Final Report

Composite Cylinder Stress Analysis Software Development and Validation

Project Title: Composite Cylinder Stress Analysis Software Development and Validation

Project Period: 30 September 2018 – 29 September 2020

Date of Report: 19 September 2020

Contract Number: 693JK318C000008
Contractor: Newhouse Technology, LLC
Norman L. Newhouse, Ph.D., P.E.
Cell: 402-432-8700
6521 Perry Circle, Lincoln, NE 68516
newhousetech@windstream.net

Contract Specialist: Mr. Ben Patterson; Ben.Patterson@dot.gov
Contracting Officer's Representative: Ms. Andrea Smith; andrea.smith@dot.gov

Index

1. Introduction

The development of NewCAP (Newhouse Cylinder Analysis Program) is based on a need for a composite cylinder analysis tool that is accurate, simple to use, and readily available to the cylinder industry. The industry places an emphasis on testing when qualifying a cylinder for use, but also relies on analysis to some extent.

Early analysis used relatively simple analysis methods, but flexibility and detail were limited. The availability of finite element analysis (FEA) offered a more powerful alternative, but early software still had limitations. Modern FEA software is very powerful, but requires more sophistication to achieve the best results.

FEA is often used more for design and optimization of a cylinder than for qualification. Given the sophistication needed for accurate results, and the variety of FEA software programs available, it is not always run to its full capabilities, and checking the results in a review of the design is problematic. Qualification still relies, appropriately, on results of testing.

However, one aspect of composite cylinder qualification is safety for the full life of the cylinder if it remains pressurized. A phenomenon generally known as stress rupture could occur if the fiber is stressed continuously to too high a level [1]. This is addressed by industry requirements to meet a “stress ratio”. The stress ratio is defined as the fiber stress at minimum burst pressure divided by the fiber stress at working pressure.

Meeting the stress ratio requirements meets a performance requirement of reliability related to stress rupture. The stress ratios are chosen to give 0.999999^+ reliability if held at working pressure for the cylinder lifetime.

Calculation of stress ratios in Type 4 cylinders with non-loadsharing liners is relatively straightforward, as stress is directly related to applied load, i.e. pressure. Calculation of stress ratios for Type 3 cylinders with loadsharing liners is more difficult. The load share of the liner varies once the liner is yielded. Yielding occurs as a Type 3 cylinder approaches autofrettage pressure. When pressure is returned to zero, the liner will be in compression.

The cyclic fatigue life of a Type 3 cylinder is improved when the liner has a lower average stress level, which is a result of the autofrettage. However, the average composite stress level is increased by autofrettage. The stress ratio requirements may be violated if the liner is thick and the autofrettage pressure is high [2].

The burst pressure will not be affected by autofrettage level, so a burst test will not be able to differentiate a properly designed and manufactured cylinder from one that has an excessive autofrettage pressure. There is anecdotal evidence that composite cylinders have been placed in service that have thick liners, and high autofrettage pressure, such that stress ratios were violated. There is other anecdotal evidence that cylinders have been placed in service that have not been analyzed with finite element analysis to accurately determine the stress ratios.

The possibility that composite cylinders are in service that violate the stress ratio requirements, and therefore higher risk of rupturing during service, is a significant safety concern. The development of NewCAP provides a composite cylinder analysis tool that is accurate, simple to use, and readily available to the cylinder industry. It will be easy for PHMSA to review or duplicate the analysis that is provided with a Special Permit application. This will improve the safety of industry cylinders used in transportation of hazardous materials.

2. Theory of analysis.

The foundation of the NewCAP computer software is based on a force balance of a differential element. With the differential element in equilibrium:

$$\frac{d\sigma}{dr} + \frac{(\sigma_r - \sigma_h)}{r} = -\rho\,\omega^2\,r \qquad (1).$$

The governing equation is developed from this equilibrium equation, the constitutive equations:

$$\{\sigma\} = [D]\,\{\varepsilon - \alpha'\} \qquad (2)$$

and from the strain/displacement relations:

$$\varepsilon_r = {du}/{dr} \quad (3)$$

$$\varepsilon_h = {u}/{r} \qquad (4)$$

$$\alpha' = \alpha\,(T_s + T_k\,r). \quad (5)$$

An exact solution to the governing equation is obtained in terms of the deflection of the layer boundaries. A unit displacement method is used to build element stiffness matrices and unit force matrices for each layer using the exact solution. These matrices are built into global stiffness and force matrices which are solved for the actual displacement of the layer boundaries.

From the layer boundary displacements, the stresses and strains within each layer may be calculated. The NewCAP computer program was based on this solution technique. Further details are provided in Annex A [3]. The analysis uses linear geometry, i.e. it does not update dimensions due to deflection, in the analysis.

The composite material properties are developed from the theory of Chamis [4]. The unidirectional properties are calculated based on the fiber properties, resin properties, and the fiber volume fraction. The modulus of elasticity in the meridional, hoop, and radial directions are calculated from the unidirectional properties and the given wind angle.

The composite coefficients of thermal expansion are developed from the theory of Ran Zhiguo et al [5]. Unidirectional properties are based on fiber and resin properties. The coefficients of thermal expansion in the meridional, hoop, and radial directions are calculated from the unidirectional properties and the given wind angle.

The analysis may be run with a yielding metal liner. A von Mises (J_2) plasticity model was used. Equivalent stresses and strains may be calculated from the principal stresses and strains:

$$\sigma_{EQ} = \sqrt{\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}} \quad (6)$$

$$\varepsilon_{EQ} = \sqrt{\frac{(\varepsilon_1-\epsilon_2)^2+(\varepsilon_2-\varepsilon_3)^2+(\varepsilon_3-\varepsilon_1)^2}{2\,(1+\mu)}} \quad (7)$$

The stress-strain relationship may be modelled either by a multi-linear model or a Ramberg-Osgood model [6]:

$$\varepsilon = \frac{\sigma}{E}\left[1 + k\left(\frac{\sigma}{\sigma_0}\right)^{n-1}\right] \quad (8)$$

The linear properties of the liner material are used for the first pass through the solver at a given loading condition. If there is no liner yielding, the solver proceeds to the next loading condition. If yielding is detected, the liner material properties are updated, and a second pass is made through the solver. Additional passes are made if further yielding is detected until the solution converges. The calculated stresses and strains are printed out when the solution converges, and the solver proceeds to the next loading condition.

Metal lined composite cylinders are generally pressurized to an autofrettage pressure, then returned to zero pressure, before entering service. NewCAP tracks the liner material properties through this process. The software accounts for the tensile stress state at autofrettage pressure as it returns to zero pressure, with linear response as the stress returns to a point of zero equivalent stress, and from that point, uses the original stress-strain relationship to zero pressure.

Liner yielding may or may not occur during this pressure decrease, and it is handled the same way as described above. The software then accounts for the compressive stress state at zero pressure after autofrettage as pressure is reapplied, with linear response as the stress returns to a point of zero equivalent stress, and from that point, uses the original stress-strain relationship.

3. Software capabilities and operation.

The NewCAP software can be used to analyze all-composite (Type 4) cylinders and metal-lined cylinders (Type 3 and Type 2). It can also be used to analyze all-metal (Type 1) cylinders. The software addresses non-linear material properties and linear geometry in the analysis. The software only analyzes the cylinder section, not the domes.

The analysis allows the use of up to 40 materials, 90 layers, and 30 load steps. Loads may be from internal pressure, external pressure, and/or temperature profiles. Stresses and strains are calculated at the inner and outer surfaces of each layer, and up to 9 points within each layer.

Each yielding material may only be tied to one layer. If the liner is divided into more than one layer, then each must have a unique material tied to it, i.e. 5 layers would require 5 materials with the liner properties, one material for each layer.

An Excel spreadsheet has been developed that may be used to generate the input file for NewCAP. Setup information is entered into the first worksheet. When the setup information is entered, Excel generates additional worksheets that identify the remaining data inputs required. When data entry is complete, Excel generates the necessary input file and runs NewCAP. Excel retrieves program output and makes it available for plotting. The input file may also be generated manually.

4. Software inputs and outputs.

The first inputs to the NewCAP computer program are a description of the analysis being conducted, the inner radius, number of layers, number of material types, number of load steps, points for stress/strain calculation within a layer, a control number that may be used to echo the input lines as they are entered, and a print control number.

Material properties, including modulus of elasticity, Poisson's ratio, and thermal coefficients are entered for each material. The material and thickness are identified for each layer. Loads, including internal pressure, external pressure, and a temperature profile are identified for each load step. A listing of the required input parameters, along with a description of the variables, is provided in Annex B. Annex B also contains an input sheet that may be filled in as a worksheet when entering the input data directly into the input file.

A guide to running the program using the Excel spreadsheet is provided as Annex C.

The NewCAP outputs are displayed on the monitor and are printed to a file (NC-OUTPUT.txt) which may be saved or sent to a printer. The Excel spreadsheet may access a separate file (NC-EXOUT.txt) so that the output may be viewed or plotted within the Excel spreadsheet.

The output files include an echo of the input, including the description of the analysis, the setup information (inner radius, number of layers, number of material types, number of load steps, number of internal points in each layer for calculating results, and printout options), material property information, layer information (material type number and thickness), and loading conditions (internal pressure, external pressure, and nodal temperatures) for each load step.

The analysis results are then printed. Each load step is identified by the load step description. For the inner surface of each layer, starting from the innermost layer, each layer number and material number are identified, followed by the radius, strain in the radial, hoop, and meridional directions, the stress in the radial, hoop, and meridional directions, the radial displacement, and the total axial force on the layer. For points within the layer, and at the outer surface of the layer, the radius is given, followed by the strain in the radial, hoop, and meridional directions, the stress in the radial, hoop, and meridional directions, and the radial displacement.

The fiber strain and stress are computed for layers using material model 4 and material model 5. The fiber strain is calculated from the meridional and hoop strains, using a second order tensor transformation based on the fiber wind angle. The fiber stress is calculated from the fiber strain and the fiber modulus. The fiber strain and stress are printed in columns after the total axial force for the layers using material model 4 and material model 5.

Following the analysis results of each load step, the stress ratio at each step is printed. This stress ratio is based on the ratio of the strain on the inner surface of the first non-yielding layer (material models 1, 4, or 5) at the minimum burst pressure (step ID = 6) to the strain on the same surface at any given pressure.

5. Verification results.

NewCAP was verified by conducting closed form analysis and finite element analysis, and then comparing the results with NewCAP analysis.

The closed form analysis focused on comparison with known analytical solutions for metal cylinders, comparison with similar programs for analyzing composite cylinders, and examples showing consistency of results. Explanations of results are provided with each analysis. All verification analyses indicated that NewCAP is producing accurate results, and was therefore verified. The report on closed form analysis verification is included as Annex D.

The finite element analysis addressed the analysis of a Type 3 cylinder with a yielding liner with pressure loading, a Type 4 cylinder with pressure loading, and the same Type 4 cylinder with thermal loading. In all cases, the calculated NewCAP strains were less than 1 percent different than the FEA results, indicating that NewCAP is producing accurate results, and was therefore verified. The report on finite element analysis verification is included as Annex E.

6. Validation results.

NewCAP was validated by comparing analysis results with strain measurements from Type 3 and Type 4 cylinders that were subjected to pressure loads. Two Type 3 cylinders with aluminum liners and three Type 4 cylinders with non-loadsharing liners were tested. The Type 3 cylinders include one with a 6.8-inch outer diameter and an operating pressure of 2745 psi, and one with a 7.5-inch outer diameter and an operating pressure of 10,000 psi. Both of these Type 3 cylinders were reinforced with carbon fiber. Two of the Type 4 cylinders were carbon fiber reinforced, one with a 9.9-inch outer diameter and an operating pressure of 3600 psi, and the other with a 27.7-inch outer diameter and an operating pressure of 10,000 psi. The third Type 4 cylinder was reinforced with a hybrid carbon/e-glass laminate, with a 13.7-inch outer diameter and an operating pressure of 3600 psi.

Multiple strain gages were used on each cylinder. There was good correlation between the predicted strains and the measured strains. It is recognized that some gages failed during testing. Looking at gage results where they remained functional, the ability of NewCAP to analyze Type 3 and Type 4 composite cylinders was validated. The report on validation of NewCAP is included as Annex F.

7. Trade studies.

Trade studies were conducted that show the effect of increasing aluminum liner thickness and autofrettage pressure when looking at carbon fiber and glass fiber reinforced composite cylinders. As discussed in the introduction, use of a thicker liner and higher autofrettage pressure puts the liner in a lower stress state, improving its cyclic fatigue performance, but correspondingly increases the stress in the fibers, which can be a risk for stress rupture.

In these trade studies, the baseline is an all-composite cylinder, with fiber thickness to meet the required burst pressure and associated stress ratio at working pressure. An aluminum liner is then introduced with discrete thicknesses, and the composite thickness reduced to maintain the same burst pressure as the all-composite cylinder.

The first trade study looked at a carbon fiber reinforced cylinder. The working pressure is 10,000 psi, with a burst pressure of 22,500 psi to result in a stress ratio of 2.25 for an all-composite cylinder. The inside radius is 5.0 inches. The composite thickness is 0.5247 inch. Liner thicknesses of 0.2, 0.4, 0.6, and 0.8 inches were used in the study. Figure 1 plots stress ratio vs. liner thickness and autofrettage pressure. Figure 2 gives details of liner thickness, fiber thickness, and stress ratios at different autofrettage pressures.

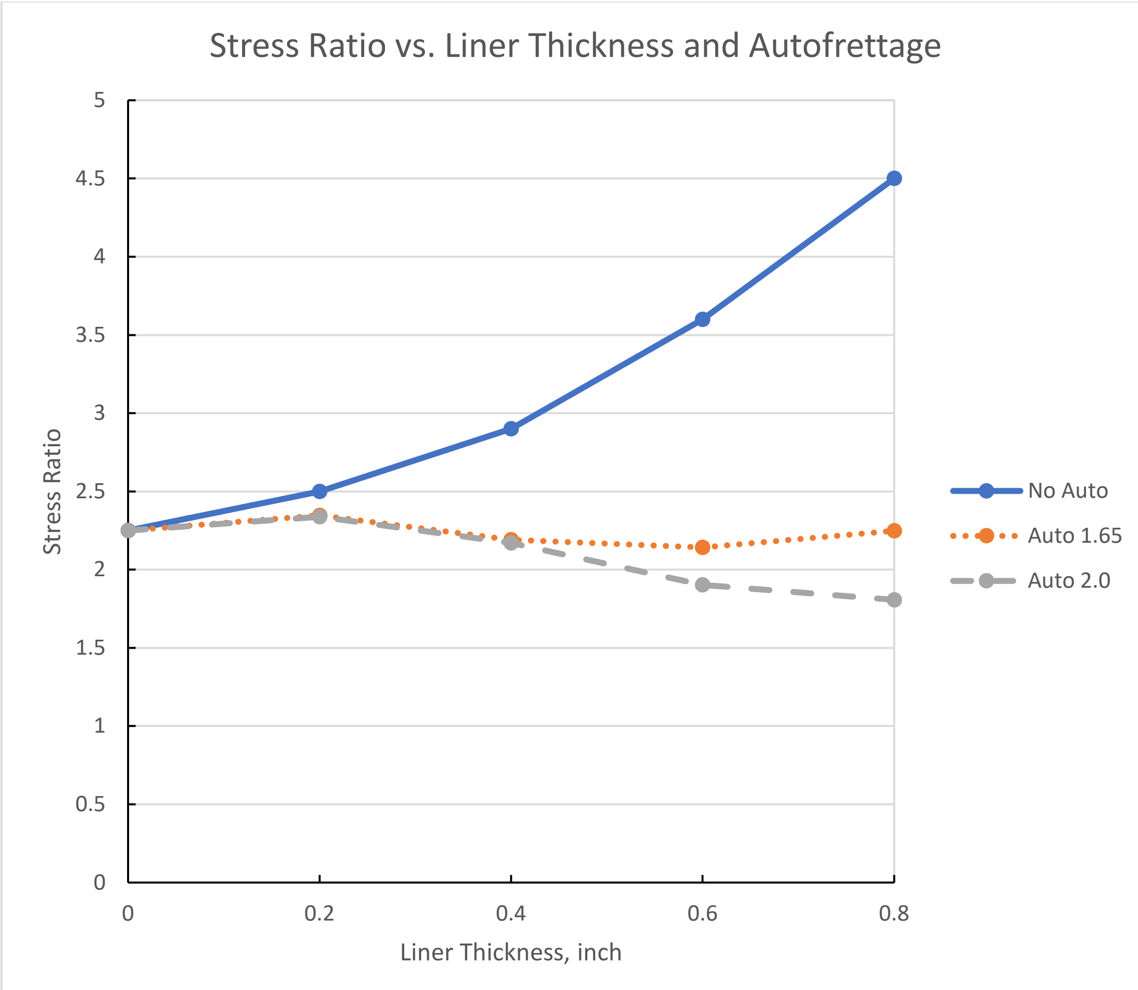


Figure 1 – Carbon stress ratio vs. liner thickness and autofrettage

Liner T:	0	0.2	0.4	0.6	0.8
Comp T:	0.5247	0.5081	0.4826	0.4767	0.4538
Auto Pressure:					
0.0 (pre-auto)	2.25	2.5	2.9	3.6	4.5
1.65	2.25	2.347	2.190	2.142	2.247
1.7	2.25	2.346	2.188	2.096	2.166
1.75	2.25	2.345	2.185	2.053	2.090
1.8	2.25	2.344	2.182	2.012	2.019
1.85	2.25	2.342	2.180	1.974	1.951
1.9	2.25	2.341	2.177	1.937	1.892
1.95	2.25	2.339	2.174	1.907	1.848
2	2.25	2.338	2.171	1.903	1.807

Figure 2 – Carbon design, pressure, and stress ratio details

Referring to Figure 1, note that the starting point for stress ratio is 2.25 when there is no liner. As liner thickness is increased, and there is no autofrettage, Figure 1 shows the extent to which the liner would share load with the composite.

At an autofrettage pressure 1.65 times the working pressure, which is typical for Type 3 cylinders, the stress ratio increases slightly, then drops slightly, and then rises again, as liner thickness increases. When the autofrettage increases to 2.0 times the working pressure, the stress ratio increases slightly, then drops significantly as liner thickness increases.

Referring to Figure 2, note that the stress ratio decreases as autofrettage pressure increases at each liner thickness. It can also be seen that the total wall thickness stays relatively constant, with composite thickness decreasing at about the same rate as liner thickness increases.

The second trade study looked at a glass fiber reinforced cylinder. The working pressure is 10,000 psi, with a burst pressure of 35,000 psi to result in a stress ratio of 3.50 for an all-composite cylinder. The composite thickness is 2.2367 inch. The thickness of the glass fiber reinforcement is significantly higher than the carbon fiber reinforcement due to differences in fiber strength and stress ratios. Liner thicknesses of 0.2, 0.4, 0.6, and 0.8 inches were used in the study. Figure 3 plots stress ratio vs. liner thickness and autofrettage pressure. Figure 4 gives details of liner thickness, fiber thickness, and stress ratios at different autofrettage pressures.

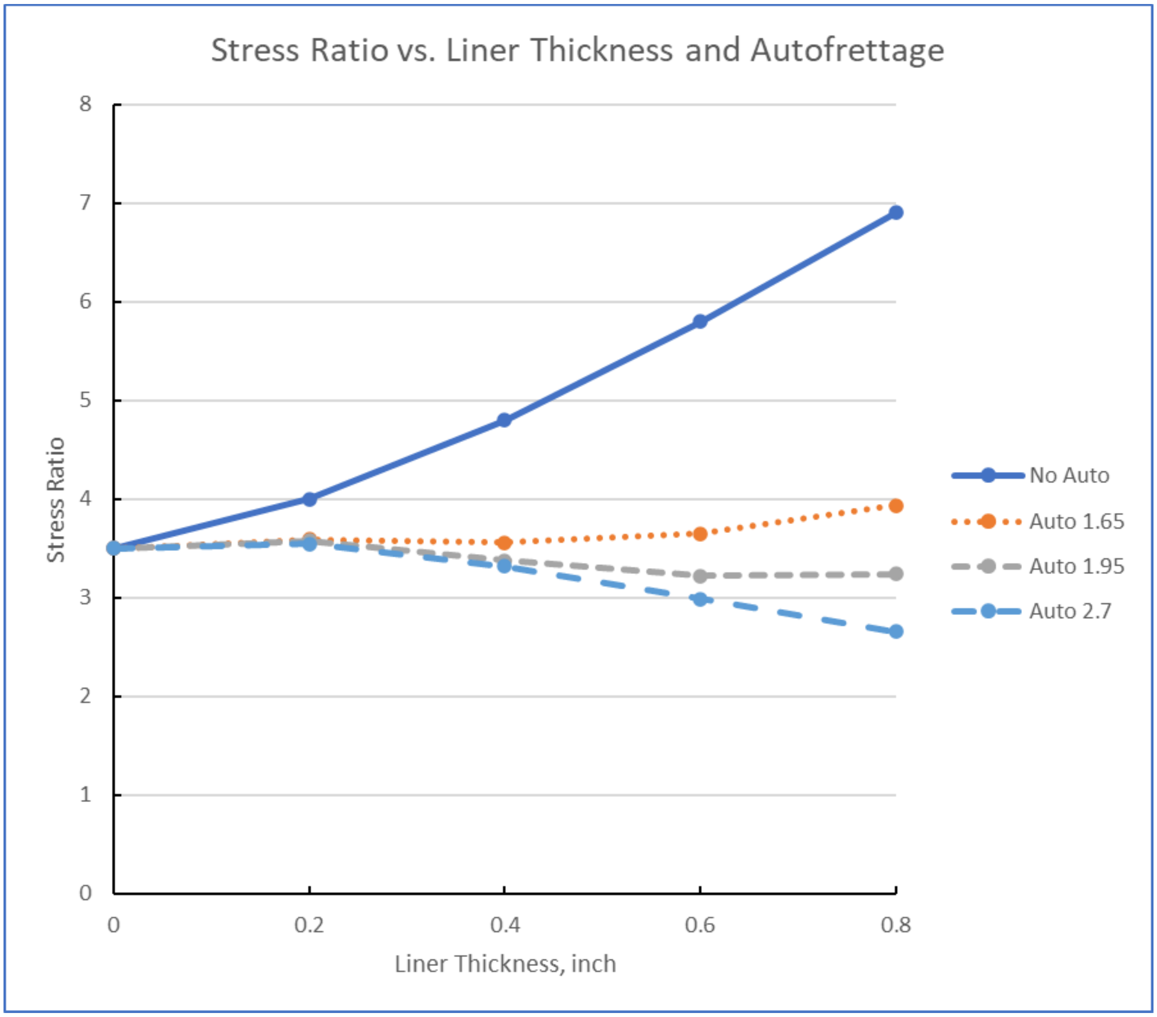


Figure 3 – Glass stress ratio vs. liner thickness and autofrettage

Liner T:	0	0.2	0.4	0.6	0.8
Comp T:	2.2367	2.1127	2.0207	1.9457	1.8827
Auto Pressure:					
0.0 (pre-auto)	3.5	4	4.8	5.8	6.9
1.65	3.5	3.591	3.557	3.652	3.938
1.8	3.5	3.585	3.426	3.401	3.554
1.95	3.5	3.579	3.378	3.221	3.244
2.1	3.5	3.573	3.367	3.086	3.011
2.25	3.5	3.567	3.356	3.035	2.848
2.4	3.5	3.561	3.344	3.020	2.718
2.55	3.5	3.548	3.333	3.006	2.671
2.7	3.5	3.548	3.321	2.991	2.655

Figure 4 – Glass design, pressure, and stress ratio details

Referring to Figure 3, note that the starting point for stress ratio is 3.50 when there is no liner. As liner thickness is increased, and there is no autofrettage, Figure 3 shows the extent to which the liner would share load with the composite.

At an autofrettage pressure 1.65 times the working pressure, which is typical for Type 3 cylinders, the stress ratio increases above 3.50 as liner thickness increases. When the autofrettage pressure increases to 1.95 time the working pressure, the stress ratio increases slightly, then decreases as liner thickness increases.

When the autofrettage increases to 2.7 times the working pressure, the stress ratio increases slightly, then drops significantly as liner thickness increases. At the stress ratios seen for glass fiber at the high thickness, high autofrettage condition, failure is likely to occur in less than 10 years.

Referring to Figure 4, note that the stress ratio decreases as autofrettage pressure increases at each liner thickness. It can also be seen that the total wall thickness increases as liner thickness increases, with composite thickness decreasing at about the half the rate of liner thickness increase.

One overall observation of these trade studies is that if the autofrettage pressure is limited to 1.65 times the working pressure, the stress ratio will not go significantly lower than the prescribed value, even as the liner gets significantly thick.

A second overall observation of these trade studies is that if the liner is relatively thin, the stress ratio will not go significantly lower than the prescribed value, even as the autofrettage pressure increases significantly.

An observation of greatest concern is that if the liner is thick, and the autofrettage pressure is relatively high, the stress ratios may be significantly lower than their prescribed values, putting the cylinders at significant risk of failure due to stress rupture.

8. Recommendations for “round robin” studies.

NewCAP analysis has been verified and validated. The next step to gain acceptance for use by the industry is to conduct a “round robin” type of evaluation. Manufacturers that have submitted Special Permit requests that involved finite element analysis and/or testing with strain gages could be asked to repeat the analysis using NewCAP and return the results of NewCAP and prior analysis and/or testing to PHMSA for comparison.

The manufacturers could also be asked to conduct another analysis that used the capabilities of NewCAP, and to suggest any improvements to NewCAP based on this analysis. The analyses from the manufacturers would be shared within the industry for comment. The intent of this analysis would be to familiarize the industry with the capabilities of NewCAP, and to address possible improvements that would add value to NewCAP and its acceptance by the industry.

Newhouse Technology LLC will also make NewCAP available to Engineers outside of the commercial cylinder industry, and solicit their input as to improvements that could be made.

Manufacturers could also be asked to submit their recommendations for standard fiber and resin materials, and the values they would use for these materials. These recommendations would be reviewed, and included as standard materials if there is consensus/consistency for material properties.

9. Summary and recommendations.

The need for a composite cylinder analysis tool that is accurate, easy to use, and readily available to the cylinder industry was identified. NewCAP was developed to fill this need.

The foundation for NewCAP was developed from closed form equations for each layer. A unit displacement method was used to build element stiffness matrices and unit force matrices which are solved for layer boundary displacement. Stresses and strains are calculated from the boundary displacements.

Yielding metal material models were incorporated to represent the liner, and were incorporated into the foundation program. An iterative approach is used to address yielding and achieve convergence of the solution.

NewCAP is primarily for analysis of Type 4 and Type 3 cylinders, but may also be used for analysis of Type 2 and Type 1 cylinders. Cylinders may be constructed with multiple layers and made of multiple materials. Loading may be by internal pressure, external pressure, and/or temperature profiles. Stresses, strains, and displacements are calculated.

The analysis results of NewCAP were verified by closed form and finite element analysis, and validated by comparison with test results on several cylinders. Trade studies were presented that show capabilities of NewCAP and its value in evaluation cylinders. Conditions were identified, specifically use of thick metal liners and high autofrettage pressures, that would put composite cylinders at risk of failure by stress rupture.

It is recommended that NewCAP be used by PHMSA and the cylinder industry to analyze cylinders for which Special Permit or Approval requests are made. Manufacturers should also be encouraged to run NewCAP to become familiar with its capabilities, to share observations, and make recommendations for improvement. Manufacturers will also be encouraged to suggest standard materials that would be used within NewCAP.

Newhouse Technology LLC will provide support to PHMSA for one year after submission of this report, and will incorporate improvements as appropriate. Use of NewCAP for composite cylinder analysis will improve safety within the cylinder transportation industry by providing an accurate assessment of cylinder stresses.

Bibliography

[1] ISO/TR 13086-1 Gas cylinders – Guidance for design of composite cylinders – Part 1: Stress rupture of fibres and burst ratios related to test pressure, 2011.

[2] ISO/TR 13086-3 Gas cylinders – Guidance for design of composite cylinders – Part 3: Calculation of stress ratios, 2018.

[3] Newhouse, Norman L, "Mechanical and Transient Hygrothermal Loading of Multilayer Orthotropic Cylinders, Ph.D Dissertation, University of Nebraska, Lincoln, Nebraska, January 1984.

[4] Chamis, Christos C., "Computer Code for the Analysis of Multilayered Fiber Composites – Users Manual", NASA TN D-7013, Lewis Research Center, Cleveland, Ohio, March 1971.

[5] Ran Zhiguo, Yan Ying, Li Jianfeng, Qi Zhongxing, Yang Lei, "Determination of thermal expansion coefficients for unidirectional fiber-reinforced composites", Chinese Journal of Aeronautics, March 2014.

[6] Ramberg, Walter, and Osgood, William R., "Description of stress-strain curves by three parameters", NACA TN 902, July 1943.

Annex A. Stress, strain, deflection theory

MECHANICAL AND TRANSIENT HYGROTHERMAL LOADING OF MULTILAYER ORTHOTROPIC CYLINDERS

by

Norman L. Newhouse

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Major: Interdepartmental Area of Engineering

(Mechanics and Energetics)

Under the Supervision of Professor Ralph F. Foral

Lincoln, Nebraska

January, 1984

CHAPTER IV

STRESS, STRAIN, AND DEFLECTION

Nomenclature

Variables

A - surface area
$A^\circ, B^\circ, C^\circ, D^\circ, E^\circ, F^\circ$ - coefficients of r in the homogeneous and particular solutions
a - outer radius of a layer
b - inner radius of a layer
D - elastic stiffness term in constitutive matrix
E - elastic modulus
$\underline{F}$ - force
$\overline{F}, G, H$ - functions of r
g_c - gravitational constant
k - stiffness matrix term
ℓ - number of layers in a cylinder
M - moisture content
n - orthotropy ratio, Equation (17)
P - pressure
r - radius
RE - rotational energy
T - temperature difference
u - radial displacement
V - volume
Z - coefficient in the displacement equation

α - thermal expansion coefficient
β - moisture expansion coefficient
ε - strain
θ - angle
ν - Poisson's ratio
ρ - mass density
σ - stress
ω - rotational velocity

Subscripts

h - hoop direction; homogeneous, Equation (17)
i - relating to the inner surface of a layer
k - relating to a slope of a temperature or moisture profile
m - meridional direction
o - relating to the outer surface of a layer
p - particular, Equation (17)
r - radial direction
s - relating to a constant term of a temperature or moisture profile

Approach

The development and implementation of the stress-strain model is described in this chapter. The governing equation is developed from the constitutive and equilibrium equations and from the strain/displacement relations. An exact solution to the governing equation is obtained in terms of the deflection of the layer boundaries. A unit displacement method is used to build element stiffness matrices and unit force matrices for each layer using this exact solution. These matrices are built into global stiffness and force matrices which are solved for the actual displacement of the layer boundaries. From the layer boundary displacements, the stresses and strains within each layer may be calculated. A computer program has been written based on this solution technique. The accuracy and validity of this approach is demonstrated by comparison with classical solutions.

Development of Theory

The stress/strain model is based on a force balance on a differential element, Figure 6. With the differential element in equilibrium:

$$d\sigma_r/dr + (\sigma_r - \sigma_h)/r = -\rho\ \omega^2\ r \tag{12}$$

The constitutive equations for orthotropic materials under plane strain conditions are as follows. The strains due to thermal and moisture expansion, as shown in Equation (13a), are strains at a point. Equation (13c) defines the point values of the thermal and moisture expansion. The temperature difference is expressed in terms of a linear profile having a constant slope and intercept. To proceed with the numerical analysis, it is necessary to assume a particular profile for the temperature. Each layer within the cylinder will have its own values for slope and intercept. The assumption of a linear profile is based on the fact that for filament wound structures, the layers are generally thin to the extent that there would be little if any difference between a linear profile and any other profile within the layer.

$$\begin{Bmatrix} \sigma_r \\ \sigma_h \\ \sigma_m \end{Bmatrix} = \begin{bmatrix} D_{rr} & D_{rh} & D_{rm} \\ D_{hr} & D_{hh} & D_{hm} \\ D_{mr} & D_{mh} & D_{mm} \end{bmatrix} \begin{Bmatrix} \varepsilon_r - \alpha_r' - \beta_r' \\ \varepsilon_h - \alpha_h' - \beta_h' \\ \varepsilon_m - \alpha_m' - \beta_m' \end{Bmatrix} \tag{13a}$$

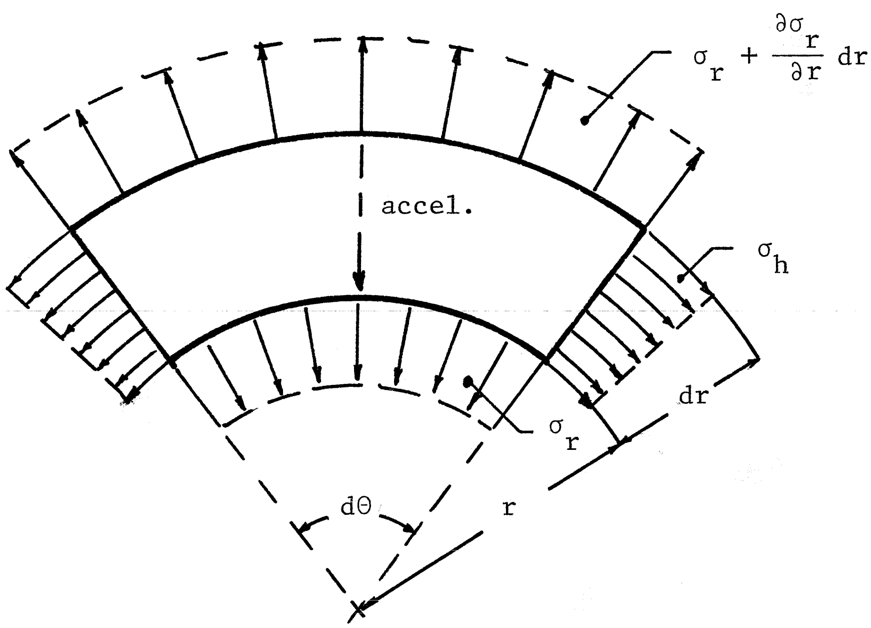


Figure 6

Differential Element for Stress/Strain

Where,

$$
\begin{aligned}
D_{rr} &= E_r\ (1 - \nu_{hm}\ \nu_{mh})/DEN \\
D_{rh} &= E_r\ (\nu_{hr} + \nu_{mr}\ \nu_{hm})/DEN \\
D_{rm} &= E_r\ (\nu_{mr} + \nu_{hr}\ \nu_{mh})/DEN \\
D_{hr} &= E_h\ (\nu_{rh} + \nu_{mh}\ \nu_{rm})/DEN = D_{rh} \\
D_{hh} &= E_h\ (1 - \nu_{rm}\ \nu_{mr})/DEN \\
D_{hm} &= E_h\ (\nu_{mh} + \nu_{rh}\ \nu_{mr})/DEN \\
D_{mr} &= E_m\ (\nu_{rm} + \nu_{rh}\ \nu_{hm})/DEN = D_{rm} \\
D_{mh} &= E_m\ (\nu_{hm} + \nu_{hr}\ \nu_{rm})/DEN = D_{hm} \\
D_{mm} &= E_m\ (1 - \nu_{rh}\ \nu_{hr})/DEN \\
DEN &= 1 - \nu_{rh}\ \nu_{hr} - \nu_{hm}\ \nu_{mh} - \nu_{mr}\ \nu_{rm} - 2\nu_{hr}\ \nu_{mh}\ \nu_{rm}
\end{aligned}
\qquad (13b)
$$

$$
\begin{aligned}
\alpha_r' &= \alpha_r\ (T_s + T_k r) \\
\alpha_h' &= \alpha_h\ (T_s + T_k r) \\
\alpha_m' &= \alpha_m\ (T_s + T_k r) \\
\beta_r' &= \beta_r\ (M_s + M_k r) \\
\beta_h' &= \beta_h\ (M_s + M_k r) \\
\beta_m' &= \beta_m\ (M_s + M_k r)
\end{aligned}
\qquad (13c)
$$

The strain/displacement relations are:

$$\varepsilon_r = du/dr \qquad (14a)$$

$$\varepsilon_h = u/r \qquad (14b)$$

We can now substitute the strain/displacement Equations (14) into the constitutive Equations (13), and this then substituted into the equilibrium equation. The resulting equation will be evaluated to find stresses and strains:

$$
\begin{aligned}
&d^2u/dr^2 + (1/r)(du/dr) - (D_{hh}/D_{rr})(u/r^2) \\
&\quad = -\rho\ \omega^2\ r/D_{rr} + \alpha_r T_k + \alpha_r(T_s/r + T_k) \\
&\quad + (D_{rh}/D_{rr})[\alpha_h T_k + (\alpha_h - \alpha_r)(T_s/r + T_k)] \\
&\quad - (D_{hh}/D_{rr})\alpha_h(T_s/r + T_k) + \beta_r M_k \\
&\quad + \beta_r(M_s/r + M_k) + (D_{rh}/D_{rr})[\beta_h M_k + (\beta_h - \beta_r)(M_s/r + M_k)] \qquad (15) \\
&\quad - (D_{hh}/D_{rr})\beta_h(M_s/r + M_k) \\
&\quad + (D_{hm}/D_{rr} - D_{rm}/D_{rr})\ [\varepsilon_m/r - \alpha_m(T_s/r + T_k) - \beta_m(M_s/r + M_k)] \\
&\quad + (D_{rm}/D_{rr})\alpha_m T_k + \beta_m M_k
\end{aligned}
$$

Where the boundary conditions are either:

$$\sum_{j=1}^{\ell} (\sigma_m)_j\ (A_m)_j = \text{(Applied Axial Force)} \qquad (16a)$$

or,

$$\varepsilon_m = \text{(A Predetermined Constant)} \qquad (16b)$$

and,

$$(\sigma_{ri})_1 = \text{(Applied Internal Pressure)} \qquad (16c)$$

$$(\sigma_{ro})_\ell = \text{(Applied External Pressure)} \qquad (16d)$$

Solution of Equation

The solution of Equation (15) is made up of a homogeneous solution and a particular solution:

$$
\begin{aligned}
&u = u_h + u_p \\
&u_h = A^\circ r^n + B^\circ r^{-n}, \text{ where } n = \sqrt{D_{hh}/D_{rr}} \qquad (17) \\
&u_p = C^\circ r^3 + D^\circ r^2 + E^\circ r + F^\circ
\end{aligned}
$$

The constants, C°, D°, E°, and F° can be resolved directly by substitution into Equation (15) and equating like terms. The constant C° relates to the rotational loading, the constant D° relates to the slope term for temperature and moisture, and the constant E° relates to the constant term for temperature and moisture and to the axial strain.

$$C^\circ = \rho\,\omega^2/[D_{rr}(n^2-9)] \tag{18a}$$

$$\begin{aligned} D^\circ = \{&[2\alpha_r + (D_{rh}/D_{rr})(2\alpha_h-\alpha_r) - (D_{hh}/D_{rr})\alpha_h]T_k \\ &+ [2\beta_r + (D_{rh}/D_{rr})(2\beta_h-\beta_r) - (D_{hh}/D_{rr})\beta_h]M_k \\ &+ [(2D_{rm}/D_{rr}) - (D_{hm}/D_{rr})][\alpha_m T_k + \beta_m M_k]\}/(4-n^2) \end{aligned} \tag{18b}$$

$$\begin{aligned} E^\circ = \{&[\alpha_r + (D_{rh}/D_{rr})(\alpha_h-\alpha_r) - (D_{hh}/D_{rr})\alpha_h]T_s \\ &+ [\beta_r + (D_{rh}/D_{rr})(\beta_h-\beta_r) - (D_{hh}/D_{rr})\beta_h]M_s \\ &+ [(D_{hm}/D_{rr}) - (D_{rm}/D_{rr})][\varepsilon_m - \alpha_m T_s - \beta_m M_s]\}/(1-n^2) \end{aligned} \tag{18c}$$

$$F^\circ = 0 \tag{18d}$$

To solve for the constants A° and B°, it is necessary to define boundary conditions. Typically, the inner surface of the cylinder provides one of the boundary conditions, having either a fixed displacement or a given surface pressure. The outer surface usually provides the other boundary condition, generally a given surface pressure. While the boundary conditions of Equation (16) are sufficient for a single layer cylinder, additional boundary conditions are required to evaluate a multilayered cylinder. The boundary conditions for the individual layers must reflect the fact that numerical methods will be used to evaluate a multilayered cylinder. To this end, we will choose the boundary conditions for each layer to be the defined displacements of the inner and outer surfaces of that layer. With the surface displacements defined, we can now use Equation (17), written in terms of these boundary displacements.

The additional boundary conditions required to provide continuity between layers are:

$$(u_o)_j = (u_i)_{j+1} \tag{19a}$$

$$(\sigma_{ro})_j = (\sigma_{ri})_{j+1} \tag{19b}$$

$$(\varepsilon_m)_j = (\varepsilon_m)_{j+1} \tag{19c}$$

$$u_i = A^\circ b^n + B^\circ b^{-n} + C^\circ b^3 + D^\circ b^2 + E^\circ b \tag{20a}$$

$$u_o = A^\circ a^n + B^\circ a^{-n} + C^\circ a^3 + D^\circ a^2 + E^\circ a \tag{20b}$$

With two equations and two unknowns, we can now rearrange Equation (20) to solve for A° and B° in terms of the boundary displacements, the constants from the particular solution, and the radii.

$$A^\circ = [-(u_i a^{-n} - u_o b^{-n}) + C^\circ(b^3 a^{-n} - a^3 b^{-n}) + D^\circ(b^2 a^{-n} - a^2 b^{-n}) + E^\circ(ba^{-n} - ab^{-n})]/[a^n b^{-n} - a^{-n} b^n] \tag{21a}$$

$$B^\circ = [(u_i a^n - u_o b^n) - C^\circ(b^3 a^n - a^3 b^n) - D^\circ(b^2 a^n - a^2 b^n) - E^\circ(ba^n - ab^n)]/[a^n b^{-n} - a^{-n} b^n] \tag{21b}$$

With all constants now defined, we can rewrite Equation (17) to calculate radial deflection as a function of radius. We can, at the same time, calculate the radial and hoop strains, which can then be used to calculate stresses. Numerical singularities exist in the functions of r in the following equations. The function F, which is associated with the rotational inertia term, has a singularity when the orthotropy ratio n is equal to three. The function G, which is associated with the thermal and moisture gradient terms, has a singularity when the orthotropy ratio n is equal to two. The function H, which is associated with the thermal and moisture constant terms and with the axial strain, has a singularity when the orthotropy ratio n is equal to one (i.e. isotropic). Alternate equations are presented at these singular points.

$$u = Z_1\ b(r/b)^n + Z_2\ b(r/b)^{-n} + Z_3\ F(r) + Z_4\ G(r) + Z_5\ H(r) \tag{22}$$

$$\varepsilon_r = du/dr = nZ_1(r/b)^{n-1} - nZ_2(r/b)^{-n-1} + Z_3\ dF(r)/dr + Z_4\ dG(r)/dr + Z_5\ dH(r)/dr \tag{23}$$

$$\varepsilon_h = u/r = Z_1(r/b)^{n-1} + Z_2(r/b)^{-n-1} + Z_3\ F(r)/r + Z_4\ G(r)/r + Z_5\ H(r)/r \tag{24}$$

Where,

$$Z_1 = [(u_o/b) - (u_i/b)(b/a)^n]/[(a/b)^n - (b/a)^n] \tag{25a}$$

$$Z_2 = [(u_i/b)(a/b)^n - (u_o/b)]/[(a/b)^n - (b/a)^n] \tag{25b}$$

$$Z_3 = [\rho\ \omega^2\ b^2]/\{D_{rr}[(a/b)^n - (b/a)^n]\} \tag{25c}$$

$$\begin{aligned} Z_4 = b\{&[2\alpha_r + (D_{rh}/D_{rr})(2\alpha_h-\alpha_r) - (D_{hh}/D_{rr})\alpha_h]T_k \\ &+ [2\beta_r + (D_{rh}/D_{rr})(2\beta_h-\beta_r) - (D_{hh}/D_{rr})\beta_h]M_k \\ &+ [(2\ D_{rm}/D_{rr}) - (D_{hm}/D_{rr})][\alpha_m T_k + \beta_m M_k]\}/[(a/b)^n - (b/a)^n] \end{aligned} \tag{25d}$$

$$\begin{aligned} Z_5 = \{&[\alpha_r + (D_{rh}/D_{rr})(\alpha_h-\alpha_r) - (D_{hh}/D_{rr})\alpha_h]T_s \\ &+ [\beta_r + (D_{rh}/D_{rr})(\beta_h-\beta_r) - (D_{hh}/D_{rr})\beta_h]M_s \\ &+ [(D_{hm}/D_{rr}) - (D_{rm}/D_{rr})][\varepsilon_m - \alpha_m T_s - \beta_m M_s]\}/[(a/b)^n - (b/a)^n] \end{aligned} \tag{25e}$$

If $n \neq 3$,

$$\begin{aligned} dF(r)/dr = [1/(n^2-9)]\ (b/r)\ \{&n(r/b)^n\ [(b/a)^n - (a/b)^3] \\ &+ n\ (b/r)^n\ [(a/b)^n - (a/b)^3] + 3(r/b)^3\ [(a/b)^n - (b/a)^n]\} \end{aligned} \tag{26a}$$

$$\begin{aligned} F(r)/r = [1/(n^2-9)]\ (b/r)\ \{&(r/b)^n\ [(b/a)^n - (a/b)^3] \\ &- (b/r)^n\ [(a/b)^n - (a/b)^3] + (r/b)^3\ [(a/b)^n - (b/a)^n]\} \end{aligned} \tag{26b}$$

If $n = 3$,

$$\begin{aligned} dF(r)/dr = (1/6)(b/r)\ \{&3(r/a)^3\ \ln(r/b) + 3(a/b)^3(r/b)^3\ \ln(a/r) \\ &+ 3(a/r)^3\ \ln(a/b) + (r/a)^3 - (a/b)^3(r/b)^3\} \end{aligned} \tag{26c}$$

$$\begin{aligned} F(r)/r = (1/6)(b/r)\ \{&(r/a)^3\ \ln(r/b) + (a/b)^3(r/b)^3\ \ln(a/r) \\ &- (a/r)^3\ \ln(a/b)\} \end{aligned} \tag{26d}$$

If $n \neq 2$,

$$\begin{aligned} dG(r)/dr = [1/(4-n^2)](b/r)\ \{&n(r/b)^n\ [(b/a)^n - (a/b)^2] \\ &+ n(b/r)^n\ [(a/b)^n - (a/b)^2] + 2(r/b)^2\ [(a/b)^n - (b/a)^n]\} \end{aligned} \tag{27a}$$

$$G(r)/r = [1/(4-n^2)](b/r)\ \{(r/b)^n\ [(b/a)^n - (a/b)^2] - (b/r)^n\ [(a/b)^n - (a/b)^2] + (r/b)^2\ [(a/b)^n - (b/a)^n]\} \tag{27b}$$

If n = 2,

$$dG(r)/dr = (1/4)(b/r)\ \{2(r/a)^2\ \ln(b/r) + 2(a/b)^2(r/b)^2\ \ln(r/a) - 2(a/r)^2\ \ln(a/b) + (a/b)^2(r/b)^2 - (r/a)^2\} \tag{27c}$$

$$G(r)/r = (1/4)(b/r)\ \{(r/a)^2\ \ln(b/r) + (a/b)^2(r/b)^2\ \ln(r/a) + (a/r)^2\ \ln(a/b)\} \tag{27d}$$

If n ≠ 1,

$$dH(r)/dr = [1/(1-n^2)]\ (b/r)\ \{n(r/b)^n\ [(b/a)^n - (a/b)] + n(b/r)^n\ [(a/b)^n - (a/b)] + (r/b)\ [(a/b)^n - (b/a)^n]\} \tag{28a}$$

$$H(r)/r = [1/(1-n^2)]\ (b/r)\ \{(r/b)^n\ [(b/a)^n - (a/b)] - (b/r)^n\ [(a/b)^n - (a/b)] + (r/b)\ [(a/b)^n - (b/a)^n]\} \tag{28b}$$

If n = 1,

$$dH(r)/dr = (1/2)(b/r)\{(a/b)(r/b)\ \ln(r/a) + (r/a)\ \ln(b/r) - (a/r)\ \ln(a/b) + (a/b)(r/b) - (r/a)\} \tag{28c}$$

$$H(r)/r = (1/2)(b/r)\{(a/b)(r/b)\ \ln(r/a) + (r/a)\ \ln(b/r) + (a/r)\ \ln(a/b)\} \tag{28d}$$

