 Shear resultant due to axial load/bowing effect=     4.3687E-07
 Axial coordinate corresponding to lowest buckling=   1.3000E+02
 Total shear resultant from pressure + bowing     =   4.3687E-07
 Axial coordinate corresponding to pressure part  =   1.3000E+02

 SHEAR RESULTANT IN WEB AT RING ENDS...
 Shear resultant due to circ. load/bowing effect=     0.0000E+00
 Axial coordinate corresponding to lowest buckling=   0.0000E+00
 Total shear resultant from pressure + bowing     =   0.0000E+00
 Axial coordinate corresponding to pressure part  =   0.0000E+00

==========================================================================================
================================

 APPLIED RESULTANTS: AXIAL, Nx = -1.0000E+03, CIRC., Ny = -1.0000E-03,  IN-PLANE SHEAR,
Nxy =  5.0000E+00 (LOAD SET A)
 APPLIED RESULTANTS: AXIAL, Nxo=  0.0000E+00, CIRC., Nyo=          0.0000E+00,  IN-PLANE
SHEAR, Nxyo=  0.0000E+00 (LOAD SET B)
 REDUCTION FACTOR NUMBER 1 FOR THE AXIAL LENGTH OF THE PANEL:
  (USED IN THE DETERMINATION OF THE AMPLITUDE FACTOR FOR
  BOWING.  LESS THAN 1.0 ONLY IF THE PANEL IS CLAMPED IN THE
  PREBUCKLING PHASE) =  1.0000E+00
 REDUCTION FACTOR NUMBER 2 FOR THE AXIAL LENGTH OF THE PANEL:
  (USED IN THE DETERMINATION OF THE BIFURCATION BUCKLING LOAD.
  LESS THAN 1.0 ONLY IF THE PANEL IS CLAMPED IN THE BUCKLING
  PHASE)             =  1.0000E+00
 DISTANCE FROM REFER. SURFACE OF PANEL MODULE SEGMENT 1 (SKIN) TO NEUTRAL SURFACES
(positive as for z in Fig. 9):
        X-DIRECTION :     DNEUTX = -2.3136E-01
        Y-DIRECTION :     DNEUTY = -7.6016E-02

 ECCENTRICITY OF AXIAL LOAD (DISTANCE FROM X-DIRECTION NEUTRAL SURFACE TO WHERE Nx AND
Nxo ARE APPLIED (pos. as for z in Fig.9):
    AXIAL LOAD ECCENTRICITY, ECC =  0.0000E+00

 AVERAGE REFERENCE SURFACE STRAINS AND CHANGES IN CURVATURE
 FOR PANEL WITH SMEARED STRINGERS AND RINGS:

  REFERENCE    Due to Nx, Ny, Nxy    Due to Nxo, Nyo        Due to      Due to
               Mx, My applied to     applied to panel as    pressure   temperature
   SURFACE     panel as bowed by     bowed by global im-
               global imperfection   perfection and all
 QUANTITIES    and all loadings.     loadings.
                   EPSLOD                EPSLD0              EAVEP      ETHERM
 AXIAL STRAIN     -1.9042E-03          0.0000E+00          1.0328E-05    0.0000E+00
 TRAN. STRAIN      4.7760E-04          0.0000E+00          5.0258E-07    0.0000E+00
 SHEAR STRAIN      5.3317E-05          0.0000E+00          0.0000E+00    0.0000E+00
 AXIAL KAPPA       5.6859E-13          0.0000E+00         -4.6945E-05    0.0000E+00
```

```
 TRAN. KAPPA       4.8211E-11          0.0000E+00          0.0000E+00    0.0000E+00
    TWIST          0.0000E+00          0.0000E+00          0.0000E+00    0.0000E+00

 INTERNAL FORCES AND MOMENTS IN SKIN, STRINGER BASE,
 AND RING BASE FOR FOUR TYPES OF LOADING:
 1(Nx,Ny,Nxy,Mx,My), 2(Nxo,Nyo), 3(pressure), 4(temperature)

 PART OF          I N T E R N A L   F O R C E S   A N D   M O M E N T S
  PANEL       Nx          Ny           Nxy          Mx           My          Mt

 Internal forces and moments from Nx,Ny,Nxy,Mx,My:
  SKIN    -4.7183E+02 -2.5098E+01  5.0000E+00  1.9560E-10  6.2957E-10  0.0000E+00
 STRBASE -4.7183E+02 -2.5098E+01  5.0000E+00  1.9560E-10  6.2957E-10  0.0000E+00
 RNGBASE -2.5098E+01 -4.7183E+02  5.0000E+00  6.2957E-10  1.9560E-10  0.0000E+00

 Internal forces and moments from Nxo, Nyo:
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Internal forces and moments from overall
 response of the panel to pressure, p (Load Set A):
  SKIN    2.8078E+00  9.6487E-01  0.0000E+00 -6.1088E-04 -1.8326E-04  0.0000E+00
 STRBASE  2.8078E+00  9.6487E-01  0.0000E+00 -6.1088E-04 -1.8326E-04  0.0000E+00
 RNGBASE  1.2813E+02  4.0958E+01  0.0000E+00 -1.8326E-04 -6.1088E-04  0.0000E+00
 Internal forces and moments from overall
 response of the panel to pressure, p (Load Set B):
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 Internal forces and moments from thermal loads:
  SKIN    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 STRBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 RNGBASE  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 ======================================================================

 REFERENCE SURFACE (SKIN REFER. SURFACE) STRAINS, CHANGES IN CURVATURE, AND TWIST CAUSED
BY APPLIED IN-PLANE LOADS, Nx, Ny, Nxy
 AND Nxo, Nyo, Nxyo AND CAUSED BY THERMAL LOADING

 REFERENCE       CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
  SURFACE                  (LOAD SET A)                        (LOAD SET B)
(LOAD SET B)
 QUANTITIES          SKIN  STRINGER BASE RING BASE          SKIN   STRINGER BASE RING BASE
SKIN  STRINGER BASE RING BASE
 AXIAL STRAIN    -1.904E-03 -1.904E-03  4.776E-04       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 TRAN. STRAIN     4.776E-04  4.776E-04 -1.904E-03       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 SHEAR STRAIN     5.332E-05  5.332E-05  5.332E-05       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 AXIAL KAPPA      5.686E-13  5.686E-13  4.821E-11       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 TRAN. KAPPA      4.821E-11  4.821E-11  5.686E-13       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
    TWIST         0.000E+00  0.000E+00  0.000E+00       0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
```

```
===========================================================================================
================================
                        CAUSED BY ALL LOADS
        S T R A I N S    I N   V A R I O U S   P A R T S  O F   T H E   P A N E L  S K
I N   A N D   S T I F F E N E R S
     ITEM        CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
                           (LOAD SET A)                         (LOAD SET B)
(LOAD SET B)
                    SKIN     STRINGER     RING            SKIN     STRINGER     RING
SKIN     STRINGER     RING
  SKIN AXIAL     -1.904E-03     -           -          0.000E+00     -           -
0.000E+00     -           -
  SKIN CIRC.      4.776E-04     -           -          0.000E+00     -           -
0.000E+00     -           -
  SKIN SHEAR      5.332E-05     -           -          0.000E+00     -           -
0.000E+00     -           -
                             STRINGER     RING                     STRINGER     RING
STRINGER     RING
 STIFFENER BASE ALONG AXIS -1.904E-03  4.776E-04                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE TRANSVERSE  4.776E-04 -1.904E-03                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE   SHEAR     5.332E-05 -5.332E-05                  0.000E+00  0.000E+00
0.000E+00  0.000E+00

 ALONG STIFFENER WEB AXIS  -1.904E-03  4.751E-04                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 TRANSVERSE  TO  WEB AXIS   5.713E-04 -1.425E-04                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 IN-PLANE SHEARING OF WEB   1.404E-12  0.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00


===========================================================================================
===============================
                        CAUSED BY ALL LOADS
    R E S U L T A N T S   I N   V A R I O U S   P A R T S  O F   T H E   P A N E L  S K
I N   A N D   S T I F F E N E R S
     ITEM        CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
                           (LOAD SET A)                         (LOAD SET B)
(LOAD SET B)
                    SKIN     STRINGER     RING            SKIN     STRINGER     RING
SKIN     STRINGER     RING
  SKIN AXIAL     -4.718E+02     -           -          0.000E+00     -           -
0.000E+00     -           -
  SKIN CIRC.     -2.510E+01     -           -          0.000E+00     -           -
0.000E+00     -           -
  SKIN SHEAR      5.000E+00     -           -          0.000E+00     -           -
0.000E+00     -           -
                             STRINGER     RING                     STRINGER     RING
STRINGER     RING
 STIFFENER BASE ALONG AXIS -4.718E+02 -2.510E+01                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 STIFFENER BASE TRANSVERSE -2.510E+01 -4.718E+02                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
```

```
 STIFFENER BASE   SHEAR     5.000E+00  5.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00

 ALONG STIFFENER WEB AXIS  -1.540E+03  2.882E+02                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 TRANSVERSE  TO  WEB AXIS   0.000E+00  0.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 IN-PLANE SHEARING OF WEB   4.369E-07  0.000E+00                  0.000E+00  0.000E+00
0.000E+00  0.000E+00

 AXIAL RESULTANTS AT THE ROOT AND TIP OF WEBS:
 AT THE ROOT OF THE WEBS   -1.540E+03  2.882E+02                  0.000E+00  0.000E+00
0.000E+00  0.000E+00
 AT THE TIP  OF THE WEBS   -1.540E+03  2.882E+02                  0.000E+00  0.000E+00
0.000E+00  0.000E+00


==========================================================================================
===============================
                        CAUSED BY ALL LOADS
       E Q U I L I B R I U M   O F   R E S U L T A N T S   F R O M   A P P L I E D   A N
D   T H E R M A L   L O A D S
     ITEM        CAUSED BY APPLIED LOADS, Nx,Ny,Nxy  CAUSED BY APPLIED LOADS,
Nxo,Nyo,Nxyo      CAUSED BY THERMAL LOADING
                           (LOAD SET A)                        (LOAD SET B)
(LOAD SET B)
                     Nx         Ny         Nxy             Nx          Ny         Nxy
Nx         Ny         Nxy

   DERIVED       -1.000E+03 -1.315E-01  5.000E+00      0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
   APPLIED       -1.000E+03 -1.000E-03  5.000E+00      0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00
 DIFFERENCE       0.000E+00 -1.305E-01  0.000E+00      0.000E+00  0.000E+00  0.000E+00
0.000E+00  0.000E+00  0.000E+00

==========================================================================================
================================

==========================================================================================
================================

 BOUNDARY CONDITIONS AND BOWING AMPLITUDE FACTORS:
   AXIAL BOUNDARY CONDITIONS FOR PREBUCKLING PHASE    =BENDING THEORY
   AXIAL BOUNDARY CONDITIONS FOR BIFURCATION BUCKLING =SIMPLE SUPPORT
   AMPLITUDE FACTOR FOR BOWING DUE TO PRESSURE, THERMAL
   THRU-THICKNESS GRADIENT, EDGE MOMENTS,       AMPLT2=  1.0502E+00
   AMPLITUDE FACTOR FOR DEFORMATION FROM GLOBAL IMPERFECTION
                                                AMPLIT=  3.1279E+00
 THE CONSTITUTIVE C(i,j) MATRIX WITH REDUCED SKIN STIFFNESS
 IS USED BECAUSE  LOCAL BUCKLING OF THE SKIN IS PERMITTED.

 **** END SUBROUTINE FORCES (LOAD DISTRIB. IN SEGMENTS) *******
 *** END OF CALCS. FOR PREBUCKLING FORCE DISTRIBUTIONS ***
 Prebuckling bending due to initial imperfections neglected.
 **************************************************************
```

```
 ***************************************************************
 ***************************************************************
 ***************************************************************
 ************          CHAPTER 8            ****************
 ***************************************************************
 ***************************************************************
 ***************************************************************
 **** CHAPTER  8: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 **************************************************************
 CHAPTER 8  Do PANDA-type local, inter-ring, general buckling
            analyses and PANDA-type stringer web and ring web
            buckling analyses to get knockdown factors to
            compensate for lack of in-plane shear Nxy loading
            and anisotropy in discretized BOSOR4-type models.
            (See Section 11 of [1A] and Item No. 81 in [1L]).

*** BEGIN SUBROUTINE BUCPAN (KNOCKDOWN PANDA-TYPE BUCKLING) ***
**** The purpose of the following BUCPAN execution is to find:
*** LOCAL BUCKLING (buckling of skin between stiffeners):
**** a.with in-plane shear Nxy and anisotropic effects included
**** b.without in-plane shear Nxy and anisotropic effects
*** INTER-RING BUCKLING (stringers smeared out):
**** a.with in-plane shear Nxy and anisotropic effects included
**** b.without in-plane shear Nxy and anisotropic effects
*** GENERAL INSTABILITY (rings and stringers smeared out):
**** a.with in-plane shear Nxy and anisotropic effects included
**** b.without in-plane shear Nxy and anisotropic effects
*** THE PURPOSE IS TO FIND KNOCKDOWN FACTORS TO COMPENSATE
*** FOR THE ABSENCE OF IN-PLANE SHEAR AND ANISOTROPY IN BOSOR4-
*** TYPE MODELS (DISCRETIZED MODULE MODELS).
**** See Section 11, p. 509, of Reference [1].
*** NOTE: This set of calculations does NOT include the effect
***       of initial geometric buckling modal imperfections.
  LABEL NO. IN STRUCT= 9140
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9140     2     0     0  1.0000E+07

 Local buckling, C11=  2.6794E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7010    9140       0       1       1       1       0       1
  Radius  R,   Axial length, A,   Width  B
 -5.000000E+01  9.779300E+00  2.470500E+00
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
 Out-of-roundness,                    WG1  =  0.0000E+00
 General buckling modal,              WG2  =  0.0000E+00
 Inter-ring buckling modal,         W0PAN =  0.0000E+00
```

```
Local buckling modal,               W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 2.6794E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 1.0000E+04  1.0000E+00  4.8566E-05  4.8566E-05  1.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=3.96E+00
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    1  1.000E-02  1.709E-01  3.958E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  2.30E-01  1.00E+17  1.71E-01  1.00E+17  1.00E+17  4.40E-01  1.00E+17
SLOPEX=  1.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  2.00E-02  0.00E+00
MWAVEX=    2         0         4         0         0         1         0
NWAVEX=    1         0         1         0         0         1         0
TESTX =  3.96E+00  0.00E+00  3.96E+00  0.00E+00  0.00E+00  3.96E+00  0.00E+00
Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.7087E-01  1.7087E-01
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.7069E-01  1.7069E-01
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

Sanders theory is used for these buckling calculations in this case.
Local buckling load factors & mode shapes before any knockdown factors applied:
EIGMNC=  2.30E-01  1.00E+17  1.71E-01  1.00E+17  1.00E+17  4.40E-01  1.00E+17
SLOPEX=  1.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  2.00E-02  0.00E+00
MWAVEX=    2         0         4         0         0         1         0
NWAVEX=    1         0         1         0         0         1         0
NOTE: The buckling nodal line slopes, SLOPEX, are as
defined in Fig. 9a or Fig. 9b of the 1987 "Theoretical
basis of the PANDA...",if NWAVEX > 0; that is, there
has not yet been any inversion of SLOPEX when 9b holds.

LOCAL BUCKLING FROM PANDA-TYPE THEORY [1B] AFTER KNOCKDOWN FOR t.s.d.:
EIGLOC =   1.7069E-01(m=   4,n=   1)

Entering ALTSOL: radius, axial, circ. dimensions =  5.0000E+01  9.7793E+00  2.4705E+00
See ITEMs 438, 444  in the file ..panda2/doc/panda2.news .
and AIAA paper 99-1233, Proc. 40th AIAA SDM Meeting, 1999
pp 302-345, especially pp 304-316 and associated figures.
*** BUCKLING BETW MAJOR STIFFENERS, SMEARED SUBSTIFFENERS ***
        Number of discrete stringers, rings: NUMSTR, NUMRNG=  0  0
Membrane stiffnesses, C11,C12,C22,C33=
 2.6794E+05  8.0382E+04  2.6794E+05  9.3778E+04

No alternative solution sought because user did not want one.
```

```
(IALTSN was set equal to zero in MAINSETUP)

Local buckling, C11=  2.6794E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7055    9140       0       1       1       1       0       1
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  2.470500E+00
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 2.6794E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 1.0000E+04  1.0000E+00  4.8566E-05  4.8566E-05  1.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=3.96E+00
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    1  0.000E+00  1.709E-01  3.958E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  2.30E-01  1.00E+17  1.71E-01  1.00E+17  1.00E+17  4.40E-01  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    2         0         4         0         0         1         0
NWAVEX=    1         0         1         0         0         1         0
TESTX =  3.96E+00  0.00E+00  3.96E+00  0.00E+00  0.00E+00  3.96E+00  0.00E+00
Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.7087E-01  1.7087E-01
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.7069E-01  1.7069E-01
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
IPRELM=    2  ILOWSS(IPRELM+1,19)=    0

inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
```

```
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7130    9140       0       1       3       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 3.1831E-01  1.0000E+00  7.7874E-02  2.3863E-05  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.09E-03
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    1   18  0.000E+00  4.142E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.14E+00  4.95E+00  4.14E+00  1.00E+17  1.00E+17  4.14E+00  8.18E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=     1         1         1         0         0         1         1
NWAVEX=    18        83        18         0         0        18         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.1420E+00  4.1420E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.9335E+00  3.9335E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R=  1.5738E+06
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7145    9140       0       1       3       1       0       1
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
```

```
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 1.0000E+04  1.0000E+00  7.7874E-02  2.3863E-05  1.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.09E-03
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   10  0.000E+00  4.231E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.38E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0         1         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2308E+00  4.2308E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0135E+00  4.0135E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

INTER-RING BUCKLING load factors and (axial, circumfer.) halfwaves:
Sanders theory is used for these buckling calculations in this case.
INTER-RING BUCKLING FROM PANDA-TYPE THEORY [1B]
   AFTER KNOCKDOWN FOR t.s.d. AND FOR SMEARED STRINGERS:
EIGSS =   2.0500E+00(m=   1,n=  18)
Inter-ring eigenvalue with panel as flat:
EIGSS2=   2.0939E+00(m=   1,n=  10)
IPRELM=    2  ILOWSS(IPRELM+1,19)=    1

inter-ring buckling: smeared stringers, C11=  5.4530E+05, (No Nxy)
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7155    9140       0       1       3       1       0       0
```

```
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 1.0019E+04  1.0000E+00  7.7874E-02  2.3863E-05  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.09E-03
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   10  0.000E+00  4.231E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.23E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0        10         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2308E+00  4.2308E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0135E+00  4.0135E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7195    9140       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  0.0000E+00
Local buckling modal,              W0LOC =  1.0000E-07
```

```
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 3.1831E-01  1.0000E+00  7.7874E-02  2.1076E-02  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=4.31E-01
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.640E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.64E+00  1.64E+00  1.64E+00  1.00E+17  1.00E+17  1.64E+00  9.79E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         5
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6396E+00  1.6396E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5674E+00  1.5674E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

general buckling: smeared stiffeners, C11=  5.4530E+05, (No Nxy)
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7230    9140       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
Out-of-roundness,                    WG1  =  0.0000E+00
```

```
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  0.0000E+00
Local buckling modal,               W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 3.1831E-01  1.0000E+00  7.7874E-02  2.1076E-02  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=4.31E-01
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.640E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.64E+00  1.64E+00  1.64E+00  1.00E+17  1.00E+17  1.64E+00  9.79E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         5
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  1.00E+01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6396E+00  1.6396E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5674E+00  1.5674E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********

Label No. in STRUCT= 9140: Modifiers for knockdowns
generated from use of the alternative buckling soln.(if any)
 General Instability, FKNOCK(1), EIGRT9 =  1.0000E+00  1.0000E+00
 Local Buckling,      FKNOCK(2), EIGRT7 =  9.9999E-01  1.0000E+00
**** END SUBROUTINE BUCPAN (KNOCKDOWN PANDA-TYPE BUCKL.) ******
**** Knockdown factors to account for anisotropy and/or the
**** presence of in-plane shear, in order to compensate for the
**** neglect of these in the BOSOR4-type discretized models for
**** buckling.
*****************************************************************
```

```
 Conservativeness indicator, ICONSV= 1 (See panda2.news Item No. 676)
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  0.0000E+00
 Out-of-roundness,                   WG1  =  0.0000E+00
 General buckling modal,             WG2  =  0.0000E+00
 Inter-ring buckling modal,         W0PAN =  0.0000E+00
 Local buckling modal,              W0LOC =  1.0000E-07
 **** CHAPTER  9: DESIGN PERTURBATION INDEX, IMOD=  0 *****



 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 9             ****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER  9: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 *************************************************************
 CHAPTER 9  Do BOSOR4-type "skin"-ring buckling analyses to
            compute knockdown factor to compensate for
            inherent unconservativeness of models with
            smeared rings. (See Items 509, 511, 522, and
            605 in [1L]; "skin"=skin+smeared stringers).

 *** BEGIN "SKIN"-RING BUCKLING, DISCRETE MODULE MODEL ***
 See Ref.[6]: Bushnell, D., et al, "Additional buckling
 solutions in PANDA2", AIAA Paper 99-1233, Proc. 40th AIAA
 SDM Conference, pp 302-345 (1999). See especially pp 318-323
 and Figs. 30-33. Also, read ITEMs 509, 511, 522, 605 of the
 file, ..panda2/doc/panda2.news, about how PANDA2 develops a
 knockdown factor to compensate for the unconservativeness of
 buckling models in which the rings are smeared out.
 Check to see if "skin"-ring discretized model is analyzed.
 Whether it is or not depends on the following quantities:
  Is the panel curved (IFLAT = 0)?,              IFLAT= 0
  What is the ring cross section?,            ISTIF(2)= 3
  Did PANDA2 compute resultants at IXNUMB pts in SKIN?, IXNUMB=26
  Is the applied axial resultant in Load Set A negative,    Nx= -1.0000E+03
  Is the applied hoop  resultant in Load Set A negative,    Ny= -1.0000E-03
  Is the average hoop load in the panel skin negative,  FNYAVE= -2.4986E+01
  Is the average hoop load in the ring web negative,    FCEWEB=  2.9067E+02
  Is the average hoop load in the ring flange negative, FCEFLG=  0.0000E+00
  Is in-plane shear load Nxy .LT. 2*SQRT(Nx**2 + Ny**2),   Nxy=  5.0000E+00
  LABEL NO. IN STRUCT= 9142

*** Infinite cyl, external lateral pressure) **
 Uniform external lateral pressure,      PRESS=  1.0000E+00
 Buck. axial halfwaves from PANDA-type, MGENQQ=  1
 Buck. circ. halfwaves from PANDA-type, NGENQQ=  2
 Buck. circ. halfwaves over arc=pi*r,   NGENNW=  2
 NGENNW is used for the buckling analysis in BUCKLE.

 Constitutive law, C(i,j), for locally deformed
```

```
panel between rings with smeared stringers.....
      5.4530E+05  8.0382E+04  0.0000E+00  1.2083E+05  0.0000E+00  0.0000E+00
      8.0382E+04  2.6794E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      0.0000E+00  0.0000E+00  9.3778E+04  0.0000E+00  0.0000E+00  0.0000E+00
      1.2083E+05  0.0000E+00  0.0000E+00  6.9240E+04  3.9038E+00  0.0000E+00
      0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00
      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.1574E+01

**** PREBUCKLING LOADS IN "SKIN"-RING DISCRETIZED MODULE ****
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     1     1
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 1
 5.4530E+05  2.6794E+05  9.3778E+04  6.9240E+04  1.3013E+01  6.1574E+01
Total axial nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01
-4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01
Fixed axial nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     2     1
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 2
 5.4530E+05  2.6794E+05  9.3778E+04  6.9240E+04  1.3013E+01  6.1574E+01
Total axial nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01
-4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01
Fixed axial nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     3     3
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 3
 6.6660E+05  6.6660E+05  2.3331E+05  2.0038E+02  2.0038E+02  7.0133E+01
Total meridional nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-9.8272E+01 -9.8272E+01 -9.8272E+01 -9.8272E+01 -9.8272E+01 -9.8272E+01
-9.8272E+01 -9.8272E+01 -9.8272E+01 -9.8272E+01 -9.8272E+01
Fixed meridional nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
```

```
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     4     1
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 4
 5.4530E+05  2.6794E+05  9.3778E+04  6.9240E+04  1.3013E+01  6.1574E+01
Total axial nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01
-4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01 -4.1487E+01
Fixed axial nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
=============================================================

** BEGIN SUB. MODE ("SKIN"-RING n=   2 GENERAL BUCKLNG MODE) **
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  2.5030E-06
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  2.4076E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  1.4184E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  1.4184E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  1.1755E-18
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  2.4560E-18
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  2.4076E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  2.5030E-06
AMPLIT.OF BUCKLING MODE MIDWAY BETWEEN RINGS, WMID =  9.9977E-01
AMPLIT.OF BUCKLING MODE AT   RING   WEB TIP,  WTIP =  2.6587E-14
AMPLIT.OF BUCKLING MODE AT   RING   MIDWEB,  WCRIP =  2.6573E-14
AMPLIT.OF BUCKLING MODE AT  RING FLANGE TIP,, WFLG =  0.0000E+00
      Internal Ring

     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"-RING PANEL MODULE HAS 4 SEGMENTS
NUMBER OF HALF-WAVES IN THE CIRC. DIRECTION, n= 2

NODE	Z	W	WD	WDD	U	V	WDDD
			MODAL DISPLACEMENTS FOR SEGMENT NO. 1				
1	0.00E+00	1.00E+00	4.54E-16	3.86E-05	-4.79E-20	4.98E-01	-4.99E-06
2	0.00E+00	1.00E+00	1.36E-05	3.68E-05	-2.73E-06	4.98E-01	-4.99E-06
3	0.00E+00	1.00E+00	2.68E-05	3.50E-05	-5.38E-06	4.98E-01	-4.99E-06
4	0.00E+00	1.00E+00	3.91E-05	3.19E-05	-7.85E-06	4.98E-01	-8.33E-06
5	0.00E+00	1.00E+00	5.00E-05	2.76E-05	-1.01E-05	4.98E-01	-1.17E-05
6	0.00E+00	1.00E+00	5.91E-05	2.21E-05	-1.19E-05	4.98E-01	-1.51E-05
7	0.00E+00	1.00E+00	6.59E-05	1.53E-05	-1.33E-05	4.98E-01	-1.86E-05
8	0.00E+00	1.00E+00	7.00E-05	7.12E-06	-1.41E-05	4.98E-01	-2.22E-05
9	0.00E+00	1.00E+00	7.09E-05	-2.35E-06	-1.43E-05	4.98E-01	-2.58E-05
10	0.00E+00	1.00E+00	6.81E-05	-1.32E-05	-1.38E-05	4.98E-01	-2.96E-05
11	0.00E+00	1.00E+00	6.10E-05	-2.40E-05	-1.24E-05	4.98E-01	-2.96E-05
			MODAL DISPLACEMENTS FOR SEGMENT NO. 2				
1	0.00E+00	1.00E+00	6.10E-05	-2.48E-05	-1.24E-05	4.98E-01	-3.94E-05
2	0.00E+00	1.00E+00	5.37E-05	-3.44E-05	-1.09E-05	4.98E-01	-3.94E-05
3	0.00E+00	1.00E+00	4.41E-05	-4.40E-05	-8.98E-06	4.98E-01	-3.94E-05
4	0.00E+00	1.00E+00	3.20E-05	-5.43E-05	-6.54E-06	4.98E-01	-4.21E-05
5	0.00E+00	1.00E+00	1.74E-05	-6.53E-05	-3.57E-06	4.98E-01	-4.49E-05
6	0.00E+00	1.00E+00	0.00E+00	-7.72E-05	-2.67E-14	4.98E-01	-4.87E-05
7	0.00E+00	1.00E+00	-1.74E-05	-6.53E-05	3.57E-06	4.98E-01	4.87E-05
8	0.00E+00	1.00E+00	-3.20E-05	-5.43E-05	6.54E-06	4.98E-01	4.49E-05
9	0.00E+00	1.00E+00	-4.41E-05	-4.40E-05	8.98E-06	4.98E-01	4.21E-05
10	0.00E+00	1.00E+00	-5.37E-05	-3.44E-05	1.09E-05	4.98E-01	3.94E-05
11	0.00E+00	1.00E+00	-6.10E-05	-2.48E-05	1.24E-05	4.98E-01	3.94E-05
			MODAL DISPLACEMENTS FOR SEGMENT NO. 3				
1	-1.21E-02	-2.66E-14	1.11E-17	-5.90E-16	-1.00E+00	4.98E-01	2.76E-15
2	-9.68E-02	-2.66E-14	-2.90E-17	-3.56E-16	-1.00E+00	5.01E-01	2.76E-15
3	-1.81E-01	-2.66E-14	-4.92E-17	-1.22E-16	-1.00E+00	5.03E-01	2.76E-15
4	-2.66E-01	-2.66E-14	-5.66E-17	-5.36E-17	-1.00E+00	5.06E-01	8.02E-16
5	-3.51E-01	-2.66E-14	-5.54E-17	8.26E-17	-1.00E+00	5.08E-01	1.61E-15
6	-4.36E-01	-2.66E-14	-4.74E-17	1.06E-16	-1.00E+00	5.11E-01	2.73E-16
7	-5.20E-01	-2.66E-14	-3.98E-17	7.27E-17	-1.00E+00	5.13E-01	-3.90E-16
8	-6.05E-01	-2.66E-14	-3.39E-17	6.80E-17	-1.00E+00	5.16E-01	-5.59E-17
9	-6.90E-01	-2.66E-14	-3.00E-17	2.32E-17	-1.00E+00	5.18E-01	-5.28E-16
10	-7.74E-01	-2.66E-14	-2.90E-17	6.37E-19	-1.00E+00	5.21E-01	-2.67E-16
11	-8.59E-01	-2.66E-14	-3.02E-17	-2.20E-17	-1.00E+00	5.24E-01	-2.67E-16
			MODAL DISPLACEMENTS FOR SEGMENT NO. 4				
1	0.00E+00	1.00E+00	-6.10E-05	-2.40E-05	1.24E-05	4.98E-01	2.96E-05
2	0.00E+00	1.00E+00	-6.81E-05	-1.32E-05	1.38E-05	4.98E-01	2.96E-05
3	0.00E+00	1.00E+00	-7.09E-05	-2.35E-06	1.43E-05	4.98E-01	2.96E-05
4	0.00E+00	1.00E+00	-7.00E-05	7.12E-06	1.41E-05	4.98E-01	2.58E-05
5	0.00E+00	1.00E+00	-6.59E-05	1.53E-05	1.33E-05	4.98E-01	2.22E-05
6	0.00E+00	1.00E+00	-5.91E-05	2.21E-05	1.19E-05	4.98E-01	1.86E-05
7	0.00E+00	1.00E+00	-5.00E-05	2.76E-05	1.01E-05	4.98E-01	1.51E-05

```
 8  0.00E+00  1.00E+00 -3.91E-05  3.19E-05  7.85E-06  4.98E-01  1.17E-05
 9  0.00E+00  1.00E+00 -2.68E-05  3.50E-05  5.38E-06  4.98E-01  8.33E-06
10  0.00E+00  1.00E+00 -1.36E-05  3.68E-05  2.73E-06  4.98E-01  4.99E-06
11  0.00E+00  1.00E+00  0.00E+00  3.86E-05  1.48E-17  4.98E-01  4.99E-06

**** END  SUB. MODE ("SKIN"-RING n=   2 GENERAL BUCKLNG MODE) **
Mode shape properties for n=  2 circ. halfwaves:
Normal displacement midway between rings,   WFIRST=  9.9977E-01
Normal displacement midway between rings,    WLAST=  9.9977E-01
Normal displacement in skin at web root,     WMIDQ=  1.0000E+00
Normal displacement in ring at flange tip,    WFLG=  1.0000E+00
Normal displacement, ring flange at web tip, WFLGW=  1.0000E+00
Normalized difference,     ABS(WFLG-WFLGW)/WFLGMAX=  0.0000E+00
Possible candidate for knockdown factor,     WFLGK=  1.0000E+00
Eigenvalues for  1 roots:  EIGRPP=   2.8014E-01
Buckling load factor BEFORE knockdown for smeared stringers=  2.8014E-01
In this n=   2 general buckling analysis there is no knockdown
for smeared stringers.
NOTE: The buckling load factor,  2.8014E-01, will not be
further reduced by the "shear/anisotropy" factor.

Mode number  1 is     a suitable ring mode.

Knockdown for smeared rings on cylindrical shell...
 Buckling load factor for n+dn = FNARCQ=  2.0000E+00
                              from discrete model =  2.8014E-01
 Buckling load factor for ring with bending stiffness EI:
                     pcrit=[(n+dn)**2-1]*EI/r**3/p=  2.7583E-01
 Knockdown factor, general buckling,   EIGR/EIGRNG=  1.0000E+00
END OF SECTION ON GENERATION OF KNOCKDOWN FACTOR FOR
COMPENSATING FOR THE UNCONSERVATIVENESS OF SMEARING RINGS
---------------------------------------------------------


Knockdown for smeared rings, RNGKNZ=  1.0000E+00(FNARCQ=  2.0000E+00)




**************************************************************
**************************************************************
**************************************************************
************          CHAPTER 10             ****************
**************************************************************
**************************************************************
**************************************************************
**** CHAPTER 10: DESIGN PERTURBATION INDEX, IMOD=  0 ****

*************************************************************
CHAPTER 10 Compute knockdown factors and prebuckling bending
           associated with initial general, inter-ring, local
           buckling modal imperfections. (See Ref.[1E].
           Also see Sections 13 and 14 and Tables 9 and 10
           of Ref.[1K]).

***** ENTERING IMPERFECTION SECTION (subroutine STRIMP) *****
Please see the following articles for details on the theory:
 1. D. Bushnell and W.D. Bushnell, "Approximate method..."
```

```
    Computers & Structures, Vol. 29, No. 3, pp. 489-527, 1996
    (The theory here is called "PANDA2" in the output below)
 2. D. Bushnell, "Recent enhancements to PANDA2", Proceedings
    37th AIAA SDM meeting, April 1996 (see pp 131-136)
    (The theory here is called "ARBOCZ" in the output below)
For discussions of fractional wavenumbers, see following Items
in ...panda2/doc/panda2.news: 125g,367,405,412,436,449,453
*** There are three parts to this "IMPERFECTIONS" section:
***   PART 1: general buckling (rings and stringers smeared)
***   PART 2: inter-ring buckling (stringers smeared)
***   PART 3: local buckling: skin buckling between stiffners
**  In each part both "PANDA2" and "ARBOCZ" theories are used.

******** PANDA2 is using STRATEGY (2) with respect to *******
******** the treatment of buckling modal imperfections *******
******** See Step1 - Step 3 and Ref.[17] for details. ********

Step 1. Use the critical buckling mode shape, (m,n,slope) =
       (axial halfwaves, circ. halfwaves, nodal line slope)
       corresponding to the PERFECT rather than the IMPERFECT
       geometry if the axial halfwavelength of the critical
       buckling mode of the IMPERFECT geometry is less than or
       equal to half the user-specified axial halfwavelength
       of the imperfection.

Step 2. Change the amplitude of whatever imperfection results
       from Step 1 by the factor (ratio):
      (axial halfwavelength of the critical buckling mode)/
      (user-specified axial halfwavelength of the imperfection)

Step 3. Reduce the buckling modal imperfection amplitude
       remaining after Steps 1 and 2 if it leads to an
       out-of-plane wall rotation that is greater than
       0.1 radian.
******* End of description of STRATEGY (2)  Ref.[17]   ********



***************************************************************
***************************************************************
***************************************************************
************          CHAPTER 10.1           *****************
***************************************************************
***************************************************************
***************************************************************
**** CHAPTER 10.1: DESIGN PERTURBATION INDEX, IMOD=  0 ***

**************************************************************
CHAPTER 10.1 Compute knockdown factor and prebuckling bending
             associated with GENERAL buckling modal initial
             imperfection. (See Sectons 13 and 14 and
             Tables 9 and 10 of [1K] for a detailed example)

Entering imperfection section, PART 1...
 General buckling of panel with rings. Rings and
 Stringers are smeared out.
**** WARNING ***** WARNING ***** WARNING ****
```

```
 YOU SHOULD CONSIDER USING THE "REDUCED SKIN STIFFNESS"
 OPTION IN THE "MAINSETUP" INTERACTIVE SESSION,
 ESPECIALLY IF THE GENERAL BUCKLING FACTOR OF SAFETY,
 FSGEN, IS GREATER THAN THE LOCAL BUCKLING F.S., FSLOC.
 **** END WARNING *** END WARNING *** END WARNING ****

*** BEGIN BUCPAN (IMPERF. SENSITIVITY, PERFECT PANEL) ****
  LABEL NO. IN STRIMP= 9150
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9150     3     0     0  1.0000E+07

 general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01

 PANDA2 can optimize imperfect stiffened panels and shells [4].
 Imperfections are assumed to be in the shapes of the general,
 inter-ring, and local buckling modes obtained from the "PANDA-
 type" model [2]. This section of PANDA2 applies to stiffened
 panels with a general buckling modal imperfection, that is, an
 imperfection shape that is determined from a model in which
 the stiffeners are smeared out. A general buckling modal
 imperfection in a stiffened shell has two major effects:

 1. The imperfect stiffened panel or shell bends as soon as any
 loading is applied. This bending causes significant
 redistribution of stresses between the panel skin and the
 various stiffener parts, thus affecting significantly many
 local and inter-ring buckling and stress constraints.

 2. The "effective" curvature of an imperfect cylindrical panel
 or shell depends on the amplitude of the initial imperfection,
 on the circumferential wavelength of the critical buckling
 mode of the perfect and of the imperfect shell, and on the
 amount that the initial imperfection grows as the loading
 increases from zero to the design load. The "effective"
 circumferential radius of curvature of the imperfect and
 loaded shell is larger than its nominal radius of curvature
 because this radius corresponds to the maximum local radius of
 a typical inward circumferential lobe of the initial and
 subsequently load-amplified buckling modal imperfection.

 In PANDA2 this larger local radius of curvature is assumed to
 be the governing radius in the buckling equations pertaining
 to the imperfect shell. For each type of buckling modal
 imperfection (general, inter-ring, local) PANDA2 computes a
 "knockdown" factor based on the ratio:
 (buckling load factor: panel with its "effective" radius)/
 (buckling load factor: panel with its nominal radius)

 In the following "imperfection sensitivity" calculations
 PANDA2 does the following (using Donnell shell theory):

 1. Computes the buckling load factor for a PERFECT panel
    from PANDA-type theory [2].

 2  Computes the buckling load factor for a PERFECT panel
    from ARBOCZ theory. Equations are from "The effect of
    initial imperfections on shell stability - an updated
```

review" by Johann Arbocz, Faculty of Aerospace Engineering, Delft University of Technology, Report LR-695, Sept.1992. in particular, see Equation No. (3.61) in that report. This ARBOCZ theory is also described briefly in [5].

3. Computes the buckling load factor for an IMPERFECT panel from ARBOCZ theory.

4. Computes the buckling load factor for an IMPERFECT panel from PANDA-type theory [2]. This is done iteratively since the "effective" circumferential radius of curvature of the imperfect panel depends on the buckling load factor that is being computed.

5. Decides (partly depending on user-provided input) on whether to use the buckling mode for the PERFECT shell or the buckling mode of the IMPERFECT shell as the imperfection shape.

6. Computes the curvature changes and twist, Wxx, Wyy, Wxy, generated because of prebuckling bending of the imperfect shell as it is loaded by the design load.

