CAUTION!
NONLINEAR AXISYMMETRIC COLLAPSE WITH BIGBOSOR4 (INDIC = 0)

The first curve in Fig. 1, obtained with INDIC = 0 and BIGBOSOR4, was obtained with use of the following data in the *.ALL file:

```
--------------------------------------------------------------------
    H      $ GLOBAL DATA BEGINS...
      1   $ NLAST = plot options  (-1=none, 0=geometry, 1=u,v,w)
   N      $ Are there any regions for which you want expanded plots?
 46.0000   $ P      = pressure or surface traction multiplier
 46.0000   $ DP     = pressure or surface traction multiplier increment
 0.000000  $ TEMP   = temperature rise multiplier
 0.000000  $ DTEMP  = temperature rise multiplier increment
     20   $ Number of load steps
 0.000000  $ OMEGA  = angular vel. about axis of revolution (rad/sec)
 0.000000  $ DOMEGA = angular velocity increment (rad/sec)
    H      $ CONSTRAINT CONDITIONS FOLLOW....
--------------------------------------------------------------------
```

The second curve in Fig. 1 was obtained with use of the same BIGBOSOR4 input file, except the starting pressure, P, and pressure increment, DP, were as listed here:

```
--------------------------------------------------------------------
    H      $ GLOBAL DATA BEGINS...
      1   $ NLAST = plot options  (-1=none, 0=geometry, 1=u,v,w)
   N      $ Are there any regions for which you want expanded plots?
 350.0000  $ P      = pressure or surface traction multiplier
 5.000000  $ DP     = pressure or surface traction multiplier increment
 0.000000  $ TEMP   = temperature rise multiplier
 0.000000  $ DTEMP  = temperature rise multiplier increment
     20   $ Number of load steps
 0.000000  $ OMEGA  = angular vel. about axis of revolution (rad/sec)
 0.000000  $ DOMEGA = angular velocity increment (rad/sec)
    H      $ CONSTRAINT CONDITIONS FOLLOW....
--------------------------------------------------------------------
```

Apparently for this particular problem (externally pressurized ellipsoidal shell with uniform thickness), there exist nonlinear solutions above the pressure at which the externally pressurized ellipsoidal shell initially collapses axisymmetrically, that is, an external pressure of about 425 psi. The BIGBOSOR4 solution with a large initial pressure (P = 350 psi) and small pressure increment (DP = 5 psi) indicates that noticeable nonlinear behavior initiates at an external pressure of about 370 psi, with axisymmetric collapse occurring at about 425 psi (second curve in Fig. 1).

With the use of large load increments (DP = 46 psi) the nonlinear solution sails right by the initial nonlinear behavior at about 370 psi and the axisymmetric collapse pressure at about 425 psi. This BIGBOSOR4 run yields collapse at an external pressure slightly under 600 psi. Hence, nonlinear solutions exist above the collapse pressure and BIGBOSOR4 converges to them. These solutions are mathematically possible but do not make physical sense: An actual shell will start to exhibit significant nonlinear behavior at a pressure of about 370 psi and will collapse axisymmetrically at a pressure of about 425 psi, not at a pressure of about 600 psi.

The third and fourth curves in Fig. 1 are obtained from BOSOR5 runs. The fifth curve in Fig. 1 is obtained from a STAGS model of the ellipsoidal shell. STAGS indicates collapse at a significantly lower external presssure than BIGBOSOR4 or BOSOR5 because there is a certain amount of finite element "lock-up" in the BOSOR programs in shell segments for which the meridional curvature, 1/R1, varies within a shell segment. It is always best to model an ellipsoidal shell as an "equivalent" ellipsoidal shell, as described in the file ../bigbosor4/doc/bosor.caution.pdf.

The purpose of this message is to urge the BIGBOSOR4 user (as well as the BOSOR5 user) to verify nonlinear axisymmetric solutions (solutions obtained with INDIC = 0) by running at least one case with a reasonably large initial pressure, P, and a very small pressure increment, DP, just to make sure that there isn't an "early" collapse load "hiding" below that indicated in a more approximate previous BIGBOSOR4 execution. Make sure that the "reasonably large initial pressure, P" is smaller than the smallest possible axisymmetric collapse pressure.