The radial and hoop strains, having now been defined, are substituted into the constitutive equations to find the axial stress. In order to complete our numerical analysis, we must integrate the axial stress over the face of the cylinder to obtain the axial force. This is developed as follows, using the axial strain which is as yet undefined:

$$\underline{F}_m/2\pi = \int_b^a \sigma_m \, r \, dr$$

$$= D_{mr} \, b^2 \int_b^a (\varepsilon_r/b^2) \, r \, dr + D_{mh} \, b^2 \int_b^a (\varepsilon_h/b^2) \, r \, dr$$

$$+ D_{mm} \, b^2 \int_b^a (\varepsilon_m/b^2) \, r \, dr - b^2 \int_b^a [D_{mr} \, (\alpha_r{}'+\beta_r{}') + D_{mh} \, (\alpha_h{}'+\beta_h{}') \tag{29}$$

$$+ D_{mm} \, (\alpha_m{}'+\beta_m{}')] \, (1/b^2) \, r \, dr$$

Where,

$$D_{mr} \, b^2 \int_b^a (\varepsilon_r/b^2) \, r \, dr = D_{mr} \, b^2 \, \{ \int_b^a n(Z_1/b)(r/b)^n \, dr$$

$$+ \int_b^a - n(Z_2/b)(r/b)^{-n} \, dr + \int_b^a Z_3(r/b^2) \, [dF(r)/dr] \, dr \tag{30a}$$

$$+ \int_b^a Z_4(r/b^2) \, [dG(r)/dr] \, dr + \int_b^a Z_5(r/b^2) \, [dH(r)/dr] \, dr \, \}$$

$$D_{mh} \, b^2 \int_b^a (\varepsilon_h/b^2) \, r \, dr = D_{mh} \, b^2 \, \{ \int_b^a (Z_1/b)(r/b)^n \, dr$$

$$+ \int_b^a (Z_2/b)(r/b)^{-n} \, dr + \int_b^a Z_3 \, [F(r)/b^2] \, dr \tag{30b}$$

$$+ \int_b^a Z_4 \, [G(r)/b^2] \, dr + \int_b^a Z_5 \, [H(r)/b^2] \, dr \, \}$$

$$- b^2 \int_b^a [D_{mr}(\alpha_r'+\beta_r') + D_{mh}(\alpha_h'+\beta_h') + D_{mm}(\alpha_m'+\beta_m')](1/b^2)\ r\ dr$$

$$= b^2\ [D_{mr}\ \alpha_r + D_{mh}\ \alpha_h + D_{mm}\ \alpha_m] \int_b^a (T_s+T_k r)/b^2\ dr \qquad (30c)$$

$$+ b^2\ [D_{mr}\ \beta_r + D_{mh}\ \beta_h + D_{mm}\ \beta_m] \int_b^a (M_s+M_k r)/b^2\ dr$$

Evaluating the individual integrals from Equation (30a):

$$\int_b^a n(Z_1/b)(r/b)^n\ dr = [n/(n + 1)]\ Z_1\ [(a/b)n+1 - 1] \qquad (31)$$

If $n \neq 1$,

$$\int_b^a - n(Z_2/b)(r/b)^{-n}\ dr = [n/(n-1)]\ Z_2\ [(a/b)^{1-n} - 1] \qquad (32a)$$

If $n = 1$,

$$\int_b^a - n(Z_2/b)(r/b)^{-n}\ dr = Z_2\ \ln(b/a) \qquad (32b)$$

If $n \neq 3$ and $n \neq 1$,

$$\int_b^a Z_3\ (r/b^2)\ [dF(r)/dr]\ dr$$

$$= [Z_3/(n^2-9)]\{[n/(n+1)][(a/b) + (a/b)^3 - (b/a)^n - (a/b)^4(a/b)^n]$$

$$(33a)$$

$$+ [n/(1-n)]\ [(a/b) + (a/b)^3 - (a/b)^n - (a/b)^4(b/a)^n]$$

$$+ (3/4)\ [(b/a)^n - (a/b)^n + (a/b)^4(a/b)^n - (a/b)^4(b/a)^n]\ \}$$

If n = 3,

$$\int_b^a Z_3(r/b^2)\ [dF(r)/dr]\ dr$$
$$= (Z_3/6)\ \{\ (3/4)\ \ln(a/b)\ [(a/b)^3 - (a/b)]$$
$$+ (1/16)\ [(a/b) + (a/b)^3 - (b/a)^3 - (a/b)^7]\ \} \qquad (33b)$$

If n = 1,

$$\int_b^a Z_3(r/b^2)\ [dF(r)/dr]\ dr$$
$$= -(Z_3/8)\ \{\ (1/4)\ [(a/b)^5 - (a/b)^3 - (a/b) + (b/a)]$$
$$+ [(a/b) - (a/b)^3]\ \ln\ (a/b)\ \} \qquad (33c)$$

If n ≠ 2 and n ≠ 1,

$$\int_b^a Z_4(r/b^2)\ [dG(r)/dr]\ dr$$
$$= [Z_4/(4-n^2)]\{[n/(n+1)][(a/b) + (a/b)^2 - (b/a)^n - (a/b)^3(a/b)^n]$$
$$+ [n/(1-n)]\ [(a/b) + (a/b)^2 - (a/b)^n - (a/b)^3(b/a)^n]$$
$$+ (2/3)\ [(b/a)^n - (a/b)^n + (a/b)^3(a/b)^n - (a/b)^3(b/a)^n]\ \} \qquad (34a)$$

If n = 2,

$$\int_b^a Z_4(r/b^2)\ [dG(r)/dr]\ dr$$
$$= (Z_4/4)\ \{\ (4/3)\ \ln(a/b)\ [(a/b) - (a/b)^2]$$
$$+ (1/9)\ [(a/b)^5 - (a/b)^2 - (a/b) + (b/a)^2]\ \} \qquad (34b)$$

If n = 1,

$$\int_b^a Z_4(r/b^2)\ [dG(r)/dr]\ dr$$
$$= (Z_4/3)\ \{\ (1/6)\ [(a/b)^4 - (a/b)^2 - (a/b) + (b/a)] + \ln(a/b)\ [(a/b) - (a/b)^2]\ \} \qquad (34c)$$

If n ≠ 1,

$$\int_b^a Z_5(r/b^2)\ [dH(r)/dr]\ dr$$
$$= [Z_5/(1-n^2)]\ \{\ [n/(n+1)]\ [2(a/b) - (b/a)^n - (a/b)^2(a/b)^n] \qquad (35a)$$
$$+ [n/(1-n)]\ [2(a/b) - (a/b)^n - (a/b)^2(b/a)^n]$$
$$+ (1/2)\ [(a/b)^2(a/b)^n - (a/b)^n - (a/b)^2(b/a)^n + (b/a)^n]\ \}$$

If n = 1,

$$\int_b^a Z_5(r/b^2)\ [dH(r)/dr]\ dr$$
$$= (Z_5/2)\ \{\ (1/4)\ [(a/b)^3 - 2(a/b) + (b/a)] - (a/b)\ \ln(a/b)\ \ln(a/b)\ \} \qquad (35b)$$

Evaluating the individual integrals from Equation (30b):

$$\int_b^a (Z_1/b)\ (r/b)^n\ dr = [Z_1/(n+1)]\ [(a/b)^{n+1} - 1] \qquad (36)$$

If n ≠ 1,

$$\int_b^a (Z_2/b)\ (r/b)^{-n}\ dr = [Z_2/(1-n)]\ [(a/b)^{1-n} - 1\ ] \qquad (37a)$$

If n = 1,

$$\int_b^a (Z_2/b)\,(r/b)^{-n}\,dr = Z_2 \ln(a/b) \tag{37b}$$

If $n \neq 3$ and $n \neq 1$,

$$\int_b^a Z_3\,[F(r)/b^2]\,dr$$

$$= [Z_3/(n^2-9)]\{[1/(n+1)][(a/b) + (a/b)^3 - (b/a)^n - (a/b)^4(a/b)^n]$$

$$- [1/(1-n)]\,[(a/b) + (a/b)^3 - (a/b)^n - (a/b)^4(b/a)^n] \tag{38a}$$

$$+ (1/4)\,[(b/a)^n - (a/b)^n + (a/b)^4(a/b)^n - (a/b)^4(b/a)^n]\,\}$$

If n = 3,

$$\int_b^a Z_3[F(r)/b^2]\,dr$$

$$= (Z_3/6)\,\{\,(3/4)\ln(a/b)\,[(a/b) - (a/b)^3] \tag{38b}$$

$$+ (1/16)\,[(b/a)^3 + (a/b)^7 - (a/b)^3 - (a/b)]\,\}$$

If n = 1,

$$\int_b^a Z_3[F(r)/b^2]\,dr$$

$$= -(Z_3/8)\,\{\,(1/4)\,[(a/b) - (b/a) + (a/b)^3 - (a/b)^5] \tag{38c}$$

$$+ [(a/b)^3 - (a/b)]\ln(a/b)\,\}$$

If $n \neq 2$ and $n \neq 1$,

$$\int_b^a Z_4[G(r)/b^2]\,dr$$

$$= [Z_4/(4-n^2)]\{[1/(n+1)][(a/b) + (a/b)^2 - (b/a)^n - (a/b)^3(a/b)^n]$$

$$- [1/(1-n)]\,[(a/b) + (a/b)^2 - (a/b)^n - (a/b)^3(b/a)^n] \qquad (39a)$$

$$+ (1/3)\,[(b/a)^n - (a/b)^n + (a/b)^3(a/b)^n - (a/b)^3(b/a)^n]\,\}$$

If $n = 2$,

$$\int_b^a Z_4[G(r)/b^2]\,dr$$

$$= (Z_4/4)\,\{\,(4/3)\,\ln(a/b)\,[(a/b)^2 - (a/b)] \qquad (39b)$$

$$- (1/9)\,[(a/b)^5 - (a/b)^2 - (a/b) + (b/a)^2]\,\}$$

If $n = 1$,

$$\int_b^a Z_4[G(r)/b^2]\,dr$$

$$= (Z_4/3)\,\{\,-(1/6)\,[(a/b)^4 - (a/b)^2 - (a/b) + (b/a)] \qquad (39c)$$

$$+ \ln(a/b)\,[(a/b)^2 - (a/b)]\,\}$$

If $n \neq 1$,

$$\int_b^a Z_5[H(r)/b^2]\,dr$$

$$= [Z_5/(1-n^2)]\,\{\,[1/(n+1)]\,[2(a/b) - (b/a)^n - (a/b)^2(a/b)^n]$$

$$- [1/(1-n)]\,[2(a/b) - (a/b)^n - (a/b)^2(b/a)^n] \qquad (40a)$$

$$+ (1/2)\,[(a/b)^2(a/b)^n - (a/b)^n - (a/b)^2(b/a)^n + (b/a)^n]\,\}$$

If n = 1,

$$\int_b^a Z_5[H(r)/b^2]\,dr$$

$$= (Z_5/2)\ \{\ -(1/4)\ [(a/b)^3 - 2(a/b) + (b/a)] + (a/b)\ \ln(a/b)\ \ln(a/b)\ \} \qquad (40b)$$

Evaluating the integral involving meridional strain in Equation (29):

$$\int_b^a (\varepsilon_m/b^2)\ r\,dr = (\varepsilon_m/2)\ [(a/b)^2 - 1] \qquad (41)$$

Evaluating the individual integrals from Equation (30c):

$$\int_b^a [(T_s+T_k r)/b^2]\ r\,dr$$

$$= (T_s/2)\ [(a/b)^2 - 1] + (T_k b/3)\ [(a/b)^3 - 1] \qquad (42)$$

$$\int_b^a [(M_s+M_k r)/b^2]\ r\,dr$$

$$= (M_s/2)\ [(a/b)^2 - 1] + (M_k b/3)\ [(a/b)^3 - 1] \qquad (43)$$

Multilayered Cylinder Analysis

We can now apply the equations developed in this chapter to analysis of a multilayered cylinder. These equations will allow us to use the unit displacement method to build a stiffness matrix and unit force matrices. The layer, or element, stiffness matrix is formed by successively setting the inner boundary displacement, the outer boundary displacement, and the axial strain to a unit value, and solving for the force at the inner boundary, outer boundary, and axial face, while the forcing functions are set to zero. Since the driving potential is unity, the calculated force is the stiffness term. The element stiffness matrix takes the form:

$$\begin{Bmatrix} \underline{F}_i \\ \underline{F}_o \\ \underline{F}_m \end{Bmatrix} = \begin{bmatrix} k_{ii} & k_{io} & k_{im} \\ k_{oi} & k_{oo} & k_{om} \\ k_{mi} & k_{mo} & k_{mm} \end{bmatrix} \begin{Bmatrix} u_i \\ u_o \\ \varepsilon_m \end{Bmatrix} \tag{44}$$

For example, set $u_i = 1$, $u_o = 0$, and $\varepsilon_m = 0$. Then calculate the force at the inner boundary, the outer boundary, and the axial face using the equations which have been developed. The appropriate force is, of course, found by multiplying the radial or axial stress times the area over which it acts. The element stiffness matrix terms calculated are:

$$k_{ii} = \underline{F}_i \tag{45a}$$

$$k_{oi} = \underline{F}_o \tag{45b}$$

$$k_{mi} = \underline{F}_m \tag{45c}$$

The remaining terms in the element stiffness matrix are found in the same manner by next setting $u_o = 1$, and finally setting $\varepsilon_m = 1$. The resulting matrix is symmetric. The layer stiffness terms are then added into the global stiffness matrix. As shown in Figure 7, this results in a square matrix with $\ell + 2$ rows and columns, where ℓ is the total number of layers in the cylinder.

The force matrix is calculated in much the same way as the stiffness matrix, but now the boundary displacements are set equal to

$$
\begin{bmatrix}
K_{ii}(1) & K_{io}(1) & 0 & \cdots & 0 & 0 & K_{im}(1) \\
K_{oi}(1) & K_{oo}(1) + K_{ii}(2) & K_{io}(2) & \cdots & 0 & 0 & K_{om}(1) + K_{im}(2) \\
0 & K_{oi}(2) & K_{oo}(2) + K_{ii}(3) & \cdots & 0 & 0 & K_{om}(2) + K_{im}(3) \\
0 & 0 & \cdot & & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & & \cdot & \cdot & \cdot \\
0 & 0 & 0 & \cdots & K_{oo}(\ell - 1) + K_{ii}(\ell) & K_{io}(\ell) & K_{om}(\ell - 1) + K_{im}(\ell) \\
0 & 0 & 0 & \cdots & K_{oi}(\ell) & K_{oo}(\ell) & K_{om}(\ell) \\
K_{mi}(1) & K_{mo}(1) + K_{mi}(2) & K_{mo}(2) + K_{mi}(3) & \cdots & K_{mo}(\ell - 1) + K_{mi}(\ell) & K_{mo}(\ell) & K_{mm}(1) + \cdots + K_{mm}(\ell)
\end{bmatrix}
$$

Figure 7

Global Stiffness Matrix

zero and the various rotation, temperature, and moisture terms (ω, T_s, T_k, M_s, and M_k) to their proper values. The global force matrix is as follows:

$$\begin{Bmatrix} \underline{F}(1) \\ \underline{F}(2) \\ \underline{F}(3) \\ \bullet \\ \bullet \\ \bullet \\ \underline{F}(\ell) \\ \underline{F}(\ell+1) \\ \underline{F}(\ell+2) \end{Bmatrix} = \begin{Bmatrix} \underline{F}_i(1) \\ \underline{F}_o(1) + \underline{F}_i(2) \\ \underline{F}_o(2) + \underline{F}_i(3) \\ \bullet \\ \bullet \\ \bullet \\ \underline{F}_o(\ell-1) + \underline{F}_i(\ell) \\ \underline{F}_o(\ell) \\ \underline{F}_m(1) + \underline{F}_m(2) + \ldots + \underline{F}_m(\ell) \end{Bmatrix} \qquad (46)$$

The global stiffness matrix and force matrix which have been developed are used when the axial force is given as the third boundary condition. When the axial strain is given as the third boundary condition, a degree of freedom is removed from the system of equations. The $\ell + 2$ row and column are removed from the stiffness matrix, and the force matrix is reduced:

$$\begin{Bmatrix} \underline{F}(1) \\ \underline{F}(2) \\ \bullet \\ \bullet \\ \bullet \\ \underline{F}(\ell) \\ \underline{F}(\ell+1) \end{Bmatrix} = \begin{Bmatrix} \underline{F}(1) - k(1, \ell+2) \times \varepsilon_m \\ \underline{F}(2) - k(2, \ell+2) \times \varepsilon_m \\ \bullet \\ \bullet \\ \bullet \\ \underline{F}(\ell) - k(\ell, \ell+2) \times \varepsilon_m \\ \underline{F}(\ell+1) - k(\ell+1, \ell+2) \times \varepsilon_m \end{Bmatrix} \qquad (47)$$

The displacement matrix {u} is now found by solving Equation (48), where all terms in the column force matrix $\{\underline{F}\}$ and the square stiffness matrix [k] are known.

$$\{\underline{F}\} = [k]\ \{u\} \tag{48}$$

Once the displacement matrix is calculated, the displacements and the forcing functions are substituted into Equation (23) to determine radial strain at any point within the layer, and Equation (24) to determine hoop strain at any point within the layer. Radial deflection is calculated by multiplying the hoop strain times the radius. The radial, hoop, and meridional stresses are determined using the constitutive equations presented in Equation (13). The axial force acting on each layer is found by substituting into Equation (29).

Since energy can be stored in a rotating cylinder, rotational energy will be calculated for individual layers and for the total cylinder. The energy stored in a solid cylinder per unit length is:

$$RE = (1/2)\ I\ \omega^2 = (1/4)\ \pi\ (\rho/g_c)\ r^4\ \omega^2 \tag{49}$$

Applying this equation to a layered cylinder,

$$RE = (\pi/4)(\omega^2/g_c) \sum_{j=1}^{\ell} \rho_j\ (a_j^4 - b_j^4) \tag{50}$$

Looking at energy per unit volume and energy per unit mass,

$$(RE/V) = RE/[\pi \sum_{j=1}^{\ell} (a_j^2 - b_j^2)] \qquad (51)$$

$$(RE/M) = RE/[\pi \sum_{j=1}^{\ell} \rho_j (a_j^2 - b_j^2)] \qquad (52)$$

Computerization

Computer program TDCYL2 is based on the equations developed in this chapter. TDCYL2 is a FORTRAN computer program which is modular in nature to permit future changes with a minimum of effort or problems. The MAIN program is used almost exclusively to call subroutines. A block flowchart of TDCYL2, showing the purpose of each subroutine, is presented as Figure 8. Figure 9 shows in more detail the logic in subroutine STIFFE, where the element stiffness and unit force matrices are generated. The basic logic of TDCYL2 is to read all input data, print the data back, calculate the strains, stresses, radial displacements, and axial forces, and print the results.

The data which is input in each of the subroutines includes:

SETUP--A description of the project being evaluated, the inner radius of the cylinder, the number of layers and materials, the number of intermediate points in a layer where stresses and strains are calculated, and parameters for selecting either plane stress or plane strain, and either axial force or axial strain boundary conditions.

RMATIN--Mechanical and physical properties for each material, including moduli of elasticity, Poisson's ratios, mass densities, thermal expansion coefficients, and moisture expansion coefficients.

ELGIN--The thickness of each layer and the material of which the layer is constructed.

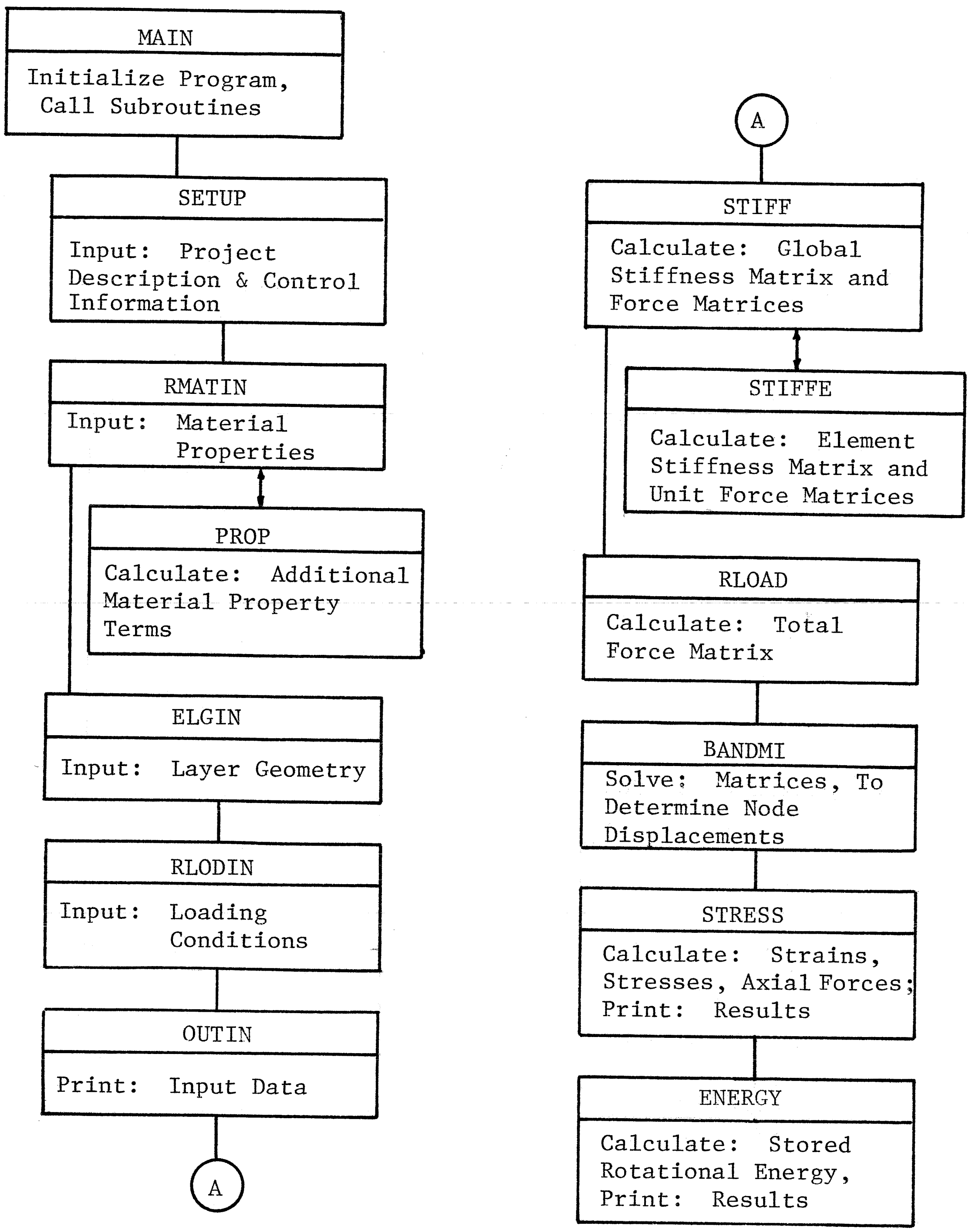


Figure 8

Program Structure--TDCYL2

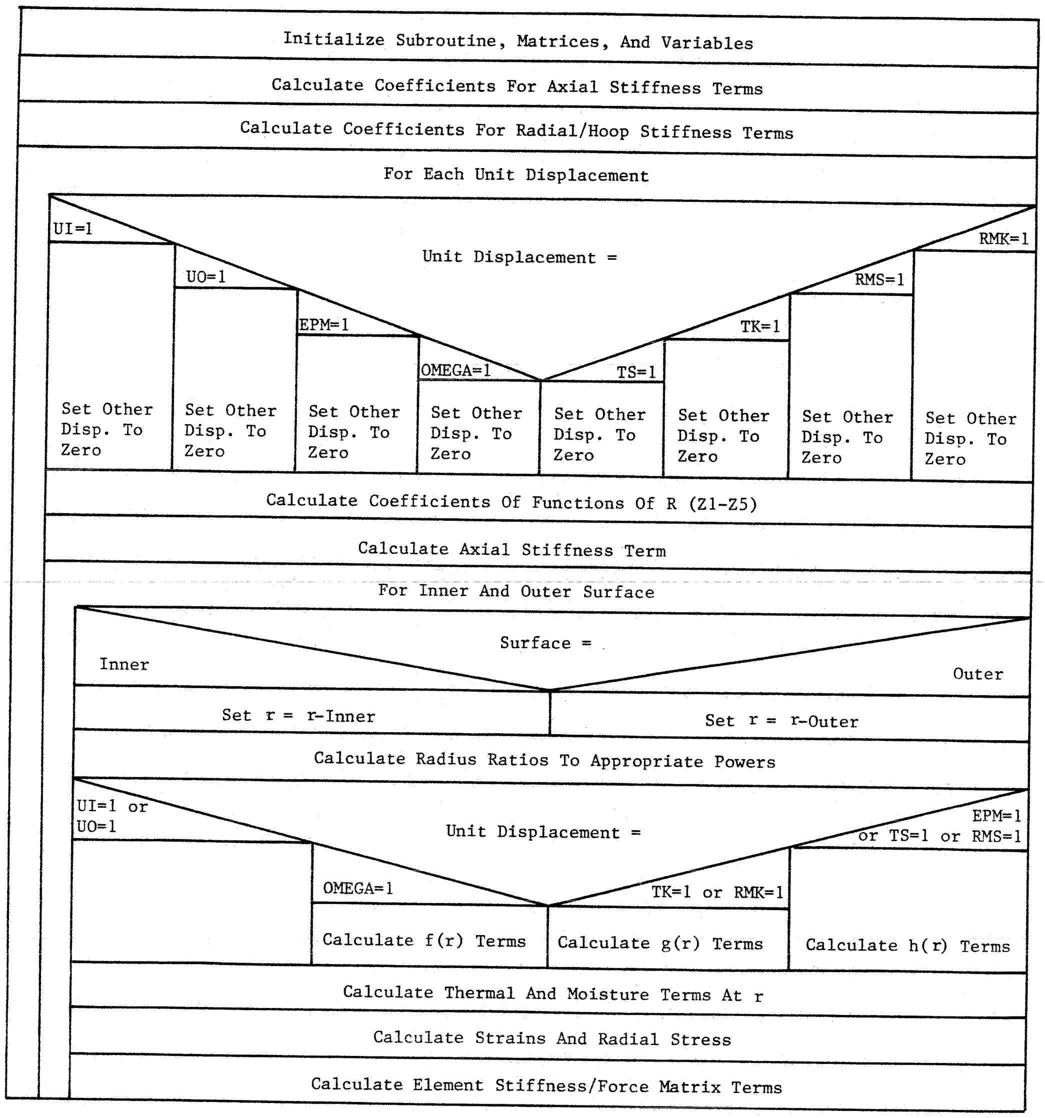


Figure 9

Subroutine Structure--STIFFE

RLODIN--The internal and external pressures, the rotational velocity, the temperature and moisture profiles, and either the axial force or axial strain.

Following inputting of all data, the data is printed out in subroutine OUTIN, so that the input data and the results will be integral.

The first step in calculating the stresses and strains is calculation of the global stiffness and force matrices. Subroutine STIFF calls subroutine STIFFE for each layer, and assembles the results into the global stiffness matrix and the force matrices. STIFFE calculates the terms for each layer which constitute the element stiffness and unit force matrices, using the unit displacement method described earlier. The subroutine RLOAD combines the force matrices from the individual forcing functions into a single global force matrix. If an axial force is specified, it is added to the global force matrix in RLOAD. If an axial strain is specified, the force matrix is reduced in RLOAD and the axial degree of freedom is removed from the stiffness matrix. The axial degree of freedom would likewise be removed if a plane stress solution was specified. With the stiffness matrix $[k]$ and the force matrix $\{\underline{F}\}$ now calculated, subroutine BANDMI solves Equation (48) for the displacement $\{u\}$ by elimination methods. Subroutine STRESS uses these displacements to calculate, at the specified number of points within each layer, the stresses and strains in each of the three principal directions, and the radial deflection. Finally, subroutine ENERGY computes the energy stored in the cylinder if it is rotating.

Comparison with Classical Solutions

Verification of the computer program TDCYL2 included comparison with classical analyses. These analyses included single layers with internal and external pressure, an equilibrium temperature change, temperature profiles, and rotation.

Example 4. Internal and External Pressure [20]

This example is a hollow isotropic cylinder with both internal and external pressure and no axial load. Plane strain assumptions are made. Stresses in the radial and hoop direction are calculated as are the radial displacement and axial strain.

$$\sigma_r = (P_i b^2 - P_o a^2)/(a^2 - b^2) + [a^2 b^2/r^2]\ [(P_o - P_i)/(a^2 - b^2)] \tag{53a}$$

$$\sigma_h = (P_i b^2 - P_o a^2)/(a^2 - b^2) - [a^2 b^2/r^2]\ [(P_o - P_i)/(a^2 - b^2)] \tag{53b}$$

$$u_r = [(1-\nu)/E]\ [(P_i b^2 - P_o a^2)/(a^2 - b^2)]\ r + [(1+\nu)/E]\ (a^2 b^2)\ [(P_i - P_o)/(a^2 - b^2)]/r \tag{53c}$$

$$\varepsilon_m = (2\nu/E)\ [(P_i b^2 - P_o a^2)/(b^2 - a^2)] \tag{53d}$$

Given b = 5 inches, a = 7 inches, ν = .3, E = 10^7 psi, P_i = 500 psi, and P_o = 100 psi, the results in Table 7 were obtained:

Table 7. Stresses, Strains, and Displacements as a Function of Radius in a Cylinder with Internal and External Pressure

		Classical	Numerical
σ_r,psi:	r = 5 inches	-500.000	-500.00
	6	-250.463	-250.46
	7	-100.000	-100.00
σ_h,psi:	r = 5	1133.333	1133.3
	6	883.796	883.80
	7	733.333	733.33
u_r,in.:	r = 5	.64167 x 10-3	.64167 x 10-3
	6	.57536 x 10-3	.57536 x 10-3
	7	.53433 x 10-3	.53433 x 10-3
ε_m:		.019 x 10-3	.019 x 10-3

Example 5. Equilibrium Temperature Change [21]

If we have an isotropic cylinder which is hollow, we can subject it to a change in temperature as a function of radial position. We can integrate the temperature profile across the radius in order to calculate the stresses in the three principal directions.

$$\sigma_r = [\alpha E/(1-\nu)]\ (1/r^2)\ \{\ [(r^2-b^2)/(a^2-b^2)] \int_b^a T\ r\ dr - \int_b^r T\ r\ dr\ \} \qquad (54a)$$

$$\sigma_h = [\alpha E/(1-\nu)]\ (1/r^2)\ \{\ [(r^2+b^2)/(a^2-b^2)] \int_b^a T\ r\ dr + \int_b^r T\ r\ dr - T\ r^2\ \} \quad (54b)$$

$$\sigma_m = [\alpha E/(1-\nu)]\ \{\ [2/(a^2-b^2)] \int_b^a T\ r\ dr - T\ \} \quad (54c)$$

If T = constant, the above equations reduce to:

$$\sigma_r = 0$$

$$\sigma_h = 0$$

$$\sigma_m = 0$$

The numerical results agreed.

Example 6. Temperature Profile [21]

In this example, we also look at a hollow isotropic cylinder. We will evaluate a special case of thermal stresses in which a steady heat flow between the boundaries is established in the cylinder. The resulting temperature profile will be logarithmic.

$$T = [T_i/\log(a/b)]\ \log(a/r) \qquad (\text{assuming } T_o = 0) \quad (55)$$

We now have the following expressions for thermal stresses:

$$\sigma_r = \{\ \alpha E T_i/[2(1-\nu)\ \log(a/b)]\ \}\ \{\ -\log(a/r) - [b^2/(a^2-b^2)]\ (1-a^2/r^2)\ \log(a/b)\ \} \quad (56a)$$

$$\sigma_h = \{ \alpha E T_i / [2(1-\nu) \log(a/b)] \} \{ 1 - \log(a/r) - [b^2/(a^2-b^2)] (1+a^2/r^2) \log(a/b) \} \quad (56b)$$

$$\sigma_m = \{ \alpha E T_i / [2(1-\nu) \log(a/b)] \} \{ 1 - 2\log(a/r) - [2b^2/(a^2-b^2)] \log(a/b) \} \quad (56c)$$

Given b=5 inches, a=9 inches, $\alpha = 13 \times 10^{-6}$ in/in/°F, $T_i = 100$°F, $E = 10^7$ psi, $\nu = .3$

Table 8. Stresses in a Hollow Cylinder with Steady Heat Flow

	Radius	Stresses: Classical	Stresses: Numerical
σ_r, psi:	5 inches	0	0
	6	-1,223.68	-1,223.8
	7	-1,263.00	-1,263.1
	8	-759.58	-759.62
	9	0	0
σ_h, psi:	5	-11,064.48	-11,064.0
	6	-4,080.26	-4,079.4
	7	829.54	830.48
	8	4,545.11	4,546.1
	9	7,506.95	7,507.8
σ_m, psi:	5	-11,064.48	-11,064.0
	6	-5,303.94	-5,303.1
	7	-433.47	-432.59
	8	3,785.53	3,786.5
	9	7,506.95	7,507.8

It should be noted that the numerical results were for a cylinder with 32 distinct layers. The temperatures at the surfaces of these layers follows the logorithmic profile, but within the layer, the profile is considered to be linear.

Example 7. Rotation [21]

This example is that of a hollow isotropic cylinder which is sufficiently short axially to be considered a thin disk subject to plane stress assumptions. This thin disk, which is isotropic, will be rotated about its meridional axis which will produce radial and hoop stresses.

$$\sigma_r = [(3+\nu)/8]\ (\rho\ \omega^2/g_c)\ [b^2+a^2 - (a^2b^2/r^2) - r^2] \tag{57a}$$

$$\sigma_h = [(3+\nu)/8](\rho\ \omega^2/g_c)[b^2+a^2 + (a^2b^2/r^2) - r^2(1+3\nu)/(3+\nu)] \tag{57b}$$

Given $\rho = .1\ lb/in^3$, $\omega = 100\pi$ rad/sec, $\nu = .3$, b = 4 inches, a = 9 inches

Table 9. Stresses in a Rotating Thin Disk

		Stresses	
		Classical	Numerical
σ_r,psi:	r = 4 inches	0	0
	5	212.41	212.41
	6	263.41	263.41
	7	227.07	227.07
	8	134.34	134.34
	9	0	0
σ_h,psi:	r = 4	1778.39	1778.4
	5	1416.56	1416.6
	6	1182.93	1182.9
	7	1003.44	1003.4
	8	847.13	847.13
	9	699.22	699.23

Example 8. Orthotropic Cylinder [22]

This example is a hollow orthotropic cylinder with internal pressure. The axial load is zero and plane strain conditions are assumed. The stresses are evaluated in terms of the geometry, the internal and external pressures, and orthotropy ratio.

$$\sigma_r = [(P_i\, b^{n+1} - P_o\, a^{n+1})/(a^{2n}-b^{2n})](r^{n-1}) \tag{58a}$$
$$+[(P_o b^{n-1} - P_i\, a^{n-1})/(a^{2n}-b^{2n})](b^{n+1}\, a^{n+1}\, r^{-n-1})$$

$$\sigma_h = [(P_i\, b^{n+1} - P_o\, a^{n+1})/(a^{2n} - b^{2n})](n\, r^{n-1}) \tag{58b}$$
$$- [(P_o\, b^{n-1} - P_i\, a^{n-1})/(a^{2n} - b^{2n})](n\, b^{n+1}\, a^{n+1}\, r^{-n-1})$$

Given P_i = 10,000 psi, P_o = 0 psi, b = 5 inches, a = 10 inches, and n = 1

Table 10. Stresses in an Orthotropic Cylinder Under Internal Pressure

	Radius	Stresses: Classical	Stresses: Numerical
σ_r,psi:	5 inches	-10,000.	-10,000.
	6	-3,966.8	-3,967.9
	7	-1,759.0	-1,760.3
	8	-796.79	-797.88
	9	-302.59	-302.23
	10	0	0
σ_h,psi:	5	40,313.	40,303.
	6	16,409.	16,405.
	7	7,897.0	7,896.1
	8	4,472.2	4,473.9
	9	3,040.0	3,044.3
	10	2,509.8	2,517.1

The results of the examples above demonstrate the accuracy and validity of the numerical method which was developed for cylinders which consist of a single layer. While classical solutions are limited to those involving a single layer, some comparisons between classical solutions and the numerical methods which have been developed can be made by analyzing layers of a multilayer cylinder independently, matching displacements and radial stresses between adjacent layers and superimposing if necessary.

In addition to comparison with classical solutions, the accuracy and validity of the multilayer numerical method may be demonstrated by first analyzing a single layer cylinder, then breaking it into several layers and comparing results. The accuracy and validity of the multilayer numerical method is further demonstrated in that the boundary conditions of Equations (16) and (19) have always been met.

Other Considerations

An additional consideration of the analysis is the behavior of the solution at or near a singularity. Singularities result when the orthotropy ratio n is numerically equal to one, two, or three, corresponding to load conditions relating to axial strain and temperature and moisture constants, temperature and moisture gradients, and rotation, respectively. In the numerical solution, a tolerance zone was established about each singularity. If the orthotropy ratio fell within that tolerance zone, the singular solution was used. Comparative computer runs were made with one having an orthotropy ratio just inside the tolerance zone, the other having an orthotropy ratio just outside the tolerance zone. The results were virtually identical, establishing continuity at the singularities.

In evaluating the three dimensional stresses and strains, it was assumed that the ends remain plane and, therefore, the axial strain is constant at all radial locations. The analysis calculates the forces required on each layer to maintain constant strain at all radial locations.

Annex B. NewCAP-3 Inputs

NewCAP-3 Inputs

Rev 18Sep20

OPEN (UNIT=5, NAME="NC-3IN.txt") (INPUT)
OPEN (UNIT=7, NAME=”NC-OUTPUT.txt”) (OUTPUT)
OPEN (UNIT=8, NAME=”NC-EXOUT.txt”) (OUTPUT FOR EXCEL USE)
OPEN (UNIT=11, NAME=”NCFIB.txt”) (FIBER LIBRARY)
OPEN (UNIT=12, NAME=”NCRES.txt”) (RESIN LIBRARY)

Subroutine SETUP

READ (5,1) DESCRIPTION *[description of the analysis]*

1 FORMAT (20A4)

READ (5,*) RIN,NL,NMT,NLS,ISPL,ICON,IPO *[inside radius, number of layers, number of material types, internal points per layer for stress analysis, internal control (=0 normally), printout option (=0 for normal, =1 for stiffness/force matrix printout]*

Subroutine RMATIN (MATERIAL INPUT)

For the number of materials

READ (5,*) MT, MMN(MT) *[material number, material model number]*

For type 1 general material properties

401 READ (5,*) (EM,EH,ER,PRMH,PRMR,PRHR) *[elastic moduli and Poisson’s ratios in the indicated directions]*

READ (5,*) (ALPM,ALPH,ALPR) *[coefficients of thermal expansion in the indicated directions]*

For type 2 multi-linear metal model

402 READ (5,*) #SEGMENTS *[number of line segments in the model]*

For the number of segments

READ (5,*) (X1,Y1 -> X5,Y5) *[strain, stress coordinates of the line segments (0,0 is the starting point, but not entered)]*

For the material

READ (5,*) ALPHA *[coefficient of thermal expansion]*

For type 3 Ramberg-Osgood metal model

403 READ (5,*) E1,SZ,n,K *[modulus of elasticity, sigma*$_0$*,, n (exponent), k(multiplier)]*

READ (5,*) ALPHA *[coefficient of thermal expansion]*

For type 4 fiber inputs

404 READ (5,*) EF11,EF22,VF12,VF23,GF12,GF23,ALPF1,ALPF2 *[fiber longitudinal modulus, transverse modulus, Poisson's ratios, shear modulii, and coefficients in the longitudinal and transverse direction]*

READ (5,*) EM,VM,GM,ALPM *[resin matrix modulus of elasticity, Poisson's ratio, shear modulus, and coefficient of thermal expansion]*

READ (5,*) WA,FVF,VVF *[fiber wind angle, fiber volume fraction, and void volume fraction]*

For type 5 fiber inputs

405 READ (5,*) NFIB,NRES *[fiber number, resin number, from standard list]*

Fiber input contains

DESC/EF11,EF22,VF12,VF23,GF12,GF23,ALPF1,ALPF2 *[see descriptions above]*

Resin input contains DESC/EM,VM,GM,ALPM *[see descriptions above]*

READ (5,*) WA,FVF,VVF *[see descriptions above]*

Subroutine ELGIN (LAYER INPUT)

For each layer

READ (5,*) LN,MTM(LN),THICKNESS(LN) *[layer number, material number for that layer, layer thickness]*

Subroutine RLODIN

For each load step

READ (5,11) DESCRIPTION-LOAD STEP *[load step description]*

11 FORMAT (5A4)

READ (5,*) PI,PO,LSI *[internal pressure, external pressure, load step number: 1=increasing pressure, 2=autofrettage pressure, 3=decreasing pressure from autofrettage, 4=zero pressure after autofrettage, 5=increasing pressure after autofrettage/zero, 6=design burst pressure, 7=pressure above burst]*

READ (5,*) (NODE TEMPS) I=1,NL+1) *[node temperatures, from inside surface to outside surface (number of nodes = number of layers + 1)]*

NewCAP-3 input

18-Sep-20

Description

SETUP info

RIN	NL	NMT	NLS	ISPL	ICON	IPO

Input Material Number and Material Model Number, then appropriate data

RIN - inside radius
NL = 90 max
NMT = 40 max
NLS = 30 max
ISPL = 9 max
ICON = 0 (not currently used)
IPO = 0 normally

LSI
1 = zero to autofrettage
2 = autofrettage
3 = autofrettage to zero
4 = zero after autofrettage
5 = increasing from zero
6 = burst pressure
7 = above burst pressure

MMN = 1 General material property input

MT	MMN				
EM	EH	ER	PRMH	PRMR	PRHR
ALPM	ALPH	ALPR			

MMN=2 Multi-linear metal properties

MT	MMN
NSEQ	
X1 (strain)	Y1 (stress)
X2	Y2
X3	Y3
X4	Y4
X5	Y5
ALPM	

MMN=3 Ramberg-Osgood metal properties

MT	MMN		
E1	SZ	N	K
ALPM			

MMN=4 Fiber and resin properties

MT	MMN						
EF11	EF22	VF12	VF23	GF12	GF23	ALPF11	ALPF22
EM	VM	GM	ALPM				
WA	FVF	VVF					

ALP1	ALP2	ALP3
WA	FVF	VVF

Input layer information

LN	MT	TL
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

Load information

Load step description								
PI	PO	LSI						
Node temperatures								

Annex C. Excel User Guidelines

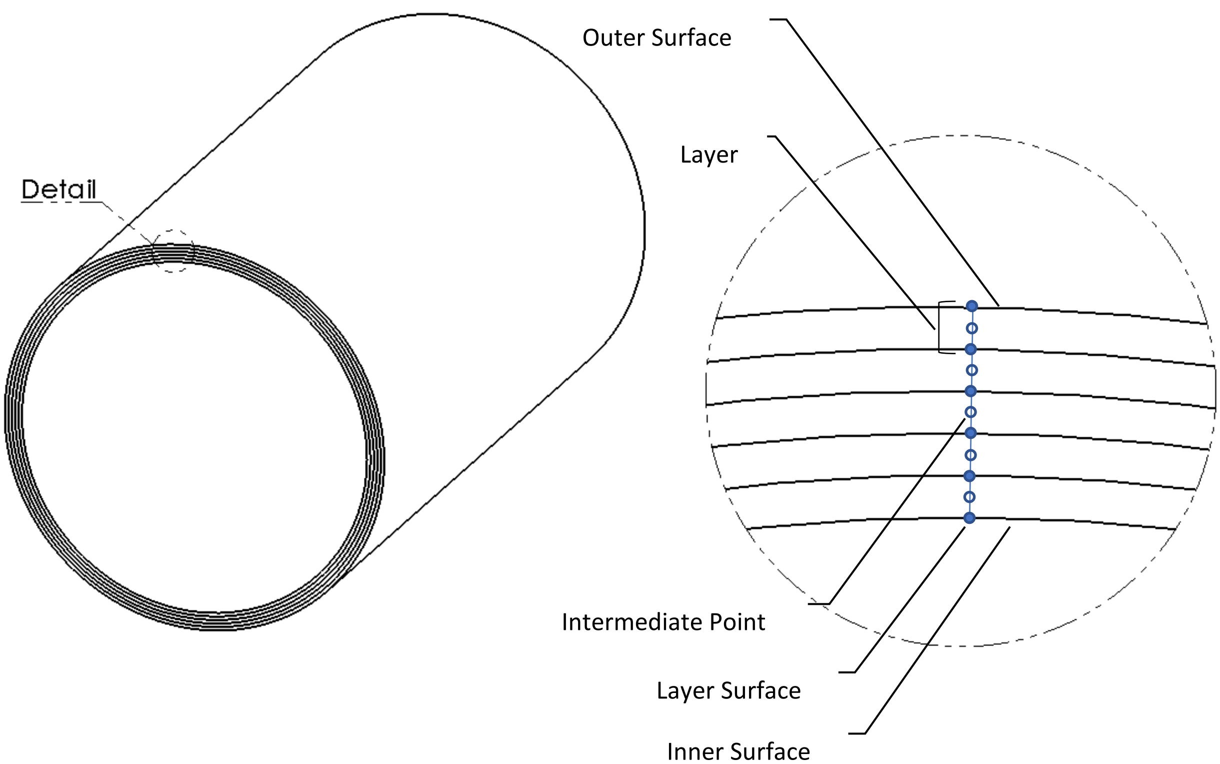
NewCAP 3 – User Guidelines
Last Updated 18 September 2020

1 About

Licensed to US DOT under Contract 693JK318C000008

2 Model Description
NewCAP creates a 1D through thickness model of the cylinder section of a closed end pressure vessel. It supports internal pressure, external pressure, and through thickness thermal gradients.

The following figure is a representation of what the model is simulating.



3 Installation

3.1 PC Installation
Place the PC program files in the folder the program will be run from. All noted files must be in this folder for the program to function correctly.

PC Program Files:
- NewCAP_3.xlsm
- NewCAP-3a.exe
- NCFIB.txt
- NCRES.txt
- af77mathdll.dll
- af90mathdll.dll
- afiodll.dll
- libacml_mv_dll.dll

3.2 Mac Installation
Place the Mac program files in the folder the program will be run from. All noted files must be in this folder for the program to function correctly.

Mac Program Files:
- NewCAP_3.xlsm
- NewCAP-3a.app
- NCFIB.txt
- NCRES.txt

Additionally, the Mac Script files must be install in the following location,
MacintoshHD/Users/<user>/Library/Application Scripts/com.microsoft.Excel.

This location may be hidden by default, use Cmd + shift + . (dot) to enter/exit hidden file mode. If the com.microsoft.Excel folder is not present it may be created but name must be as shown and is case sensitive.

Mac Script Files:
- RunNewCAP.scpt

3.3 File Descriptions

3.3.1 NewCAP_3.xlsm (PC and Mac)
Acts as a GUI for NewCAP3a.exe and NewCAP-3a.app. Used to assist in the creation of program input and viewing program outputs. The file is an Excel Office 365 file. Office 365 installation will be required to use this file. The file uses Excel macros that must be allowed to function to use the file properly. The name is the default name. Changes to the file name may be made without altering the functionality.

3.3.2 NewCAP-3a.exe (PC only)

The primary NewCAP program file for PCs. Reads input files, performs calculations, and writes the results file.

3.3.3 NewCAP-3a.app (Mac only)

The primary NewCAP program file for Macs. Reads input files, performs calculations, and writes the results file.

3.3.4 NCFIB.txt (PC and Mac)

Data file that contains a library of predefined fibers that can be used in NewCAP.

3.3.5 NCRES.txt (PC and Mac)

Data file that contains a library of predefined resins that can be used in NewCAP.

3.3.6 af77mathdll.dll (PC only)

Dynamic Link Library (DLL) file required for NewCAP3a.exe to function on PCs.

3.3.7 Af90mathdll.dll (PC only)

Dynamic Link Library (DLL) file required for NewCAP3a.exe to function on PCs.

3.3.8 afiodll.dll (PC only)

Dynamic Link Library (DLL) file required for NewCAP3a.exe to function on PCs.

3.3.9 libacml_mv_dll.dll (PC only)

Dynamic Link Library (DLL) file required for NewCAP3a.exe to function on PCs.

3.3.10 RunNewCAP.scpt (Mac only)

Mac Script file required for NewCAP_3.xlsm to run NewCAP-3a.app on Macs.

4 In Process Files

The following files are created when NewCAP is running. All files are the same on both PC and Mac.

4.1 NC-3IN.txt

This is the file that contains all the model input for NewCAP to execute. The file is automatically created by NewCAP_3.xlsm while running. Alternatively, the user can manually create this file prior to manually running the NewCAP exe or app program. In this case, all NewCAP input formatting requirements must be followed.

4.2 NC-3IN - <Date and Time>.txt

This is a copy of NC-3IN.txt created by NewCAP_3.xlsm. The <Date and Time> is replaced with the date and time the program input file was created. This file is created each time the program is run from NewCAP_3.xlsm. The file serves as a backup file that can be reloaded into NewCAP_3.xlsm should an older run need to be recreated.

4.3 NC-OUTPUT.txt

This file contains the results from a NewCAP execution. It can be used to manually read the results.

4.4 NC-EXOUT.txt

This file contains the results from a NewCAP execution. It is used for importing into NewCAP_3.xlsm for viewing.

5 GUI Structure

This section outlines the structure of the provided GUI, NewCAP_3.xlsm. The GUI is built using an Excel Office 365 file. This file contains six (6) sheet tabs. The tabs and their content and function are outlined below.

The content of the GUI is color coded to help the user understand the input requirements. The cell color schemes are explained below.