7. Presents a summary of "knockdown" factors to be used in connection with local, inter-ring, and general buckling of the stiffened shell.

For more information on the behavior of imperfect stiffened shells, please see the following news items in the file, ..doc/panda2/news: 377, 456, 525, 553, 564, 594, and 596. Also, please read the papers [4] and [5].

```
SOME DEFINITIONS:
GENSTB = subroutine that computes PANDA-type buckling loads
ARBOCZ = subroutine that computes ARBOCZ theory buckling loads
t.s.d. = transverse shear deformation effect
NX, NY, NXY=axial, hoop, in-plane shear prebuckling resultants
ILOADS = load combination number (up to 5 load combos allowed)
ICASE  = subcase number (1 means midbay; 2 means at rings)
LOAD SET A = "eigenvalue loads" (in load-geometric matrix)
LOAD SET B = "constant" loads (contribute to stiffness matrix)
Four digit label starting with 9 (9xxx): SUBROUTINE BUCPAN
is called from Label 9xxx in SUBROUTINE STRUCT or STRIMP
Four digit label starting with 7 (7xxx): SUBROUTINE GENSTB
is called from Label 7xxx in SUBROUTINE BUCPAN
IDESGN = 0 for current design; = 1 for perturbed design
ISAND  = 0 for Donnell shell theory; 1 for Sanders theory
INDX   = 2 for general buckling
IFFLAT = 0 for curved (cylindrical) panel; 1 for flat panel
EILC91 = buckling load factor for PERFECT panel
EILOC9 = buckling load factor for IMPERFECT panel
WYYAMP = buckling modal imperfection is amplified by WYYAMP
         due to the applied load
RNGKNZ = knockdown factor to compensate for unconservativeness
         of smearing rings
R(radwav) = "effective" circumferential radius of curvature
            of the imperfect shell as loaded by the design
            load combination, NX, NY, NXY. THIS IS IMPORTANT!
```

```
EIGVAL = eigenvalue with fractional wavenumbers and
         "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
JJJ+1  = design iteration number.
DMWAVE = fractional axial halfwaves
DNWAVE = fractional circ. halfwaves
MBAR   = number of axial halfwaves (floating point)
NBAR   = number of circumferential halfwaves (floating point)
MWAVEX = number of axial halfwaves (integer)
NWAVEX = number of circumferential halfwaves (integer)
SLOPEX = slope of buckling nodal lines(assumed to be straight)
EIGMNC = buckling load factors (eigenvalues)
W0GLOB = out-of-roundness +general buckling modal imperfection
WG1    = out-of-roundness (n = 2 imperfection, prismatic)
WG2    = general buckling modal imperfection
W0PAN  = inter-ring ("panel") buckling modal imperfection
W0LOC  = local (panel skin between stiffeners) buckling modal
         imperfection
m,n,s  = axial halfwaves, circumferential halfwaves, slope in
         the buckling mode shape
eig1   = one eigenvalue when there are multiple minima with
         respect to (m,n,s)
eig2   = the other eigenvalue when there are multiple minima
(eig2-eig1)/abs(eig2-eig1) = ratio that, when its sign
         changes, tells the user that there has been an abrupt
         change in the critical buckling mode shape, which may
         give rise to very large constraint gradients.
MWAVE  = number of axial halfwaves (integer)
NWAVE  = number of circumferential halfwaves (integer)
CSLOPE = slope of buckling nodal lines(assumed to be straight)
TEST   = control for type of buckling mode, PANDA-type model:
         TEST < 1.0 means that Fig. 9(b) of [2] applies.
         TEST > 1.0 means that Fig. 9(a) of [2] applies.
Wxx,Wyy,Wxy = changes in curvature and twist of the imperfect
              shell as loaded by the design load
L      = axial length of the  buckling domain
CIRC   = circumferential arc length of the buckling domain
Eq.(3.61) = ARBOCZ theory buckling equation; Eq.(19) of [5]

NOTE: In the following output there occur listings in the form

EIGMNC=  2.25E+00  2.25E+00  2.57E+00  2.98E+00  2.57E+00  2.25E+00  1.00E+17
SLOPEX=  4.73E-01  4.73E-01  0.00E+00  1.58E-01  0.00E+00  4.73E-01  0.00E+00
MWAVEX=    1         1         7         6         7         1         0
NWAVEX=    3         3         1         4         1         3         0

These data represent the buckling load factors, EIGMNC, and
mode shapes, (SLOPEX,MWAVEX,NWAVEX), corresponding to the
critical values found from searching for minima with respect
to (m,n,slope) over seven (m,n) subspaces:
(low-m, low-n), (low-m, high-m), (high-m, low-n), (high-m, high-n), etc.
in which (m=MWAVEX,n=NWAVEX,slope=SLOPEX) = (axial halfwaves,
circumferential halfwaves, slope of buckling nodal lines).
Please see ..doc/panda2.news Items 415 and 443 for details.

ANOTHER NOTE: In the following output there may also occur listings in the form:

Computation of fractional circumferential wavenumber, DNWAVE:
```

```
after knockdown factor=  9.3779E-01 for smeared stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      1.      3.  2.1122E+00
Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      1.      2.  2.2875E+00
Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      1.      4.  2.2609E+00
Fractional circumferential wavenumber,    DNWAVE=  4.1013E-02
```

"Fractional" wavenumbers, m+dm = MBAR + DMWAVE and n + dn = NBAR + DNWAVE, are used in PANDA2 in order to try to smooth the behavior with respect to buckling mode shape, (m,n,slope). The redistribution of stresses and stress resultants between panel skin and stiffener parts as an imperfect shell bends under loading depends upon the curvature changes and twist, Wxx, Wyy, Wxy, which involve the second derivatives of the mode shape and hence the products m^2, n^2, and m*n. If the critical buckling mode shape has few halfwaves (m,n), then Wxx, Wxy, Wxy change dramatically when m and/or n change by 1. This dramatic change causes a dramatic change in many of the stress and buckling constraints. Such changes give rise to very large constraint gradients and "jumpy" margins from design iteration to iteration, making it very difficult to find a "global" optimum design. The use of fractional wave numbers, DMWAVE and DNWAVE, smooths the constraints because a small change in the design leads to a correspondingly small change in MBAR + DMWAVE and NBAR + DNWAVE and thus a small change in Wxx, Wyy, Wxy at the design load.

In order to obtain a "fractional" wavenumbers, PANDA2 first computes buckling load factors for n, n-1, and n+1 with m fixed and for m, m-1, m+1 with n fixed, then uses parabolic interpolation for m,n to obtain the "fractional" wave numbers such as the quantity DNWAVE listed above. "Fractional" wave numbers are not computed unless the critical m and/or n are at least 3. Please see ..doc/panda2.news Items 125g, 367, 412 449, and 453 for more details about "fractional" wavenumbers.

A THIRD NOTE: In the following output there may also occur listings in the form:

```
***** Multiple Minima Eigenvalues: Two different mode shapes:
        [MWAVEX(1),NWAVEX(1)] and [MWAVEX(3),NWAVEX(3)] *****
Two buckling mode shapes for ILOADS,ICASE=  1  1
Axial halfwaves: first mode, MWAVEX(1)= 1; second mode, MWAVEX(3)= 7
Circ. halfwaves: first mode, NWAVEX(1)= 3; second mode, NWAVEX(3)= 1
JJJ+1,  eig2,         eig1,     (eig2-eig1)/abs(eig2-eig1)=
  1   2.5715E+00    2.2525E+00       1.0000E+00

***** Multiple Minima Eigenvalues vs Slope for Mode (M,N)=     1     3 *****
Normalized ratio, (eig2-eig1)/abs(eig2-eig1)= -1.0000E+00 for iteration no.  1
I,SLOPE,EIGENVALUE=  1  4.7076E-01  2.2526E+00
I,SLOPE,EIGENVALUE=  2  1.9665E+00  2.2476E+00
```

This output informs the user about potential abrupt changes in the critical general buckling mode shape with possibly very small changes in the design. The first seven lines have to do with possible abrupt changes in (m,n); the second four lines have to do with a possible abrupt change in the slope of the buckling nodal lines for given (m,n). Abrupt changes of either of these types from design iteration to iteration may cause "jumpy" margins and make it very difficult to determine a

```
"global" optimum design. See Item 596 in panda2.news for more.

Now start the "imperfection" section for general instability:

Buckling of PERFECT panel...
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7175    9150       0       0       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    7  0.000E+00  1.670E+00  1.100E+00
EIGTST needed for EIGRAT = EIGTST/EIGTS2: EIGTST=  1.6698E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    7  0.000E+00  1.670E+00  4.306E-01
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  1.6698E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.67E+00  1.67E+00  1.67E+00  1.00E+17  1.00E+17  1.67E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         0
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  4.31E-01  0.00E+00  0.00E+00  4.31E-01  0.00E+00

 ILABLY, ILABEL, IRMOD, MMSML, INOT4(IRMOD)=
  9150   7175      2      4      1
```

```
Axial/hoop bending stiffnesses, C44N/C55N=  3.6948E+00
Axial halfwavelength of buckle, AXLENG=  3.2500E+01
Rather than arbitrarily set the amplitude factor for
the growth of the buckling modal imperfection equal to
4.0 (WYYAMP = 4.0), which is ordinarily done for shells
under almost pure axial compression, the strategy
described in the PANDA2 news Item No. 662 will be pursued.
This strategy is thought to be valid because of one or
more of the following conditions:
 1. The critical number of axial halfwaves, m = 1.
 2. The axial bending stiffness is more than 2 times the
    hoop bending stiffness. (C44n/C55n > 2.0).
 3. The axial halfwavelength of the critical buckling mode
    is greater than or equal to the shell diameter.
The effect is to make optimum designs less conservative.


IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
MWAVE,NWAVE,CSLOPE,EIGVAL=     4     7  0.0000E+00  1.6698E+00
EIGVAL=  1.6698E+00 (before knockdown for smeared stringers
                     and before knockdown for t.s.d.
                     and before knockdown for smeared rings)

Computation of fractional circumferential wavenumber, DNWAVE:
after knockdown factor=  9.3779E-01 for smeared stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      4.       7.  1.5659E+00
Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      4.       6.  1.8284E+00
Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      4.       8.  1.6005E+00
Fractional circumferential wavenumber,    DNWAVE=  3.8347E-01

Corresponding slopes and knockdowns for smeared stringers:
Original slope CSLNW1 and knockdown SMRNW1=  0.0000E+00  9.3779E-01
Original slope CSLNW2 and knockdown SMRNW2=  0.0000E+00  9.3779E-01
Original slope CSLNW3 and knockdown SMRNW3=  0.0000E+00  9.3779E-01

Computation of fractional number of axial halfwaves, DMWAVE:
after knockdown factor=  9.3779E-01 for smearing stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXMW1=      4.       7.  1.5659E+00
Decrement in axial wavenumber,MBAR-1,NBAR,ESXMW2=      3.       7.  1.6617E+00
Increment in axial wavenumber,MBAR+1,NBAR,ESXMW3=      5.       7.  1.6529E+00
Fractional number of axial halfwaves,     DMWAVE=  2.4014E-02

********* NOTE ********* NOTE ********** NOTE *********
Factor by which general buckling modal imperfection
amplitude will be changed for the purpose of computing
the effective radius of curvature of the initially
imperfect and loaded panel, AXLRED =  2.4851E-01
Axial length in this model of the panel, A =   1.3000E+02
Axial halfwaves in critical general mode, MBAR+DMWAVE=  4.0240E+00
******* END NOTE ****** END NOTE ****** END NOTE *********


Halfwavenumbers m and n, nodal line slope, SLOPE, and eigenvalues
(NOTE: No knockdown factors have yet been applied)
  Axial    Circumf.  nodal line     eigenvalue
```

halfwaves	halfwaves	slope	from Sub. EIG1
1	1	0.0000E+00	0.0000E+00
1	2	0.0000E+00	0.0000E+00
1	3	0.0000E+00	0.0000E+00
1	4	0.0000E+00	0.0000E+00
1	5	0.0000E+00	0.0000E+00
1	6	0.0000E+00	0.0000E+00
1	7	0.0000E+00	0.0000E+00
1	8	0.0000E+00	0.0000E+00
1	9	0.0000E+00	0.0000E+00
1	10	0.0000E+00	0.0000E+00
1	11	0.0000E+00	0.0000E+00
1	12	0.0000E+00	0.0000E+00
1	13	0.0000E+00	0.0000E+00
1	14	0.0000E+00	0.0000E+00
1	15	0.0000E+00	0.0000E+00
1	16	0.0000E+00	0.0000E+00
1	17	0.0000E+00	0.0000E+00
1	18	0.0000E+00	0.0000E+00
1	19	0.0000E+00	0.0000E+00
1	20	0.0000E+00	0.0000E+00
2	1	0.0000E+00	0.0000E+00
2	2	0.0000E+00	0.0000E+00
2	3	0.0000E+00	0.0000E+00
2	4	0.0000E+00	0.0000E+00
2	5	0.0000E+00	0.0000E+00
2	6	0.0000E+00	0.0000E+00
2	7	0.0000E+00	0.0000E+00
2	8	0.0000E+00	0.0000E+00
2	9	0.0000E+00	0.0000E+00
2	10	0.0000E+00	0.0000E+00
2	11	0.0000E+00	0.0000E+00
2	12	0.0000E+00	0.0000E+00
2	13	0.0000E+00	0.0000E+00
2	14	0.0000E+00	0.0000E+00
2	15	0.0000E+00	0.0000E+00
2	16	0.0000E+00	0.0000E+00
2	17	0.0000E+00	0.0000E+00
2	18	0.0000E+00	0.0000E+00
2	19	0.0000E+00	0.0000E+00
2	20	0.0000E+00	0.0000E+00
3	1	0.0000E+00	0.0000E+00
3	2	0.0000E+00	0.0000E+00
3	3	0.0000E+00	0.0000E+00
3	4	0.0000E+00	0.0000E+00
3	5	0.0000E+00	0.0000E+00
3	6	0.0000E+00	0.0000E+00
3	7	0.0000E+00	0.0000E+00
3	8	0.0000E+00	0.0000E+00
3	9	0.0000E+00	0.0000E+00
3	10	0.0000E+00	0.0000E+00
3	11	0.0000E+00	0.0000E+00
3	12	0.0000E+00	0.0000E+00
3	13	0.0000E+00	0.0000E+00
3	14	0.0000E+00	0.0000E+00
3	15	0.0000E+00	0.0000E+00
3	16	0.0000E+00	0.0000E+00
3	17	0.0000E+00	0.0000E+00

3	18	0.0000E+00	0.0000E+00
3	19	0.0000E+00	0.0000E+00
3	20	0.0000E+00	0.0000E+00
4	1	0.0000E+00	0.0000E+00
4	2	0.0000E+00	0.0000E+00
4	3	0.0000E+00	0.0000E+00
4	4	0.0000E+00	0.0000E+00
4	5	0.0000E+00	0.0000E+00
4	6	0.0000E+00	0.0000E+00
4	7	0.0000E+00	0.0000E+00
4	8	0.0000E+00	0.0000E+00
4	9	0.0000E+00	0.0000E+00
4	10	0.0000E+00	0.0000E+00
4	11	0.0000E+00	0.0000E+00
4	12	0.0000E+00	0.0000E+00
4	13	0.0000E+00	0.0000E+00
4	14	0.0000E+00	0.0000E+00
4	15	0.0000E+00	0.0000E+00
4	16	0.0000E+00	0.0000E+00
4	17	0.0000E+00	0.0000E+00
4	18	0.0000E+00	0.0000E+00
4	19	0.0000E+00	0.0000E+00
4	20	0.0000E+00	0.0000E+00
5	1	0.0000E+00	0.0000E+00
5	2	0.0000E+00	0.0000E+00
5	3	0.0000E+00	0.0000E+00
5	4	0.0000E+00	0.0000E+00
5	5	0.0000E+00	0.0000E+00
5	6	0.0000E+00	0.0000E+00
5	7	0.0000E+00	0.0000E+00
5	8	0.0000E+00	0.0000E+00
5	9	0.0000E+00	0.0000E+00
5	10	0.0000E+00	0.0000E+00
5	11	0.0000E+00	0.0000E+00
5	12	0.0000E+00	0.0000E+00
5	13	0.0000E+00	0.0000E+00
5	14	0.0000E+00	0.0000E+00
5	15	0.0000E+00	0.0000E+00
5	16	0.0000E+00	0.0000E+00
5	17	0.0000E+00	0.0000E+00
5	18	0.0000E+00	0.0000E+00
5	19	0.0000E+00	0.0000E+00
5	20	0.0000E+00	0.0000E+00
6	1	0.0000E+00	0.0000E+00
6	2	0.0000E+00	0.0000E+00
6	3	0.0000E+00	0.0000E+00
6	4	0.0000E+00	0.0000E+00
6	5	0.0000E+00	0.0000E+00
6	6	0.0000E+00	0.0000E+00
6	7	0.0000E+00	0.0000E+00
6	8	0.0000E+00	0.0000E+00
6	9	0.0000E+00	0.0000E+00
6	10	0.0000E+00	0.0000E+00
6	11	0.0000E+00	0.0000E+00
6	12	0.0000E+00	0.0000E+00
6	13	0.0000E+00	0.0000E+00
6	14	0.0000E+00	0.0000E+00
6	15	0.0000E+00	0.0000E+00