NOTE: You can get an inkling that an "early" axisymmetric collapse load may be bypassed by inspecting the *.OUT file. Start at the beginning of the *.OUT file. Search for the string, "NEWTON", repeatedly. If you notice that there are some loads at which significantly more NEWTON iterations are needed for convergence than others, suspect axisymmetric collapse at a nearby load. For example, here are BIGBOSOR4 results for a sequence of load steps in the same problem to which Fig. 1 pertains:

PRESSURE MULTIPLIER, P=   3.700000E+02, TEMPERATURE
MULTIPLIER,TEMP =   0.000000E+00
ANGULAR VELOCITY, OMEGA=   0.000000E+00

PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   0.
START FACTORING AND SOLVING
Factoring done for iteration   0; Load step, ISTEP= 13
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 0
ITERATION NO. 0 MAXIMUM DISPLACEMENT= 2.2181E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   1.
START FACTORING AND SOLVING
Factoring done for iteration   1; Load step, ISTEP= 13
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 1
ITERATION NO. 1 MAXIMUM DISPLACEMENT= 2.2161E-01
NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR
CONVERGENCE = ITER = 1

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PRESSURE MULTIPLIER, P=   3.800000E+02, TEMPERATURE
MULTIPLIER,TEMP =   0.000000E+00
ANGULAR VELOCITY, OMEGA=   0.000000E+00

PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   0.
START FACTORING AND SOLVING
Factoring done for iteration   0; Load step, ISTEP= 14
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 0
ITERATION NO. 0 MAXIMUM DISPLACEMENT= 2.2721E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   1.
START FACTORING AND SOLVING
Factoring done for iteration   1; Load step, ISTEP= 14
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 1
ITERATION NO. 1 MAXIMUM DISPLACEMENT= 2.2495E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   2.
START FACTORING AND SOLVING
Factoring done for iteration   2; Load step, ISTEP= 14
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 2
ITERATION NO. 2 MAXIMUM DISPLACEMENT= 2.2552E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   3.
START FACTORING AND SOLVING
Factoring done for iteration   3; Load step, ISTEP= 14
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 3
ITERATION NO. 3 MAXIMUM DISPLACEMENT= 2.2557E-01

NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR CONVERGENCE = ITER = 3

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PRESSURE MULTIPLIER, P= 3.900000E+02, TEMPERATURE MULTIPLIER,TEMP = 0.000000E+00
ANGULAR VELOCITY, OMEGA= 0.000000E+00

PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 0.
START FACTORING AND SOLVING
Factoring done for iteration 0; Load step, ISTEP= 15
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 0
ITERATION NO. 0 MAXIMUM DISPLACEMENT= 2.2820E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 1.
START FACTORING AND SOLVING
Factoring done for iteration 1; Load step, ISTEP= 15
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 1
ITERATION NO. 1 MAXIMUM DISPLACEMENT= 2.2802E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 2.
START FACTORING AND SOLVING
Factoring done for iteration 2; Load step, ISTEP= 15
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 2
ITERATION NO. 2 MAXIMUM DISPLACEMENT= 2.2793E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 3.
START FACTORING AND SOLVING
Factoring done for iteration 3; Load step, ISTEP= 15
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 3
ITERATION NO. 3 MAXIMUM DISPLACEMENT= 2.2793E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 4.
START FACTORING AND SOLVING
Factoring done for iteration 4; Load step, ISTEP= 15
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 4
ITERATION NO. 4 MAXIMUM DISPLACEMENT= 2.2793E-01
NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR CONVERGENCE = ITER = 4

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PRESSURE MULTIPLIER, P= 4.000000E+02, TEMPERATURE MULTIPLIER,TEMP = 0.000000E+00
ANGULAR VELOCITY, OMEGA= 0.000000E+00

PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 0.

START FACTORING AND SOLVING
Factoring done for iteration 0; Load step, ISTEP= 16
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 0
ITERATION NO. 0 MAXIMUM DISPLACEMENT= 2.3604E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 1.
START FACTORING AND SOLVING
Factoring done for iteration 1; Load step, ISTEP= 16
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 1
ITERATION NO. 1 MAXIMUM DISPLACEMENT= 2.3666E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 2.
START FACTORING AND SOLVING
Factoring done for iteration 2; Load step, ISTEP= 16
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 2
ITERATION NO. 2 MAXIMUM DISPLACEMENT= 2.3667E-01
NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR
CONVERGENCE = ITER = 2

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PRESSURE MULTIPLIER, P= 4.100000E+02, TEMPERATURE
MULTIPLIER,TEMP = 0.000000E+00
ANGULAR VELOCITY, OMEGA= 0.000000E+00

PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 0.
START FACTORING AND SOLVING
Factoring done for iteration 0; Load step, ISTEP= 17
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 0
ITERATION NO. 0 MAXIMUM DISPLACEMENT= 2.4777E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 1.
START FACTORING AND SOLVING
Factoring done for iteration 1; Load step, ISTEP= 17
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 1
ITERATION NO. 1 MAXIMUM DISPLACEMENT= 2.4905E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 2.
START FACTORING AND SOLVING
Factoring done for iteration 2; Load step, ISTEP= 17
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 2
ITERATION NO. 2 MAXIMUM DISPLACEMENT= 2.4909E-01
NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR
CONVERGENCE = ITER = 2

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PRESSURE MULTIPLIER, P= 4.200000E+02, TEMPERATURE

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MULTIPLIER,TEMP =   0.000000E+00
 ANGULAR VELOCITY, OMEGA=   0.000000E+00

 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   0.
START FACTORING AND SOLVING
 Factoring done for iteration   0; Load step, ISTEP=  18
 FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  0
 ITERATION NO.  0 MAXIMUM DISPLACEMENT=  2.6404E-01
 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   1.
START FACTORING AND SOLVING
 Factoring done for iteration   1; Load step, ISTEP=  18
 FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  1
 ITERATION NO.  1 MAXIMUM DISPLACEMENT=  2.6821E-01
 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   2.
START FACTORING AND SOLVING
 Factoring done for iteration   2; Load step, ISTEP=  18
 FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  2
 ITERATION NO.  2 MAXIMUM DISPLACEMENT=  2.6890E-01
 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   3.
START FACTORING AND SOLVING
 Factoring done for iteration   3; Load step, ISTEP=  18
 FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  3
 ITERATION NO.  3 MAXIMUM DISPLACEMENT=  2.6892E-01
  NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR
CONVERGENCE = ITER =  3

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 PRESSURE MULTIPLIER, P=   4.300000E+02, TEMPERATURE
MULTIPLIER,TEMP =   0.000000E+00
 ANGULAR VELOCITY, OMEGA=   0.000000E+00

 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   0.
START FACTORING AND SOLVING
 Factoring done for iteration   0; Load step, ISTEP=  19
 FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  0
 ITERATION NO.  0 MAXIMUM DISPLACEMENT=  2.9932E-01
 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   1.
START FACTORING AND SOLVING
 Factoring done for iteration   1; Load step, ISTEP=  19
 FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  1
 ITERATION NO.  1 MAXIMUM DISPLACEMENT=  2.4869E-01
 PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.   2.
START FACTORING AND SOLVING
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Factoring done for iteration 2; Load step, ISTEP= 19
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 2
ITERATION NO. 2 MAXIMUM DISPLACEMENT= 2.4641E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 3.
START FACTORING AND SOLVING
Factoring done for iteration 3; Load step, ISTEP= 19
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 3
ITERATION NO. 3 MAXIMUM DISPLACEMENT= 2.5934E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 4.
START FACTORING AND SOLVING
Factoring done for iteration 4; Load step, ISTEP= 19
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 4
ITERATION NO. 4 MAXIMUM DISPLACEMENT= 2.6209E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 5.
START FACTORING AND SOLVING
Factoring done for iteration 5; Load step, ISTEP= 19
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 5
ITERATION NO. 5 MAXIMUM DISPLACEMENT= 2.6220E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 6.
START FACTORING AND SOLVING
Factoring done for iteration 6; Load step, ISTEP= 19
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 6
ITERATION NO. 6 MAXIMUM DISPLACEMENT= 2.6220E-01
NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR CONVERGENCE = ITER = 6

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PRESSURE MULTIPLIER, P= 4.400000E+02, TEMPERATURE MULTIPLIER,TEMP = 0.000000E+00
ANGULAR VELOCITY, OMEGA= 0.000000E+00

PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 0.
START FACTORING AND SOLVING
Factoring done for iteration 0; Load step, ISTEP= 20
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 0
ITERATION NO. 0 MAXIMUM DISPLACEMENT= 2.6882E-01
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO. 1.
START FACTORING AND SOLVING
Factoring done for iteration 1; Load step, ISTEP= 20
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO. 1
ITERATION NO. 1 MAXIMUM DISPLACEMENT= 2.6885E-01
NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR CONVERGENCE = ITER = 1

More NEWTON iterations are required at P = 380 psi (3 iterations) and at 390 psi (4 iterations) than at 400 psi (2 iterations). This sequence indicates that there may well be a collapse, or at least some nonlinear behavior leading to collapse, that occurs starting just before P = 370 or 380 psi. Smaller pressure steps than DP=10 psi should by used in this particular case in order to pin down axisymmetric collapse with accuracy.