Description Inputs
– User entry required

Calculation Inputs
– User entry required and filled in

Calculation Inputs
– User entry required and missing

Imported Results
– Program controlled

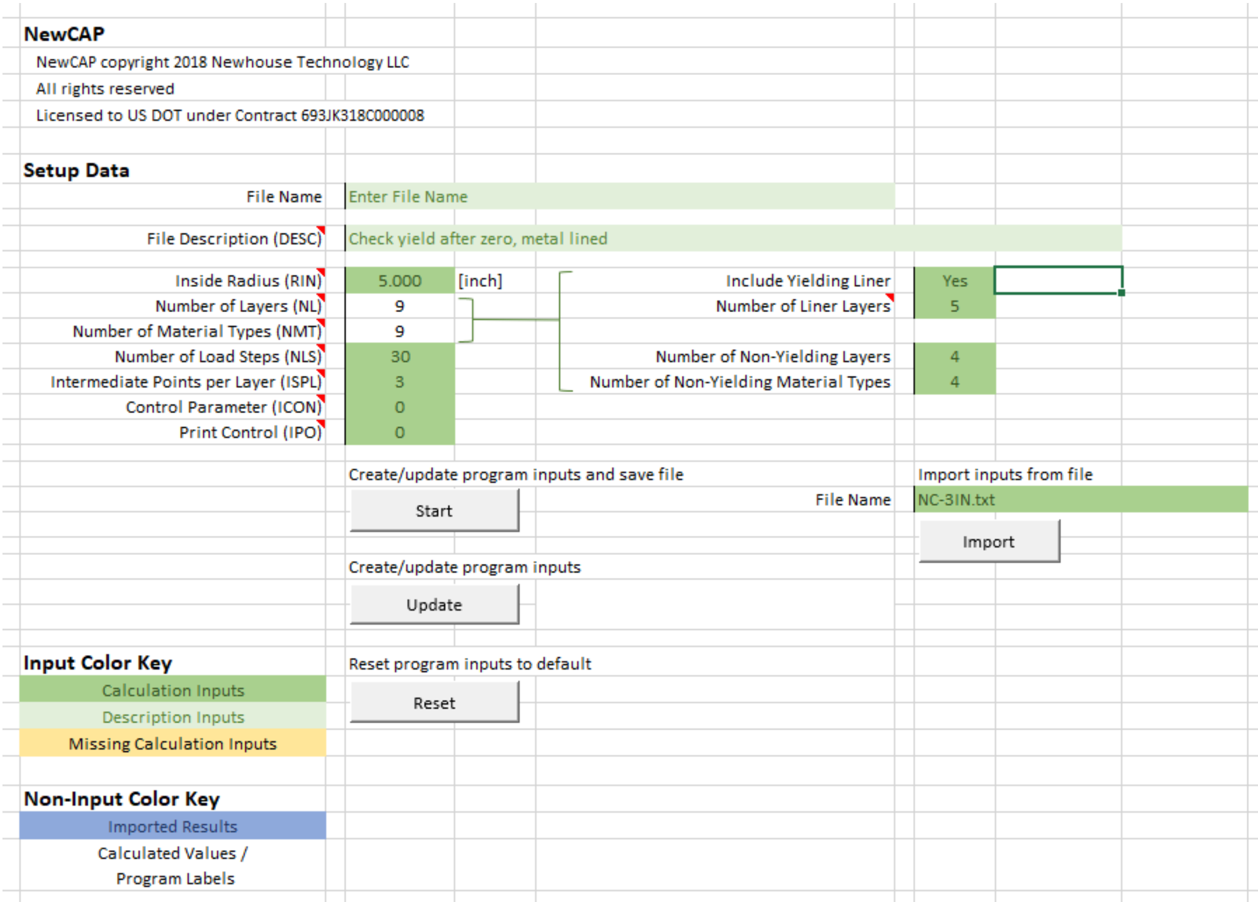
Calculated Values / Program Labels
– Program controlled

This GUI was developed using U.S. Customary units as labeled in the form. All GUI input should conform to these units to get proper results output.

The NewCAP executable does not have any unit assumption. For manual operation, either U.S. Customary or Metric units may be used, as long as the dimensions used are consistent. That is, only one value may be used for M, L, and T. Do not mix inches and feet, mm and cm, °F and °C, pounds and kilograms, or seconds and hours. No internal conversions are used.

5.1 Setup Tab

This tab contains the analysis descriptions and the primary input parameters for the model. Initially only the Setup Tab will be visible. Once input is initiated the other tabs will be become visible. Resetting the GUI will return the other tabs to a non-visible state. The tab structure is shown below.



5.1.1 Field – File Name (primary location)

Description field used to rename the NewCAP_3.xlsm file when the Start button is pressed.

5.1.2 Field – File Description (DESC)

Description field used to describe the analysis being input. This description is passed to NewCAP and used in the program input and output files. Description string is limited to 80 characters (including spaces).

5.1.3 Field – Inside Radius (RIN)

The inside radius of the model. If a liner is included this is the inside radius of the liner. This value must be greater than zero (0).

5.1.4 Field – Number of Layers (NL)

The number of layers to be entered into the program. This field is program controlled based on the inputs from: Include Yielding Liner, Number of Liner Layers, and Number of Non-Yielding Layers. Inputs must combine to create less than or equal to 90 layers.

5.1.5 Field – Number of Material Types (NMT)

The number of material types to be entered into the program. This field is program controlled based on the inputs from: Include Yielding Liner, Number of Liner Layers, and Number of Non-Yielding Material Types. Inputs must combine to create less than or equal to 40 material types.

5.1.6 Field – Include Yielding Liner

Designates whether a yielding liner will be included in the model. The cell contains a pull-down menu with "Yes" and "No" options.

5.1.7 Field – Number of Liner Layers

The number of yielding liner layers to be included in the model. If Including Yielding Liner is marked as "No", this field is ignored. Minimum acceptable value is 5. Maximum acceptable value is 10.

5.1.8 Field – Number of Non-Yielding Layers

The number of non-yielding layers to be included in the model. When combined with yielding layers it must meet the requirements of Number of Layers (NL).

5.1.9 Field – Number of Non-Yielding Material Types

The number of non-yielding material types to be included in the model. When combined with yielding layers it must meet the requirements of Number of Material Types (NMT).

5.1.10 Field – Number of Load Steps (NLS)

The number of load steps to use in the model. Minimum acceptable value is 1. Maximum acceptable value is 30.

5.1.11 Field – Intermediate Points per Layer (ISPL)

Designated the number of intermediate points to be used within each layer. Results will be provided for each intermediate point. Minimum acceptable value is 0. Maximum acceptable value is 9.

5.1.12 Field – Control Parameter (ICON)

Parameter for control within the program. Normally set = 0. If set to 1, input lines are echoed to the output file as entered from the NC-3IN file.

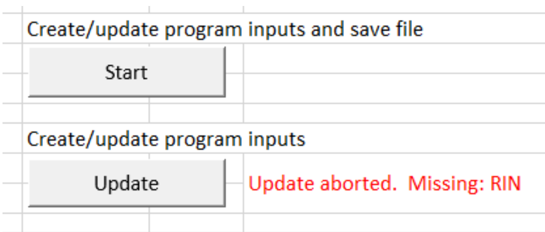
5.1.13 Field – Print Control (IPO)

Controls printout level. Normally set = 0. If set to 1, stiffness and force matrices are printed.

5.1.14 Button – Start

The button renames the Excel file to the name present in the primary File Name field. It then exposed the data entry, results, and graphing tabs. The data entry tabs are updated to match the model settings on this tab.

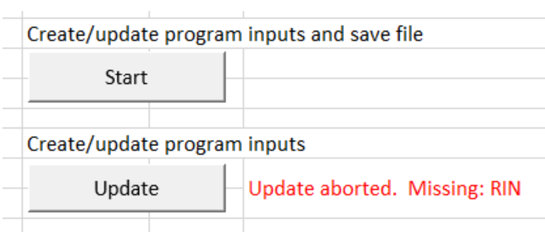
If an entry field is missing from the setup tab, the update portion of the function will be aborted. Red text will be created next to the Update Button. The text will specify the missing field.



5.1.15 Button – Update

The button performs the same function as the Start button without renaming the Excel file. It exposes the data entry, results, and graphing tabs. The data entry tabs are updated to match the model settings on this tab.

If an entry field is missing from the setup tab the update will be aborted. Red text will be created next to the Update Button. The text will specify the missing field.



5.1.16 Button – Reset

The button resets the Excel form to its initial state. All data entry, results, and graphing tabs are hidden. All model setting fields on the Settings tab is reset to initial values.

5.1.17 Field – File Name (import location)

The field designates the file name to be imported using the Import button. The value should be the file name and file extension. Name should not include the full file path. File should be in the same folder as the Excel file.

5.1.18 Button – Import

The button reads the input file designated in the adjacent File Name field. All setting fields are entered per the file. The data entry, results, and graphing tabs are exposed. All model entry data is filled in and the program is ready to be ran.

5.2 Materials Tab

This tab contains the material types to be used in the model. The user enters the individual material properties for each material type. The number of materials defined is set based on the inputs from the Settings tab. The tab is setup with each material type getting its own row. The individual properties for each material are defined within the columns of the row.

NewCAP has five (5) material type models available for use. Two (2) of the models are for yielding liner materials. The other three (3) are for non-yielding materials.

The five (5) models are,

- Type 1, General Material, non-yielding material
- Type 2, Multi-Linear Metal, yielding material
- Type 3, Ramberg-Osgood Metal, yielding material
- Type 4, General Composite Material, non-yielding material
- Type 5, Standard Composite Material, non-yielding material

The tab structure is shown below in two (2) images.

Material Data

	Number of Material Types	9					
MT	Material Description	Material Model	Inputs				
1	< Enter Yielding Liner Material Description >	Type 2 - Multi-Linear Metal	NSEG	X1 [in/in]	Y1 [psi]	X2 [in/in]	Y2 [psi]
2	< Enter Yielding Liner Material Description >	Type 2 - Multi-Linear Metal	NSEG	X1 [in/in]	Y1 [psi]	X2 [in/in]	Y2 [psi]
3	< Enter Yielding Liner Material Description >	Type 2 - Multi-Linear Metal	NSEG	X1 [in/in]	Y1 [psi]	X2 [in/in]	Y2 [psi]
4	< Enter Yielding Liner Material Description >	Type 3 - Ramberg Osgood Metal	E1 [psi]	SZ	n	K	ALP [in/in/°F]
5	< Enter Yielding Liner Material Description >	Type 3 - Ramberg Osgood Metal	E1 [psi]	SZ	n	K	ALP [in/in/°F]
6	< Enter Non-Yielding Material Description >	Type 1 - General	EM [psi]	EH [psi]	ER [psi]	PRMH [-]	PRMR [-]
7	< Enter Non-Yielding Material Description >	Type 1 - General	EM [psi]	EH [psi]	ER [psi]	PRMH [-]	PRMR [-]
8	< Enter Non-Yielding Material Description >	Type 4 - General Composite	EF11 [psi]	EF22 [psi]	VF12 [-]	VF23 [-]	GF12 [psi]
9	< Enter Non-Yielding Material Description >	Type 5 - Standard Composite	Fiber			Matrix	

X3 [in/in]	Y3 [psi]	X4 [in/in]	Y4 [psi]	X5 [in/in]	Y5 [psi]	ALP [in/in/°F]			
X3 [in/in]	Y3 [psi]	X4 [in/in]	Y4 [psi]	X5 [in/in]	Y5 [psi]	ALP [in/in/°F]			
X3 [in/in]	Y3 [psi]	X4 [in/in]	Y4 [psi]	X5 [in/in]	Y5 [psi]	ALP [in/in/°F]			
PRHR [-]	ALPM [in/in/°F]	ALPH [in/in/°F]	ALPR [in/in/°F]						
PRHR [-]	ALPM [in/in/°F]	ALPH [in/in/°F]	ALPR [in/in/°F]						
GF23 [psi]	ALPF11 [in/in/°F]	ALPF22 [in/in/°F]	EM [psi]	VM [-]	GM [psi]	ALPM [in/in/°F]	WA [°]	FVF [-]	VVF [-]
	WA [°]	FVF [-]	VVF [-]						

5.2.1 Field – MT

The number associated with each material type. The number is automatically assigned based on the predefined number of material types.

5.2.2 Field – Material Description

The material description to be applied to each material type. The description is a text string used for identification only. When the tab is first loaded or updated, the initial string will not identify whether the material type has been reserved as a yielding liner or non-yielding material type.

5.2.3 Field – Material Model

The material model to be used for each material type. The cell contains a pull-down list of the available material models. If the material type is reserved for yielding liner materials the pull-down will contain Type 2 and Type 3 models. If the material type is reserved for non-yielding materials the pull-down will contain Type 1, Type 4, and Type 5 models. Selecting a material model will alter the subsequent column field to the input parameters required for that material model.

5.2.4 Material Model – Type 1 Fields

The material model is a generic non-yielding material. The following fields are required for material types using the Type 1 material model. The fields are listed in the order they appear from left to right.

5.2.4.1 Field – EM [psi]

The meridional modulus in units of psi.

5.2.4.2 Field – EH [psi]

The hoop modulus in units of psi.

5.2.4.3 Field – ER [psi]
The radial modulus in units of psi.

5.2.4.4 Field – PRMH [-]
The meridional-hoop Poisson's Ratio.

5.2.4.5 Field – PRMR [-]
The meridional-radial Poisson's Ratio.

5.2.4.6 Field – PRHR [-]
The hoop-radial Poisson's Ratio.

5.2.4.7 Field – ALPM [in/in/°F]
The meridional coefficient of thermal expansion in units of in/in/°F.

5.2.4.8 Field – ALPH [in/in/°F]
The hoop coefficient of thermal expansion in units of in/in/°F.

5.2.4.9 Field – ALPR [in/in/°F]
The radial coefficient of thermal expansion in units of in/in/°F.

5.2.5 Material Model – Type 2 Fields
The material model is a yielding liner material based on a multi-linear stress/strain curve. The following fields are required for material types using the Type 2 material model. The fields are listed in the order they appear from left to right.

5.2.5.1 Field – NSEG
The number of points to be included in the multi-linear curve. The subsequent fields allow up to five (5) sets of point data to be entered. During program execution only the points defined by this field will be used. Excess point data beyond the defined number of points will be ignored.

5.2.5.2 Fields – X1 [in/in], X2 [in/in], X3 [in/in], X4 [in/in], X5 [in/in]
The strain value in units of in/in. Each subsequent number is associated with the point set data, i.e. X1 is for point set 1, X2 is for point set 2.

5.2.5.3 Fields – Y1 [psi], Y2 [psi], Y3 [psi], Y4 [psi], Y5 [psi]
The stress value in units of in/in. Each subsequent number is associated with the point set data, i.e. Y1 is for point set 1, Y2 is for point set 2.

5.2.5.4 Field – ALP [in/in/°F]
The coefficient of thermal expansion in units of in/in/°F.

5.2.6 Material Model – Type 3 Fields

The material model is a yielding liner material based on a Ramberg-Osgood stress/strain curve. The following fields are required for material types using the Type 3 material model. The fields are listed in the order they appear from left to right.

5.2.6.1 Field – E1 [psi]

The extensional modulus in units of psi.

5.2.6.2 Field – SZ

The SZ (σ_0) Ramberg-Osgood parameter.

5.2.6.3 Field – n

The n (exponent) Ramberg-Osgood parameter.

5.2.6.4 Field – k

The k (multiplier) Ramberg-Osgood parameter.

5.2.6.5 Field – ALP [in/in/°F]

The coefficient of thermal expansion in units of in/in/°F.

5.2.7 Material Model – Type 4 Fields

The material model is a non-yielding general composite material. The following fields are required for material types using the Type 4 material model. The fields are listed in the order they appear from left to right.

5.2.7.1 Field – EF11 [psi]

The longitudinal fiber modulus in units of psi.

5.2.7.2 Field – EF22 [psi]

The transverse fiber modulus in units of psi.

5.2.7.3 Field – VF12 [-]

The longitudinal-transverse Poisson's Ratio.

5.2.7.4 Field – VF23 [-]

The transverse-transverse Poisson's Ratio.

5.2.7.5 Field – GF12 [psi]

The longitudinal-transverse shear modulus in units of psi.

5.2.7.6 Field – GF23 [psi]

The transverse-transverse shear modulus in units of psi.

5.2.7.7 Field – ALP11 [in/in/°F]
The longitudinal fiber coefficient of thermal expansion in units of in/in/°F.

5.2.7.8 Field – ALP22 [in/in/°F]
The transverse fiber coefficient of thermal expansion in units of in/in/°F.

5.2.7.9 Field – EM [psi]
The matrix modulus in units of psi.

5.2.7.10 Field – VM [-]
The matrix Poisson's Ratio.

5.2.7.11 Field – GM [psi]
The matrix shear modulus in units of psi.

5.2.7.12 Field – ALPM [in/in/°F]
The matrix coefficient of thermal expansion in units of in/in/°F.

5.2.7.13 Field – WA [°]
The wind angle in units of degrees.

5.2.7.14 Field – FVF [-]
The fiber volume fraction in decimal form (for 60% fiber volume enter 0.60).

5.2.7.15 Field – VVF [-]
The void volume fraction in decimal form (for 3% fiber volume enter 0.03).

5.2.8 Material Model – Type 5 Fields
The material model is a non-yielding standard composite material. The model uses predefined fiber and resin materials with standardized material properties. The following fields are required for material types using the Type 5 material model. The fields are listed in the order they appear from left to right.

5.2.8.1 Field – Fiber
The fiber to be used for the layer. The cell contains a pulldown list of all available fibers. The list is populated from the NCFIB.txt file every time the GUI is updated.

5.2.8.2 Field – Matrix
The matrix to be used for the layer. The cell contains a pulldown list of all available matrices. The list is populated from the NCRES.txt file every time the GUI is updated.

5.2.8.3 Field – WA [°]

The wind angle in units of degrees.

5.2.8.4 Field – FVF [-]

The fiber volume fraction in decimal form (for 60% fiber volume enter 0.60).

5.2.8.5 Field – VVF [-]

The void volume fraction in decimal form (for 3% fiber volume enter 0.03).

5.3 Layers Tab

This tab contains the layer definition to be used in the model. The user enters the individual material type and thickness for each layer. The number of layers defined is set based on the inputs from the Settings tab. The tab is setup with each layer getting its own row.

The tab structure is shown below.

Layer Data					
			Number of Layers	9	
			Cylinder Inside Radius	5.0000	[inch]
			Cylinder Outside Radius	5.0000	[inch]
			Total Cylinder Thickness	0.0000	[inch]
Layer Number (LN)	Material Number (MT)	Material Description	Layer Thickness (TL) [inch]	Inside Radius [inch]	Outside Radius [inch]
1	1	< Enter Yielding Liner Material Description >		5.0000	5.0000
2	2	< Enter Yielding Liner Material Description >		5.0000	5.0000
3	3	< Enter Yielding Liner Material Description >		5.0000	5.0000
4	4	< Enter Yielding Liner Material Description >		5.0000	5.0000
5	5	< Enter Yielding Liner Material Description >		5.0000	5.0000
6		#N/A		5.0000	5.0000
7		#N/A		5.0000	5.0000
8		#N/A		5.0000	5.0000
9		#N/A		5.0000	5.0000

5.3.1 Field – Layer Number (LN)

The number associated with each layer. The number is automatically assigned based on the predefined number of layers.

5.3.2 Field – Material Number (MT)

The material type number associated with each layer. Yielding liner layers will have the material type number automatically assigned. Non-yielding layers will have an in-cell pulldown that lists all the non-yielding material type numbers defined on the Materials tab.

5.3.3 Field – Material Description

The material description associated with the material type number assigned to each layer. The Field will be automatically filled based on the description entered on the Materials tab.

5.3.4 Field – Layer Thickness (TL)

The thickness of each layer in units of inch.

5.3.5 Field – Number of Layers

The number of layers in the model. Value is automatically assigned based on the Settings tab properties.

5.3.6 Field – Cylinder Inside Radius

The inside radius of the model. Value is automatically assigned based on the Settings tab value.

5.3.7 Field – Cylinder Outside Radius

The outside radius of the model. Value is automatically calculated based on the cylinder inside radius and the defined layer thicknesses.

5.3.8 Field – Inside Radius

The inside radius of each layer. Value is automatically calculated based on the cylinder inside radius and the defined layer thicknesses.

5.3.9 Field – Outside Radius

The outside radius of each layer. Value is automatically calculated based on the cylinder inside radius and the defined layer thicknesses.

5.4 Loading Tab

This tab contains the definition of the load steps and their associated loads. The user enters the user enters the loads associated with each step. The number of load steps is set based on the inputs from the Settings tab. The tab is setup with each load step in a separate column.

The tab structure is shown below.

Loading Data					
	Load Step	1	2	3	4
	Description				
	PI [psi]				
	PO [psi]				
	Load Step Indicator (LSI)				
Node	Location	T [°F]			
1	Inside Layer 1				
2	Outside Layer 1 / Inside Layer 2				
3	Outside Layer 2 / Inside Layer 3				
4	Outside Layer 3 / Inside Layer 4				
5	Outside Layer 4 / Inside Layer 5				
6	Outside Layer 5 / Inside Layer 6				
7	Outside Layer 6 / Inside Layer 7				
8	Outside Layer 7 / Inside Layer 8				
9	Outside Layer 8 / Inside Layer 9				
10	Outside Layer 9				

5.4.1 Field – Load Step

The number associated with each load step. The number is automatically assigned based on the predefined number of load steps.

5.4.2 Field – Description

The user defined description associated with each load step.

5.4.3 Field – PI [psi]

The pressure in units of psi applied to the inside radius for each load step.

5.4.4 Field – PO [psi]

The pressure in units of psi applied to the outside radius for each load step.

5.4.5 Field – Load Step Indicator (LSI)

The load step type associated with each load step. The cell contains a pulldown list with seven (7) options to pick from.

5.4.5.1 Field – Load Step Indicator – 1 = Increase

Indicates the load step is increasing load prior to reaching autofrettage pressure. If only temperatures are evaluated, label each step as this option.

5.4.5.2 Field – Load Step Indicator – 2 = Autofrettage

Indicates the load step is the autofrettage pressure.

5.4.5.3 Field – Load Step Indicator – 3 = Decrease

Indicates the load step is decreasing load after reaching autofrettage pressure.

5.4.5.4 Field – Load Step Indicator – 4 = Zero

Indicates the load step is zero load, or unloaded, after reaching autofrettage pressure. If zero pressure is used when there is not a thermal stress or a stress due to liner yielding, the matrix solver will have an indeterminate solution (division by zero), and the program will stop.

5.4.5.5 Field – Load Step Indicator – 5 = Increase

Indicates the load step is increasing load after reaching autofrettage pressure and returning to zero load.

5.4.5.6 Field – Load Step Indicator – 6 = Burst

Indicates the load step is at burst pressure, which could be on an initial pressurization or after reaching autofrettage pressure and returning to zero load.

5.4.5.7 Field – Load Step Indicator – 7 = Increase Above Burst

Indicates the load step is at pressure above the burst pressure.

5.4.6 Field – Node

The number associated with each layer's surface, inside and outside. The number is automatically assigned based on the predefined number of layers.

5.4.7 Field – Location

The description assigned to each node. The description is automatically assigned based on the predefined number of layers.

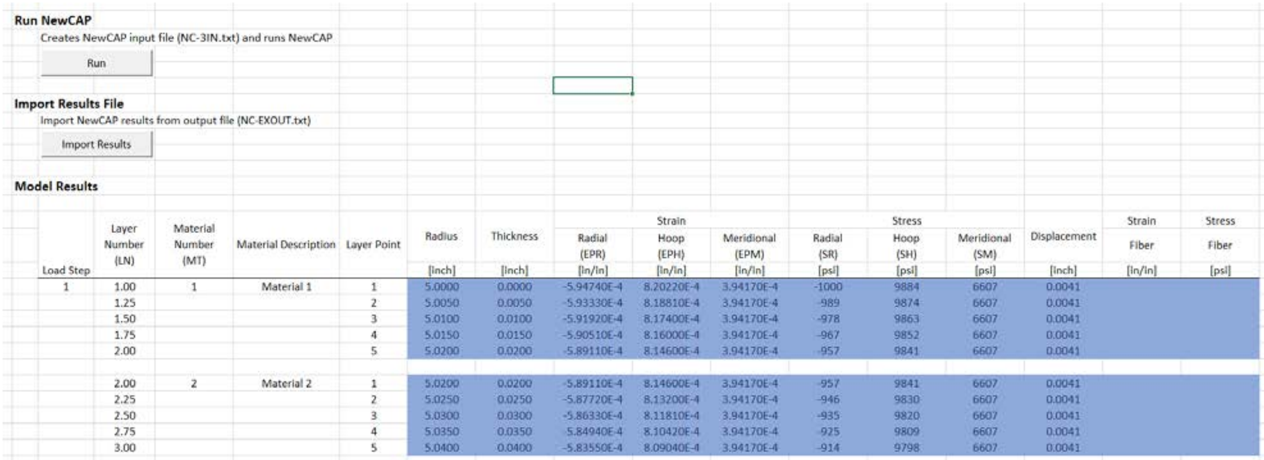
5.4.8 Field – T [°F]

The temperature in units of °F at each node and at each load step. Each column defines the node temperatures for the associated load step.

5.5 Results Tab

This tab contains the buttons for running NewCAP and importing the results for viewing.

The tab structure is shown below.



Run NewCAP

Creates NewCAP input file (NC-3IN.txt) and runs NewCAP

Run

Import Results File

Import NewCAP results from output file (NC-EXOUT.txt)

Import Results

Model Results

Load Step	Layer Number (LN)	Material Number (MT)	Material Description	Layer Point	Radius [inch]	Thickness [inch]	Strain Radial (EPR) [in/in]	Strain Hoop (EPH) [in/in]	Strain Meridional (EPM) [in/in]	Stress Radial (SR) [psi]	Stress Hoop (SH) [psi]	Stress Meridional (SM) [psi]	Displacement [inch]	Strain Fiber [in/in]	Stress Fiber [psi]
1	1.00	1	Material 1	1	5.0000	0.0000	-5.94740E-4	8.20220E-4	3.94170E-4	-1000	9884	6607	0.0041		
	1.25			2	5.0050	0.0050	-5.93330E-4	8.18810E-4	3.94170E-4	-989	9874	6607	0.0041		
	1.50			3	5.0100	0.0100	-5.91920E-4	8.17400E-4	3.94170E-4	-978	9863	6607	0.0041		
	1.75			4	5.0150	0.0150	-5.90510E-4	8.16000E-4	3.94170E-4	-967	9852	6607	0.0041		
	2.00			5	5.0200	0.0200	-5.89110E-4	8.14600E-4	3.94170E-4	-957	9841	6607	0.0041		
	2.00	2	Material 2	1	5.0200	0.0200	-5.89110E-4	8.14600E-4	3.94170E-4	-957	9841	6607	0.0041		
	2.25			2	5.0250	0.0250	-5.87720E-4	8.13200E-4	3.94170E-4	-946	9830	6607	0.0041		
	2.50			3	5.0300	0.0300	-5.86330E-4	8.11810E-4	3.94170E-4	-935	9820	6607	0.0041		
	2.75			4	5.0350	0.0350	5.84940E-4	8.10420E-4	3.94170E-4	-925	9809	6607	0.0041		
	3.00			5	5.0400	0.0400	-5.83550E-4	8.09040E-4	3.94170E-4	-914	9798	6607	0.0041		

5.5.1 Button – Run

The button generates the NewCAP input file have on the data entered on the Settings, Materials, Layers, and Loading tabs. The input file is named NC-3IN.txt. A copy is also created with a date and time added to the name for future reference. After creating the input file, NewCAP is run using this file. NewCAP will create output files named NC-OUTPUT.txt and NC-EXOUT.txt.

5.5.2 Button – Import Results

The button imports the results in NC-EXOUT.txt into the Results tab.

5.5.3 Field – Load Step

The load step number associated with each result.

5.5.4 Field – Layer Number (LN)

The layer number associated with each result. Intermediate layer points are shown as fractional layer numbers.

5.5.5 Field – Material Number (MT)

The material type number associated with each result.

5.5.6 Field – Material Description

The material description associated with each material number.

5.5.7 Field – Layer Point

The intermediate layer point number associated with each result.

5.5.8 Field – Radius

The radius associated with each result.

5.5.9 Field – Thickness
The thickness associated with each result.

5.5.10 Field – Strain – Radial (EPR)
The radial strain associated with each result in units of in/in.

5.5.11 Field – Strain – Hoop (EPH)
The hoop strain associated with each result in units of in/in.

5.5.12 Field – Strain – Meridional (EPM)
The meridional strain associated with each result in units of in/in.

5.5.13 Field – Stress – Radial (SR)
The radial stress associated with each result in units of psi.

5.5.14 Field – Stress – Hoop (SH)
The hoop stress associated with each result in units of psi.

5.5.15 Field – Stress – Meridional (SM)
The meridional stress associated with each result in units of psi.

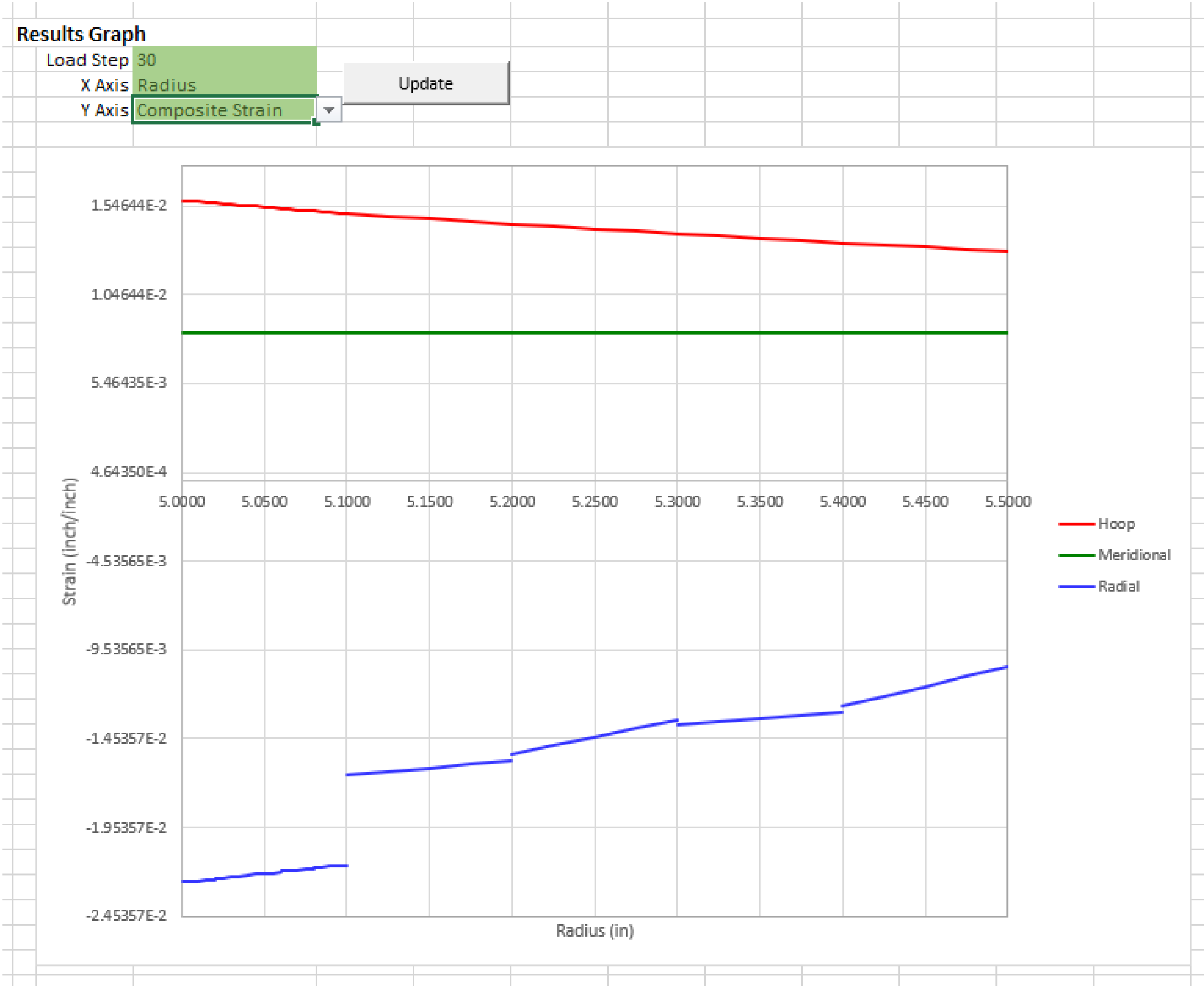
5.5.16 Field – Displacement
The radial displacement associated with each result in units of inch.

5.5.17 Field – Strain – Fiber
The fiber strain associated with each result in units of in/in. Values will only be calculated for Type 4 and Type 5 materials.

5.5.18 Field – Stress – Fiber
The fiber stress associated with each result in units of psi. Values will only be calculated for Type 4 and Type 5 materials.

5.6 Graph Tab
This tab plots the results found on the Results tab.

The tab structure is shown below.



5.6.1 Field – Load Step

The load step to be plotted in the graph. The cell contains a pulldown menu with all available load steps.

5.6.2 Field – X Axis

The results data to be plotted along the x axis in the graph. The cell contains a pulldown menu with the following options,

- Layer Number
- Radius
- Thickness

5.6.3 Field – Y Axis

The results data to be plotted along the y axis in the graph. The cell contains a pulldown menu with the following options,

- Composite Strain
- Composite Stress
- Fiber Strain
- Fiber Stress

5.6.4 Button – Update

The button updates the graph based on the selections in the Load Step, X Axis, and Y Axis fields.

6 Running NewCAP

This section outlines the general steps necessary to execute NewCAP.

6.1 Using the GUI

The following outline walks through running NewCAP through the Excel file GUI.

1. Open an Excel GUI file from the folder the program is located in.
2. If not already selected, select the Setup tab.
3. Fill out all required fields on the Setup tab.
    a. Enter a new file name in the File Name field if you want to create a new Excel file to save these inputs.
    b. Enter a description for this analysis in the File Description (DESC) field.
    c. Enter the inside radius of the cylinder in the Inside Radius (RIN) field.
    d. Select "Yes" or "No" in the Include Yielding Liner field to designate of a yielding liner material will be used.
    e. If a yielding liner is to be used, enter the number of layers to divide the liner into in the Number of Liner Layers field.
    f. Enter the number of non-yielding layers to be include in the model in the Number of Non-Yielding Layers field.
    g. Enter the number of non-yielding material types to be include in the model in the Number of Non-Yielding Material Types field.
    h. Enter the number of load steps to be used the Number of Load Steps (NLS) field.
    i. Enter the number of intermediate points to be used in each layer in the Intermediate Points per Layer (ISPL) field.
    j. The Control Parameter (ICON) field is normally left at "0".
    k. Select "0" or "1" in the Print Control (IPO) field to designate if stiffness and force matrices should be printed in the output.
4. If the new file name is to be used select the Start button. To proceed without renaming the file select the Update button. The additional input tabs will be exposed and formatted based on the above inputs.
    a. If a previous run is to be imported, enter the file name into the File Name field adjacent to the Import button and select the Import button. The Setup tab and all other input tabs will be filled out according to the input file.
    b. If the Excel form needs to be reset, select the Reset button. All other input tabs will be hidden, and the Setup tab will be reset to the starting conditions.
5. Select the Material tab.
6. Fill out the required fields for each material type on the Materials tab.
    a. Enter a description for the material type in the Material Description field.
    b. Select the material model to be used in the Material Model field.
    c. Enter all subsequently required material properties in the Input fields. Input requirements change based on the material model selected.
7. Select the Layers tab.
8. Fill out the required fields for each layer on the Layers tab.

    a. For non-yielding layers only, select the material type number to be used for that layer in the Material Number (MT) field.
    b. Enter the layer thickness in the Layer Thickness (TL) field. Note that the liner will be divided into a minimum 5 sub layers. The liner thickness will need to be divided accordingly.
9. Select the Loading tab.
10. Fill out the required fields for each load step on the Loading tab. It is assumed that the cylinder pressure is initially at zero but does not calculate at that point.
    a. Enter a description for the load step in the Description field.
    b. Enter the internal pressure to be used for the load step in the PI field.
    c. Enter the external pressure to be used for the load step in the PO field.
    d. Select the type of load step from the Load Step Indicator (LSI) field.
    e. Enter the temperatures for each layer surface in the T fields. If temperature will not be used, enter all zero values.
11. Select the Results tab.
12. Select the Run button. The NewCAP input files will be created in the working folder and NewCAP will be executed. When execution has concluded, output files will be created in the working folder containing the results.
13. Select the Import Results button. The primary results from the output file will be read into the Results tab. Results values can be reviewed within the Results tab. The output files can be manually viewed for additional information.
14. Select the Graph tab (optional).
15. Select the information to be plotted in the graph.
    a. Select the load step to be plotted in the Load Step field
    b. Select the value to be plotted on the x-axis in the X Axis field.
    c. Select the value to be plotted on the y-axis in the Y Axis field.
16. Select the Update button to refresh the graph.

6.2 Running Manually

The following outline walks through running NewCAP manually.

1. Manually create the input file. See section above for file name requirements. For aid in properly formatting the file, see the input guidelines provided in the Appendix. Input is either alphanumeric for descriptions, or free format for numbers. Real numbers, for example, are input as 1234.5 or 1.2345e3 (Excel) or 1.2345d3 (when running the program without Excel).
2. Place the input file in the working folder with the NewCAP executable.
3. Execute the NewCAP application via double clicking or command line.
4. View the results in the output files. See section above for output file names.

Annex D. Verification using Closed Form Analysis

Report – Task 2.1 Verification – Comparison with closed form analysis

Project Title: Composite Cylinder Stress Analysis Software Development and Validation

Project Period: 30 September 2018 – 29 September 2020

Date of Report: 12 February 2020

Contract Number: 693JK318C000008
Contractor: Newhouse Technology, LLC
Norman L. Newhouse, Ph.D., P.E.
Cell: 402-432-8700
6521 Perry Circle, Lincoln, NE 68516
newhousetech@windstream.net

Contract Specialist: Mr. Ben Patterson; Ben.Patterson@dot.gov
Contracting Officer's Representative: Ms. Andrea Smith; andrea.smith@dot.gov

Discussion: This report discusses specific examples used to verify NewCAP. There are three examples using a metal cylinder for which closed form solutions exist. Two examples compare with a computer program that was previously developed. Other verification examples are evaluated for consistency of results. A synopsis of verification runs follows.

- Verification 1: aluminum cylinder with internal pressure, results match closed form solutions
- Verification 2: aluminum cylinder with temperature change
- Verification 3: composite cylinder with pressure steps
- Verification 4: metal lined composite cylinder with pressure steps
- Verification 5: metal lined composite cylinder with high pressure steps
- Verification 6: aluminum cylinder with internal pressure, multi-layer, matching prior results
- Verification 7: metal lined composite cylinder with pressure and temperature
- Verification 8: composite cylinder with pressure, compare with prior computer program
- Verification 9: composite cylinder with temperature change, compare with prior computer program
- Verification 10: metal lined composite cylinder, compare three runs addressing a correlation factor

Detailed discussion is on the following pages. The discussion is followed by the respective output file(s), then by the respective input file.

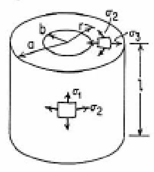
Conclusion: Results from NewCAP have been verified by matching closed form and other analysis methods and/or are showing consistent results. This leads to the conclusion that the NewCAP software program is accurate and running as expected.

Verification 1: aluminum cylinder with internal pressure, results match closed form solutions

An aluminum cylinder containing an internal pressure of 2000 psi is analyzed. The closed form solution is taken from Roark, 6th edition, as follows:

TABLE 32 Formulas for thick-walled vessels under internal and external loading

NOTATION: q = unit pressure (force per unit area); δ and δ_b = radial body forces (force per unit volume); a = outer radius; b = inner radius; σ_1, σ_2, and σ_3 are normal stresses in the longitudinal, circumferential, and radial directions, respectively (positive when tensile); E = modulus of elasticity; ν = Poisson's ratio. Δa, Δb, and Δl are the changes in the radii a and b and in the length l, respectively. ε_1 = unit normal strain in the longitudinal direction

Case no., form of vessel	Case no., manner of loading	Formulas
1. Cylindrical disk or shell 	1a. Uniform internal radial pressure q, longitudinal pressure zero or externally balanced; for a disk or a shell	$\sigma_1 = 0$ $\sigma_2 = \frac{qb^2(a^2 + r^2)}{r^2(a^2 - b^2)}$ max $\sigma_2 = q\frac{a^2 + b^2}{a^2 - b^2}$ at $r = b$ $\sigma_3 = \frac{-qb^2(a^2 - r^2)}{r^2(a^2 - b^2)}$ max $\sigma_3 = -q$ at $r = b$ Max shear stress $= \frac{\sigma_2 - \sigma_3}{2} = q\frac{a^2}{a^2 - b^2}$ at $r = b$ $\Delta a = \frac{q}{E}\frac{2ab^2}{a^2 - b^2}$ $\Delta b = \frac{qb}{E}\left(\frac{a^2 + b^2}{a^2 - b^2} + \nu\right)$ $\Delta l = \frac{-q\nu l}{E}\frac{2b^2}{a^2 - b^2}$
	1b. Uniform internal pressure q, in all directions; ends capped; for a disk or a shell	$\sigma_1 = \frac{qb^2}{a^2 - b^2}$ (σ_2, σ_3, and the max shear stress are the same as for case 1a) $\Delta a = \frac{qa}{E}\frac{b^2(2 - \nu)}{a^2 - b^2}$ $\Delta b = \frac{qb}{E}\frac{a^2(1 + \nu) + b^2(1 - 2\nu)}{a^2 - b^2}$ $\Delta l = \frac{ql}{E}\frac{b^2(1 - 2\nu)}{a^2 - b^2}$

638 Formulas for Stress and Strain

The equations were programmed into Excel, with the following results:

1 Roark 6th p.638 Table 32 Case 1b

				sig1	sig2	sig3
a	10	r				
b	5		5	666.666667	3333.33333	-2000
q	2000		6	666.666667	2518.51852	-1185.1852
E	10000000		7	666.666667	2027.21088	-693.87755
pr	0.3		8	666.666667	1708.33333	-375
l	10		9	666.666667	1489.71193	-156.3786
			10	666.666667	1333.33333	0

delta-a	delta-b	delta-l
0.001133	0.001867	0.000267

The following page contains the results of the NewCAP analysis of the same cylinder. Note that:

- The results at 2000 psi match the results from the Roark/Excel analysis
- The results at 1000 psi are 1/2 the results at 2000 psi
- The radial stress at the inner and outer surface match the pressure conditions
- The axial stress and strain are constant across the cross-section

-->NewCAP<-- LAST MODIFIED 3JAN2020 VERSION 1a

Ver1 - Internal Pressure, Aluminum

RI= 5.0000 NL= 1 NMT= 1 NLS= 2 ISPL= 9 IPO= 0

* MATERIAL MODEL 1 - GENERAL PROPERTIES

MT	EM	EH	ER	PRMH	PRMR	PRHR	PRHM	PRRM	PRRH	N
1	0.1000D+08	0.1000D+08	0.1000D+08	0.3000D+00	0.3000D+00	0.3000D+00	0.3000D+00	0.3000D+00	0.3000D+00	0.1000D+01

MT	ALPM	ALPH	ALPR
1	0.1310D-04	0.1310D-04	0.1310D-04

LN	MT	TL	NODE	TEMP	
1	1	5.0000	1	0.00	0.00
			2	0.00	0.00

STEP DESCRIPTION	PI	PO
1000 psi	1000.000	0.000
2000 psi	2000.000	0.000

@ 1000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	-0.16000D-03	0.18667D-03	0.13333D-04	-0.10000D+04	0.16667D+04	0.33333D+03	0.93333D-03	0.78540D+05
		5.500	-0.12992D-03	0.15658D-03	0.13333D-04	-0.76860D+03	0.14353D+04	0.33333D+03	0.86121D-03	
		6.000	-0.10704D-03	0.13370D-03	0.13333D-04	-0.59259D+03	0.12593D+04	0.33333D+03	0.80222D-03	
		6.500	-0.89231D-04	0.11590D-03	0.13333D-04	-0.45562D+03	0.11223D+04	0.33333D+03	0.75333D-03	
		7.000	-0.75102D-04	0.10177D-03	0.13333D-04	-0.34694D+03	0.10136D+04	0.33333D+03	0.71238D-03	
		7.500	-0.63704D-04	0.90370D-04	0.13333D-04	-0.25926D+03	0.92593D+03	0.33333D+03	0.67778D-03	
		8.000	-0.54375D-04	0.81042D-04	0.13333D-04	-0.18750D+03	0.85417D+03	0.33333D+03	0.64833D-03	
		8.500	-0.46644D-04	0.73310D-04	0.13333D-04	-0.12803D+03	0.79469D+03	0.33333D+03	0.62314D-03	
		9.000	-0.40165D-04	0.66831D-04	0.13333D-04	-0.78189D+02	0.74486D+03	0.33333D+03	0.60148D-03	
		9.500	-0.34681D-04	0.61348D-04	0.13333D-04	-0.36011D+02	0.70268D+03	0.33333D+03	0.58281D-03	
		10.000	-0.30000D-04	0.56667D-04	0.13333D-04	0.15632D-12	0.66667D+03	0.33333D+03	0.56667D-03	

@ 2000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	-0.32000D-03	0.37333D-03	0.26667D-04	-0.20000D+04	0.33333D+04	0.66667D+03	0.18667D-02	0.15708D+06
		5.500	-0.25983D-03	0.31317D-03	0.26667D-04	-0.15372D+04	0.28705D+04	0.66667D+03	0.17224D-02	
		6.000	-0.21407D-03	0.26741D-03	0.26667D-04	-0.11852D+04	0.25185D+04	0.66667D+03	0.16044D-02	
		6.500	-0.17846D-03	0.23179D-03	0.26667D-04	-0.91124D+03	0.22446D+04	0.66667D+03	0.15067D-02	
		7.000	-0.15020D-03	0.20354D-03	0.26667D-04	-0.69388D+03	0.20272D+04	0.66667D+03	0.14248D-02	
		7.500	-0.12741D-03	0.18074D-03	0.26667D-04	-0.51852D+03	0.18519D+04	0.66667D+03	0.13556D-02	
		8.000	-0.10875D-03	0.16208D-03	0.26667D-04	-0.37500D+03	0.17083D+04	0.66667D+03	0.12967D-02	
		8.500	-0.93287D-04	0.14662D-03	0.26667D-04	-0.25606D+03	0.15894D+04	0.66667D+03	0.12463D-02	
		9.000	-0.80329D-04	0.13366D-03	0.26667D-04	-0.15638D+03	0.14897D+04	0.66667D+03	0.12030D-02	
		9.500	-0.69363D-04	0.12270D-03	0.26667D-04	-0.72022D+02	0.14054D+04	0.66667D+03	0.11656D-02	
		10.000	-0.60000D-04	0.11333D-03	0.26667D-04	0.31264D-12	0.13333D+04	0.66667D+03	0.11333D-02	

STEP	DESCRIPTION	STRESS RATIO
1	1000 psi	2.000
2	2000 psi	1.000

```
Ver1 - Internal Pressure, Aluminum
5.,1,1,2,9,0
1,1
10.d6,10.d6,10.d6,.3,.3,.3
13.1d-6,13.1d-6,13.1d-6
1,1,5.0
1000 psi
1000.,0.
2000 psi
2000.,0.
0,0
```

Verification 2: aluminum cylinder with temperature change

An aluminum cylinder with no internal pressure, subjected to a 100F temperature increase is analyzed.

The following page contains the results of the NewCAP analysis of the same cylinder. Note that:

- The strains reflect the temperature increase times the coefficient of thermal expansion
- The radial deflection represents the strain times the diameter
- The stresses are zero, considering significant figures

```
   -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
                COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020



 Ver2 - 100F temperature increase, Aluminum



 RI=  5.0000     NL=  1     NMT=  1     NLS=  1     ISPL=  9     IPO= 0



 * MATERIAL MODEL 1 - GENERAL PROPERTIES
 MT       EM           EH           ER          PRMH         PRMR         PRHR         PRHM         PRRM         PRRH           N

  1   0.1000D+08   0.1000D+08   0.1000D+08   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.1000D+01


   MT      ALPM         ALPH         ALPR

    1   0.1310D-04   0.1310D-04   0.1310D-04


   LN  MT   TL        NODE    TEMP

    1   1   5.0000       1100.00
                         2100.00

 STEP DESCRIPTION          PI          PO
 100F                       0.000       0.000


@ 100F
  LN  MT    R         EPR           EPH           EPM            SR            SH            SM            U            AF

    1   1  5.000   0.13100D-02   0.13100D-02   0.13100D-02  -0.20850D-10   0.55878D-10  -0.25020D-11   0.65500D-02  -0.29258D-08
           5.500   0.13100D-02   0.13100D-02   0.13100D-02  -0.14178D-10   0.49206D-10  -0.25020D-11   0.72050D-02
           6.000   0.13100D-02   0.13100D-02   0.13100D-02  -0.91740D-11   0.44202D-10  -0.25020D-11   0.78600D-02
           6.500   0.13100D-02   0.13100D-02   0.13100D-02  -0.41700D-11   0.39198D-10  -0.25020D-11   0.85150D-02
           7.000   0.13100D-02   0.13100D-02   0.13100D-02  -0.25020D-11   0.37530D-10  -0.25020D-11   0.91700D-02
           7.500   0.13100D-02   0.13100D-02   0.13100D-02   0.83400D-12   0.34194D-10  -0.25020D-11   0.98250D-02
           8.000   0.13100D-02   0.13100D-02   0.13100D-02   0.25020D-11   0.32526D-10  -0.25020D-11   0.10480D-01
           8.500   0.13100D-02   0.13100D-02   0.13100D-02   0.41700D-11   0.30858D-10  -0.25020D-11   0.11135D-01
           9.000   0.13100D-02   0.13100D-02   0.13100D-02   0.10008D-10   0.33360D-10   0.32312D-26   0.11790D-01
           9.500   0.13100D-02   0.13100D-02   0.13100D-02   0.75060D-11   0.27522D-10  -0.25020D-11   0.12445D-01
          10.000   0.13100D-02   0.13100D-02   0.13100D-02   0.75060D-11   0.27522D-10  -0.25020D-11   0.13100D-01
  STEP  DESCRIPTION          STRESS RATIO
     1    100F                 ********
```

```
Ver2 - 100F temperature increase, Aluminum
5.,1,1,1,9,0
1,1
10.d6,10.d6,10.d6,.3,.3,.3
13.1d-6,13.1d-6,13.1d-6
1,1,5.0
100F
0.,0.
100,100
```

Verification 3: composite cylinder with pressure steps

A composite cylinder with internal pressure.