6	16	0.0000E+00	0.0000E+00
6	17	0.0000E+00	0.0000E+00
6	18	0.0000E+00	0.0000E+00
6	19	0.0000E+00	0.0000E+00
6	20	0.0000E+00	0.0000E+00
7	1	0.0000E+00	0.0000E+00
7	2	0.0000E+00	0.0000E+00
7	3	0.0000E+00	0.0000E+00
7	4	0.0000E+00	0.0000E+00
7	5	0.0000E+00	0.0000E+00
7	6	0.0000E+00	0.0000E+00
7	7	0.0000E+00	0.0000E+00
7	8	0.0000E+00	0.0000E+00
7	9	0.0000E+00	0.0000E+00
7	10	0.0000E+00	0.0000E+00
7	11	0.0000E+00	0.0000E+00
7	12	0.0000E+00	0.0000E+00
7	13	0.0000E+00	0.0000E+00
7	14	0.0000E+00	0.0000E+00
7	15	0.0000E+00	0.0000E+00
7	16	0.0000E+00	0.0000E+00
7	17	0.0000E+00	0.0000E+00
7	18	0.0000E+00	0.0000E+00
7	19	0.0000E+00	0.0000E+00
7	20	0.0000E+00	0.0000E+00
8	1	0.0000E+00	0.0000E+00
8	2	0.0000E+00	0.0000E+00
8	3	0.0000E+00	0.0000E+00
8	4	0.0000E+00	0.0000E+00
8	5	0.0000E+00	0.0000E+00
8	6	0.0000E+00	0.0000E+00
8	7	0.0000E+00	0.0000E+00
8	8	0.0000E+00	0.0000E+00
8	9	0.0000E+00	0.0000E+00
8	10	0.0000E+00	0.0000E+00
8	11	0.0000E+00	0.0000E+00
8	12	0.0000E+00	0.0000E+00
8	13	0.0000E+00	0.0000E+00
8	14	0.0000E+00	0.0000E+00
8	15	0.0000E+00	0.0000E+00
8	16	0.0000E+00	0.0000E+00
8	17	0.0000E+00	0.0000E+00
8	18	0.0000E+00	0.0000E+00
8	19	0.0000E+00	0.0000E+00
8	20	0.0000E+00	0.0000E+00
9	1	0.0000E+00	0.0000E+00
9	2	0.0000E+00	0.0000E+00
9	3	0.0000E+00	0.0000E+00
9	4	0.0000E+00	0.0000E+00
9	5	0.0000E+00	0.0000E+00
9	6	0.0000E+00	0.0000E+00
9	7	0.0000E+00	0.0000E+00
9	8	0.0000E+00	0.0000E+00
9	9	0.0000E+00	0.0000E+00
9	10	0.0000E+00	0.0000E+00
9	11	0.0000E+00	0.0000E+00
9	12	0.0000E+00	0.0000E+00
9	13	0.0000E+00	0.0000E+00

```
     9        14     0.0000E+00     0.0000E+00
     9        15     0.0000E+00     0.0000E+00
     9        16     0.0000E+00     0.0000E+00
     9        17     0.0000E+00     0.0000E+00
     9        18     0.0000E+00     0.0000E+00
     9        19     0.0000E+00     0.0000E+00
     9        20     0.0000E+00     0.0000E+00
    10         1     0.0000E+00     0.0000E+00
    10         2     0.0000E+00     0.0000E+00
    10         3     0.0000E+00     0.0000E+00
    10         4     0.0000E+00     0.0000E+00
    10         5     0.0000E+00     0.0000E+00
    10         6     0.0000E+00     0.0000E+00
    10         7     0.0000E+00     0.0000E+00
    10         8     0.0000E+00     0.0000E+00
    10         9     0.0000E+00     0.0000E+00
    10        10     0.0000E+00     0.0000E+00
    10        11     0.0000E+00     0.0000E+00
    10        12     0.0000E+00     0.0000E+00
    10        13     0.0000E+00     0.0000E+00
    10        14     0.0000E+00     0.0000E+00
    10        15     0.0000E+00     0.0000E+00
    10        16     0.0000E+00     0.0000E+00
    10        17     0.0000E+00     0.0000E+00
    10        18     0.0000E+00     0.0000E+00
    10        19     0.0000E+00     0.0000E+00
    10        20     0.0000E+00     0.0000E+00

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  7.3835E+00  4.0240E+00  1.5462E+00
Original:  NBAR,       MBAR,       ESXNW1=  7.0000E+00  4.0000E+00  1.5659E+00
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
Knockdown for smeared stringers, SMROPT =   9.3779E-01

Final values of DMWAVE, DNWAVE on leaving GENSTB=  2.4014E-02  3.8347E-01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  9.3779E-01

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6488E+00  1.6698E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5759E+00  1.5950E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  1.4778E+00  1.4958E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
GENERAL BUCKLING EIGENV. OF PERFECT PANEL, IMOD= 0
  EILC91(m,dm,n,dn,s)=  1.4778E+00(  4, 2.401E-02,  7, 3.835E-01, 0.000E+00)
BUCKLING LOAD FACTOR WITHOUT FRACTIONAL WAVENUMBERS
AND INCLUDING THE FACTOR EIGTST/EIGTS2=EIGRAT=  1.0000E+00
  EIGVL9(m, 0,n, 0,s)=  1.4958E+00(  4,  7, 0.000E+00)
This eigenvalue is the factor EIGPAN used to
normalize the buckling load factors computed in
SUBROUTINE ARBOCZ

General buckling: smeared stiffeners, C11=  5.4530E+05 (PERFECT PANEL)
```

```
Entering ARBOCZ. Label=9150
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  1.4958E+00
IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9150    2    0  0.0000E+00
NOTE: The normalizer, EIGPAN, includes knockdown for smeared
stringers, but the "ARBOCZ" eigenvalues do not yet include it.
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
In ARBOCZ:
The eigenvalue corresponding to m=MMXCHK=  4 axial
halfwaves and n=  7 circ. halfwaves is critical and is
at the upper end of the final search for missed eigenvalues.
Therefore, we must continue the search over m >   4
EIGMNC=  1.12E+00  1.12E+00  1.12E+00  1.00E+17  1.00E+17  1.12E+00  1.00E+17
ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         0
NWAVEX=    7         7         7         0         0         7         0
TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
IN ARBOCZ: 9150: INDX= 2: R,L,CIRC,W0=-5.00E+01 1.30E+02 1.57E+02 0.00E+00
Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  3.5475E+00
Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  1.1163E+00

NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
 NORMALIZED buckling load factor neglecting trans.shear.def.=  1.1163E+00
 NORMALIZED buckling load factor including  trans.shear.def.=  1.0663E+00
 Buckling mode shape: axial m, hoop n, slope =    4    7  0.0000E+00
Leaving ARBOCZ.  Label=9150
Buckling load factor BEFORE knockdown for smeared stringers=  1.0663E+00
Buckling load factor AFTER  knockdown for smeared stringers=  1.0000E+00

General buckling: smeared stiffeners, C11=  5.4530E+05 (IMPERFECT PANEL)
Entering ARBOCZ. Label=9151
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  1.4958E+00
```

```
 IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9151    2    0  2.4851E-11
 NOTE: The normalizer, EIGPAN, includes knockdown for smeared
 stringers, but the "ARBOCZ" eigenvalues do not yet include it.
 Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
 In ARBOCZ:
 The eigenvalue corresponding to m=MMXCHK=  4 axial
 halfwaves and n=  7 circ. halfwaves is critical and is
 at the upper end of the final search for missed eigenvalues.
 Therefore, we must continue the search over m >   4
 EIGMNC=  1.12E+00  1.12E+00  1.12E+00  1.00E+17  1.00E+17  1.12E+00  1.00E+17
 ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    4         4         4         0         0         4         0
 NWAVEX=    7         7         7         0         0         7         0
 TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 IN ARBOCZ: 9151: INDX= 2: R,L,CIRC,W0=-5.00E+01 1.30E+02 1.57E+02 2.49E-11
 Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  3.5475E+00
 Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  1.1163E+00

 NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
  NORMALIZED buckling load factor neglecting trans.shear.def.=  1.1163E+00
  NORMALIZED buckling load factor including  trans.shear.def.=  1.0663E+00
  Buckling mode shape: axial m, hoop n, slope =    4    7  0.0000E+00
 Leaving ARBOCZ.  Label=9151
 Buckling load factor BEFORE knockdown for smeared stringers=  1.0663E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  1.0000E+00

 GENERAL BUCKLING FROM 1992 ARBOCZ EQ.(3.61)
 RATIO (LOAD FACTOR FROM ARBOCZ)/(LOAD FACTOR FROM PANDA2):
  Perfect shell general buckling load(m,n,slope)=  1.0000E+00(   4,   7, 0.00E+00)
  Imperf. shell general buckling load(m,n,slope)=  1.0000E+00(   4,   7, 0.00E+00)
  Knockdown factor from Koiter Special Theory (K.S.T.)=  1.0000E+00
  Knockdown from K.S.T. without the use of EIGMOD     =  1.0000E+00


 ************ ITERATION LOOP FOR IMPERFECT PANEL ***********
 Begin iteration loop for general buckling of the imperfect
 panel. The general imperfection is amplified by the factor
 WYYAMP, which increases from iteration to iteration.

 *************** ITERATION NUMBER  1 *****************

*** BEGIN BUCPAN (IMPERF. SENSITIVITY, IMPERFECT PANEL) ****
  LABEL NO. IN STRIMP= 9160
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9160     3     0     0  1.0000E+07

 general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
 Buckling of IMPERFECT panel...
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
```

```
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7175    9160      0       0       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    7  0.000E+00  1.670E+00  1.100E+00
EIGTST needed for EIGRAT = EIGTST/EIGTS2: EIGTST=  1.6698E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    7  0.000E+00  1.670E+00  4.306E-01
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  1.6698E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.67E+00  1.67E+00  1.67E+00  1.00E+17  1.00E+17  1.67E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         0
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  4.31E-01  0.00E+00  0.00E+00  4.31E-01  0.00E+00

IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
MWAVE,NWAVE,CSLOPE,EIGVAL=     4     7  0.0000E+00  1.6698E+00
EIGVAL=  1.6698E+00 (before knockdown for smeared stringers
                     and before knockdown for t.s.d.
                     and before knockdown for smeared rings)

Computation of fractional circumferential wavenumber, DNWAVE:
after knockdown factor=  9.3779E-01 for smeared stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      4.      7.  1.5659E+00
Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      4.      6.  1.8284E+00
```

```
Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      4.      8.  1.6005E+00
Fractional circumferential wavenumber,    DNWAVE=  3.8347E-01

Corresponding slopes and knockdowns for smeared stringers:
Original slope CSLNW1 and knockdown SMRNW1=  0.0000E+00  9.3779E-01
Original slope CSLNW2 and knockdown SMRNW2=  0.0000E+00  9.3779E-01
Original slope CSLNW3 and knockdown SMRNW3=  0.0000E+00  9.3779E-01

Computation of fractional number of axial halfwaves, DMWAVE:
after knockdown factor=  9.3779E-01 for smearing stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXMW1=      4.      7.  1.5659E+00
Decrement in axial wavenumber,MBAR-1,NBAR,ESXMW2=      3.      7.  1.6617E+00
Increment in axial wavenumber,MBAR+1,NBAR,ESXMW3=      5.      7.  1.6529E+00
Fractional number of axial halfwaves,     DMWAVE=  2.4014E-02

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  7.3835E+00  4.0240E+00  1.5462E+00
Original:  NBAR,       MBAR,       ESXNW1=  7.0000E+00  4.0000E+00  1.5659E+00
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
Knockdown for smeared stringers, SMROPT =   9.3779E-01

Final values of DMWAVE, DNWAVE on leaving GENSTB=  2.4014E-02  3.8347E-01
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  9.3779E-01

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6488E+00  1.6698E+00
Buckling load factor before t.s.d.=  1.6488E+00 After t.s.d.=  1.5759E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5759E+00  1.5950E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  1.4778E+00  1.4958E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
GENERAL BUCKLING EIGENV. OF IMPERFECT PANEL, IMOD= 0
  EILOC9(m,dm,n,dn,s)=  1.4778E+00(  4, 2.401E-02,  7, 3.835E-01, 0.000E+00)
IMPERFECTION AMPLITUDE FACTOR, WYYAMP=  3.0928E+00
EIGEFF =RNGKNZ*(FACIM1*EILOC9 +FACIM2*FMULT2*EILC91)/(FACIM1+FMULT2*FACIM2)=  1.4778E+00
in which FACIM1, FACIM2, and EILC91 are given by:
FACIM1=1./(EILOC9 - 1.) =  2.0928E+00
FACIM2=1./(EILC91 - 1.) =  2.0928E+00
EILC91                  =  1.4778E+00
FMULT2                  =  1.0000E+00
RNGKNZ                  =  1.0000E+00

*************** ITERATION NUMBER  2 *****************

*** NOTE: The number of circ. halfwaves in the general
          buckling mode of the PERFECT panel is less than or
          equal to that for the IMPERFECT panel. Therefore,
          the IMPERFECT panel mode is used for computation
          of deformations Wxx, Wyy, Wxy in SUBROUTINE CURIMP.
ICD91, ICD9  = indicators for coordinate direction
               in which panel is longest.
General buckling mode for the PERFECT panel (PANDA theory):
(m=  4, dm=  2.40E-02, n=  7, dn=  3.83E-01, slope=  0.00E+00, ICD91= 1)
```

```
 General buckling mode for the IMPERFECT panel (PANDA theory):
 (m=  4, dm=  2.40E-02, n=  7, dn=  3.83E-01, slope=  0.00E+00 ICD9= 1)
 (0.1 radian)/(shell wall rotation), AMPTST =  1.0000E+00

 General imperfection amplitude is modified because the
 critical buckling mode has a shorter axial halfwavelength
 than that specified by the user:            AXLINP=  1.3000E+02
 Critical buckling mode axial halfwavelength,AXLTST=  3.2306E+01
 Imperfection amplitude is reduced by factor,AMPMD9=  2.4851E-01

 QUANTITIES USED FOR OVERALL BENDING OF IMPERFECT PANEL
 (used for generation of WXX9,WYY9,WXY9), IMOD= 0:
  Amplitude of overall ovalization,              WG1=  0.0000E+00
  Amplitude of general buckling modal imperf.,AMWIMP=  0.0000E+00
  Effective load factor for general buckling, EIGEFF=  1.4778E+00
  Number of  axial halfwaves in general mode,      m=    4
  Fractional axial halfwaves in general mode,     dm=  2.4014E-02
  Number of  circ. halfwaves in general mode,      n=    7
  Fractional circ. halfwaves in general mode,     dn=  3.8347E-01
  Slope of nodal lines in general bucklng mode,slope=  0.0000E+00
  Additional amplitude factor,                FACIM3=  1.0000E+00
  Original imperfection is increased by 1/(EIGEFF-1)=  2.0928E+00
 Amplitude of prebuckling bending due to loading, WAMP=WIMP/(EIGEFF-1.)=  0.0000E+00 in
which
 WIMP = Amplitude of initial buckling modal imperfection=  0.0000E+00
 EIGEFF = effective buckling load factor=                 1.4778E+00



 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 10.2          *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 10.2: DESIGN PERTURBATION INDEX, IMOD=  0 ***

 *************************************************************
 CHAPTER 10.2 Compute knockdown factor and prebuckling bending
              associated with INTER-RING buckling modal
              initial imperfection.

 Entering imperfection section, PART 2...
  Inter-ring buckling of panel with stringers.
  Stringers are smeared out.

***** BEGIN SUBROUTINE STRCON (GET DELSKN FOR SS.BUCK.) ******
 DELSKN = change in stress resultants, dNx,dNy,dNxy, in the
          various segments of the skin-stringer module due to
          prebuckling bending of the imperfect panel or shell.
 Additional resultants (Nx,Ny) in panel skin from
 global bending of imperfect panel:
   Additional axial resultant, dNx =  0.0000E+00
   Additional  hoop resultant, dNy =  0.0000E+00
 *****  END  SUBROUTINE STRCON (GET DELSKN FOR SS.BUCK.) ******
*** BEGIN BUCPAN (IMPERF. SENSITIVITY FOR "PERFECT" PANEL) ***
```

```
(The effect of resultant redistribution, dNx, dNy, to panel
 skin caused by overall bending is included here, but the
 change in radius of curvature dR is not. dR is included later)
 LABEL NO. IN STRIMP= 9210
******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
 9210     5     0     0  1.0000E+07
IPRELM=    5  ILOWSS(IPRELM+1,30)=    0

inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7130    9210       0       0       3       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   18  0.000E+00  4.168E+00  1.090E-03
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  4.1676E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.17E+00  4.95E+00  4.17E+00  1.00E+17  1.00E+17  4.17E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   18        83        18         0         0        18         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00

 ILABLY, ILABEL, IRMOD, MMSML, INOT4(IRMOD)=
  9210   7130      3      1      1
Axial/hoop bending stiffnesses, C44N/C55N=  3.2634E+03
Axial halfwavelength of buckle, AXLENG=  9.7793E+00
Rather than arbitrarily set the amplitude factor for
the growth of the buckling modal imperfection equal to
4.0 (WYYAMP = 4.0), which is ordinarily done for shells
under almost pure axial compression, the strategy
described in the PANDA2 news Item No. 662 will be pursued.
This strategy is thought to be valid because of one or
more of the following conditions:
 1. The critical number of axial halfwaves, m = 1.
```

```
  2. The axial bending stiffness is more than 2 times the
     hoop bending stiffness. (C44n/C55n > 2.0).
  3. The axial halfwavelength of the critical buckling mode
     is greater than or equal to the shell diameter.
 The effect is to make optimum designs less conservative.


 IN GENSTB:
 Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

 Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
 MWAVE,NWAVE,CSLOPE,EIGVAL=     1    18  0.0000E+00  4.1676E+00
 EIGVAL=  4.1676E+00 (before knockdown for smeared stringers
                      and before knockdown for t.s.d.
                      and before knockdown for smeared rings)

 Computation of fractional circumferential wavenumber, DNWAVE:
 after knockdown factor=  5.1813E-01 for smeared stringers
 Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      1.     18.  2.1593E+00
 Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      1.     17.  2.1621E+00
 Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      1.     19.  2.1613E+00
 Fractional circumferential wavenumber,    DNWAVE=  8.3392E-02

 Corresponding slopes and knockdowns for smeared stringers:
 Original slope CSLNW1 and knockdown SMRNW1=  0.0000E+00  5.1813E-01
 Original slope CSLNW2 and knockdown SMRNW2=  0.0000E+00  5.1813E-01
 Original slope CSLNW3 and knockdown SMRNW3=  0.0000E+00  5.1813E-01

 Compare fractional waves, eigv. and original waves, eigv:
 Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  1.8083E+01  1.0000E+00  2.1593E+00
 Original:  NBAR,       MBAR,       ESXNW1=  1.8000E+01  1.0000E+00  2.1593E+00
 "Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
 Knockdown for smeared stringers, SMROPT =   5.1813E-01

 Final values of DMWAVE, DNWAVE on leaving GENSTB=  0.0000E+00  8.3392E-02
 Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06
 EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
 and/or rings, that is, before knockdown by the factor,  5.1813E-01

 If EIGVAL and EIGVLX are different:
 EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
 EIGVLX = original eigenvalue: no "fractional" refinement
 EIGVAL,EIGVLX before knockdown for t.s.d.=  4.1676E+00  4.1676E+00
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.9566E+00  3.9566E+00
 EIGVAL,EIGVLX after knockdown for smearing stringers=  2.0500E+00  2.0500E+00
               but before knockdown for smearing rings.
 EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

 inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R=  1.5738E+06
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7145    9210       0       0       3       1       0       1
```

```
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
               0     0    1   10  0.000E+00  4.231E+00  1.090E-03
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  4.2308E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.38E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0         1         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00

 ILABLY, ILABEL, IRMOD, MMSML, INOT4(IRMOD)=
  9210   7145      3      1      1
Axial/hoop bending stiffnesses, C44N/C55N=  3.2634E+03
Axial halfwavelength of buckle, AXLENG=  9.7793E+00
Rather than arbitrarily set the amplitude factor for
the growth of the buckling modal imperfection equal to
4.0 (WYYAMP = 4.0), which is ordinarily done for shells
under almost pure axial compression, the strategy
described in the PANDA2 news Item No. 662 will be pursued.
This strategy is thought to be valid because of one or
more of the following conditions:
 1. The critical number of axial halfwaves, m = 1.
 2. The axial bending stiffness is more than 2 times the
    hoop bending stiffness. (C44n/C55n > 2.0).
 3. The axial halfwavelength of the critical buckling mode
    is greater than or equal to the shell diameter.
The effect is to make optimum designs less conservative.


IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
MWAVE,NWAVE,CSLOPE,EIGVAL=     1    10  0.0000E+00  4.2308E+00
EIGVAL=  4.2308E+00 (before knockdown for smeared stringers
                     and before knockdown for t.s.d.
                     and before knockdown for smeared rings)

Computation of fractional circumferential wavenumber, DNWAVE:
after knockdown factor=  5.2132E-01 for smeared stringers
```

```
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      1.     10.  2.2056E+00
Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      1.      9.  2.2057E+00
Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      1.     11.  2.2090E+00
Fractional circumferential wavenumber,    DNWAVE= -4.6015E-01

Corresponding slopes and knockdowns for smeared stringers:
Original slope CSLNW1 and knockdown SMRNW1=  0.0000E+00  5.2132E-01
Original slope CSLNW2 and knockdown SMRNW2=  0.0000E+00  5.2132E-01
Original slope CSLNW3 and knockdown SMRNW3=  0.0000E+00  5.2132E-01

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  9.5398E+00  1.0000E+00  2.2052E+00
Original:  NBAR,       MBAR,       ESXNW1=  1.0000E+01  1.0000E+00  2.2056E+00
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
Knockdown for smeared stringers, SMROPT =   5.2132E-01

Final values of DMWAVE, DNWAVE on leaving GENSTB=  0.0000E+00 -4.6015E-01
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  5.2132E-01

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2301E+00  4.2308E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0129E+00  4.0135E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  2.0920E+00  2.0923E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

INTER-RING BUCKLING load factors and (axial, circumfer.) halfwaves:
Donnell theory is used for these buckling calculations in this case.
INTER-RING BUCKLING FROM PANDA-TYPE THEORY [1B]
   AFTER KNOCKDOWN FOR t.s.d. AND FOR SMEARED STRINGERS:
EIGSS =   2.0626E+00(m=   1,n=  18)
Inter-ring eigenvalue with panel as flat:
EIGSS2=   2.0936E+00(m=   1,n=  10)
IPRELM=    5  ILOWSS(IPRELM+1,30)=    1
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
INTER-RING BUCKLING EIGENV. OF "PERFECT" PANEL, IMOD= 0
  EILC81(m,dm,n,dn,s)=  2.0936E+00(  1, 0.000E+00, 10,-4.602E-01, 0.000E+00)
BUCKLING LOAD FACTOR WITHOUT FRACTIONAL WAVENUMBERS
AND INCLUDING THE FACTOR EIGTST/EIGTS2=EIGRAT=  1.0000E+00
  EIGVL8(m, 0,n, 0,s)=  2.0939E+00(  1, 10, 0.000E+00)
This eigenvalue is the factor EIGPAN used to
normalize the buckling load factors computed in
SUBROUTINE ARBOCZ

Inter-ring buckling: smeared stringers, C11=  5.4530E+05 (PERFECT PANEL)
Entering ARBOCZ. Label=9210
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
```

```
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  2.0939E+00
IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9210    3    0  0.0000E+00
NOTE: The normalizer, EIGPAN, includes knockdown for smeared
stringers, but the "ARBOCZ" eigenvalues do not yet include it.
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
EIGMNC=  1.99E+00  2.36E+00  1.99E+00  1.00E+17  1.00E+17  1.99E+00  1.00E+17
ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   18        83        18         0         0        18         0
TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
IN ARBOCZ: 9210: INDX= 3: R,L,CIRC,W0=-5.00E+01 9.78E+00 1.57E+02 0.00E+00
Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  2.9072E+00
Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  1.9903E+00

NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
 NORMALIZED buckling load factor neglecting trans.shear.def.=  1.9903E+00
 NORMALIZED buckling load factor including  trans.shear.def.=  1.8895E+00
 Buckling mode shape: axial m, hoop n, slope =    1   18  0.0000E+00
Leaving ARBOCZ. Label=9210
Buckling load factor BEFORE knockdown for smeared stringers=  1.8895E+00
Buckling load factor AFTER  knockdown for smeared stringers=  9.8506E-01

Inter-ring buckling: smeared stringers, C11=  5.4530E+05 (IMPERFECT PANEL)
Entering ARBOCZ. Label=9211
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  2.0939E+00
IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9211    3    0  1.0000E-10
NOTE: The normalizer, EIGPAN, includes knockdown for smeared
stringers, but the "ARBOCZ" eigenvalues do not yet include it.
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
EIGMNC=  1.99E+00  2.36E+00  1.99E+00  1.00E+17  1.00E+17  1.99E+00  1.00E+17
ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   18        83        18         0         0        18         0
TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
IN ARBOCZ: 9211: INDX= 3: R,L,CIRC,W0=-5.00E+01 9.78E+00 1.57E+02 1.00E-10
Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  2.9072E+00
```

```
Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  1.9903E+00

NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
 NORMALIZED buckling load factor neglecting trans.shear.def.=  1.9903E+00
 NORMALIZED buckling load factor including  trans.shear.def.=  1.8895E+00
 Buckling mode shape: axial m, hoop n, slope =    1   18  0.0000E+00
Leaving ARBOCZ.  Label=9211
Buckling load factor BEFORE knockdown for smeared stringers=  1.8895E+00
Buckling load factor AFTER  knockdown for smeared stringers=  9.8506E-01

Inter-ring buckling: smeared stringers, C11=  5.4530E+05 ("FLAT" PANEL)
Entering ARBOCZ. Label=9210
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  2.0939E+00
IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9210    3    0  0.0000E+00
NOTE: The normalizer, EIGPAN, includes knockdown for smeared
stringers, but the "ARBOCZ" eigenvalues do not yet include it.
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
EIGMNC=  2.02E+00  2.41E+00  2.02E+00  1.00E+17  1.00E+17  2.02E+00  1.00E+17
ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        83        10         0         0        10         0
TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
IN ARBOCZ: 9210: INDX= 3: R,L,CIRC,W0=-5.00E+03 9.78E+00 1.57E+02 0.00E+00
Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  2.0964E+00
Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  2.0200E+00

NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
 NORMALIZED buckling load factor neglecting trans.shear.def.=  2.0200E+00
 NORMALIZED buckling load factor including  trans.shear.def.=  1.9163E+00
 Buckling mode shape: axial m, hoop n, slope =    1   10  0.0000E+00
Leaving ARBOCZ.  Label=9210
Buckling load factor BEFORE knockdown for smeared stromgers=  1.9163E+00
Buckling load factor AFTER  knockdown for smeared stringers=  9.9977E-01

INTER-RING BUCKLING LOAD FACTORS FROM
 THE ARBOCZ EQUATIONS FOR THE FOLLOWING PANELS:
  CURVED  PERFECT  PANEL: EIG8X=  9.8506E-01
  CURVED IMPERFECT PANEL: EIG8Y=  9.8506E-01
   FLAT   PERFECT  PANEL: EIG8Z=  9.9977E-01
THE ARBOCZ KNOCKDOWN FACTOR IS COMPUTED WITH USE
OF THE MAXIMUM OF EIG8Y AND EIG8Z.
"FLAT" eigenvalue > "curved", IFLT8A= 1
```

```
 INTER-RING BUCKLING FROM 1992 ARBOCZ EQ.(3.61)
 RATIO (LOAD FACTOR FROM ARBOCZ)/(LOAD FACTOR FROM PANDA2):
  Perfect shell inter-ring buck. load(m,n,slope)=  9.8506E-01(  1, 18, 0.00E+00)
  Imperf. shell inter-ring buck. load(m,n,slope)=  9.9977E-01(  1, 10, 0.00E+00)
  Knockdown factor from Koiter Special Theory (K.S.T.)=  1.0000E+00
  Knockdown from K.S.T. without the use of EIGMOD     =  1.0000E+00


 ************ ITERATION LOOP FOR IMPERFECT PANEL ***********
 Begin iteration loop for inter-ring buckling of the imperfect
 panel. The inter-ring imperfection is amplified by the factor
 WYYAMP, which increases from iteration to iteration.

 *************** ITERATION NUMBER  1 *****************

*** BEGIN BUCPAN (IMPERF. SENSITIVITY FOR IMPERFECT PANEL) ***
  LABEL NO. IN STRIMP= 9220
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9220     5     0     0  1.0000E+07
 IPRELM=    5  ILOWSS(IPRELM+1,31)=    0

 inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7130    9220       0       0       3       1       0       0
  Radius  R,   Axial length, A,   Width  B
 -5.000000E+01  9.779300E+00  1.570800E+02
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
 Out-of-roundness,                   WG1  =  0.0000E+00
 General buckling modal,             WG2  =  0.0000E+00
 Inter-ring buckling modal,         W0PAN =  1.0000E-10
 Local buckling modal,              W0LOC =  1.0000E-07
 ***** Donnell theory is used in this section (ISAND=0)
 Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
  5.4530E+05  8.0382E+04  0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04
 ***(low-n)***
 (high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   18  0.000E+00  4.168E+00  1.090E-03
 EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  4.1676E+00
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 EIGMNC=  4.17E+00  4.95E+00  4.17E+00  1.00E+17  1.00E+17  4.17E+00  1.00E+17
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    1         1         1         0         0         1         0
 NWAVEX=   18        83        18         0         0        18         0
 TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
```

```
IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
MWAVE,NWAVE,CSLOPE,EIGVAL=     1    18  0.0000E+00  4.1676E+00
EIGVAL=  4.1676E+00 (before knockdown for smeared stringers
                     and before knockdown for t.s.d.
                     and before knockdown for smeared rings)

Computation of fractional circumferential wavenumber, DNWAVE:
after knockdown factor=  5.2172E-01 for smeared stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      1.     18.  2.1743E+00
Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      1.     17.  2.1771E+00
Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      1.     19.  2.1763E+00
Fractional circumferential wavenumber,    DNWAVE=  8.3387E-02

Corresponding slopes and knockdowns for smeared stringers:
Original slope CSLNW1 and knockdown SMRNW1=  0.0000E+00  5.2172E-01
Original slope CSLNW2 and knockdown SMRNW2=  0.0000E+00  5.2172E-01
Original slope CSLNW3 and knockdown SMRNW3=  0.0000E+00  5.2172E-01

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  1.8083E+01  1.0000E+00  2.1743E+00
Original:  NBAR,       MBAR,       ESXNW1=  1.8000E+01  1.0000E+00  2.1743E+00
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
Knockdown for smeared stringers, SMROPT =   5.2172E-01

Final values of DMWAVE, DNWAVE on leaving GENSTB=  0.0000E+00  8.3387E-02
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  5.2172E-01

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.1676E+00  4.1676E+00
Buckling load factor before t.s.d.=  4.1676E+00 After t.s.d.=  3.9566E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.9566E+00  3.9566E+00
EIGVAL,EIGVLX after knockdown for smearing stringers=  2.0642E+00  2.0642E+00
              but before knockdown for smearing rings.
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R=  1.5738E+06
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7145    9220       0       0       3       1       0       1
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
```

```
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s       EIGENVALUE  TEST
                0     0    1   10  0.000E+00  4.231E+00  1.090E-03
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  4.2308E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.38E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0         1         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00

IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
MWAVE,NWAVE,CSLOPE,EIGVAL=     1    10  0.0000E+00  4.2308E+00
EIGVAL=  4.2308E+00 (before knockdown for smeared stringers
                     and before knockdown for t.s.d.
                     and before knockdown for smeared rings)

Computation of fractional circumferential wavenumber, DNWAVE:
after knockdown factor=  5.2132E-01 for smeared stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXNW1=      1.     10.  2.2056E+00
Decrement in circ. wavenumber,MBAR,NBAR-1,ESXNW2=      1.      9.  2.2057E+00
Increment in circ. wavenumber,MBAR,NBAR+1,ESXNW3=      1.     11.  2.2090E+00
Fractional circumferential wavenumber,    DNWAVE= -4.6015E-01

Corresponding slopes and knockdowns for smeared stringers:
Original slope CSLNW1 and knockdown SMRNW1=  0.0000E+00  5.2132E-01
Original slope CSLNW2 and knockdown SMRNW2=  0.0000E+00  5.2132E-01
Original slope CSLNW3 and knockdown SMRNW3=  0.0000E+00  5.2132E-01

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  9.5398E+00  1.0000E+00  2.2052E+00
Original:  NBAR,       MBAR,       ESXNW1=  1.0000E+01  1.0000E+00  2.2056E+00
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
Knockdown for smeared stringers, SMROPT =   5.2132E-01

Final values of DMWAVE, DNWAVE on leaving GENSTB=  0.0000E+00 -4.6015E-01
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06
EIGVAL,EIGVLX are eigenvalues before knockdown for smearing the stringers
and/or rings, that is, before knockdown by the factor,  5.2132E-01

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
```

```
 EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2301E+00  4.2308E+00
 Buckling load factor before t.s.d.=  4.2301E+00 After t.s.d.=  4.0129E+00
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0129E+00  4.0135E+00
 EIGVAL,EIGVLX after knockdown for smearing stringers=  2.0920E+00  2.0923E+00
               but before knockdown for smearing rings.
 EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

 INTER-RING BUCKLING load factors and (axial, circumfer.) halfwaves:
 Donnell theory is used for these buckling calculations in this case.
 INTER-RING BUCKLING FROM PANDA-TYPE THEORY [1B]
    AFTER KNOCKDOWN FOR t.s.d. AND FOR SMEARED STRINGERS:
 EIGSS =   2.0626E+00(m=   1,n=  18)
 Inter-ring eigenvalue with panel as flat:
 EIGSS2=   2.0936E+00(m=   1,n=  10)
 IPRELM=    5  ILOWSS(IPRELM+1,31)=    1
 ******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
 INTER-RING BUCKLING EIGENV. OF IMPERFECT PANEL, IMOD= 0
   EILOC8(m,dm,n,dn,s)=  2.0936E+00(  1, 0.000E+00, 10,-4.602E-01, 0.000E+00)
 INTER-RING IMPERFECTION AMPLITUDE FACTOR, WYYAMP=  1.9144E+00
 EIGEFF =FACIM1*EILOC8 +FACIM2*FMULT2*EILC81)/(FACIM1+FMULT2*FACIM2)=  2.0936E+00
 in which FACIM1, FACIM2, and EILC81 are given by:
 FACIM1=1./(EILOC8 - 1.) =  9.1441E-01
 FACIM2=1./(EILC81 - 1.) =  9.1441E-01
 EILC81                  =  2.0936E+00
 FMULT2                  =  1.0000E+00

 *************** ITERATION NUMBER  2 *****************
 *** END BUCPAN (IMPERF. SENSITIVITY FOR SMEARED STRINGERS) *****

 *** NOTE: The number of circ. halfwaves in the inter-ring
           buckling mode of the PERFECT panel is less than or
           equal to that for the IMPERFECT panel. Therefore,
           the IMPERFECT panel mode is used for computation
           of deformations Wxx, Wyy, Wxy in SUBROUTINE CURIMP.
 ICD81, ICD8  = indicators for coordinate direction
                in which the inter-ring portion of the
                panel is longest.
 Inter-ring buckling mode for the PERFECT panel (PANDA theory):
 (m=  1, dm=  0.00E+00, n= 10, dn= -4.60E-01, slope=  0.00E+00, ICD81= 1)
 Inter-ring buckling mode for IMPERFECT panel (PANDA theory):
 (m=  1, dm=  0.00E+00, n= 10, dn= -4.60E-01, slope=  0.00E+00 ICD8= 1)

 (0.1 radian)/(shell wall rotation), AMPTST =  3.1128E+09
 QUANTITIES USED FOR INTER-RING BENDING OF IMPERFECT PANEL
 (used for generation of WXX8,WYY8,WXY8), IMOD= 0:
  Amplitude of overall ovalization,              WG1=  0.0000E+00
  Amplitude of inter-ring buckling modal imp.,AMWIMP= -1.0000E-10
  Effective load factor for inter-ring buck., EIGEFF=  2.0936E+00
  Number of  axial halfwaves in inter-ring mode,   m=    1
  Fractional axial halfwaves in inter-ring mode,  dm=  0.0000E+00
  Number of  circ. halfwaves in inter-ring mode,   n=   10
  Fractional circ. halfwaves in inter-ring mode,  dn= -4.6015E-01
  Slope of nodal lines in inter-ring buck.mode,slope=  0.0000E+00
  Additional amplitude factor,                FACIM3=  1.0000E+00
  Original imperfection is increased by 1/(EIGEFF-1)=  9.1441E-01
 Amplitude of prebuckling bending due to loading, WAMP=WIMP/(EIGEFF-1.)=  9.1441E-11 in
which
 WIMP = Amplitude of initial buckling modal imperfection=  1.0000E-10
```

```
 EIGEFF = effective buckling load factor=                  2.0936E+00

 ********* NOTE ********* NOTE ********** NOTE *********
 Prebuckling bending and twist from inter-ring imperfection growth:
    Wxx8,Wyy8,Wxy8,ICD8= -9.4368E-12 -3.3288E-12 -5.6047E-12    1
 ******************************************************

***** BEGIN SUBROUTINE STRCON (GET DELFCE FOR WEB SHEAR) ****
 *****  END  SUBROUTINE STRCON (GET DELFCE FOR WEB SHEAR) ****

*** BEGIN BUCPAN (GET KNOCKDOWN FACTS. FOR SHEARING OF WEBS) ***
  LABEL NO. IN STRIMP= 9230
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9230     6     0     0  1.0000E+07
 ******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
 *** END BUCPAN (GET KNOCKDOWN FACTORS FOR SHEARING OF WEBS) ***




 ***************************************************************
 ***************************************************************
 ***************************************************************
 ************          CHAPTER 10.3          *****************
 ***************************************************************
 ***************************************************************
 ***************************************************************
 **** CHAPTER 10.3: DESIGN PERTURBATION INDEX, IMOD=  0 ***

 **************************************************************
 CHAPTER 10.3 Compute knockdown factor and prebuckling bending
              associated with LOCAL buckling modal initial
              imperfection.

 Entering imperfection section, PART 3...
  Local buckling of panel between stringers and rings.
  General buckling if there are no stiffeners.

***** BEGIN SUBROUTINE STRCON (GET DELSKN FOR LOC.BUCK.) ******
 DELSKN = change in stress resultants, dNx,dNy,dNxy, in the
          various segments of the skin-stringer module due to
          prebuckling bending of the imperfect panel or shell.
 Additional resultants (Nx,Ny) in panel skin from
 global and inter-ring bending of imperfect panel:
   Additional axial resultant, dNx = -5.0985E-07
   Additional  hoop resultant, dNy =  0.0000E+00
 *****  END  SUBROUTINE STRCON (GET DELSKN FOR LOC.BUCK.) ******
*** BEGIN BUCPAN (IMPERF. SENSITIVITY FOR "PERFECT" PANEL) ***
   (The effect of resultant redistribution, dNx, dNy, to panel
    skin caused by overall bending and inter-ring bending
    is included here, but the change in radius of curvature dR
    is not. dR is included later.)
  LABEL NO. IN STRIMP= 9240
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9240     4     0     0  1.0000E+07
```

```
Local buckling, C11=  2.6794E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7010    9240       0       0       1       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  2.470500E+00
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 2.6794E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    1  0.000E+00  2.015E-01  3.315E+00
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  2.0147E-01
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  2.48E-01  1.00E+17  2.01E-01  1.00E+17  2.01E-01  2.01E-01  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    2         0         4         0         4         4         0
NWAVEX=    1         0         1         0         1         1         0
TESTX =  3.31E+00  0.00E+00  3.31E+00  0.00E+00  3.31E+00  3.31E+00  0.00E+00

 ILABLY, ILABEL, IRMOD, MMSML, INOT4(IRMOD)=
  9240   7010      1      4      0
Axial/hoop bending stiffnesses, C44N/C55N=  1.0000E+00
Axial halfwavelength of buckle, AXLENG=  2.4448E+00

IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0000E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  0.0000E+00
MWAVE,NWAVE,CSLOPE,EIGVAL=     4     1  0.0000E+00  2.0147E-01

Computation of fractional number of axial halfwaves, DMWAVE:
after knockdown factor=  1.0000E+00 for smearing stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXMW1=      4.      1.  2.0147E-01
Decrement in axial wavenumber,MBAR-1,NBAR,ESXMW2=      3.      1.  2.0504E-01
Increment in axial wavenumber,MBAR+1,NBAR,ESXMW3=      5.      1.  2.1302E-01
Fractional number of axial halfwaves,     DMWAVE= -2.6389E-01

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  1.0000E+00  3.7361E+00  2.0052E-01
Original:  NBAR,       MBAR,       ESXNW1=  1.0000E+00  4.0000E+00  2.2056E+00
```

```
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
Knockdown for smeared stringers, SMROPT =   1.0000E+00

Final values of DMWAVE, DNWAVE on leaving GENSTB= -2.6389E-01  0.0000E+00
Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  2.0052E-01  2.0147E-01
EIGVAL,EIGVLX after  knockdown for t.s.d.=  2.0028E-01  2.0123E-01
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

Donnell theory is used for these buckling calculations in this case.
Local buckling load factors & mode shapes before any knockdown factors applied:
EIGMNC=  2.48E-01  1.00E+17  2.01E-01  1.00E+17  2.01E-01  2.01E-01  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    2         0         4         0         4         4         0
NWAVEX=    1         0         1         0         1         1         0
NOTE: The buckling nodal line slopes, SLOPEX, are as
defined in Fig. 9a or Fig. 9b of the 1987 "Theoretical
basis of the PANDA...",if NWAVEX > 0; that is, there
has not yet been any inversion of SLOPEX when 9b holds.

LOCAL BUCKLING FROM PANDA-TYPE THEORY [1B] AFTER KNOCKDOWN FOR t.s.d.:
EIGLOC =   2.0028E-01(m=   4,n=   1)
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
LOCAL BUCKLING EIGENV. OF "PERFECT" PANEL, IMOD= 0
  EILC71(m,dm,n,dn,s)=  2.0028E-01(  4,-2.639E-01,  1, 0.000E+00, 0.000E+00)
BUCKLING LOAD FACTOR WITHOUT FRACTIONAL WAVENUMBERS
AND INCLUDING THE FACTOR EIGTST/EIGTS2=EIGRAT=  1.0000E+00
  EIGVL7(m, 0,n, 0,s)=  2.0123E-01(  4,  1, 0.000E+00)
This eigenvalue is the factor EIGPAN used to
normalize the buckling load factors computed in
SUBROUTINE ARBOCZ

Local buckling: C11=  2.6794E+05 (PERFECT PANEL)
Eigenvalue from PANDA-type theory, EIGVL7=  2.0123E-01
Entering ARBOCZ. Label=9240
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  2.0123E-01
IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9240    1    0  0.0000E+00
NOTE: The normalizer, EIGPAN, includes knockdown for smeared
stringers, but the "ARBOCZ" eigenvalues do not yet include it.
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
```

```
EIGMNC=  1.02E+00  1.00E+17  1.00E+00  1.00E+17  1.00E+00  1.00E+00  1.00E+17
ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
SLOPEX=  8.17E-01  0.00E+00  1.00E-02  0.00E+00  0.00E+00  1.00E-02  0.00E+00
MWAVEX=    1         0         4         0         4         4         0
NWAVEX=    1         0         1         0         1         1         0
TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
IN ARBOCZ: 9240: INDX= 1: R,L,CIRC,W0=-5.00E+01 9.78E+00 2.47E+00 0.00E+00
Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  7.5625E-01
Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  1.0011E+00

NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
 NORMALIZED buckling load factor neglecting trans.shear.def.=  1.0011E+00
 NORMALIZED buckling load factor including  trans.shear.def.=  9.9988E-01
 Buckling mode shape: axial m, hoop n, slope =    4    1  1.0000E-02
Leaving ARBOCZ.  Label=9240

Local buckling: C11=  2.6794E+05 ("FLAT" PANEL)
Entering ARBOCZ. Label=9241
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
initial imperfections on shell stability - an updated review"
by Johann Arbocz, Faculty of Aerospace Engineering, Delft
University of Technology, Report LR-695, Sept. 1992. In
particular, see Equation No. (3.61).
"ARBOCZ" theory is described in the AIAA paper 96-1337-CP
D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
NOTE: Eigenvalues are NORMALIZED by the buckling load from
       the PANDA-type theory computed in SUBROUTINE GENSTB,
       that is, by the load factor EIGPAN =  2.0123E-01
IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9241    1    0  0.0000E+00
NOTE: The normalizer, EIGPAN, includes knockdown for smeared
stringers, but the "ARBOCZ" eigenvalues do not yet include it.
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
EIGMNC=  8.83E-01  1.00E+17  8.49E-01  1.00E+17  8.49E-01  8.49E-01  1.00E+17
ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
SLOPEX=  8.17E-01  0.00E+00  1.00E-02  0.00E+00  0.00E+00  1.00E-02  0.00E+00
MWAVEX=    1         0         4         0         4         4         0
NWAVEX=    1         0         1         0         1         1         0
TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
IN ARBOCZ: 9241: INDX= 1: R,L,CIRC,W0=-5.00E+03 9.78E+00 2.47E+00 0.00E+00
Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  1.5230E-02
Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  8.4907E-01

NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
 NORMALIZED buckling load factor neglecting trans.shear.def.=  8.4907E-01
 NORMALIZED buckling load factor including  trans.shear.def.=  8.4820E-01
 Buckling mode shape: axial m, hoop n, slope =    4    1  1.0000E-02
Leaving ARBOCZ.  Label=9241

Local buckling: C11=  2.6794E+05 (IMPERFECT PANEL)
Entering ARBOCZ. Label=9242
*********** ENTERING ARBOCZ: "ARBOCZ" theory ***********
THE PURPOSE IS TO FIND BUCKLING LOAD OF AN AXISYMMETRICALLY
IMPERFECT CYLINDRICAL SHELL. Equations are from "The effect of
```

```
 initial imperfections on shell stability - an updated review"
 by Johann Arbocz, Faculty of Aerospace Engineering, Delft
 University of Technology, Report LR-695, Sept. 1992. In
 particular, see Equation No. (3.61).
 "ARBOCZ" theory is described in the AIAA paper 96-1337-CP
 D. Bushnell, "Recent enhancements to PANDA2", Proc. 37th AIAA
 SDM Meeting, pp 126-182, 1996. See especially pp. 131-136.
 NOTE: Eigenvalues are NORMALIZED by the buckling load from
        the PANDA-type theory computed in SUBROUTINE GENSTB,
        that is, by the load factor EIGPAN =  2.0123E-01
 IN ARBOCZ: ILABEL,INDX,NPRNT,W0= 9242    1    0  1.0000E-07
 NOTE: The normalizer, EIGPAN, includes knockdown for smeared
 stringers, but the "ARBOCZ" eigenvalues do not yet include it.
 Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 NORMALIZED eigenvalues, EIGMNC, EIGAXY; modes, SLOPEX,MWAVEX NWAVEX from ARBOCZ theory:
 EIGMNC=  1.02E+00  1.00E+17  1.00E+00  1.00E+17  1.00E+00  1.00E+00  1.00E+17
 ERATIO=  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
 SLOPEX=  8.17E-01  0.00E+00  1.00E-02  0.00E+00  0.00E+00  1.00E-02  0.00E+00
 MWAVEX=    1         0         4         0         4         4         0
 NWAVEX=    1         0         1         0         1         1         0
 TESTX =  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 IN ARBOCZ: 9242: INDX= 1: R,L,CIRC,W0=-5.00E+01 9.78E+00 2.47E+00 1.00E-07
 Axisymmetric NORMALIZED eigenvalue of perfect shell,  Nxcrit=  1.5230E-02
 Critical NORMALIZED eigenvalue with use of Eq.(3.61), EIGVAL=  1.0011E+00

 NORMALIZED BUCKLING LOAD FACTORS FROM ARBOCZ THEORY:
  NORMALIZED buckling load factor neglecting trans.shear.def.=  1.0011E+00
  NORMALIZED buckling load factor including  trans.shear.def.=  9.9988E-01
  Buckling mode shape: axial m, hoop n, slope =    4    1  1.0000E-02
 Leaving ARBOCZ.  Label=9242

 LOCAL BUCKLING LOAD FACTORS FROM THE
  ARBOCZ EQUATIONS FOR THE FOLLOWING PANELS:
   CURVED  PERFECT  PANEL: EIG7X=  9.9988E-01
   CURVED IMPERFECT PANEL: EIG7Y=  9.9988E-01
    FLAT   PERFECT  PANEL: EIG7Z=  8.4820E-01
 THE ARBOCZ KNOCKDOWN FACTOR IS COMPUTED WITH USE
 OF THE MAXIMUM OF EIG7Y AND EIG7Z.

 LOCAL BUCKLING FROM 1992 ARBOCZ EQ.(3.61)
 RATIO (LOAD FACTOR FROM ARBOCZ)/(LOAD FACTOR FROM PANDA2):
  Perfect shell  local  buckling load(m,n,slope)=  9.9988E-01(  4,  1, 1.00E-02)
  Imperf. shell  local  buckling load(m,n,slope)=  9.9988E-01(  4,  1, 1.00E-02)
  Knockdown factor from Koiter Special Theory   =  1.0000E+00
 LOCAL IMPERFECTION AMPLITUDE FACTOR, WYYAMP=  0.0000E+00


 ************ ITERATION LOOP FOR IMPERFECT PANEL ***********
 Begin iteration loop for local buckling of the imperfect
 panel. The local imperfection is amplified by the factor
 WYYAMP, which increases from iteration to iteration.

 *************** ITERATION NUMBER  1 *****************

**** BEGIN BUCPAN (IMPERF. SENSITIVITY FOR IMPERFECT PANEL) ****

 IMPERFECT LOCAL BUCKLING, ITERATION NO. 1, LABEL NO.=9251
```

```
******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
 9251     4     0     0  1.0000E+07

Local buckling, C11=  2.6794E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7010    9251       0       0       1       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  2.470500E+00
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 2.6794E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    1  0.000E+00  2.015E-01  3.315E+00
EIGTS2 needed for EIGRAT = EIGTST/EIGTS2: EIGTS2=  2.0147E-01
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  2.48E-01  1.00E+17  2.01E-01  1.00E+17  2.01E-01  2.01E-01  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    2         0         4         0         4         4         0
NWAVEX=    1         0         1         0         1         1         0
TESTX =  3.31E+00  0.00E+00  3.31E+00  0.00E+00  3.31E+00  3.31E+00  0.00E+00

IN GENSTB:
Radius of curvature computed from RADWAV ******** R(radwav)= -5.0002E+01 *********

Change in curvature: ABS(1./RORIG) - ABS(1./R(radwav))=  6.4695E-07
MWAVE,NWAVE,CSLOPE,EIGVAL=     4     1  0.0000E+00  2.0147E-01

Computation of fractional number of axial halfwaves, DMWAVE:
after knockdown factor=  1.0000E+00 for smearing stringers
Orig. crit. waves and eigenv.,MBAR,NBAR,  ESXMW1=      4.       1.  2.0147E-01
Decrement in axial wavenumber,MBAR-1,NBAR,ESXMW2=      3.       1.  2.0504E-01
Increment in axial wavenumber,MBAR+1,NBAR,ESXMW3=      5.       1.  2.1301E-01
Fractional number of axial halfwaves,     DMWAVE= -2.6388E-01

Compare fractional waves, eigv. and original waves, eigv:
Fractional:NBAR+DNWAVE,MBAR+DMWAVE,EIGOPT=  1.0000E+00  3.7361E+00  2.0051E-01
Original:  NBAR,       MBAR,       ESXNW1=  1.0000E+00  4.0000E+00  2.2056E+00
"Fractional" slope=, CSLTRY=  0.0000E+00; "Original" slope=, CSLTRS=  0.0000E+00
```

```
Knockdown for smeared stringers, SMROPT =   1.0000E+00

Final values of DMWAVE, DNWAVE on leaving GENSTB= -2.6388E-01  0.0000E+00
Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  2.0051E-01  2.0147E-01
EIGVAL,EIGVLX after  knockdown for t.s.d.=  2.0027E-01  2.0122E-01
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

Donnell theory is used for these buckling calculations in this case.
Local buckling load factors & mode shapes before any knockdown factors applied:
EIGMNC=  2.48E-01  1.00E+17  2.01E-01  1.00E+17  2.01E-01  2.01E-01  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    2         0         4         0         4         4         0
NWAVEX=    1         0         1         0         1         1         0
NOTE: The buckling nodal line slopes, SLOPEX, are as
defined in Fig. 9a or Fig. 9b of the 1987 "Theoretical
basis of the PANDA...",if NWAVEX > 0; that is, there
has not yet been any inversion of SLOPEX when 9b holds.

LOCAL BUCKLING FROM PANDA-TYPE THEORY [1B] AFTER KNOCKDOWN FOR t.s.d.:
EIGLOC =   2.0027E-01(m=   4,n=   1)
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
LOCAL BUCKLING EIGENV. OF IMPERFECT PANEL, IMOD= 0
  EILOC7(m,dm,n,dn,s)=  2.0027E-01(  4,-2.639E-01,  1, 0.000E+00, 0.000E+00)
LOCAL IMPERFECTION AMPLITUDE FACTOR, WYYAMP=  4.0000E+00
EIGEFF =(FACIM1*EILOC7 +FACIM2*FMULT2*EILC71)/(FACIM1+FMULT2*FACIM2)=  2.0027E-01
in which FACIM1, FACIM2, and EILC71 are given by:
FACIM1=1./(EILOC7 - 1.) =  1.0000E+02
FACIM2=1./(EILC71 - 1.) =  1.0000E+02
EILC71                  =  2.0028E-01
FMULT2                  =  1.0000E+00
**** END BUCPAN (IMPERF. SENSITIVITY FOR LOCAL BUCKLING) *******

*** NOTE: The number of circ. halfwaves in the local
          buckling mode of the PERFECT panel is less than or
          equal to that for the IMPERFECT panel. Therefore,
          the IMPERFECT panel mode is used for computation
          of deformations Wxx, Wyy, Wxy in SUBROUTINE CURIMP.
ICD71, ICD7  = indicators for coordinate direction
               in which the "local" portion of the
               panel is longest.
Local buckling mode for the PERFECT panel (PANDA theory):
(m=  4, dm= -2.64E-01, n=  1, dn=  0.00E+00, slope=  0.00E+00, ICD71= 1)
Inter-ring buckling mode for IMPERFECT panel (PANDA theory):
(m=  4, dm= -2.64E-01, n=  1, dn=  0.00E+00, slope=  0.00E+00 ICD7= 1)
(0.1 radian)/(shell wall rotation), AMPTST =  7.8638E+05
QUANTITIES USED FOR LOCAL BENDING OF IMPERFECT PANEL
(used for generation of WXX7,WYY7,WXY7), IMOD= 0:
 Amplitude of overall ovalization,             WG1=  0.0000E+00
 Amplitude of  local  buckling modal imperf.,AMWIMP=  1.0000E-07
 Effective load factor for  local  buckling, EIGEFF=  2.0027E-01
 Number of  axial halfwaves in  local  mode,      m=    4
 Fractional axial halfwaves in  local  mode,     dm= -2.6388E-01
 Number of  circ. halfwaves in  local  mode,      n=    1
```

```
  Fractional circ. halfwaves in  local  mode,     dn=  0.0000E+00
  Slope of nodal lines in local buckling mode, slope=  0.0000E+00
  Additional amplitude factor,               FACIM3=  4.9931E+00
  Original imperfection is increased by 1/(EIGEFF-1)=  1.2504E+00
 Amplitude of prebuckling bending due to loading, WAMP=WIMP/(EIGEFF-1.)= -1.4979E-06 in
which
 WIMP = Amplitude of initial buckling modal imperfection= -1.0000E-07
 EIGEFF = effective buckling load factor=                 2.0027E-01

 ********* NOTE ********* NOTE ********** NOTE *********
 Prebuckling bending and twist from local imperfection growth:
  Wxx7(1),Wyy7(1),Wxy7(1),ICD7=  2.1578E-06  2.4223E-06  0.0000E+00    1
 ******************************************************
 Amplitude of prebuckling bending due to loading, WAMP=WIMP/(EIGEFF-1.)= -1.4979E-06 in
which
 WIMP = Amplitude of initial buckling modal imperfection= -1.0000E-07
 EIGEFF = effective buckling load factor=                 2.0027E-01
 Local imperfection growth: Wxx7(2),Wyy7(2),Wxy7(2),ICD7=  0.0000E+00  0.0000E+00
2.2862E-06    1




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 10.4          ****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 10.4: DESIGN PERTURBATION INDEX, IMOD=  0 ***

 *************************************************************
 CHAPTER 10.4 Present a summary of imperfection sensitivity
              results. (See Section 13 and Table 9 of [1K])

 ******* SUMMARY OF IMPERFECTION SENSITIVITY RESULTS *********

 LOCAL AND GLOBAL IMPERFECTION AMPLITUDES,
 AMPLITUDE MODIFIERS THAT KEEP MAX. WALL ROTATION GENERATED
 BY THE MODAL IMPERFECTION COMPONENT LESS THAT 0.1 RADIAN,
 AND AMPLIFICATION FACTORS TO ACCOUNT FOR GROWTH OF THE
 INITIAL IMPERFECTIONS DURING LOADING:
                     USER-PROVIDED  SHELL WALL    AMPLITUDE    AMPLIFICATION
                     IMPERFECTION    ROTATION     MODIFIER     FACTOR WYYAMP
                       AMPLITUDE    WALRTi(rad)    AMPMDi      FROM LOADING
 local imperfection    1.0000E-07   1.2716E-07   1.0000E+00   4.0000E+00
 inter-ring imperf.    1.0000E-10  -3.2125E-11   1.0000E+00   1.9144E+00
 gen. out-of-round.    0.0000E+00   0.0000E+00   1.0000E+00   3.0928E+00
 gen. modal imperf.    0.0000E+00   0.0000E+00   2.4851E-01   3.0928E+00
 low-m genrl. modal    0.0000E+00   0.0000E+00   2.4851E-01   1.0000E+00

 BUCKLING LOAD FACTORS OF PERFECT AND IMPERFECT GEOMETRIES.
 NOTE: IN THIS SHORT SECTION, THE PANEL IS MODELLED AS IF IT
       WERE A COMPLETE CYLINDRICAL SHELL (PANEL THAT SUBTENDS
       180 DEGREES OF CIRCUMFERENCE).:
                    PERFECT PANEL,   PERFECT PANEL,  IMPERFECT
                   ORIGINAL STRESS   REDISTRIBUTION    PANEL
```

```
                    DISTRIBUTION    OF PREBUCKLING
                                      RESULTANTS
 local buckling        not computed  2.0028E-01    2.0027E-01
 inter-ring bucklng    2.0939E+00    2.0936E+00    2.0936E+00
 general buckling      1.4778E+00    1.4778E+00    1.4778E+00
 low-m general buck    0.0000E+00    0.0000E+00    0.0000E+00

 growth of local imperfection is (1=hyperbolic; 2=nonhyper): 1

 KNOCKDOWN FACTORS FOR IMPERFECT GEOMETRY:
  KNOCKDOWN FACTORS k AND MODE SHAPES (M,N,SLOPE,i) k (axial, circ., daxial, dcirc.,
slope, type)
    Knockdown factor for local instability=   1.00E+00(m=  4,n=  1,dm=-0.264,dn= 0.000,s=
0.00,icd=1)
 Local changes in curv.,twist, Wxx1,Wyy1,Wxy1=  2.16E-06  2.42E-06  0.00E+00
 Local changes in curv.,twist, Wxx2,Wyy2,Wxy2=  0.00E+00  0.00E+00  2.29E-06

    Knockdown factor for inter-ring buckling= 1.00E+00(m=  1,n= 10,dm= 0.000,dn=-0.460,s=
0.00,icd=0)
    Bay changes in curv.,twist, Wxx,Wyy,Wxy=    0.00E+00  0.00E+00  0.00E+00

    Knockdown factor for general instability= 1.00E+00(m=  4,n=  7,dm= 0.024,dn= 0.383,s=
0.00,icd=0)
    Genrl changes in curv.,twist, Wxx,Wyy,Wxy=  0.00E+00  0.00E+00  0.00E+00

    Knockdown factor for low-m general instability= 1.00E+00(m=  0,n=  0,dm= 0.000,dn=
0.000,s=   0.00,icd=0)
    Genrl changes in curv.,twist, Wxx,Wyy,Wxy=  0.00E+00  0.00E+00  0.00E+00

 ******** WARNING ******* WARNING ******** WARNING ********
 THE PANEL IS CURVED, HAS RINGS, YET HAS NO OVERALL IMPERFEC-
 TION. OVERALL IMPERFECTIONS (OUT-OF-ROUNDNESS AND/OR BUCKLING
 MODAL IMPERFECTION) GIVE RISE TO CONSIDERABLE ADDITIONAL HOOP
 COMPRESSION IN THE RING WEBS AND OUTSTANDING FLANGES, AS WELL
 AS IN THE PANEL SKIN. PLEASE NOTE THAT, EVEN THOUGH YOU MAY
 HAVE SET THE APPLIED LOAD TO A VALUE HIGHER THAN THE DESIGN
 ULTIMATE LOAD BY A FACTOR EQUAL TO THE INVERSE OF A TYPICAL
 KNOCKDOWN FACTOR, OR YOU MAY HAVE SET A RATHER HIGH FACTOR OF
 SAFETY FOR GENERAL INSTABILITY, YOUR DESIGN MAY BE UNCONSER-
 VATIVE.  PLEASE REDESIGN WITH USE OF REASONABLE AMPLITUDE(S)
 FOR OUT-OF-ROUNDNESS AND/OR GENERAL BUCKLING MODAL IMPERFECT-
 TION. YOU MAY COMPENSATE BY REDUCING THE FACTOR OF SAFETY
 AND/OR THE APPLIED LOAD (AS LONG AS THE APPLIED LOAD REMAINS
 AT LEAST AS LARGE AS THE ULTIMATE LOAD)
 ****** END WARNING **** END WARNING *****END WARNING ********

 ==========================================================
 BUCKLING LOAD FACTORS AND IMPERFECTION SENSITIVITY SUMMARY
 ----------------------------------------------------------
                         LOCAL     INTER-RING      GENERAL
                       BUCKLING     BUCKLING      BUCKLING
 RATIOS OF BUCKLING LOADS FROM ARBOCZ THEORY TO THOSE FROM
 PANDA2 THEORY FOR THE PERFECT STRUCTURE:
    (ARBOCZ/PANDA2):   9.9988E-01   9.8506E-01   1.0000E+00
 ----------------------------------------------------------
 KNOCKDOWN FACTORS FOR IMPERFECTIONS DERIVED FROM
 PANDA2 THEORY VS THOSE FROM ARBOCZ 1992 UPDATE OF KOITERs
 1963 SPECIAL THEORY:
```

```
 FROM PANDA2 THEORY:   9.9999E-01   1.0000E+00   1.0000E+00
 FROM ARBOCZ THEORY:   1.0000E+00   1.0000E+00   1.0000E+00
 THE GOVERNING KNOCKDOWN FACTOR FOR EACH TYPE OF BUCKLING
 (LOCAL, INTER-RING, GENERAL) IS SET EQUAL TO THE MINIMUM
 KNOCKDOWN FACTOR FOR THAT TYPE OF BUCKLING, REDUCED
 FURTHER BY THE RATIO (ARBOCZ/PANDA2) FOR THE PERFECT PANEL
 IF THE RATIO (ARBOCZ/PANDA2) IS LESS THAN UNITY:
 The ARBOCZ theory is used only if ICONSV=1. ICONSV= 1

 USED NOW IN PANDA2:   9.9987E-01   9.8506E-01   1.0000E+00

 FACTOR APPLIED TO   1.0000E+00 FOR ALTERNATIVE SOLUTION FOR
 GENERAL    BUCKLING WITH DISCRETE STIFFENERS, FKNMLT=  1.0000E+00
 FACTOR APPLIED TO   9.8506E-01 FOR ALTERNATIVE SOLUTION FOR
 INTER-RING BUCKLING WITH DISCRETE STIFFENERS, FKNMLS=  1.0000E+00

 ***NOTE*** IF THERE IS INTERNAL PRESSURE THESE KNOCKDOWN
            FACTORS MAY BE CHANGED AS NOTED BELOW.
 ==========================================================
 **** CHAPTER 11: DESIGN PERTURBATION INDEX, IMOD=  0 ****



 ***************************************************************
 ***************************************************************
 ***************************************************************
 ************          CHAPTER 11            ****************
 ***************************************************************
 ***************************************************************
 ***************************************************************
 **** CHAPTER 11: DESIGN PERTURBATION INDEX, IMOD=  0 ****

 **************************************************************
 CHAPTER 11 Get change in stress resultants, Nx, Ny, Nxy in
            various segments of the skin-stringer module
            during prebuckling bending of the imperfect shell.
            Also, do PANDA-type [1B] local, inter-ring, gen-
            eral buckling analyses and PANDA-type stringer web
            and ring web buckling analyses to get knockdown
            factors to compensate for the lack of in-plane
            shear Nxy loading and anisotropy in discretized
            BOSOR4-type models. (See Section 11 in [1A])

***** BEGIN SUBROUTINE STRCON (GET DELSKN FOR LOC.BUCK.) *****
 DELSKN = change in stress resultants, dNx,dNy,dNxy, in the
          various segments of the skin-stringer module due to
          prebuckling bending of the imperfect panel or shell.
 *****  END  SUBROUTINE STRCON (GET DELSKN FOR LOC.BUCK.) ******

*** BEGIN SUBROUTINE BUCPAN (KNOCKDOWN PANDA-TYPE BUCKLING) ***
**** The purpose of the following BUCPAN execution is to find:
*** LOCAL BUCKLING (buckling of skin between stiffeners):
**** a.with in-plane shear Nxy and anisotropic effects included
**** b.without in-plane shear Nxy and anisotropic effects
*** INTER-RING BUCKLING (stringers smeared out):
**** a.with in-plane shear Nxy and anisotropic effects included
**** b.without in-plane shear Nxy and anisotropic effects
```

```
*** GENERAL INSTABILITY (rings and stringers smeared out):
**** a.with in-plane shear Nxy and anisotropic effects included
**** b.without in-plane shear Nxy and anisotropic effects
*** THE PURPOSE IS TO FIND KNOCKDOWN FACTORS TO COMPENSATE
*** FOR THE ABSENCE OF IN-PLANE SHEAR AND ANISOTROPY IN BOSOR4-
*** TYPE MODELS (DISCRETIZED MODULE MODELS).
*** NOTE: This set of calculations DOES include the effect
***       of initial geometric buckling modal imperfections.
  LABEL NO. IN STRIMP= 9255
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
  9255     2     0     0  1.0000E+07

 Local buckling, C11=  2.6794E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7010    9255       0       0       1       1       0       1
  Radius  R,   Axial length, A,   Width  B
 -5.000000E+01  9.779300E+00  2.470500E+00
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
 Out-of-roundness,                    WG1  =  0.0000E+00
 General buckling modal,              WG2  =  0.0000E+00
 Inter-ring buckling modal,          W0PAN =  1.0000E-10
 Local buckling modal,               W0LOC =  1.0000E-07
 ***** NOTE: Panel is modelled as if it were flat. *****
 ***** Donnell theory is used in this section (ISAND=0)
 Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
  2.6794E+05  8.0382E+04  0.0000E+00
  8.0382E+04  2.6794E+05  0.0000E+00
  0.0000E+00  0.0000E+00  9.3778E+04
 ***(low-n)***
 (high-m) mode:ICHEK ISAND  m    n      s       EIGENVALUE  TEST
                  0     0   4    1  1.000E-02  1.709E-01  3.958E+00
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 EIGMNC=  2.30E-01  1.00E+17  1.71E-01  1.00E+17  1.00E+17  4.40E-01  1.00E+17
 SLOPEX=  1.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  2.00E-02  0.00E+00
 MWAVEX=    2         0         4         0         0         1         0
 NWAVEX=    1         0         1         0         0         1         0
 TESTX =  3.96E+00  0.00E+00  3.96E+00  0.00E+00  0.00E+00  3.96E+00  0.00E+00
 Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

 If EIGVAL and EIGVLX are different:
 EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
 EIGVLX = original eigenvalue: no "fractional" refinement
 EIGVAL,EIGVLX before knockdown for t.s.d.=  1.7087E-01  1.7087E-01
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.7069E-01  1.7069E-01
 EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
```

```
Donnell theory is used for these buckling calculations in this case.
Local buckling load factors & mode shapes before any knockdown factors applied:
EIGMNC=  2.30E-01  1.00E+17  1.71E-01  1.00E+17  1.00E+17  4.40E-01  1.00E+17
SLOPEX=  1.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  2.00E-02  0.00E+00
MWAVEX=    2         0         4         0         0         1         0
NWAVEX=    1         0         1         0         0         1         0
NOTE: The buckling nodal line slopes, SLOPEX, are as
defined in Fig. 9a or Fig. 9b of the 1987 "Theoretical
basis of the PANDA...",if NWAVEX > 0; that is, there
has not yet been any inversion of SLOPEX when 9b holds.

LOCAL BUCKLING FROM PANDA-TYPE THEORY [1B] AFTER KNOCKDOWN FOR t.s.d.:
EIGLOC =   1.7069E-01(m=   4,n=   1)

Local buckling, C11=  2.6794E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7055    9255       0       0       1       1       0       1
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  2.470500E+00
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -4.6902E+02 -2.4133E+01  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 2.6794E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    1  0.000E+00  1.709E-01  3.958E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  2.30E-01  1.00E+17  1.71E-01  1.00E+17  1.00E+17  4.40E-01  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    2         0         4         0         0         1         0
NWAVEX=    1         0         1         0         0         1         0
TESTX =  3.96E+00  0.00E+00  3.96E+00  0.00E+00  0.00E+00  3.96E+00  0.00E+00
Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.7087E-01  1.7087E-01
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.7069E-01  1.7069E-01
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
```

```
IPRELM=    2  ILOWSS(IPRELM+1,36)=    0

inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7130    9255       0       0       3       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   18  0.000E+00  4.168E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.17E+00  4.95E+00  4.17E+00  1.00E+17  1.00E+17  4.17E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   18        83        18         0         0        18         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.1676E+00  4.1676E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.9566E+00  3.9566E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

inter-ring buckling: smeared stringers, C11=  5.4530E+05, radius, R=  1.5738E+06
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7145    9255       0       0       3       1       0       1
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
```

```
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   10  0.000E+00  4.231E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.38E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0         1         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2308E+00  4.2308E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0135E+00  4.0135E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

INTER-RING BUCKLING load factors and (axial, circumfer.) halfwaves:
Donnell theory is used for these buckling calculations in this case.
INTER-RING BUCKLING FROM PANDA-TYPE THEORY [1B]
   AFTER KNOCKDOWN FOR t.s.d. AND FOR SMEARED STRINGERS:
EIGSS =   2.0626E+00(m=   1,n=  18)
Inter-ring eigenvalue with panel as flat:
EIGSS2=   2.0939E+00(m=   1,n=  10)
IPRELM=    2  ILOWSS(IPRELM+1,36)=    1

inter-ring buckling: smeared stringers, C11=  5.4530E+05, (No Nxy)
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7155    9255       0       0       3       1       0       0
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
```

```
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.4133E+01  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  2.6794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1   10  0.000E+00  4.231E+00  1.090E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.23E+00  5.03E+00  4.23E+00  1.00E+17  1.00E+17  4.23E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=   10        89        10         0         0        10         0
TESTX =  1.09E-03  1.09E-03  1.09E-03  0.00E+00  0.00E+00  1.09E-03  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  4.2308E+00  4.2308E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  4.0135E+00  4.0135E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

general buckling: smeared stiffeners, C11=  5.4530E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7195    9255       0       0       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
```

```
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    7  0.000E+00  1.670E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.67E+00  1.67E+00  1.67E+00  1.00E+17  1.00E+17  1.67E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         0
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6698E+00  1.6698E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5950E+00  1.5950E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

general buckling: smeared stiffeners, C11=  5.4530E+05, (No Nxy)
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7230    9255       0       0       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** Donnell theory is used in this section (ISAND=0)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  0.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 5.4530E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04

The following section is entered only if TEST < 1.0 and the
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
```

```
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    7  0.000E+00  1.670E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.67E+00  1.67E+00  1.67E+00  1.00E+17  1.00E+17  1.67E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         0
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.31E-01  4.31E-01  1.10E+00  0.00E+00  0.00E+00  4.31E-01  0.00E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.6698E+00  1.6698E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.5950E+00  1.5950E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
**** END SUBROUTINE BUCPAN (KNOCKDOWN PANDA-TYPE BUCKL.) *******

Label No. in STRIMP= 9255: Modifiers for knockdowns...
 General Instability, FKNOCK(1), EIGRT9 =  1.0000E+00  1.0000E+00
 Local Buckling,      FKNOCK(2), EIGRT7 =  9.9999E-01  1.0000E+00


Preliminary general buckling (from PANDA)=   1.4958E+00
(axial,circ.) waves with    shear and with anisotropic C(i,j)=(   4,   7)
(axial,circ.) waves without shear and without anisotrc C(i,j)=(   4,   7)
Preliminary local buckling (from PANDA: flat skin!) =   1.7069E-01
Number of (axial,circ.) waves,    (MLOC,NLOC) =(  4,  1)
Slope of the local buckling nodal lines,      CSLOPE=  1.0000E-02
Radius of curvature, R, used for preliminary
   local buckling load factor from PANDA,         R =  2.0390E+06

Above local buckling load and mode may include rolling
of the stringers. This model is used for the calculation of
the knockdown factor given below to account for the effect of
in-plane shear and anisotropy [e.g.C(4,6)] on local buckling.
In-plane shear and anisotropy are not directly accounted for
in any of the BOSOR4-type of discretized models. In order to
compensate for this error, knockdown factors are established
as given below for various types of buckling. These knockdowns
account for:
 1. the effect of in-plane shear, and
 2. anisotropy [e.g. C(4,6), C(5,6)] in the panel skin.

In-plane shear and anisotropy are not directly accounted for
in any of the BOSOR4-type of discretized models. In order to
compensate for this error, knockdown factors are established
as given below for various types of buckling. These knockdowns
account for:
 1. the effect of in-plane shear, and
 2. anisotropy [e.g. C(4,6), C(5,6)] in the panel skin.
Knockdown factors from PANDA-type analysis are as follows:
```

```
    Knockdown factor for general instability=   1.0000E+00
    Knockdown factor for local instability=     9.9999E-01
    Knockdown factor (under hat crippling)=     1.0000E+00
    Knockdown factor for inter-ring buckling=   1.0000E+00
    Knockdown factor for stringer web bucklng=  1.0000E+00
    Knockdown factor for   ring   web bucklng=  1.0000E+00
 Please note that the purpose of these knockdown factors is NOT
 to compensate for initial imperfections.  You can account for
 initial imperfections by assigning amplitudes of local, inter-
 ring, and general imperfections in the forms of the local,
 inter-ring and general buckling modes. And/or you can use
 appropriate factors of safety (different for different
 buckling modes) to compensate for initial imperfections.

 Resultants in prebuckled panel module segments: SEG. 1      SEG. 2     SEG. 3     SEG.4
Nave(calc.)  Nave(given)
                  Axial resultant,   Nx =    -4.6902E+02 -4.6902E+02 -1.5485E+03
0.0000E+00 -1.0000E+03 -1.0000E+03
        Circumferential resultant,   Ny =    -2.4133E+01 -2.4133E+01  2.5594E-32
0.0000E+00  8.3334E-01 -9.9942E-04
         In-plane shear resultant,  Nxy =     5.0000E+00  5.0000E+00  4.3687E-07
0.0000E+00  5.0000E+00  5.0000E+00

 Constitutive terms, C(i,i), i=1,6, in skin=  2.6794E+05  2.6794E+05  9.3778E+04
1.3013E+01  1.3013E+01  4.5544E+00

 In discretized local buckling model the panel skin is being
 modelled as flat if IICURV=0; as curved if IICURV=1: IICURV= 0
 Radius of curvature used in SUBROUTINE LOCAL, RMAX =  2.0390E+06
 LOADING IN THE PANEL SKIN BEFORE ADJUSTMENTS:
 PREBUCKLING TOTAL RESULTANTS, Nx, Ny, Nxy = -4.6902E+02 -2.4133E+01  5.0000E+00
 PREBUCKLING FIXED RESULTANTS, Nxo,Nyo,Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Axial halfwaves in skin buckling mode (PANDA), MLOC71=    4
 Axial length used for "hungry-horse" analysis, RNGSPA=  9.7793E+00
 Number of nodal points used in "hungry-horse" analysis= 26

***** BEGIN SUBROUTINE STRCON (GET DELFCX,DELCUR,DELWBX) *****
 DELFCX =changes in resultants, dNx,dNy,dNxy, in skin-stringer
         module caused by growth of the initial imperfections.
 DELCUR =changes in curvature and twist in the panel skin.
 DELWBX =change in axial resultant dNx at web root and web tip.
 ******* END SUBROUTINE STRCON (GET DELFCX,DELCUR,DELWBX) ******




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 12           ****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 12: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 *************************************************************
 CHAPTER 12 Obtain prebuckled state of the initially imperfect
            and loaded and bent panel or shell. This section
```

```
           includes the redistribution of Nx, Ny, Nxy in the
           various segments of the stiffened shell structure.

********** BEGIN OUTPUT FOR STATE CHANGE ***********
CHANGES IN STATE OF THE PANEL DUE TO GROWTH OF INITIAL
IMPERFECTIONS AS THE LOADING IS APPLIED. THESE CHANGES AFFECT
THE BUCKLING LOAD FACTORS AND STRESSES IN THE VARIOUS SEGMENTS
OF THE SKIN-STRINGER AND SKIN-RING PANEL MODULES.....

CHANGES IN CURVATURE AND TWIST, CHANGES IN RESULTANTS USED
IN THE IQUICK = 0 (DISCRETIZED MODULE) TYPE OF ANALYSIS.
THE FOLLOWING RESULT FROM GROWTH OF INITIAL IMPERFECTIONS
DURING LOADING. THEY DEPEND ON THE SIGNS OF THE
IMPERFECTION AMPLITUDES....
Curvature changes and twist: axial, hoop, twist:
 DELCUR(1), DELCUR(2), DELCUR(3)=      0.0000E+00  0.0000E+00  0.0000E+00
Change in axial resultant Nx in: skin, stringer base, flange:
 DELFCX(1,1),DELFCX(1,2),DELFCX(1,4)=  0.0000E+00  0.0000E+00  0.0000E+00
Change in circ. resultant Ny in: skin, stringer base, flange:
 DELFCX(2,1),DELFCX(2,2),DELFCX(2,4)=  0.0000E+00  0.0000E+00  0.0000E+00
Change in in-plane shear Nxy in: skin, stringer base, flange:
 DELFCX(3,1),DELFCX(3,2),DELFCX(3,4)=  0.0000E+00  0.0000E+00  0.0000E+00
Change in axial resultant Nx in web at: web root,    web tip:
 DELWBX(1), DELWBX(2)=                 0.0000E+00  0.0000E+00
Change in in-plane shear Nxy in stringer web:
               DELWEB(1)    =  3.7543E-07

FOR PANELS THAT ARE NOT ISOGRID NOR TRUSS-CORE...
CHANGES IN RESULTANTS USED IN THE IQUICK = 1 (CLOSED FORM)
TYPE OF ANALYSIS. THE VALUES ARE INDEPENDENT OF THE SIGNS
OF THE IMPERFECTIONS BECAUSE THE IQUICK = 1 MODE OF
ANALYSIS USES THE MOST COMPRESSIVE VALUES FOR EITHER
POSITIVE OR NEGATIVE IMPERFECTION AMPLITUDES...
Change in axial resultant Nx in: skin and stringer base:
 DELSKN(1,1,1),DELSKN(1,2,1)=  0.0000E+00  0.0000E+00
Change in circ. resultant Ny in: skin and stringer base:
 DELSKN(2,1,1),DELSKN(2,2,1)=  0.0000E+00  0.0000E+00
Change in in-plane shear Nxy in: skin and stringer base:
 DELSKN(3,1,1),DELSKN(3,2,1)=  0.0000E+00  0.0000E+00
Change in axial resultant Nx at the tip of the stringer web:
              DELFCE(JWEB,1)=  0.0000E+00
Change in axial resultant Nx in the outstndg stringer flange:
             DELFCE(JWEBP,1)=  0.0000E+00
Change in in-plane shear Nxy in stringer web:
               DELWEB(1)    =  3.7543E-07

ADDITIONAL CIRCUMFERENTIAL CHANGE IN CURVATURE
FROM GROWTH OF INTER-RING BUCKLING MODAL IMPERFECTION,
TO BE USED IN THE COMPUTATION OF STRESSES IN THE PANEL SKIN
IN SUBROUTINE STRTHK DURING AN IQUICK=0 ANALYSIS: DELCRC=  0.0000E+00




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