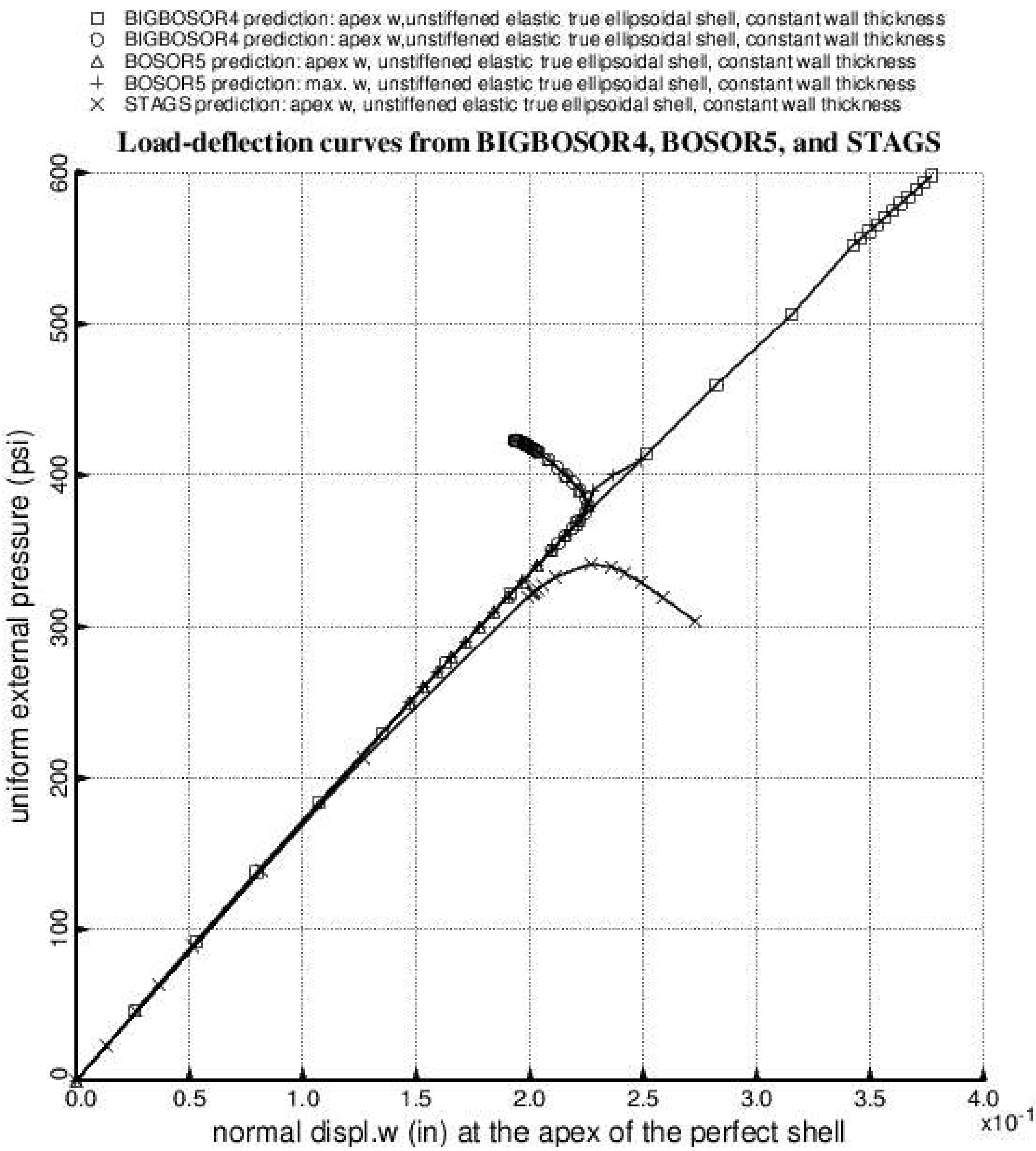

FIG. 1 Nonlinear results from BIGBOSOR4, BOSOR5 and STAGS for externally pressurized ellipsoidal shell with unitorm thickness.