The following pages contains the results of the NewCAP analysis of the cylinder. Note that:

- The composite properties are not affected by stress level, and therefore note that the stresses and strains at any two pressures are related by their relative pressure ratios
- The radial stresses at the surfaces are equal to the respective applied pressure
- The radial stress at the outer surface of one layer is equal to the radial stress at the inner surface of the next layer
- The meridional strains are constant across the cross-section
- The stress ratios reflect the pressure ratios, given that the composite properties are not affected by stress level

```
  -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
             COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020



Ver3 - pressure steps, composite



RI=  5.0000    NL=  4    NMT=  4    NLS=  7    ISPL=  9    IPO= 0



* MATERIAL MODEL 1 - GENERAL PROPERTIES
MT      EM           EH           ER          PRMH         PRMR         PRHR         PRHM         PRRM         PRRH          N

 1   0.5810D+07   0.1508D+07   0.2411D+07   0.1393D+01  -0.2390D+00   0.3436D+00   0.3616D+00  -0.9918D-01   0.5493D+00   0.1109D+01
 2   0.2228D+07   0.1938D+08   0.2228D+07   0.3481D-01   0.5195D+00   0.3029D+00   0.3028D+00   0.5195D+00   0.3482D-01   0.2533D+01


  MT      ALPM         ALPH         ALPR

   1  -0.4960D-05   0.1950D-04   0.2310D-04
   2   0.2000D-04   0.2000D-06   0.2000D-04


* MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES
MT        EF1          EF2          VF12         VF23         GF12         GF23          EM           VF           GM

 3   0.3200D+08   0.3200D+08   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1860D+06
 4   0.3200D+08   0.3200D+08   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1860D+06

MT      ALP1         ALP2         ALP3          WA           FVF          VVF

 3   0.1100D-05   0.5000D-05   0.5000D-05   0.3000D+02   0.6000D+00   0.3000D-01
 4   0.1100D-05   0.5000D-05   0.5000D-05   0.9000D+02   0.6000D+00   0.3000D-01


  LN  MT   TL        NODE    TEMP

   1   1   0.1000       1  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   2   2   0.1000       2  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   3   3   0.1000       3  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   4   4   0.1000       4  0.00  0.00  0.00  0.00  0.00  0.00  0.00
                        5  0.00  0.00  0.00  0.00  0.00  0.00  0.00

STEP DESCRIPTION          PI          PO
1000 psi               1000.000       0.000
2000 psi               2000.000       0.000
5000 psi               5000.000       0.000
6000 psi               6000.000       0.000
7500 psi               7500.000       0.000
10000 psi             10000.000       0.000
12500 psi             12500.000       0.000


@ 1000 psi
  LN  MT    R         EPR           EPH           EPM           SR            SH            SM            U             AF

   1   1  5.000  -0.11512D-02   0.11067D-02   0.54089D-03  -0.10000D+04   0.51334D+04   0.10532D+05   0.55336D-02   0.33215D+05
          5.010  -0.11449D-02   0.11022D-02   0.54089D-03  -0.98777D+03   0.51261D+04   0.10519D+05   0.55221D-02
          5.020  -0.11388D-02   0.10977D-02   0.54089D-03  -0.97559D+03   0.51188D+04   0.10506D+05   0.55107D-02
          5.030  -0.11326D-02   0.10933D-02   0.54089D-03  -0.96348D+03   0.51116D+04   0.10493D+05   0.54993D-02
          5.040  -0.11265D-02   0.10889D-02   0.54089D-03  -0.95144D+03   0.51044D+04   0.10480D+05   0.54880D-02
          5.050  -0.11205D-02   0.10845D-02   0.54089D-03  -0.93945D+03   0.50973D+04   0.10468D+05   0.54768D-02
          5.060  -0.11145D-02   0.10802D-02   0.54089D-03  -0.92753D+03   0.50903D+04   0.10455D+05   0.54656D-02
          5.070  -0.11085D-02   0.10758D-02   0.54089D-03  -0.91567D+03   0.50833D+04   0.10442D+05   0.54545D-02
          5.080  -0.11025D-02   0.10715D-02   0.54089D-03  -0.90387D+03   0.50763D+04   0.10430D+05   0.54434D-02
          5.090  -0.10966D-02   0.10673D-02   0.54089D-03  -0.89212D+03   0.50695D+04   0.10418D+05   0.54324D-02
          5.100  -0.10907D-02   0.10630D-02   0.54089D-03  -0.88044D+03   0.50627D+04   0.10405D+05   0.54215D-02

   2   2  5.100  -0.10630D-02   0.10630D-02   0.54089D-03  -0.88044D+03   0.20780D+05   0.14711D+04   0.54215D-02   0.50769D+04
          5.110  -0.10476D-02   0.10589D-02   0.54089D-03  -0.83811D+03   0.20719D+05   0.14909D+04   0.54110D-02
          5.120  -0.10324D-02   0.10548D-02   0.54089D-03  -0.79607D+03   0.20658D+05   0.15107D+04   0.54006D-02
          5.130  -0.10173D-02   0.10507D-02   0.54089D-03  -0.75430D+03   0.20598D+05   0.15303D+04   0.53903D-02
          5.140  -0.10023D-02   0.10467D-02   0.54089D-03  -0.71282D+03   0.20539D+05   0.15498D+04   0.53802D-02
          5.150  -0.98742D-03   0.10428D-02   0.54089D-03  -0.67161D+03   0.20481D+05   0.15691D+04   0.53703D-02
          5.160  -0.97263D-03   0.10388D-02   0.54089D-03  -0.63067D+03   0.20423D+05   0.15884D+04   0.53605D-02
          5.170  -0.95795D-03   0.10350D-02   0.54089D-03  -0.59001D+03   0.20366D+05   0.16075D+04   0.53508D-02
          5.180  -0.94337D-03   0.10311D-02   0.54089D-03  -0.54961D+03   0.20310D+05   0.16266D+04   0.53413D-02
          5.190  -0.92890D-03   0.10273D-02   0.54089D-03  -0.50947D+03   0.20254D+05   0.16455D+04   0.53319D-02
          5.200  -0.91453D-03   0.10236D-02   0.54089D-03  -0.46959D+03   0.20199D+05   0.16643D+04   0.53227D-02

   3   3  5.200  -0.94012D-03   0.10236D-02   0.54089D-03  -0.46959D+03   0.51543D+04   0.10437D+05   0.53227D-02   0.34254D+05
          5.210  -0.93476D-03   0.10198D-02   0.54089D-03  -0.45880D+03   0.51485D+04   0.10426D+05   0.53134D-02
          5.220  -0.92942D-03   0.10161D-02   0.54089D-03  -0.44807D+03   0.51427D+04   0.10415D+05   0.53040D-02
          5.230  -0.92411D-03   0.10124D-02   0.54089D-03  -0.43738D+03   0.51370D+04   0.10405D+05   0.52948D-02
          5.240  -0.91883D-03   0.10087D-02   0.54089D-03  -0.42675D+03   0.51313D+04   0.10394D+05   0.52855D-02
          5.250  -0.91358D-03   0.10050D-02   0.54089D-03  -0.41617D+03   0.51256D+04   0.10384D+05   0.52764D-02
          5.260  -0.90836D-03   0.10014D-02   0.54089D-03  -0.40564D+03   0.51200D+04   0.10374D+05   0.52673D-02
          5.270  -0.90317D-03   0.99776D-03   0.54089D-03  -0.39516D+03   0.51144D+04   0.10363D+05   0.52582D-02
          5.280  -0.89800D-03   0.99417D-03   0.54089D-03  -0.38473D+03   0.51089D+04   0.10353D+05   0.52492D-02
          5.290  -0.89287D-03   0.99060D-03   0.54089D-03  -0.37435D+03   0.51034D+04   0.10343D+05   0.52403D-02
          5.300  -0.88776D-03   0.98705D-03   0.54089D-03  -0.36402D+03   0.50980D+04   0.10333D+05   0.52314D-02

   4   4  5.300  -0.86412D-03   0.98705D-03   0.54089D-03  -0.36402D+03   0.19537D+05   0.16960D+04   0.52314D-02   0.59945D+04
          5.310  -0.85066D-03   0.98357D-03   0.54089D-03  -0.32659D+03   0.19487D+05   0.17137D+04   0.52228D-02
          5.320  -0.83728D-03   0.98014D-03   0.54089D-03  -0.28939D+03   0.19437D+05   0.17312D+04   0.52143D-02
          5.330  -0.82400D-03   0.97674D-03   0.54089D-03  -0.25243D+03   0.19387D+05   0.17487D+04   0.52060D-02
          5.340  -0.81080D-03   0.97338D-03   0.54089D-03  -0.21570D+03   0.19339D+05   0.17661D+04   0.51979D-02
          5.350  -0.79770D-03   0.97006D-03   0.54089D-03  -0.17919D+03   0.19290D+05   0.17834D+04   0.51898D-02
          5.360  -0.78468D-03   0.96677D-03   0.54089D-03  -0.14291D+03   0.19243D+05   0.18006D+04   0.51819D-02
```

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
		5.370	−0.77175D−03	0.96352D−03	0.54089D−03	−0.10686D+03	0.19196D+05	0.18177D+04	0.51741D−02	
		5.380	−0.75891D−03	0.96031D−03	0.54089D−03	−0.71019D+02	0.19150D+05	0.18347D+04	0.51665D−02	
		5.390	−0.74615D−03	0.95713D−03	0.54089D−03	−0.35402D+02	0.19104D+05	0.18516D+04	0.51589D−02	
		5.400	−0.73348D−03	0.95399D−03	0.54089D−03	−0.51955D−10	0.19059D+05	0.18684D+04	0.51515D−02	

@ 2000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	−0.23023D−02	0.22134D−02	0.10818D−02	−0.20000D+04	0.10267D+05	0.21065D+05	0.11067D−01	0.66429D+05
		5.010	−0.22899D−02	0.22044D−02	0.10818D−02	−0.19755D+04	0.10252D+05	0.21039D+05	0.11044D−01	
		5.020	−0.22776D−02	0.21955D−02	0.10818D−02	−0.19512D+04	0.10238D+05	0.21012D+05	0.11021D−01	
		5.030	−0.22653D−02	0.21866D−02	0.10818D−02	−0.19270D+04	0.10223D+05	0.20987D+05	0.10999D−01	
		5.040	−0.22531D−02	0.21778D−02	0.10818D−02	−0.19029D+04	0.10209D+05	0.20961D+05	0.10976D−01	
		5.050	−0.22410D−02	0.21690D−02	0.10818D−02	−0.18789D+04	0.10195D+05	0.20935D+05	0.10954D−01	
		5.060	−0.22289D−02	0.21603D−02	0.10818D−02	−0.18551D+04	0.10181D+05	0.20910D+05	0.10931D−01	
		5.070	−0.22169D−02	0.21517D−02	0.10818D−02	−0.18313D+04	0.10167D+05	0.20885D+05	0.10909D−01	
		5.080	−0.22050D−02	0.21431D−02	0.10818D−02	−0.18077D+04	0.10153D+05	0.20860D+05	0.10887D−01	
		5.090	−0.21931D−02	0.21346D−02	0.10818D−02	−0.17842D+04	0.10139D+05	0.20835D+05	0.10865D−01	
		5.100	−0.21814D−02	0.21261D−02	0.10818D−02	−0.17609D+04	0.10125D+05	0.20811D+05	0.10843D−01	
2	2	5.100	−0.21259D−02	0.21261D−02	0.10818D−02	−0.17609D+04	0.41561D+05	0.29422D+04	0.10843D−01	0.10154D+05
		5.110	−0.20953D−02	0.21178D−02	0.10818D−02	−0.16762D+04	0.41438D+05	0.29819D+04	0.10822D−01	
		5.120	−0.20648D−02	0.21096D−02	0.10818D−02	−0.15921D+04	0.41316D+05	0.30213D+04	0.10801D−01	
		5.130	−0.20346D−02	0.21015D−02	0.10818D−02	−0.15086D+04	0.41197D+05	0.30606D+04	0.10781D−01	
		5.140	−0.20046D−02	0.20935D−02	0.10818D−02	−0.14256D+04	0.41078D+05	0.30995D+04	0.10760D−01	
		5.150	−0.19748D−02	0.20855D−02	0.10818D−02	−0.13432D+04	0.40961D+05	0.31383D+04	0.10741D−01	
		5.160	−0.19453D−02	0.20777D−02	0.10818D−02	−0.12613D+04	0.40846D+05	0.31768D+04	0.10721D−01	
		5.170	−0.19159D−02	0.20699D−02	0.10818D−02	−0.11800D+04	0.40732D+05	0.32151D+04	0.10702D−01	
		5.180	−0.18867D−02	0.20623D−02	0.10818D−02	−0.10992D+04	0.40619D+05	0.32531D+04	0.10683D−01	
		5.190	−0.18578D−02	0.20547D−02	0.10818D−02	−0.10189D+04	0.40508D+05	0.32910D+04	0.10664D−01	
		5.200	−0.18291D−02	0.20472D−02	0.10818D−02	−0.93919D+03	0.40398D+05	0.33286D+04	0.10645D−01	
3	3	5.200	−0.18802D−02	0.20472D−02	0.10818D−02	−0.93919D+03	0.10309D+05	0.20874D+05	0.10645D−01	0.68508D+05
		5.210	−0.18695D−02	0.20397D−02	0.10818D−02	−0.91761D+03	0.10297D+05	0.20852D+05	0.10627D−01	
		5.220	−0.18588D−02	0.20322D−02	0.10818D−02	−0.89613D+03	0.10285D+05	0.20831D+05	0.10608D−01	
		5.230	−0.18482D−02	0.20248D−02	0.10818D−02	−0.87477D+03	0.10274D+05	0.20810D+05	0.10590D−01	
		5.240	−0.18377D−02	0.20174D−02	0.10818D−02	−0.85350D+03	0.10263D+05	0.20789D+05	0.10571D−01	
		5.250	−0.18272D−02	0.20101D−02	0.10818D−02	−0.83234D+03	0.10251D+05	0.20768D+05	0.10553D−01	
		5.260	−0.18167D−02	0.20028D−02	0.10818D−02	−0.81128D+03	0.10240D+05	0.20747D+05	0.10535D−01	
		5.270	−0.18063D−02	0.19955D−02	0.10818D−02	−0.79032D+03	0.10229D+05	0.20727D+05	0.10516D−01	
		5.280	−0.17960D−02	0.19883D−02	0.10818D−02	−0.76946D+03	0.10218D+05	0.20706D+05	0.10498D−01	
		5.290	−0.17857D−02	0.19812D−02	0.10818D−02	−0.74870D+03	0.10207D+05	0.20686D+05	0.10481D−01	
		5.300	−0.17755D−02	0.19741D−02	0.10818D−02	−0.72804D+03	0.10196D+05	0.20666D+05	0.10463D−01	
4	4	5.300	−0.17282D−02	0.19741D−02	0.10818D−02	−0.72804D+03	0.39075D+05	0.33919D+04	0.10463D−01	0.11989D+05
		5.310	−0.17013D−02	0.19671D−02	0.10818D−02	−0.65318D+03	0.38973D+05	0.34273D+04	0.10446D−01	
		5.320	−0.16746D−02	0.19603D−02	0.10818D−02	−0.57878D+03	0.38873D+05	0.34625D+04	0.10429D−01	
		5.330	−0.16480D−02	0.19535D−02	0.10818D−02	−0.50486D+03	0.38775D+05	0.34974D+04	0.10412D−01	
		5.340	−0.16216D−02	0.19468D−02	0.10818D−02	−0.43139D+03	0.38677D+05	0.35322D+04	0.10396D−01	
		5.350	−0.15954D−02	0.19401D−02	0.10818D−02	−0.35838D+03	0.38581D+05	0.35668D+04	0.10380D−01	
		5.360	−0.15694D−02	0.19335D−02	0.10818D−02	−0.28582D+03	0.38486D+05	0.36012D+04	0.10364D−01	
		5.370	−0.15435D−02	0.19270D−02	0.10818D−02	−0.21371D+03	0.38392D+05	0.36354D+04	0.10348D−01	
		5.380	−0.15178D−02	0.19206D−02	0.10818D−02	−0.14204D+03	0.38300D+05	0.36694D+04	0.10333D−01	
		5.390	−0.14923D−02	0.19143D−02	0.10818D−02	−0.70803D+02	0.38208D+05	0.37032D+04	0.10318D−01	
		5.400	−0.14670D−02	0.19080D−02	0.10818D−02	−0.10391D−09	0.38118D+05	0.37369D+04	0.10303D−01	

@ 5000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	−0.57558D−02	0.55336D−02	0.27045D−02	−0.50000D+04	0.25667D+05	0.52662D+05	0.27668D−01	0.16607D+06
		5.010	−0.57247D−02	0.55111D−02	0.27045D−02	−0.49388D+04	0.25630D+05	0.52596D+05	0.27610D−01	
		5.020	−0.56939D−02	0.54887D−02	0.27045D−02	−0.48780D+04	0.25594D+05	0.52531D+05	0.27553D−01	
		5.030	−0.56632D−02	0.54665D−02	0.27045D−02	−0.48174D+04	0.25558D+05	0.52466D+05	0.27497D−01	
		5.040	−0.56327D−02	0.54445D−02	0.27045D−02	−0.47572D+04	0.25522D+05	0.52402D+05	0.27440D−01	
		5.050	−0.56024D−02	0.54226D−02	0.27045D−02	−0.46973D+04	0.25487D+05	0.52338D+05	0.27384D−01	
		5.060	−0.55723D−02	0.54008D−02	0.27045D−02	−0.46376D+04	0.25451D+05	0.52275D+05	0.27328D−01	
		5.070	−0.55423D−02	0.53792D−02	0.27045D−02	−0.45783D+04	0.25416D+05	0.52212D+05	0.27272D−01	
		5.080	−0.55125D−02	0.53577D−02	0.27045D−02	−0.45193D+04	0.25382D+05	0.52150D+05	0.27217D−01	
		5.090	−0.54829D−02	0.53364D−02	0.27045D−02	−0.44606D+04	0.25347D+05	0.52088D+05	0.27162D−01	
		5.100	−0.54534D−02	0.53152D−02	0.27045D−02	−0.44022D+04	0.25313D+05	0.52026D+05	0.27108D−01	
2	2	5.100	−0.53149D−02	0.53152D−02	0.27045D−02	−0.44022D+04	0.10390D+06	0.73555D+04	0.27108D−01	0.25385D+05
		5.110	−0.52382D−02	0.52945D−02	0.27045D−02	−0.41906D+04	0.10359D+06	0.74547D+04	0.27055D−01	
		5.120	−0.51621D−02	0.52740D−02	0.27045D−02	−0.39803D+04	0.10329D+06	0.75533D+04	0.27003D−01	
		5.130	−0.50866D−02	0.52537D−02	0.27045D−02	−0.37715D+04	0.10299D+06	0.76514D+04	0.26952D−01	
		5.140	−0.50115D−02	0.52337D−02	0.27045D−02	−0.35641D+04	0.10270D+06	0.77488D+04	0.26901D−01	
		5.150	−0.49371D−02	0.52138D−02	0.27045D−02	−0.33581D+04	0.10240D+06	0.78457D+04	0.26851D−01	
		5.160	−0.48632D−02	0.51942D−02	0.27045D−02	−0.31534D+04	0.10211D+06	0.79420D+04	0.26802D−01	
		5.170	−0.47898D−02	0.51749D−02	0.27045D−02	−0.29500D+04	0.10183D+06	0.80377D+04	0.26754D−01	
		5.180	−0.47169D−02	0.51557D−02	0.27045D−02	−0.27480D+04	0.10155D+06	0.81328D+04	0.26707D−01	
		5.190	−0.46445D−02	0.51367D−02	0.27045D−02	−0.25473D+04	0.10127D+06	0.82274D+04	0.26660D−01	
		5.200	−0.45727D−02	0.51180D−02	0.27045D−02	−0.23480D+04	0.10100D+06	0.83214D+04	0.26614D−01	
3	3	5.200	−0.47006D−02	0.51180D−02	0.27045D−02	−0.23480D+04	0.25772D+05	0.52184D+05	0.26614D−01	0.17127D+06
		5.210	−0.46738D−02	0.50992D−02	0.27045D−02	−0.22940D+04	0.25742D+05	0.52130D+05	0.26567D−01	
		5.220	−0.46471D−02	0.50805D−02	0.27045D−02	−0.22403D+04	0.25714D+05	0.52077D+05	0.26520D−01	
		5.230	−0.46206D−02	0.50619D−02	0.27045D−02	−0.21869D+04	0.25685D+05	0.52024D+05	0.26474D−01	
		5.240	−0.45942D−02	0.50435D−02	0.27045D−02	−0.21338D+04	0.25656D+05	0.51972D+05	0.26428D−01	
		5.250	−0.45679D−02	0.50251D−02	0.27045D−02	−0.20808D+04	0.25628D+05	0.51920D+05	0.26382D−01	
		5.260	−0.45418D−02	0.50069D−02	0.27045D−02	−0.20282D+04	0.25600D+05	0.51868D+05	0.26336D−01	
		5.270	−0.45158D−02	0.49888D−02	0.27045D−02	−0.19758D+04	0.25572D+05	0.51817D+05	0.26291D−01	
		5.280	−0.44900D−02	0.49708D−02	0.27045D−02	−0.19236D+04	0.25545D+05	0.51766D+05	0.26246D−01	
		5.290	−0.44643D−02	0.49530D−02	0.27045D−02	−0.18717D+04	0.25517D+05	0.51716D+05	0.26201D−01	
		5.300	−0.44388D−02	0.49352D−02	0.27045D−02	−0.18201D+04	0.25490D+05	0.51665D+05	0.26157D−01	
4	4	5.300	−0.43206D−02	0.49352D−02	0.27045D−02	−0.18201D+04	0.97687D+05	0.84798D+04	0.26157D−01	0.29972D+05
		5.310	−0.42533D−02	0.49179D−02	0.27045D−02	−0.16329D+04	0.97433D+05	0.85683D+04	0.26114D−01	
		5.320	−0.41864D−02	0.49007D−02	0.27045D−02	−0.14470D+04	0.97183D+05	0.86562D+04	0.26072D−01	
		5.330	−0.41200D−02	0.48837D−02	0.27045D−02	−0.12621D+04	0.96937D+05	0.87436D+04	0.26030D−01	
		5.340	−0.40540D−02	0.48669D−02	0.27045D−02	−0.10785D+04	0.96693D+05	0.88305D+04	0.25989D−01	
		5.350	−0.39885D−02	0.48503D−02	0.27045D−02	−0.89596D+03	0.96452D+05	0.89170D+04	0.25949D−01	
		5.360	−0.39234D−02	0.48339D−02	0.27045D−02	−0.71456D+03	0.96215D+05	0.90030D+04	0.25910D−01	
		5.370	−0.38588D−02	0.48176D−02	0.27045D−02	−0.53428D+03	0.95980D+05	0.90885D+04	0.25871D−01	

		5.380	−0.37945D−02	0.48016D−02	0.27045D−02	−0.35510D+03	0.95749D+05	0.91735D+04	0.25832D−01	
		5.390	−0.37308D−02	0.47857D−02	0.27045D−02	−0.17701D+03	0.95520D+05	0.92581D+04	0.25795D−01	
		5.400	−0.36674D−02	0.47700D−02	0.27045D−02	0.19099D−10	0.95295D+05	0.93422D+04	0.25758D−01	

@ 6000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	−0.69069D−02	0.66403D−02	0.32454D−02	−0.60000D+04	0.30800D+05	0.63194D+05	0.33201D−01	0.19929D+06
		5.010	−0.68697D−02	0.66133D−02	0.32454D−02	−0.59266D+04	0.30756D+05	0.63116D+05	0.33133D−01	
		5.020	−0.68327D−02	0.65865D−02	0.32454D−02	−0.58536D+04	0.30713D+05	0.63037D+05	0.33064D−01	
		5.030	−0.67959D−02	0.65598D−02	0.32454D−02	−0.57809D+04	0.30669D+05	0.62960D+05	0.32996D−01	
		5.040	−0.67593D−02	0.65334D−02	0.32454D−02	−0.57086D+04	0.30626D+05	0.62883D+05	0.32928D−01	
		5.050	−0.67229D−02	0.65071D−02	0.32454D−02	−0.56367D+04	0.30584D+05	0.62806D+05	0.32861D−01	
		5.060	−0.66867D−02	0.64810D−02	0.32454D−02	−0.55652D+04	0.30542D+05	0.62730D+05	0.32794D−01	
		5.070	−0.66508D−02	0.64550D−02	0.32454D−02	−0.54940D+04	0.30500D+05	0.62655D+05	0.32727D−01	
		5.080	−0.66150D−02	0.64293D−02	0.32454D−02	−0.54232D+04	0.30458D+05	0.62580D+05	0.32661D−01	
		5.090	−0.65794D−02	0.64037D−02	0.32454D−02	−0.53527D+04	0.30417D+05	0.62506D+05	0.32595D−01	
		5.100	−0.65441D−02	0.63783D−02	0.32454D−02	−0.52826D+04	0.30376D+05	0.62432D+05	0.32529D−01	
2	2	5.100	−0.63778D−02	0.63783D−02	0.32454D−02	−0.52826D+04	0.12468D+06	0.88266D+04	0.32529D−01	0.30462D+05
		5.110	−0.62858D−02	0.63534D−02	0.32454D−02	−0.50287D+04	0.12431D+06	0.89457D+04	0.32466D−01	
		5.120	−0.61945D−02	0.63288D−02	0.32454D−02	−0.47764D+04	0.12395D+06	0.90640D+04	0.32403D−01	
		5.130	−0.61039D−02	0.63045D−02	0.32454D−02	−0.45258D+04	0.12359D+06	0.91817D+04	0.32342D−01	
		5.140	−0.60139D−02	0.62804D−02	0.32454D−02	−0.42769D+04	0.12323D+06	0.92986D+04	0.32281D−01	
		5.150	−0.59245D−02	0.62566D−02	0.32454D−02	−0.40297D+04	0.12288D+06	0.94148D+04	0.32222D−01	
		5.160	−0.58358D−02	0.62331D−02	0.32454D−02	−0.37840D+04	0.12254D+06	0.95304D+04	0.32163D−01	
		5.170	−0.57477D−02	0.62098D−02	0.32454D−02	−0.35400D+04	0.12219D+06	0.96452D+04	0.32105D−01	
		5.180	−0.56602D−02	0.61868D−02	0.32454D−02	−0.32976D+04	0.12186D+06	0.97594D+04	0.32048D−01	
		5.190	−0.55734D−02	0.61641D−02	0.32454D−02	−0.30568D+04	0.12152D+06	0.98729D+04	0.31992D−01	
		5.200	−0.54872D−02	0.61416D−02	0.32454D−02	−0.28176D+04	0.12119D+06	0.99857D+04	0.31936D−01	
3	3	5.200	−0.56407D−02	0.61416D−02	0.32454D−02	−0.28176D+04	0.30926D+05	0.62621D+05	0.31936D−01	0.20552D+06
		5.210	−0.56085D−02	0.61190D−02	0.32454D−02	−0.27528D+04	0.30891D+05	0.62556D+05	0.31880D−01	
		5.220	−0.55765D−02	0.60966D−02	0.32454D−02	−0.26884D+04	0.30856D+05	0.62492D+05	0.31824D−01	
		5.230	−0.55447D−02	0.60743D−02	0.32454D−02	−0.26243D+04	0.30822D+05	0.62429D+05	0.31769D−01	
		5.240	−0.55130D−02	0.60522D−02	0.32454D−02	−0.25605D+04	0.30788D+05	0.62366D+05	0.31713D−01	
		5.250	−0.54815D−02	0.60302D−02	0.32454D−02	−0.24970D+04	0.30754D+05	0.62304D+05	0.31658D−01	
		5.260	−0.54502D−02	0.60083D−02	0.32454D−02	−0.24338D+04	0.30720D+05	0.62242D+05	0.31604D−01	
		5.270	−0.54190D−02	0.59866D−02	0.32454D−02	−0.23710D+04	0.30687D+05	0.62180D+05	0.31549D−01	
		5.280	−0.53880D−02	0.59650D−02	0.32454D−02	−0.23084D+04	0.30653D+05	0.62119D+05	0.31495D−01	
		5.290	−0.53572D−02	0.59436D−02	0.32454D−02	−0.22461D+04	0.30621D+05	0.62059D+05	0.31442D−01	
		5.300	−0.53265D−02	0.59223D−02	0.32454D−02	−0.21841D+04	0.30588D+05	0.61998D+05	0.31388D−01	
4	4	5.300	−0.51847D−02	0.59223D−02	0.32454D−02	−0.21841D+04	0.11722D+06	0.10176D+05	0.31388D−01	0.35967D+05
		5.310	−0.51039D−02	0.59014D−02	0.32454D−02	−0.19595D+04	0.11692D+06	0.10282D+05	0.31337D−01	
		5.320	−0.50237D−02	0.58808D−02	0.32454D−02	−0.17364D+04	0.11662D+06	0.10387D+05	0.31286D−01	
		5.330	−0.49440D−02	0.58605D−02	0.32454D−02	−0.15146D+04	0.11632D+06	0.10492D+05	0.31236D−01	
		5.340	−0.48648D−02	0.58403D−02	0.32454D−02	−0.12942D+04	0.11603D+06	0.10597D+05	0.31187D−01	
		5.350	−0.47862D−02	0.58204D−02	0.32454D−02	−0.10751D+04	0.11574D+06	0.10700D+05	0.31139D−01	
		5.360	−0.47081D−02	0.58006D−02	0.32454D−02	−0.85747D+03	0.11546D+06	0.10804D+05	0.31091D−01	
		5.370	−0.46305D−02	0.57811D−02	0.32454D−02	−0.64113D+03	0.11518D+06	0.10906D+05	0.31045D−01	
		5.380	−0.45534D−02	0.57619D−02	0.32454D−02	−0.42612D+03	0.11490D+06	0.11008D+05	0.30999D−01	
		5.390	−0.44769D−02	0.57428D−02	0.32454D−02	−0.21241D+03	0.11462D+06	0.11110D+05	0.30954D−01	
		5.400	−0.44009D−02	0.57239D−02	0.32454D−02	−0.14916D−09	0.11435D+06	0.11211D+05	0.30909D−01	

@ 7500 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	−0.86337D−02	0.83004D−02	0.40567D−02	−0.75000D+04	0.38500D+05	0.78993D+05	0.41502D−01	0.24911D+06
		5.010	−0.85871D−02	0.82666D−02	0.40567D−02	−0.74082D+04	0.38445D+05	0.78894D+05	0.41416D−01	
		5.020	−0.85409D−02	0.82331D−02	0.40567D−02	−0.73170D+04	0.38391D+05	0.78797D+05	0.41330D−01	
		5.030	−0.84948D−02	0.81998D−02	0.40567D−02	−0.72261D+04	0.38337D+05	0.78700D+05	0.41245D−01	
		5.040	−0.84491D−02	0.81667D−02	0.40567D−02	−0.71358D+04	0.38283D+05	0.78603D+05	0.41160D−01	
		5.050	−0.84036D−02	0.81338D−02	0.40567D−02	−0.70459D+04	0.38230D+05	0.78508D+05	0.41076D−01	
		5.060	−0.83584D−02	0.81012D−02	0.40567D−02	−0.69565D+04	0.38177D+05	0.78413D+05	0.40992D−01	
		5.070	−0.83134D−02	0.80688D−02	0.40567D−02	−0.68675D+04	0.38125D+05	0.78318D+05	0.40909D−01	
		5.080	−0.82687D−02	0.80366D−02	0.40567D−02	−0.67790D+04	0.38073D+05	0.78225D+05	0.40826D−01	
		5.090	−0.82243D−02	0.80046D−02	0.40567D−02	−0.66909D+04	0.38021D+05	0.78132D+05	0.40743D−01	
		5.100	−0.81801D−02	0.79728D−02	0.40567D−02	−0.66033D+04	0.37970D+05	0.78040D+05	0.40661D−01	
2	2	5.100	−0.79723D−02	0.79728D−02	0.40567D−02	−0.66033D+04	0.15585D+06	0.11033D+05	0.40661D−01	0.38077D+05
		5.110	−0.78573D−02	0.79417D−02	0.40567D−02	−0.62858D+04	0.15539D+06	0.11182D+05	0.40582D−01	
		5.120	−0.77432D−02	0.79110D−02	0.40567D−02	−0.59705D+04	0.15494D+06	0.11330D+05	0.40504D−01	
		5.130	−0.76298D−02	0.78806D−02	0.40567D−02	−0.56573D+04	0.15449D+06	0.11477D+05	0.40427D−01	
		5.140	−0.75173D−02	0.78505D−02	0.40567D−02	−0.53462D+04	0.15404D+06	0.11623D+05	0.40352D−01	
		5.150	−0.74056D−02	0.78208D−02	0.40567D−02	−0.50371D+04	0.15360D+06	0.11769D+05	0.40277D−01	
		5.160	−0.72947D−02	0.77914D−02	0.40567D−02	−0.47301D+04	0.15317D+06	0.11913D+05	0.40203D−01	
		5.170	−0.71846D−02	0.77623D−02	0.40567D−02	−0.44251D+04	0.15274D+06	0.12057D+05	0.40131D−01	
		5.180	−0.70753D−02	0.77335D−02	0.40567D−02	−0.41221D+04	0.15232D+06	0.12199D+05	0.40060D−01	
		5.190	−0.69668D−02	0.77051D−02	0.40567D−02	−0.38210D+04	0.15190D+06	0.12341D+05	0.39990D−01	
		5.200	−0.68590D−02	0.76770D−02	0.40567D−02	−0.35219D+04	0.15149D+06	0.12482D+05	0.39920D−01	
3	3	5.200	−0.70509D−02	0.76770D−02	0.40567D−02	−0.35219D+04	0.38658D+05	0.78276D+05	0.39920D−01	0.25690D+06
		5.210	−0.70107D−02	0.76488D−02	0.40567D−02	−0.34410D+04	0.38614D+05	0.78195D+05	0.39850D−01	
		5.220	−0.69706D−02	0.76207D−02	0.40567D−02	−0.33605D+04	0.38570D+05	0.78116D+05	0.39780D−01	
		5.230	−0.69308D−02	0.75929D−02	0.40567D−02	−0.32804D+04	0.38527D+05	0.78036D+05	0.39711D−01	
		5.240	−0.68912D−02	0.75652D−02	0.40567D−02	−0.32006D+04	0.38484D+05	0.77958D+05	0.39642D−01	
		5.250	−0.68519D−02	0.75377D−02	0.40567D−02	−0.31213D+04	0.38442D+05	0.77880D+05	0.39573D−01	
		5.260	−0.68127D−02	0.75104D−02	0.40567D−02	−0.30423D+04	0.38400D+05	0.77802D+05	0.39505D−01	
		5.270	−0.67738D−02	0.74832D−02	0.40567D−02	−0.29637D+04	0.38358D+05	0.77725D+05	0.39437D−01	
		5.280	−0.67350D−02	0.74563D−02	0.40567D−02	−0.28855D+04	0.38317D+05	0.77649D+05	0.39369D−01	
		5.290	−0.66965D−02	0.74295D−02	0.40567D−02	−0.28076D+04	0.38276D+05	0.77573D+05	0.39302D−01	
		5.300	−0.66582D−02	0.74029D−02	0.40567D−02	−0.27301D+04	0.38235D+05	0.77498D+05	0.39235D−01	
4	4	5.300	−0.64809D−02	0.74029D−02	0.40567D−02	−0.27301D+04	0.14653D+06	0.12720D+05	0.39235D−01	0.44959D+05
		5.310	−0.63799D−02	0.73768D−02	0.40567D−02	−0.24494D+04	0.14615D+06	0.12852D+05	0.39171D−01	
		5.320	−0.62796D−02	0.73510D−02	0.40567D−02	−0.21704D+04	0.14578D+06	0.12984D+05	0.39108D−01	
		5.330	−0.61800D−02	0.73256D−02	0.40567D−02	−0.18932D+04	0.14540D+06	0.13115D+05	0.39045D−01	
		5.340	−0.60810D−02	0.73004D−02	0.40567D−02	−0.16177D+04	0.14504D+06	0.13246D+05	0.38984D−01	
		5.350	−0.59827D−02	0.72754D−02	0.40567D−02	−0.13439D+04	0.14468D+06	0.13375D+05	0.38924D−01	
		5.360	−0.58851D−02	0.72508D−02	0.40567D−02	−0.10718D+04	0.14432D+06	0.13504D+05	0.38864D−01	
		5.370	−0.57881D−02	0.72264D−02	0.40567D−02	−0.80141D+03	0.14397D+06	0.13633D+05	0.38806D−01	
		5.380	−0.56918D−02	0.72023D−02	0.40567D−02	−0.53264D+03	0.14362D+06	0.13760D+05	0.38749D−01	

		5.390	−0.55961D−02	0.71785D−02	0.40567D−02	−0.26551D+03	0.14328D+06	0.13887D+05	0.38692D−01	
		5.400	−0.55011D−02	0.71549D−02	0.40567D−02	0.73669D−10	0.14294D+06	0.14013D+05	0.38637D−01	

@ 10000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	−0.11512D−01	0.11067D−01	0.54089D−02	−0.10000D+05	0.51334D+05	0.10532D+06	0.55336D−01	0.33215D+06
		5.010	−0.11449D−01	0.11022D−01	0.54089D−02	−0.98777D+04	0.51261D+05	0.10519D+06	0.55221D−01	
		5.020	−0.11388D−01	0.10977D−01	0.54089D−02	−0.97559D+04	0.51188D+05	0.10506D+06	0.55107D−01	
		5.030	−0.11326D−01	0.10933D−01	0.54089D−02	−0.96348D+04	0.51116D+05	0.10493D+06	0.54993D−01	
		5.040	−0.11265D−01	0.10889D−01	0.54089D−02	−0.95144D+04	0.51044D+05	0.10480D+06	0.54880D−01	
		5.050	−0.11205D−01	0.10845D−01	0.54089D−02	−0.93945D+04	0.50973D+05	0.10468D+06	0.54768D−01	
		5.060	−0.11145D−01	0.10802D−01	0.54089D−02	−0.92753D+04	0.50903D+05	0.10455D+06	0.54656D−01	
		5.070	−0.11085D−01	0.10758D−01	0.54089D−02	−0.91567D+04	0.50833D+05	0.10442D+06	0.54545D−01	
		5.080	−0.11025D−01	0.10715D−01	0.54089D−02	−0.90387D+04	0.50763D+05	0.10430D+06	0.54434D−01	
		5.090	−0.10966D−01	0.10673D−01	0.54089D−02	−0.89212D+04	0.50695D+05	0.10418D+06	0.54324D−01	
		5.100	−0.10907D−01	0.10630D−01	0.54089D−02	−0.88044D+04	0.50627D+05	0.10405D+06	0.54215D−01	
2	2	5.100	−0.10630D−01	0.10630D−01	0.54089D−02	−0.88044D+04	0.20780D+06	0.14711D+05	0.54215D−01	0.50769D+05
		5.110	−0.10476D−01	0.10589D−01	0.54089D−02	−0.83811D+04	0.20719D+06	0.14909D+05	0.54110D−01	
		5.120	−0.10324D−01	0.10548D−01	0.54089D−02	−0.79607D+04	0.20658D+06	0.15107D+05	0.54006D−01	
		5.130	−0.10173D−01	0.10507D−01	0.54089D−02	−0.75430D+04	0.20598D+06	0.15303D+05	0.53903D−01	
		5.140	−0.10023D−01	0.10467D−01	0.54089D−02	−0.71282D+04	0.20539D+06	0.15498D+05	0.53802D−01	
		5.150	−0.98742D−02	0.10428D−01	0.54089D−02	−0.67161D+04	0.20481D+06	0.15691D+05	0.53703D−01	
		5.160	−0.97263D−02	0.10388D−01	0.54089D−02	−0.63067D+04	0.20423D+06	0.15884D+05	0.53605D−01	
		5.170	−0.95795D−02	0.10350D−01	0.54089D−02	−0.59001D+04	0.20366D+06	0.16075D+05	0.53508D−01	
		5.180	−0.94337D−02	0.10311D−01	0.54089D−02	−0.54961D+04	0.20310D+06	0.16266D+05	0.53413D−01	
		5.190	−0.92890D−02	0.10273D−01	0.54089D−02	−0.50947D+04	0.20254D+06	0.16455D+05	0.53319D−01	
		5.200	−0.91453D−02	0.10236D−01	0.54089D−02	−0.46959D+04	0.20199D+06	0.16643D+05	0.53227D−01	
3	3	5.200	−0.94012D−02	0.10236D−01	0.54089D−02	−0.46959D+04	0.51543D+05	0.10437D+06	0.53227D−01	0.34254D+06
		5.210	−0.93476D−02	0.10198D−01	0.54089D−02	−0.45880D+04	0.51485D+05	0.10426D+06	0.53134D−01	
		5.220	−0.92942D−02	0.10161D−01	0.54089D−02	−0.44807D+04	0.51427D+05	0.10415D+06	0.53040D−01	
		5.230	−0.92411D−02	0.10124D−01	0.54089D−02	−0.43738D+04	0.51370D+05	0.10405D+06	0.52948D−01	
		5.240	−0.91883D−02	0.10087D−01	0.54089D−02	−0.42675D+04	0.51313D+05	0.10394D+06	0.52855D−01	
		5.250	−0.91358D−02	0.10050D−01	0.54089D−02	−0.41617D+04	0.51256D+05	0.10384D+06	0.52764D−01	
		5.260	−0.90836D−02	0.10014D−01	0.54089D−02	−0.40564D+04	0.51200D+05	0.10374D+06	0.52673D−01	
		5.270	−0.90317D−02	0.99776D−02	0.54089D−02	−0.39516D+04	0.51144D+05	0.10363D+06	0.52582D−01	
		5.280	−0.89800D−02	0.99417D−02	0.54089D−02	−0.38473D+04	0.51089D+05	0.10353D+06	0.52492D−01	
		5.290	−0.89287D−02	0.99060D−02	0.54089D−02	−0.37435D+04	0.51034D+05	0.10343D+06	0.52403D−01	
		5.300	−0.88776D−02	0.98705D−02	0.54089D−02	−0.36402D+04	0.50980D+05	0.10333D+06	0.52314D−01	
4	4	5.300	−0.86412D−02	0.98705D−02	0.54089D−02	−0.36402D+04	0.19537D+06	0.16960D+05	0.52314D−01	0.59945D+05
		5.310	−0.85066D−02	0.98357D−02	0.54089D−02	−0.32659D+04	0.19487D+06	0.17137D+05	0.52228D−01	
		5.320	−0.83728D−02	0.98014D−02	0.54089D−02	−0.28939D+04	0.19437D+06	0.17312D+05	0.52143D−01	
		5.330	−0.82400D−02	0.97674D−02	0.54089D−02	−0.25243D+04	0.19387D+06	0.17487D+05	0.52060D−01	
		5.340	−0.81080D−02	0.97338D−02	0.54089D−02	−0.21570D+04	0.19339D+06	0.17661D+05	0.51979D−01	
		5.350	−0.79770D−02	0.97006D−02	0.54089D−02	−0.17919D+04	0.19290D+06	0.17834D+05	0.51898D−01	
		5.360	−0.78468D−02	0.96677D−02	0.54089D−02	−0.14291D+04	0.19243D+06	0.18006D+05	0.51819D−01	
		5.370	−0.77175D−02	0.96352D−02	0.54089D−02	−0.10686D+04	0.19196D+06	0.18177D+05	0.51741D−01	
		5.380	−0.75891D−02	0.96031D−02	0.54089D−02	−0.71019D+03	0.19150D+06	0.18347D+05	0.51665D−01	
		5.390	−0.74615D−02	0.95713D−02	0.54089D−02	−0.35402D+03	0.19104D+06	0.18516D+05	0.51589D−01	
		5.400	−0.73348D−02	0.95399D−02	0.54089D−02	0.38199D−10	0.19059D+06	0.18684D+05	0.51515D−01	

@ 12500 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	5.000	−0.14389D−01	0.13834D−01	0.67612D−02	−0.12500D+05	0.64167D+05	0.13166D+06	0.69170D−01	0.41518D+06
		5.010	−0.14312D−01	0.13778D−01	0.67612D−02	−0.12347D+05	0.64076D+05	0.13149D+06	0.69026D−01	
		5.020	−0.14235D−01	0.13722D−01	0.67612D−02	−0.12195D+05	0.63985D+05	0.13133D+06	0.68883D−01	
		5.030	−0.14158D−01	0.13666D−01	0.67612D−02	−0.12044D+05	0.63895D+05	0.13117D+06	0.68741D−01	
		5.040	−0.14082D−01	0.13611D−01	0.67612D−02	−0.11893D+05	0.63805D+05	0.13101D+06	0.68600D−01	
		5.050	−0.14006D−01	0.13556D−01	0.67612D−02	−0.11743D+05	0.63716D+05	0.13085D+06	0.68460D−01	
		5.060	−0.13931D−01	0.13502D−01	0.67612D−02	−0.11594D+05	0.63628D+05	0.13069D+06	0.68320D−01	
		5.070	−0.13856D−01	0.13448D−01	0.67612D−02	−0.11446D+05	0.63541D+05	0.13053D+06	0.68181D−01	
		5.080	−0.13781D−01	0.13394D−01	0.67612D−02	−0.11298D+05	0.63454D+05	0.13037D+06	0.68043D−01	
		5.090	−0.13707D−01	0.13341D−01	0.67612D−02	−0.11152D+05	0.63368D+05	0.13022D+06	0.67906D−01	
		5.100	−0.13633D−01	0.13288D−01	0.67612D−02	−0.11006D+05	0.63283D+05	0.13007D+06	0.67769D−01	
2	2	5.100	−0.13287D−01	0.13288D−01	0.67612D−02	−0.11006D+05	0.25976D+06	0.18389D+05	0.67769D−01	0.63462D+05
		5.110	−0.13096D−01	0.13236D−01	0.67612D−02	−0.10476D+05	0.25899D+06	0.18637D+05	0.67637D−01	
		5.120	−0.12905D−01	0.13185D−01	0.67612D−02	−0.99508D+04	0.25823D+06	0.18883D+05	0.67507D−01	
		5.130	−0.12716D−01	0.13134D−01	0.67612D−02	−0.94288D+04	0.25748D+06	0.19128D+05	0.67379D−01	
		5.140	−0.12529D−01	0.13084D−01	0.67612D−02	−0.89103D+04	0.25674D+06	0.19372D+05	0.67253D−01	
		5.150	−0.12343D−01	0.13035D−01	0.67612D−02	−0.83951D+04	0.25601D+06	0.19614D+05	0.67128D−01	
		5.160	−0.12158D−01	0.12986D−01	0.67612D−02	−0.78834D+04	0.25529D+06	0.19855D+05	0.67006D−01	
		5.170	−0.11974D−01	0.12937D−01	0.67612D−02	−0.73751D+04	0.25457D+06	0.20094D+05	0.66885D−01	
		5.180	−0.11792D−01	0.12889D−01	0.67612D−02	−0.68701D+04	0.25387D+06	0.20332D+05	0.66766D−01	
		5.190	−0.11611D−01	0.12842D−01	0.67612D−02	−0.63684D+04	0.25317D+06	0.20569D+05	0.66649D−01	
		5.200	−0.11432D−01	0.12795D−01	0.67612D−02	−0.58699D+04	0.25249D+06	0.20804D+05	0.66534D−01	
3	3	5.200	−0.11752D−01	0.12795D−01	0.67612D−02	−0.58699D+04	0.64429D+05	0.13046D+06	0.66534D−01	0.42817D+06
		5.210	−0.11684D−01	0.12748D−01	0.67612D−02	−0.57350D+04	0.64356D+05	0.13033D+06	0.66417D−01	
		5.220	−0.11618D−01	0.12701D−01	0.67612D−02	−0.56008D+04	0.64284D+05	0.13019D+06	0.66300D−01	
		5.230	−0.11551D−01	0.12655D−01	0.67612D−02	−0.54673D+04	0.64212D+05	0.13006D+06	0.66185D−01	
		5.240	−0.11485D−01	0.12609D−01	0.67612D−02	−0.53344D+04	0.64141D+05	0.12993D+06	0.66069D−01	
		5.250	−0.11420D−01	0.12563D−01	0.67612D−02	−0.52021D+04	0.64070D+05	0.12980D+06	0.65955D−01	
		5.260	−0.11355D−01	0.12517D−01	0.67612D−02	−0.50705D+04	0.64000D+05	0.12967D+06	0.65841D−01	
		5.270	−0.11290D−01	0.12472D−01	0.67612D−02	−0.49395D+04	0.63930D+05	0.12954D+06	0.65728D−01	
		5.280	−0.11225D−01	0.12427D−01	0.67612D−02	−0.48091D+04	0.63861D+05	0.12942D+06	0.65615D−01	
		5.290	−0.11161D−01	0.12382D−01	0.67612D−02	−0.46794D+04	0.63793D+05	0.12929D+06	0.65503D−01	
		5.300	−0.11097D−01	0.12338D−01	0.67612D−02	−0.45502D+04	0.63725D+05	0.12916D+06	0.65392D−01	
4	4	5.300	−0.10802D−01	0.12338D−01	0.67612D−02	−0.45502D+04	0.24422D+06	0.21200D+05	0.65392D−01	0.74931D+05
		5.310	−0.10633D−01	0.12295D−01	0.67612D−02	−0.40824D+04	0.24358D+06	0.21421D+05	0.65285D−01	
		5.320	−0.10466D−01	0.12252D−01	0.67612D−02	−0.36174D+04	0.24296D+06	0.21640D+05	0.65179D−01	
		5.330	−0.10300D−01	0.12209D−01	0.67612D−02	−0.31554D+04	0.24234D+06	0.21859D+05	0.65075D−01	
		5.340	−0.10135D−01	0.12167D−01	0.67612D−02	−0.26962D+04	0.24173D+06	0.22076D+05	0.64973D−01	
		5.350	−0.99712D−02	0.12126D−01	0.67612D−02	−0.22399D+04	0.24113D+06	0.22292D+05	0.64873D−01	
		5.360	−0.98085D−02	0.12085D−01	0.67612D−02	−0.17864D+04	0.24054D+06	0.22507D+05	0.64774D−01	
		5.370	−0.96469D−02	0.12044D−01	0.67612D−02	−0.13357D+04	0.23995D+06	0.22721D+05	0.64677D−01	
		5.380	−0.94864D−02	0.12004D−01	0.67612D−02	−0.88774D+03	0.23937D+06	0.22934D+05	0.64581D−01	
		5.390	−0.93269D−02	0.11964D−01	0.67612D−02	−0.44252D+03	0.23880D+06	0.23145D+05	0.64487D−01	

5.400	-0.91685D-02	0.11925D-01	0.67612D-02	0.29104D-10	0.23824D+06	0.23355D+05	0.64394D-01

STEP	DESCRIPTION	STRESS RATIO
1	1000 psi	12.500
2	2000 psi	6.250
3	5000 psi	2.500
4	6000 psi	2.083
5	7500 psi	1.667
6	10000 psi	1.250
7	12500 psi	1.000

```
Ver3 - pressure steps, composite
5.,4,4,7,9,0
1,1
5.81d6,1.508d6,2.411d6,1.393,-.239,.3436
-4.96D-6,19.5D-6,23.1D-6
2,1
2.228d6,19.38d6,2.228d6,.03481,.5195,.3029
20.D-6,0.2D-6,20.D-6
3,4
32.d6,32.d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5d-6,5d-6
30,.6,.03
4,4
32.d6,32.d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5d-6,5d-6
90,.6,.03
1,1,0.1
2,2,0.1
3,3,0.1
4,4,0.1
1000 psi
1000.,0.
0,0,0,0,0
2000 psi
2000.,0.
0,0,0,0,0
5000 psi
5000.,0.
0,0,0,0,0
6000 psi
6000.,0,
0,0,0,0,0
7500 psi
7500.,0.
0,0,0,0,0
10000 psi
10000.,0.
0,0,0,0,0
12500 psi
12500.,0.
0,0,0,0,0
```

Verification 4: metal lined composite cylinder with pressure steps

A composite cylinder with metal liner and internal pressure steps.