```
************          CHAPTER 13           ****************
**************************************************************
**************************************************************
**************************************************************
**** CHAPTER 13: DESIGN PERTURBATION INDEX, IMOD=  0 *****

*************************************************************
CHAPTER 13 Get prebuckling stress resultants, Nx, Ny, needed
           for the discretized single-module skin-stringer
           model used for local buckling and bending-torsion
           buckling (BOSOR4-type model: see Figs. 18, 20,
           22, 97, and 98 of [1A], for examples of the
           discretized single skin-stringer BOSOR4-type
           module model.).

Effective circumferential radius of curvature, RADNEW= -5.0002E+01
      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

==============================================
BEGIN: PREBUCKLING STRESS RESULTANTS USED IN THE
DISCRETIZED SINGLE MODULE MODEL WITH IQUICK = 0...
----------------------------------------------------------
PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 1 .....
 "Total." loads, Nx(var),Ny(var),Nxy(var)= -4.6902E+02 -2.4133E+01  5.0000E+00
 "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
```

```
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 2 .....
  "Total." loads, Nx(var),Ny(var),Nxy(var)= -4.6902E+02 -2.4133E+01  5.0000E+00
  "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
 PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 3 .....
  "Total." loads, Nx(var),Ny(var),Nxy(var)= -1.5324E+03  2.5594E-32  4.3687E-07
  "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00

 AXIAL CURVATURE CHANGES FROM SOURCES OTHER THAN
 INITIAL IMPERFECTIONS (FROM EPSLOD(4) AND ETHERM(4))...
  "Eigenvalue" axial curvature change
       CURVAR = EPSLOD(4) - FFIABT*ETHERM(4) = -4.6945E-05
  "Fixed" axial curvature change
       CURFIX = EPSLDF(4)                    =  0.0000E+00

 PREBUCKLING AXIAL RESULTANTS IN STRINGER WEB: SEGMENT NO.  3
  "Eigenvalue" axial resultant, Nx(var)=
 -1.5324E+03 -1.5356E+03 -1.5388E+03 -1.5421E+03 -1.5453E+03 -1.5485E+03
 -1.5517E+03 -1.5549E+03 -1.5581E+03 -1.5614E+03 -1.5646E+03
  "  fixed   " axial resultant, Nx(fix)=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 4 .....
  "Total." loads, Nx(var),Ny(var),Nxy(var)= -4.6902E+02 -2.4133E+01  5.0000E+00
  "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
 -------------------------------------------------
 END:  PREBUCKLING STRESS RESULTANTS USED IN THE
 DISCRETIZED SINGLE MODULE MODEL WITH IQUICK = 0...
 =========================================================
 ********** END OF OUTPUT FOR STATE CHANGE ************
 New C(i,j) and Nx, Ny, Nxy have now been calculated for  design iter. no.  0, load set
no.  1, matl iter. no.  0




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 14             *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** 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.

 EXPLANATION OF FOLLOWING CALCULATIONS (LOAD SET NO. 1):
     Eigenvalues corresponding to local buckling of the skin
     obtained from the BOSOR4-discretized panel module model
     are calculated for a range of axial wavenumbers. All four
     edges of the panel are assumed to be simply supported,
```

```
     even if you indicated "clamped" in your input, and the in-
     plane loading is assumed to be uniform (N1, N2, N12), even
     if you provided for axial load Nx varying in the L2 (cir-
     cumferential) direction.


 Local buckling load factors from discretized model of a single panel module for
 design iteration no.  0, load set no. 1,  material iteration no.  0. These load factors
 include the knockdown factor,  9.9999E-01 that accounts for the
 effect of in-plane shear loading and anisotropy [e.g. C(4,6)]
 in the panel skin.  Resultants are uniform and given by:
   LOAD SET A: axial, Nx = -1.00E+03; circ., Ny = -1.00E-03; in-plane shear, Nxy =
5.00E+00 (Not from normal pressure)
   LOAD SET B: axial, Nxo=  0.00E+00; circ., Nyo=  0.00E+00; in-plane shear, Nxyo=
0.00E+00 (Not from normal pressure)
   LOAD SET A: Uniform normal pressure, P =   2.0000E-05
      Resultants from global (smeared stiffener) model: Nx(p)=  0.00E+00,  Ny(p)=
0.00E+00,  Nxy(p)= 0.0
      Resultants from local (discrete stiffener) model: Nx(p)= -5.21E-04,  Ny(p)=  5.80E-
07,  Nxy(p)= 0.0 :

**** BEGIN SUBROUTINE LOCAL (INITIAL LOCAL BUCKLING SEARCH) ****
  LABEL NO. IN STRUCT= 9310
 Before CALL LOCAL: N =     0

 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-stringer discretized module of local buckling)
  AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    M        EIGOLD            KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
    5      3.21937E-01      1.00000E+00      9.99993E-01     3.21935E-01
    6      3.14345E-01      1.00000E+00      9.99993E-01     3.14343E-01
    7      3.26322E-01      1.00000E+00      9.99993E-01     3.26320E-01
 Buckling load factor before t.s.d.=  3.1434E-01 After t.s.d.=  3.1375E-01
    6      3.14345E-01      9.98117E-01      9.99993E-01     3.13751E-01

 In the iterative refinement section: No.of axial halfwaves, m=     6
 dm =  0.0000E+00, Eigenvalue (without knockdowns)=  3.1435E-01

 In the iterative refinement section: No.of axial halfwaves, m=     6
 dm =  5.0000E-01, Eigenvalue (without knockdowns)=  3.1834E-01

 In the iterative refinement section: No.of axial halfwaves, m=     6
 dm = -5.0000E-01, Eigenvalue (without knockdowns)=  3.1516E-01

 In the iterative refinement section: No.of axial halfwaves, m=     6
 dm = -1.6500E-01, Eigenvalue (without knockdowns)=  3.1403E-01

 Value of dm used in SUBROUTINE ARRAYS= -1.6500E-01
 IMOD= 0; Eigenvalue passed to STRUCT=  3.1344E-01
 Knockdown for transverse shear deformation=  9.9812E-01
 Buckling load factor from SUB. LOCAL, EIGITR(1)=  3.1344E-01
 Number of axial halfwaves between rings, N=    6
 ****  END  SUBROUTINE LOCAL (INITIAL LOCAL BUCKLING SEARCH) ****
  **** END OF LOCAL BUCKLING EIGENVALUE CALC.****
```

```
**** BEGIN SUBROUTINE MODE (LOCAL BUCKLING MODE SHAPE) ****

 WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR =
 pi**2*EI/[abs(local hoop load)*WIDTH**2]=  8.7193E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  8.9737E-03
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  1.0235E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  9.6179E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  9.6179E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  8.7126E-03
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  2.9676E-03
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  1.0235E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  8.9738E-03
       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= 6