The following page contains the results of the NewCAP analysis of the cylinder. Note that:

- The composite properties are not affected by stress level, but the metal liner materials are affected once the material has yielded, therefore, the stresses are not equal to the ratios of pressures
- The radial stresses at the surfaces are equal to the respective applied pressure
- The radial stress at the outer surface of one layer is equal to the radial stress at the inner surface of the next layer
- The meridional strains are constant across the cross-section
- The stress ratios are not equal to the pressure ratios, given that the liner material has yielded
- The stresses and strains at zero pressure after autofrettage pressure are not zero, reflecting interface pressure between the metal liner and the composite as a result of liner yielding during autofrettage
- The stresses and strains at 1000 psi before and after autofrettage are not equal, reflecting the yielding of the liner
- The stresses and strains at 1000 psi after autofrettage are equal to the stresses and strains at 1000 psi before autofrettage plus the stresses and strains at zero pressure after autofrettage, reflecting the yielding after autofrettage and subsequent elastic behavior between zero psi and 1000 psi.
- The stresses and strains at 5000 psi on the first cycle and on the second cycle are the same, reflecting consistency of the yielding liner model and that there was not further yielding in compression at zero pressure after autofrettage.
- Looking at stresses and strains, the difference in values from 4500 psi to 5000 psi are the same as the values from 5000 psi to 5500 psi, indicating that the liner is operating in the third linear region, and the model is performing as expected.

-->NewCAP<-- LAST MODIFIED 3JAN2020 VERSION 1a


```
Ver4 - pressure steps, metal lined


RI=  5.0000    NL=  5    NMT=  5    NLS=  9    ISPL=  9    IPO= 0



* MATERIAL MODEL 1 - GENERAL PROPERTIES
MT       EM           EH           ER           PRMH         PRMR         PRHR         PRHM         PRRM         PRRH          N

 1   0.5810D+07   0.1508D+07   0.2411D+07   0.1393D+01  -0.2390D+00   0.3436D+00   0.3616D+00  -0.9918D-01   0.5493D+00   0.1109D+01
 2   0.2228D+07   0.1938D+08   0.2228D+07   0.3481D-01   0.5195D+00   0.3029D+00   0.3028D+00   0.5195D+00   0.3482D-01   0.2533D+01


  MT      ALPM         ALPH         ALPR

   1  -0.4960D-05   0.1950D-04   0.2310D-04
   2   0.2000D-04   0.2000D-06   0.2000D-04


* MATERIAL MODEL 2 - MULTI-LINEAR STRESS/STRAIN
MT    STRAIN1      STRESS1      STRAIN2      STRESS2      STRAIN3      STRESS3      STRAIN4      STRESS4      STRAIN5      STRESS5

 5   0.2800D-02   0.2800D+05   0.5400D-02   0.4000D+05   0.3180D-01   0.4800D+05   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
  MT
 5   0.1310D-04


* MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES
MT        EF1          EF2          VF12         VF23         GF12         GF23          EM           VF           GM

 3   0.3200D+08   0.3200D+08   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1860D+06
 4   0.3200D+08   0.3200D+08   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1860D+06

MT      ALP1         ALP2         ALP3          WA           FVF          VVF

 3   0.1100D-05   0.5000D-05   0.5000D-05   0.3000D+02   0.6000D+00   0.3000D-01
 4   0.1100D-05   0.5000D-05   0.5000D-05   0.9000D+02   0.6000D+00   0.3000D-01


  LN  MT   TL        NODE    TEMP

   1   5   0.1000       1  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   2   1   0.1000       2  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   3   2   0.1000       3  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   4   3   0.1000       4  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
   5   4   0.1000       5  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
                        6  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00

STEP DESCRIPTION         PI          PO
1000 psi              1000.000       0.000
5000 psi autofrettag  5000.000       0.000
0 psi after auto         0.000       0.000
1000 psi              1000.000       0.000
3000 psi (wkg)        3000.000       0.000
4500 psi (test)       4500.000       0.000
5000 psi              5000.000       0.000
5500 psi              5500.000       0.000
7500 psi (min burst)  7500.000       0.000


@ 1000 psi
  LN  MT    R         EPR           EPH           EPM            SR            SH            SM             U             AF

   1   5  5.000  -0.62063D-03   0.91139D-03   0.36342D-03  -0.10000D+04   0.10785D+05   0.65696D+04   0.45570D-02   0.20845D+05
          5.010  -0.61758D-03   0.90834D-03   0.36342D-03  -0.97650D+03   0.10761D+05   0.65696D+04   0.45508D-02
          5.020  -0.61454D-03   0.90530D-03   0.36342D-03  -0.95314D+03   0.10738D+05   0.65696D+04   0.45446D-02
          5.030  -0.61152D-03   0.90228D-03   0.36342D-03  -0.92992D+03   0.10715D+05   0.65696D+04   0.45385D-02
          5.040  -0.60852D-03   0.89928D-03   0.36342D-03  -0.90684D+03   0.10692D+05   0.65696D+04   0.45324D-02
          5.050  -0.60554D-03   0.89630D-03   0.36342D-03  -0.88390D+03   0.10669D+05   0.65696D+04   0.45263D-02
          5.060  -0.60257D-03   0.89333D-03   0.36342D-03  -0.86109D+03   0.10646D+05   0.65696D+04   0.45203D-02
          5.070  -0.59963D-03   0.89039D-03   0.36342D-03  -0.83841D+03   0.10623D+05   0.65696D+04   0.45143D-02
          5.080  -0.59670D-03   0.88746D-03   0.36342D-03  -0.81587D+03   0.10601D+05   0.65696D+04   0.45083D-02
          5.090  -0.59378D-03   0.88454D-03   0.36342D-03  -0.79347D+03   0.10578D+05   0.65696D+04   0.45023D-02
          5.100  -0.59089D-03   0.88165D-03   0.36342D-03  -0.77119D+03   0.10556D+05   0.65696D+04   0.44964D-02

   2   1  5.100  -0.87642D-03   0.88165D-03   0.36342D-03  -0.77119D+03   0.38170D+04   0.76129D+04   0.44964D-02   0.24472D+05
          5.110  -0.87180D-03   0.87821D-03   0.36342D-03  -0.76222D+03   0.38112D+04   0.76027D+04   0.44877D-02
          5.120  -0.86720D-03   0.87480D-03   0.36342D-03  -0.75329D+03   0.38055D+04   0.75925D+04   0.44790D-02
          5.130  -0.86263D-03   0.87141D-03   0.36342D-03  -0.74441D+03   0.37998D+04   0.75825D+04   0.44703D-02
          5.140  -0.85809D-03   0.86804D-03   0.36342D-03  -0.73557D+03   0.37941D+04   0.75725D+04   0.44617D-02
          5.150  -0.85357D-03   0.86469D-03   0.36342D-03  -0.72678D+03   0.37885D+04   0.75626D+04   0.44532D-02
          5.160  -0.84908D-03   0.86137D-03   0.36342D-03  -0.71804D+03   0.37830D+04   0.75527D+04   0.44446D-02
          5.170  -0.84461D-03   0.85806D-03   0.36342D-03  -0.70934D+03   0.37774D+04   0.75429D+04   0.44362D-02
          5.180  -0.84017D-03   0.85478D-03   0.36342D-03  -0.70068D+03   0.37719D+04   0.75332D+04   0.44278D-02
          5.190  -0.83576D-03   0.85152D-03   0.36342D-03  -0.69207D+03   0.37665D+04   0.75236D+04   0.44194D-02
          5.200  -0.83137D-03   0.84828D-03   0.36342D-03  -0.68350D+03   0.37611D+04   0.75140D+04   0.44110D-02

   3   2  5.200  -0.80565D-03   0.84828D-03   0.36342D-03  -0.68350D+03   0.16545D+05   0.10305D+04   0.44110D-02   0.36522D+04
          5.210  -0.79372D-03   0.84511D-03   0.36342D-03  -0.65048D+03   0.16498D+05   0.10461D+04   0.44030D-02
          5.220  -0.78188D-03   0.84199D-03   0.36342D-03  -0.61767D+03   0.16452D+05   0.10615D+04   0.43952D-02
          5.230  -0.77012D-03   0.83889D-03   0.36342D-03  -0.58508D+03   0.16407D+05   0.10769D+04   0.43874D-02
          5.240  -0.75844D-03   0.83583D-03   0.36342D-03  -0.55269D+03   0.16362D+05   0.10921D+04   0.43798D-02
          5.250  -0.74684D-03   0.83281D-03   0.36342D-03  -0.52052D+03   0.16317D+05   0.11073D+04   0.43722D-02
```

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
		5.260	−0.73533D−03	0.82981D−03	0.36342D−03	−0.48855D+03	0.16274D+05	0.11224D+04	0.43648D−02	
		5.270	−0.72389D−03	0.82686D−03	0.36342D−03	−0.45678D+03	0.16230D+05	0.11374D+04	0.43575D−02	
		5.280	−0.71254D−03	0.82393D−03	0.36342D−03	−0.42522D+03	0.16188D+05	0.11523D+04	0.43503D−02	
		5.290	−0.70126D−03	0.82104D−03	0.36342D−03	−0.39385D+03	0.16146D+05	0.11671D+04	0.43433D−02	
		5.300	−0.69006D−03	0.81817D−03	0.36342D−03	−0.36268D+03	0.16104D+05	0.11819D+04	0.43363D−02	
4	3	5.300	−0.71416D−03	0.81817D−03	0.36342D−03	−0.36268D+03	0.38348D+04	0.75414D+04	0.43363D−02	0.25212D+05
		5.310	−0.71017D−03	0.81529D−03	0.36342D−03	−0.35478D+03	0.38302D+04	0.75330D+04	0.43292D−02	
		5.320	−0.70620D−03	0.81243D−03	0.36342D−03	−0.34692D+03	0.38255D+04	0.75247D+04	0.43221D−02	
		5.330	−0.70224D−03	0.80958D−03	0.36342D−03	−0.33910D+03	0.38210D+04	0.75164D+04	0.43151D−02	
		5.340	−0.69831D−03	0.80676D−03	0.36342D−03	−0.33131D+03	0.38164D+04	0.75082D+04	0.43081D−02	
		5.350	−0.69440D−03	0.80395D−03	0.36342D−03	−0.32356D+03	0.38119D+04	0.75001D+04	0.43011D−02	
		5.360	−0.69052D−03	0.80115D−03	0.36342D−03	−0.31585D+03	0.38074D+04	0.74920D+04	0.42942D−02	
		5.370	−0.68665D−03	0.79838D−03	0.36342D−03	−0.30818D+03	0.38029D+04	0.74839D+04	0.42873D−02	
		5.380	−0.68280D−03	0.79562D−03	0.36342D−03	−0.30054D+03	0.37985D+04	0.74760D+04	0.42805D−02	
		5.390	−0.67898D−03	0.79288D−03	0.36342D−03	−0.29294D+03	0.37942D+04	0.74680D+04	0.42736D−02	
		5.400	−0.67517D−03	0.79016D−03	0.36342D−03	−0.28537D+03	0.37898D+04	0.74602D+04	0.42669D−02	
5	4	5.400	−0.65257D−03	0.79016D−03	0.36342D−03	−0.28537D+03	0.15596D+05	0.12042D+04	0.42669D−02	0.43587D+04
		5.410	−0.64205D−03	0.78750D−03	0.36342D−03	−0.25606D+03	0.15557D+05	0.12181D+04	0.42604D−02	
		5.420	−0.63160D−03	0.78488D−03	0.36342D−03	−0.22692D+03	0.15519D+05	0.12319D+04	0.42540D−02	
		5.430	−0.62122D−03	0.78228D−03	0.36342D−03	−0.19795D+03	0.15482D+05	0.12457D+04	0.42478D−02	
		5.440	−0.61091D−03	0.77971D−03	0.36342D−03	−0.16916D+03	0.15445D+05	0.12594D+04	0.42416D−02	
		5.450	−0.60066D−03	0.77716D−03	0.36342D−03	−0.14055D+03	0.15408D+05	0.12729D+04	0.42355D−02	
		5.460	−0.59049D−03	0.77465D−03	0.36342D−03	−0.11210D+03	0.15372D+05	0.12865D+04	0.42296D−02	
		5.470	−0.58038D−03	0.77216D−03	0.36342D−03	−0.83827D+02	0.15337D+05	0.12999D+04	0.42237D−02	
		5.480	−0.57033D−03	0.76971D−03	0.36342D−03	−0.55719D+02	0.15302D+05	0.13133D+04	0.42180D−02	
		5.490	−0.56035D−03	0.76727D−03	0.36342D−03	−0.27777D+02	0.15267D+05	0.13266D+04	0.42123D−02	
		5.500	−0.55044D−03	0.76487D−03	0.36342D−03	0.18872D−10	0.15233D+05	0.13399D+04	0.42068D−02	

@ 5000 psi autofrettag

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.43883D−02	0.48845D−02	0.19621D−02	−0.50000D+04	0.40379D+05	0.26078D+05	0.24422D−01	0.82745D+05
		5.010	−0.43698D−02	0.48660D−02	0.19621D−02	−0.49095D+04	0.40289D+05	0.26078D+05	0.24379D−01	
		5.020	−0.43514D−02	0.48476D−02	0.19621D−02	−0.48196D+04	0.40199D+05	0.26078D+05	0.24335D−01	
		5.030	−0.43332D−02	0.48293D−02	0.19621D−02	−0.47302D+04	0.40109D+05	0.26078D+05	0.24292D−01	
		5.040	−0.43150D−02	0.48112D−02	0.19621D−02	−0.46413D+04	0.40021D+05	0.26078D+05	0.24248D−01	
		5.050	−0.42970D−02	0.47931D−02	0.19621D−02	−0.45529D+04	0.39932D+05	0.26078D+05	0.24205D−01	
		5.060	−0.42790D−02	0.47752D−02	0.19621D−02	−0.44651D+04	0.39844D+05	0.26078D+05	0.24162D−01	
		5.070	−0.42612D−02	0.47573D−02	0.19621D−02	−0.43778D+04	0.39757D+05	0.26078D+05	0.24120D−01	
		5.080	−0.42434D−02	0.47396D−02	0.19621D−02	−0.42910D+04	0.39670D+05	0.26078D+05	0.24077D−01	
		5.090	−0.42258D−02	0.47220D−02	0.19621D−02	−0.42047D+04	0.39584D+05	0.26078D+05	0.24035D−01	
		5.100	−0.42083D−02	0.47044D−02	0.19621D−02	−0.41189D+04	0.39498D+05	0.26078D+05	0.23993D−01	
2	1	5.100	−0.46888D−02	0.47044D−02	0.19621D−02	−0.41189D+04	0.20463D+05	0.40889D+05	0.23993D−01	0.13144D+06
		5.110	−0.46641D−02	0.46861D−02	0.19621D−02	−0.40709D+04	0.20432D+05	0.40834D+05	0.23946D−01	
		5.120	−0.46395D−02	0.46678D−02	0.19621D−02	−0.40230D+04	0.20401D+05	0.40780D+05	0.23899D−01	
		5.130	−0.46151D−02	0.46497D−02	0.19621D−02	−0.39755D+04	0.20371D+05	0.40727D+05	0.23853D−01	
		5.140	−0.45908D−02	0.46317D−02	0.19621D−02	−0.39281D+04	0.20341D+05	0.40673D+05	0.23807D−01	
		5.150	−0.45666D−02	0.46138D−02	0.19621D−02	−0.38810D+04	0.20311D+05	0.40620D+05	0.23761D−01	
		5.160	−0.45425D−02	0.45961D−02	0.19621D−02	−0.38342D+04	0.20281D+05	0.40568D+05	0.23716D−01	
		5.170	−0.45186D−02	0.45784D−02	0.19621D−02	−0.37875D+04	0.20251D+05	0.40516D+05	0.23670D−01	
		5.180	−0.44949D−02	0.45609D−02	0.19621D−02	−0.37412D+04	0.20222D+05	0.40464D+05	0.23625D−01	
		5.190	−0.44712D−02	0.45434D−02	0.19621D−02	−0.36950D+04	0.20193D+05	0.40412D+05	0.23580D−01	
		5.200	−0.44477D−02	0.45261D−02	0.19621D−02	−0.36491D+04	0.20164D+05	0.40361D+05	0.23536D−01	
3	2	5.200	−0.43117D−02	0.45261D−02	0.19621D−02	−0.36491D+04	0.88291D+05	0.55493D+04	0.23536D−01	0.19654D+05
		5.210	−0.42481D−02	0.45092D−02	0.19621D−02	−0.34729D+04	0.88042D+05	0.56322D+04	0.23493D−01	
		5.220	−0.41848D−02	0.44925D−02	0.19621D−02	−0.32978D+04	0.87796D+05	0.57146D+04	0.23451D−01	
		5.230	−0.41221D−02	0.44760D−02	0.19621D−02	−0.31239D+04	0.87553D+05	0.57965D+04	0.23409D−01	
		5.240	−0.40597D−02	0.44596D−02	0.19621D−02	−0.29510D+04	0.87314D+05	0.58779D+04	0.23368D−01	
		5.250	−0.39979D−02	0.44435D−02	0.19621D−02	−0.27793D+04	0.87077D+05	0.59589D+04	0.23328D−01	
		5.260	−0.39364D−02	0.44275D−02	0.19621D−02	−0.26087D+04	0.86843D+05	0.60394D+04	0.23289D−01	
		5.270	−0.38754D−02	0.44117D−02	0.19621D−02	−0.24392D+04	0.86612D+05	0.61194D+04	0.23249D−01	
		5.280	−0.38147D−02	0.43960D−02	0.19621D−02	−0.22708D+04	0.86384D+05	0.61990D+04	0.23211D−01	
		5.290	−0.37546D−02	0.43806D−02	0.19621D−02	−0.21034D+04	0.86159D+05	0.62781D+04	0.23173D−01	
		5.300	−0.36948D−02	0.43653D−02	0.19621D−02	−0.19371D+04	0.85937D+05	0.63568D+04	0.23136D−01	
4	3	5.300	−0.38222D−02	0.43653D−02	0.19621D−02	−0.19371D+04	0.20557D+05	0.40506D+05	0.23136D−01	0.13542D+06
		5.310	−0.38008D−02	0.43499D−02	0.19621D−02	−0.18947D+04	0.20532D+05	0.40462D+05	0.23098D−01	
		5.320	−0.37795D−02	0.43346D−02	0.19621D−02	−0.18526D+04	0.20508D+05	0.40417D+05	0.23060D−01	
		5.330	−0.37583D−02	0.43194D−02	0.19621D−02	−0.18107D+04	0.20483D+05	0.40373D+05	0.23022D−01	
		5.340	−0.37373D−02	0.43043D−02	0.19621D−02	−0.17689D+04	0.20459D+05	0.40329D+05	0.22985D−01	
		5.350	−0.37164D−02	0.42892D−02	0.19621D−02	−0.17274D+04	0.20435D+05	0.40286D+05	0.22947D−01	
		5.360	−0.36956D−02	0.42743D−02	0.19621D−02	−0.16861D+04	0.20411D+05	0.40243D+05	0.22910D−01	
		5.370	−0.36749D−02	0.42595D−02	0.19621D−02	−0.16450D+04	0.20387D+05	0.40200D+05	0.22874D−01	
		5.380	−0.36543D−02	0.42448D−02	0.19621D−02	−0.16040D+04	0.20364D+05	0.40157D+05	0.22837D−01	
		5.390	−0.36338D−02	0.42301D−02	0.19621D−02	−0.15633D+04	0.20340D+05	0.40115D+05	0.22800D−01	
		5.400	−0.36134D−02	0.42156D−02	0.19621D−02	−0.15228D+04	0.20317D+05	0.40073D+05	0.22764D−01	
5	4	5.400	−0.34941D−02	0.42156D−02	0.19621D−02	−0.15228D+04	0.83220D+05	0.64769D+04	0.22764D−01	0.23433D+05
		5.410	−0.34379D−02	0.42014D−02	0.19621D−02	−0.13663D+04	0.83014D+05	0.65510D+04	0.22730D−01	
		5.420	−0.33821D−02	0.41874D−02	0.19621D−02	−0.12108D+04	0.82812D+05	0.66248D+04	0.22695D−01	
		5.430	−0.33267D−02	0.41735D−02	0.19621D−02	−0.10563D+04	0.82611D+05	0.66981D+04	0.22662D−01	
		5.440	−0.32717D−02	0.41597D−02	0.19621D−02	−0.90264D+03	0.82414D+05	0.67710D+04	0.22629D−01	
		5.450	−0.32170D−02	0.41461D−02	0.19621D−02	−0.74995D+03	0.82219D+05	0.68436D+04	0.22596D−01	
		5.460	−0.31627D−02	0.41327D−02	0.19621D−02	−0.59817D+03	0.82026D+05	0.69157D+04	0.22565D−01	
		5.470	−0.31088D−02	0.41194D−02	0.19621D−02	−0.44729D+03	0.81836D+05	0.69875D+04	0.22533D−01	
		5.480	−0.30552D−02	0.41063D−02	0.19621D−02	−0.29731D+03	0.81648D+05	0.70589D+04	0.22502D−01	
		5.490	−0.30019D−02	0.40933D−02	0.19621D−02	−0.14822D+03	0.81463D+05	0.71299D+04	0.22472D−01	
		5.500	−0.29490D−02	0.40804D−02	0.19621D−02	0.25102D−09	0.81280D+05	0.72005D+04	0.22442D−01	

@ 0 psi after auto

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.12851D−02	0.32750D−03	0.14505D−03	−0.33288D−09	−0.13545D+05	−0.67701D+04	0.16375D−02	−0.21482D+05
		5.010	−0.12819D−02	0.32428D−03	0.14505D−03	−0.27008D+02	−0.13518D+05	−0.67701D+04	0.16247D−02	
		5.020	−0.12787D−02	0.32109D−03	0.14505D−03	−0.53856D+02	−0.13491D+05	−0.67701D+04	0.16119D−02	
		5.030	−0.12756D−02	0.31791D−03	0.14505D−03	−0.80543D+02	−0.13464D+05	−0.67701D+04	0.15991D−02	
		5.040	−0.12724D−02	0.31475D−03	0.14505D−03	−0.10707D+03	−0.13438D+05	−0.67701D+04	0.15863D−02	

		5.050	−0.12693D−02	0.31161D−03	0.14505D−03	−0.13344D+03	−0.13411D+05	−0.67701D+04	0.15736D−02	
		5.060	−0.12661D−02	0.30849D−03	0.14505D−03	−0.15966D+03	−0.13385D+05	−0.67701D+04	0.15610D−02	
		5.070	−0.12630D−02	0.30539D−03	0.14505D−03	−0.18572D+03	−0.13359D+05	−0.67701D+04	0.15483D−02	
		5.080	−0.12599D−02	0.30230D−03	0.14505D−03	−0.21162D+03	−0.13333D+05	−0.67701D+04	0.15357D−02	
		5.090	−0.12569D−02	0.29924D−03	0.14505D−03	−0.23738D+03	−0.13307D+05	−0.67701D+04	0.15231D−02	
		5.100	−0.12538D−02	0.29619D−03	0.14505D−03	−0.26298D+03	−0.13282D+05	−0.67701D+04	0.15106D−02	
2	1	5.100	−0.30675D−03	0.29619D−03	0.14505D−03	−0.26298D+03	0.13775D+04	0.28244D+04	0.15106D−02	0.90847D+04
		5.110	−0.30512D−03	0.29501D−03	0.14505D−03	−0.25977D+03	0.13756D+04	0.28210D+04	0.15075D−02	
		5.120	−0.30351D−03	0.29384D−03	0.14505D−03	−0.25658D+03	0.13737D+04	0.28176D+04	0.15045D−02	
		5.130	−0.30190D−03	0.29268D−03	0.14505D−03	−0.25340D+03	0.13718D+04	0.28142D+04	0.15014D−02	
		5.140	−0.30030D−03	0.29152D−03	0.14505D−03	−0.25024D+03	0.13699D+04	0.28108D+04	0.14984D−02	
		5.150	−0.29871D−03	0.29037D−03	0.14505D−03	−0.24710D+03	0.13680D+04	0.28075D+04	0.14954D−02	
		5.160	−0.29713D−03	0.28923D−03	0.14505D−03	−0.24397D+03	0.13662D+04	0.28042D+04	0.14924D−02	
		5.170	−0.29556D−03	0.28810D−03	0.14505D−03	−0.24086D+03	0.13644D+04	0.28009D+04	0.14895D−02	
		5.180	−0.29399D−03	0.28698D−03	0.14505D−03	−0.23776D+03	0.13626D+04	0.27976D+04	0.14865D−02	
		5.190	−0.29244D−03	0.28586D−03	0.14505D−03	−0.23468D+03	0.13608D+04	0.27944D+04	0.14836D−02	
		5.200	−0.29089D−03	0.28475D−03	0.14505D−03	−0.23161D+03	0.13590D+04	0.27911D+04	0.14807D−02	
3	2	5.200	−0.28348D−03	0.28475D−03	0.14505D−03	−0.23161D+03	0.55684D+04	0.39668D+03	0.14807D−02	0.13934D+04
		5.210	−0.27945D−03	0.28366D−03	0.14505D−03	−0.22050D+03	0.55523D+04	0.40190D+03	0.14779D−02	
		5.220	−0.27546D−03	0.28259D−03	0.14505D−03	−0.20945D+03	0.55363D+04	0.40708D+03	0.14751D−02	
		5.230	−0.27149D−03	0.28152D−03	0.14505D−03	−0.19848D+03	0.55206D+04	0.41223D+03	0.14724D−02	
		5.240	−0.26755D−03	0.28047D−03	0.14505D−03	−0.18758D+03	0.55051D+04	0.41735D+03	0.14697D−02	
		5.250	−0.26364D−03	0.27943D−03	0.14505D−03	−0.17675D+03	0.54898D+04	0.42245D+03	0.14670D−02	
		5.260	−0.25975D−03	0.27840D−03	0.14505D−03	−0.16599D+03	0.54746D+04	0.42751D+03	0.14644D−02	
		5.270	−0.25589D−03	0.27739D−03	0.14505D−03	−0.15531D+03	0.54596D+04	0.43254D+03	0.14618D−02	
		5.280	−0.25206D−03	0.27638D−03	0.14505D−03	−0.14469D+03	0.54449D+04	0.43754D+03	0.14593D−02	
		5.290	−0.24826D−03	0.27538D−03	0.14505D−03	−0.13413D+03	0.54303D+04	0.44252D+03	0.14568D−02	
		5.300	−0.24448D−03	0.27440D−03	0.14505D−03	−0.12365D+03	0.54159D+04	0.44746D+03	0.14543D−02	
4	3	5.300	−0.25134D−03	0.27440D−03	0.14505D−03	−0.12365D+03	0.13831D+04	0.27995D+04	0.14543D−02	0.93640D+04
		5.310	−0.24993D−03	0.27341D−03	0.14505D−03	−0.12081D+03	0.13816D+04	0.27967D+04	0.14518D−02	
		5.320	−0.24852D−03	0.27243D−03	0.14505D−03	−0.11799D+03	0.13801D+04	0.27939D+04	0.14493D−02	
		5.330	−0.24713D−03	0.27145D−03	0.14505D−03	−0.11518D+03	0.13785D+04	0.27911D+04	0.14468D−02	
		5.340	−0.24574D−03	0.27048D−03	0.14505D−03	−0.11238D+03	0.13770D+04	0.27883D+04	0.14444D−02	
		5.350	−0.24436D−03	0.26952D−03	0.14505D−03	−0.10960D+03	0.13756D+04	0.27856D+04	0.14419D−02	
		5.360	−0.24299D−03	0.26856D−03	0.14505D−03	−0.10683D+03	0.13741D+04	0.27829D+04	0.14395D−02	
		5.370	−0.24162D−03	0.26761D−03	0.14505D−03	−0.10408D+03	0.13726D+04	0.27802D+04	0.14371D−02	
		5.380	−0.24026D−03	0.26666D−03	0.14505D−03	−0.10133D+03	0.13712D+04	0.27775D+04	0.14347D−02	
		5.390	−0.23891D−03	0.26572D−03	0.14505D−03	−0.98601D+02	0.13697D+04	0.27749D+04	0.14323D−02	
		5.400	−0.23757D−03	0.26479D−03	0.14505D−03	−0.95884D+02	0.13683D+04	0.27722D+04	0.14299D−02	
5	4	5.400	−0.23123D−03	0.26479D−03	0.14505D−03	−0.95884D+02	0.52420D+04	0.45580D+03	0.14299D−02	0.16395D+04
		5.410	−0.22768D−03	0.26388D−03	0.14505D−03	−0.86029D+02	0.52287D+04	0.46045D+03	0.14276D−02	
		5.420	−0.22416D−03	0.26297D−03	0.14505D−03	−0.76236D+02	0.52155D+04	0.46508D+03	0.14253D−02	
		5.430	−0.22066D−03	0.26208D−03	0.14505D−03	−0.66502D+02	0.52025D+04	0.46969D+03	0.14231D−02	
		5.440	−0.21719D−03	0.26120D−03	0.14505D−03	−0.56828D+02	0.51897D+04	0.47427D+03	0.14209D−02	
		5.450	−0.21374D−03	0.26032D−03	0.14505D−03	−0.47213D+02	0.51771D+04	0.47882D+03	0.14188D−02	
		5.460	−0.21031D−03	0.25946D−03	0.14505D−03	−0.37657D+02	0.51646D+04	0.48335D+03	0.14166D−02	
		5.470	−0.20690D−03	0.25860D−03	0.14505D−03	−0.28157D+02	0.51522D+04	0.48786D+03	0.14145D−02	
		5.480	−0.20352D−03	0.25775D−03	0.14505D−03	−0.18715D+02	0.51400D+04	0.49234D+03	0.14125D−02	
		5.490	−0.20016D−03	0.25692D−03	0.14505D−03	−0.93297D+01	0.51280D+04	0.49680D+03	0.14105D−02	
		5.500	−0.19682D−03	0.25609D−03	0.14505D−03	0.10959D−09	0.51161D+04	0.50123D+03	0.14085D−02	

@ 1000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.19058D−02	0.12389D−02	0.50847D−03	−0.10000D+04	−0.27600D+04	−0.20051D+03	0.61945D−02	−0.63621D+03
		5.010	−0.18995D−02	0.12326D−02	0.50847D−03	−0.10035D+04	−0.27564D+04	−0.20051D+03	0.61754D−02	
		5.020	−0.18933D−02	0.12264D−02	0.50847D−03	−0.10070D+04	−0.27530D+04	−0.20051D+03	0.61565D−02	
		5.030	−0.18871D−02	0.12202D−02	0.50847D−03	−0.10105D+04	−0.27495D+04	−0.20051D+03	0.61376D−02	
		5.040	−0.18809D−02	0.12140D−02	0.50847D−03	−0.10139D+04	−0.27460D+04	−0.20051D+03	0.61187D−02	
		5.050	−0.18748D−02	0.12079D−02	0.50847D−03	−0.10173D+04	−0.27426D+04	−0.20051D+03	0.61000D−02	
		5.060	−0.18687D−02	0.12018D−02	0.50847D−03	−0.10207D+04	−0.27392D+04	−0.20051D+03	0.60812D−02	
		5.070	−0.18627D−02	0.11958D−02	0.50847D−03	−0.10241D+04	−0.27358D+04	−0.20051D+03	0.60626D−02	
		5.080	−0.18566D−02	0.11898D−02	0.50847D−03	−0.10275D+04	−0.27325D+04	−0.20051D+03	0.60440D−02	
		5.090	−0.18507D−02	0.11838D−02	0.50847D−03	−0.10308D+04	−0.27291D+04	−0.20051D+03	0.60254D−02	
		5.100	−0.18447D−02	0.11778D−02	0.50847D−03	−0.10342D+04	−0.27258D+04	−0.20051D+03	0.60070D−02	
2	1	5.100	−0.11832D−02	0.11778D−02	0.50847D−03	−0.10342D+04	0.51945D+04	0.10437D+05	0.60070D−02	0.33556D+05
		5.110	−0.11769D−02	0.11732D−02	0.50847D−03	−0.10220D+04	0.51868D+04	0.10424D+05	0.59952D−02	
		5.120	−0.11707D−02	0.11686D−02	0.50847D−03	−0.10099D+04	0.51792D+04	0.10410D+05	0.59834D−02	
		5.130	−0.11645D−02	0.11641D−02	0.50847D−03	−0.99781D+03	0.51716D+04	0.10397D+05	0.59718D−02	
		5.140	−0.11584D−02	0.11596D−02	0.50847D−03	−0.98582D+03	0.51640D+04	0.10383D+05	0.59601D−02	
		5.150	−0.11523D−02	0.11551D−02	0.50847D−03	−0.97388D+03	0.51566D+04	0.10370D+05	0.59486D−02	
		5.160	−0.11462D−02	0.11506D−02	0.50847D−03	−0.96201D+03	0.51492D+04	0.10357D+05	0.59371D−02	
		5.170	−0.11402D−02	0.11462D−02	0.50847D−03	−0.95020D+03	0.51418D+04	0.10344D+05	0.59257D−02	
		5.180	−0.11342D−02	0.11418D−02	0.50847D−03	−0.93844D+03	0.51345D+04	0.10331D+05	0.59143D−02	
		5.190	−0.11282D−02	0.11374D−02	0.50847D−03	−0.92675D+03	0.51273D+04	0.10318D+05	0.59030D−02	
		5.200	−0.11223D−02	0.11330D−02	0.50847D−03	−0.91511D+03	0.51201D+04	0.10305D+05	0.58917D−02	
3	2	5.200	−0.10891D−02	0.11330D−02	0.50847D−03	−0.91511D+03	0.22113D+05	0.14272D+04	0.58917D−02	0.50455D+04
		5.210	−0.10732D−02	0.11288D−02	0.50847D−03	−0.87097D+03	0.22050D+05	0.14480D+04	0.58809D−02	
		5.220	−0.10573D−02	0.11246D−02	0.50847D−03	−0.82712D+03	0.21988D+05	0.14686D+04	0.58703D−02	
		5.230	−0.10416D−02	0.11204D−02	0.50847D−03	−0.78356D+03	0.21927D+05	0.14891D+04	0.58598D−02	
		5.240	−0.10260D−02	0.11163D−02	0.50847D−03	−0.74027D+03	0.21867D+05	0.15095D+04	0.58494D−02	
		5.250	−0.10105D−02	0.11122D−02	0.50847D−03	−0.69727D+03	0.21807D+05	0.15297D+04	0.58392D−02	
		5.260	−0.99508D−03	0.11082D−02	0.50847D−03	−0.65454D+03	0.21748D+05	0.15499D+04	0.58292D−02	
		5.270	−0.97979D−03	0.11042D−02	0.50847D−03	−0.61209D+03	0.21690D+05	0.15699D+04	0.58193D−02	
		5.280	−0.96460D−03	0.11003D−02	0.50847D−03	−0.56990D+03	0.21633D+05	0.15898D+04	0.58096D−02	
		5.290	−0.94952D−03	0.10964D−02	0.50847D−03	−0.52799D+03	0.21576D+05	0.16096D+04	0.58001D−02	
		5.300	−0.93454D−03	0.10926D−02	0.50847D−03	−0.48633D+03	0.21520D+05	0.16293D+04	0.57906D−02	
4	3	5.300	−0.96550D−03	0.10926D−02	0.50847D−03	−0.48633D+03	0.52179D+04	0.10341D+05	0.57906D−02	0.34576D+05
		5.310	−0.96010D−03	0.10887D−02	0.50847D−03	−0.47560D+03	0.52117D+04	0.10330D+05	0.57810D−02	
		5.320	−0.95472D−03	0.10849D−02	0.50847D−03	−0.46491D+03	0.52056D+04	0.10319D+05	0.57714D−02	
		5.330	−0.94937D−03	0.10810D−02	0.50847D−03	−0.45428D+03	0.51995D+04	0.10308D+05	0.57619D−02	
		5.340	−0.94405D−03	0.10772D−02	0.50847D−03	−0.44370D+03	0.51935D+04	0.10297D+05	0.57524D−02	
		5.350	−0.93877D−03	0.10735D−02	0.50847D−03	−0.43316D+03	0.51874D+04	0.10286D+05	0.57430D−02	
		5.360	−0.93350D−03	0.10697D−02	0.50847D−03	−0.42268D+03	0.51815D+04	0.10275D+05	0.57337D−02	
		5.370	−0.92827D−03	0.10660D−02	0.50847D−03	−0.41225D+03	0.51756D+04	0.10264D+05	0.57244D−02	

		5.380	−0.92307D−03	0.10623D−02	0.50847D−03	−0.40187D+03	0.51697D+04	0.10253D+05	0.57151D−02	
		5.390	−0.91789D−03	0.10586D−02	0.50847D−03	−0.39154D+03	0.51639D+04	0.10243D+05	0.57059D−02	
		5.400	−0.91274D−03	0.10550D−02	0.50847D−03	−0.38126D+03	0.51581D+04	0.10232D+05	0.56967D−02	
5	4	5.400	−0.88379D−03	0.10550D−02	0.50847D−03	−0.38126D+03	0.20838D+05	0.16600D+04	0.56967D−02	0.59982D+04
		5.410	−0.86973D−03	0.10514D−02	0.50847D−03	−0.34209D+03	0.20786D+05	0.16786D+04	0.56880D−02	
		5.420	−0.85576D−03	0.10479D−02	0.50847D−03	−0.30315D+03	0.20735D+05	0.16970D+04	0.56794D−02	
		5.430	−0.84188D−03	0.10444D−02	0.50847D−03	−0.26445D+03	0.20684D+05	0.17154D+04	0.56709D−02	
		5.440	−0.82809D−03	0.10409D−02	0.50847D−03	−0.22599D+03	0.20635D+05	0.17336D+04	0.56625D−02	
		5.450	−0.81440D−03	0.10375D−02	0.50847D−03	−0.18776D+03	0.20585D+05	0.17518D+04	0.56543D−02	
		5.460	−0.80079D−03	0.10341D−02	0.50847D−03	−0.14976D+03	0.20537D+05	0.17698D+04	0.56462D−02	
		5.470	−0.78728D−03	0.10308D−02	0.50847D−03	−0.11198D+03	0.20489D+05	0.17878D+04	0.56383D−02	
		5.480	−0.77385D−03	0.10275D−02	0.50847D−03	−0.74434D+02	0.20442D+05	0.18056D+04	0.56305D−02	
		5.490	−0.76051D−03	0.10242D−02	0.50847D−03	−0.37107D+02	0.20395D+05	0.18234D+04	0.56228D−02	
		5.500	−0.74725D−03	0.10210D−02	0.50847D−03	0.14097D−09	0.20349D+05	0.18411D+04	0.56153D−02	

@ 3000 psi (wkg)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.31470D−02	0.30617D−02	0.12353D−02	−0.30000D+04	0.18810D+05	0.12939D+05	0.15308D−01	0.41055D+05
		5.010	−0.31347D−02	0.30493D−02	0.12353D−02	−0.29565D+04	0.18766D+05	0.12939D+05	0.15277D−01	
		5.020	−0.31224D−02	0.30370D−02	0.12353D−02	−0.29133D+04	0.18723D+05	0.12939D+05	0.15246D−01	
		5.030	−0.31101D−02	0.30248D−02	0.12353D−02	−0.28703D+04	0.18680D+05	0.12939D+05	0.15215D−01	
		5.040	−0.30980D−02	0.30126D−02	0.12353D−02	−0.28276D+04	0.18637D+05	0.12939D+05	0.15184D−01	
		5.050	−0.30859D−02	0.30005D−02	0.12353D−02	−0.27851D+04	0.18595D+05	0.12939D+05	0.15153D−01	
		5.060	−0.30739D−02	0.29885D−02	0.12353D−02	−0.27429D+04	0.18553D+05	0.12939D+05	0.15122D−01	
		5.070	−0.30619D−02	0.29765D−02	0.12353D−02	−0.27010D+04	0.18511D+05	0.12939D+05	0.15091D−01	
		5.080	−0.30500D−02	0.29647D−02	0.12353D−02	−0.26592D+04	0.18469D+05	0.12939D+05	0.15061D−01	
		5.090	−0.30382D−02	0.29529D−02	0.12353D−02	−0.26178D+04	0.18427D+05	0.12939D+05	0.15030D−01	
		5.100	−0.30265D−02	0.29411D−02	0.12353D−02	−0.25766D+04	0.18386D+05	0.12939D+05	0.15000D−01	
2	1	5.100	−0.29360D−02	0.29411D−02	0.12353D−02	−0.25766D+04	0.12829D+05	0.25663D+05	0.15000D−01	0.82500D+05
		5.110	−0.29205D−02	0.29296D−02	0.12353D−02	−0.25464D+04	0.12809D+05	0.25629D+05	0.14971D−01	
		5.120	−0.29051D−02	0.29182D−02	0.12353D−02	−0.25165D+04	0.12790D+05	0.25595D+05	0.14941D−01	
		5.130	−0.28898D−02	0.29069D−02	0.12353D−02	−0.24866D+04	0.12771D+05	0.25562D+05	0.14912D−01	
		5.140	−0.28746D−02	0.28956D−02	0.12353D−02	−0.24570D+04	0.12752D+05	0.25528D+05	0.14884D−01	
		5.150	−0.28594D−02	0.28844D−02	0.12353D−02	−0.24275D+04	0.12734D+05	0.25495D+05	0.14855D−01	
		5.160	−0.28444D−02	0.28733D−02	0.12353D−02	−0.23981D+04	0.12715D+05	0.25462D+05	0.14826D−01	
		5.170	−0.28294D−02	0.28623D−02	0.12353D−02	−0.23689D+04	0.12697D+05	0.25430D+05	0.14798D−01	
		5.180	−0.28145D−02	0.28513D−02	0.12353D−02	−0.23398D+04	0.12678D+05	0.25397D+05	0.14770D−01	
		5.190	−0.27997D−02	0.28404D−02	0.12353D−02	−0.23109D+04	0.12660D+05	0.25365D+05	0.14742D−01	
		5.200	−0.27850D−02	0.28296D−02	0.12353D−02	−0.22821D+04	0.12642D+05	0.25333D+05	0.14714D−01	
3	2	5.200	−0.27004D−02	0.28296D−02	0.12353D−02	−0.22821D+04	0.55202D+05	0.34883D+04	0.14714D−01	0.12350D+05
		5.210	−0.26606D−02	0.28190D−02	0.12353D−02	−0.21719D+04	0.55046D+05	0.35401D+04	0.14687D−01	
		5.220	−0.26211D−02	0.28085D−02	0.12353D−02	−0.20625D+04	0.54892D+05	0.35916D+04	0.14661D−01	
		5.230	−0.25818D−02	0.27982D−02	0.12353D−02	−0.19537D+04	0.54740D+05	0.36428D+04	0.14635D−01	
		5.240	−0.25429D−02	0.27880D−02	0.12353D−02	−0.18457D+04	0.54590D+05	0.36937D+04	0.14609D−01	
		5.250	−0.25042D−02	0.27779D−02	0.12353D−02	−0.17383D+04	0.54442D+05	0.37443D+04	0.14584D−01	
		5.260	−0.24657D−02	0.27678D−02	0.12353D−02	−0.16316D+04	0.54296D+05	0.37946D+04	0.14559D−01	
		5.270	−0.24276D−02	0.27580D−02	0.12353D−02	−0.15256D+04	0.54151D+05	0.38447D+04	0.14534D−01	
		5.280	−0.23897D−02	0.27482D−02	0.12353D−02	−0.14203D+04	0.54008D+05	0.38944D+04	0.14510D−01	
		5.290	−0.23520D−02	0.27385D−02	0.12353D−02	−0.13157D+04	0.53868D+05	0.39439D+04	0.14487D−01	
		5.300	−0.23147D−02	0.27289D−02	0.12353D−02	−0.12117D+04	0.53729D+05	0.39931D+04	0.14463D−01	
4	3	5.300	−0.23938D−02	0.27289D−02	0.12353D−02	−0.12117D+04	0.12888D+05	0.25424D+05	0.14463D−01	0.85000D+05
		5.310	−0.23804D−02	0.27193D−02	0.12353D−02	−0.11852D+04	0.12872D+05	0.25396D+05	0.14439D−01	
		5.320	−0.23671D−02	0.27097D−02	0.12353D−02	−0.11588D+04	0.12857D+05	0.25368D+05	0.14416D−01	
		5.330	−0.23539D−02	0.27002D−02	0.12353D−02	−0.11325D+04	0.12841D+05	0.25340D+05	0.14392D−01	
		5.340	−0.23407D−02	0.26907D−02	0.12353D−02	−0.11063D+04	0.12826D+05	0.25313D+05	0.14369D−01	
		5.350	−0.23276D−02	0.26814D−02	0.12353D−02	−0.10803D+04	0.12811D+05	0.25286D+05	0.14345D−01	
		5.360	−0.23145D−02	0.26720D−02	0.12353D−02	−0.10544D+04	0.12796D+05	0.25259D+05	0.14322D−01	
		5.370	−0.23016D−02	0.26627D−02	0.12353D−02	−0.10286D+04	0.12781D+05	0.25232D+05	0.14299D−01	
		5.380	−0.22887D−02	0.26535D−02	0.12353D−02	−0.10030D+04	0.12767D+05	0.25205D+05	0.14276D−01	
		5.390	−0.22758D−02	0.26444D−02	0.12353D−02	−0.97742D+03	0.12752D+05	0.25179D+05	0.14253D−01	
		5.400	−0.22631D−02	0.26353D−02	0.12353D−02	−0.95201D+03	0.12738D+05	0.25153D+05	0.14230D−01	
5	4	5.400	−0.21889D−02	0.26353D−02	0.12353D−02	−0.95201D+03	0.52029D+05	0.40685D+04	0.14230D−01	0.14716D+05
		5.410	−0.21538D−02	0.26264D−02	0.12353D−02	−0.85420D+03	0.51900D+05	0.41148D+04	0.14209D−01	
		5.420	−0.21190D−02	0.26176D−02	0.12353D−02	−0.75698D+03	0.51773D+05	0.41609D+04	0.14187D−01	
		5.430	−0.20843D−02	0.26089D−02	0.12353D−02	−0.66036D+03	0.51648D+05	0.42067D+04	0.14166D−01	
		5.440	−0.20499D−02	0.26003D−02	0.12353D−02	−0.56432D+03	0.51524D+05	0.42523D+04	0.14146D−01	
		5.450	−0.20157D−02	0.25918D−02	0.12353D−02	−0.46885D+03	0.51402D+05	0.42977D+04	0.14125D−01	
		5.460	−0.19818D−02	0.25834D−02	0.12353D−02	−0.37396D+03	0.51281D+05	0.43428D+04	0.14105D−01	
		5.470	−0.19480D−02	0.25751D−02	0.12353D−02	−0.27964D+03	0.51162D+05	0.43876D+04	0.14086D−01	
		5.480	−0.19145D−02	0.25669D−02	0.12353D−02	−0.18587D+03	0.51045D+05	0.44323D+04	0.14066D−01	
		5.490	−0.18812D−02	0.25587D−02	0.12353D−02	−0.92662D+02	0.50929D+05	0.44766D+04	0.14047D−01	
		5.500	−0.18481D−02	0.25507D−02	0.12353D−02	0.16826D−09	0.50814D+05	0.45208D+04	0.14029D−01	

@ 4500 psi (test)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.40780D−02	0.44288D−02	0.17804D−02	−0.45000D+04	0.34987D+05	0.22793D+05	0.22144D−01	0.72323D+05
		5.010	−0.40610D−02	0.44118D−02	0.17804D−02	−0.44213D+04	0.34908D+05	0.22793D+05	0.22103D−01	
		5.020	−0.40442D−02	0.43949D−02	0.17804D−02	−0.43430D+04	0.34830D+05	0.22793D+05	0.22063D−01	
		5.030	−0.40274D−02	0.43782D−02	0.17804D−02	−0.42652D+04	0.34752D+05	0.22793D+05	0.22022D−01	
		5.040	−0.40107D−02	0.43615D−02	0.17804D−02	−0.41879D+04	0.34675D+05	0.22793D+05	0.21982D−01	
		5.050	−0.39942D−02	0.43450D−02	0.17804D−02	−0.41110D+04	0.34598D+05	0.22793D+05	0.21942D−01	
		5.060	−0.39777D−02	0.43285D−02	0.17804D−02	−0.40346D+04	0.34521D+05	0.22793D+05	0.21902D−01	
		5.070	−0.39614D−02	0.43121D−02	0.17804D−02	−0.39586D+04	0.34445D+05	0.22793D+05	0.21863D−01	
		5.080	−0.39451D−02	0.42959D−02	0.17804D−02	−0.38831D+04	0.34370D+05	0.22793D+05	0.21823D−01	
		5.090	−0.39289D−02	0.42797D−02	0.17804D−02	−0.38080D+04	0.34295D+05	0.22793D+05	0.21784D−01	
		5.100	−0.39128D−02	0.42636D−02	0.17804D−02	−0.37333D+04	0.34220D+05	0.22793D+05	0.21744D−01	
2	1	5.100	−0.42506D−02	0.42636D−02	0.17804D−02	−0.37333D+04	0.18554D+05	0.37082D+05	0.21744D−01	0.11921D+06
		5.110	−0.42282D−02	0.42470D−02	0.17804D−02	−0.36897D+04	0.18526D+05	0.37033D+05	0.21702D−01	
		5.120	−0.42059D−02	0.42304D−02	0.17804D−02	−0.36464D+04	0.18498D+05	0.36984D+05	0.21660D−01	
		5.130	−0.41837D−02	0.42140D−02	0.17804D−02	−0.36032D+04	0.18471D+05	0.36935D+05	0.21618D−01	
		5.140	−0.41617D−02	0.41977D−02	0.17804D−02	−0.35603D+04	0.18444D+05	0.36887D+05	0.21576D−01	
		5.150	−0.41398D−02	0.41815D−02	0.17804D−02	−0.35176D+04	0.18416D+05	0.36839D+05	0.21535D−01	
		5.160	−0.41180D−02	0.41654D−02	0.17804D−02	−0.34751D+04	0.18389D+05	0.36791D+05	0.21493D−01	

		5.170	−0.40963D−02	0.41494D−02	0.17804D−02	−0.34329D+04	0.18363D+05	0.36744D+05	0.21452D−01	
		5.180	−0.40748D−02	0.41335D−02	0.17804D−02	−0.33908D+04	0.18336D+05	0.36697D+05	0.21411D−01	
		5.190	−0.40533D−02	0.41177D−02	0.17804D−02	−0.33490D+04	0.18310D+05	0.36650D+05	0.21371D−01	
		5.200	−0.40320D−02	0.41020D−02	0.17804D−02	−0.33074D+04	0.18284D+05	0.36604D+05	0.21330D−01	
3	2	5.200	−0.39089D−02	0.41020D−02	0.17804D−02	−0.33074D+04	0.80019D+05	0.50341D+04	0.21330D−01	0.17828D+05
		5.210	−0.38512D−02	0.40867D−02	0.17804D−02	−0.31476D+04	0.79793D+05	0.51092D+04	0.21292D−01	
		5.220	−0.37939D−02	0.40715D−02	0.17804D−02	−0.29890D+04	0.79570D+05	0.51839D+04	0.21253D−01	
		5.230	−0.37370D−02	0.40565D−02	0.17804D−02	−0.28313D+04	0.79350D+05	0.52581D+04	0.21216D−01	
		5.240	−0.36805D−02	0.40417D−02	0.17804D−02	−0.26747D+04	0.79133D+05	0.53319D+04	0.21179D−01	
		5.250	−0.36244D−02	0.40271D−02	0.17804D−02	−0.25191D+04	0.78918D+05	0.54053D+04	0.21142D−01	
		5.260	−0.35687D−02	0.40126D−02	0.17804D−02	−0.23645D+04	0.78706D+05	0.54782D+04	0.21106D−01	
		5.270	−0.35134D−02	0.39982D−02	0.17804D−02	−0.22108D+04	0.78497D+05	0.55507D+04	0.21071D−01	
		5.280	−0.34585D−02	0.39841D−02	0.17804D−02	−0.20582D+04	0.78290D+05	0.56228D+04	0.21036D−01	
		5.290	−0.34039D−02	0.39700D−02	0.17804D−02	−0.19065D+04	0.78086D+05	0.56945D+04	0.21002D−01	
		5.300	−0.33497D−02	0.39562D−02	0.17804D−02	−0.17557D+04	0.77885D+05	0.57658D+04	0.20968D−01	
4	3	5.300	−0.34651D−02	0.39562D−02	0.17804D−02	−0.17557D+04	0.18640D+05	0.36736D+05	0.20968D−01	0.12282D+06
		5.310	−0.34457D−02	0.39422D−02	0.17804D−02	−0.17173D+04	0.18617D+05	0.36695D+05	0.20933D−01	
		5.320	−0.34264D−02	0.39284D−02	0.17804D−02	−0.16791D+04	0.18595D+05	0.36655D+05	0.20899D−01	
		5.330	−0.34072D−02	0.39146D−02	0.17804D−02	−0.16411D+04	0.18573D+05	0.36615D+05	0.20865D−01	
		5.340	−0.33882D−02	0.39009D−02	0.17804D−02	−0.16033D+04	0.18551D+05	0.36575D+05	0.20831D−01	
		5.350	−0.33692D−02	0.38873D−02	0.17804D−02	−0.15656D+04	0.18529D+05	0.36536D+05	0.20797D−01	
		5.360	−0.33503D−02	0.38738D−02	0.17804D−02	−0.15282D+04	0.18507D+05	0.36497D+05	0.20763D−01	
		5.370	−0.33315D−02	0.38603D−02	0.17804D−02	−0.14909D+04	0.18486D+05	0.36458D+05	0.20730D−01	
		5.380	−0.33129D−02	0.38470D−02	0.17804D−02	−0.14538D+04	0.18465D+05	0.36419D+05	0.20697D−01	
		5.390	−0.32943D−02	0.38337D−02	0.17804D−02	−0.14168D+04	0.18443D+05	0.36381D+05	0.20664D−01	
		5.400	−0.32758D−02	0.38205D−02	0.17804D−02	−0.13801D+04	0.18422D+05	0.36343D+05	0.20631D−01	
5	4	5.400	−0.31678D−02	0.38205D−02	0.17804D−02	−0.13801D+04	0.75422D+05	0.58748D+04	0.20631D−01	0.21254D+05
		5.410	−0.31169D−02	0.38076D−02	0.17804D−02	−0.12383D+04	0.75236D+05	0.59420D+04	0.20599D−01	
		5.420	−0.30663D−02	0.37949D−02	0.17804D−02	−0.10974D+04	0.75052D+05	0.60088D+04	0.20568D−01	
		5.430	−0.30161D−02	0.37823D−02	0.17804D−02	−0.95728D+03	0.74870D+05	0.60753D+04	0.20538D−01	
		5.440	−0.29663D−02	0.37699D−02	0.17804D−02	−0.81806D+03	0.74691D+05	0.61413D+04	0.20508D−01	
		5.450	−0.29167D−02	0.37576D−02	0.17804D−02	−0.67967D+03	0.74514D+05	0.62071D+04	0.20479D−01	
		5.460	−0.28675D−02	0.37454D−02	0.17804D−02	−0.54212D+03	0.74340D+05	0.62725D+04	0.20450D−01	
		5.470	−0.28186D−02	0.37333D−02	0.17804D−02	−0.40538D+03	0.74167D+05	0.63375D+04	0.20421D−01	
		5.480	−0.27700D−02	0.37214D−02	0.17804D−02	−0.26945D+03	0.73997D+05	0.64022D+04	0.20393D−01	
		5.490	−0.27217D−02	0.37096D−02	0.17804D−02	−0.13433D+03	0.73829D+05	0.64666D+04	0.20366D−01	
		5.500	−0.26738D−02	0.36980D−02	0.17804D−02	0.29104D−09	0.73664D+05	0.65306D+04	0.20339D−01	

@ 5000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.43883D−02	0.48845D−02	0.19621D−02	−0.50000D+04	0.40379D+05	0.26078D+05	0.24422D−01	0.82745D+05
		5.010	−0.43698D−02	0.48660D−02	0.19621D−02	−0.49095D+04	0.40289D+05	0.26078D+05	0.24379D−01	
		5.020	−0.43514D−02	0.48476D−02	0.19621D−02	−0.48196D+04	0.40199D+05	0.26078D+05	0.24335D−01	
		5.030	−0.43332D−02	0.48293D−02	0.19621D−02	−0.47302D+04	0.40109D+05	0.26078D+05	0.24292D−01	
		5.040	−0.43150D−02	0.48112D−02	0.19621D−02	−0.46413D+04	0.40021D+05	0.26078D+05	0.24248D−01	
		5.050	−0.42970D−02	0.47931D−02	0.19621D−02	−0.45529D+04	0.39932D+05	0.26078D+05	0.24205D−01	
		5.060	−0.42790D−02	0.47752D−02	0.19621D−02	−0.44651D+04	0.39844D+05	0.26078D+05	0.24162D−01	
		5.070	−0.42612D−02	0.47573D−02	0.19621D−02	−0.43778D+04	0.39757D+05	0.26078D+05	0.24120D−01	
		5.080	−0.42434D−02	0.47396D−02	0.19621D−02	−0.42910D+04	0.39670D+05	0.26078D+05	0.24077D−01	
		5.090	−0.42258D−02	0.47220D−02	0.19621D−02	−0.42047D+04	0.39584D+05	0.26078D+05	0.24035D−01	
		5.100	−0.42083D−02	0.47044D−02	0.19621D−02	−0.41189D+04	0.39498D+05	0.26078D+05	0.23993D−01	
2	1	5.100	−0.46888D−02	0.47044D−02	0.19621D−02	−0.41189D+04	0.20463D+05	0.40889D+05	0.23993D−01	0.13144D+06
		5.110	−0.46641D−02	0.46861D−02	0.19621D−02	−0.40709D+04	0.20432D+05	0.40834D+05	0.23946D−01	
		5.120	−0.46395D−02	0.46678D−02	0.19621D−02	−0.40230D+04	0.20401D+05	0.40780D+05	0.23899D−01	
		5.130	−0.46151D−02	0.46497D−02	0.19621D−02	−0.39755D+04	0.20371D+05	0.40727D+05	0.23853D−01	
		5.140	−0.45908D−02	0.46317D−02	0.19621D−02	−0.39281D+04	0.20341D+05	0.40673D+05	0.23807D−01	
		5.150	−0.45666D−02	0.46138D−02	0.19621D−02	−0.38810D+04	0.20311D+05	0.40620D+05	0.23761D−01	
		5.160	−0.45425D−02	0.45961D−02	0.19621D−02	−0.38342D+04	0.20281D+05	0.40568D+05	0.23716D−01	
		5.170	−0.45186D−02	0.45784D−02	0.19621D−02	−0.37875D+04	0.20251D+05	0.40516D+05	0.23670D−01	
		5.180	−0.44949D−02	0.45609D−02	0.19621D−02	−0.37412D+04	0.20222D+05	0.40464D+05	0.23625D−01	
		5.190	−0.44712D−02	0.45434D−02	0.19621D−02	−0.36950D+04	0.20193D+05	0.40412D+05	0.23580D−01	
		5.200	−0.44477D−02	0.45261D−02	0.19621D−02	−0.36491D+04	0.20164D+05	0.40361D+05	0.23536D−01	
3	2	5.200	−0.43117D−02	0.45261D−02	0.19621D−02	−0.36491D+04	0.88291D+05	0.55493D+04	0.23536D−01	0.19654D+05
		5.210	−0.42481D−02	0.45092D−02	0.19621D−02	−0.34729D+04	0.88042D+05	0.56322D+04	0.23493D−01	
		5.220	−0.41848D−02	0.44925D−02	0.19621D−02	−0.32978D+04	0.87796D+05	0.57146D+04	0.23451D−01	
		5.230	−0.41221D−02	0.44760D−02	0.19621D−02	−0.31239D+04	0.87553D+05	0.57965D+04	0.23409D−01	
		5.240	−0.40597D−02	0.44596D−02	0.19621D−02	−0.29510D+04	0.87314D+05	0.58779D+04	0.23368D−01	
		5.250	−0.39979D−02	0.44435D−02	0.19621D−02	−0.27793D+04	0.87077D+05	0.59589D+04	0.23328D−01	
		5.260	−0.39364D−02	0.44275D−02	0.19621D−02	−0.26087D+04	0.86843D+05	0.60394D+04	0.23289D−01	
		5.270	−0.38754D−02	0.44117D−02	0.19621D−02	−0.24392D+04	0.86612D+05	0.61194D+04	0.23249D−01	
		5.280	−0.38147D−02	0.43960D−02	0.19621D−02	−0.22708D+04	0.86384D+05	0.61990D+04	0.23211D−01	
		5.290	−0.37546D−02	0.43806D−02	0.19621D−02	−0.21034D+04	0.86159D+05	0.62781D+04	0.23173D−01	
		5.300	−0.36948D−02	0.43653D−02	0.19621D−02	−0.19371D+04	0.85937D+05	0.63568D+04	0.23136D−01	
4	3	5.300	−0.38222D−02	0.43653D−02	0.19621D−02	−0.19371D+04	0.20557D+05	0.40506D+05	0.23136D−01	0.13542D+06
		5.310	−0.38008D−02	0.43499D−02	0.19621D−02	−0.18947D+04	0.20532D+05	0.40462D+05	0.23098D−01	
		5.320	−0.37795D−02	0.43346D−02	0.19621D−02	−0.18526D+04	0.20508D+05	0.40417D+05	0.23060D−01	
		5.330	−0.37583D−02	0.43194D−02	0.19621D−02	−0.18107D+04	0.20483D+05	0.40373D+05	0.23022D−01	
		5.340	−0.37373D−02	0.43043D−02	0.19621D−02	−0.17689D+04	0.20459D+05	0.40329D+05	0.22985D−01	
		5.350	−0.37164D−02	0.42892D−02	0.19621D−02	−0.17274D+04	0.20435D+05	0.40286D+05	0.22947D−01	
		5.360	−0.36956D−02	0.42743D−02	0.19621D−02	−0.16861D+04	0.20411D+05	0.40243D+05	0.22910D−01	
		5.370	−0.36749D−02	0.42595D−02	0.19621D−02	−0.16450D+04	0.20387D+05	0.40200D+05	0.22874D−01	
		5.380	−0.36543D−02	0.42448D−02	0.19621D−02	−0.16040D+04	0.20364D+05	0.40157D+05	0.22837D−01	
		5.390	−0.36338D−02	0.42301D−02	0.19621D−02	−0.15633D+04	0.20340D+05	0.40115D+05	0.22800D−01	
		5.400	−0.36134D−02	0.42156D−02	0.19621D−02	−0.15228D+04	0.20317D+05	0.40073D+05	0.22764D−01	
5	4	5.400	−0.34941D−02	0.42156D−02	0.19621D−02	−0.15228D+04	0.83220D+05	0.64769D+04	0.22764D−01	0.23433D+05
		5.410	−0.34379D−02	0.42014D−02	0.19621D−02	−0.13663D+04	0.83014D+05	0.65510D+04	0.22730D−01	
		5.420	−0.33821D−02	0.41874D−02	0.19621D−02	−0.12108D+04	0.82812D+05	0.66248D+04	0.22695D−01	
		5.430	−0.33267D−02	0.41735D−02	0.19621D−02	−0.10563D+04	0.82611D+05	0.66981D+04	0.22662D−01	
		5.440	−0.32717D−02	0.41597D−02	0.19621D−02	−0.90264D+03	0.82414D+05	0.67710D+04	0.22629D−01	
		5.450	−0.32170D−02	0.41461D−02	0.19621D−02	−0.74995D+03	0.82219D+05	0.68436D+04	0.22596D−01	
		5.460	−0.31627D−02	0.41327D−02	0.19621D−02	−0.59817D+03	0.82026D+05	0.69157D+04	0.22565D−01	
		5.470	−0.31088D−02	0.41194D−02	0.19621D−02	−0.44729D+03	0.81836D+05	0.69875D+04	0.22533D−01	
		5.480	−0.30552D−02	0.41063D−02	0.19621D−02	−0.29731D+03	0.81648D+05	0.70589D+04	0.22502D−01	
		5.490	−0.30019D−02	0.40933D−02	0.19621D−02	−0.14822D+03	0.81463D+05	0.71299D+04	0.22472D−01	

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
		5.500	−0.29490D−02	0.40804D−02	0.19621D−02	0.25102D−09	0.81280D+05	0.72005D+04	0.22442D−01	

@ 5500 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.46986D−02	0.53402D−02	0.21438D−02	−0.55000D+04	0.45772D+05	0.29363D+05	0.26701D−01	0.93168D+05
		5.010	−0.46786D−02	0.53201D−02	0.21438D−02	−0.53978D+04	0.45669D+05	0.29363D+05	0.26654D−01	
		5.020	−0.46587D−02	0.53002D−02	0.21438D−02	−0.52961D+04	0.45568D+05	0.29363D+05	0.26607D−01	
		5.030	−0.46389D−02	0.52805D−02	0.21438D−02	−0.51951D+04	0.45467D+05	0.29363D+05	0.26561D−01	
		5.040	−0.46193D−02	0.52608D−02	0.21438D−02	−0.50947D+04	0.45366D+05	0.29363D+05	0.26514D−01	
		5.050	−0.45997D−02	0.52413D−02	0.21438D−02	−0.49949D+04	0.45267D+05	0.29363D+05	0.26468D−01	
		5.060	−0.45803D−02	0.52218D−02	0.21438D−02	−0.48956D+04	0.45167D+05	0.29363D+05	0.26422D−01	
		5.070	−0.45610D−02	0.52025D−02	0.21438D−02	−0.47970D+04	0.45069D+05	0.29363D+05	0.26377D−01	
		5.080	−0.45418D−02	0.51833D−02	0.21438D−02	−0.46989D+04	0.44971D+05	0.29363D+05	0.26331D−01	
		5.090	−0.45227D−02	0.51642D−02	0.21438D−02	−0.46014D+04	0.44873D+05	0.29363D+05	0.26286D−01	
		5.100	−0.45037D−02	0.51453D−02	0.21438D−02	−0.45045D+04	0.44776D+05	0.29363D+05	0.26241D−01	
2	1	5.100	−0.51270D−02	0.51453D−02	0.21438D−02	−0.45045D+04	0.22371D+05	0.44695D+05	0.26241D−01	0.14368D+06
		5.110	−0.51000D−02	0.51252D−02	0.21438D−02	−0.44520D+04	0.22337D+05	0.44636D+05	0.26190D−01	
		5.120	−0.50731D−02	0.51052D−02	0.21438D−02	−0.43997D+04	0.22304D+05	0.44577D+05	0.26139D−01	
		5.130	−0.50464D−02	0.50854D−02	0.21438D−02	−0.43477D+04	0.22271D+05	0.44518D+05	0.26088D−01	
		5.140	−0.50198D−02	0.50657D−02	0.21438D−02	−0.42959D+04	0.22238D+05	0.44459D+05	0.26038D−01	
		5.150	−0.49934D−02	0.50462D−02	0.21438D−02	−0.42444D+04	0.22205D+05	0.44402D+05	0.25988D−01	
		5.160	−0.49671D−02	0.50267D−02	0.21438D−02	−0.41932D+04	0.22172D+05	0.44344D+05	0.25938D−01	
		5.170	−0.49409D−02	0.50074D−02	0.21438D−02	−0.41422D+04	0.22140D+05	0.44287D+05	0.25888D−01	
		5.180	−0.49149D−02	0.49883D−02	0.21438D−02	−0.40915D+04	0.22108D+05	0.44230D+05	0.25839D−01	
		5.190	−0.48891D−02	0.49692D−02	0.21438D−02	−0.40411D+04	0.22076D+05	0.44174D+05	0.25790D−01	
		5.200	−0.48634D−02	0.49503D−02	0.21438D−02	−0.39909D+04	0.22045D+05	0.44118D+05	0.25741D−01	
3	2	5.200	−0.47145D−02	0.49503D−02	0.21438D−02	−0.39909D+04	0.96564D+05	0.60646D+04	0.25741D−01	0.21480D+05
		5.210	−0.46449D−02	0.49318D−02	0.21438D−02	−0.37981D+04	0.96291D+05	0.61552D+04	0.25695D−01	
		5.220	−0.45758D−02	0.49135D−02	0.21438D−02	−0.36066D+04	0.96022D+05	0.62454D+04	0.25649D−01	
		5.230	−0.45071D−02	0.48954D−02	0.21438D−02	−0.34164D+04	0.95757D+05	0.63349D+04	0.25603D−01	
		5.240	−0.44390D−02	0.48775D−02	0.21438D−02	−0.32274D+04	0.95494D+05	0.64240D+04	0.25558D−01	
		5.250	−0.43713D−02	0.48599D−02	0.21438D−02	−0.30396D+04	0.95235D+05	0.65125D+04	0.25514D−01	
		5.260	−0.43041D−02	0.48424D−02	0.21438D−02	−0.28530D+04	0.94980D+05	0.66006D+04	0.25471D−01	
		5.270	−0.42373D−02	0.48251D−02	0.21438D−02	−0.26676D+04	0.94727D+05	0.66881D+04	0.25428D−01	
		5.280	−0.41710D−02	0.48080D−02	0.21438D−02	−0.24834D+04	0.94478D+05	0.67751D+04	0.25386D−01	
		5.290	−0.41052D−02	0.47911D−02	0.21438D−02	−0.23003D+04	0.94232D+05	0.68617D+04	0.25345D−01	
		5.300	−0.40398D−02	0.47744D−02	0.21438D−02	−0.21184D+04	0.93989D+05	0.69477D+04	0.25304D−01	
4	3	5.300	−0.41792D−02	0.47744D−02	0.21438D−02	−0.21184D+04	0.22475D+05	0.44277D+05	0.25304D−01	0.14803D+06
		5.310	−0.41559D−02	0.47575D−02	0.21438D−02	−0.20721D+04	0.22448D+05	0.44228D+05	0.25262D−01	
		5.320	−0.41326D−02	0.47408D−02	0.21438D−02	−0.20261D+04	0.22421D+05	0.44180D+05	0.25221D−01	
		5.330	−0.41095D−02	0.47242D−02	0.21438D−02	−0.19802D+04	0.22394D+05	0.44131D+05	0.25180D−01	
		5.340	−0.40865D−02	0.47076D−02	0.21438D−02	−0.19346D+04	0.22367D+05	0.44084D+05	0.25139D−01	
		5.350	−0.40636D−02	0.46912D−02	0.21438D−02	−0.18892D+04	0.22341D+05	0.44036D+05	0.25098D−01	
		5.360	−0.40408D−02	0.46749D−02	0.21438D−02	−0.18440D+04	0.22315D+05	0.43989D+05	0.25057D−01	
		5.370	−0.40182D−02	0.46587D−02	0.21438D−02	−0.17991D+04	0.22289D+05	0.43942D+05	0.25017D−01	
		5.380	−0.39957D−02	0.46426D−02	0.21438D−02	−0.17543D+04	0.22263D+05	0.43895D+05	0.24977D−01	
		5.390	−0.39733D−02	0.46266D−02	0.21438D−02	−0.17098D+04	0.22238D+05	0.43849D+05	0.24937D−01	
		5.400	−0.39510D−02	0.46107D−02	0.21438D−02	−0.16654D+04	0.22212D+05	0.43803D+05	0.24898D−01	
5	4	5.400	−0.38203D−02	0.46107D−02	0.21438D−02	−0.16654D+04	0.91018D+05	0.70790D+04	0.24898D−01	0.25612D+05
		5.410	−0.37589D−02	0.45952D−02	0.21438D−02	−0.14943D+04	0.90793D+05	0.71601D+04	0.24860D−01	
		5.420	−0.36979D−02	0.45798D−02	0.21438D−02	−0.13243D+04	0.90571D+05	0.72407D+04	0.24822D−01	
		5.430	−0.36374D−02	0.45646D−02	0.21438D−02	−0.11552D+04	0.90352D+05	0.73209D+04	0.24786D−01	
		5.440	−0.35772D−02	0.45496D−02	0.21438D−02	−0.98722D+03	0.90136D+05	0.74007D+04	0.24750D−01	
		5.450	−0.35174D−02	0.45347D−02	0.21438D−02	−0.82022D+03	0.89923D+05	0.74800D+04	0.24714D−01	
		5.460	−0.34580D−02	0.45200D−02	0.21438D−02	−0.65422D+03	0.89712D+05	0.75589D+04	0.24679D−01	
		5.470	−0.33990D−02	0.45055D−02	0.21438D−02	−0.48920D+03	0.89504D+05	0.76374D+04	0.24645D−01	
		5.480	−0.33403D−02	0.44911D−02	0.21438D−02	−0.32517D+03	0.89299D+05	0.77155D+04	0.24611D−01	
		5.490	−0.32821D−02	0.44769D−02	0.21438D−02	−0.16211D+03	0.89096D+05	0.77932D+04	0.24578D−01	
		5.500	−0.32242D−02	0.44629D−02	0.21438D−02	0.40745D−09	0.88896D+05	0.78704D+04	0.24546D−01	

@ 7500 psi (min burst)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.59399D−02	0.71630D−02	0.28707D−02	−0.75000D+04	0.67341D+05	0.42502D+05	0.35815D−01	0.13486D+06
		5.010	−0.59138D−02	0.71368D−02	0.28707D−02	−0.73508D+04	0.67192D+05	0.42502D+05	0.35755D−01	
		5.020	−0.58878D−02	0.71109D−02	0.28707D−02	−0.72024D+04	0.67044D+05	0.42502D+05	0.35696D−01	
		5.030	−0.58620D−02	0.70850D−02	0.28707D−02	−0.70550D+04	0.66896D+05	0.42502D+05	0.35638D−01	
		5.040	−0.58363D−02	0.70594D−02	0.28707D−02	−0.69084D+04	0.66750D+05	0.42502D+05	0.35579D−01	
		5.050	−0.58108D−02	0.70339D−02	0.28707D−02	−0.67627D+04	0.66604D+05	0.42502D+05	0.35521D−01	
		5.060	−0.57854D−02	0.70085D−02	0.28707D−02	−0.66178D+04	0.66459D+05	0.42502D+05	0.35463D−01	
		5.070	−0.57602D−02	0.69833D−02	0.28707D−02	−0.64738D+04	0.66315D+05	0.42502D+05	0.35405D−01	
		5.080	−0.57352D−02	0.69582D−02	0.28707D−02	−0.63307D+04	0.66172D+05	0.42502D+05	0.35348D−01	
		5.090	−0.57103D−02	0.69333D−02	0.28707D−02	−0.61884D+04	0.66030D+05	0.42502D+05	0.35291D−01	
		5.100	−0.56855D−02	0.69086D−02	0.28707D−02	−0.60469D+04	0.65888D+05	0.42502D+05	0.35234D−01	
2	1	5.100	−0.68799D−02	0.69086D−02	0.28707D−02	−0.60469D+04	0.30005D+05	0.59921D+05	0.35234D−01	0.19262D+06
		5.110	−0.68436D−02	0.68816D−02	0.28707D−02	−0.59764D+04	0.29960D+05	0.59841D+05	0.35165D−01	
		5.120	−0.68075D−02	0.68548D−02	0.28707D−02	−0.59063D+04	0.29915D+05	0.59762D+05	0.35097D−01	
		5.130	−0.67716D−02	0.68282D−02	0.28707D−02	−0.58365D+04	0.29870D+05	0.59683D+05	0.35029D−01	
		5.140	−0.67360D−02	0.68018D−02	0.28707D−02	−0.57670D+04	0.29826D+05	0.59604D+05	0.34961D−01	
		5.150	−0.67005D−02	0.67756D−02	0.28707D−02	−0.56980D+04	0.29782D+05	0.59527D+05	0.34894D−01	
		5.160	−0.66652D−02	0.67495D−02	0.28707D−02	−0.56293D+04	0.29738D+05	0.59450D+05	0.34827D−01	
		5.170	−0.66302D−02	0.67236D−02	0.28707D−02	−0.55609D+04	0.29695D+05	0.59373D+05	0.34761D−01	
		5.180	−0.65953D−02	0.66978D−02	0.28707D−02	−0.54929D+04	0.29652D+05	0.59297D+05	0.34695D−01	
		5.190	−0.65606D−02	0.66722D−02	0.28707D−02	−0.54252D+04	0.29609D+05	0.59221D+05	0.34629D−01	
		5.200	−0.65261D−02	0.66468D−02	0.28707D−02	−0.53579D+04	0.29567D+05	0.59146D+05	0.34563D−01	
3	2	5.200	−0.63258D−02	0.66468D−02	0.28707D−02	−0.53579D+04	0.12965D+06	0.81257D+04	0.34563D−01	0.28785D+05
		5.210	−0.62324D−02	0.66220D−02	0.28707D−02	−0.50991D+04	0.12929D+06	0.82474D+04	0.34501D−01	
		5.220	−0.61395D−02	0.65975D−02	0.28707D−02	−0.48420D+04	0.12893D+06	0.83684D+04	0.34439D−01	
		5.230	−0.60474D−02	0.65732D−02	0.28707D−02	−0.45866D+04	0.12857D+06	0.84887D+04	0.34378D−01	
		5.240	−0.59558D−02	0.65492D−02	0.28707D−02	−0.43328D+04	0.12822D+06	0.86082D+04	0.34318D−01	
		5.250	−0.58650D−02	0.65255D−02	0.28707D−02	−0.40806D+04	0.12787D+06	0.87271D+04	0.34259D−01	
		5.260	−0.57747D−02	0.65020D−02	0.28707D−02	−0.38301D+04	0.12753D+06	0.88453D+04	0.34201D−01	
		5.270	−0.56851D−02	0.64788D−02	0.28707D−02	−0.35812D+04	0.12719D+06	0.89629D+04	0.34143D−01	
		5.280	−0.55961D−02	0.64558D−02	0.28707D−02	−0.33338D+04	0.12685D+06	0.90797D+04	0.34087D−01	

		5.290	-0.55077D-02	0.64331D-02	0.28707D-02	-0.30880D+04	0.12652D+06	0.91959D+04	0.34031D-01	
		5.300	-0.54199D-02	0.64107D-02	0.28707D-02	-0.28438D+04	0.12620D+06	0.93114D+04	0.33977D-01	
4	3	5.300	-0.56076D-02	0.64107D-02	0.28707D-02	-0.28438D+04	0.30144D+05	0.59360D+05	0.33977D-01	0.19845D+06
		5.310	-0.55762D-02	0.63881D-02	0.28707D-02	-0.27817D+04	0.30108D+05	0.59294D+05	0.33921D-01	
		5.320	-0.55450D-02	0.63656D-02	0.28707D-02	-0.27199D+04	0.30072D+05	0.59229D+05	0.33865D-01	
		5.330	-0.55140D-02	0.63433D-02	0.28707D-02	-0.26584D+04	0.30036D+05	0.59164D+05	0.33810D-01	
		5.340	-0.54831D-02	0.63211D-02	0.28707D-02	-0.25972D+04	0.30000D+05	0.59100D+05	0.33755D-01	
		5.350	-0.54524D-02	0.62991D-02	0.28707D-02	-0.25363D+04	0.29965D+05	0.59036D+05	0.33700D-01	
		5.360	-0.54219D-02	0.62772D-02	0.28707D-02	-0.24757D+04	0.29930D+05	0.58973D+05	0.33646D-01	
		5.370	-0.53915D-02	0.62555D-02	0.28707D-02	-0.24154D+04	0.29895D+05	0.58910D+05	0.33592D-01	
		5.380	-0.53613D-02	0.62338D-02	0.28707D-02	-0.23554D+04	0.29860D+05	0.58847D+05	0.33538D-01	
		5.390	-0.53312D-02	0.62124D-02	0.28707D-02	-0.22956D+04	0.29826D+05	0.58785D+05	0.33485D-01	
		5.400	-0.53013D-02	0.61910D-02	0.28707D-02	-0.22362D+04	0.29792D+05	0.58724D+05	0.33431D-01	
5	4	5.400	-0.51255D-02	0.61910D-02	0.28707D-02	-0.22362D+04	0.12221D+06	0.94875D+04	0.33431D-01	0.34330D+05
		5.410	-0.50430D-02	0.61702D-02	0.28707D-02	-0.20064D+04	0.12191D+06	0.95963D+04	0.33381D-01	
		5.420	-0.49611D-02	0.61495D-02	0.28707D-02	-0.17781D+04	0.12161D+06	0.97046D+04	0.33331D-01	
		5.430	-0.48798D-02	0.61292D-02	0.28707D-02	-0.15511D+04	0.12132D+06	0.98123D+04	0.33281D-01	
		5.440	-0.47990D-02	0.61090D-02	0.28707D-02	-0.13255D+04	0.12103D+06	0.99194D+04	0.33233D-01	
		5.450	-0.47187D-02	0.60891D-02	0.28707D-02	-0.11013D+04	0.12074D+06	0.10026D+05	0.33185D-01	
		5.460	-0.46389D-02	0.60693D-02	0.28707D-02	-0.87842D+03	0.12046D+06	0.10132D+05	0.33139D-01	
		5.470	-0.45597D-02	0.60498D-02	0.28707D-02	-0.65686D+03	0.12018D+06	0.10237D+05	0.33093D-01	
		5.480	-0.44810D-02	0.60305D-02	0.28707D-02	-0.43661D+03	0.11990D+06	0.10342D+05	0.33047D-01	
		5.490	-0.44028D-02	0.60115D-02	0.28707D-02	-0.21766D+03	0.11963D+06	0.10446D+05	0.33003D-01	
		5.500	-0.43251D-02	0.59926D-02	0.28707D-02	0.25784D-09	0.11936D+06	0.10550D+05	0.32959D-01	

STEP	DESCRIPTION	STRESS RATIO
1	1000 psi	7.861
2	5000 psi autofrettag	1.466
3	0 psi after auto	21.783
4	1000 psi	5.776
5	3000 psi (wkg)	2.339
6	4500 psi (test)	1.617
7	5000 psi	1.466
8	5500 psi	1.341
9	7500 psi (min burst)	1.000

```
Ver4 - pressure steps, metal lined
5.,5,5,9,9,0
1,1
5.81d6,1.508d6,2.411d6,1.393,-.239,.3436
-4.96D-6,19.5D-6,23.1D-6
2,1
2.228d6,19.38d6,2.228d6,.03481,.5195,.3029
20.D-6,0.2D-6,20.D-6
3,4
32.d6,32.d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5.0d-6,5.0d-6
30,.6,.03
4,4
32.0d6,32.0d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5d-6,5d-6
90,.6,.03
5,2
3
.0028,28000
.0054,40000
.0318,48000
13.1d-6
1,5,0.1
2,1,0.1
3,2,0.1
4,3,0.1
5,4,0.1
1000 psi
1000.,0.
0,0,0,0,0,0
5000 psi autofrettage
5000.,0.
0,0,0,0,0,0
0 psi after auto
0000.,0.
0,0,0,0,0,0
1000 psi
1000.,0,
0,0,0,0,0,0
3000 psi (wkg)
3000.,0.
0,0,0,0,0,0
4500 psi (test)
4500.,0.
0,0,0,0,0,0
5000 psi
5000.,0.
0,0,0,0,0,0
```

```
5500 psi
5500.,0.
0,0,0,0,0,0
7500 psi (min burst)
7500.,0.
0,0,0,0,0,0
```

Verification 5: metal lined composite cylinder with high pressure steps

A composite cylinder with metal liner and internal pressure steps, at higher pressures than the prior example.

The following page contains the results of the NewCAP analysis of the cylinder. Note that:

- The composite properties are not affected by stress level, but the metal liner materials are affected once the material has yielded, therefore, the stresses are not equal to the ratios of pressures
- The radial stresses at the surfaces are equal to the respective applied pressure
- The radial stress at the outer surface of one layer is equal to the radial stress at the inner surface of the next layer
- The meridional strains are constant across the cross-section
- The stress ratios are not equal to the pressure ratios, given that the liner material has yielded
- The stresses and strains at zero pressure after autofrettage pressure are not zero, reflecting interface pressure between the metal liner and the composite as a result of liner yielding during autofrettage
- The stresses and strains at 1000 psi before and after autofrettage are not equal, reflecting the yielding of the liner
- The stresses and strains at 1000 psi after autofrettage are equal to the stresses and strains at 1000 psi before autofrettage plus the stresses and strains at zero pressure after autofrettage, reflecting the yielding after autofrettage and subsequent elastic behavior between zero psi and 1000 psi.
- The stresses and strains at 8000 psi on the first cycle and on the second cycle are not the same, likely because there was further yielding in compression at zero pressure after autofrettage.
- Looking at stresses and strains, the difference in values from 7500 psi to 8000 psi are the same as the values from 8000 psi to 8500 psi, indicating that the liner is operating in the third linear region, and the model is performing as expected.

-->NewCAP<-- LAST MODIFIED 3JAN2020 VERSION 1a
COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020

Ver5 - pressure steps, metal lined, high pressure

RI= 5.0000 NL= 5 NMT= 5 NLS= 10 ISPL= 9 IPO= 0

* MATERIAL MODEL 1 - GENERAL PROPERTIES

MT	EM	EH	ER	PRMH	PRMR	PRHR	PRHM	PRRM	PRRH	N
1	0.5810D+07	0.1508D+07	0.2411D+07	0.1393D+01	-0.2390D+00	0.3436D+00	0.3616D+00	-0.9918D-01	0.5493D+00	0.1109D+01
2	0.2228D+07	0.1938D+08	0.2228D+07	0.3481D-01	0.5195D+00	0.3029D+00	0.3028D+00	0.5195D+00	0.3482D-01	0.2533D+01

MT	ALPM	ALPH	ALPR
1	-0.4960D-05	0.1950D-04	0.2310D-04
2	0.2000D-04	0.2000D-06	0.2000D-04

* MATERIAL MODEL 2 - MULTI-LINEAR STRESS/STRAIN

MT	STRAIN1	STRESS1	STRAIN2	STRESS2	STRAIN3	STRESS3	STRAIN4	STRESS4	STRAIN5	STRESS5
5	0.2800D-02	0.2800D+05	0.5400D-02	0.4000D+05	0.3180D-01	0.4800D+05	0.0000D+00	0.0000D+00	0.0000D+00	0.0000D+00

MT	
5	0.1310D-04

* MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES

MT	EF1	EF2	VF12	VF23	GF12	GF23	EM	VF	GM
3	0.3200D+08	0.3200D+08	0.3200D+00	0.3200D+00	0.5000D+06	0.5000D+06	0.5000D+06	0.3500D+00	0.1860D+06
4	0.3200D+08	0.3200D+08	0.3200D+00	0.3200D+00	0.5000D+06	0.5000D+06	0.5000D+06	0.3500D+00	0.1860D+06

MT	ALP1	ALP2	ALP3	WA	FVF	VVF
3	0.1100D-05	0.5000D-05	0.5000D-05	0.3000D+02	0.6000D+00	0.3000D-01
4	0.1100D-05	0.5000D-05	0.5000D-05	0.9000D+02	0.6000D+00	0.3000D-01

LN	MT	TL	NODE	TEMP									
1	5	0.1000	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	0.1000	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	0.1000	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	0.1000	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	0.1000	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STEP DESCRIPTION	PI	PO
1000 psi	1000.000	0.000
8000 psi autofrettag	8000.000	0.000
0 psi after auto	0.000	0.000
1000 psi	1000.000	0.000
5000 psi (wkg)	5000.000	0.000
7500 psi (test)	7500.000	0.000
8000 psi	8000.000	0.000
8500 psi	8500.000	0.000
10000 psi	10000.000	0.000
12500 psi (min burst	12500.000	0.000

@ 1000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	-0.62063D-03	0.91139D-03	0.36342D-03	-0.10000D+04	0.10785D+05	0.65696D+04	0.45570D-02	0.20845D+05
		5.010	-0.61758D-03	0.90834D-03	0.36342D-03	-0.97650D+03	0.10761D+05	0.65696D+04	0.45508D-02	
		5.020	-0.61454D-03	0.90530D-03	0.36342D-03	-0.95314D+03	0.10738D+05	0.65696D+04	0.45446D-02	
		5.030	-0.61152D-03	0.90228D-03	0.36342D-03	-0.92992D+03	0.10715D+05	0.65696D+04	0.45385D-02	
		5.040	-0.60852D-03	0.89928D-03	0.36342D-03	-0.90684D+03	0.10692D+05	0.65696D+04	0.45324D-02	
		5.050	-0.60554D-03	0.89630D-03	0.36342D-03	-0.88390D+03	0.10669D+05	0.65696D+04	0.45263D-02	
		5.060	-0.60257D-03	0.89333D-03	0.36342D-03	-0.86109D+03	0.10646D+05	0.65696D+04	0.45203D-02	
		5.070	-0.59963D-03	0.89039D-03	0.36342D-03	-0.83841D+03	0.10623D+05	0.65696D+04	0.45143D-02	
		5.080	-0.59670D-03	0.88746D-03	0.36342D-03	-0.81587D+03	0.10601D+05	0.65696D+04	0.45083D-02	
		5.090	-0.59378D-03	0.88454D-03	0.36342D-03	-0.79347D+03	0.10578D+05	0.65696D+04	0.45023D-02	
		5.100	-0.59089D-03	0.88165D-03	0.36342D-03	-0.77119D+03	0.10556D+05	0.65696D+04	0.44964D-02	
2	1	5.100	-0.87642D-03	0.88165D-03	0.36342D-03	-0.77119D+03	0.38170D+04	0.76129D+04	0.44964D-02	0.24472D+05
		5.110	-0.87180D-03	0.87821D-03	0.36342D-03	-0.76222D+03	0.38112D+04	0.76027D+04	0.44877D-02	
		5.120	-0.86720D-03	0.87480D-03	0.36342D-03	-0.75329D+03	0.38055D+04	0.75925D+04	0.44790D-02	
		5.130	-0.86263D-03	0.87141D-03	0.36342D-03	-0.74441D+03	0.37998D+04	0.75825D+04	0.44703D-02	
		5.140	-0.85809D-03	0.86804D-03	0.36342D-03	-0.73557D+03	0.37941D+04	0.75725D+04	0.44617D-02	
		5.150	-0.85357D-03	0.86469D-03	0.36342D-03	-0.72678D+03	0.37885D+04	0.75626D+04	0.44532D-02	
		5.160	-0.84908D-03	0.86137D-03	0.36342D-03	-0.71804D+03	0.37830D+04	0.75527D+04	0.44446D-02	
		5.170	-0.84461D-03	0.85806D-03	0.36342D-03	-0.70934D+03	0.37774D+04	0.75429D+04	0.44362D-02	
		5.180	-0.84017D-03	0.85478D-03	0.36342D-03	-0.70068D+03	0.37719D+04	0.75332D+04	0.44278D-02	
		5.190	-0.83576D-03	0.85152D-03	0.36342D-03	-0.69207D+03	0.37665D+04	0.75236D+04	0.44194D-02	
		5.200	-0.83137D-03	0.84828D-03	0.36342D-03	-0.68350D+03	0.37611D+04	0.75140D+04	0.44110D-02	
3	2	5.200	-0.80565D-03	0.84828D-03	0.36342D-03	-0.68350D+03	0.16545D+05	0.10305D+04	0.44110D-02	0.36522D+04
		5.210	-0.79372D-03	0.84511D-03	0.36342D-03	-0.65048D+03	0.16498D+05	0.10461D+04	0.44030D-02	
		5.220	-0.78188D-03	0.84199D-03	0.36342D-03	-0.61767D+03	0.16452D+05	0.10615D+04	0.43952D-02	
		5.230	-0.77012D-03	0.83889D-03	0.36342D-03	-0.58508D+03	0.16407D+05	0.10769D+04	0.43874D-02	

		5.240	-0.75844D-03	0.83583D-03	0.36342D-03	-0.55269D+03	0.16362D+05	0.10921D+04	0.43798D-02	
		5.250	-0.74684D-03	0.83281D-03	0.36342D-03	-0.52052D+03	0.16317D+05	0.11073D+04	0.43722D-02	
		5.260	-0.73533D-03	0.82981D-03	0.36342D-03	-0.48855D+03	0.16274D+05	0.11224D+04	0.43648D-02	
		5.270	-0.72389D-03	0.82686D-03	0.36342D-03	-0.45678D+03	0.16230D+05	0.11374D+04	0.43575D-02	
		5.280	-0.71254D-03	0.82393D-03	0.36342D-03	-0.42522D+03	0.16188D+05	0.11523D+04	0.43503D-02	
		5.290	-0.70126D-03	0.82104D-03	0.36342D-03	-0.39385D+03	0.16146D+05	0.11671D+04	0.43433D-02	
		5.300	-0.69006D-03	0.81817D-03	0.36342D-03	-0.36268D+03	0.16104D+05	0.11819D+04	0.43363D-02	
4	3	5.300	-0.71416D-03	0.81817D-03	0.36342D-03	-0.36268D+03	0.38348D+04	0.75414D+04	0.43363D-02	0.25212D+05
		5.310	-0.71017D-03	0.81529D-03	0.36342D-03	-0.35478D+03	0.38302D+04	0.75330D+04	0.43292D-02	
		5.320	-0.70620D-03	0.81243D-03	0.36342D-03	-0.34692D+03	0.38255D+04	0.75247D+04	0.43221D-02	
		5.330	-0.70224D-03	0.80958D-03	0.36342D-03	-0.33910D+03	0.38210D+04	0.75164D+04	0.43151D-02	
		5.340	-0.69831D-03	0.80676D-03	0.36342D-03	-0.33131D+03	0.38164D+04	0.75082D+04	0.43081D-02	
		5.350	-0.69440D-03	0.80395D-03	0.36342D-03	-0.32356D+03	0.38119D+04	0.75001D+04	0.43011D-02	
		5.360	-0.69052D-03	0.80115D-03	0.36342D-03	-0.31585D+03	0.38074D+04	0.74920D+04	0.42942D-02	
		5.370	-0.68665D-03	0.79838D-03	0.36342D-03	-0.30818D+03	0.38029D+04	0.74839D+04	0.42873D-02	
		5.380	-0.68280D-03	0.79562D-03	0.36342D-03	-0.30054D+03	0.37985D+04	0.74760D+04	0.42805D-02	
		5.390	-0.67898D-03	0.79288D-03	0.36342D-03	-0.29294D+03	0.37942D+04	0.74680D+04	0.42736D-02	
		5.400	-0.67517D-03	0.79016D-03	0.36342D-03	-0.28537D+03	0.37898D+04	0.74602D+04	0.42669D-02	
5	4	5.400	-0.65257D-03	0.79016D-03	0.36342D-03	-0.28537D+03	0.15596D+05	0.12042D+04	0.42669D-02	0.43587D+04
		5.410	-0.64205D-03	0.78750D-03	0.36342D-03	-0.25606D+03	0.15557D+05	0.12181D+04	0.42604D-02	
		5.420	-0.63160D-03	0.78488D-03	0.36342D-03	-0.22692D+03	0.15519D+05	0.12319D+04	0.42540D-02	
		5.430	-0.62122D-03	0.78228D-03	0.36342D-03	-0.19795D+03	0.15482D+05	0.12457D+04	0.42478D-02	
		5.440	-0.61091D-03	0.77971D-03	0.36342D-03	-0.16916D+03	0.15445D+05	0.12594D+04	0.42416D-02	
		5.450	-0.60066D-03	0.77716D-03	0.36342D-03	-0.14055D+03	0.15408D+05	0.12729D+04	0.42355D-02	
		5.460	-0.59049D-03	0.77465D-03	0.36342D-03	-0.11210D+03	0.15372D+05	0.12865D+04	0.42296D-02	
		5.470	-0.58038D-03	0.77216D-03	0.36342D-03	-0.83827D+02	0.15337D+05	0.12999D+04	0.42237D-02	
		5.480	-0.57033D-03	0.76971D-03	0.36342D-03	-0.55719D+02	0.15302D+05	0.13133D+04	0.42180D-02	
		5.490	-0.56035D-03	0.76727D-03	0.36342D-03	-0.27777D+02	0.15267D+05	0.13266D+04	0.42123D-02	
		5.500	-0.55044D-03	0.76487D-03	0.36342D-03	0.18872D-10	0.15233D+05	0.13399D+04	0.42068D-02	