NODE	Z	W	WD	WDD	U	V	WDDD
MODAL DISPLACEMENTS FOR SEGMENT NO. 1							
1	0.00E+00	1.00E+00	0.00E+00	-2.72E+00	0.00E+00	5.59E-05	1.29E+00
2	0.00E+00	9.91E-01	-2.16E-01	-2.61E+00	1.29E-05	5.65E-05	1.29E+00
3	0.00E+00	9.64E-01	-4.27E-01	-2.50E+00	2.60E-05	5.67E-05	1.29E+00
4	0.00E+00	9.21E-01	-6.26E-01	-2.33E+00	3.93E-05	5.71E-05	2.14E+00
5	0.00E+00	8.61E-01	-8.08E-01	-2.08E+00	5.30E-05	5.74E-05	2.99E+00
6	0.00E+00	7.88E-01	-9.66E-01	-1.77E+00	6.71E-05	5.77E-05	3.84E+00

```
  7  0.00E+00  7.02E-01 -1.10E+00 -1.38E+00  8.18E-05  5.79E-05  4.69E+00
  8  0.00E+00  6.07E-01 -1.19E+00 -9.22E-01  9.72E-05  5.76E-05  5.55E+00
  9  0.00E+00  5.06E-01 -1.24E+00 -3.92E-01  1.13E-04  5.68E-05  6.44E+00
 10  0.00E+00  4.02E-01 -1.25E+00  2.16E-01  1.30E-04  5.51E-05  7.38E+00
 11  0.00E+00  3.00E-01 -1.21E+00  8.23E-01  1.48E-04  5.19E-05  7.38E+00

                 MODAL DISPLACEMENTS FOR SEGMENT NO. 2
  1  0.00E+00  3.00E-01 -1.21E+00  7.95E-01  1.48E-04  5.19E-05  1.09E+01
  2  0.00E+00  2.04E-01 -1.10E+00  1.70E+00  1.67E-04  4.75E-05  1.09E+01
  3  0.00E+00  1.19E-01 -9.21E-01  2.60E+00  1.86E-04  4.06E-05  1.09E+01
  4  0.00E+00  5.20E-02 -6.65E-01  3.64E+00  2.06E-04  3.08E-05  1.26E+01
  5  0.00E+00  9.56E-03 -3.16E-01  4.84E+00  2.27E-04  1.71E-05  1.47E+01
  6  0.00E+00  1.53E-09 -1.16E-01  6.28E-06  2.38E-04 -4.21E-10 -5.88E+01
  7  0.00E+00 -9.56E-03 -3.16E-01 -4.84E+00  2.27E-04 -1.71E-05 -5.88E+01
  8  0.00E+00 -5.20E-02 -6.65E-01 -3.64E+00  2.06E-04 -3.08E-05  1.47E+01
  9  0.00E+00 -1.19E-01 -9.21E-01 -2.60E+00  1.86E-04 -4.06E-05  1.26E+01
 10  0.00E+00 -2.04E-01 -1.10E+00 -1.70E+00  1.67E-04 -4.75E-05  1.09E+01
 11  0.00E+00 -3.00E-01 -1.21E+00 -7.95E-01  1.48E-04 -5.19E-05  1.09E+01

                 MODAL DISPLACEMENTS FOR SEGMENT NO. 3
  1 -1.21E-02 -1.16E-03 -1.16E-01  3.22E-01 -1.53E-09 -3.87E-10 -7.34E-01
  2 -9.68E-02 -9.88E-03 -9.18E-02  2.60E-01 -1.49E-09 -2.43E-10 -7.34E-01
  3 -1.81E-01 -1.67E-02 -7.24E-02  1.98E-01 -1.45E-09 -1.21E-10 -7.34E-01
  4 -2.66E-01 -2.21E-02 -5.78E-02  1.47E-01 -1.41E-09 -1.90E-11 -6.02E-01
  5 -3.51E-01 -2.65E-02 -4.71E-02  1.05E-01 -1.38E-09  7.06E-11 -4.97E-01
  6 -4.36E-01 -3.01E-02 -3.97E-02  7.00E-02 -1.34E-09  1.55E-10 -4.14E-01
  7 -5.20E-01 -3.32E-02 -3.50E-02  4.04E-02 -1.32E-09  2.42E-10 -3.50E-01
  8 -6.05E-01 -3.61E-02 -3.27E-02  1.49E-02 -1.29E-09  3.38E-10 -3.00E-01
  9 -6.90E-01 -3.88E-02 -3.24E-02 -7.50E-03 -1.26E-09  4.51E-10 -2.65E-01
 10 -7.74E-01 -4.15E-02 -3.39E-02 -2.78E-02 -1.23E-09  5.89E-10 -2.40E-01
 11 -8.59E-01 -4.45E-02 -3.67E-02 -4.82E-02 -1.20E-09  7.48E-10 -2.40E-01

                 MODAL DISPLACEMENTS FOR SEGMENT NO. 4
  1  0.00E+00 -3.00E-01 -1.21E+00 -8.23E-01  1.48E-04 -5.19E-05  7.38E+00
  2  0.00E+00 -4.02E-01 -1.25E+00 -2.16E-01  1.30E-04 -5.51E-05  7.38E+00
  3  0.00E+00 -5.06E-01 -1.24E+00  3.92E-01  1.13E-04 -5.68E-05  7.38E+00
  4  0.00E+00 -6.07E-01 -1.19E+00  9.22E-01  9.72E-05 -5.76E-05  6.44E+00
  5  0.00E+00 -7.02E-01 -1.10E+00  1.38E+00  8.18E-05 -5.79E-05  5.55E+00
  6  0.00E+00 -7.88E-01 -9.66E-01  1.77E+00  6.71E-05 -5.77E-05  4.69E+00
  7  0.00E+00 -8.61E-01 -8.08E-01  2.08E+00  5.30E-05 -5.74E-05  3.84E+00
  8  0.00E+00 -9.21E-01 -6.26E-01  2.33E+00  3.93E-05 -5.71E-05  2.99E+00
  9  0.00E+00 -9.64E-01 -4.27E-01  2.50E+00  2.60E-05 -5.67E-05  2.14E+00
 10  0.00E+00 -9.91E-01 -2.16E-01  2.61E+00  1.29E-05 -5.65E-05  1.29E+00
 11  0.00E+00 -1.00E+00  0.00E+00  2.72E+00  0.00E+00 -5.59E-05  1.29E+00
**** END SUBROUTINE MODE (LOCAL BUCKLING MODE SHAPE) ******
EILOCL,EIGLCS(1),FKNOCS,EIGRAT=
 1.7069E-01  3.1344E-01  9.9999E-01  5.4457E-01
 **** END OF LOCAL BUCKLING EIGENVECTOR CALC.****
IPANDA= 0
Margin=  2.1375E+00  Local buckling from discrete model-1.,M=6   axial halfwaves;FS=0.1
```

```
**************************************************************
**************************************************************
**************************************************************
************          CHAPTER 15            *****************
```

```
***************************************************************
***************************************************************
***************************************************************
**** CHAPTER 15: DESIGN PERTURBATION INDEX, IMOD=  0 *****

**************************************************************
CHAPTER 15 Compute bending-torsion (low-m) buckling from
           BOSOR4-type discretized skin-stringer single
           module model. See Section 12.2 (lower table on
           p. 511) in [1A], for example.

**** BEGIN SUBROUTINE LOCAL (LOW-M LOCAL BUCKLING SEARCH) ****
 LABEL NO. IN STRUCT= 9340

BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
         (skin-stringer discretized module of local buckling)
 AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
 HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
 WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                              ANISOTROPY
   M        EIGOLD            KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
   1      8.11197E-01      1.00000E+00      9.99993E-01     8.11191E-01
   2      6.20753E-01      1.00000E+00      9.99993E-01     6.20749E-01
   3      4.51711E-01      1.00000E+00      9.99993E-01     4.51708E-01
   4      3.60491E-01      1.00000E+00      9.99993E-01     3.60488E-01
   5      3.21937E-01      1.00000E+00      9.99993E-01     3.21935E-01
   6      3.14345E-01      1.00000E+00      9.99993E-01     3.14343E-01
Buckling load factor before t.s.d.=  3.1434E-01 After t.s.d.=  3.1375E-01
   6      3.14345E-01      9.98117E-01      9.99993E-01     3.13751E-01
Buckling load factor from SUB. LOCAL, EIGITR(4)=  3.1375E-01
Number of axial halfwaves between rings, NLOW=    6
**** END SUBROUTINE LOCAL (LOW-M LOCAL BUCKLING SEARCH) ******
 **** END OF LOW-AXIAL-WAVENUMBER CHECK FOR ****
 ***************  LOCAL BUCKLING  **************



***************************************************************
***************************************************************
***************************************************************
************          CHAPTER 16          *****************
***************************************************************
***************************************************************
***************************************************************
**** CHAPTER 16: DESIGN PERTURBATION INDEX, IMOD=  0 *****

**************************************************************
CHAPTER 16 Compute post-local buckling from the Koiter
           theory given in Ref.[1C]. See Figs. 23, 24, and
           Figs. 47-49 in [1A], Fig. 6 in [1C], and Fig. 4 in
Bushnell, D.
"Optimization of an axially compressed ring and stringer
stiffened cylindrical shell with a general buckling modal
imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
Honolulu, Hawaii, April 2007

*** BEGIN CALCULATIONS RELATING TO THE KOITER THEORY ***
```

```
*** See Ref.[3]: Bushnell, D., "Optimization of composite,
*** stiffened, imperfect panels under combined loads for
*** service in the posbuckling regime", CMAME, vol.103,
*** pp 43-114 (1993)
** BEGIN SUBROUTINE INTMOD (INTEGRALS OF PRODUCTS OF MODES) **
 SUB.INTMOD computes the quantities given on pp 58 and 59 of
 the paper just cited.

        INTEGRATED MODAL PRODUCTS A(I,ISEG)
 FORMULA SEGMENT 1   SEGMENT 2   SEGMENT 3   SEGMENT 4   SEGMENT 5   SEGMENT 6
   NO.
     1  3.9677E-01  6.5592E-03  3.1140E-04  0.0000E+00  0.0000E+00  0.0000E+00
     2  2.9724E-01  3.4224E-04  3.9987E-07  0.0000E+00  0.0000E+00  0.0000E+00
     3  2.4660E-01  2.2632E-05  5.8048E-10  0.0000E+00  0.0000E+00  0.0000E+00
     4  5.7879E-01  2.2149E-01  1.1032E-03  0.0000E+00  0.0000E+00  0.0000E+00
     5  2.2994E-01  7.9915E-03  4.9834E-07  0.0000E+00  0.0000E+00  0.0000E+00
     6  1.2245E-01  4.5345E-04  5.2108E-10  0.0000E+00  0.0000E+00  0.0000E+00
     7 -8.7999E-01  6.8612E-02 -4.7777E-04  0.0000E+00  0.0000E+00  0.0000E+00
     8  2.1520E-01  1.7180E-06  9.0157E-13  0.0000E+00  0.0000E+00  0.0000E+00
     9  1.9337E-01  1.4159E-07  1.4633E-15  0.0000E+00  0.0000E+00  0.0000E+00
    10  1.7707E-01  1.2201E-08  2.4504E-18  0.0000E+00  0.0000E+00  0.0000E+00
    11  3.3172E+00  1.1733E-01  1.2869E-05  0.0000E+00  0.0000E+00  0.0000E+00
    12  1.4676E+01 -1.4335E-02  1.2044E-08  0.0000E+00  0.0000E+00  0.0000E+00
    13  3.3867E+01  2.7557E-03  2.5120E-11  0.0000E+00  0.0000E+00  0.0000E+00
    14  3.4103E+01 -1.5814E-04  2.0097E-14  0.0000E+00  0.0000E+00  0.0000E+00
    15  1.2855E+01  2.1048E-05  1.2824E-17  0.0000E+00  0.0000E+00  0.0000E+00
    16 -7.2348E-01  1.9913E-03 -1.5394E-07  0.0000E+00  0.0000E+00  0.0000E+00
    17 -6.2094E-01  9.8611E-05  3.5957E-11  0.0000E+00  0.0000E+00  0.0000E+00
    18  2.1864E+00  2.7882E+00  6.7599E-03  0.0000E+00  0.0000E+00  0.0000E+00
    19  6.2312E+00  8.8485E-01 -1.6849E-05  0.0000E+00  0.0000E+00  0.0000E+00
    20  1.3675E+01  4.5552E-01  3.1024E-08  0.0000E+00  0.0000E+00  0.0000E+00
    21  3.9677E-01  6.5592E-03  3.1140E-04  0.0000E+00  0.0000E+00  0.0000E+00
    22  1.4232E-08  2.1325E-08  6.0929E-19  0.0000E+00  0.0000E+00  0.0000E+00
    23  2.1462E-09  4.3108E-10  3.9434E-20  0.0000E+00  0.0000E+00  0.0000E+00
    24  0.0000E+00  0.0000E+00 -1.8461E-04  0.0000E+00  0.0000E+00  0.0000E+00
    25  2.9724E-01  3.4224E-04  3.9987E-07  0.0000E+00  0.0000E+00  0.0000E+00
    26  2.2633E+01  4.6996E-04  1.3745E-11  0.0000E+00  0.0000E+00  0.0000E+00
    27  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
    28  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
    29  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
    30  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 **** END SUBROUTINE INTMOD (INTEGRALS OF PRODUCTS OF MODES) ****

 EXPLANATION OF FOLLOWING CALCULATIONS (LOAD SET NO. 1):
  Corresponding to M=  6 waves from the local buckling
  analysis above, the distributions of Nx, Ny, and Nxy
  in the locally imperfect and additionally deformed panel are
  next calculated.  The maximum stress components in the
  deformed skin as well as in the stiffener segments are also
  computed. In addition, the tangent membrane stiffness CTAN
  in the locally deformed skin is calculated.  CTAN is needed
  for subsequent calculation of the load factor corres-
  ponding to wide column panel buckling (buckling between
  rings) and general instability.

  BEFORE POSSIBLE CHANGE: INITIAL LOCAL IMPERFECTION W0=  1.00000001E-07
  AFTER POSSIBLE CHANGE: INITIAL LOCAL IMPERFECTION W0=  1.00000001E-07
  IF W0 WAS CHANGED, SEE PANDA2.NEWS ITEM 141 FOR WHY IT WAS
```

```
***** BEGIN SUBROUTINE KOIT2 (KOITER THEORY POSTBUCKLING) ****

 ******** ENTERING KOITER BRANCH, SUBROUTINE KOIT2 *********
 This subroutine is an implementation of the theory described
 in the PANDA2 paper by David Bushnell:
     "Optimization of composite, stiffened, imperfect panels
      under combined loads for service in the postbuckling
      regime", Computer Methods in Applied Mechanics and
      Engineering, Vol. 103 (1993) 43-114 (volume in honor of
      Besselings 65th birthday).

 NOTE: Computations herein do not include the effect of
       "hungry-horse" adjustments to the hoop resultant in the
       panel skin: FNYADJ=  0.0000E+00 for Load Set A and
                   FNYAD0=  0.0000E+00 for Load Set B.
       unless a negative eigenvalue is computed in SUBROUTINE
       EIGKOI.

 BIFURCATION BUCKLING EIGENVALUE FROM KOITER-TYPE THEORY
  AXIAL    ITER.    SLOPE       DSLOPE      EIGKOI
  WAVES     NO.       m           dm
    6         1  6.3039E-03  5.3039E-03  3.0812E-01
    6         2  6.3035E-03 -3.9252E-07  3.0814E-01
    6         3  6.3035E-03  3.4007E-10  3.0814E-01

 BIFURCATION BUCKLING EIGENVALUE FROM KOITER-TYPE THEORY
  AXIAL    ITER.    SLOPE       DSLOPE      EIGKOI
  WAVES     NO.       m           dm
    7         1  5.7832E-03 -5.2032E-04  3.2261E-01
    7         2  5.7832E-03 -5.9933E-09  3.2261E-01
    7         3  5.7832E-03 -6.6674E-10  3.2261E-01

 BIFURCATION BUCKLING EIGENVALUE FROM KOITER-TYPE THEORY
  AXIAL    ITER.    SLOPE       DSLOPE      EIGKOI
  WAVES     NO.       m           dm
    5         1  7.3183E-03  1.5351E-03  3.1435E-01
    5         2  7.3183E-03 -3.8270E-08  3.1436E-01
    5         3  7.3183E-03 -1.4225E-10  3.1436E-01

 BIFURCATION BUCKLING EIGENVALUE FROM KOITER-TYPE THEORY
  AXIAL    ITER.    SLOPE       DSLOPE      EIGKOI
  WAVES     NO.       m           dm
    6         1  6.3036E-03 -1.0147E-03  3.0814E-01
    6         2  6.3035E-03 -1.9438E-08  3.0814E-01
    6         3  6.3035E-03 -3.1089E-10  3.0814E-01

 LOCAL BIFURCATION BUCKLING LOAD FACTOR ESTIMATES
 AND AMPLITUDE Wo OF LOCAL IMPERFECTION, Wo*(buckling mode)
 Critical number of axial half-waves                 =  6
 Slope of buckling nodal lines from Koiter Theory, m=  6.30E-03
 Knockdown factor for C44, C45, C55 for transv.shear=  9.98E-01
 Local buckling load Factor from Koiter-type Theory =  3.08E-01
 Load Factor from BOSOR4-type panel module model    =  3.13E-01
 BOSOR4-type load factor without knockdowns for
   effects of anisotropy [e.g. C(4,6)] of the skin,
   transverse shear def., or in-plane shear loading =  3.14E-01
 Amplitude Wo of local imperfection                 =  1.0000E-07
```

```
Even if the load factor from Koiter-type theory is greater
than unity, the panel is in a "post-locally-buckled" state
because there is always a finite local imperfection in the
panel skin and stringer that grows under the applied loads.

The load factor computed from Koiter theory may not agree well
with that computed from the BOSOR4-type module model. Some
reasons for the discrepancy are:
       1. there are significant non-zero coupling terms
             C13, C16, C23, C26, C34, C35, C46, C56
          in the constitutive matrix Cij,
       2. significant in-plane shear loads exist,
       3. there is a significant effect of transverse
          shear deformation,
       4. the stringer web deforms significantly in the
          local buckling mode,
       5. there is significant hoop compression.
       6. the temperature varies significantly in a seg-
          ment where the material props. are temp.-dependent,
       7. the critical number of axial half-waves is one,
       8. the configuration is TRUSS-CORE SANDWICH.
       9. any segment laminate is unbalanced.
      10. the user selected "N" for the MAINSETUP prompt:
Do you want "flat skin" discretized module for local buckling?
      11. there is significant prebuckling axial bending,
          especially in panels with rectangular stringers.
      12. "hungry-horse" skin hoop resultant adjustments are
          ignored: for Load Set A: FNYADJ=  0.0000E+00
                   for Load Set B: FNYAD0=  0.0000E+00
Margin=  2.0814E+00  Local buckling from Koiter theory,M=6   axial halfwaves;FS=0.1
ENTERING "NEWTON", LABEL=8002; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION IGNORED  (Wo = 0):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8002
NEWTON ITERATIONS BEGIN; SLOPE=  6.3035E-03; a=  0.0000E+00; f=  0.0000E+00
Imperfection, Wo=  0.0000E+00; Load Perturbation=  0.0000E+00
 ITER   SLOPE       DSLOPE        a           da          f           df
   1  1.1154E-02  4.8505E-03 -1.3650E-01 -1.3650E-01  5.4678E-02  6.8171E-03
   2  1.8421E-02  7.2674E-03 -1.9531E-01 -5.8802E-02  5.8471E-02  3.3138E-03
   3  2.1605E-02  3.1836E-03 -2.0608E-01 -1.0772E-02  5.9118E-02  6.1553E-04
   4  2.1806E-02  2.0087E-04 -2.0641E-01 -3.3386E-04  5.9136E-02  1.9041E-05
   5  2.1806E-02  3.7325E-07 -2.0641E-01 -2.1438E-07  5.9136E-02  1.2233E-08
LEAVING "NEWTON", LABEL=8002; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  5.9136E-02 -2.0641E-01  2.1806E-02  9.2881E-01
ENTERING "NEWTON", LABEL=8004; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION INCLUDED (Wo =  1.0000E-07):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8004
NEWTON ITERATIONS BEGIN; SLOPE=  2.1806E-02; a= -2.0641E-01; f=  5.9136E-02
Imperfection, Wo=  2.4141E-06; Load Perturbation=  0.0000E+00
 ITER   SLOPE       DSLOPE        a           da          f           df
   1  2.1809E-02  2.2250E-06 -2.0642E-01 -9.4218E-06  5.9135E-02 -1.7165E-06
   2  2.1809E-02 -2.6672E-09 -2.0642E-01 -1.2991E-07  5.9135E-02  1.0749E-08
```

```
   3  2.1809E-02  5.5450E-10 -2.0642E-01  3.7165E-08  5.9135E-02 -3.5316E-09
LABEL= 8004 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  5.9135E-02 -2.0642E-01  2.1809E-02
LEAVING "NEWTON", LABEL=8004; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  5.9135E-02 -2.0642E-01  2.1809E-02  9.2881E-01

Modification of axial curvature change to account for
post-local-buckling change in distribution of axial load, Nx:
 Change in axial curvature before local buckling     = -4.6945E-05
 Average axial resultant in skin and base, unbuckled = -4.6902E+02
 Average axial resultant in skin and base,   buckled = -3.4527E+02
 Fraction of axial resultant from non-thermal loads  =  1.0000E+00
 Change in average resultant in skin and base from
  non-thermal loads,   DELFCE*(non-thermal fraction) =  1.2375E+02
 Distance from axial neutral axis to skin ref. surf. =  2.2159E-01
 Axial bending rigidity (C44N) of unbuckled panel    =  4.2465E+04
 Increment in axial curvature from Nx redistribution =  6.4575E-04
 Increment in axial curvature from ref. surf. shift  =  0.0000E+00
 Bowing amplitude from Nx redistribution             = -3.1286E-03
 Bowing amplitude from reference surface shift       =  0.0000E+00
 Bowing amplitude from both of previous two lines    = -3.1286E-03
 Change in axial curvature after post-local-buckling =  5.9880E-04

Modification of hoop curvature change to account for the
post-local-buckling moment applied by the skin to the rings:
 Change in hoop curvature before local buckling      =  4.8211E-11
 Average hoop resultant in skin before buckling      = -2.4133E+01
 Average hoop resultant in skin after  buckling      = -1.9923E+01
 Fraction of hoop resultant from non-thermal loads   =  1.0000E+00
 Change in average resultant in skin and base from
  non-thermal loads,   DELFCE*(non-thermal fraction) =  2.1048E+00
 Distance from skin reference surface to neutral axis=  7.1429E-02
 Load eccentricity from curvature:      0.125*b**2/R = -1.5258E-02
 Hoop bending rigidity (C55N) of postbuckled panel   =  1.1493E+04
 Increment in hoop curvature due to local buckling   =  1.0287E-05
ENTERING "NEWTON", LABEL=8004; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION INCLUDED (Wo =  1.0000E-07):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8004
NEWTON ITERATIONS BEGIN; SLOPE=  2.1809E-02; a= -2.0642E-01; f=  5.9135E-02
Imperfection, Wo=  2.4141E-06; Load Perturbation=  0.0000E+00
 ITER   SLOPE       DSLOPE        a           da          f           df
   1  2.1748E-02 -6.0996E-05 -2.1569E-01 -9.2689E-03  6.3091E-02  3.9563E-03
   2  2.1749E-02  1.7334E-06 -2.1516E-01  5.2875E-04  6.2842E-02 -2.4869E-04
   3  2.1749E-02  2.3374E-11 -2.1516E-01  1.9036E-06  6.2841E-02 -1.0182E-06
LABEL= 8004 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  6.2841E-02 -2.1516E-01  2.1749E-02
LEAVING "NEWTON", LABEL=8004; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  6.2841E-02 -2.1516E-01  2.1749E-02  9.2881E-01

NEWTON ITERATIONS BEGIN IN SUBROUTINE ENERGY
CALLED FROM SUBROUTINE KOIT2 AT LABEL = 8010.
PURPOSE IS TO OBTAIN NEW SOLUTION ALLOWING THE AXIAL
HALFWAVELENGTH OF THE LOCAL POSTBUCKLED PATTERN TO CHANGE.

ITER.       UNKNOWNS IN THE LOCAL POSTBUCKLING PROBLEM
```

```
 NO.    AMPLITUDE   FLATTENING   NODAL LINE  PI**2*n**2/4L**2   AXIAL HALFWAVELENGTH
          f            a        SLOPE,  m         N          OF BUCKLES,(L/n)
 0    6.28412E-02  -2.15159E-01   2.17492E-02   9.28810E-01   1.62988E+00
 1    5.95259E-02  -2.44126E-01   1.98637E-02   1.13200E+00   1.47638E+00
 2    5.83214E-02  -2.52053E-01   1.93437E-02   1.21452E+00   1.42533E+00
 3    5.81605E-02  -2.52795E-01   1.92756E-02   1.22529E+00   1.41906E+00
 4    5.81580E-02  -2.52805E-01   1.92746E-02   1.22545E+00   1.41897E+00
 CONVERGENCE SUCCESSFUL!
YES CONVERGENCE IN "ENERGY", LABEL=8010: IMOD,F,AL,M,N= 0
 5.8158E-02 -2.5280E-01  1.9275E-02  1.2255E+00
VALUES FOR UNPERTURBED DESIGN: F,A,M,N=   5.82E-02  -2.53E-01   1.93E-02   1.23E+00
ENTERING "NEWTON", LABEL=8240; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION INCLUDED (Wo =  1.0000E-07):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8240
NEWTON ITERATIONS BEGIN; SLOPE=  1.9275E-02; a= -2.5280E-01; f=  5.8158E-02
Imperfection, Wo=  2.4141E-06; Load Perturbation=  0.0000E+00
 ITER   SLOPE       DSLOPE        a           da         f           df
   1  1.9275E-02 -2.5254E-09 -2.5280E-01 -6.6040E-08  5.8158E-02  5.0040E-09
   2  1.9275E-02 -4.3985E-12 -2.5280E-01 -3.7795E-08  5.8158E-02  4.7415E-09
   3  1.9275E-02 -2.6752E-10 -2.5280E-01 -3.6504E-08  5.8158E-02  4.3276E-09
LABEL= 8240 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  5.8158E-02 -2.5280E-01  1.9275E-02
LEAVING "NEWTON", LABEL=8240; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  5.8158E-02 -2.5280E-01  1.9275E-02  1.2255E+00
 AMPLITUDES: F00, F =  0.0581579767  0.0581579879
VALUES FOR UNPERTURBED DESIGN: F,A,M,N=   5.82E-02  -2.53E-01   1.93E-02   1.23E+00

LOCAL DEFORMATION CHARACTERISTICS:
Average axial strain(not including thermal),EXAVE = -2.5671E-03
Initial local imperfection amplitude,           Wo=  1.0000E-07
Slope of local buckling nodal lines in skin     M =  1.9275E-02
Parameter "a" in the expression f*(phi +a*phi**3) = -2.5280E-01
Amplitude  f  in the expression f*(phi +a*phi**3) =  5.8158E-02
Normal displacement amplitude between stringers W =  4.3455E-02
Number of axial halfwaves at local bifurcation    =     6
Number of axial halfwaves in postbuckled regime   =  6.8918E+00
Convergence characteristic,               NOCONV  =  0


RESULTS FOR  6.8918E+00 AXIAL WAVES...
LOCAL DEFORMATION PARAMETERS:
   SLOPE, a, f       =  1.9275E-02 -2.5280E-01  5.8158E-02
APPLIED STRESS RESULTANTS (Load set A):
   Nx, Ny, Nxy       = -1.0000E+03  9.6387E-01  5.0000E+00
APPLIED STRESS RESULTANTS (Load set B):
  Nxo, Nyo, Nxyo     =  0.0000E+00  0.0000E+00  0.0000E+00
STRAIN AND STRESS FROM APPLIED LOADS:
AVERAGE STRAIN COMPONENTS:
  EPS1, EPS2, EPS12  = -2.5671E-03 -8.2017E-05  9.6244E-05
AVERAGE RESULTANTS IN SKIN:
N1SKIN,N2SKIN,N12SKIN= -3.6032E+02 -2.3132E+01  5.0000E+00
NOTE: N1SKIN includes average of Nx in skin and stringer base.

 -------------------------------------------
 PERTURB THE APPLIED AXIAL LOAD, Nx...
```

```
ENTERING "NEWTON", LABEL=8250; IMOD= 0

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8250
NEWTON ITERATIONS BEGIN; SLOPE=  1.9275E-02; a= -2.5280E-01; f=  5.8158E-02
Imperfection, Wo=  2.4141E-06; Load Perturbation=  2.0000E+01
 ITER   SLOPE       DSLOPE        a           da         f           df
   1  1.9257E-02 -1.7513E-05 -2.5554E-01 -2.7324E-03  5.9089E-02  9.3108E-04
   2  1.9257E-02  8.2757E-08 -2.5550E-01  3.3188E-05  5.9076E-02 -1.2907E-05
   3  1.9257E-02  1.4469E-09 -2.5550E-01 -1.5214E-07  5.9076E-02  1.1563E-08
LABEL= 8250 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  5.9076E-02 -2.5550E-01  1.9257E-02
LEAVING "NEWTON", LABEL=8250; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  5.9076E-02 -2.5550E-01  1.9257E-02  1.2255E+00
 -------------------------------------------
 PERTURB THE APPLIED HOOP LOAD, Ny...
ENTERING "NEWTON", LABEL=8260; IMOD= 0

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8260
NEWTON ITERATIONS BEGIN; SLOPE=  1.9275E-02; a= -2.5280E-01; f=  5.8158E-02
Imperfection, Wo=  2.4141E-06; Load Perturbation=  1.1755E+01
 ITER   SLOPE       DSLOPE        a           da         f           df
   1  2.0027E-02  7.5281E-04 -2.5457E-01 -1.7700E-03  5.8705E-02  5.4675E-04
   2  2.0022E-02 -5.1951E-06 -2.5456E-01  1.2915E-05  5.8700E-02 -4.2394E-06
   3  2.0022E-02 -1.1088E-10 -2.5456E-01  1.2154E-07  5.8700E-02 -5.3981E-09
LABEL= 8260 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  5.8700E-02 -2.5456E-01  2.0022E-02
LEAVING "NEWTON", LABEL=8260; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  5.8700E-02 -2.5456E-01  2.0022E-02  1.2255E+00
 -------------------------------------------
 PERTURB THE APPLIED IN-PLANE SHEAR LOAD, Nxy...
ENTERING "NEWTON", LABEL=8270; IMOD= 0

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8270
NEWTON ITERATIONS BEGIN; SLOPE=  1.9275E-02; a= -2.5280E-01; f=  5.8158E-02
Imperfection, Wo=  2.4141E-06; Load Perturbation=  3.4395E+00
 ITER   SLOPE       DSLOPE        a           da         f           df
   1  3.2531E-02  1.3257E-02 -2.5286E-01 -5.8836E-05  5.8179E-02  2.1418E-05
   2  3.2521E-02 -1.0461E-05 -2.5285E-01  1.4735E-05  5.8175E-02 -4.7124E-06
   3  3.2521E-02 -1.0484E-09 -2.5285E-01 -4.3217E-08  5.8175E-02  7.5267E-09
LABEL= 8270 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  5.8175E-02 -2.5285E-01  3.2521E-02
LEAVING "NEWTON", LABEL=8270; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  5.8175E-02 -2.5285E-01  3.2521E-02  1.2255E+00
 -------------------------------------------

 3X3 MATRICES FOR STRAIN AND FORCE CHANGE...
      EMAT, THE STRAIN-CHANGE MATRIX       NMAT, THE FORCE-CHANGE MATRIX
      d(EPS1)    d(EPS2)    d(EPS12)     d(N1skin)  d(N2skin)   d(N12skn)
 dNx -5.224E-05 -6.582E-06  1.117E-06   -5.511E+00 -4.156E-01 -4.768E-07
 dNy -2.585E-06 -4.747E-05  2.361E-06    7.169E-01 -9.703E+00 -4.768E-07
dNxy -2.671E-07 -1.023E-06  6.621E-05    7.401E-02  1.157E-02  3.440E+00

TANGENT STIFFNESS BEFORE SYMMETRIZATION
AVERAGE SKIN TANGENT STIFFNESS MATRIX
(Segments 1 and 2 averaged),    CTAN...
 1.0816E+05 -2.0932E+04  1.2305E+03
-1.7875E+04  2.0556E+05  3.2782E+03
 7.9130E+02  2.5430E+03  5.1988E+04
```

```
TANGENT STIFFNESS AFTER SYMMETRIZATION
AVERAGE SKIN TANGENT STIFFNESS MATRIX
(Segments 1 and 2 averaged),    CTAN...
 1.0816E+05 -1.9404E+04  1.0109E+03
-1.9404E+04  2.0556E+05  2.9106E+03
 1.0109E+03  2.9106E+03  5.1988E+04

(APPLIED LOAD)/(BUCKLING LOAD)=  3.2453E+00

NORMALIZED AVERAGE SKIN TANGENT STIFFNESS MATRIX
(CTAN(i,i)/CX(i,i,1), i=1,2,3) =   4.0366E-01  7.6718E-01  5.5437E-01
TANGENT POISSON RATIO
CTAN(1,2)/CTAN(1,1) =  -1.7940E-01
NORMALIZED AVERAGE (N1skin,N12skn) COUPLING
CTAN(1,3)/CX(1,1,1) =   3.7729E-03
NORMALIZED AVERAGE (N2skin,N12skn) COUPLING
CTAN(2,3)/CX(2,2,1) =   1.0863E-02

 Average tangent stiffnesses of the panel skin
have been calculated by integration of the local tangent
stiffnesses, C11TAN, C12TAN, C22TAN, and C33TAN with
Simpsons rule integration:
Average axial tangent stiffness,         CTAN(1,1) =  1.1786E+05
Average (1,2) tangent stiffness,         CTAN(1,2) =  6.2584E+03
Average hoop  tangent stiffness,         CTAN(2,2) =  2.0540E+05
Average shear tangent stiffness,         CTAN(3,3) =  5.1945E+04
These tangent stiffness components affect wide column,
general instability, and panel instability load factors.

      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


        LOCALLY DEFORMED STATE IN THE PANEL MODULE SHOWN ABOVE
                 PANEL MODULE HAS 4 SEGMENTS
 Nodal Disp.       Membrane Strains                Resultants
 Point  W        Ex         Ey         Exy        Nx         Ny         Nxy     C11TAN
C12TAN    C22TAN     C33TAN

                 Locally Deformed State for Segment Number 1
  1  4.35E-02 -2.53E-04 -1.05E-05  5.33E-05 -6.86E+01 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  2  4.33E-02 -2.67E-04 -6.36E-06  5.33E-05 -7.19E+01 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  3  4.29E-02 -3.12E-04  7.17E-06  5.33E-05 -8.29E+01 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  4  4.21E-02 -3.98E-04  3.31E-05  5.33E-05 -1.04E+02 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  5  4.07E-02 -5.37E-04  7.49E-05  5.33E-05 -1.38E+02 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  6  3.86E-02 -7.39E-04  1.35E-04  5.33E-05 -1.87E+02 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  7  3.57E-02 -1.00E-03  2.14E-04  5.33E-05 -2.51E+02 -2.31E+01  5.00E+00  4.44E+04
0.00E+00  2.05E+05  5.19E+04
  8  3.20E-02 -1.31E-03  3.07E-04  5.33E-05 -3.26E+02 -2.31E+01  5.00E+00  7.80E+04
0.00E+00  2.05E+05  5.19E+04
  9  2.75E-02 -1.64E-03  4.05E-04  5.33E-05 -4.06E+02 -2.31E+01  5.00E+00  1.17E+05
0.00E+00  2.05E+05  5.19E+04
 10  2.24E-02 -1.95E-03  4.99E-04  5.33E-05 -4.82E+02 -2.31E+01  5.00E+00  1.56E+05
0.00E+00  2.05E+05  5.19E+04
 11  1.70E-02 -2.21E-03  5.77E-04  5.33E-05 -5.46E+02 -2.31E+01  5.00E+00  1.90E+05
6.32E+03  2.05E+05  5.19E+04

                 Locally Deformed State for Segment Number 2
  1  1.70E-02 -2.21E-03  5.77E-04  5.33E-05 -5.46E+02 -2.31E+01  5.00E+00  1.90E+05
6.32E+03  2.05E+05  5.19E+04
  2  1.17E-02 -2.40E-03  6.33E-04  5.33E-05 -5.92E+02 -2.31E+01  5.00E+00  2.15E+05
1.44E+04  2.05E+05  5.19E+04
  3  6.90E-03 -2.51E-03  6.66E-04  5.33E-05 -6.19E+02 -2.31E+01  5.00E+00  2.30E+05
1.93E+04  2.05E+05  5.19E+04
  4  3.02E-03 -2.56E-03  6.80E-04  5.33E-05 -6.30E+02 -2.31E+01  5.00E+00  2.37E+05
2.14E+04  2.05E+05  5.19E+04
  5  5.56E-04 -2.57E-03  6.84E-04  5.33E-05 -6.33E+02 -2.31E+01  5.00E+00  2.38E+05
2.18E+04  2.05E+05  5.19E+04
  6  8.88E-11 -2.57E-03  6.84E-04  5.33E-05 -6.33E+02 -2.31E+01  5.00E+00  2.38E+05
2.18E+04  2.05E+05  5.19E+04
  7 -5.56E-04 -2.57E-03  6.84E-04  5.33E-05 -6.33E+02 -2.31E+01  5.00E+00  2.38E+05
2.18E+04  2.05E+05  5.19E+04
  8 -3.02E-03 -2.56E-03  6.80E-04  5.33E-05 -6.30E+02 -2.31E+01  5.00E+00  2.37E+05
2.14E+04  2.05E+05  5.19E+04
  9 -6.90E-03 -2.51E-03  6.66E-04  5.33E-05 -6.19E+02 -2.31E+01  5.00E+00  2.30E+05
1.93E+04  2.05E+05  5.19E+04
 10 -1.17E-02 -2.40E-03  6.33E-04  5.33E-05 -5.92E+02 -2.31E+01  5.00E+00  2.15E+05
1.44E+04  2.05E+05  5.19E+04
 11 -1.70E-02 -2.21E-03  5.77E-04  5.33E-05 -5.46E+02 -2.31E+01  5.00E+00  1.90E+05
```

```
6.32E+03  2.05E+05  5.19E+04

                  Locally Deformed State for Segment Number 3
  1 -6.77E-05 -2.56E-03  7.68E-04 -8.57E-11 -2.07E+03  4.70E-06 -2.67E-05  8.89E+05
2.67E+05  8.89E+05  3.11E+05
  2 -5.74E-04 -2.51E-03  7.53E-04 -8.40E-11 -2.03E+03  3.61E-05 -2.61E-05  8.89E+05
2.67E+05  8.89E+05  3.11E+05
  3 -9.72E-04 -2.46E-03  7.37E-04 -9.84E-11 -1.99E+03  1.57E-05 -3.06E-05  8.88E+05
2.66E+05  8.89E+05  3.11E+05
  4 -1.29E-03 -2.41E-03  7.22E-04 -1.06E-10 -1.95E+03 -4.69E-06 -3.31E-05  8.88E+05
2.66E+05  8.89E+05  3.11E+05
  5 -1.54E-03 -2.35E-03  7.06E-04 -1.09E-10 -1.90E+03 -1.47E-05 -3.38E-05  8.87E+05
2.66E+05  8.89E+05  3.11E+05
  6 -1.75E-03 -2.30E-03  6.91E-04 -1.05E-10 -1.86E+03  2.70E-05 -3.28E-05  8.87E+05
2.66E+05  8.89E+05  3.11E+05
  7 -1.93E-03 -2.25E-03  6.75E-04 -9.72E-11 -1.82E+03  2.73E-05 -3.03E-05  8.86E+05
2.66E+05  8.89E+05  3.11E+05
  8 -2.10E-03 -2.20E-03  6.60E-04 -8.36E-11 -1.78E+03 -1.37E-05 -2.60E-05  8.86E+05
2.66E+05  8.89E+05  3.11E+05
  9 -2.25E-03 -2.15E-03  6.44E-04 -6.39E-11 -1.74E+03  7.27E-06 -1.99E-05  8.86E+05
2.66E+05  8.89E+05  3.11E+05
 10 -2.42E-03 -2.10E-03  6.29E-04 -3.74E-11 -1.70E+03 -1.31E-05 -1.16E-05  8.85E+05
2.66E+05  8.89E+05  3.11E+05
 11 -2.59E-03 -2.04E-03  6.13E-04 -4.26E-11 -1.65E+03  1.83E-05 -1.32E-05  8.84E+05
2.65E+05  8.89E+05  3.11E+05

                  Locally Deformed State for Segment Number 4
  1 -1.70E-02 -2.21E-03  5.77E-04  5.33E-05 -5.46E+02 -2.31E+01  5.00E+00  1.90E+05
6.32E+03  2.05E+05  5.19E+04
  2 -2.24E-02 -1.95E-03  4.99E-04  5.33E-05 -4.82E+02 -2.31E+01  5.00E+00  1.56E+05
0.00E+00  2.05E+05  5.19E+04
  3 -2.75E-02 -1.64E-03  4.05E-04  5.33E-05 -4.06E+02 -2.31E+01  5.00E+00  1.17E+05
0.00E+00  2.05E+05  5.19E+04
  4 -3.20E-02 -1.31E-03  3.07E-04  5.33E-05 -3.26E+02 -2.31E+01  5.00E+00  7.80E+04
0.00E+00  2.05E+05  5.19E+04
  5 -3.57E-02 -1.00E-03  2.14E-04  5.33E-05 -2.51E+02 -2.31E+01  5.00E+00  4.44E+04
0.00E+00  2.05E+05  5.19E+04
  6 -3.86E-02 -7.39E-04  1.35E-04  5.33E-05 -1.87E+02 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  7 -4.07E-02 -5.37E-04  7.49E-05  5.33E-05 -1.38E+02 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  8 -4.21E-02 -3.98E-04  3.31E-05  5.33E-05 -1.04E+02 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
  9 -4.29E-02 -3.12E-04  7.17E-06  5.33E-05 -8.29E+01 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
 10 -4.33E-02 -2.67E-04 -6.36E-06  5.33E-05 -7.19E+01 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04
 11 -4.35E-02 -2.53E-04 -1.05E-05  5.33E-05 -6.86E+01 -2.31E+01  5.00E+00  2.68E+04
0.00E+00  2.05E+05  5.19E+04

  AVERAGE AXIAL RESULTANT IN SKIN, Nsknave= -361.360382
  NOTE: Nskave includes Nx averaged in skin and stringer base.
  AVERAGE AXIAL RESULTANT OVERALL, Nx(ave)= -1000.00061
  AVERAGE STRESS RESULTANTS IN STIFFENER PARTS
  FROM LOAD SET A (eigenvalue loads)..
 STRINGER  BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR= -6.1350E+02 -2.3132E+01  5.0000E+00
 STRINGER  WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR= -1.8625E+03  4.6964E-06 -2.6668E-05
 STRINGER FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
```

```
  RING    BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00 -4.3087E+02  5.0000E+00
  RING    WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  2.8821E+02  0.0000E+00  0.0000E+00
  RING   FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
 FROM LOAD SET B (fixed applied loads)..
STRINGER  BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER  WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
  RING    BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
  RING    WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
  RING   FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
 RESULTANTS FROM THERMAL LOADING:
STRINGER  BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER  WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
  RING    BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
  RING    WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
  RING   FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
***** END SUBROUTINE KOIT2 (KOITER THEORY POSTBUCKLING) ******
********** END OF NONLINEAR EQUILIBRIUM CALCS.************



***************************************************************
***************************************************************
***************************************************************
************          CHAPTER 17           ****************
***************************************************************
***************************************************************
***************************************************************
**** CHAPTER 17: DESIGN PERTURBATION INDEX, IMOD=  0 *****

**************************************************************
CHAPTER 17 Compute stresses in layers and at various
           locations in skin-stringer module model, including
           local post-buckling, if any. Compute stringer
           popoff constraints (Figs. 5 - 7 in [1A]). Local
           post-buckling such as that shown in Figs. 48 & 49
           of [1A] is included. Therefore, SUBROUTINE STRTHK
           is used.

***** BEGIN SUBROUTINE STRTHK (POSTBUCKLING STRESSES) ******
       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
```

```
 Start calculation of stresses in the panel module depicted above...
 (Segment numbering below refers to the **BOTTOMMOST** of the sketches above.)

 STRESSES AT CRITICAL NODES IN SEGMENTS OF MODULE...
 BUCK.  LOCATION  IN  PANEL   WINDING   IN-PLANE STRESSES IN MATL COORDS.  MODE OF
TRANSVERSE CRACKING  ALLOWABLE  MATERIAL
 MODE  SEG. NODE LAYER    Z    ANGLE     SIG1        SIG2        SIG12     FAILURE  (1.0
means inactive)   STRESS      TYPE

 ----------------------------  OR ----------------------------

 STRESSES AT CRITICAL NODES IN SEGMENTS OF MODULE...
 BUCK.  LOCATION  IN  PANEL   WINDING   IN-PLANE STRESSES IN MATL COORDS.  MODE OF
VON MISES        ALLOWABLE  MATERIAL
 MODE  SEG. NODE LAYER    Z    ANGLE     SIG1        SIG2        SIG12     FAILURE
EFFECTIVE STRESS      STRESS      TYPE
 POS    1     1    1 -1.21E-02   0.0 -3.2717E+04 -1.4227E+04  5.9214E+02   no failure
2.8432E+04                     1
 NEG    1     1    1 -1.21E-02   0.0  2.6051E+04  8.5408E+03 -1.7791E+02   no failure
2.3004E+04                     1
 POS    1     1    1  1.21E-02   0.0  2.8417E+04  1.6915E+04 -1.7791E+02   no failure
2.4760E+04                     1
 NEG    1     1    1  1.21E-02   0.0 -3.3113E+04 -1.5061E+04  5.9214E+02   no failure
2.8734E+04                     1
 POS    1     3    1 -1.21E-02   0.0 -3.3335E+04 -1.5412E+04 -1.3596E+03   no failure
2.8992E+04                     1
 NEG    1     3    1 -1.21E-02   0.0  2.5581E+04  1.0066E+04  1.7738E+03   no failure
2.2531E+04                     1
 POS    1     3    1  1.21E-02   0.0  2.8596E+04  2.0603E+04  1.7738E+03   no failure
2.5739E+04                     1
 NEG    1     3    1  1.21E-02   0.0 -3.4584E+04 -1.9089E+04 -1.3596E+03   no failure
3.0096E+04                     1
 POS    1     5    1 -1.21E-02   0.0 -3.4993E+04 -1.7728E+04 -4.0749E+03   no failure
3.1117E+04                     1
 NEG    1     5    1 -1.21E-02   0.0  2.2879E+04  1.3050E+04  4.4891E+03   no failure
2.1345E+04                     1
 POS    1     5    1  1.21E-02   0.0  2.7386E+04  2.8562E+04  4.4891E+03   no failure
2.9052E+04                     1
 NEG    1     5    1  1.21E-02   0.0 -3.8135E+04 -2.7716E+04 -4.0749E+03   no failure
3.4862E+04                     1
 POS    1     7    1 -1.21E-02   0.0 -3.6548E+04 -1.7159E+04 -8.0823E+03   no failure
```

```
3.4627E+04                        1
 NEG    1     7    1 -1.21E-02   0.0  1.5387E+04  1.3558E+04  8.4966E+03   no failure
2.0701E+04                        1
 POS    1     7    1  1.21E-02   0.0  2.0778E+04  3.2015E+04  8.4966E+03   no failure
3.1750E+04                        1
 NEG    1     7    1  1.21E-02   0.0 -4.1220E+04 -3.2246E+04 -8.0823E+03   no failure
4.0071E+04                        1
 POS    1     9    1 -1.21E-02   0.0 -3.5984E+04 -1.0196E+04 -1.1904E+04   no failure
3.8171E+04                        1
 NEG    1     9    1 -1.21E-02   0.0  2.3790E+03  8.0254E+03  1.2318E+04   no failure
2.2498E+04                        1
 POS    1     9    1  1.21E-02   0.0  7.1457E+03  2.4401E+04  1.2318E+04   no failure
3.0452E+04                        1
 NEG    1     9    1  1.21E-02   0.0 -4.0891E+04 -2.6063E+04 -1.1904E+04   no failure
4.1361E+04                        1
 POS    1    11    1 -1.21E-02   0.0 -3.1463E+04  3.2705E+03 -1.3357E+04   no failure
4.0482E+04                        1
 NEG    1    11    1 -1.21E-02   0.0 -1.3211E+04 -3.7871E+03  1.3771E+04   no failure
2.6604E+04                        1
 POS    1    11    1  1.21E-02   0.0 -1.0312E+04  6.3626E+03  1.3771E+04   no failure
2.7953E+04                        1
 NEG    1    11    1  1.21E-02   0.0 -3.5494E+04 -9.6787E+03 -1.3357E+04   no failure
3.9309E+04                        1
 POS    2     1    1 -1.21E-02   0.0 -3.1491E+04  3.1770E+03 -1.3357E+04   no failure
4.0461E+04                        1
 NEG    2     1    1 -1.21E-02   0.0 -1.3176E+04 -3.6707E+03  1.3771E+04   no failure
2.6601E+04                        1
 POS    2     1    1  1.21E-02   0.0 -1.0262E+04  6.5278E+03  1.3771E+04   no failure
2.7997E+04                        1
 NEG    2     1    1  1.21E-02   0.0 -3.5551E+04 -9.8668E+03 -1.3357E+04   no failure
3.9315E+04                        1
 Change local hoop curvature in panel skin at web root
 in order to avoid unconservative hoop bending strain:
 discretized module segment 2, nodal point 6
 curvature change now used at nodal point 6: WDDPB =  3.5424E-01
 post-local-buckling curvatures at the previous three nodal points:
 WDDVAR(I-1,2),WDDVAR(I-2,2),WDDVAR(I-3,2) =  2.8164E-01  2.0903E-01  1.4057E-01
 POS    2     6    1 -1.21E-02   0.0 -1.0927E+04  4.9762E+04 -1.1943E+03   no failure
5.6068E+04                        1
 NEG    2     6    1 -1.21E-02   0.0 -3.9439E+04 -4.5280E+04  1.6085E+03   no failure
4.2752E+04                        1
 POS    2     6    1  1.21E-02   0.0 -4.1467E+04 -5.1552E+04  1.6085E+03   no failure
4.7404E+04                        1
 NEG    2     6    1  1.21E-02   0.0 -1.3030E+04  4.3237E+04 -1.1943E+03   no failure
5.1058E+04                        1
 POS    2    11    1 -1.21E-02   0.0 -9.1070E+03  9.8924E+03 -1.3357E+04   no failure
2.8392E+04                        1
 NEG    2    11    1 -1.21E-02   0.0 -3.5560E+04 -1.0386E+04  1.3771E+04   no failure
3.9648E+04                        1
 POS    2    11    1  1.21E-02   0.0 -3.2647E+04 -1.8760E+02  1.3771E+04   no failure
4.0357E+04                        1
 NEG    2    11    1  1.21E-02   0.0 -1.3166E+04 -3.1514E+03 -1.3357E+04   no failure
2.6019E+04                        1
 POS    3     1    1 -4.00E-02   0.0 -2.3208E+04  8.3780E+03 -4.6491E+03   no failure
2.9463E+04                        1
 NEG    3     1    1 -4.00E-02   0.0 -2.8503E+04 -8.3780E+03  4.6491E+03   no failure
2.6620E+04                        1
 POS    3     1    1  4.00E-02   0.0 -2.8503E+04 -8.3780E+03  4.6491E+03   no failure
```

```
2.6620E+04                    1
 NEG    3     1    1  4.00E-02   0.0 -2.3208E+04  8.3780E+03 -4.6491E+03   no failure
2.9463E+04                    1

 Maximum in-plane tensile force in stringer web
 tending to peel the faying flange from the panel skin:
 ********* STRINGER POPOFF MARGIN **********
  Segment number in the discretized model  =  3
  Nodal point number in the discrete model =  1
  Peel force that varies axially as cos(nx)=  2.0129E+02
  Peel force that varies axially as sin(nx)=  2.0129E+02
  Peel force used in popoff constraint,FPOP=  6.0387E+01
 Maximum allowable peel force, FPOPMAX     =  1.0000E+06
 Stringer popoff margin=FPOPMAX/FPOP - 1.0 =  1.6559E+04
 ******* END OF STRINGER POPOFF CALCULATIONS *******

 POS    3     6    1 -4.00E-02   0.0 -1.8896E+04  2.9536E+03 -1.5897E+03   no failure
2.0717E+04                    1
 NEG    3     6    1 -4.00E-02   0.0 -2.7615E+04 -2.9536E+03  1.5897E+03   no failure
2.6407E+04                    1
 POS    3     6    1  4.00E-02   0.0 -2.7615E+04 -2.9536E+03  1.5897E+03   no failure
2.6407E+04                    1
 NEG    3     6    1  4.00E-02   0.0 -1.8896E+04  2.9536E+03 -1.5897E+03   no failure
2.0717E+04                    1
 POS    3    11    1 -4.00E-02   0.0 -1.5384E+04  4.4614E+02 -1.4699E+03   no failure
1.5818E+04                    1
 NEG    3    11    1 -4.00E-02   0.0 -2.5914E+04 -4.4614E+02  1.4699E+03   no failure
2.5819E+04                    1
 POS    3    11    1  4.00E-02   0.0 -2.5914E+04 -4.4614E+02  1.4699E+03   no failure
2.5819E+04                    1
 NEG    3    11    1  4.00E-02   0.0 -1.5384E+04  4.4614E+02 -1.4699E+03   no failure
1.5818E+04                    1
 POS    4     1    1 -1.21E-02   0.0 -9.7460E+03  7.7623E+03 -1.3357E+04   no failure
2.7679E+04                    1
 NEG    4     1    1 -1.21E-02   0.0 -3.4928E+04 -8.2789E+03  1.3771E+04   no failure
3.9601E+04                    1
 POS    4     1    1  1.21E-02   0.0 -3.2029E+04  1.8707E+03  1.3771E+04   no failure
4.0721E+04                    1
 NEG    4     1    1  1.21E-02   0.0 -1.3777E+04 -5.1869E+03 -1.3357E+04   no failure
2.6086E+04                    1
 POS    4     6    1 -1.21E-02   0.0  2.5230E+04  3.1795E+04 -5.9792E+03   no failure
3.0863E+04                    1
 NEG    4     6    1 -1.21E-02   0.0 -4.0462E+04 -3.3303E+04  6.3935E+03   no failure
3.9005E+04                    1
 POS    4     6    1  1.21E-02   0.0 -3.6160E+04 -1.8478E+04  6.3935E+03   no failure
3.3218E+04                    1
 NEG    4     6    1  1.21E-02   0.0  2.0392E+04  1.6154E+04 -5.9792E+03   no failure
2.1322E+04                    1
 POS    4    11    1 -1.21E-02   0.0  2.8236E+04  1.5824E+04 -1.7791E+02   no failure
2.4514E+04                    1
 NEG    4    11    1 -1.21E-02   0.0 -3.4098E+04 -1.8831E+04  5.9214E+02   no failure
2.9601E+04                    1
 POS    4    11    1  1.21E-02   0.0 -3.2536E+04 -1.3136E+04  5.9214E+02   no failure
2.8369E+04                    1
 NEG    4    11    1  1.21E-02   0.0  2.7035E+04  1.2311E+04 -1.7791E+02   no failure
2.3447E+04                    1
 Margin=  7.0128E-02  eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.0121; MID.;FS=1.
 Margin=  1.6559E+04  stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
```

```
 ***** END SUBROUTINE STRTHK (POSTBUCKLING STRESSES) ********

***** BEGIN SUBROUTINE STRCON (STRESSES IN RINGS) ******
 ***** END   SUBROUTINE STRCON (STRESSES IN RINGS) ******
  **** END OF STRESS CALCULATIONS ***




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 18           ****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 18: DESIGN PERTURBATION INDEX, IMOD=  0 *****

 *************************************************************
 CHAPTER 18 Present summary of state of loaded imperfect panel
            and give effective stiffnesses of possibly locally
            postbuckled skin-stringer module. These effective
            stiffnesses are used later for overall buckling
            and inter-ring buckling. See Table 12 in the paper
 Bushnell, D.
 "Optimization of an axially compressed ring and stringer
 stiffened cylindrical shell with a general buckling modal
 imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
 Honolulu, Hawaii, April 2007

 PANEL OVERALL & LOCAL IMPERFECTIONS AND DEFORMATION
 General out-of-roundness of cylindrical panel,WIMPG1 =  0.0000E+00
 General initial buckling modal imperfection amplitude=  0.0000E+00
 General modified imperfection amplitude, Wimp(global)=  0.0000E+00
 Local   initial imperfection amplitude, Wimp(local)  =  1.0000E-07
 Panel (inter-ring) initial imp. amplt., Wimp(panel)  =  1.0000E-10
 Bowing due to temperature effects,     W(residual)   =  0.0000E+00
 Overall (inter-ring in cyl) bowing from pressure ,Wp =  2.8069E-04
 Inter-ring bowing (flat panel) from pressure, WPRESR =  0.0000E+00
 Maximum local "pillowing" between stringers,  WLPRES =  5.0496E-03
 Inter-ring bowing due to postbucking effects, WDELKP = -3.1286E-03
 Amplitude factor for bowing except from press,AMPLIT =  3.1279E+00
 Amplitude factor for bowing due to pressure,  AMPLT2 =  1.0502E+00
 Amplitude factor for inter-ring bowing,       AMPLT3 =  1.4916E+00
 Eccentricity of application of axial loads,     ECC  =  0.0000E+00
 Midbay normal displacements for a CURVED panel from SUB.SKIN:
 Midbay normal displacement from Load Set A,   WMIDA =  2.4037E-02
 Midbay normal displacement from Load Set B,   WMIDB =  0.0000E+00
 Midbay normal displacement from temperature,  WMIDT =  0.0000E+00
 Total Midbay normal displacement,           WMDTOT =  2.4037E-02

 *** BEGIN SUBROUTINE LOCAL (HI-M POST-POSTBUCKLING SEARCH) ***
  LABEL NO. IN STRUCT= 9360

 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-stringer discretized module of local buckling)
  AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
```

```
 WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                              ANISOTROPY
   M       EIGOLD            KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
  12      1.21547E+00      1.00000E+00      9.99993E-01     1.21546E+00
  13      1.30898E+00      1.00000E+00      9.99993E-01     1.30897E+00
Buckling load factor before t.s.d.=  1.2155E+00 After t.s.d.=  1.2067E+00
  12      1.21547E+00      9.92758E-01      9.99993E-01     1.20666E+00
Buckling load factor from SUB. LOCAL, EIGITR(6)=  1.2067E+00
Number of axial halfwaves between rings,NPP=   12
 **** END SUBROUTINE LOCAL (HI-M POST-POSTBUCKLING SEARCH) ****

**** BEGIN SUBROUTINE  MODE (HI-M POST-POSTBUCKLING MODE) ****

WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR =
pi**2*EI/[abs(local hoop load)*WIDTH**2]=  9.0968E-01
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  7.3742E-03
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  1.4037E-01
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  1.7796E-01
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  1.7796E-01
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  1.2392E-02
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  4.9872E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  1.4037E-01
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  7.3742E-03
      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= 12

MODAL DISPLACEMENTS FOR SEGMENT NO. 1

NODE	Z	W	WD	WDD	U	V	WDDD
1	0.00E+00	8.59E-01	0.00E+00	2.52E+00	0.00E+00	5.37E-05	-6.25E+00
2	0.00E+00	8.66E-01	1.72E-01	2.01E+00	2.20E-05	5.77E-05	-6.25E+00
3	0.00E+00	8.87E-01	3.16E-01	1.49E+00	4.55E-05	6.26E-05	-6.25E+00
4	0.00E+00	9.18E-01	4.03E-01	6.08E-01	7.21E-05	7.10E-05	-1.07E+01
5	0.00E+00	9.53E-01	4.01E-01	-6.50E-01	1.03E-04	8.32E-05	-1.53E+01
6	0.00E+00	9.84E-01	2.82E-01	-2.23E+00	1.41E-04	9.92E-05	-1.92E+01
7	0.00E+00	1.00E+00	2.70E-02	-3.97E+00	1.88E-04	1.19E-04	-2.12E+01
8	0.00E+00	9.89E-01	-3.67E-01	-5.59E+00	2.46E-04	1.43E-04	-1.96E+01
9	0.00E+00	9.40E-01	-8.71E-01	-6.67E+00	3.18E-04	1.70E-04	-1.32E+01
10	0.00E+00	8.45E-01	-1.43E+00	-6.78E+00	4.07E-04	1.99E-04	-1.36E+00
11	0.00E+00	7.05E-01	-1.93E+00	-6.89E+00	5.10E-04	2.19E-04	-1.36E+00

MODAL DISPLACEMENTS FOR SEGMENT NO. 2

NODE	Z	W	WD	WDD	U	V	WDDD
1	0.00E+00	7.05E-01	-1.93E+00	-7.24E+00	5.10E-04	2.19E-04	5.47E+01
2	0.00E+00	5.27E-01	-2.27E+00	-2.73E+00	6.47E-04	2.47E-04	5.47E+01
3	0.00E+00	3.30E-01	-2.31E+00	1.78E+00	8.05E-04	2.50E-04	5.47E+01
4	0.00E+00	1.46E-01	-1.91E+00	8.10E+00	9.88E-04	2.22E-04	7.68E+01
5	0.00E+00	1.65E-02	-8.87E-01	1.67E+01	1.19E-03	1.40E-04	1.04E+02
6	0.00E+00	-1.81E-09	-2.01E-01	-1.62E-05	1.30E-03	4.26E-10	-2.02E+02
7	0.00E+00	-1.65E-02	-8.87E-01	-1.67E+01	1.19E-03	-1.40E-04	-2.02E+02
8	0.00E+00	-1.46E-01	-1.91E+00	-8.10E+00	9.88E-04	-2.22E-04	1.04E+02
9	0.00E+00	-3.30E-01	-2.31E+00	-1.78E+00	8.05E-04	-2.50E-04	7.68E+01
10	0.00E+00	-5.27E-01	-2.27E+00	2.73E+00	6.47E-04	-2.47E-04	5.47E+01
11	0.00E+00	-7.05E-01	-1.93E+00	7.24E+00	5.10E-04	-2.19E-04	5.47E+01

MODAL DISPLACEMENTS FOR SEGMENT NO. 3

NODE	Z	W	WD	WDD	U	V	WDDD
1	-1.21E-02	-1.12E-03	-2.01E-01	1.26E+00	1.81E-09	3.43E-10	-4.37E+00
2	-9.68E-02	-1.35E-02	-1.08E-01	8.93E-01	1.58E-09	4.61E-11	-4.37E+00
3	-1.81E-01	-1.95E-02	-4.85E-02	5.22E-01	1.35E-09	-1.30E-10	-4.37E+00
4	-2.66E-01	-2.17E-02	-1.42E-02	2.88E-01	1.14E-09	-2.07E-10	-2.76E+00
5	-3.51E-01	-2.19E-02	4.05E-03	1.42E-01	9.70E-10	-2.28E-10	-1.72E+00
6	-4.36E-01	-2.11E-02	1.23E-02	5.22E-02	8.31E-10	-2.22E-10	-1.07E+00
7	-5.20E-01	-1.98E-02	1.44E-02	-2.92E-03	7.26E-10	-2.09E-10	-6.51E-01
8	-6.05E-01	-1.86E-02	1.27E-02	-3.63E-02	6.49E-10	-2.04E-10	-3.94E-01
9	-6.90E-01	-1.77E-02	8.80E-03	-5.64E-02	5.96E-10	-2.24E-10	-2.38E-01
10	-7.74E-01	-1.71E-02	3.50E-03	-6.87E-02	5.55E-10	-2.87E-10	-1.45E-01
11	-8.59E-01	-1.71E-02	-2.54E-03	-8.09E-02	5.17E-10	-3.89E-10	-1.45E-01

MODAL DISPLACEMENTS FOR SEGMENT NO. 4

NODE	Z	W	WD	WDD	U	V	WDDD
1	0.00E+00	-7.05E-01	-1.93E+00	6.89E+00	5.10E-04	-2.19E-04	-1.36E+00
2	0.00E+00	-8.45E-01	-1.43E+00	6.78E+00	4.07E-04	-1.99E-04	-1.36E+00
3	0.00E+00	-9.40E-01	-8.71E-01	6.67E+00	3.18E-04	-1.70E-04	-1.36E+00
4	0.00E+00	-9.89E-01	-3.67E-01	5.59E+00	2.46E-04	-1.43E-04	-1.32E+01
5	0.00E+00	-1.00E+00	2.70E-02	3.97E+00	1.88E-04	-1.19E-04	-1.96E+01
6	0.00E+00	-9.84E-01	2.82E-01	2.23E+00	1.41E-04	-9.92E-05	-2.12E+01
7	0.00E+00	-9.53E-01	4.01E-01	6.50E-01	1.03E-04	-8.32E-05	-1.92E+01
8	0.00E+00	-9.18E-01	4.03E-01	-6.08E-01	7.21E-05	-7.10E-05	-1.53E+01
9	0.00E+00	-8.87E-01	3.16E-01	-1.49E+00	4.55E-05	-6.26E-05	-1.07E+01
10	0.00E+00	-8.66E-01	1.72E-01	-2.01E+00	2.20E-05	-5.77E-05	-6.25E+00
11	0.00E+00	-8.59E-01	0.00E+00	-2.52E+00	0.00E+00	-5.37E-05	-6.25E+00

**** END SUBROUTINE MODE (HI-M POST-POSTBUCKLING MODE) ****

Margin= 2.0666E-01 Hi-axial-wave post-post-buckling of module - 1;   M=12 ;FS=1.

******** THE HI-AXIAL-WAVE POST-POST BUCKL. MARGIN COMPUTED:

```
Hi-axial-wave post-post-buckling of module - 1;   M=12 ;FS=1.
 ******** CONSTRAINT NO.  5; LOAD SET NO. 1; SUBCASE NO. 1

*** BEGIN SUBROUTINE DEFCIJ (POST-LOCALLY BUCKLED CS(I,J)) ****
 IN SUB.CSTIF; STRINGERS; ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00
 IN SUB.CSTIF;   RINGS;   ISMEAR=3; ZSTART,TBASE,UNBAL=  1.2071E-02  2.4141E-02
0.0000E+00
 Effective stiffnesses of undeformed and of
 locally deformed module segments:
                                                       Undeformed   Deformed
     Effective axial stiffness of panel SKIN + BASE =  2.6794E+05  1.1786E+05
     Effective hoop  stiffness of panel SKIN + BASE =  2.6794E+05  2.0540E+05
     Effective (1,2) stiffness of panel SKIN + BASE =  8.0382E+04  6.2584E+03
     Effective axial stiffness of stringer   WEB    =  8.8888E+05  8.8684E+05
     Effective axial stiffness of stringer   FLANGE =  0.0000E+00  0.0000E+00
     Effective shear stiffness of panel SKIN + BASE =  9.3778E+04  5.1945E+04
     Effective shear stiffness of stringer   WEB    =  3.1111E+05  3.1111E+05
     Effective shear stiffness of stringer   FLANGE =  0.0000E+00  0.0000E+00

 Integrated stringer stiffnesses...
     Effective axial stiffness of stringer,   STIFL =  2.7679E+05
     Effective first moment, Int[STIF*zdz],   STIFM =  1.2049E+05
     Effective second moment,Int[STIF*z**2dz],STIFMM=  6.9005E+04

 Constitutive law, CS(i,j), for locally deformed
 panel with smeared stringers and rings.....
       3.9634E+05  6.0869E+03  0.0000E+00  1.2049E+05  0.0000E+00  0.0000E+00
       6.0869E+03  2.5794E+05  0.0000E+00  0.0000E+00  2.2892E+04  0.0000E+00
       0.0000E+00  0.0000E+00  5.1945E+04  0.0000E+00  0.0000E+00  0.0000E+00
       1.2049E+05  0.0000E+00  0.0000E+00  6.9018E+04  3.9038E+00  0.0000E+00
       0.0000E+00  2.2892E+04  0.0000E+00  3.9038E+00  1.3128E+04  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.7649E+01

 Constitutive law, C(i,j), for locally deformed
 panel between rings with smeared stringers.....
       3.9634E+05  6.0869E+03  0.0000E+00  1.2049E+05  0.0000E+00  0.0000E+00
       6.0869E+03  2.0540E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
       0.0000E+00  0.0000E+00  5.1945E+04  0.0000E+00  0.0000E+00  0.0000E+00
       1.2049E+05  0.0000E+00  0.0000E+00  6.9018E+04  3.9038E+00  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.1574E+01
 *** END   SUBROUTINE DEFCIJ (POST-LOCALLY BUCKLED CS(I,J)) ****
 ********* DESIGN PERTURBATION INDEX, IMOD=  0 *********

 EXPLANATION OF FOLLOWING CALCULATION (LOAD SET NO. 1):
     Next, the load factor for wide column panel buckling is
     computed from the discretized panel module model. The
     analysis takes into account local deformation of the
     skin between stringers and local deformation of the
     stringers.

     Clamping of the L2 edges (edges that lie in the plane of
     the screen and parallel to it) is accounted for by doing
     the wide column calculation for a panel that is shorter in
     the axial direction by a factor, LENMOD =  1.0000E+00 than the
     axial dimension that you gave in your input.
```

```
************************************************************
************************************************************
************************************************************
************          CHAPTER 19          ****************
************************************************************
************************************************************
************************************************************
**** CHAPTER 19: DESIGN PERTURBATION INDEX, IMOD=  0 *****

***********************************************************
CHAPTER 19 Do wide-column inter-ring buckling analysis with
           possibly locally postbuckled skin-stringer module
           model. (See Figs. 20c, 22c, 46d, and 67 of [1A],
           for examples.).

*** BEGIN SUBROUTINE BUCKLE (WIDE-COLUMN BUCKLING - MODULE) ****
  LABEL NO. IN STRUCT= 9450
 Skin stiffnesses, CX(1,1,1),CX(1,2,1),CX(2,2,1),CX(3,3,1)=
  6.7881E+04  5.7459E+02  2.0540E+05  5.1945E+04
*** END SUBROUTINE BUCKLE (WIDE-COLUMN BUCKLING - MODULE) ****

*** BEGIN SUBROUTINE MODE (WIDE-COLUMN BUCKLING MODE SHAPE) ****

 WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR =
 pi**2*EI/[abs(local hoop load)*WIDTH**2]=  9.0968E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  3.9635E-03
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  6.2318E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  5.8963E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  5.8962E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  3.9327E-17
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  4.0097E-17
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  6.2317E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  3.9634E-03

 NUMBER OF AXIAL HALFWAVES =      1
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR  =  4.0895E-01
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,  WSTR/WSKIN =  4.0895E-01
 NOTE: THERE IS SIGNIFICANT DEFORMATION OF THE CROSS SECTION
       OF THE PANEL MODULE IN THIS BUCKLING MODE. THIS
       DEFORMATION MAY WELL CAUSE THE WIDE COLUMN BUCKLING
       LOAD FACTOR TO BE CONSIDERABLY LESS THAN THE GENERAL
       OR PANEL (BETWEEN RINGS) INSTABILITY LOAD FACTORS.

 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP  =  3.9972E-16
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,  WMID  =  1.9957E-16
 *** END SUBROUTINE MODE (WIDE-COLUMN BUCKLING MODE SHAPE) ****
  KNOCKDOWN FACTOR FOR INTER-RING BUCKLING
  HAS BEEN CHANGED FROM FKNOCK(4)=  0.999999225
  TO A NEW VALUE,          FTEMP =  0.999999583
  BECAUSE OF DEVELOPMENT OF A DIAGONAL TENSION
  FIELD, WHICH IS ACCOUNTED FOR IN SUB. KOIT2.

 Wide column buckling factor from discretized model of a single panel module for
 design iteration no.  0, load set no. 1,  material iteration no.  0. This load factor
```

```
in-
 cludes the knockdown factor,  1.0000E+00 that accounts for the
 effect of in-plane shear loading and anisotropy [e.g. C(4,6)]
 in the panel skin.  The axial length of the wide column is
  9.7793E+00.  Resultants are uniform and given by:
   LOAD SET A: axial, Nx = -1.00E+03; circ., Ny = -1.00E-03; in-plane shear, Nxy =
5.00E+00
   LOAD SET B: axial, Nxo=  0.00E+00; circ., Nyo=  0.00E+00; in-plane shear, Nxyo=
0.00E+00 (Not from normal pressure)
   LOAD SET A: Uniform normal pressure, P =   2.0000E-05
      Resultants from global (smeared stiffener) model: Nx(p)=  0.00E+00,  Ny(p)=
0.00E+00,  Nxy(p)= 0.0
      Resultants from local (discrete stiffener) model: Nx(p)= -5.21E-04,  Ny(p)=  5.80E-
07,  Nxy(p)= 0.0 :

  WIDE COLUMN PANEL BUCKLING LOAD FACTOR =          2.6648E+00
 ISKIN = 0. WIDE COLUMN BUCKLING IS IGNORED IF ISKIN = 1.
 IWIDE = 0. WIDE COLUMN BUCKLING IS IGNORED IF IWIDE = 0.
 ITIP  = 0. MODE OF BUCKLING IS STRINGER SIDESWAY IF ITIP=1
  *** END OF WIDE COLUMN BUCKLING CALCULATIONS ***
 ********* DESIGN PERTURBATION INDEX, IMOD=  0 *********




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

 *************************************************************
 CHAPTER 20 Compute width-wise wide column buckling and
            lateral-torsional buckling load factors from the
            possibly locally postbuckled skin-stringer module
            model (inter-ring buckling modes).
            See panda2.news Item Numbers 379 and 381 in [1L].

 EXPLANATION OF FOLLOWING CALC. (LOAD SET NO. 1):
     Next, the load factor for m=?? lateral-torsional buckling
     is computed from the discretized panel module model. The
     analysis takes into account local deformation of the
     panel module cross section, the redistribution of axial
     stress resultants Nx over the discretized module cross
     section, and the axial "softening" of a locally post-
     buckled skin-stringer discretized module.

 Effective axial length of the panel,           AXLEN2=  9.7793E+00
 LATERAL-TORSIONAL BUCKLING: Search for critical load...
  LABEL NO. IN STRUCT= 9460
 Number of axial halfwaves=  1; Buckling load factor=  1.0159E+00

 WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR =
 pi**2*EI/[abs(local hoop load)*WIDTH**2]=  9.0968E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  5.9349E-03
```

```
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  9.0058E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  9.3821E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  9.3861E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  9.3501E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  9.2203E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  9.0104E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  5.9407E-03

 NUMBER OF AXIAL HALFWAVES =      1
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR  =  1.7986E-04
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,  WSTR/WSKIN =  1.7986E-04
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP  =  9.5444E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,  WMID  =  4.9364E-01
  LABEL NO. IN STRUCT= 9460
 Number of axial halfwaves=  2; Buckling load factor=  1.0222E+00

 WIDTH-WISE WIDE COLUMN BUCKLING LOAD FACTOR =
 pi**2*EI/[abs(local hoop load)*WIDTH**2]=  9.0968E-01
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  6.6977E-03
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  9.5104E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  9.5774E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  9.5774E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  6.6102E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  6.2347E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  9.5104E-02
 Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  6.6977E-03

 NUMBER OF AXIAL HALFWAVES =      2
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR  =  3.6781E-08
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,  WSTR/WSKIN =  3.6781E-08
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP  =  6.5798E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,  WMID  =  3.4686E-01
 Margin=  1.6919E-02  (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 *** THE LATERAL-TORSIONAL BUCKLING MARGIN JUST COMPUTED:
(m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 ******* CONSTRAINT NO.  6; LOAD SET NO. 1; SUBCASE NO. 1
 LATERAL-TORSIONAL BUCKLING LOAD FACTOR =         1.0159E+00
  *** END OF LATERAL-TORSIONAL BUCKLING CALCULATIONS ***
 ** CHAPTER 21,22: DESIGN PERTURBATION INDEX, IMOD=  0 ***




 *************************************************************
 *************************************************************
 *************************************************************
 ************          CHAPTER 21          *****************
 *************************************************************
 *************************************************************
 *************************************************************
 **** CHAPTER 21: DESIGN PERTURBATION INDEX, IMOD=  0 ****

 ************************************************************
 CHAPTER 21 Compute "skin"-ring buckling load factor for
            computing knockdown to compensate for inherent
            unconservativeness of smeared ring models.
```

```
           (See bottom row in Fig. 30 of Ref.[1G]. Also see
           panda2.news Items 509, 511, 522, 532, 605, 617
           619, 632, 633, 676.

 *** BEGIN "SKIN"-RING BUCKLING, DISCRETE MODULE MODEL ***
 See Item No. 463 of the file, ../doc/panda2.news and Ref.[6]:
 Bushnell, D., et al, "Additional buckling solutions in PANDA2"
 AIAA Paper 99-1233, Proc. 40th AIAA Structures and Materials
 Conference, pp 302-345 (1999) [6]. See especially pp 318-323
 and Figs. 30-33. Also, read ITEMs 509, 511, 522, 605 of the
 file, ..panda2/doc/panda2.news, about how PANDA2 develops a
 knockdown factor to compensate for the unconservativeness of
 buckling models in which the rings are smeared out.

 Check to see if "skin"-ring discretized model is analyzed.
 Whether it is or not depends on the following quantities:
  Is the panel curved (IFLAT = 0)?,              IFLAT= 0
  What is the ring cross section?,           ISTIF(2)= 3
  Did PANDA2 compute resultants at IXNUMB pts in SKIN?, IXNUMB=26
  Is the applied axial resultant in Load Set A negative,    Nx= -1.0000E+03
  Is the applied hoop  resultant in Load Set A negative,    Ny= -1.0000E-03
  Is the average hoop load in the panel skin negative,  FNYAVE= -2.4986E+01
  Is the average hoop load in the ring web negative,    FCEWEB=  2.9067E+02
  Is the average hoop load in the ring flange negative, FCEFLG=  0.0000E+00
  Is in-plane shear load Nxy .LT. 2*SQRT(Nx**2 + Ny**2),   Nxy=  5.0000E+00
  LABEL NO. IN STRUCT= 9480

*** Infinite cyl, external lateral pressure) **
 Uniform external lateral pressure,      PRESS=  1.0000E+00
 Buck. circ. halfwaves from PANDA-type, NGENQQ=  2
 Buck. circ. halfwaves over arc=pi*r,   NGENNW=  2
 NGENNW is used for the buckling analysis in BUCKLE.

 ** BEGIN SUB. BUCKLE ("SKIN"-RING n=   2 GENERAL BUCKLNG MODEL) **

 Constitutive law, C(i,j), for locally deformed
 panel between rings with smeared stringers.....
       3.9634E+05  6.0869E+03  0.0000E+00  1.2049E+05  0.0000E+00  0.0000E+00
       6.0869E+03  2.0540E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
       0.0000E+00  0.0000E+00  5.1945E+04  0.0000E+00  0.0000E+00  0.0000E+00
       1.2049E+05  0.0000E+00  0.0000E+00  6.9018E+04  3.9038E+00  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.1574E+01

 **** PREBUCKLING LOADS IN "SKIN"-RING DISCRETIZED MODULE ****
 --------------------------------------------------------------
 Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     1     1
 Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 1
  3.9634E+05  2.0540E+05  5.1945E+04  6.9018E+04  1.3013E+01  6.1574E+01
 Total axial nodal point resultants, (Nx+Nxo)=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Total circ. nodal point resultants, (Ny+Nyo)=
 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01
 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01
 Fixed axial nodal point resultants, Nxo=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
```

```
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     2     1
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 2
 3.9634E+05  2.0540E+05  5.1945E+04  6.9018E+04  1.3013E+01  6.1574E+01
Total axial nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01
-3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01
Fixed axial nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     3     3
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 3
 6.6660E+05  6.6660E+05  2.3331E+05  2.0038E+02  2.0038E+02  7.0133E+01
Total meridional nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-1.1763E+02 -1.1763E+02 -1.1763E+02 -1.1763E+02 -1.1763E+02 -1.1763E+02
-1.1763E+02 -1.1763E+02 -1.1763E+02 -1.1763E+02 -1.1763E+02
Fixed meridional nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=     2     4     1
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 4
 3.9634E+05  2.0540E+05  5.1945E+04  6.9018E+04  1.3013E+01  6.1574E+01
Total axial nodal point resultants, (Nx+Nxo)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
-3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01
-3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01 -3.9810E+01
Fixed axial nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
=============================================================
**  END  SUB. BUCKLE ("SKIN"-RING n=   2 GENERAL BUCKLNG MODEL) **

** BEGIN SUB. MODE ("SKIN"-RING n=   2 GENERAL BUCKLNG MODE) **
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  3.2180E-06
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  3.0869E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  1.8116E-05
```

```
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  1.8116E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  8.8799E-16
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  1.6317E-14
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  3.0869E-05
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  3.2180E-06
AMPLIT.OF BUCKLING MODE MIDWAY BETWEEN RINGS, WMID =  9.9971E-01
AMPLIT.OF BUCKLING MODE AT   RING   WEB TIP,  WTIP =  4.9124E-10
AMPLIT.OF BUCKLING MODE AT   RING   MIDWEB,  WCRIP =  4.9117E-10
AMPLIT.OF BUCKLING MODE AT  RING FLANGE TIP,, WFLG =  0.0000E+00
      Internal Ring

     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"-RING PANEL MODULE HAS 4 SEGMENTS
        NUMBER OF HALF-WAVES IN THE CIRC. DIRECTION, n=  2
```

NODE	Z	W	WD	WDD	U	V	WDDD

MODAL DISPLACEMENTS FOR SEGMENT NO. 1

1	0.00E+00	1.00E+00	1.06E-15	4.99E-05	-1.79E-19	4.97E-01	-6.52E-06
2	0.00E+00	1.00E+00	1.76E-05	4.75E-05	-5.19E-06	4.97E-01	-6.52E-06
3	0.00E+00	1.00E+00	3.46E-05	4.51E-05	-1.02E-05	4.97E-01	-6.52E-06
4	0.00E+00	1.00E+00	5.04E-05	4.11E-05	-1.49E-05	4.97E-01	-1.09E-05
5	0.00E+00	1.00E+00	6.44E-05	3.55E-05	-1.90E-05	4.97E-01	-1.53E-05
6	0.00E+00	1.00E+00	7.62E-05	2.83E-05	-2.25E-05	4.97E-01	-1.97E-05
7	0.00E+00	1.00E+00	8.49E-05	1.94E-05	-2.51E-05	4.97E-01	-2.42E-05
8	0.00E+00	1.00E+00	9.01E-05	8.90E-06	-2.66E-05	4.97E-01	-2.87E-05
9	0.00E+00	1.00E+00	9.11E-05	-3.32E-06	-2.69E-05	4.97E-01	-3.33E-05

```
10  0.00E+00  1.00E+00  8.74E-05 -1.73E-05 -2.58E-05  4.97E-01 -3.80E-05
11  0.00E+00  1.00E+00  7.81E-05 -3.12E-05 -2.31E-05  4.97E-01 -3.80E-05

                MODAL DISPLACEMENTS FOR SEGMENT NO. 2
 1  0.00E+00  1.00E+00  7.81E-05 -3.21E-05 -2.31E-05  4.97E-01 -5.00E-05
 2  0.00E+00  1.00E+00  6.87E-05 -4.44E-05 -2.03E-05  4.97E-01 -5.00E-05
 3  0.00E+00  1.00E+00  5.63E-05 -5.66E-05 -1.67E-05  4.97E-01 -5.00E-05
 4  0.00E+00  1.00E+00  4.09E-05 -6.96E-05 -1.21E-05  4.97E-01 -5.33E-05
 5  0.00E+00  1.00E+00  2.22E-05 -8.34E-05 -6.58E-06  4.97E-01 -5.66E-05
 6  0.00E+00  1.00E+00 -1.36E-15 -9.83E-05 -4.91E-10  4.97E-01 -6.08E-05
 7  0.00E+00  1.00E+00 -2.22E-05 -8.34E-05  6.58E-06  4.97E-01  6.08E-05
 8  0.00E+00  1.00E+00 -4.09E-05 -6.96E-05  1.21E-05  4.97E-01  5.66E-05
 9  0.00E+00  1.00E+00 -5.63E-05 -5.66E-05  1.67E-05  4.97E-01  5.33E-05
10  0.00E+00  1.00E+00 -6.87E-05 -4.44E-05  2.03E-05  4.97E-01  5.00E-05
11  0.00E+00  1.00E+00 -7.81E-05 -3.21E-05  2.31E-05  4.97E-01  5.00E-05

                MODAL DISPLACEMENTS FOR SEGMENT NO. 3
 1 -1.21E-02 -4.91E-10 -1.07E-16 -2.48E-13 -1.00E+00  4.98E-01  4.19E-14
 2 -9.68E-02 -4.91E-10 -2.11E-14 -2.44E-13 -1.00E+00  5.00E-01  4.19E-14
 3 -1.81E-01 -4.91E-10 -4.16E-14 -2.41E-13 -1.00E+00  5.03E-01  4.19E-14
 4 -2.66E-01 -4.91E-10 -6.19E-14 -2.38E-13 -1.00E+00  5.05E-01  3.12E-14
 5 -3.51E-01 -4.91E-10 -8.20E-14 -2.36E-13 -1.00E+00  5.08E-01  2.06E-14
 6 -4.36E-01 -4.91E-10 -1.02E-13 -2.36E-13 -1.00E+00  5.10E-01  9.83E-15
 7 -5.20E-01 -4.91E-10 -1.22E-13 -2.36E-13 -1.00E+00  5.13E-01 -9.37E-16
 8 -6.05E-01 -4.91E-10 -1.42E-13 -2.37E-13 -1.00E+00  5.15E-01 -1.18E-14
 9 -6.90E-01 -4.91E-10 -1.62E-13 -2.39E-13 -1.00E+00  5.18E-01 -2.27E-14
10 -7.74E-01 -4.91E-10 -1.82E-13 -2.41E-13 -1.00E+00  5.20E-01 -3.37E-14
11 -8.59E-01 -4.91E-10 -2.03E-13 -2.44E-13 -1.00E+00  5.23E-01 -3.37E-14

                MODAL DISPLACEMENTS FOR SEGMENT NO. 4
 1  0.00E+00  1.00E+00 -7.81E-05 -3.12E-05  2.31E-05  4.97E-01  3.80E-05
 2  0.00E+00  1.00E+00 -8.74E-05 -1.73E-05  2.58E-05  4.97E-01  3.80E-05
 3  0.00E+00  1.00E+00 -9.11E-05 -3.32E-06  2.69E-05  4.97E-01  3.80E-05
 4  0.00E+00  1.00E+00 -9.01E-05  8.90E-06  2.66E-05  4.97E-01  3.33E-05
 5  0.00E+00  1.00E+00 -8.49E-05  1.94E-05  2.51E-05  4.97E-01  2.87E-05
 6  0.00E+00  1.00E+00 -7.62E-05  2.83E-05  2.25E-05  4.97E-01  2.42E-05
 7  0.00E+00  1.00E+00 -6.44E-05  3.55E-05  1.90E-05  4.97E-01  1.97E-05
 8  0.00E+00  1.00E+00 -5.04E-05  4.11E-05  1.49E-05  4.97E-01  1.53E-05
 9  0.00E+00  1.00E+00 -3.46E-05  4.51E-05  1.02E-05  4.97E-01  1.09E-05
10  0.00E+00  1.00E+00 -1.76E-05  4.75E-05  5.19E-06  4.97E-01  6.52E-06
11  0.00E+00  1.00E+00  1.51E-16  4.99E-05  5.00E-18  4.97E-01  6.52E-06
**** END  SUB. MODE ("SKIN"-RING n=   2 GENERAL BUCKLNG MODE) **
Mode shape properties for n=  2 circ. halfwaves:
Normal displacement midway between rings,   WFIRST=  9.9971E-01
Normal displacement midway between rings,    WLAST=  9.9971E-01
Normal displacement in skin at web root,     WMIDQ=  1.0000E+00
Normal displacement in ring at flange tip,    WFLG=  1.0000E+00
Normal displacement, ring flange at web tip, WFLGW=  1.0000E+00
Normalized difference,     ABS(WFLG-WFLGW)/WFLGMAX=  0.0000E+00
Possible candidate for knockdown factor,     WFLGK=  1.0000E+00
Eigenvalues for  1 roots:  EIGRPP=   2.6971E-01

Mode number  1 is     a suitable ring mode.
Buckling load factor BEFORE knockdown for smeared stringers=  2.6971E-01
In this n=   2 general buckling analysis there is no knockdown
for smeared stringers.
NOTE: The buckling load factor,  2.6971E-01, will not be
further reduced by the "shear/anisotropy" factor.
```

```
 Knockdown for smeared rings on cylindrical shell...
  Buckling load factor for n+dn = FNARCQ=  2.0000E+00
                               from discrete model =  2.6971E-01
  Buckling load factor for ring with bending stiffness EI:
                      pcrit=[(n+dn)**2-1]*EI/r**3/p=  2.6632E-01
  Knockdown factor, general buckling,   EIGR/EIGRNG=  1.0000E+00

 Knockdown for smeared rings, RNGKNK=  1.0000E+00(FNARCQ=  2.0000E+00)
 END OF SECTION ON GENERATION OF KNOCKDOWN FACTOR FOR
 COMPENSATING FOR THE UNCONSERVATIVENESS OF SMEARING RINGS
 ---------------------------------------------------------

  Is the number of buckling axial halfwaves .LT. 4?, MINTRG= 1

 If ANY of the following conditions is TRUE, then "skin"-ring
 buckling with discrete module model is NOT investigated:
  Panel is flat (IFLAT = 1)
  No rings or Rings are hats or truss-core (ISTIF(2)=0, 4 or 5)
  PANDA2 did not compute resultants at IXNUMB points(IXNUMB=0)
  All prebuckling loads, Nx, Ny, FNYAVE, FCEWEB, FCEFLG, are positive
  In-plane shear load Nxy is greater than 2*SQRT(Nx**2 +Ny**2)
  Number of buckling axial halfwaves between rings .GE. 4




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 22            *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 22: DESIGN PERTURBATION INDEX, IMOD=  0 ****

 *************************************************************
 CHAPTER 22 Compute "skin"-ring buckling load factors for:
            1. medium-n inter-ring buckling mode (See
               rightmost three mode shapes in top row of
               Fig. 30 of Ref.[1G]),
            2. high-n inter-ring buckling mode (See rightmost
               mode shape in middle row of Fig. 30, Ref.[1G]),
            3. low-n inter-ring buckling mode (See leftmost
               mode shape in top row of Fig. 30, Ref.[1G]).

*** BEGIN "SKIN"-RING BUCKLING, DISCRETE MODULE MODEL) **

***** BEGIN SUBROUTINE STRCON (GET DELFCR,DELWBR) *****
 DELFCR =changes in resultants, dNx,dNy,dNxy, in skin-ring
         module caused by growth of the initial imperfections.
 DELWBR =change in axial resultant dNx in the ring web at the
         ring web root and ring web tip.
 ******* END SUBROUTINE STRCON (GET DELFCR,DELWBR) ******

 CHANGES IN RESULTANTS USED IN THE BUCKLING ANALYSIS
 OF THE "SKIN"-RING DISCRETIZED MODULE.
 THE FOLLOWING RESULT FROM GROWTH OF INITIAL IMPERFECTIONS
```

```
 DURING LOADING. THEY DEPEND ON THE SIGNS OF THE
 IMPERFECTION AMPLITUDES....
 Change in hoop resultant Ny in: skin, ring base, flange:
  DELFCR(1,1),DELFCR(1,2),DELFCR(1,4)=  0.0000E+00  0.0000E+00  0.0000E+00
 Change in axial resultant Ny in: Seg. 1, ring base, flange:
  DELFCR(2,1),DELFCR(2,2),DELFCR(2,4)=  0.0000E+00  0.0000E+00  0.0000E+00
 Change in in-plane shear Nxy in: Seg. 1, ring base, flange:
  DELFCR(3,1),DELFCR(3,2),DELFCR(3,4)=  0.0000E+00  0.0000E+00  0.0000E+00
 Change in resultant Ny in ring web at: web root,   web tip:
  DELWBR(1), DELWBR(2)=                 0.0000E+00  0.0000E+00

*** BEGIN "SKIN"-RING BUCKLING, DISCRETE MODEL) **
  LABEL NO. IN STRUCT= 9485
 *** BEGIN SUB. LOCAL ("SKIN"-RING BUCKLING, DISCRETE MODEL) **

 Constitutive law, C(i,j), for locally deformed
 panel between rings with smeared stringers.....
       3.9634E+05  6.0869E+03  0.0000E+00  1.2049E+05  0.0000E+00  0.0000E+00
       6.0869E+03  2.0540E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
       0.0000E+00  0.0000E+00  5.1945E+04  0.0000E+00  0.0000E+00  0.0000E+00
       1.2049E+05  0.0000E+00  0.0000E+00  6.9018E+04  3.9038E+00  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00
       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  6.1574E+01

 **** PREBUCKLING LOADS IN "SKIN"-RING DISCRETIZED MODULE ****
 -------------------------------------------------------------
 Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=    10     1     1
 Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 1
  3.9634E+05  2.0540E+05  5.1945E+04  6.9018E+04  1.3013E+01  6.1574E+01
 Total axial nodal point resultants, (Nx+Nxo)=
 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03
 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03
 Total circ. nodal point resultants, (Ny+Nyo)=
 -2.3460E+01 -2.3491E+01 -2.3582E+01 -2.3731E+01 -2.3935E+01 -2.4190E+01
 -2.4492E+01 -2.4835E+01 -2.5212E+01 -2.5615E+01 -2.6034E+01
 Fixed axial nodal point resultants, Nxo=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Fixed circ. nodal point resultants, Nyo=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -------------------------------------------------------------
 Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=    10     2     1
 Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 2
  3.9634E+05  2.0540E+05  5.1945E+04  6.9018E+04  1.3013E+01  6.1574E+01
 Total axial nodal point resultants, (Nx+Nxo)=
 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03
 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03
 Total circ. nodal point resultants, (Ny+Nyo)=
 -2.6034E+01 -2.6318E+01 -2.6600E+01 -2.6878E+01 -2.7148E+01 -2.7407E+01
 -2.7148E+01 -2.6878E+01 -2.6600E+01 -2.6318E+01 -2.6034E+01
 Fixed axial nodal point resultants, Nxo=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Fixed circ. nodal point resultants, Nyo=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -------------------------------------------------------------
```

```
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=    10     3     3
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 3
 6.6660E+05  6.6660E+05  2.3331E+05  2.0038E+02  2.0038E+02  7.0133E+01
Eigenvalue hoop resultants in ring web from bending:
 resultant at web root, DLWBR1=  0.0000E+00; at tip, DLWBR2=  0.0000E+00
Fixed hoop resultants in ring web:
 resultant at web root, WBROTF=  0.0000E+00; at tip, WBTIPF=  0.0000E+00
Total meridional nodal point resultants, (Nx+Nxo)=
 4.9248E+00  4.4323E+00  3.9398E+00  3.4473E+00  2.9549E+00  2.4624E+00
 1.9699E+00  1.4774E+00  9.8496E-01  4.9248E-01  0.0000E+00
Total circ. nodal point resultants, (Ny+Nyo)=
 2.8821E+02  2.8870E+02  2.8919E+02  2.8968E+02  2.9018E+02  2.9067E+02
 2.9117E+02  2.9167E+02  2.9217E+02  2.9267E+02  2.9318E+02
Fixed meridional nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-------------------------------------------------------------
Circ. waves, Discretized seg., Seg. type, N,ISEG,JSEG=    10     4     1
Integrated constitutive diagonal, (C(i,i),i=1,6), Seg. 4
 3.9634E+05  2.0540E+05  5.1945E+04  6.9018E+04  1.3013E+01  6.1574E+01
Total axial nodal point resultants, (Nx+Nxo)=
-1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03
-1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03 -1.0000E+03
Total circ. nodal point resultants, (Ny+Nyo)=
-2.6034E+01 -2.5615E+01 -2.5212E+01 -2.4835E+01 -2.4492E+01 -2.4190E+01
-2.3935E+01 -2.3731E+01 -2.3582E+01 -2.3491E+01 -2.3460E+01
Fixed axial nodal point resultants, Nxo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Fixed circ. nodal point resultants, Nyo=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
=============================================================

BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-smeared-stringer-ring discretized module)
 HOOP     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
 HALF-    LOAD FACTOR    TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
 WAVES  BEFORE KNOCKDOWN    DEFORMATION    LOADING AND/OR  AFTER KNOCKDOWN
                                             ANISOTROPY
   n        EIGOLD            KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
  10      3.32601E+00      1.00000E+00      9.99999E-01     3.32600E+00
  11      3.29180E+00      1.00000E+00      9.99999E-01     3.29180E+00
  12      3.27102E+00      1.00000E+00      9.99999E-01     3.27102E+00
  13      3.26202E+00      1.00000E+00      9.99999E-01     3.26201E+00
  14      3.26314E+00      1.00000E+00      9.99999E-01     3.26314E+00
Buckling load factor before t.s.d.=  3.2620E+00 After t.s.d.=  3.1313E+00
  13      3.26202E+00      9.59931E-01      9.99999E-01     3.13131E+00
Buckling load factor from SUB. LOCAL, EIGITR(16)=  3.1313E+00
Number of axial halfwaves between rings, NSTART=   13
*** END   SUB. LOCAL ("SKIN"-RING BUCKLING, DISCRETE MODEL) **

**** BEGIN SUB. MODE ("SKIN"-RING MODULE BUCKLING MODE) ****
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    1  6.9303E-03
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    1    2  1.0592E-01
```

```
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    1  7.3697E-02
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    2    2  7.3697E-02
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    1  2.7032E-02
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    3    2  2.5897E-02
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    1  1.0592E-01
Check for FICTITIOUS buckling mode(WDIFF>0.8): ISEG,IEND,WDIFF=    4    2  6.9303E-03
AMPLIT.OF BUCKLING MODE MIDWAY BETWEEN RINGS, WMID =  1.0000E+00
AMPLIT.OF BUCKLING MODE AT   RING   WEB TIP,  WTIP =  1.6757E-01
AMPLIT.OF BUCKLING MODE AT   RING   MIDWEB,  WCRIP =  3.7921E-02
AMPLIT.OF BUCKLING MODE AT  RING FLANGE TIP,, WFLG =  0.0000E+00
      Internal Ring

     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"-RING PANEL MODULE HAS 4 SEGMENTS
         NUMBER OF HALF-WAVES IN THE CIRC. DIRECTION, n= 13
```

NODE	Z	W	WD	WDD	U	V	WDDD

MODAL DISPLACEMENTS FOR SEGMENT NO. 1

1	0.00E+00	1.00E+00	0.00E+00	-1.04E-01	0.00E+00	8.17E-02	5.82E-03
2	0.00E+00	9.93E-01	-3.77E-02	-1.02E-01	1.16E-02	8.12E-02	5.82E-03
3	0.00E+00	9.72E-01	-7.48E-02	-1.00E-01	2.30E-02	7.95E-02	5.82E-03
4	0.00E+00	9.38E-01	-1.11E-01	-9.67E-02	3.41E-02	7.67E-02	9.60E-03
5	0.00E+00	8.91E-01	-1.45E-01	-9.18E-02	4.47E-02	7.28E-02	1.33E-02
6	0.00E+00	8.31E-01	-1.78E-01	-8.57E-02	5.47E-02	6.80E-02	1.67E-02
7	0.00E+00	7.60E-01	-2.08E-01	-7.84E-02	6.40E-02	6.22E-02	2.00E-02
8	0.00E+00	6.79E-01	-2.35E-01	-7.00E-02	7.24E-02	5.55E-02	2.29E-02

```
  9  0.00E+00  5.88E-01 -2.59E-01 -6.06E-02  7.97E-02  4.81E-02  2.56E-02
 10  0.00E+00  4.89E-01 -2.80E-01 -5.04E-02  8.60E-02  4.00E-02  2.79E-02
 11  0.00E+00  3.83E-01 -2.97E-01 -4.01E-02  9.13E-02  3.13E-02  2.79E-02

               MODAL DISPLACEMENTS FOR SEGMENT NO. 2
  1  0.00E+00  3.83E-01 -2.97E-01 -3.96E-02  9.13E-02  3.13E-02  3.19E-02
  2  0.00E+00  3.09E-01 -3.05E-01 -3.18E-02  9.39E-02  2.53E-02  3.19E-02
  3  0.00E+00  2.33E-01 -3.12E-01 -2.40E-02  9.60E-02  1.91E-02  3.19E-02
  4  0.00E+00  1.56E-01 -3.17E-01 -1.60E-02  9.75E-02  1.28E-02  3.25E-02
  5  0.00E+00  7.85E-02 -3.20E-01 -7.97E-03  9.84E-02  6.42E-03  3.30E-02
  6  0.00E+00 -5.52E-18 -3.21E-01  1.85E-16  9.87E-02  0.00E+00  3.26E-02
  7  0.00E+00 -7.85E-02 -3.20E-01  7.97E-03  9.84E-02 -6.42E-03  3.26E-02
  8  0.00E+00 -1.56E-01 -3.17E-01  1.60E-02  9.75E-02 -1.28E-02  3.30E-02
  9  0.00E+00 -2.33E-01 -3.12E-01  2.40E-02  9.60E-02 -1.91E-02  3.25E-02
 10  0.00E+00 -3.09E-01 -3.05E-01  3.18E-02  9.39E-02 -2.53E-02  3.19E-02
 11  0.00E+00 -3.83E-01 -2.97E-01  3.96E-02  9.13E-02 -3.13E-02  3.19E-02

               MODAL DISPLACEMENTS FOR SEGMENT NO. 3
  1 -1.21E-02  9.48E-02 -3.21E-01  4.60E-02  1.41E-17  3.85E-19 -7.19E-02
  2 -9.68E-02  6.78E-02 -3.17E-01  3.99E-02  1.41E-17  7.63E-20 -7.19E-02
  3 -1.81E-01  4.10E-02 -3.14E-01  3.38E-02  1.41E-17 -2.32E-19 -7.19E-02
  4 -2.66E-01  1.45E-02 -3.12E-01  2.78E-02  1.41E-17 -5.39E-19 -7.02E-02
  5 -3.51E-01 -1.18E-02 -3.10E-01  2.21E-02  1.41E-17 -8.46E-19 -6.79E-02
  6 -4.36E-01 -3.79E-02 -3.08E-01  1.66E-02  1.41E-17 -1.15E-18 -6.51E-02
  7 -5.20E-01 -6.39E-02 -3.07E-01  1.14E-02  1.41E-17 -1.46E-18 -6.15E-02
  8 -6.05E-01 -8.99E-02 -3.06E-01  6.50E-03  1.41E-17 -1.77E-18 -5.74E-02
  9 -6.90E-01 -1.16E-01 -3.06E-01  2.05E-03  1.41E-17 -2.07E-18 -5.25E-02
 10 -7.74E-01 -1.42E-01 -3.06E-01 -1.93E-03  1.41E-17 -2.38E-18 -4.70E-02
 11 -8.59E-01 -1.68E-01 -3.06E-01 -5.92E-03  1.41E-17 -2.69E-18 -4.70E-02

               MODAL DISPLACEMENTS FOR SEGMENT NO. 4
  1  0.00E+00 -3.83E-01 -2.97E-01  4.01E-02  9.13E-02 -3.13E-02  2.79E-02
  2  0.00E+00 -4.89E-01 -2.80E-01  5.04E-02  8.60E-02 -4.00E-02  2.79E-02
  3  0.00E+00 -5.88E-01 -2.59E-01  6.06E-02  7.97E-02 -4.81E-02  2.79E-02
  4  0.00E+00 -6.79E-01 -2.35E-01  7.00E-02  7.24E-02 -5.55E-02  2.56E-02
  5  0.00E+00 -7.60E-01 -2.08E-01  7.84E-02  6.40E-02 -6.22E-02  2.29E-02
  6  0.00E+00 -8.31E-01 -1.78E-01  8.57E-02  5.47E-02 -6.80E-02  2.00E-02
  7  0.00E+00 -8.91E-01 -1.45E-01  9.18E-02  4.47E-02 -7.28E-02  1.67E-02
  8  0.00E+00 -9.38E-01 -1.11E-01  9.67E-02  3.41E-02 -7.67E-02  1.33E-02
  9  0.00E+00 -9.72E-01 -7.48E-02  1.00E-01  2.30E-02 -7.95E-02  9.60E-03
 10  0.00E+00 -9.93E-01 -3.77E-02  1.02E-01  1.16E-02 -8.12E-02  5.81E-03
 11  0.00E+00 -1.00E+00  0.00E+00  1.04E-01  0.00E+00 -8.17E-02  5.81E-03
  **** END   SUB. MODE ("SKIN"-RING MODULE BUCKLING MODE) ****

knockdown for smeared stringers from SUB.EIGMOD,
                                         SMRFAC=  5.1559E-01
knockdown for transverse shear deformation (t.s.d.) from SUB.SHRRED,
                                         SHRFAC=  9.5993E-01
Buckling load factor BEFORE knockdown for smeared stringers=  3.1313E+00
Buckling load factor AFTER  knockdown for smeared stringers=  1.6145E+00
NOTE: The buckling load factor,  1.6145E+00, has not yet been
further reduced by the "shear/anisotropy" factor, FKNSRG(1)=  1.0000E+00
Ratio (AFTER/BEFORE) knockdown for smeared stringers=   5.156E-01
Knockdown factors, EIGKNS(1),FKNSRG(1),FKNOCK(8)=  5.1559E-01  1.0000E+00  9.8506E-01
Margin=  5.9193E-01  Inter-ring bucklng, discrete model, n=13  circ.halfwaves;FS=0.999

Next, explore "skin"-ring module buckling from n=  15 to   66 circ. waves.
Minimum buckling load factor found so far, EIGBEF=  3.1313E+00
```

```
Corresponding critical number of circ. waves, n=  13
n circ. waves   Buckling Load Factor
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.2730E+00 After t.s.d.=  3.1414E+00
      15          3.1414E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.3139E+00 After t.s.d.=  3.1791E+00
      17          3.1791E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.3758E+00 After t.s.d.=  3.2360E+00
      19          3.2360E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.4524E+00 After t.s.d.=  3.3063E+00
      21          3.3063E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.5382E+00 After t.s.d.=  3.3849E+00
      23          3.3849E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.6294E+00 After t.s.d.=  3.4683E+00
      25          3.4683E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.7226E+00 After t.s.d.=  3.5533E+00
      27          3.5533E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.8159E+00 After t.s.d.=  3.6382E+00
      29          3.6382E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  3.9514E+00 After t.s.d.=  3.7612E+00
      32          3.7612E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.0780E+00 After t.s.d.=  3.8758E+00
      35          3.8758E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.1932E+00 After t.s.d.=  3.9797E+00
      38          3.9797E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.2957E+00 After t.s.d.=  4.0718E+00
      41          4.0718E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.3851E+00 After t.s.d.=  4.1521E+00
      44          4.1521E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.4846E+00 After t.s.d.=  4.2412E+00
      48          4.2412E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.5636E+00 After t.s.d.=  4.3118E+00
      52          4.3118E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.6249E+00 After t.s.d.=  4.3665E+00
      56          4.3665E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.6717E+00 After t.s.d.=  4.4082E+00
      60          4.4082E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.7147E+00 After t.s.d.=  4.4465E+00
      65          4.4465E+00
 LABEL NO. IN STRUCT= 9490
Buckling load factor before t.s.d.=  4.7463E+00 After t.s.d.=  4.4745E+00
```

```
      70          4.4745E+00
==================================================

No critical (minimum) eigenvalue detected in high-n range.
Therefore, no "hi-n" buckling margin for the discretized
"skin"-ring single module will be recorded.
Maximum number of circ. waves, NMAXRG=   70
Minimum eigenvalue in N-range, EIGMNH=  3.1791E+00

Next, explore "skin"-ring module buckling from n=   1 to    9 circ. waves.
n circ. waves   Buckling Load Factor
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  4.1529E+00 After t.s.d.=  3.9433E+00
       1          3.9433E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  4.0822E+00 After t.s.d.=  3.8796E+00
       2          3.8796E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.9792E+00 After t.s.d.=  3.7864E+00
       3          3.7864E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.8596E+00 After t.s.d.=  3.6780E+00
       4          3.6780E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.7378E+00 After t.s.d.=  3.5672E+00
       5          3.5672E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.6240E+00 After t.s.d.=  3.4634E+00
       6          3.4634E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.5242E+00 After t.s.d.=  3.3721E+00
       7          3.3721E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.4411E+00 After t.s.d.=  3.2960E+00
       8          3.2960E+00
 LABEL NO. IN STRUCT= 9510
Buckling load factor before t.s.d.=  3.3753E+00 After t.s.d.=  3.2356E+00
       9          3.2356E+00
==================================================

No critical (minimum) eigenvalue detected in low-n range.
Therefore, no "lo-n" buckling margin for the discretized
"skin"-ring single module will be recorded.
** CHAPTER 23,24: DESIGN PERTURBATION INDEX, IMOD=  0 **
 LABEL NO. IN STRUCT= 9550



*************************************************************
*************************************************************
*************************************************************
************          CHAPTER 23             ****************
*************************************************************
*************************************************************
*************************************************************
**** CHAPTER 23: DESIGN PERTURBATION INDEX, IMOD=  0 ****
```

```
 ************************************************************
 CHAPTER 23 Compute stresses in layers and at various
            locations in modules for both positive and
            negative imperfection amplitudes from SUBROUTINE
            STRCON (local postbuckling neglected). See [1L]
            (panda2.news) Items 36b,d,w, 41b, and Section E
            of Table 122.6 in Item 122.

***** BEGIN SUBROUTINE STRCON (IQUICK = 1 TYPE STRESSES) ******
       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

 Start calculation of stresses in the panel module depicted above...
 (Segment numbering below refers to the **TOPMOST** of the sketches above.)
 SEG.NODE LAYER  THICKNESS  WINDING   IN-PLANE STRESSES IN MATL COORDS.   MATERIAL
MODE OF     TRANSVERSE  ALLOWABLE  MATL
 NO.  NO.  NO.  COORDINATE   ANGLE       SIG1        SIG2        SIG12     STATUS
FAILURE      CRACKING    STRESS    TYPE
                     (z)       (deg)
(1.0 means inactive)
  positive imperfection factor
  skin-stringer module stresses:
   Stresses from sinxsiny or cosxcosy deformations (at peaks and valleys):
 SKN 1 n=1  1 -1.2071E-02  0.0000E+00 -2.0007E+04 -2.9115E+03  2.0712E+02     OK       no
failure     1.000                 1
 SKN 1 n=1  1  1.2071E-02  0.0000E+00 -1.8849E+04  9.1216E+02  2.0712E+02     OK       no
failure     1.000                 1
   Stresses from sinxcosy or cosxsiny deformations (at nodal lines):
```

```
 SKN 1 n=1  1 -1.2071E-02  0.0000E+00 -2.0008E+04 -2.9119E+03  2.0690E+02     OK       no
failure     1.000                1
 SKN 1 n=1  1  1.2071E-02  0.0000E+00 -1.8849E+04  9.1257E+02  2.0733E+02     OK       no
failure     1.000                1
   Stresses from sinxsiny or cosxcosy deformations (at peaks and valleys):
 SKN 1 n=11 1 -1.2071E-02  0.0000E+00 -1.9232E+04 -3.2711E+02  2.0712E+02     OK       no
failure     1.000                1
 SKN 1 n=11 1  1.2071E-02  0.0000E+00 -1.9624E+04 -1.6722E+03  2.0712E+02     OK       no
failure     1.000                1
   Stresses from sinxcosy or cosxsiny deformations (at nodal lines):
 SKN 1 n=11 1 -1.2071E-02  0.0000E+00 -1.9232E+04 -3.2711E+02  2.0712E+02     OK       no
failure     1.000                1
 SKN 1 n=11 1  1.2071E-02  0.0000E+00 -1.9624E+04 -1.6722E+03  2.0712E+02     OK       no
failure     1.000                1
 STR 2 n=1  1 -1.2071E-02  0.0000E+00 -1.9229E+04 -3.1567E+02  2.0690E+02     OK       no
failure     1.000                1
 STR 2 n=1  1  1.2071E-02  0.0000E+00 -1.9628E+04 -1.6837E+03  2.0733E+02     OK       no
failure     1.000                1
 STR 2 n=6  1 -1.2071E-02  0.0000E+00 -1.8483E+04  2.1719E+03  2.0712E+02     OK       no
failure     1.000                1
 STR 2 n=6  1  1.2071E-02  0.0000E+00 -2.0374E+04 -4.1713E+03  2.0712E+02     OK       no
failure     1.000                1
 STR 3 ROOT 1  0.0000E+00  0.0000E+00 -1.9134E+04  1.5234E-01  5.4549E-06     OK       no
failure     1.000                1
 STR 3 TIP  1  0.0000E+00  0.0000E+00 -1.9536E+04 -1.5233E-01  5.4549E-06     OK       no
failure     1.000                1
       Internal Ring

      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
```

```
 Start calculation of stresses in the panel module depicted above...
 (Segment numbering below refers to the **TOPMOST** of the sketches above.)
 SEG.NODE LAYER  THICKNESS  WINDING   IN-PLANE STRESSES IN MATL COORDS.   MATERIAL
MODE OF     TRANSVERSE  ALLOWABLE  MATL
 NO.  NO.  NO.  COORDINATE   ANGLE       SIG1        SIG2        SIG12     STATUS
FAILURE      CRACKING    STRESS    TYPE
                    (z)       (deg)
(1.0 means inactive)
  positive imperfection factor
  skin-ring module stresses:
 RNG 3 ROOT 1  0.0000E+00  0.0000E+00  4.7987E+03 -1.6325E-04  0.0000E+00     OK        no
failure     1.000                1
 RNG 3 TIP  1  0.0000E+00  0.0000E+00  4.7987E+03  3.0560E-05  0.0000E+00     OK        no
failure     1.000                1
  negative imperfection factor
  skin-stringer module stresses:
   Stresses from sinxsiny or cosxcosy deformations (at peaks and valleys):
 SKN 1 n=1  1 -1.2071E-02  0.0000E+00 -2.0008E+04 -2.9123E+03  2.0712E+02     OK        no
failure     1.000                1
 SKN 1 n=1  1  1.2071E-02  0.0000E+00 -1.8849E+04  9.1298E+02  2.0712E+02     OK        no
failure     1.000                1
   Stresses from sinxcosy or cosxsiny deformations (at nodal lines):
 SKN 1 n=1  1 -1.2071E-02  0.0000E+00 -2.0008E+04 -2.9119E+03  2.0733E+02     OK        no
failure     1.000                1
 SKN 1 n=1  1  1.2071E-02  0.0000E+00 -1.8849E+04  9.1257E+02  2.0690E+02     OK        no
failure     1.000                1
   Stresses from sinxsiny or cosxcosy deformations (at peaks and valleys):
 SKN 1 n=11 1 -1.2071E-02  0.0000E+00 -1.9232E+04 -3.2711E+02  2.0712E+02     OK        no
failure     1.000                1
 SKN 1 n=11 1  1.2071E-02  0.0000E+00 -1.9624E+04 -1.6722E+03  2.0712E+02     OK        no
failure     1.000                1
   Stresses from sinxcosy or cosxsiny deformations (at nodal lines):
 SKN 1 n=11 1 -1.2071E-02  0.0000E+00 -1.9232E+04 -3.2711E+02  2.0712E+02     OK        no
failure     1.000                1
 SKN 1 n=11 1  1.2071E-02  0.0000E+00 -1.9624E+04 -1.6722E+03  2.0712E+02     OK        no
failure     1.000                1
 STR 2 n=1  1 -1.2071E-02  0.0000E+00 -1.9229E+04 -3.1567E+02  2.0733E+02     OK        no
failure     1.000                1
 STR 2 n=1  1  1.2071E-02  0.0000E+00 -1.9628E+04 -1.6837E+03  2.0690E+02     OK        no
failure     1.000                1
 STR 2 n=6  1 -1.2071E-02  0.0000E+00 -1.8483E+04  2.1719E+03  2.0712E+02     OK        no
failure     1.000                1
 STR 2 n=6  1  1.2071E-02  0.0000E+00 -2.0374E+04 -4.1713E+03  2.0712E+02     OK        no
failure     1.000                1
 STR 3 ROOT 1  0.0000E+00  0.0000E+00 -1.9134E+04  1.5234E-01  5.4549E-06     OK        no
failure     1.000                1
 STR 3 TIP  1  0.0000E+00  0.0000E+00 -1.9536E+04 -1.5233E-01  5.4549E-06     OK        no
failure     1.000                1
  negative imperfection factor
  skin-ring module stresses:
 RNG 3 ROOT 1  0.0000E+00  0.0000E+00  4.7987E+03 -1.6325E-04  0.0000E+00     OK        no
failure     1.000                1
 RNG 3 TIP  1  0.0000E+00  0.0000E+00  4.7987E+03  3.0560E-05  0.0000E+00     OK        no
failure     1.000                1
 Margin=  2.0516E+00  eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.0121;-MID.;FS=1.
 ***** END   SUBROUTINE STRCON (IQUICK = 1 TYPE STRESSES) ******
  **** END OF STRESS CALCULATIONS ***
```

```
*************************************************************
*************************************************************
*************************************************************
************          CHAPTER 24            ****************
*************************************************************
*************************************************************
*************************************************************
**** CHAPTER 24: DESIGN PERTURBATION INDEX, IMOD=  0 ****

************************************************************
CHAPTER 24 Present short summary of redistribution of stress
           resultants, Nx, Ny, Nxy, caused by prebuckling
           bending of an initially imperfect shell.
           See Section 6.0 in [1K], for example.

Additional resultants (Nx,Ny) in panel skin from
global and inter-ring bending of imperfect panel:
           Additional axial resultant, dNx =  0.0000E+00
           Additional  hoop resultant, dNy =  0.0000E+00
  Additional in-plane shear resultant, dNxy=  0.0000E+00

Additional axial resultants dNx along webs and flanges of
stringers from global and inter-ring bending of imperfect panel:
    Additional Nx in  base  of stringer, dNx =  0.0000E+00
    Additional Nx at webtip of stringer, dNx =  0.0000E+00
    Additional Nx in flange of stringer, dNx =  0.0000E+00

Additional axial resultants dNx along webs and flanges of
rings from global and inter-ring bending of imperfect panel:
    Additional Nx in  base  of   ring,   dNx =  0.0000E+00
    Additional Nx at webtip of   ring,   dNx =  0.0000E+00
    Additional Nx in flange of   ring,   dNx =  0.0000E+00
 LABEL NO. IN STRUCT= 9560



*************************************************************
*************************************************************
*************************************************************
************          CHAPTER 25            ****************
*************************************************************
*************************************************************
*************************************************************
**** CHAPTER 25: DESIGN PERTURBATION INDEX, IMOD=  0 ****

************************************************************
CHAPTER 25 Compute buckling load factors from PANDA-type
           theory for the various segments of a stringer and
           a ring. Typical buckling modes are displayed in
           Figs. 5 and 6 of Ref.[1B].

***** BEGIN SUBROUTINE STFEIG (BUCKLING IN STIFFENERS) ******
 ENTERING STFEIG: MIDEND=    1
```

```
 IMOD= 0, Wavenumbers: MSKIN=    4, NSKIN=    1



 STRINGER:

 ***  BUCKLING (short wavelength buckling) of parts of the panel module cross section
perpendicular to generator ***
 NOTE: The segment numbering scheme used here corresponds to
       that used when the user provides input data.  It may
       differ from that used for the discretized module model.
       Please see ITEM 272 in the file panda2/doc/panda2.news.
 STIFFENER   MODULE    PRELOAD     RESULTANT   BUCKLING       BUCKLING     NO. OF
BUCKLING            COMMENT
   TYPE     SEGMENT   RESULTANT    FROM LOAD  LOAD FACTOR    LOAD FACTOR      HALFWAVES
                     (LOAD SET B)    SET A  (no transverse (with transverse   BETWEEN
                      (average)     (ave.)   shear deform.) shear deform.)   STIFFENERS
 Prebuck.resultant along stringer axis at root and tip of web:
   At root of web: -2.0707E+03;   At tip of web: -1.6537E+03
 Knockdown factor to account for in-plane shearing of web and
   any anisotropic properties of the web, FKNOCK(5)=  1.0000E+00

 Entering CRIPPL:
 Eigenvalue preload at web root and tip= -2.0707E+03 -1.6537E+03
 Fixed      preload at web root and tip=  0.0000E+00  0.0000E+00
 M = SQRT(SQRT((EFOUND+C(5,5)*FACT**2)/C(4,4)))*A0/3.1415927=     4
 IN SUB. ENDBUK: EIG=  2.0279E+00
 In CRIPPL, before SHRRED: LAMBDA,SHRLOD,T,GT(1),GT(2)=
  2.0279E+00 -1.8625E+03  8.0087E-02  3.8846E+06  3.8846E+06
 ISEG,ISRIDY,NMINSR,NWAVE,NMAXSR,FKNOCK=    3    1    5    4    7  1.0000E+00
 NOTE: If FKNOCK is less than 0.99 the stringer web buckling
       WILL be recorded as a margin even if the critical number
       of axial halfwaves lies within the range, NMINSR - NMAXSR
 Margin=  9.9882E-01  buckling margin stringer Iseg.3 . Local halfwaves=4  .MID.;FS=1.
  stringer     3     0.0000E+00  -1.8625E+03   2.0279E+00    1.9988E+00         4



 RING:

 ***  BUCKLING (short wavelength buckling) of parts of the panel module cross section
parallel    to generator ***
 NOTE: The segment numbering scheme used here corresponds to
       that used when the user provides input data.  It may
       differ from that used for the discretized module model.
       Please see ITEM 272 in the file panda2/doc/panda2.news.
 STIFFENER   MODULE    PRELOAD     RESULTANT   BUCKLING       BUCKLING     NO. OF
BUCKLING            COMMENT
   TYPE     SEGMENT   RESULTANT    FROM LOAD  LOAD FACTOR    LOAD FACTOR      HALFWAVES
                     (LOAD SET B)    SET A  (no transverse (with transverse   BETWEEN
                      (average)     (ave.)   shear deform.) shear deform.)   STIFFENERS
 Prebuck.resultant along   ring   axis at root and tip of web:
   At root of web:  2.8821E+02;   At tip of web:  2.8821E+02
 Knockdown factor to account for in-plane shearing of web and
   any anisotropic properties of the web, FKNOCK(6)=  1.0000E+00

 Entering CRIPPL:
 Eigenvalue preload at web root and tip=  2.8821E+02  2.8821E+02
```

```
 Fixed      preload at web root and tip=  0.0000E+00  0.0000E+00
 M = SQRT(SQRT((EFOUND+C(5,5)*FACT**2)/C(4,4)))*A0/3.1415927=     1
 IN SUB. ENDBUK: EIG=  1.0000E+17
 Prestress in   ring segments   to be neglected in ALTSOL
 ***** END   SUBROUTINE STFEIG (BUCKLING IN STIFFENERS) ******
  LABEL NO. IN STRUCT= 9565

***** BEGIN SUBROUTINE STFEIG (NO POSTBUCKLING EFFECT) ******
 ENTERING STFEIG: MIDEND=    1
 IMOD= 0, Wavenumbers: MSKIN=    4, NSKIN=    1



 STRINGER:

 ***  BUCKLING (short wavelength buckling) of parts of the panel module cross section
perpendicular to generator ***
 NOTE: The segment numbering scheme used here corresponds to
       that used when the user provides input data.  It may
       differ from that used for the discretized module model.
       Please see ITEM 272 in the file panda2/doc/panda2.news.
 STIFFENER   MODULE    PRELOAD     RESULTANT   BUCKLING       BUCKLING     NO. OF
BUCKLING            COMMENT
   TYPE     SEGMENT   RESULTANT    FROM LOAD  LOAD FACTOR    LOAD FACTOR      HALFWAVES
                     (LOAD SET B)     SET A  (no transverse (with transverse   BETWEEN
                      (average)     (ave.)   shear deform.) shear deform.)   STIFFENERS
 Prebuck.resultant along stringer axis at root and tip of web:
   At root of web: -1.5324E+03;   At tip of web: -1.5646E+03
 Knockdown factor to account for in-plane shearing of web and
   any anisotropic properties of the web, FKNOCK(5)=  1.0000E+00

 Entering CRIPPL:
 Eigenvalue preload at web root and tip= -1.5324E+03 -1.5646E+03
 Fixed      preload at web root and tip=  0.0000E+00  0.0000E+00
 M = SQRT(SQRT((EFOUND+C(5,5)*FACT**2)/C(4,4)))*A0/3.1415927=     4
 IN SUB. ENDBUK: EIG=  2.2904E+00
 In CRIPPL, before SHRRED: LAMBDA,SHRLOD,T,GT(1),GT(2)=
  2.2904E+00 -1.5549E+03  8.0087E-02  3.8846E+06  3.8846E+06
 ISEG,ISRIDY,NMINSR,NWAVE,NMAXSR,FKNOCK=    3    1    5    4    7  1.0000E+00
 NOTE: If FKNOCK is less than 0.99 the stringer web buckling
       WILL be recorded as a margin even if the critical number
       of axial halfwaves lies within the range, NMINSR - NMAXSR
 Margin=  1.2593E+00  buckling margin stringer Iseg.3 . Local halfwaves=4  .NOPO;FS=1.
  stringer     3     0.0000E+00  -1.5549E+03   2.2904E+00    2.2593E+00         4



 RING:

 ***  BUCKLING (short wavelength buckling) of parts of the panel module cross section
parallel    to generator ***
 NOTE: The segment numbering scheme used here corresponds to
       that used when the user provides input data.  It may
       differ from that used for the discretized module model.
       Please see ITEM 272 in the file panda2/doc/panda2.news.
 STIFFENER   MODULE    PRELOAD     RESULTANT   BUCKLING       BUCKLING     NO. OF
BUCKLING            COMMENT
   TYPE     SEGMENT   RESULTANT    FROM LOAD  LOAD FACTOR    LOAD FACTOR      HALFWAVES
```

```
                     (LOAD SET B)    SET A  (no transverse (with transverse   BETWEEN
                      (average)     (ave.)   shear deform.) shear deform.)   STIFFENERS
 Prebuck.resultant along   ring   axis at root and tip of web:
   At root of web:  2.8821E+02;   At tip of web:  2.8821E+02
 Knockdown factor to account for in-plane shearing of web and
   any anisotropic properties of the web, FKNOCK(6)=  1.0000E+00

 Entering CRIPPL:
 Eigenvalue preload at web root and tip=  2.8821E+02  2.8821E+02
 Fixed      preload at web root and tip=  0.0000E+00  0.0000E+00
 M = SQRT(SQRT((EFOUND+C(5,5)*FACT**2)/C(4,4)))*A0/3.1415927=     1
 IN SUB. ENDBUK: EIG=  1.0000E+17
 Prestress in   ring segments   to be neglected in ALTSOL
 ******* END SUBROUTINE STFEIG (NO POSTBUCKLING EFFECT) ******
  *** END OF STIFFENER SEGMENT BUCKLING (if any) ****

  LABEL NO. IN STRUCT= 9570

 Buckling load factors from PANDA-type models for
 design iteration no.  0,  load set no. 1,  material iteration no.  0.
 These load factors include the effect of in-plane shear loading.  M = axial half-waves;
N = circ. half-waves.
 Loading is uniform, with resultants given by:
   LOAD SET A: axial, Nx = -1.00E+03; circ., Ny = -1.00E-03; in-plane shear, Nxy =
5.00E+00
   LOAD SET B: axial, Nxo=  0.00E+00; circ., Nyo=  0.00E+00; in-plane shear, Nxyo=
0.00E+00 (Not from normal pressure)
   LOAD SET A: Uniform normal pressure, P =   2.0000E-05
      Resultants from global (smeared stiffener) model: Nx(p)=  0.00E+00,  Ny(p)=
0.00E+00,  Nxy(p)= 0.0
      Resultants from local (discrete stiffener) model: Nx(p)= -5.21E-04,  Ny(p)=  5.80E-
07,  Nxy(p)= 0.0 :
 BEHAVIORAL  EIGENVALUE      MODEL DESCRIPTION AND BUCKLING MODE
 CONSTRAINT (load factor)




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 26            *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 26: DESIGN PERTURBATION INDEX, IMOD=  0 ****

 *************************************************************
 CHAPTER 26 Compute local, inter-ring, general buckling load
            factors from PANDA-type models [1B] and from
            "alternative" (double-trigonometric series
            expansion) models, Ref.[1G]. Also compute
            sandwich wall behavior [1F], if applicable.
            Also, compute buckling load factors appropriate
            when substiffeners are present.

*** BEGIN SUBROUTINE BUCPAN (PANDA-TYPE BUCKLING LOADS) ****
```

```
Number of constraints, NCONST=       0

 LABEL NO. IN STRUCT= 9260
******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
ILABEL,IPRELM,IGENRL,IGENX,   EIGMAX=
 9260     0     0     0  1.0000E+07

Local buckling, C11=  6.7881E+04, radius, R= -5.0000E+01

C(i,j) for skin with smeared substringers and subrings.
 Reference surface is at the reference surface of the skin.
 6.7881E+04  5.7459E+02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 5.7459E+02  2.0540E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  5.1945E+04  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  1.3013E+01  3.9038E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  3.9038E+00  1.3013E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  4.5544E+00
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7010    9260       0       1       1       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  2.470500E+00
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                    WG1  =  0.0000E+00
General buckling modal,              WG2  =  0.0000E+00
Inter-ring buckling modal,          W0PAN =  1.0000E-10
Local buckling modal,               W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -2.3531E+02 -2.3132E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 6.7881E+04  5.7459E+02  0.0000E+00
 5.7459E+02  2.0540E+05  0.0000E+00
 0.0000E+00  0.0000E+00  5.1945E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 2.0239E+01  1.1079E+00  1.9170E-04  1.9170E-04  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=3.76E+00
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    3    1  1.000E-02  3.483E-01  3.761E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  4.08E-01  1.00E+17  3.48E-01  1.00E+17  3.48E-01  3.48E-01  1.00E+17
SLOPEX=  1.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  1.00E-02  0.00E+00
MWAVEX=    2         0         3         0         3         3         0
NWAVEX=    1         0         1         0         1         1         0
TESTX =  3.76E+00  0.00E+00  3.76E+00  0.00E+00  3.76E+00  3.76E+00  0.00E+00
Before refinement (before CALL EIG), EIGVAL,CSLOPE=  3.4835E-01  1.0000E-02
```

```
 After refinement ( after CALL EIG), EIGVAL,CSLOPE=  3.4835E-01  1.0000E-02
Teff(1),Teff(2),G13,G23=  2.4141E-02  2.4141E-02  3.8846E+06  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  3.4835E-01  3.4835E-01
Buckling load factor before t.s.d.=  3.4835E-01 After t.s.d.=  3.4798E-01
EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.4798E-01  3.4798E-01
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00

Sanders theory is used for these buckling calculations in this case.
Local buckling load factors & mode shapes before any knockdown factors applied:
EIGMNC=  4.08E-01  1.00E+17  3.48E-01  1.00E+17  3.48E-01  3.48E-01  1.00E+17
SLOPEX=  1.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  1.00E-02  0.00E+00
MWAVEX=    2         0         3         0         3         3         0
NWAVEX=    1         0         1         0         1         1         0
NOTE: The buckling nodal line slopes, SLOPEX, are as
defined in Fig. 9a or Fig. 9b of the 1987 "Theoretical
basis of the PANDA...",if NWAVEX > 0; that is, there
has not yet been any inversion of SLOPEX when 9b holds.