@ 8000 psi autofrettag

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	-0.96751D-02	0.84242D-02	0.35187D-02	-0.80000D+04	0.38672D+05	0.26022D+05	0.42121D-01	0.82569D+05
		5.010	-0.96390D-02	0.83881D-02	0.35187D-02	-0.79069D+04	0.38579D+05	0.26022D+05	0.42024D-01	
		5.020	-0.96032D-02	0.83522D-02	0.35187D-02	-0.78144D+04	0.38486D+05	0.26022D+05	0.41928D-01	
		5.030	-0.95675D-02	0.83166D-02	0.35187D-02	-0.77225D+04	0.38394D+05	0.26022D+05	0.41832D-01	
		5.040	-0.95321D-02	0.82811D-02	0.35187D-02	-0.76311D+04	0.38303D+05	0.26022D+05	0.41737D-01	
		5.050	-0.94968D-02	0.82459D-02	0.35187D-02	-0.75402D+04	0.38212D+05	0.26022D+05	0.41642D-01	
		5.060	-0.94618D-02	0.82108D-02	0.35187D-02	-0.74499D+04	0.38122D+05	0.26022D+05	0.41547D-01	
		5.070	-0.94270D-02	0.81760D-02	0.35187D-02	-0.73601D+04	0.38032D+05	0.26022D+05	0.41452D-01	
		5.080	-0.93923D-02	0.81414D-02	0.35187D-02	-0.72708D+04	0.37943D+05	0.26022D+05	0.41358D-01	
		5.090	-0.93579D-02	0.81070D-02	0.35187D-02	-0.71821D+04	0.37854D+05	0.26022D+05	0.41265D-01	
		5.100	-0.93237D-02	0.80728D-02	0.35187D-02	-0.70938D+04	0.37766D+05	0.26022D+05	0.41171D-01	
2	1	5.100	-0.81274D-02	0.80728D-02	0.35187D-02	-0.70938D+04	0.35743D+05	0.71928D+05	0.41171D-01	0.23126D+06
		5.110	-0.80845D-02	0.80411D-02	0.35187D-02	-0.70101D+04	0.35690D+05	0.71835D+05	0.41090D-01	
		5.120	-0.80418D-02	0.80097D-02	0.35187D-02	-0.69267D+04	0.35637D+05	0.71742D+05	0.41010D-01	
		5.130	-0.79994D-02	0.79784D-02	0.35187D-02	-0.68438D+04	0.35585D+05	0.71650D+05	0.40929D-01	
		5.140	-0.79572D-02	0.79474D-02	0.35187D-02	-0.67613D+04	0.35534D+05	0.71558D+05	0.40850D-01	
		5.150	-0.79152D-02	0.79165D-02	0.35187D-02	-0.66792D+04	0.35483D+05	0.71467D+05	0.40770D-01	
		5.160	-0.78735D-02	0.78859D-02	0.35187D-02	-0.65976D+04	0.35432D+05	0.71377D+05	0.40691D-01	
		5.170	-0.78320D-02	0.78555D-02	0.35187D-02	-0.65163D+04	0.35381D+05	0.71288D+05	0.40613D-01	
		5.180	-0.77907D-02	0.78252D-02	0.35187D-02	-0.64355D+04	0.35331D+05	0.71199D+05	0.40535D-01	
		5.190	-0.77497D-02	0.77952D-02	0.35187D-02	-0.63550D+04	0.35282D+05	0.71110D+05	0.40457D-01	
		5.200	-0.77089D-02	0.77653D-02	0.35187D-02	-0.62750D+04	0.35233D+05	0.71022D+05	0.40380D-01	
3	2	5.200	-0.74836D-02	0.77653D-02	0.35187D-02	-0.62750D+04	0.15158D+06	0.98561D+04	0.40380D-01	0.34826D+05
		5.210	-0.73743D-02	0.77361D-02	0.35187D-02	-0.59725D+04	0.15114D+06	0.99983D+04	0.40305D-01	
		5.220	-0.72657D-02	0.77073D-02	0.35187D-02	-0.56719D+04	0.15072D+06	0.10140D+05	0.40232D-01	
		5.230	-0.71578D-02	0.76788D-02	0.35187D-02	-0.53733D+04	0.15030D+06	0.10280D+05	0.40160D-01	
		5.240	-0.70508D-02	0.76506D-02	0.35187D-02	-0.50766D+04	0.14989D+06	0.10420D+05	0.40089D-01	
		5.250	-0.69444D-02	0.76227D-02	0.35187D-02	-0.47818D+04	0.14948D+06	0.10559D+05	0.40019D-01	
		5.260	-0.68389D-02	0.75951D-02	0.35187D-02	-0.44889D+04	0.14907D+06	0.10697D+05	0.39950D-01	
		5.270	-0.67340D-02	0.75678D-02	0.35187D-02	-0.41979D+04	0.14867D+06	0.10834D+05	0.39882D-01	
		5.280	-0.66299D-02	0.75408D-02	0.35187D-02	-0.39088D+04	0.14828D+06	0.10971D+05	0.39815D-01	
		5.290	-0.65265D-02	0.75141D-02	0.35187D-02	-0.36214D+04	0.14789D+06	0.11106D+05	0.39750D-01	
		5.300	-0.64238D-02	0.74877D-02	0.35187D-02	-0.33359D+04	0.14751D+06	0.11241D+05	0.39685D-01	
4	3	5.300	-0.66342D-02	0.74877D-02	0.35187D-02	-0.33359D+04	0.35903D+05	0.71266D+05	0.39685D-01	0.23829D+06
		5.310	-0.65971D-02	0.74611D-02	0.35187D-02	-0.32621D+04	0.35860D+05	0.71189D+05	0.39619D-01	
		5.320	-0.65601D-02	0.74348D-02	0.35187D-02	-0.31886D+04	0.35818D+05	0.71113D+05	0.39553D-01	
		5.330	-0.65234D-02	0.74085D-02	0.35187D-02	-0.31154D+04	0.35776D+05	0.71038D+05	0.39487D-01	
		5.340	-0.64868D-02	0.73825D-02	0.35187D-02	-0.30426D+04	0.35735D+05	0.70962D+05	0.39422D-01	
		5.350	-0.64505D-02	0.73566D-02	0.35187D-02	-0.29702D+04	0.35694D+05	0.70888D+05	0.39358D-01	
		5.360	-0.64143D-02	0.73309D-02	0.35187D-02	-0.28981D+04	0.35653D+05	0.70814D+05	0.39293D-01	
		5.370	-0.63784D-02	0.73053D-02	0.35187D-02	-0.28263D+04	0.35613D+05	0.70740D+05	0.39229D-01	
		5.380	-0.63426D-02	0.72799D-02	0.35187D-02	-0.27549D+04	0.35572D+05	0.70667D+05	0.39166D-01	
		5.390	-0.63070D-02	0.72547D-02	0.35187D-02	-0.26839D+04	0.35533D+05	0.70595D+05	0.39103D-01	
		5.400	-0.62716D-02	0.72296D-02	0.35187D-02	-0.26131D+04	0.35493D+05	0.70523D+05	0.39040D-01	
5	4	5.400	-0.60751D-02	0.72296D-02	0.35187D-02	-0.26131D+04	0.14282D+06	0.11453D+05	0.39040D-01	0.41369D+05
		5.410	-0.59786D-02	0.72051D-02	0.35187D-02	-0.23446D+04	0.14247D+06	0.11580D+05	0.38979D-01	
		5.420	-0.58829D-02	0.71808D-02	0.35187D-02	-0.20778D+04	0.14212D+06	0.11706D+05	0.38920D-01	
		5.430	-0.57877D-02	0.71569D-02	0.35187D-02	-0.18125D+04	0.14177D+06	0.11832D+05	0.38862D-01	
		5.440	-0.56932D-02	0.71332D-02	0.35187D-02	-0.15489D+04	0.14143D+06	0.11957D+05	0.38804D-01	
		5.450	-0.55993D-02	0.71097D-02	0.35187D-02	-0.12869D+04	0.14109D+06	0.12082D+05	0.38748D-01	
		5.460	-0.55061D-02	0.70865D-02	0.35187D-02	-0.10264D+04	0.14076D+06	0.12205D+05	0.38692D-01	
		5.470	-0.54134D-02	0.70636D-02	0.35187D-02	-0.76752D+03	0.14043D+06	0.12328D+05	0.38638D-01	
		5.480	-0.53214D-02	0.70409D-02	0.35187D-02	-0.51016D+03	0.14010D+06	0.12451D+05	0.38584D-01	
		5.490	-0.52299D-02	0.70185D-02	0.35187D-02	-0.25433D+03	0.13978D+06	0.12573D+05	0.38531D-01	
		5.500	-0.51391D-02	0.69963D-02	0.35187D-02	0.38199D-09	0.13947D+06	0.12694D+05	0.38480D-01	

@ 0 psi after auto

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	-0.41386D-02	0.98164D-03	0.55374D-03	0.11096D-08	-0.41409D+05	-0.23672D+05	0.49082D-02	-0.75111D+05
		5.010	-0.41284D-02	0.97143D-03	0.55374D-03	-0.82570D+02	-0.41326D+05	-0.23672D+05	0.48669D-02	
		5.020	-0.41183D-02	0.96128D-03	0.55374D-03	-0.16465D+03	-0.41244D+05	-0.23672D+05	0.48256D-02	

		5.030	−0.41082D−02	0.95119D−03	0.55374D−03	−0.24623D+03	−0.41163D+05	−0.23672D+05	0.47845D−02	
		5.040	−0.40981D−02	0.94117D−03	0.55374D−03	−0.32734D+03	−0.41082D+05	−0.23672D+05	0.47435D−02	
		5.050	−0.40882D−02	0.93120D−03	0.55374D−03	−0.40796D+03	−0.41001D+05	−0.23672D+05	0.47025D−02	
		5.060	−0.40783D−02	0.92129D−03	0.55374D−03	−0.48810D+03	−0.40921D+05	−0.23672D+05	0.46617D−02	
		5.070	−0.40684D−02	0.91144D−03	0.55374D−03	−0.56777D+03	−0.40841D+05	−0.23672D+05	0.46210D−02	
		5.080	−0.40586D−02	0.90164D−03	0.55374D−03	−0.64697D+03	−0.40762D+05	−0.23672D+05	0.45803D−02	
		5.090	−0.40489D−02	0.89191D−03	0.55374D−03	−0.72571D+03	−0.40683D+05	−0.23672D+05	0.45398D−02	
		5.100	−0.40392D−02	0.88223D−03	0.55374D−03	−0.80398D+03	−0.40605D+05	−0.23672D+05	0.44994D−02	
2	1	5.100	−0.97898D−03	0.88223D−03	0.55374D−03	−0.80398D+03	0.46073D+04	0.98273D+04	0.44994D−02	0.31636D+05
		5.110	−0.97375D−03	0.87859D−03	0.55374D−03	−0.79339D+03	0.46017D+04	0.98170D+04	0.44896D−02	
		5.120	−0.96854D−03	0.87498D−03	0.55374D−03	−0.78286D+03	0.45962D+04	0.98068D+04	0.44799D−02	
		5.130	−0.96336D−03	0.87139D−03	0.55374D−03	−0.77238D+03	0.45907D+04	0.97967D+04	0.44702D−02	
		5.140	−0.95822D−03	0.86783D−03	0.55374D−03	−0.76195D+03	0.45853D+04	0.97866D+04	0.44606D−02	
		5.150	−0.95310D−03	0.86429D−03	0.55374D−03	−0.75158D+03	0.45799D+04	0.97767D+04	0.44511D−02	
		5.160	−0.94800D−03	0.86077D−03	0.55374D−03	−0.74125D+03	0.45746D+04	0.97668D+04	0.44416D−02	
		5.170	−0.94294D−03	0.85727D−03	0.55374D−03	−0.73097D+03	0.45693D+04	0.97569D+04	0.44321D−02	
		5.180	−0.93791D−03	0.85380D−03	0.55374D−03	−0.72074D+03	0.45641D+04	0.97472D+04	0.44227D−02	
		5.190	−0.93290D−03	0.85036D−03	0.55374D−03	−0.71057D+03	0.45589D+04	0.97375D+04	0.44134D−02	
		5.200	−0.92792D−03	0.84693D−03	0.55374D−03	−0.70044D+03	0.45537D+04	0.97279D+04	0.44040D−02	
3	2	5.200	−0.91234D−03	0.84693D−03	0.55374D−03	−0.70044D+03	0.16640D+05	0.14491D+04	0.44040D−02	0.50323D+04
		5.210	−0.90025D−03	0.84357D−03	0.55374D−03	−0.66720D+03	0.16590D+05	0.14646D+04	0.43950D−02	
		5.220	−0.88825D−03	0.84024D−03	0.55374D−03	−0.63419D+03	0.16540D+05	0.14800D+04	0.43860D−02	
		5.230	−0.87633D−03	0.83694D−03	0.55374D−03	−0.60140D+03	0.16491D+05	0.14953D+04	0.43772D−02	
		5.240	−0.86450D−03	0.83369D−03	0.55374D−03	−0.56883D+03	0.16442D+05	0.15106D+04	0.43685D−02	
		5.250	−0.85276D−03	0.83046D−03	0.55374D−03	−0.53647D+03	0.16394D+05	0.15257D+04	0.43599D−02	
		5.260	−0.84110D−03	0.82727D−03	0.55374D−03	−0.50433D+03	0.16346D+05	0.15407D+04	0.43515D−02	
		5.270	−0.82952D−03	0.82412D−03	0.55374D−03	−0.47240D+03	0.16299D+05	0.15557D+04	0.43431D−02	
		5.280	−0.81802D−03	0.82100D−03	0.55374D−03	−0.44068D+03	0.16253D+05	0.15706D+04	0.43349D−02	
		5.290	−0.80661D−03	0.81791D−03	0.55374D−03	−0.40917D+03	0.16207D+05	0.15853D+04	0.43267D−02	
		5.300	−0.79527D−03	0.81486D−03	0.55374D−03	−0.37786D+03	0.16162D+05	0.16000D+04	0.43187D−02	
4	3	5.300	−0.80913D−03	0.81486D−03	0.55374D−03	−0.37786D+03	0.46222D+04	0.97482D+04	0.43187D−02	0.32630D+05
		5.310	−0.80457D−03	0.81180D−03	0.55374D−03	−0.36845D+03	0.46178D+04	0.97398D+04	0.43107D−02	
		5.320	−0.80003D−03	0.80877D−03	0.55374D−03	−0.35908D+03	0.46134D+04	0.97315D+04	0.43026D−02	
		5.330	−0.79551D−03	0.80575D−03	0.55374D−03	−0.34975D+03	0.46091D+04	0.97232D+04	0.42947D−02	
		5.340	−0.79102D−03	0.80276D−03	0.55374D−03	−0.34047D+03	0.46048D+04	0.97150D+04	0.42867D−02	
		5.350	−0.78656D−03	0.79978D−03	0.55374D−03	−0.33123D+03	0.46006D+04	0.97069D+04	0.42788D−02	
		5.360	−0.78211D−03	0.79683D−03	0.55374D−03	−0.32203D+03	0.45964D+04	0.96988D+04	0.42710D−02	
		5.370	−0.77769D−03	0.79389D−03	0.55374D−03	−0.31288D+03	0.45922D+04	0.96908D+04	0.42632D−02	
		5.380	−0.77330D−03	0.79098D−03	0.55374D−03	−0.30377D+03	0.45880D+04	0.96829D+04	0.42554D−02	
		5.390	−0.76892D−03	0.78808D−03	0.55374D−03	−0.29469D+03	0.45839D+04	0.96750D+04	0.42477D−02	
		5.400	−0.76457D−03	0.78520D−03	0.55374D−03	−0.28566D+03	0.45799D+04	0.96672D+04	0.42401D−02	
5	4	5.400	−0.75231D−03	0.78520D−03	0.55374D−03	−0.28566D+03	0.15628D+05	0.16292D+04	0.42401D−02	0.58123D+04
		5.410	−0.74169D−03	0.78237D−03	0.55374D−03	−0.25629D+03	0.15586D+05	0.16430D+04	0.42326D−02	
		5.420	−0.73114D−03	0.77956D−03	0.55374D−03	−0.22710D+03	0.15545D+05	0.16568D+04	0.42252D−02	
		5.430	−0.72067D−03	0.77679D−03	0.55374D−03	−0.19809D+03	0.15504D+05	0.16704D+04	0.42180D−02	
		5.440	−0.71027D−03	0.77405D−03	0.55374D−03	−0.16926D+03	0.15464D+05	0.16840D+04	0.42108D−02	
		5.450	−0.69993D−03	0.77133D−03	0.55374D−03	−0.14061D+03	0.15424D+05	0.16975D+04	0.42038D−02	
		5.460	−0.68967D−03	0.76865D−03	0.55374D−03	−0.11214D+03	0.15384D+05	0.17109D+04	0.41968D−02	
		5.470	−0.67947D−03	0.76599D−03	0.55374D−03	−0.83848D+02	0.15346D+05	0.17242D+04	0.41900D−02	
		5.480	−0.66934D−03	0.76336D−03	0.55374D−03	−0.55727D+02	0.15307D+05	0.17375D+04	0.41832D−02	
		5.490	−0.65928D−03	0.76076D−03	0.55374D−03	−0.27779D+02	0.15269D+05	0.17507D+04	0.41766D−02	
		5.500	−0.64929D−03	0.75819D−03	0.55374D−03	0.24556D−09	0.15232D+05	0.17638D+04	0.41700D−02	

@ 1000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.47592D−02	0.18930D−02	0.91715D−03	−0.10000D+04	−0.30624D+05	−0.17102D+05	0.94652D−02	−0.54266D+05
		5.010	−0.47460D−02	0.18798D−02	0.91715D−03	−0.10591D+04	−0.30565D+05	−0.17102D+05	0.94177D−02	
		5.020	−0.47328D−02	0.18666D−02	0.91715D−03	−0.11178D+04	−0.30506D+05	−0.17102D+05	0.93703D−02	
		5.030	−0.47197D−02	0.18535D−02	0.91715D−03	−0.11762D+04	−0.30448D+05	−0.17102D+05	0.93230D−02	
		5.040	−0.47067D−02	0.18404D−02	0.91715D−03	−0.12342D+04	−0.30390D+05	−0.17102D+05	0.92759D−02	
		5.050	−0.46937D−02	0.18275D−02	0.91715D−03	−0.12919D+04	−0.30332D+05	−0.17102D+05	0.92289D−02	
		5.060	−0.46808D−02	0.18146D−02	0.91715D−03	−0.13492D+04	−0.30275D+05	−0.17102D+05	0.91820D−02	
		5.070	−0.46680D−02	0.18018D−02	0.91715D−03	−0.14062D+04	−0.30218D+05	−0.17102D+05	0.91352D−02	
		5.080	−0.46553D−02	0.17891D−02	0.91715D−03	−0.14628D+04	−0.30161D+05	−0.17102D+05	0.90886D−02	
		5.090	−0.46427D−02	0.17765D−02	0.91715D−03	−0.15192D+04	−0.30105D+05	−0.17102D+05	0.90421D−02	
		5.100	−0.46301D−02	0.17639D−02	0.91715D−03	−0.15752D+04	−0.30049D+05	−0.17102D+05	0.89958D−02	
2	1	5.100	−0.18554D−02	0.17639D−02	0.91715D−03	−0.15752D+04	0.84243D+04	0.17440D+05	0.89958D−02	0.56108D+05
		5.110	−0.18455D−02	0.17568D−02	0.91715D−03	−0.15556D+04	0.84130D+04	0.17420D+05	0.89773D−02	
		5.120	−0.18357D−02	0.17498D−02	0.91715D−03	−0.15362D+04	0.84017D+04	0.17399D+05	0.89589D−02	
		5.130	−0.18260D−02	0.17428D−02	0.91715D−03	−0.15168D+04	0.83905D+04	0.17379D+05	0.89406D−02	
		5.140	−0.18163D−02	0.17359D−02	0.91715D−03	−0.14975D+04	0.83794D+04	0.17359D+05	0.89223D−02	
		5.150	−0.18067D−02	0.17290D−02	0.91715D−03	−0.14784D+04	0.83684D+04	0.17339D+05	0.89042D−02	
		5.160	−0.17971D−02	0.17221D−02	0.91715D−03	−0.14593D+04	0.83575D+04	0.17319D+05	0.88862D−02	
		5.170	−0.17876D−02	0.17153D−02	0.91715D−03	−0.14403D+04	0.83467D+04	0.17300D+05	0.88683D−02	
		5.180	−0.17781D−02	0.17086D−02	0.91715D−03	−0.14214D+04	0.83360D+04	0.17280D+05	0.88505D−02	
		5.190	−0.17687D−02	0.17019D−02	0.91715D−03	−0.14026D+04	0.83253D+04	0.17261D+05	0.88327D−02	
		5.200	−0.17593D−02	0.16952D−02	0.91715D−03	−0.13839D+04	0.83148D+04	0.17242D+05	0.88151D−02	
3	2	5.200	−0.17180D−02	0.16952D−02	0.91715D−03	−0.13839D+04	0.33185D+05	0.24796D+04	0.88151D−02	0.86845D+04
		5.210	−0.16940D−02	0.16887D−02	0.91715D−03	−0.13177D+04	0.33088D+05	0.25107D+04	0.87980D−02	
		5.220	−0.16701D−02	0.16822D−02	0.91715D−03	−0.12519D+04	0.32992D+05	0.25415D+04	0.87812D−02	
		5.230	−0.16465D−02	0.16758D−02	0.91715D−03	−0.11865D+04	0.32897D+05	0.25722D+04	0.87646D−02	
		5.240	−0.16229D−02	0.16695D−02	0.91715D−03	−0.11215D+04	0.32804D+05	0.26027D+04	0.87483D−02	
		5.250	−0.15996D−02	0.16633D−02	0.91715D−03	−0.10570D+04	0.32711D+05	0.26330D+04	0.87322D−02	
		5.260	−0.15764D−02	0.16571D−02	0.91715D−03	−0.99288D+03	0.32620D+05	0.26631D+04	0.87163D−02	
		5.270	−0.15534D−02	0.16510D−02	0.91715D−03	−0.92918D+03	0.32530D+05	0.26931D+04	0.87006D−02	
		5.280	−0.15306D−02	0.16449D−02	0.91715D−03	−0.86590D+03	0.32441D+05	0.27228D+04	0.86852D−02	
		5.290	−0.15079D−02	0.16389D−02	0.91715D−03	−0.80302D+03	0.32353D+05	0.27525D+04	0.86700D−02	
		5.300	−0.14853D−02	0.16330D−02	0.91715D−03	−0.74054D+03	0.32266D+05	0.27819D+04	0.86551D−02	
4	3	5.300	−0.15233D−02	0.16330D−02	0.91715D−03	−0.74054D+03	0.84570D+04	0.17290D+05	0.86551D−02	0.57842D+05
		5.310	−0.15147D−02	0.16271D−02	0.91715D−03	−0.72323D+03	0.84480D+04	0.17273D+05	0.86399D−02	
		5.320	−0.15062D−02	0.16212D−02	0.91715D−03	−0.70600D+03	0.84390D+04	0.17256D+05	0.86248D−02	
		5.330	−0.14978D−02	0.16153D−02	0.91715D−03	−0.68885D+03	0.84301D+04	0.17240D+05	0.86097D−02	
		5.340	−0.14893D−02	0.16095D−02	0.91715D−03	−0.67178D+03	0.84212D+04	0.17223D+05	0.85948D−02	
		5.350	−0.14810D−02	0.16037D−02	0.91715D−03	−0.65480D+03	0.84124D+04	0.17207D+05	0.85800D−02	

		5.360	-0.14726D-02	0.15980D-02	0.91715D-03	-0.63789D+03	0.84038D+04	0.17191D+05	0.85652D-02	
		5.370	-0.14643D-02	0.15923D-02	0.91715D-03	-0.62106D+03	0.83951D+04	0.17175D+05	0.85505D-02	
		5.380	-0.14561D-02	0.15866D-02	0.91715D-03	-0.60431D+03	0.83866D+04	0.17159D+05	0.85359D-02	
		5.390	-0.14479D-02	0.15810D-02	0.91715D-03	-0.58763D+03	0.83781D+04	0.17143D+05	0.85214D-02	
		5.400	-0.14397D-02	0.15754D-02	0.91715D-03	-0.57104D+03	0.83697D+04	0.17127D+05	0.85069D-02	
5	4	5.400	-0.14049D-02	0.15754D-02	0.91715D-03	-0.57104D+03	0.31224D+05	0.28334D+04	0.85069D-02	0.10171D+05
		5.410	-0.13837D-02	0.15699D-02	0.91715D-03	-0.51234D+03	0.31143D+05	0.28611D+04	0.84930D-02	
		5.420	-0.13627D-02	0.15644D-02	0.91715D-03	-0.45401D+03	0.31064D+05	0.28887D+04	0.84793D-02	
		5.430	-0.13419D-02	0.15591D-02	0.91715D-03	-0.39604D+03	0.30986D+05	0.29161D+04	0.84657D-02	
		5.440	-0.13212D-02	0.15538D-02	0.91715D-03	-0.33842D+03	0.30908D+05	0.29433D+04	0.84524D-02	
		5.450	-0.13006D-02	0.15485D-02	0.91715D-03	-0.28116D+03	0.30832D+05	0.29704D+04	0.84393D-02	
		5.460	-0.12802D-02	0.15433D-02	0.91715D-03	-0.22424D+03	0.30757D+05	0.29974D+04	0.84264D-02	
		5.470	-0.12598D-02	0.15382D-02	0.91715D-03	-0.16767D+03	0.30682D+05	0.30242D+04	0.84137D-02	
		5.480	-0.12397D-02	0.15331D-02	0.91715D-03	-0.11145D+03	0.30609D+05	0.30508D+04	0.84012D-02	
		5.490	-0.12196D-02	0.15280D-02	0.91715D-03	-0.55556D+02	0.30536D+05	0.30773D+04	0.83889D-02	
		5.500	-0.11997D-02	0.15231D-02	0.91715D-03	0.27694D-09	0.30464D+05	0.31037D+04	0.83768D-02	

@ 5000 psi (wkg)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	-0.72418D-02	0.55386D-02	0.23708D-02	-0.50000D+04	0.12515D+05	0.91761D+04	0.27693D-01	0.29116D+05
		5.010	-0.72163D-02	0.55131D-02	0.23708D-02	-0.49651D+04	0.12480D+05	0.91761D+04	0.27621D-01	
		5.020	-0.71910D-02	0.54878D-02	0.23708D-02	-0.49304D+04	0.12446D+05	0.91761D+04	0.27549D-01	
		5.030	-0.71658D-02	0.54626D-02	0.23708D-02	-0.48958D+04	0.12411D+05	0.91761D+04	0.27477D-01	
		5.040	-0.71407D-02	0.54376D-02	0.23708D-02	-0.48615D+04	0.12377D+05	0.91761D+04	0.27405D-01	
		5.050	-0.71159D-02	0.54127D-02	0.23708D-02	-0.48274D+04	0.12343D+05	0.91761D+04	0.27334D-01	
		5.060	-0.70911D-02	0.53880D-02	0.23708D-02	-0.47935D+04	0.12309D+05	0.91761D+04	0.27263D-01	
		5.070	-0.70665D-02	0.53634D-02	0.23708D-02	-0.47598D+04	0.12275D+05	0.91761D+04	0.27192D-01	
		5.080	-0.70421D-02	0.53389D-02	0.23708D-02	-0.47263D+04	0.12242D+05	0.91761D+04	0.27122D-01	
		5.090	-0.70178D-02	0.53146D-02	0.23708D-02	-0.46930D+04	0.12208D+05	0.91761D+04	0.27051D-01	
		5.100	-0.69936D-02	0.52905D-02	0.23708D-02	-0.46599D+04	0.12175D+05	0.91761D+04	0.26981D-01	
2	1	5.100	-0.53611D-02	0.52905D-02	0.23708D-02	-0.46599D+04	0.23692D+05	0.47892D+05	0.26981D-01	0.15399D+06
		5.110	-0.53327D-02	0.52697D-02	0.23708D-02	-0.46045D+04	0.23658D+05	0.47830D+05	0.26928D-01	
		5.120	-0.53045D-02	0.52490D-02	0.23708D-02	-0.45493D+04	0.23624D+05	0.47770D+05	0.26875D-01	
		5.130	-0.52765D-02	0.52284D-02	0.23708D-02	-0.44944D+04	0.23590D+05	0.47709D+05	0.26822D-01	
		5.140	-0.52487D-02	0.52080D-02	0.23708D-02	-0.44398D+04	0.23556D+05	0.47649D+05	0.26769D-01	
		5.150	-0.52210D-02	0.51877D-02	0.23708D-02	-0.43855D+04	0.23523D+05	0.47589D+05	0.26717D-01	
		5.160	-0.51934D-02	0.51676D-02	0.23708D-02	-0.43314D+04	0.23489D+05	0.47530D+05	0.26665D-01	
		5.170	-0.51660D-02	0.51476D-02	0.23708D-02	-0.42777D+04	0.23456D+05	0.47472D+05	0.26613D-01	
		5.180	-0.51388D-02	0.51277D-02	0.23708D-02	-0.42242D+04	0.23424D+05	0.47413D+05	0.26561D-01	
		5.190	-0.51117D-02	0.51079D-02	0.23708D-02	-0.41709D+04	0.23391D+05	0.47355D+05	0.26510D-01	
		5.200	-0.50847D-02	0.50883D-02	0.23708D-02	-0.41179D+04	0.23359D+05	0.47298D+05	0.26459D-01	
3	2	5.200	-0.49406D-02	0.50883D-02	0.23708D-02	-0.41179D+04	0.99363D+05	0.66017D+04	0.26459D-01	0.23293D+05
		5.210	-0.48689D-02	0.50691D-02	0.23708D-02	-0.39196D+04	0.99080D+05	0.66949D+04	0.26410D-01	
		5.220	-0.47976D-02	0.50502D-02	0.23708D-02	-0.37225D+04	0.98800D+05	0.67875D+04	0.26362D-01	
		5.230	-0.47269D-02	0.50314D-02	0.23708D-02	-0.35268D+04	0.98523D+05	0.68796D+04	0.26314D-01	
		5.240	-0.46567D-02	0.50128D-02	0.23708D-02	-0.33323D+04	0.98250D+05	0.69712D+04	0.26267D-01	
		5.250	-0.45870D-02	0.49945D-02	0.23708D-02	-0.31391D+04	0.97981D+05	0.70622D+04	0.26221D-01	
		5.260	-0.45177D-02	0.49763D-02	0.23708D-02	-0.29471D+04	0.97715D+05	0.71526D+04	0.26176D-01	
		5.270	-0.44490D-02	0.49584D-02	0.23708D-02	-0.27563D+04	0.97452D+05	0.72426D+04	0.26131D-01	
		5.280	-0.43807D-02	0.49406D-02	0.23708D-02	-0.25668D+04	0.97192D+05	0.73320D+04	0.26087D-01	
		5.290	-0.43129D-02	0.49231D-02	0.23708D-02	-0.23784D+04	0.96936D+05	0.74209D+04	0.26043D-01	
		5.300	-0.42456D-02	0.49057D-02	0.23708D-02	-0.21913D+04	0.96683D+05	0.75093D+04	0.26000D-01	
4	3	5.300	-0.43799D-02	0.49057D-02	0.23708D-02	-0.21913D+04	0.23796D+05	0.47455D+05	0.26000D-01	0.15869D+06
		5.310	-0.43554D-02	0.48883D-02	0.23708D-02	-0.21424D+04	0.23769D+05	0.47405D+05	0.25957D-01	
		5.320	-0.43310D-02	0.48709D-02	0.23708D-02	-0.20937D+04	0.23741D+05	0.47355D+05	0.25913D-01	
		5.330	-0.43067D-02	0.48537D-02	0.23708D-02	-0.20452D+04	0.23714D+05	0.47305D+05	0.25870D-01	
		5.340	-0.42826D-02	0.48365D-02	0.23708D-02	-0.19970D+04	0.23687D+05	0.47256D+05	0.25827D-01	
		5.350	-0.42586D-02	0.48195D-02	0.23708D-02	-0.19490D+04	0.23660D+05	0.47207D+05	0.25784D-01	
		5.360	-0.42347D-02	0.48026D-02	0.23708D-02	-0.19013D+04	0.23633D+05	0.47159D+05	0.25742D-01	
		5.370	-0.42109D-02	0.47858D-02	0.23708D-02	-0.18538D+04	0.23607D+05	0.47111D+05	0.25700D-01	
		5.380	-0.41873D-02	0.47691D-02	0.23708D-02	-0.18065D+04	0.23581D+05	0.47063D+05	0.25658D-01	
		5.390	-0.41638D-02	0.47525D-02	0.23708D-02	-0.17594D+04	0.23555D+05	0.47015D+05	0.25616D-01	
		5.400	-0.41404D-02	0.47360D-02	0.23708D-02	-0.17125D+04	0.23529D+05	0.46968D+05	0.25574D-01	
5	4	5.400	-0.40151D-02	0.47360D-02	0.23708D-02	-0.17125D+04	0.93606D+05	0.76503D+04	0.25574D-01	0.27606D+05
		5.410	-0.39519D-02	0.47199D-02	0.23708D-02	-0.15366D+04	0.93372D+05	0.77336D+04	0.25535D-01	
		5.420	-0.38891D-02	0.47039D-02	0.23708D-02	-0.13617D+04	0.93141D+05	0.78164D+04	0.25495D-01	
		5.430	-0.38268D-02	0.46882D-02	0.23708D-02	-0.11878D+04	0.92913D+05	0.78988D+04	0.25457D-01	
		5.440	-0.37648D-02	0.46726D-02	0.23708D-02	-0.10151D+04	0.92688D+05	0.79807D+04	0.25419D-01	
		5.450	-0.37032D-02	0.46572D-02	0.23708D-02	-0.84335D+03	0.92465D+05	0.80622D+04	0.25382D-01	
		5.460	-0.36421D-02	0.46419D-02	0.23708D-02	-0.67265D+03	0.92246D+05	0.81432D+04	0.25345D-01	
		5.470	-0.35813D-02	0.46268D-02	0.23708D-02	-0.50298D+03	0.92029D+05	0.82239D+04	0.25309D-01	
		5.480	-0.35210D-02	0.46119D-02	0.23708D-02	-0.33432D+03	0.91815D+05	0.83040D+04	0.25273D-01	
		5.490	-0.34610D-02	0.45971D-02	0.23708D-02	-0.16667D+03	0.91604D+05	0.83838D+04	0.25238D-01	
		5.500	-0.34015D-02	0.45825D-02	0.23708D-02	0.43974D-09	0.91396D+05	0.84631D+04	0.25204D-01	

@ 7500 psi (test)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	-0.87934D-02	0.78171D-02	0.32794D-02	-0.75000D+04	0.39477D+05	0.25600D+05	0.39085D-01	0.81229D+05
		5.010	-0.87602D-02	0.77840D-02	0.32794D-02	-0.74063D+04	0.39384D+05	0.25600D+05	0.38998D-01	
		5.020	-0.87273D-02	0.77510D-02	0.32794D-02	-0.73132D+04	0.39290D+05	0.25600D+05	0.38910D-01	
		5.030	-0.86946D-02	0.77183D-02	0.32794D-02	-0.72207D+04	0.39198D+05	0.25600D+05	0.38823D-01	
		5.040	-0.86620D-02	0.76858D-02	0.32794D-02	-0.71286D+04	0.39106D+05	0.25600D+05	0.38736D-01	
		5.050	-0.86297D-02	0.76534D-02	0.32794D-02	-0.70372D+04	0.39014D+05	0.25600D+05	0.38650D-01	
		5.060	-0.85976D-02	0.76213D-02	0.32794D-02	-0.69463D+04	0.38924D+05	0.25600D+05	0.38564D-01	
		5.070	-0.85656D-02	0.75893D-02	0.32794D-02	-0.68559D+04	0.38833D+05	0.25600D+05	0.38478D-01	
		5.080	-0.85338D-02	0.75576D-02	0.32794D-02	-0.67660D+04	0.38743D+05	0.25600D+05	0.38392D-01	
		5.090	-0.85022D-02	0.75260D-02	0.32794D-02	-0.66767D+04	0.38654D+05	0.25600D+05	0.38307D-01	
		5.100	-0.84709D-02	0.74946D-02	0.32794D-02	-0.65879D+04	0.38565D+05	0.25600D+05	0.38222D-01	
2	1	5.100	-0.75521D-02	0.74946D-02	0.32794D-02	-0.65879D+04	0.33235D+05	0.66924D+05	0.38222D-01	0.21517D+06
		5.110	-0.75122D-02	0.74652D-02	0.32794D-02	-0.65100D+04	0.33186D+05	0.66837D+05	0.38147D-01	
		5.120	-0.74726D-02	0.74360D-02	0.32794D-02	-0.64325D+04	0.33137D+05	0.66751D+05	0.38072D-01	
		5.130	-0.74331D-02	0.74069D-02	0.32794D-02	-0.63555D+04	0.33089D+05	0.66665D+05	0.37998D-01	
		5.140	-0.73939D-02	0.73781D-02	0.32794D-02	-0.62788D+04	0.33041D+05	0.66580D+05	0.37924D-01	

		5.150	−0.73549D−02	0.73495D−02	0.32794D−02	−0.62025D+04	0.32994D+05	0.66496D+05	0.37850D−01	
		5.160	−0.73161D−02	0.73210D−02	0.32794D−02	−0.61265D+04	0.32947D+05	0.66412D+05	0.37776D−01	
		5.170	−0.72776D−02	0.72927D−02	0.32794D−02	−0.60510D+04	0.32900D+05	0.66329D+05	0.37703D−01	
		5.180	−0.72392D−02	0.72646D−02	0.32794D−02	−0.59759D+04	0.32854D+05	0.66246D+05	0.37631D−01	
		5.190	−0.72011D−02	0.72367D−02	0.32794D−02	−0.59011D+04	0.32808D+05	0.66164D+05	0.37559D−01	
		5.200	−0.71632D−02	0.72090D−02	0.32794D−02	−0.58267D+04	0.32762D+05	0.66083D+05	0.37487D−01	
3	2	5.200	−0.69547D−02	0.72090D−02	0.32794D−02	−0.58267D+04	0.14072D+06	0.91781D+04	0.37487D−01	0.32424D+05
		5.210	−0.68532D−02	0.71819D−02	0.32794D−02	−0.55458D+04	0.14032D+06	0.93101D+04	0.37418D−01	
		5.220	−0.67523D−02	0.71551D−02	0.32794D−02	−0.52667D+04	0.13993D+06	0.94413D+04	0.37350D−01	
		5.230	−0.66522D−02	0.71286D−02	0.32794D−02	−0.49895D+04	0.13954D+06	0.95718D+04	0.37283D−01	
		5.240	−0.65528D−02	0.71024D−02	0.32794D−02	−0.47140D+04	0.13915D+06	0.97014D+04	0.37217D−01	
		5.250	−0.64541D−02	0.70765D−02	0.32794D−02	−0.44403D+04	0.13877D+06	0.98304D+04	0.37152D−01	
		5.260	−0.63561D−02	0.70509D−02	0.32794D−02	−0.41684D+04	0.13840D+06	0.99586D+04	0.37088D−01	
		5.270	−0.62587D−02	0.70255D−02	0.32794D−02	−0.38983D+04	0.13803D+06	0.10086D+05	0.37025D−01	
		5.280	−0.61621D−02	0.70005D−02	0.32794D−02	−0.36298D+04	0.13766D+06	0.10213D+05	0.36962D−01	
		5.290	−0.60661D−02	0.69757D−02	0.32794D−02	−0.33631D+04	0.13730D+06	0.10339D+05	0.36901D−01	
		5.300	−0.59707D−02	0.69512D−02	0.32794D−02	−0.30980D+04	0.13694D+06	0.10464D+05	0.36841D−01	
4	3	5.300	−0.61654D−02	0.69512D−02	0.32794D−02	−0.30980D+04	0.33383D+05	0.66309D+05	0.36841D−01	0.22172D+06
		5.310	−0.61308D−02	0.69265D−02	0.32794D−02	−0.30293D+04	0.33344D+05	0.66237D+05	0.36780D−01	
		5.320	−0.60965D−02	0.69020D−02	0.32794D−02	−0.29610D+04	0.33305D+05	0.66167D+05	0.36719D−01	
		5.330	−0.60623D−02	0.68776D−02	0.32794D−02	−0.28930D+04	0.33266D+05	0.66096D+05	0.36658D−01	
		5.340	−0.60284D−02	0.68534D−02	0.32794D−02	−0.28253D+04	0.33228D+05	0.66027D+05	0.36597D−01	
		5.350	−0.59946D−02	0.68294D−02	0.32794D−02	−0.27580D+04	0.33190D+05	0.65957D+05	0.36537D−01	
		5.360	−0.59610D−02	0.68055D−02	0.32794D−02	−0.26909D+04	0.33152D+05	0.65889D+05	0.36477D−01	
		5.370	−0.59276D−02	0.67817D−02	0.32794D−02	−0.26242D+04	0.33114D+05	0.65820D+05	0.36418D−01	
		5.380	−0.58943D−02	0.67581D−02	0.32794D−02	−0.25578D+04	0.33077D+05	0.65753D+05	0.36359D−01	
		5.390	−0.58612D−02	0.67347D−02	0.32794D−02	−0.24917D+04	0.33040D+05	0.65685D+05	0.36300D−01	
		5.400	−0.58283D−02	0.67114D−02	0.32794D−02	−0.24260D+04	0.33003D+05	0.65619D+05	0.36242D−01	
5	4	5.400	−0.56466D−02	0.67114D−02	0.32794D−02	−0.24260D+04	0.13259D+06	0.10661D+05	0.36242D−01	0.38502D+05
		5.410	−0.55570D−02	0.66886D−02	0.32794D−02	−0.21767D+04	0.13226D+06	0.10779D+05	0.36186D−01	
		5.420	−0.54681D−02	0.66661D−02	0.32794D−02	−0.19290D+04	0.13194D+06	0.10896D+05	0.36130D−01	
		5.430	−0.53798D−02	0.66439D−02	0.32794D−02	−0.16827D+04	0.13162D+06	0.11013D+05	0.36076D−01	
		5.440	−0.52921D−02	0.66218D−02	0.32794D−02	−0.14380D+04	0.13130D+06	0.11129D+05	0.36023D−01	
		5.450	−0.52049D−02	0.66001D−02	0.32794D−02	−0.11947D+04	0.13099D+06	0.11245D+05	0.35970D−01	
		5.460	−0.51183D−02	0.65785D−02	0.32794D−02	−0.95291D+03	0.13068D+06	0.11359D+05	0.35919D−01	
		5.470	−0.50323D−02	0.65572D−02	0.32794D−02	−0.71255D+03	0.13037D+06	0.11474D+05	0.35868D−01	
		5.480	−0.49468D−02	0.65362D−02	0.32794D−02	−0.47362D+03	0.13007D+06	0.11587D+05	0.35818D−01	
		5.490	−0.48619D−02	0.65153D−02	0.32794D−02	−0.23611D+03	0.12977D+06	0.11700D+05	0.35769D−01	
		5.500	−0.47776D−02	0.64947D−02	0.32794D−02	0.71122D−09	0.12948D+06	0.11813D+05	0.35721D−01	

@ 8000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.91037D−02	0.82728D−02	0.34611D−02	−0.80000D+04	0.44870D+05	0.28885D+05	0.41364D−01	0.91652D+05
		5.010	−0.90690D−02	0.82381D−02	0.34611D−02	−0.78946D+04	0.44764D+05	0.28885D+05	0.41273D−01	
		5.020	−0.90346D−02	0.82037D−02	0.34611D−02	−0.77898D+04	0.44659D+05	0.28885D+05	0.41183D−01	
		5.030	−0.90003D−02	0.81695D−02	0.34611D−02	−0.76856D+04	0.44555D+05	0.28885D+05	0.41092D−01	
		5.040	−0.89663D−02	0.81354D−02	0.34611D−02	−0.75821D+04	0.44452D+05	0.28885D+05	0.41003D−01	
		5.050	−0.89325D−02	0.81016D−02	0.34611D−02	−0.74791D+04	0.44349D+05	0.28885D+05	0.40913D−01	
		5.060	−0.88988D−02	0.80680D−02	0.34611D−02	−0.73768D+04	0.44246D+05	0.28885D+05	0.40824D−01	
		5.070	−0.88654D−02	0.80345D−02	0.34611D−02	−0.72751D+04	0.44145D+05	0.28885D+05	0.40735D−01	
		5.080	−0.88322D−02	0.80013D−02	0.34611D−02	−0.71740D+04	0.44044D+05	0.28885D+05	0.40647D−01	
		5.090	−0.87991D−02	0.79683D−02	0.34611D−02	−0.70734D+04	0.43943D+05	0.28885D+05	0.40558D−01	
		5.100	−0.87663D−02	0.79354D−02	0.34611D−02	−0.69735D+04	0.43843D+05	0.28885D+05	0.40471D−01	
2	1	5.100	−0.79903D−02	0.79354D−02	0.34611D−02	−0.69735D+04	0.35144D+05	0.70730D+05	0.40471D−01	0.22741D+06
		5.110	−0.79481D−02	0.79043D−02	0.34611D−02	−0.68911D+04	0.35092D+05	0.70638D+05	0.40391D−01	
		5.120	−0.79062D−02	0.78734D−02	0.34611D−02	−0.68092D+04	0.35040D+05	0.70547D+05	0.40312D−01	
		5.130	−0.78644D−02	0.78427D−02	0.34611D−02	−0.67277D+04	0.34989D+05	0.70457D+05	0.40233D−01	
		5.140	−0.78229D−02	0.78121D−02	0.34611D−02	−0.66465D+04	0.34938D+05	0.70367D+05	0.40154D−01	
		5.150	−0.77817D−02	0.77818D−02	0.34611D−02	−0.65658D+04	0.34888D+05	0.70277D+05	0.40076D−01	
		5.160	−0.77407D−02	0.77517D−02	0.34611D−02	−0.64856D+04	0.34838D+05	0.70188D+05	0.39999D−01	
		5.170	−0.76999D−02	0.77218D−02	0.34611D−02	−0.64057D+04	0.34789D+05	0.70100D+05	0.39922D−01	
		5.180	−0.76593D−02	0.76920D−02	0.34611D−02	−0.63262D+04	0.34740D+05	0.70013D+05	0.39845D−01	
		5.190	−0.76190D−02	0.76625D−02	0.34611D−02	−0.62471D+04	0.34691D+05	0.69926D+05	0.39768D−01	
		5.200	−0.75788D−02	0.76331D−02	0.34611D−02	−0.61684D+04	0.34642D+05	0.69840D+05	0.39692D−01	
3	2	5.200	−0.73575D−02	0.76331D−02	0.34611D−02	−0.61684D+04	0.14900D+06	0.96933D+04	0.39692D−01	0.34250D+05
		5.210	−0.72500D−02	0.76045D−02	0.34611D−02	−0.58710D+04	0.14857D+06	0.98331D+04	0.39619D−01	
		5.220	−0.71433D−02	0.75761D−02	0.34611D−02	−0.55756D+04	0.14816D+06	0.99721D+04	0.39547D−01	
		5.230	−0.70373D−02	0.75481D−02	0.34611D−02	−0.52820D+04	0.14774D+06	0.10110D+05	0.39476D−01	
		5.240	−0.69320D−02	0.75203D−02	0.34611D−02	−0.49904D+04	0.14734D+06	0.10248D+05	0.39407D−01	
		5.250	−0.68275D−02	0.74929D−02	0.34611D−02	−0.47006D+04	0.14693D+06	0.10384D+05	0.39338D−01	
		5.260	−0.67237D−02	0.74658D−02	0.34611D−02	−0.44127D+04	0.14654D+06	0.10520D+05	0.39270D−01	
		5.270	−0.66207D−02	0.74390D−02	0.34611D−02	−0.41267D+04	0.14614D+06	0.10655D+05	0.39203D−01	
		5.280	−0.65183D−02	0.74124D−02	0.34611D−02	−0.38424D+04	0.14576D+06	0.10789D+05	0.39138D−01	
		5.290	−0.64167D−02	0.73862D−02	0.34611D−02	−0.35600D+04	0.14537D+06	0.10922D+05	0.39073D−01	
		5.300	−0.63157D−02	0.73602D−02	0.34611D−02	−0.32793D+04	0.14500D+06	0.11055D+05	0.39009D−01	
4	3	5.300	−0.65224D−02	0.73602D−02	0.34611D−02	−0.32793D+04	0.35301D+05	0.70079D+05	0.39009D−01	0.23433D+06
		5.310	−0.64859D−02	0.73341D−02	0.34611D−02	−0.32067D+04	0.35259D+05	0.70004D+05	0.38944D−01	
		5.320	−0.64496D−02	0.73082D−02	0.34611D−02	−0.31345D+04	0.35218D+05	0.69929D+05	0.38880D−01	
		5.330	−0.64135D−02	0.72824D−02	0.34611D−02	−0.30625D+04	0.35177D+05	0.69855D+05	0.38815D−01	
		5.340	−0.63775D−02	0.72568D−02	0.34611D−02	−0.29910D+04	0.35136D+05	0.69781D+05	0.38751D−01	
		5.350	−0.63418D−02	0.72313D−02	0.34611D−02	−0.29197D+04	0.35096D+05	0.69707D+05	0.38688D−01	
		5.360	−0.63062D−02	0.72061D−02	0.34611D−02	−0.28489D+04	0.35056D+05	0.69635D+05	0.38624D−01	
		5.370	−0.62709D−02	0.71809D−02	0.34611D−02	−0.27783D+04	0.35016D+05	0.69562D+05	0.38562D−01	
		5.380	−0.62357D−02	0.71560D−02	0.34611D−02	−0.27081D+04	0.34976D+05	0.69491D+05	0.38499D−01	
		5.390	−0.62007D−02	0.71311D−02	0.34611D−02	−0.26382D+04	0.34937D+05	0.69419D+05	0.38437D−01	
		5.400	−0.61659D−02	0.71065D−02	0.34611D−02	−0.25687D+04	0.34898D+05	0.69349D+05	0.38375D−01	
5	4	5.400	−0.59729D−02	0.71065D−02	0.34611D−02	−0.25687D+04	0.14039D+06	0.11263D+05	0.38375D−01	0.40682D+05
		5.410	−0.58781D−02	0.70824D−02	0.34611D−02	−0.23047D+04	0.14004D+06	0.11388D+05	0.38316D−01	
		5.420	−0.57839D−02	0.70586D−02	0.34611D−02	−0.20424D+04	0.13970D+06	0.11512D+05	0.38257D−01	
		5.430	−0.56904D−02	0.70350D−02	0.34611D−02	−0.17817D+04	0.13936D+06	0.11636D+05	0.38200D−01	
		5.440	−0.55975D−02	0.70117D−02	0.34611D−02	−0.15226D+04	0.13902D+06	0.11759D+05	0.38144D−01	
		5.450	−0.55052D−02	0.69887D−02	0.34611D−02	−0.12650D+04	0.13869D+06	0.11881D+05	0.38088D−01	
		5.460	−0.54135D−02	0.69659D−02	0.34611D−02	−0.10090D+04	0.13836D+06	0.12003D+05	0.38034D−01	
		5.470	−0.53225D−02	0.69433D−02	0.34611D−02	−0.75446D+03	0.13804D+06	0.12124D+05	0.37980D−01	