LOCAL BUCKLING FROM PANDA-TYPE THEORY [1B] AFTER KNOCKDOWN FOR t.s.d.:
EIGLOC =   3.4798E-01(m=   3,n=   1)
IPRELM=    0  ILOWSS(IPRELM+1,20)=    0

inter-ring buckling: smeared stringers, C11=  3.9634E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7130    9260       0       1       3       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.3132E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 3.9634E+05  6.0869E+03  0.0000E+00
 6.0869E+03  2.0540E+05  0.0000E+00
 0.0000E+00  0.0000E+00  5.1945E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 3.1831E-01  1.0000E+00  8.1714E-02  3.2832E-05  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.25E-03
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
```

```
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    1   14  0.000E+00  3.286E+00  1.248E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  3.29E+00  3.29E+00  3.29E+00  1.00E+17  1.00E+17  3.29E+00  7.92E+00
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         1
NWAVEX=   14        14        14         0         0        14         0
TESTX =  1.25E-03  1.25E-03  1.25E-03  0.00E+00  0.00E+00  1.25E-03  1.00E+01
Before refinement (before CALL EIG), EIGVAL,CSLOPE=  3.2859E+00  0.0000E+00
 After refinement ( after CALL EIG), EIGVAL,CSLOPE=  3.2859E+00  0.0000E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  3.2859E+00  3.2859E+00
Buckling load factor before t.s.d.=  3.2859E+00 After t.s.d.=  3.1533E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.1533E+00  3.1533E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
BEFORE KNOCKDOWN: EIGVLX=  3.1533E+00
Number of circumferential halfwaves in buckling pattern=  1.4000E+01
Buckling load factor BEFORE knockdown for smeared stringers=  3.1533E+00
Buckling load factor AFTER  knockdown for smeared stringers=  1.6263E+00
AFTER KNOCKDOWN: EIGVLX=  1.6263E+00

inter-ring buckling: smeared stringers, C11=  3.9634E+05, radius, R=  1.5738E+06
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7145    9260       0       1       3       1       0       1
 Radius  R,   Axial length, A,   Width  B
 1.573841E+06  9.779300E+00  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** NOTE: Panel is modelled as if it were flat. *****
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.3132E+01  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 3.9634E+05  6.0869E+03  0.0000E+00
 6.0869E+03  2.0540E+05  0.0000E+00
 0.0000E+00  0.0000E+00  5.1945E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 1.0000E+04  1.0000E+00  8.1714E-02  3.2832E-05  1.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.25E-03
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
```

```
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    1    3  0.000E+00  3.339E+00  1.248E-03
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  3.34E+00  3.34E+00  3.34E+00  1.00E+17  1.00E+17  3.34E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         1         0         0         1         0
NWAVEX=    3         4         3         0         0         1         0
TESTX =  1.25E-03  1.25E-03  1.25E-03  0.00E+00  0.00E+00  1.25E-03  0.00E+00
Before refinement (before CALL EIG), EIGVAL,CSLOPE=  3.3389E+00  0.0000E+00
 After refinement ( after CALL EIG), EIGVAL,CSLOPE=  3.3389E+00  0.0000E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  3.3389E+00  3.3389E+00
Buckling load factor before t.s.d.=  3.3389E+00 After t.s.d.=  3.2021E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.2021E+00  3.2021E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
BEFORE KNOCKDOWN: EIGVLX=  3.2021E+00
Number of circumferential halfwaves in buckling pattern=  3.0000E+00
Buckling load factor BEFORE knockdown for smeared stringers=  3.2021E+00
Buckling load factor AFTER  knockdown for smeared stringers=  1.6525E+00
 AFTER KNOCKDOWN: EIGVLX=  1.6525E+00

INTER-RING BUCKLING load factors and (axial, circumfer.) halfwaves:
Sanders theory is used for these buckling calculations in this case.
INTER-RING BUCKLING FROM PANDA-TYPE THEORY [1B]
   AFTER KNOCKDOWN FOR t.s.d. AND FOR SMEARED STRINGERS:
EIGSS =   1.6263E+00(m=   1,n=  14)
Inter-ring eigenvalue with panel as flat:
EIGSS2=   1.6525E+00(m=   1,n=   3)
IPRELM=    0  ILOWSS(IPRELM+1,20)=    1

Smeared stringer buck. load factor before and after knockdown:
EIGSS(before knockdown by 2 factors below)         =  1.6525E+00
Knockdown factor from inter-ring modal imperfection=  9.8506E-01
Modifying factor, FKNMOD=1 or 1/(EIG8X*FMDKD8)     =  1.0000E+00
After knockdown, EIGSS*FKNOCK(8)*FKNMOD            =  1.6278E+00
in which
EIG8X  = lambda(ARBOCZ)/lambda(original PANDA-type theory)=  9.8506E-01
      lambda(ARBOCZ)=perfect panel buckling from ARBOCZ theory
      lambda(PANDA) =perfect panel buckling from PANDA  theory
FMDKD8 = 1 or 0.9/EIG8X =  1.0000E+00

Simple-support inter-ring buckling with smeared stringers
is not recorded as a margin because this type of buckling
has been superseded by the results from the discretized
inter-ring module model, for which inter-ring buckling
load factors have been computed in the range from n =     1
to n =    70 circumferential halfwaves.
The critical simple-support inter-ring buckling model has    3
circ. half waves, which lies within this range.
Discrete stringers: EAS,EIXS,EIYS,GJSS,ECCS,SPSTRS,YLONGS=
 8.122E+05  4.089E+04  4.025E+02  1.409E+02 -4.353E-01  2.470E+00  1.482E+01
Preload in web: HH(1),RESLTS(1)-RPRES(1),RPRES(1),FNXSTR(1),FX0STR(1),ZNXSTR(1)=
```

```
 8.4714E-01 -1.8625E+03  0.0000E+00 -1.5778E+03  0.0000E+00 -4.3564E-01
Preload in flng: WW(1),RESLTS(2)-RPRES(2),RPRES(2),FNXSTR(2),FX0STR(2),ZNXSTR(2)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -8.5921E-01
Ring eig.prestress set to zero because IBLADE(2)=1
Discrete rings:     EAR,EIXR,EIYR,GJRR,ECCR,SPRNG,XLONG=
 5.139E+05  3.073E+04  1.698E+02  5.941E+01 -4.356E-01  9.779E+00  0.000E+00
Preload in web: HH(2),RESLTR(1)-RPRER(1),RPRER(1),FNXRNG(1),FX0RNG(1),ZNXRNG(1)=
 8.4714E-01  2.8821E+02  0.0000E+00  0.0000E+00  0.0000E+00 -4.3564E-01
Preload in flng: WW(2),RESLTR(2)-RPRER(2),RPRER(2),FNXRNG(2),FX0RNG(2),ZNXRNG(2)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -8.5921E-01
FNXSSA,FNYSSA,FNXYSS,FNXSPR,FNYSPR=
-2.3531E+02 -2.3132E+01  5.0000E+00  0.0000E+00  0.0000E+00

Entering ALTSOL: radius, axial, circ. dimensions =  5.0000E+01  9.7793E+00  1.4823E+01
See ITEMs 438, 444  in the file ..panda2/doc/panda2.news .
and AIAA paper 99-1233, Proc. 40th AIAA SDM Meeting, 1999
pp 302-345, especially pp 304-316 and associated figures.
***INTER-RING BUCKLING, N-STRINGER-BAY PATCH, SMEARED SUBSTF **
        Number of discrete stringers, rings: NUMSTR, NUMRNG=  7  2
Membrane stiffnesses, C11,C12,C22,C33=
 6.7881E+04  5.7459E+02  2.0540E+05  5.1945E+04

No alternative solution sought because user did not want one.
(IALTSN was set equal to zero in MAINSETUP)

general buckling: smeared stiffeners, C11=  3.9634E+05, radius, R= -5.0000E+01
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7195    9260       0       1       2       1       0       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  1.570800E+02
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 3.9634E+05  6.0869E+03  0.0000E+00
 6.0869E+03  2.5794E+05  0.0000E+00
 0.0000E+00  0.0000E+00  5.1945E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 3.1831E-01  1.0000E+00  8.1714E-02  2.7998E-02  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=4.84E-01
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).

The following section is entered only if TEST < 1.0 and the
```

```
number of axial halfwaves is at least 3. (TEST < 1.0 means
that the buckling mode from PANDA-type theory is of the
type shown in Fig.9(b),p.554 of the "Theoretical basis..."
paper. TEST > 1.0 means that Fig.9(a) applies.)
In this section a ratio, EIGRAT = EIGTST/EIGTS2, is
obtained in which EIGTST = eigenvalue with TEST > 1.0 and
                  EIGTS2 = eigenvalue with TEST < 1.0.
The ratio EIGRAT is always 1.0 unless EIGTST < EIGTS2.
High m range: New value of "TEST" is assigned: TEST =   1.1000E+00
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     1    4    7  0.000E+00  1.046E+00  1.100E+00
Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

EIGMNC=  1.05E+00  1.05E+00  1.05E+00  1.00E+17  1.00E+17  1.05E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    4         4         4         0         0         4         3
NWAVEX=    7         7         7         0         0         7         0
TESTX =  4.84E-01  4.84E-01  1.10E+00  0.00E+00  0.00E+00  4.84E-01  1.00E+01
Before refinement (before CALL EIG), EIGVAL,CSLOPE=  1.0462E+00  0.0000E+00
 After refinement ( after CALL EIG), EIGVAL,CSLOPE=  1.0462E+00  0.0000E+00
Teff(1),Teff(2),G13,G23=  8.7128E-01  8.7128E-01  2.5880E+05  4.9066E+04

If EIGVAL and EIGVLX are different:
EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
EIGVLX = original eigenvalue: no "fractional" refinement
EIGVAL,EIGVLX before knockdown for t.s.d.=  1.0462E+00  1.0462E+00
Buckling load factor before t.s.d.=  1.0462E+00 After t.s.d.=  1.0164E+00
EIGVAL,EIGVLX after  knockdown for t.s.d.=  1.0164E+00  1.0164E+00
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
Discrete stringers: EAS,EIXS,EIYS,GJSS,ECCS,SPSTR,YLONG=
 8.122E+05  4.089E+04  4.025E+02  1.409E+02 -4.353E-01  2.470E+00  1.482E+01
Preload in web: HH(1),RESLTS(1)-RPRES(1),RPRES(1),FNXSTR(1),FX0STR(1),ZNXSTR(1)=
 8.4714E-01 -1.8625E+03  0.0000E+00 -1.5778E+03  0.0000E+00 -4.3564E-01
Preload in flng: WW(1),RESLTS(2)-RPRES(2),RPRES(2),FNXSTR(2),FX0STR(2),ZNXSTR(2)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -8.5921E-01
Ring eig.prestress set to zero because IBLADE(2)=1
Discrete rings:     EAR,EIXR,EIYR,GJRR,ECCR,SPRNG,XLONG=
 5.139E+05  3.073E+04  1.698E+02  5.941E+01 -4.356E-01  9.779E+00  4.890E+01
Preload in web: HH(2),RESLTR(1)-RPRER(1),RPRER(1),FNXRNG(1),FX0RNG(1),ZNXRNG(1)=
 8.4714E-01  2.8821E+02  0.0000E+00  0.0000E+00  0.0000E+00 -4.3564E-01
Preload in flng: WW(2),RESLTR(2)-RPRER(2),RPRER(2),FNXRNG(2),FX0RNG(2),ZNXRNG(2)=
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -8.5921E-01
FNXGEN,FNYGEN,FNXYGN,FNXGPR,FNYGPR=
-2.3531E+02 -2.3132E+01  5.0000E+00  0.0000E+00  0.0000E+00

Entering ALTSOL: radius, axial, circ. dimensions =  5.0000E+01  4.8896E+01  1.4823E+01
See ITEMs 438, 444  in the file ..panda2/doc/panda2.news .
and AIAA paper 99-1233, Proc. 40th AIAA SDM Meeting, 1999
pp 302-345, especially pp 304-316 and associated figures.
*** GENERAL BUCKLING, N x M BAY PATCH, SMEARED SUBSTIFFRS ***
        Number of discrete stringers, rings: NUMSTR, NUMRNG=  7  6
Membrane stiffnesses, C11,C12,C22,C33=
 6.7881E+04  5.7459E+02  2.0540E+05  5.1945E+04

No alternative solution sought because user did not want one.
(IALTSN was set equal to zero in MAINSETUP)
General buckling loads AFTER knockdown for t.s.d.
```

```
 Number of circumferential halfwaves in buckling pattern=  7.0000E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  1.0164E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  9.5315E-01
 MGEN,NGENF,IWAVE,NGENNW=         4         7         7         2

 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)     =  9.5315E-01
 Knockdown factor from modal imperfection(s)        =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell  =  1.0000E+00
 Knockup factor to avoid twice accounting for t.s.d.=  1.0000E+00
 1st modifying factor, FKNMOD=1 or 1/(EIG9X*FMDKD9) =  1.0000E+00
 2nd modifying factor, EIGMR9=1 or EIGGNX/EIGGEN    =  1.0000E+00
 After knockdn,EIGGEN*FKNOCK(9)*(RNGKNK/SHRFCT)*FKNMOD*EIGMR9=  9.5315E-01
 in which
 EIG9X  = lambda(ARBOCZ)/lambda(original PANDA-type theory)=  1.0000E+00
       lambda(ARBOCZ)=perfect panel buckling from ARBOCZ theory
       lambda(PANDA) =perfect panel buckling from PANDA  theory
 FMDKD9 = 1 or 0.9/EIG9X =  1.0000E+00
 EIGGNX = eigenvalue for perfect panel from alternate solution
     11      9.53151E-01   buckling load factor simp-support general
buck;M=4;N=7;slope=0.
 Margin= -4.5895E-02  buck.(SAND);simp-support general buck;M=4;N=7;slope=0.;FS=0.999

                          Stringers              Rings
 Segment 1 prestress: RESLTS(1)  RPRES(1)  RESLTR(1)  RPRER(1)=
                  -1.8625E+03  0.0000E+00  2.8821E+02  0.0000E+00
 Segment 2 prestress: RESLTS(2)  RPRES(2)  RESLTR(2)  RPRER(2)=
                   0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 Enter SUBROUTINE ROLL. Label in STRUCT                =  9260
 NRS   = 1 for stringers, 2 for rings; NRS             =     1
 FL = stiffener spacing; FL                            =  2.4705E+00
 NPART = number of stiffener segments; NPART           =     1
 IEND  = 0=no edges are free; 1=one edge is free; IEND  =     1     0     0
 ANGL = 0 deg.or 180 deg.for web, 90 deg.for flange;ANGL=  0.0000E+00  0.0000E+00
0.0000E+00
 C1    = axial stiffness/length of stiffener segment; C1=  8.8684E+05  0.0000E+00
0.0000E+00
 AL    = height of stiffener segment; AL               =  8.4714E-01  0.0000E+00
0.0000E+00
 NSEG  = number of stiffener segments attached  web,NSEG=     0     0     0
 RESULT= axial resultant in stiff.seg, Load Set A;RESULT= -1.8625E+03  0.0000E+00
0.0000E+00
 RPRE  = axial resultant in stiff.seg. Load Seg B, RPRE =  0.0000E+00  0.0000E+00
0.0000E+00
 ISTIF = type of stiffener: for example, 3=blade; ISTIF =     3

 Enter SUBROUTINE ROLL. Label in STRUCT                =  9260
 NRS   = 1 for stringers, 2 for rings; NRS             =     2
 FL = stiffener spacing; FL                            =  9.7793E+00
 NPART = number of stiffener segments; NPART           =     1
 IEND  = 0=no edges are free; 1=one edge is free; IEND  =     1     0     0
 ANGL = 0 deg.or 180 deg.for web, 90 deg.for flange;ANGL=  0.0000E+00  0.0000E+00
0.0000E+00
 C1    = axial stiffness/length of stiffener segment; C1=  6.6660E+05  0.0000E+00
0.0000E+00
 AL    = height of stiffener segment; AL               =  8.4714E-01  0.0000E+00
0.0000E+00
```

```
 NSEG  = number of stiffener segments attached  web,NSEG=     0     0     0
 RESULT= axial resultant in stiff.seg, Load Set A;RESULT=  2.8821E+02  0.0000E+00
0.0000E+00
 RPRE  = axial resultant in stiff.seg. Load Seg B, RPRE =  0.0000E+00  0.0000E+00
0.0000E+00
 ISTIF = type of stiffener: for example, 3=blade; ISTIF =     3

 Inter-ring buckling/rolling:smeared stringers,C11=  3.9634E+05, radius, R= -5.0000E+01
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
    7265    9260       0       1       3       1       1       0
  Radius  R,   Axial length, A,   Width  B
 -5.000000E+01  9.779300E+00  1.570800E+02
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
 Out-of-roundness,                   WG1  =  0.0000E+00
 General buckling modal,             WG2  =  0.0000E+00
 Inter-ring buckling modal,         W0PAN =  1.0000E-10
 Local buckling modal,              W0LOC =  1.0000E-07
 ***** Sanders theory is used in this section (ISAND=1)
 Load Set A: Nx,  Ny,  Nxy= -1.0000E+03 -2.3132E+01  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
  3.9634E+05  6.0869E+03  0.0000E+00
  6.0869E+03  2.0540E+05  0.0000E+00
  0.0000E+00  0.0000E+00  5.1945E+04
      R/B,      C44MLT,      C44N,      C55N,      FFLAT=
  3.1831E-01  1.0000E+00  8.1714E-02  3.2832E-05  0.0000E+00
 Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.25E-03
 If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
 If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
 See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
 ***(low-n)***
 (high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                 0     1    1   14  0.000E+00  3.289E+00  1.248E-03
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 EIGMNC=  3.29E+00  3.29E+00  3.29E+00  1.00E+17  1.00E+17  3.29E+00  7.92E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    1         1         1         0         0         1         1
 NWAVEX=   14        14        14         0         0        14         0
 TESTX =  1.25E-03  1.25E-03  1.25E-03  0.00E+00  0.00E+00  1.25E-03  1.00E+01
 Before refinement (before CALL EIG), EIGVAL,CSLOPE=  3.2891E+00  0.0000E+00
  After refinement ( after CALL EIG), EIGVAL,CSLOPE=  3.2891E+00  0.0000E+00
 Teff(1),Teff(2),G13,G23=  8.7128E-01  2.4141E-02  2.5880E+05  3.8846E+06

 If EIGVAL and EIGVLX are different:
 EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
 EIGVLX = original eigenvalue: no "fractional" refinement
 EIGVAL,EIGVLX before knockdown for t.s.d.=  3.2891E+00  3.2891E+00
 Buckling load factor before t.s.d.=  3.2891E+00 After t.s.d.=  3.1563E+00
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  3.1563E+00  3.1563E+00
```

```
EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
Number of circumferential halfwaves in buckling pattern=  1.4000E+01
Buckling load factor BEFORE knockdown for smeared stringers=  3.1563E+00
Buckling load factor AFTER  knockdown for smeared stringers=  1.6279E+00

Smeared stringer with rolling before and after knockdown:
EIGRSS(before knockdown by 2 factors below)        =  1.6279E+00
Knockdown factor from inter-ring modal imperfection=  9.8506E-01
Modifying factor, FKNMOD=1 or 1/(EIG8X*FMDKD8)     =  1.0000E+00
After knockdown, EIGRSS*FKNOCK(8)*FKNMOD           =  1.6035E+00
in which
EIG8X  = lambda(ARBOCZ)/lambda(original PANDA-type theory)=  9.8506E-01
      lambda(ARBOCZ)=perfect panel buckling from ARBOCZ theory
      lambda(PANDA) =perfect panel buckling from PANDA  theory
FMDKD8 = 1 or 0.9/EIG8X =  1.0000E+00

Inter-ring buckling with smeared stringers and ring rolling
is not recorded as a margin because this type of buckling
has been superseded by the results from the discretized
inter-ring module model, for which inter-ring buckling
load factors have been computed in the range from n =     1
to n =    70 circumferential halfwaves.
The critical inter-ring-buckling-with-ring-rolling model has   14
circ. half waves, which lies within this range.

Buckling w/rolling between stringers with smeared rings, C11=  2.6794E+05
******** ENTERING GENSTB: PANDA-type buckling model ********
PANDA-type buckling theory is described in the journal paper:
D. Bushnell, "Theoretical basis of the PANDA computer program"
Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
Also see Items 415 and 443 in ...panda2/doc/panda2.news.
ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
ILABLY = label number near where SUBROUTINE BUCPAN is called.
  ILABEL, ILABLY, IDESGN,  ISAND,   INDX,   ITHRU,  IROLL    IFFLAT =
   7275    9260       0       1       4       1       1       0
 Radius  R,   Axial length, A,   Width  B
-5.000000E+01  1.300000E+02  2.470500E+00
Initial imperfections for general, panel, local buckling=
Total out-of-roundness + modal,    W0GLOB =  1.0000E-10
Out-of-roundness,                   WG1  =  0.0000E+00
General buckling modal,             WG2  =  0.0000E+00
Inter-ring buckling modal,         W0PAN =  1.0000E-10
Local buckling modal,              W0LOC =  1.0000E-07
***** Sanders theory is used in this section (ISAND=1)
Load Set A: Nx,  Ny,  Nxy= -2.3531E+02 -1.0000E-03  5.0000E+00
Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
 2.6794E+05  8.0382E+04  0.0000E+00
 8.0382E+04  3.2049E+05  0.0000E+00
 0.0000E+00  0.0000E+00  9.3778E+04
     R/B,      C44MLT,      C44N,      C55N,      FFLAT=
 2.0239E+01  1.4261E+00  4.8566E-05  4.2894E-02  0.0000E+00
Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=1.31E+03
If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
***(low-n)***
(high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
```

```
                0     0  186    1  0.000E+00  7.427E+00  1.310E+03
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 In GENSTB:
 The eigenvalue corresponding to m=MMXCHK= 20 axial
 halfwaves and n=  1 circ. halfwaves is critical and is
 at the upper end of the final search for missed eigenvalues.
 Therefore, we must continue the search over m >  20
 EIGMNC=  8.56E+00  1.00E+17  7.43E+00  1.00E+17  7.43E+00  7.44E+00  1.00E+17
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=  139         0       186         0       188       192         0
 NWAVEX=    1         0         1         0         1         1         0
 TESTX =  1.31E+03  0.00E+00  1.31E+03  0.00E+00  1.31E+03  1.31E+03  0.00E+00
 Before refinement (before CALL EIG), EIGVAL,CSLOPE=  7.4266E+00  0.0000E+00
  After refinement ( after CALL EIG), EIGVAL,CSLOPE=  7.4266E+00  0.0000E+00
 Teff(1),Teff(2),G13,G23=  2.4141E-02  8.7128E-01  3.8846E+06  4.9066E+04

 If EIGVAL and EIGVLX are different:
 EIGVAL = eigenvalue with fractional wavenumbers and "fractional" slope
 EIGVLX = original eigenvalue: no "fractional" refinement
 EIGVAL,EIGVLX before knockdown for t.s.d.=  7.4266E+00  7.4266E+00
 Buckling load factor before t.s.d.=  7.4266E+00 After t.s.d.=  7.0794E+00
 EIGVAL,EIGVLX after  knockdown for t.s.d.=  7.0794E+00  7.0794E+00
 EIGRAT = EIGTST/EIGTS2 =   1.0000E+00
     12      7.07937E+00   buckling load factor rolling with smear rings;
M=186;N=1;slope=0.
 Margin=  6.9794E+01  buck.(SAND);rolling with smear rings; M=186;N=1;slope=0.;FS=0.1

 STRINGER ROLLING, LOAD SET A+B Nx: WEB, FLANGE= -1.8625E+03  0.0000E+00
 STRINGER ROLLING, LOAD SET B   Nx: WEB, FLANGE=  0.0000E+00  0.0000E+00

 Lo-axial wave stringer rolling without skin participation

 In SUBROUTINE MINVAL: Eigenvalue before t.s.d.=  4.7143E+00
                       Eigenvalue after  t.s.d.=  4.5599E+00
 Prebuckling resultant, RESLTS(1)= -1.8625E+03
 Buckling load factor, EIGRLL(2)=  4.5599E+00
 Number of halfwaves over the axial distance, ABIG=  1.3000E+02; KWAVES(1,2)=   93
 STRINGER ROLLING: KWAVES(1,2),DOCSTR(1),FSROLS(1)=   93  7.0898E-01  1.4000E+00
     13      4.55992E+00   buckling load factor rolling only of
stringers;M=93;N=0;slope=0.
 Margin=  2.2571E+00  buck.(SAND);rolling only of stringers;M=93;N=0;slope=0.;FS=1.4

 Stringer rolling from PANDA-type theory [1B]:
 PANDA-type buckling load factor, EIGRLL(2)(m,n,slope)=  4.5599E+00(  93,0,0)

 high-axial wave stringer rolling without skin participation

 In SUBROUTINE MINVAL: Eigenvalue before t.s.d.=  4.7238E+00
                       Eigenvalue after  t.s.d.=  4.5687E+00
 Prebuckling resultant, RESLTS(1)= -1.8625E+03
 Buckling load factor, EROLHS=  4.5687E+00
 Number of halfwaves over the axial distance, ABIG=  1.3000E+02; MROLST=   88

 Axisymmetric ring rolling without skin participation
 Prebuckling resultant, RESLTR(1)=  2.8821E+02
 Buckling load factor,  EIGRLL(4))=  1.0000E+17
```

```
 Axisymmetric ring rolling from PANDA-type theory [1B]:
 PANDA-type buckling load factor, EIGRLL(4)(m,n,slope)=  1.0000E+17(0,   0,0)
 ******* LEAVING SUBROUTINE BUCPAN: UNPERTURBED DESIGN ********
 ****  END SUBROUTINE BUCPAN (PANDA-TYPE BUCKLING LOADS) ****
 *** END   SUBROUTINE BUCPAN (PANDA-TYPE BUCKLING LOADS) ****
  **** END OF PANDA-TYPE (CLOSED FORM) *****
  *** CALCS. FOR A VARIETY OF BUCKLING MODES ***
  LABEL NO. IN STRUCT= 9580
 Margin=  3.8854E+02  (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 ******* THE MAXIMUM AVERAGE AXIAL STRAIN MARGIN WAS COMPUTED:
(Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 ******* CONSTRAINT NO. 14; LOAD SET NO. 1; SUBCASE NO. 1
 Margin=  8.7142E-05  0.3333 *(Stringer spacing, b)/(Stringer base width, b2)-1;FS=1.
 ******* THE STRINGER SPACING/STRINGER BASE MARGIN COMPUTED:
0.3333 *(Stringer spacing, b)/(Stringer base width, b2)-1;FS=1.
 ******* CONSTRAINT NO. 15; LOAD SET NO. 1; SUBCASE NO. 1
  AFTER VARCON: IMOD,INUMTT,ICONST= 0 27 15



 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 27            *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 27: DESIGN PERTURBATION INDEX, IMOD=  0 ****

 *************************************************************
 CHAPTER 27 Compute the objective function (e.g. WEIGHT).

****** BEGIN SUBROUTINE OBJECT (OBJECTIVE FUNCTION) ******

 Objective (weight of PANDA2 model of panel), OBJ =  1.1600E+02
****** END   SUBROUTINE OBJECT (OBJECTIVE FUNCTION) ******




 **************************************************************
 **************************************************************
 **************************************************************
 ************          CHAPTER 28            *****************
 **************************************************************
 **************************************************************
 **************************************************************
 **** CHAPTER 28: DESIGN PERTURBATION INDEX, IMOD=  0 ****

 *************************************************************
 CHAPTER 28 Present design, loading, and margins for the
            current load set and subcase. See Table 6 in
 Bushnell, D.
 "Optimization of an axially compressed ring and stringer
```

```
 stiffened cylindrical shell with a general buckling modal
 imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
 Honolulu, Hawaii, April 2007
0
          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   N     N     N      0    0.00E+00  0.00E+00 2.4705E+00  0.00E+00
B(STR):stiffener spacing, b: STR seg=NA, layer=NA
   2   N     N     N      0    0.00E+00  0.00E+00 8.2342E-01  0.00E+00
B2(STR):width of stringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00  1.00E-01 8.4714E-01  3.00E+00
H(STR):height of stiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00  1.00E-02 2.4141E-02  5.00E-01    T(1
)(SKN):thickness for layer index no.(1 ): SKN seg=1
   5   Y     Y     N      0    0.00E+00  1.00E-02 8.0087E-02  5.00E-01    T(2
)(STR):thickness for layer index no.(2 ): STR seg=3
   6   N     N     N      0    0.00E+00  0.00E+00 9.7793E+00  0.00E+00
B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
   7   N     N     N      0    0.00E+00  0.00E+00 0.0000E+00  0.00E+00
B2(RNG):width of ring base, b2 (zero is allowed): RN
   8   N     N     Y      3    1.00E+00  0.00E+00 8.4714E-01  0.00E+00
H(RNG):height of stiffener (type H for sketch), h:
   9   Y     Y     N      0    0.00E+00  2.00E-02 6.0060E-02  2.00E-01    T(3
)(RNG):thickness for layer index no.(3 ): RNG seg=3
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  3.0814E-01 (flat skin)
  Local buckling load factor from BOSOR4 theory =  3.1344E-01 (flat skin)

 *********** 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= -1.0000E+03
         Applied circumferential stress resultant, Ny= -1.0000E-03
         Applied    in-plane     shear  resultant,Nxy=  5.0000E+00
         Applied     axial       moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00
         Applied pressure (positive for upward),   p =  2.0000E-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  2.14E+00 Local buckling from discrete model-1.,M=6   axial halfwaves;FS=0.1
 2  2.08E+00 Local buckling from Koiter theory,M=6   axial halfwaves;FS=0.1
 3  7.01E-02 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.0121; MID.;FS=1.
```

```
 4  1.66E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5  2.07E-01 Hi-axial-wave post-post-buckling of module - 1;   M=12 ;FS=1.
 6  1.69E-02 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  5.92E-01 Inter-ring bucklng, discrete model, n=13  circ.halfwaves;FS=0.999
 8  2.05E+00 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.0121;-MID.;FS=1.
 9  9.99E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .MID.;FS=1.
10  1.26E+00 buckling margin stringer Iseg.3 . Local halfwaves=4  .NOPO;FS=1.
11 -4.59E-02 buck.(SAND);simp-support general buck;M=4;N=7;slope=0.;FS=0.999
12  6.98E+01 buck.(SAND);rolling with smear rings; M=186;N=1;slope=0.;FS=0.1
13  2.26E+00 buck.(SAND);rolling only of stringers;M=93;N=0;slope=0.;FS=1.4
14  3.89E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
15  8.71E-05 0.3333 *(Stringer spacing, b)/(Stringer base width, b2)-1;FS=1.


 ****************************************
 ITERATION NO., LOAD SET NO., SUBCASE NO. =   0   1   2     AT RINGS
 ****************************************
 ILOADS,ICASES,NWAVES(ILOADS,ICASES)=     1     2     0


 (several thousand lines omitted in order to save space)


 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  2.11E+00 Local buckling from discrete model-1.,M=6   axial halfwaves;FS=0.1
 2  2.03E+00 Local buckling from Koiter theory,M=6   axial halfwaves;FS=0.1
 3  1.76E-01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.0121; RNGS;FS=1.
 4  1.73E+04 stringer popoff margin:(allowable/actual)-1, web 1  RNGS;FS=1.
 5  2.44E-01 Hi-axial-wave post-post-buckling of module - 1;   M=12 ;FS=1.
 6  4.36E-03 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
 7  6.01E-01 Inter-ring bucklng, discrete model, n=13  circ.halfwaves;FS=0.999
 8  2.12E+00 eff.stress:matl=1,STR,Iseg=3,at:ROOT,layer=1,z=0.;-RNGS;FS=1.
 9  8.57E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .RNGS;FS=1.
10  6.99E+01 buck.(SAND);rolling with smear rings; M=186;N=1;slope=0.;FS=0.1
11  2.17E+00 buck.(SAND);rolling only of stringers;M=93;N=0;slope=0.;FS=1.4
12  4.14E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 ***********  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   N     N     N      0    0.00E+00  0.00E+00 2.4705E+00  0.00E+00
B(STR):stiffener spacing, b: STR seg=NA, layer=NA
   2   N     N     N      0    0.00E+00  0.00E+00 8.2342E-01  0.00E+00
B2(STR):width of stringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00  1.00E-01 8.4714E-01  3.00E+00
H(STR):height of stiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00  1.00E-02 2.4141E-02  5.00E-01    T(1
)(SKN):thickness for layer index no.(1 ): SKN seg=1
   5   Y     Y     N      0    0.00E+00  1.00E-02 8.0087E-02  5.00E-01    T(2
)(STR):thickness for layer index no.(2 ): STR seg=3
   6   N     N     N      0    0.00E+00  0.00E+00 9.7793E+00  0.00E+00
B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
   7   N     N     N      0    0.00E+00  0.00E+00 0.0000E+00  0.00E+00
```

```
B2(RNG):width of ring base, b2 (zero is allowed): RN
   8   N     N     Y      3    1.00E+00  0.00E+00 8.4714E-01  0.00E+00
H(RNG):height of stiffener (type H for sketch), h:
   9   Y     Y     N      0    0.00E+00  2.00E-02 6.0060E-02  2.00E-01    T(3
)(RNG):thickness for layer index no.(3 ): RNG seg=3

 ****************************************************
 ******************** DESIGN OBJECTIVE *******************
 *************                             ***********
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
            0     0   1.160E+02   WEIGHT OF THE ENTIRE PANEL
  TOTAL WEIGHT OF SKIN                           =   4.9297E+01
  TOTAL WEIGHT OF SUBSTIFFENERS                  =   0.0000E+00
  TOTAL WEIGHT OF STRINGERS                      =   5.6079E+01
  TOTAL WEIGHT OF RINGS                          =   1.0624E+01
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   5.6806E-03
 *************                          ************
 ******************** DESIGN OBJECTIVE *******************
 ******************************************************

 PARAMETERS WHICH ARE ALWAYS FIXED.  NONE CAN BE DECISION VARIAB.
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
  1         0     0   1.300E+02  Panel length normal to the plane of the screen, L1
  2         0     0   1.571E+02  Panel length in the plane of the screen, L2
  3         0     0 RECTANGULAR  Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G):
STR seg=NA, layer=NA
  4         0     0   0.000E+00  Are the stringers cocured with the skin?: STR seg=NA,
layer=NA
  5   SKN   1     1   0.000E+00  winding angle (deg.) for layer index no.(1 ): SKN seg=1
, layer=1
  6   STR   3     1   0.000E+00  winding angle (deg.) for layer index no.(2 ): STR seg=3
, layer=1
  7         0     0   1.000E+00  choose external (0) or internal (1) stringers: STR
seg=NA, layer=NA
  8         0     0 RECTANGULAR  Identify type of stiffener along L2  (N, T, J, Z, R, A):
RNG seg=NA, layer=NA
  9         0     0   0.000E+00  Are the rings cocured with the skin?: RNG seg=NA,
layer=NA
 10   RNG   3     1   0.000E+00  winding angle (deg.) for layer index no.(3 ): RNG seg=3
, layer=1
 11         0     0   1.000E+00  choose external (0) or internal (1) rings: RNG seg=NA,
layer=NA
 12         0     0  -5.000E+01  Radius of curvature in the plane of screen, R
 13         0     0   2.039E+06  Radius of curvature normal to plane of screen, R2
 14         0     0   1.010E+07  modulus in the fiber direction, E1(1 )
 15         0     0   1.010E+07  modulus transverse to fibers,   E2(1 )
 16         0     0   3.885E+06  in-plane shear modulus,          G(1 )
 17         0     0   3.000E-01  Poissons ratio                  NU(1 )
 18         0     0   3.885E+06  transverse shear modulus,      G13(1 )
 19         0     0   3.885E+06  transverse out-of-plane shear  G23(1 )
 20         0     0   0.000E+00  Thermal expansion coeff.,    ALPHA(1 )
 21         0     0   0.000E+00  transverse thermal expansion,   A2(1 )
 22         0     0   0.000E+00  residual stress temperature (positive),TEMPTUR(1 )
 23         0     0   1.000E-01  weight density (greater than 0!) of material type(1 )
 24         0     0   0.000E+00  Thickness of a single lamina of matl type(1 )
```

```
 25         0     0   0.000E+00  Prebuckling: choose 0=bending included; 2=use membrane
theory
 26         0     0   0.000E+00  Buckling: choose 0=simple support or 1=clamping

 PARAMETERS WHICH ARE CLASSIFIED AS ALLOWABLES (e.g. max. stress)
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
  1         0     0   1.000E+06  What force/(axial length) will cause web peel-off?: STR
seg=NA, l
  2         0     0   6.000E+04  Maximum effective stress in material type(1 )

 *************************************************
          PANEL GEOMETRY IN THE AXIAL (L1) DIRECTION
       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

 WALL PROPERTIES (Segment numbering below refers to the topmost of the sketches above.)
 STR/ TYPE  SEG.  LAYER  LAYER  THICKNESS   WINDING     MATERAL   CRACKING
 RNG        NO.    NO.   TYPE                ANGLE       TYPE      RATIO

 SKN    R    1      1      1   2.4141E-02  0.0000E+00     1        1.0000E+00
 TOTAL THICKNESS OF SEG.  1 =  2.4141E-02

 STR    R    2      1      1   2.4141E-02  0.0000E+00     1        1.0000E+00
 TOTAL THICKNESS OF SEG.  2 =  2.4141E-02

 STR    R    3      1      2   8.0087E-02  0.0000E+00     1        1.0000E+00
 TOTAL THICKNESS OF SEG.  3 =  8.0087E-02
```

```
************************************************
      PANEL GEOMETRY IN THE CIRCUMFERENTIAL (L2) DIRECTION
      Internal Ring

     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
```

WALL PROPERTIES (Segment numbering below refers to the topmost of the sketches above.)

STR/ RNG	TYPE	SEG. NO.	LAYER NO.	LAYER TYPE	THICKNESS	WINDING ANGLE	MATERAL TYPE	CRACKING RATIO
RNG	R	3	1	3	6.0060E-02	0.0000E+00	1	1.0000E+00

TOTAL THICKNESS OF SEG. 3 = 6.0060E-02

DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

allenrngs.NAM = This file contains only the name of the case.
allenrngs.OPT = Input data generated by MAINSETUP.
allenrngs.OPM = Output data. Please list this file and inspect
carefully before proceeding.
allenrngs.OPP = Output data containing optimization history from
the first PANDAOPT. Inspect before proceeding.
allenrngs.CBL = Labelled common blocks for PANDA2 analysis.
(This is an unformatted sequential file.)
allenrngs.BL1 = Labelled common blocks for BOSOR4-type discretized
model of single panel module.
(This is an unformatted sequential file.)
allenrngs.BL2 = Labelled common blocks for BOSOR4-type discretized

```
           model of entire panel with smeared stiffeners.
           (This is an unformatted sequential file.)
allenrngs.RN1 = Direct access file for data base pertaining to
           BOSOR4-type discretized model of single module.
           (This is an unformatted direct access file.)
allenrngs.RN2 = Direct access file for data base pertaining to
           BOSOR4-type discretized model of entire panel
           with smeared stiffeners.
           (This is an unformatted direct access file.)
allenrngs.003 = Scratch file similar to the .OPT file.
allenrngs.PL1 = Binary file (ITYPE.EQ.1) with results for plots
allenrngs.SL1 = Binary file (ITYPE.NE.1) with results for plots
PROMPT.DAT= Prompt file for interactive input for PANDA2.
TUTORMAIN.DAT = File containing rather detailed explanations
                of theories on which PANDA2 is based.

For further information about files used and generated
during operation of PANDA2, give the command HELPAN FILES.

Menu of commands: PANDAOPT, SUPEROPT, MAINSETUP, CHANGE,
                  DECIDE, CHOOSEPLOT, PANEL, STAGSMODEL

IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
allenrngs.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
RUN SUPEROPT.
**** NOTE: It is almost always best to set the number of ****
**** iterations per execution of "PANDAOPT" equal to 5   ****
**** in response to the following prompt in "MAINSETUP": ****
"How many design iterations permitted in this run (5 to 25)?"
**** Hence, the *.OPT file should almost always have the ****
**** following line in it:                               ****
"5   $ How many design iterations in this run (5 to 25)?"
******************** END OF allenrngs.OPM FILE ****************
===================================================================
```