		5.480	−0.52320D−02	0.69210D−02	0.34611D−02	−0.50148D+03	0.13772D+06	0.12244D+05	0.37927D−01	
		5.490	−0.51421D−02	0.68990D−02	0.34611D−02	−0.25000D+03	0.13740D+06	0.12364D+05	0.37875D−01	
		5.500	−0.50528D−02	0.68771D−02	0.34611D−02	0.49658D−09	0.13709D+06	0.12483D+05	0.37824D−01	

@ 8500 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.94140D−02	0.87285D−02	0.36428D−02	−0.85000D+04	0.50262D+05	0.32170D+05	0.43642D−01	0.10207D+06
		5.010	−0.93778D−02	0.86923D−02	0.36428D−02	−0.83828D+04	0.50145D+05	0.32170D+05	0.43548D−01	
		5.020	−0.93418D−02	0.86564D−02	0.36428D−02	−0.82664D+04	0.50028D+05	0.32170D+05	0.43455D−01	
		5.030	−0.93061D−02	0.86206D−02	0.36428D−02	−0.81506D+04	0.49913D+05	0.32170D+05	0.43362D−01	
		5.040	−0.92706D−02	0.85851D−02	0.36428D−02	−0.80355D+04	0.49798D+05	0.32170D+05	0.43269D−01	
		5.050	−0.92352D−02	0.85497D−02	0.36428D−02	−0.79211D+04	0.49683D+05	0.32170D+05	0.43176D−01	
		5.060	−0.92001D−02	0.85146D−02	0.36428D−02	−0.78073D+04	0.49569D+05	0.32170D+05	0.43084D−01	
		5.070	−0.91652D−02	0.84797D−02	0.36428D−02	−0.76943D+04	0.49456D+05	0.32170D+05	0.42992D−01	
		5.080	−0.91305D−02	0.84450D−02	0.36428D−02	−0.75819D+04	0.49344D+05	0.32170D+05	0.42901D−01	
		5.090	−0.90960D−02	0.84105D−02	0.36428D−02	−0.74702D+04	0.49232D+05	0.32170D+05	0.42810D−01	
		5.100	−0.90617D−02	0.83762D−02	0.36428D−02	−0.73591D+04	0.49121D+05	0.32170D+05	0.42719D−01	
2	1	5.100	−0.84285D−02	0.83762D−02	0.36428D−02	−0.73591D+04	0.37052D+05	0.74537D+05	0.42719D−01	0.23965D+06
		5.110	−0.83840D−02	0.83434D−02	0.36428D−02	−0.72722D+04	0.36997D+05	0.74440D+05	0.42635D−01	
		5.120	−0.83398D−02	0.83108D−02	0.36428D−02	−0.71858D+04	0.36943D+05	0.74343D+05	0.42551D−01	
		5.130	−0.82957D−02	0.82784D−02	0.36428D−02	−0.70999D+04	0.36889D+05	0.74248D+05	0.42468D−01	
		5.140	−0.82520D−02	0.82462D−02	0.36428D−02	−0.70143D+04	0.36836D+05	0.74153D+05	0.42385D−01	
		5.150	−0.82085D−02	0.82142D−02	0.36428D−02	−0.69292D+04	0.36782D+05	0.74058D+05	0.42303D−01	
		5.160	−0.81652D−02	0.81824D−02	0.36428D−02	−0.68446D+04	0.36730D+05	0.73965D+05	0.42221D−01	
		5.170	−0.81222D−02	0.81508D−02	0.36428D−02	−0.67603D+04	0.36677D+05	0.73872D+05	0.42140D−01	
		5.180	−0.80794D−02	0.81194D−02	0.36428D−02	−0.66765D+04	0.36626D+05	0.73780D+05	0.42059D−01	
		5.190	−0.80368D−02	0.80883D−02	0.36428D−02	−0.65932D+04	0.36574D+05	0.73688D+05	0.41978D−01	
		5.200	−0.79945D−02	0.80573D−02	0.36428D−02	−0.65102D+04	0.36523D+05	0.73597D+05	0.41898D−01	
3	2	5.200	−0.77604D−02	0.80573D−02	0.36428D−02	−0.65102D+04	0.15727D+06	0.10209D+05	0.41898D−01	0.36076D+05
		5.210	−0.76469D−02	0.80270D−02	0.36428D−02	−0.61963D+04	0.15682D+06	0.10356D+05	0.41821D−01	
		5.220	−0.75342D−02	0.79971D−02	0.36428D−02	−0.58844D+04	0.15638D+06	0.10503D+05	0.41745D−01	
		5.230	−0.74223D−02	0.79675D−02	0.36428D−02	−0.55745D+04	0.15595D+06	0.10649D+05	0.41670D−01	
		5.240	−0.73112D−02	0.79383D−02	0.36428D−02	−0.52667D+04	0.15552D+06	0.10794D+05	0.41596D−01	
		5.250	−0.72009D−02	0.79093D−02	0.36428D−02	−0.49609D+04	0.15509D+06	0.10938D+05	0.41524D−01	
		5.260	−0.70914D−02	0.78807D−02	0.36428D−02	−0.46570D+04	0.15467D+06	0.11081D+05	0.41452D−01	
		5.270	−0.69826D−02	0.78524D−02	0.36428D−02	−0.43550D+04	0.15426D+06	0.11223D+05	0.41382D−01	
		5.280	−0.68746D−02	0.78244D−02	0.36428D−02	−0.40550D+04	0.15385D+06	0.11365D+05	0.41313D−01	
		5.290	−0.67673D−02	0.77967D−02	0.36428D−02	−0.37569D+04	0.15345D+06	0.11506D+05	0.41245D−01	
		5.300	−0.66608D−02	0.77693D−02	0.36428D−02	−0.34607D+04	0.15305D+06	0.11646D+05	0.41177D−01	
4	3	5.300	−0.68795D−02	0.77693D−02	0.36428D−02	−0.34607D+04	0.37218D+05	0.73850D+05	0.41177D−01	0.24693D+06
		5.310	−0.68410D−02	0.77418D−02	0.36428D−02	−0.33841D+04	0.37174D+05	0.73770D+05	0.41109D−01	
		5.320	−0.68027D−02	0.77144D−02	0.36428D−02	−0.33079D+04	0.37131D+05	0.73691D+05	0.41041D−01	
		5.330	−0.67646D−02	0.76872D−02	0.36428D−02	−0.32321D+04	0.37087D+05	0.73613D+05	0.40973D−01	
		5.340	−0.67267D−02	0.76602D−02	0.36428D−02	−0.31566D+04	0.37044D+05	0.73535D+05	0.40905D−01	
		5.350	−0.66890D−02	0.76333D−02	0.36428D−02	−0.30815D+04	0.37002D+05	0.73457D+05	0.40838D−01	
		5.360	−0.66515D−02	0.76066D−02	0.36428D−02	−0.30068D+04	0.36959D+05	0.73381D+05	0.40772D−01	
		5.370	−0.66142D−02	0.75801D−02	0.36428D−02	−0.29324D+04	0.36917D+05	0.73304D+05	0.40705D−01	
		5.380	−0.65771D−02	0.75538D−02	0.36428D−02	−0.28584D+04	0.36876D+05	0.73229D+05	0.40639D−01	
		5.390	−0.65402D−02	0.75276D−02	0.36428D−02	−0.27847D+04	0.36834D+05	0.73153D+05	0.40574D−01	
		5.400	−0.65035D−02	0.75016D−02	0.36428D−02	−0.27114D+04	0.36793D+05	0.73079D+05	0.40508D−01	
5	4	5.400	−0.62991D−02	0.75016D−02	0.36428D−02	−0.27114D+04	0.14819D+06	0.11865D+05	0.40508D−01	0.42861D+05
		5.410	−0.61991D−02	0.74762D−02	0.36428D−02	−0.24328D+04	0.14782D+06	0.11997D+05	0.40446D−01	
		5.420	−0.60997D−02	0.74510D−02	0.36428D−02	−0.21559D+04	0.14746D+06	0.12128D+05	0.40384D−01	
		5.430	−0.60010D−02	0.74261D−02	0.36428D−02	−0.18807D+04	0.14710D+06	0.12259D+05	0.40324D−01	
		5.440	−0.59030D−02	0.74016D−02	0.36428D−02	−0.16071D+04	0.14674D+06	0.12388D+05	0.40264D−01	
		5.450	−0.58056D−02	0.73772D−02	0.36428D−02	−0.13353D+04	0.14639D+06	0.12518D+05	0.40206D−01	
		5.460	−0.57088D−02	0.73532D−02	0.36428D−02	−0.10650D+04	0.14605D+06	0.12646D+05	0.40148D−01	
		5.470	−0.56127D−02	0.73294D−02	0.36428D−02	−0.79637D+03	0.14571D+06	0.12774D+05	0.40092D−01	
		5.480	−0.55172D−02	0.73059D−02	0.36428D−02	−0.52934D+03	0.14537D+06	0.12901D+05	0.40036D−01	
		5.490	−0.54223D−02	0.72826D−02	0.36428D−02	−0.26389D+03	0.14504D+06	0.13027D+05	0.39981D−01	
		5.500	−0.53280D−02	0.72596D−02	0.36428D−02	0.45839D−09	0.14471D+06	0.13153D+05	0.39928D−01	

@ 10000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.10345D−01	0.10096D−01	0.41879D−02	−0.10000D+05	0.66439D+05	0.42024D+05	0.50478D−01	0.13334D+06
		5.010	−0.10304D−01	0.10055D−01	0.41879D−02	−0.98476D+04	0.66287D+05	0.42024D+05	0.50375D−01	
		5.020	−0.10264D−01	0.10014D−01	0.41879D−02	−0.96961D+04	0.66135D+05	0.42024D+05	0.50272D−01	
		5.030	−0.10223D−01	0.99740D−02	0.41879D−02	−0.95455D+04	0.65985D+05	0.42024D+05	0.50169D−01	
		5.040	−0.10183D−01	0.99340D−02	0.41879D−02	−0.93957D+04	0.65835D+05	0.42024D+05	0.50067D−01	
		5.050	−0.10144D−01	0.98942D−02	0.41879D−02	−0.92469D+04	0.65686D+05	0.42024D+05	0.49966D−01	
		5.060	−0.10104D−01	0.98546D−02	0.41879D−02	−0.90990D+04	0.65538D+05	0.42024D+05	0.49864D−01	
		5.070	−0.10065D−01	0.98153D−02	0.41879D−02	−0.89519D+04	0.65391D+05	0.42024D+05	0.49764D−01	
		5.080	−0.10026D−01	0.97762D−02	0.41879D−02	−0.88057D+04	0.65245D+05	0.42024D+05	0.49663D−01	
		5.090	−0.99867D−02	0.97373D−02	0.41879D−02	−0.86604D+04	0.65100D+05	0.42024D+05	0.49563D−01	
		5.100	−0.99481D−02	0.96987D−02	0.41879D−02	−0.85159D+04	0.64955D+05	0.42024D+05	0.49463D−01	
2	1	5.100	−0.97432D−02	0.96987D−02	0.41879D−02	−0.85159D+04	0.42778D+05	0.85956D+05	0.49463D−01	0.27635D+06
		5.110	−0.96917D−02	0.96607D−02	0.41879D−02	−0.84156D+04	0.42714D+05	0.85844D+05	0.49366D−01	
		5.120	−0.96406D−02	0.96230D−02	0.41879D−02	−0.83158D+04	0.42651D+05	0.85732D+05	0.49270D−01	
		5.130	−0.95897D−02	0.95855D−02	0.41879D−02	−0.82165D+04	0.42589D+05	0.85621D+05	0.49173D−01	
		5.140	−0.95391D−02	0.95482D−02	0.41879D−02	−0.81177D+04	0.42527D+05	0.85512D+05	0.49078D−01	
		5.150	−0.94888D−02	0.95112D−02	0.41879D−02	−0.80194D+04	0.42465D+05	0.85402D+05	0.48983D−01	
		5.160	−0.94388D−02	0.94744D−02	0.41879D−02	−0.79216D+04	0.42404D+05	0.85294D+05	0.48888D−01	
		5.170	−0.93891D−02	0.94379D−02	0.41879D−02	−0.78244D+04	0.42344D+05	0.85186D+05	0.48794D−01	
		5.180	−0.93396D−02	0.94016D−02	0.41879D−02	−0.77276D+04	0.42283D+05	0.85079D+05	0.48700D−01	
		5.190	−0.92905D−02	0.93655D−02	0.41879D−02	−0.76313D+04	0.42224D+05	0.84973D+05	0.48607D−01	
		5.200	−0.92416D−02	0.93297D−02	0.41879D−02	−0.75354D+04	0.42165D+05	0.84868D+05	0.48514D−01	
3	2	5.200	−0.89688D−02	0.93297D−02	0.41879D−02	−0.75354D+04	0.18209D+06	0.11754D+05	0.48514D−01	0.41554D+05
		5.210	−0.88375D−02	0.92947D−02	0.41879D−02	−0.71720D+04	0.18157D+06	0.11925D+05	0.48425D−01	
		5.220	−0.87070D−02	0.92601D−02	0.41879D−02	−0.68109D+04	0.18106D+06	0.12095D+05	0.48338D−01	
		5.230	−0.85775D−02	0.92259D−02	0.41879D−02	−0.64522D+04	0.18056D+06	0.12264D+05	0.48251D−01	
		5.240	−0.84489D−02	0.91920D−02	0.41879D−02	−0.60958D+04	0.18006D+06	0.12432D+05	0.48166D−01	
		5.250	−0.83212D−02	0.91585D−02	0.41879D−02	−0.57416D+04	0.17957D+06	0.12599D+05	0.48082D−01	
		5.260	−0.81944D−02	0.91254D−02	0.41879D−02	−0.53898D+04	0.17908D+06	0.12765D+05	0.48000D−01	

		5.270	-0.80685D-02	0.90927D-02	0.41879D-02	-0.50402D+04	0.17860D+06	0.12929D+05	0.47918D-01	
		5.280	-0.79434D-02	0.90603D-02	0.41879D-02	-0.46929D+04	0.17813D+06	0.13093D+05	0.47838D-01	
		5.290	-0.78192D-02	0.90283D-02	0.41879D-02	-0.43477D+04	0.17766D+06	0.13257D+05	0.47760D-01	
		5.300	-0.76959D-02	0.89966D-02	0.41879D-02	-0.40047D+04	0.17720D+06	0.13419D+05	0.47682D-01	
4	3	5.300	-0.79508D-02	0.89966D-02	0.41879D-02	-0.40047D+04	0.42971D+05	0.85162D+05	0.47682D-01	0.28475D+06
		5.310	-0.79063D-02	0.89647D-02	0.41879D-02	-0.39163D+04	0.42920D+05	0.85070D+05	0.47603D-01	
		5.320	-0.78620D-02	0.89330D-02	0.41879D-02	-0.38283D+04	0.42869D+05	0.84978D+05	0.47524D-01	
		5.330	-0.78180D-02	0.89016D-02	0.41879D-02	-0.37407D+04	0.42819D+05	0.84887D+05	0.47445D-01	
		5.340	-0.77742D-02	0.88703D-02	0.41879D-02	-0.36536D+04	0.42769D+05	0.84797D+05	0.47367D-01	
		5.350	-0.77306D-02	0.88392D-02	0.41879D-02	-0.35669D+04	0.42719D+05	0.84708D+05	0.47290D-01	
		5.360	-0.76873D-02	0.88084D-02	0.41879D-02	-0.34806D+04	0.42670D+05	0.84619D+05	0.47213D-01	
		5.370	-0.76442D-02	0.87777D-02	0.41879D-02	-0.33947D+04	0.42622D+05	0.84530D+05	0.47136D-01	
		5.380	-0.76013D-02	0.87472D-02	0.41879D-02	-0.33092D+04	0.42573D+05	0.84443D+05	0.47060D-01	
		5.390	-0.75587D-02	0.87169D-02	0.41879D-02	-0.32241D+04	0.42525D+05	0.84355D+05	0.46984D-01	
		5.400	-0.75163D-02	0.86868D-02	0.41879D-02	-0.31394D+04	0.42478D+05	0.84269D+05	0.46909D-01	
5	4	5.400	-0.72780D-02	0.86868D-02	0.41879D-02	-0.31394D+04	0.17158D+06	0.13671D+05	0.46909D-01	0.49399D+05
		5.410	-0.71622D-02	0.86574D-02	0.41879D-02	-0.28168D+04	0.17116D+06	0.13824D+05	0.46837D-01	
		5.420	-0.70471D-02	0.86283D-02	0.41879D-02	-0.24962D+04	0.17074D+06	0.13976D+05	0.46766D-01	
		5.430	-0.69328D-02	0.85996D-02	0.41879D-02	-0.21776D+04	0.17032D+06	0.14127D+05	0.46696D-01	
		5.440	-0.68193D-02	0.85711D-02	0.41879D-02	-0.18609D+04	0.16991D+06	0.14277D+05	0.46627D-01	
		5.450	-0.67065D-02	0.85430D-02	0.41879D-02	-0.15461D+04	0.16951D+06	0.14427D+05	0.46559D-01	
		5.460	-0.65945D-02	0.85152D-02	0.41879D-02	-0.12332D+04	0.16911D+06	0.14576D+05	0.46493D-01	
		5.470	-0.64832D-02	0.84876D-02	0.41879D-02	-0.92211D+03	0.16871D+06	0.14723D+05	0.46427D-01	
		5.480	-0.63727D-02	0.84604D-02	0.41879D-02	-0.61292D+03	0.16832D+06	0.14871D+05	0.46363D-01	
		5.490	-0.62628D-02	0.84335D-02	0.41879D-02	-0.30555D+03	0.16794D+06	0.15017D+05	0.46300D-01	
		5.500	-0.61537D-02	0.84069D-02	0.41879D-02	0.63392D-09	0.16756D+06	0.15162D+05	0.46238D-01	

@ 12500 psi (min burst

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	-0.13166D-01	0.12708D-01	0.52271D-02	-0.12500D+05	0.79706D+05	0.52034D+05	0.63540D-01	0.16510D+06
		5.010	-0.13114D-01	0.12656D-01	0.52271D-02	-0.12316D+05	0.79522D+05	0.52034D+05	0.63409D-01	
		5.020	-0.13063D-01	0.12605D-01	0.52271D-02	-0.12133D+05	0.79340D+05	0.52034D+05	0.63278D-01	
		5.030	-0.13012D-01	0.12554D-01	0.52271D-02	-0.11952D+05	0.79158D+05	0.52034D+05	0.63148D-01	
		5.040	-0.12961D-01	0.12504D-01	0.52271D-02	-0.11771D+05	0.78977D+05	0.52034D+05	0.63018D-01	
		5.050	-0.12911D-01	0.12453D-01	0.52271D-02	-0.11592D+05	0.78798D+05	0.52034D+05	0.62888D-01	
		5.060	-0.12861D-01	0.12403D-01	0.52271D-02	-0.11413D+05	0.78619D+05	0.52034D+05	0.62759D-01	
		5.070	-0.12811D-01	0.12353D-01	0.52271D-02	-0.11236D+05	0.78442D+05	0.52034D+05	0.62631D-01	
		5.080	-0.12761D-01	0.12304D-01	0.52271D-02	-0.11059D+05	0.78266D+05	0.52034D+05	0.62503D-01	
		5.090	-0.12712D-01	0.12255D-01	0.52271D-02	-0.10884D+05	0.78090D+05	0.52034D+05	0.62376D-01	
		5.100	-0.12663D-01	0.12206D-01	0.52271D-02	-0.10710D+05	0.77916D+05	0.52034D+05	0.62249D-01	
2	1	5.100	-0.12238D-01	0.12206D-01	0.52271D-02	-0.10710D+05	0.53656D+05	0.10767D+06	0.62249D-01	0.34616D+06
		5.110	-0.12174D-01	0.12158D-01	0.52271D-02	-0.10584D+05	0.53576D+05	0.10753D+06	0.62127D-01	
		5.120	-0.12110D-01	0.12110D-01	0.52271D-02	-0.10459D+05	0.53496D+05	0.10739D+06	0.62006D-01	
		5.130	-0.12046D-01	0.12063D-01	0.52271D-02	-0.10334D+05	0.53418D+05	0.10725D+06	0.61885D-01	
		5.140	-0.11982D-01	0.12016D-01	0.52271D-02	-0.10210D+05	0.53340D+05	0.10711D+06	0.61765D-01	
		5.150	-0.11919D-01	0.11970D-01	0.52271D-02	-0.10087D+05	0.53262D+05	0.10697D+06	0.61645D-01	
		5.160	-0.11856D-01	0.11924D-01	0.52271D-02	-0.99641D+04	0.53185D+05	0.10684D+06	0.61526D-01	
		5.170	-0.11794D-01	0.11878D-01	0.52271D-02	-0.98420D+04	0.53109D+05	0.10670D+06	0.61408D-01	
		5.180	-0.11732D-01	0.11832D-01	0.52271D-02	-0.97206D+04	0.53033D+05	0.10657D+06	0.61290D-01	
		5.190	-0.11670D-01	0.11787D-01	0.52271D-02	-0.95997D+04	0.52958D+05	0.10643D+06	0.61173D-01	
		5.200	-0.11609D-01	0.11742D-01	0.52271D-02	-0.94795D+04	0.52883D+05	0.10630D+06	0.61057D-01	
3	2	5.200	-0.11263D-01	0.11742D-01	0.52271D-02	-0.94795D+04	0.22913D+06	0.14698D+05	0.61057D-01	0.51981D+05
		5.210	-0.11098D-01	0.11698D-01	0.52271D-02	-0.90221D+04	0.22848D+06	0.14913D+05	0.60945D-01	
		5.220	-0.10934D-01	0.11654D-01	0.52271D-02	-0.85677D+04	0.22784D+06	0.15126D+05	0.60835D-01	
		5.230	-0.10771D-01	0.11611D-01	0.52271D-02	-0.81163D+04	0.22721D+06	0.15339D+05	0.60726D-01	
		5.240	-0.10609D-01	0.11569D-01	0.52271D-02	-0.76678D+04	0.22659D+06	0.15550D+05	0.60620D-01	
		5.250	-0.10448D-01	0.11527D-01	0.52271D-02	-0.72222D+04	0.22597D+06	0.15760D+05	0.60514D-01	
		5.260	-0.10289D-01	0.11485D-01	0.52271D-02	-0.67795D+04	0.22536D+06	0.15969D+05	0.60411D-01	
		5.270	-0.10130D-01	0.11444D-01	0.52271D-02	-0.63395D+04	0.22476D+06	0.16176D+05	0.60309D-01	
		5.280	-0.99727D-02	0.11403D-01	0.52271D-02	-0.59024D+04	0.22416D+06	0.16383D+05	0.60208D-01	
		5.290	-0.98165D-02	0.11363D-01	0.52271D-02	-0.54681D+04	0.22358D+06	0.16588D+05	0.60109D-01	
		5.300	-0.96613D-02	0.11323D-01	0.52271D-02	-0.50365D+04	0.22300D+06	0.16792D+05	0.60012D-01	
4	3	5.300	-0.99844D-02	0.11323D-01	0.52271D-02	-0.50365D+04	0.53899D+05	0.10667D+06	0.60012D-01	0.35667D+06
		5.310	-0.99285D-02	0.11283D-01	0.52271D-02	-0.49255D+04	0.53835D+05	0.10656D+06	0.59912D-01	
		5.320	-0.98729D-02	0.11243D-01	0.52271D-02	-0.48151D+04	0.53771D+05	0.10644D+06	0.59813D-01	
		5.330	-0.98176D-02	0.11203D-01	0.52271D-02	-0.47053D+04	0.53708D+05	0.10633D+06	0.59715D-01	
		5.340	-0.97627D-02	0.11164D-01	0.52271D-02	-0.45960D+04	0.53645D+05	0.10621D+06	0.59617D-01	
		5.350	-0.97080D-02	0.11125D-01	0.52271D-02	-0.44871D+04	0.53583D+05	0.10610D+06	0.59519D-01	
		5.360	-0.96536D-02	0.11086D-01	0.52271D-02	-0.43789D+04	0.53521D+05	0.10599D+06	0.59423D-01	
		5.370	-0.95995D-02	0.11048D-01	0.52271D-02	-0.42711D+04	0.53460D+05	0.10588D+06	0.59326D-01	
		5.380	-0.95456D-02	0.11009D-01	0.52271D-02	-0.41639D+04	0.53399D+05	0.10577D+06	0.59231D-01	
		5.390	-0.94921D-02	0.10971D-01	0.52271D-02	-0.40571D+04	0.53338D+05	0.10566D+06	0.59135D-01	
		5.400	-0.94389D-02	0.10933D-01	0.52271D-02	-0.39509D+04	0.53278D+05	0.10555D+06	0.59041D-01	
5	4	5.400	-0.91366D-02	0.10933D-01	0.52271D-02	-0.39509D+04	0.21593D+06	0.17109D+05	0.59041D-01	0.61838D+05
		5.410	-0.89909D-02	0.10897D-01	0.52271D-02	-0.35449D+04	0.21539D+06	0.17301D+05	0.58950D-01	
		5.420	-0.88461D-02	0.10860D-01	0.52271D-02	-0.31415D+04	0.21487D+06	0.17492D+05	0.58861D-01	
		5.430	-0.87023D-02	0.10824D-01	0.52271D-02	-0.27405D+04	0.21434D+06	0.17682D+05	0.58773D-01	
		5.440	-0.85595D-02	0.10788D-01	0.52271D-02	-0.23419D+04	0.21383D+06	0.17871D+05	0.58687D-01	
		5.450	-0.84176D-02	0.10753D-01	0.52271D-02	-0.19457D+04	0.21332D+06	0.18060D+05	0.58602D-01	
		5.460	-0.82766D-02	0.10718D-01	0.52271D-02	-0.15519D+04	0.21282D+06	0.18247D+05	0.58519D-01	
		5.470	-0.81366D-02	0.10683D-01	0.52271D-02	-0.11605D+04	0.21232D+06	0.18433D+05	0.58436D-01	
		5.480	-0.79974D-02	0.10649D-01	0.52271D-02	-0.77136D+03	0.21183D+06	0.18618D+05	0.58356D-01	
		5.490	-0.78592D-02	0.10615D-01	0.52271D-02	-0.38454D+03	0.21135D+06	0.18802D+05	0.58277D-01	
		5.500	-0.77219D-02	0.10582D-01	0.52271D-02	0.71304D-09	0.21087D+06	0.18985D+05	0.58199D-01	

STEP	DESCRIPTION	STRESS RATIO
1	1000 psi	14.057
2	8000 psi autofrettag	1.501
3	0 psi after auto	11.646
4	1000 psi	6.369
5	5000 psi (wkg)	2.265
6	7500 psi (test)	1.614
7	8000 psi	1.527
8	8500 psi	1.448
9	10000 psi	1.254
10	12500 psi (min burst	1.000

```
Ver5 - pressure steps, metal lined, high pressure
5.,5,5,10,9,0
1,1
5.81d6,1.508d6,2.411d6,1.393,-.239,.3436
-4.96D-6,19.5D-6,23.1D-6
2,1
2.228d6,19.38d6,2.228d6,.03481,.5195,.3029
20.D-6,0.2D-6,20.D-6
3,4
32.d6,32.d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5.0d-6,5.0d-6
30,.6,.03
4,4
32.0d6,32.0d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5d-6,5d-6
90,.6,.03
5,2
3
.0028,28000
.0054,40000
.0318,48000
13.1d-6
1,5,0.1
2,1,0.1
3,2,0.1
4,3,0.1
5,4,0.1
1000 psi
1000.,0.
0,0,0,0,0,0
8000 psi autofrettage
8000.,0.
0,0,0,0,0,0
0 psi after auto
0000.,0.
0,0,0,0,0,0
1000 psi
1000.,0,
0,0,0,0,0,0
5000 psi (wkg)
5000.,0.
0,0,0,0,0,0
7500 psi (test)
7500.,0.
0,0,0,0,0,0
8000 psi
8000.,0.
0,0,0,0,0,0
```

```
8500 psi
8500.,0.
0,0,0,0,0,0
10000 psi
10000.,0.
0,0,0,0,0,0
12500 psi (min burst)
12500.,0.
0,0,0,0,0,0
```

Verification 6: aluminum cylinder with internal pressure, multi-layer, matching prior results

An aluminum cylinder containing an internal pressure of 2000 psi is analyzed. The closed form solution is taken from Roark, 6th edition, same as Verification 1, but broken into 5 layers.

The following page contains the results of the NewCAP analysis of the cylinder. Note that:

- The stresses and strains match the Roark solution, and the results of Verification 1, confirming that multiple layers give the same result as a single layer.

```
   -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
                COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020



 Ver6 - Internal Pressure,  5 layer Aluminum



 RI=  5.0000     NL=  5     NMT=  1     NLS=  2     ISPL=  1     IPO= 0



 * MATERIAL MODEL 1 - GENERAL PROPERTIES
 MT       EM           EH           ER          PRMH         PRMR         PRHR         PRHM         PRRM         PRRH           N

  1   0.1000D+08   0.1000D+08   0.1000D+08   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.1000D+01


   MT      ALPM         ALPH         ALPR

    1   0.1310D-04   0.1310D-04   0.1310D-04


   LN  MT   TL        NODE    TEMP

    1   1   1.0000       1  0.00  0.00
    2   1   1.0000       2  0.00  0.00
    3   1   1.0000       3  0.00  0.00
    4   1   1.0000       4  0.00  0.00
    5   1   1.0000       5  0.00  0.00
                         6  0.00  0.00

 STEP DESCRIPTION          PI          PO
 1000 psi               1000.000       0.000
 2000 psi               2000.000       0.000


@ 1000 psi
  LN  MT    R         EPR           EPH           EPM            SR            SH            SM             U            AF

    1   1  5.000  -0.16000D-03   0.18667D-03   0.13333D-04  -0.10000D+04   0.16667D+04   0.33333D+03   0.93333D-03   0.11519D+05
           5.500  -0.12992D-03   0.15658D-03   0.13333D-04  -0.76860D+03   0.14353D+04   0.33333D+03   0.86121D-03
           6.000  -0.10704D-03   0.13370D-03   0.13333D-04  -0.59259D+03   0.12593D+04   0.33333D+03   0.80222D-03

    2   1  6.000  -0.10704D-03   0.13370D-03   0.13333D-04  -0.59259D+03   0.12593D+04   0.33333D+03   0.80222D-03   0.13614D+05
           6.500  -0.89231D-04   0.11590D-03   0.13333D-04  -0.45562D+03   0.11223D+04   0.33333D+03   0.75333D-03
           7.000  -0.75102D-04   0.10177D-03   0.13333D-04  -0.34694D+03   0.10136D+04   0.33333D+03   0.71238D-03

    3   1  7.000  -0.75102D-04   0.10177D-03   0.13333D-04  -0.34694D+03   0.10136D+04   0.33333D+03   0.71238D-03   0.15708D+05
           7.500  -0.63704D-04   0.90370D-04   0.13333D-04  -0.25926D+03   0.92593D+03   0.33333D+03   0.67778D-03
           8.000  -0.54375D-04   0.81042D-04   0.13333D-04  -0.18750D+03   0.85417D+03   0.33333D+03   0.64833D-03

    4   1  8.000  -0.54375D-04   0.81042D-04   0.13333D-04  -0.18750D+03   0.85417D+03   0.33333D+03   0.64833D-03   0.17802D+05
           8.500  -0.46644D-04   0.73310D-04   0.13333D-04  -0.12803D+03   0.79469D+03   0.33333D+03   0.62314D-03
           9.000  -0.40165D-04   0.66831D-04   0.13333D-04  -0.78189D+02   0.74486D+03   0.33333D+03   0.60148D-03

    5   1  9.000  -0.40165D-04   0.66831D-04   0.13333D-04  -0.78189D+02   0.74486D+03   0.33333D+03   0.60148D-03   0.19897D+05
           9.500  -0.34681D-04   0.61348D-04   0.13333D-04  -0.36011D+02   0.70268D+03   0.33333D+03   0.58281D-03
          10.000  -0.30000D-04   0.56667D-04   0.13333D-04   0.10942D-11   0.66667D+03   0.33333D+03   0.56667D-03


@ 2000 psi
  LN  MT    R         EPR           EPH           EPM            SR            SH            SM             U            AF

    1   1  5.000  -0.32000D-03   0.37333D-03   0.26667D-04  -0.20000D+04   0.33333D+04   0.66667D+03   0.18667D-02   0.23038D+05
           5.500  -0.25983D-03   0.31317D-03   0.26667D-04  -0.15372D+04   0.28705D+04   0.66667D+03   0.17224D-02
           6.000  -0.21407D-03   0.26741D-03   0.26667D-04  -0.11852D+04   0.25185D+04   0.66667D+03   0.16044D-02

    2   1  6.000  -0.21407D-03   0.26741D-03   0.26667D-04  -0.11852D+04   0.25185D+04   0.66667D+03   0.16044D-02   0.27227D+05
           6.500  -0.17846D-03   0.23179D-03   0.26667D-04  -0.91124D+03   0.22446D+04   0.66667D+03   0.15067D-02
           7.000  -0.15020D-03   0.20354D-03   0.26667D-04  -0.69388D+03   0.20272D+04   0.66667D+03   0.14248D-02

    3   1  7.000  -0.15020D-03   0.20354D-03   0.26667D-04  -0.69388D+03   0.20272D+04   0.66667D+03   0.14248D-02   0.31416D+05
           7.500  -0.12741D-03   0.18074D-03   0.26667D-04  -0.51852D+03   0.18519D+04   0.66667D+03   0.13556D-02
           8.000  -0.10875D-03   0.16208D-03   0.26667D-04  -0.37500D+03   0.17083D+04   0.66667D+03   0.12967D-02

    4   1  8.000  -0.10875D-03   0.16208D-03   0.26667D-04  -0.37500D+03   0.17083D+04   0.66667D+03   0.12967D-02   0.35605D+05
           8.500  -0.93287D-04   0.14662D-03   0.26667D-04  -0.25606D+03   0.15894D+04   0.66667D+03   0.12463D-02
           9.000  -0.80329D-04   0.13366D-03   0.26667D-04  -0.15638D+03   0.14897D+04   0.66667D+03   0.12030D-02

    5   1  9.000  -0.80329D-04   0.13366D-03   0.26667D-04  -0.15638D+03   0.14897D+04   0.66667D+03   0.12030D-02   0.39794D+05
           9.500  -0.69363D-04   0.12270D-03   0.26667D-04  -0.72022D+02   0.14054D+04   0.66667D+03   0.11656D-02
          10.000  -0.60000D-04   0.11333D-03   0.26667D-04   0.21885D-11   0.13333D+04   0.66667D+03   0.11333D-02
  STEP  DESCRIPTION          STRESS RATIO
     1    1000 psi                2.000
     2    2000 psi                1.000
```

```
Ver6 - Internal Pressure,  5 layer Aluminum
5.,5,1,2,1,0
1,1
10.d6,10.d6,10.d6,.3,.3,.3
13.1d-6,13.1d-6,13.1d-6
1,1,1.0
2,1,1.0
3,1,1.0
4,1,1.0
5,1,1.0
1000 psi
1000.,0.
0,0,0,0,0,0
2000 psi
2000.,0.
0,0,0,0,0,0
```

Verification 7: metal lined composite cylinder with pressure and temperature

A composite cylinder with metal liner and internal pressure steps, with temperature change on two of the steps. This is the same as Verification 4, with temperature change on the first time at 1000 psi, and the second time at 5000 psi.

The following page contains the results of the NewCAP analysis of the cylinder. Note that:

- Where there is no temperature change, the results match between Verification 7 and Verification 4
- Where there is temperature change on the layer, the results of Verification 7 do not match the results of Verification 4, as expected

```
   -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
             COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020



 Ver7 - pressure + temp, metal lined



 RI=  5.0000     NL=  5     NMT=  5     NLS=  9     ISPL=  9     IPO= 0



 * MATERIAL MODEL 1 - GENERAL PROPERTIES
 MT       EM           EH           ER          PRMH         PRMR         PRHR         PRHM         PRRM         PRRH           N

  1   0.5810D+07   0.1508D+07   0.2411D+07   0.1393D+01  -0.2390D+00   0.3436D+00   0.3616D+00  -0.9918D-01   0.5493D+00   0.1109D+01
  2   0.2228D+07   0.1938D+08   0.2228D+07   0.3481D-01   0.5195D+00   0.3029D+00   0.3028D+00   0.5195D+00   0.3482D-01   0.2533D+01


   MT      ALPM         ALPH         ALPR

    1  -0.4960D-05   0.1950D-04   0.2310D-04
    2   0.2000D-04   0.2000D-06   0.2000D-04


 * MATERIAL MODEL 2 - MULTI-LINEAR STRESS/STRAIN
 MT    STRAIN1      STRESS1      STRAIN2      STRESS2      STRAIN3      STRESS3      STRAIN4      STRESS4      STRAIN5      STRESS5

  5   0.2800D-02   0.2800D+05   0.5400D-02   0.4000D+05   0.3180D-01   0.4800D+05   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
   MT
  5   0.1310D-04


 * MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES
 MT        EF1          EF2         VF12         VF23         GF12         GF23          EM           VF           GM

  3   0.3200D+08   0.3200D+08   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1860D+06
  4   0.3200D+08   0.3200D+08   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1860D+06

 MT      ALP1         ALP2         ALP3          WA          FVF          VVF

  3   0.1100D-05   0.5000D-05   0.5000D-05   0.3000D+02   0.6000D+00   0.3000D-01
  4   0.1100D-05   0.5000D-05   0.5000D-05   0.9000D+02   0.6000D+00   0.3000D-01


   LN  MT   TL        NODE    TEMP

    1   5   0.1000       1 10.00  0.00  0.00  0.00  0.00  0.00 50.00  0.00  0.00
    2   1   0.1000       2 10.00  0.00  0.00  0.00  0.00  0.00 50.00  0.00  0.00
    3   2   0.1000       3 10.00  0.00  0.00  0.00  0.00  0.00 50.00  0.00  0.00
    4   3   0.1000       4 10.00  0.00  0.00  0.00  0.00  0.00 50.00  0.00  0.00
    5   4   0.1000       5 10.00  0.00  0.00  0.00  0.00  0.00 50.00  0.00  0.00
                         6 10.00  0.00  0.00  0.00  0.00  0.00 50.00  0.00  0.00

 STEP DESCRIPTION          PI          PO
 1000 psi              1000.000       0.000
 5000 psi autofrettag  5000.000       0.000
 0 psi after auto         0.000       0.000
 1000 psi              1000.000       0.000
 3000 psi (wkg)        3000.000       0.000
 4500 psi (test)       4500.000       0.000
 5000 psi              5000.000       0.000
 5500 psi              5500.000       0.000
 7500 psi (min burst)  7500.000       0.000


@ 1000 psi
  LN  MT    R         EPR          EPH          EPM           SR           SH           SM            U            AF

    1   5  5.000  -0.41614D-03   0.93914D-03   0.42618D-03  -0.10000D+04   0.94252D+04   0.54794D+04   0.46957D-02   0.17386D+05
           5.010  -0.41344D-03   0.93644D-03   0.42618D-03  -0.97921D+03   0.94045D+04   0.54794D+04   0.46916D-02
           5.020  -0.41075D-03   0.93375D-03   0.42618D-03  -0.95855D+03   0.93838D+04   0.54794D+04   0.46874D-02
           5.030  -0.40808D-03   0.93108D-03   0.42618D-03  -0.93801D+03   0.93632D+04   0.54794D+04   0.46833D-02
           5.040  -0.40543D-03   0.92843D-03   0.42618D-03  -0.91759D+03   0.93428D+04   0.54794D+04   0.46793D-02
           5.050  -0.40279D-03   0.92579D-03   0.42618D-03  -0.89729D+03   0.93225D+04   0.54794D+04   0.46752D-02
           5.060  -0.40016D-03   0.92317D-03   0.42618D-03  -0.87711D+03   0.93024D+04   0.54794D+04   0.46712D-02
           5.070  -0.39756D-03   0.92056D-03   0.42618D-03  -0.85706D+03   0.92823D+04   0.54794D+04   0.46672D-02
           5.080  -0.39496D-03   0.91797D-03   0.42618D-03  -0.83712D+03   0.92624D+04   0.54794D+04   0.46633D-02
           5.090  -0.39239D-03   0.91539D-03   0.42618D-03  -0.81729D+03   0.92425D+04   0.54794D+04   0.46593D-02
           5.100  -0.38983D-03   0.91283D-03   0.42618D-03  -0.79759D+03   0.92228D+04   0.54794D+04   0.46554D-02

    2   1  5.100  -0.62314D-03   0.91283D-03   0.42618D-03  -0.79759D+03   0.37812D+04   0.82222D+04   0.46554D-02   0.26473D+05
           5.110  -0.61875D-03   0.90983D-03   0.42618D-03  -0.78863D+03   0.37767D+04   0.82138D+04   0.46492D-02
           5.120  -0.61438D-03   0.90684D-03   0.42618D-03  -0.77972D+03   0.37723D+04   0.82055D+04   0.46430D-02
           5.130  -0.61004D-03   0.90388D-03   0.42618D-03  -0.77085D+03   0.37679D+04   0.81972D+04   0.46369D-02
           5.140  -0.60572D-03   0.90094D-03   0.42618D-03  -0.76202D+03   0.37635D+04   0.81890D+04   0.46308D-02
           5.150  -0.60143D-03   0.89802D-03   0.42618D-03  -0.75324D+03   0.37592D+04   0.81809D+04   0.46248D-02
           5.160  -0.59716D-03   0.89512D-03   0.42618D-03  -0.74450D+03   0.37549D+04   0.81728D+04   0.46188D-02
           5.170  -0.59291D-03   0.89224D-03   0.42618D-03  -0.73580D+03   0.37507D+04   0.81648D+04   0.46129D-02
           5.180  -0.58869D-03   0.88937D-03   0.42618D-03  -0.72714D+03   0.37465D+04   0.81569D+04   0.46070D-02
           5.190  -0.58449D-03   0.88653D-03   0.42618D-03  -0.71853D+03   0.37423D+04   0.81490D+04   0.46011D-02
           5.200  -0.58031D-03   0.88371D-03   0.42618D-03  -0.70995D+03   0.37381D+04   0.81412D+04   0.45953D-02

    3   2  5.200  -0.55606D-03   0.88371D-03   0.42618D-03  -0.70995D+03   0.17093D+05   0.73014D+03   0.45953D-02   0.26761D+04
           5.210  -0.54397D-03   0.88095D-03   0.42618D-03  -0.67582D+03   0.17055D+05   0.74655D+03   0.45898D-02
           5.220  -0.53196D-03   0.87824D-03   0.42618D-03  -0.64189D+03   0.17018D+05   0.76288D+03   0.45844D-02
           5.230  -0.52003D-03   0.87555D-03   0.42618D-03  -0.60816D+03   0.16981D+05   0.77912D+03   0.45791D-02
           5.240  -0.50818D-03   0.87290D-03   0.42618D-03  -0.57462D+03   0.16945D+05   0.79527D+03   0.45740D-02
           5.250  -0.49641D-03   0.87028D-03   0.42618D-03  -0.54129D+03   0.16909D+05   0.81134D+03   0.45690D-02
```

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
		5.260	−0.48471D−03	0.86769D−03	0.42618D−03	−0.50815D+03	0.16874D+05	0.82733D+03	0.45641D−02	
		5.270	−0.47309D−03	0.86514D−03	0.42618D−03	−0.47520D+03	0.16839D+05	0.84324D+03	0.45593D−02	
		5.280	−0.46154D−03	0.86261D−03	0.42618D−03	−0.44244D+03	0.16805D+05	0.85907D+03	0.45546D−02	
		5.290	−0.45007D−03	0.86012D−03	0.42618D−03	−0.40986D+03	0.16771D+05	0.87482D+03	0.45500D−02	
		5.300	−0.43867D−03	0.85766D−03	0.42618D−03	−0.37748D+03	0.16738D+05	0.89049D+03	0.45456D−02	
4	3	5.300	−0.68771D−03	0.85766D−03	0.42618D−03	−0.37748D+03	0.40602D+04	0.82189D+04	0.45456D−02	0.27492D+05
		5.310	−0.68355D−03	0.85475D−03	0.42618D−03	−0.36913D+03	0.40557D+04	0.82107D+04	0.45387D−02	
		5.320	−0.67943D−03	0.85187D−03	0.42618D−03	−0.36081D+03	0.40513D+04	0.82025D+04	0.45319D−02	
		5.330	−0.67532D−03	0.84900D−03	0.42618D−03	−0.35254D+03	0.40468D+04	0.81943D+04	0.45252D−02	
		5.340	−0.67124D−03	0.84615D−03	0.42618D−03	−0.34430D+03	0.40424D+04	0.81862D+04	0.45184D−02	
		5.350	−0.66717D−03	0.84331D−03	0.42618D−03	−0.33611D+03	0.40381D+04	0.81782D+04	0.45117D−02	
		5.360	−0.66313D−03	0.84050D−03	0.42618D−03	−0.32795D+03	0.40338D+04	0.81702D+04	0.45051D−02	
		5.370	−0.65911D−03	0.83770D−03	0.42618D−03	−0.31983D+03	0.40295D+04	0.81623D+04	0.44985D−02	
		5.380	−0.65511D−03	0.83492D−03	0.42618D−03	−0.31175D+03	0.40252D+04	0.81545D+04	0.44919D−02	
		5.390	−0.65114D−03	0.83216D−03	0.42618D−03	−0.30371D+03	0.40210D+04	0.81467D+04	0.44854D−02	
		5.400	−0.64718D−03	0.82942D−03	0.42618D−03	−0.29571D+03	0.40168D+04	0.81389D+04	0.44789D−02	
5	4	5.400	−0.62582D−03	0.82942D−03	0.42618D−03	−0.29571D+03	0.16153D+05	0.12467D+04	0.44789D−02	0.45135D+04
		5.410	−0.61496D−03	0.82674D−03	0.42618D−03	−0.26534D+03	0.16115D+05	0.12612D+04	0.44727D−02	
		5.420	−0.60417D−03	0.82409D−03	0.42618D−03	−0.23515D+03	0.16077D+05	0.12755D+04	0.44666D−02	
		5.430	−0.59345D−03	0.82147D−03	0.42618D−03	−0.20515D+03	0.16039D+05	0.12898D+04	0.44606D−02	
		5.440	−0.58280D−03	0.81888D−03	0.42618D−03	−0.17532D+03	0.16003D+05	0.13040D+04	0.44547D−02	
		5.450	−0.57222D−03	0.81632D−03	0.42618D−03	−0.14567D+03	0.15966D+05	0.13182D+04	0.44489D−02	
		5.460	−0.56171D−03	0.81378D−03	0.42618D−03	−0.11619D+03	0.15930D+05	0.13322D+04	0.44433D−02	
		5.470	−0.55126D−03	0.81128D−03	0.42618D−03	−0.86889D+02	0.15895D+05	0.13462D+04	0.44377D−02	
		5.480	−0.54088D−03	0.80880D−03	0.42618D−03	−0.57757D+02	0.15860D+05	0.13601D+04	0.44322D−02	
		5.490	−0.53057D−03	0.80635D−03	0.42618D−03	−0.28795D+02	0.15825D+05	0.13740D+04	0.44269D−02	
		5.500	−0.52033D−03	0.80393D−03	0.42618D−03	0.28194D−10	0.15791D+05	0.13877D+04	0.44216D−02	

@ 5000 psi autofrettag

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.43883D−02	0.48845D−02	0.19621D−02	−0.50000D+04	0.40379D+05	0.26078D+05	0.24422D−01	0.82745D+05
		5.010	−0.43698D−02	0.48660D−02	0.19621D−02	−0.49095D+04	0.40289D+05	0.26078D+05	0.24379D−01	
		5.020	−0.43514D−02	0.48476D−02	0.19621D−02	−0.48196D+04	0.40199D+05	0.26078D+05	0.24335D−01	
		5.030	−0.43332D−02	0.48293D−02	0.19621D−02	−0.47302D+04	0.40109D+05	0.26078D+05	0.24292D−01	
		5.040	−0.43150D−02	0.48112D−02	0.19621D−02	−0.46413D+04	0.40021D+05	0.26078D+05	0.24248D−01	
		5.050	−0.42970D−02	0.47931D−02	0.19621D−02	−0.45529D+04	0.39932D+05	0.26078D+05	0.24205D−01	
		5.060	−0.42790D−02	0.47752D−02	0.19621D−02	−0.44651D+04	0.39844D+05	0.26078D+05	0.24162D−01	
		5.070	−0.42612D−02	0.47573D−02	0.19621D−02	−0.43778D+04	0.39757D+05	0.26078D+05	0.24120D−01	
		5.080	−0.42434D−02	0.47396D−02	0.19621D−02	−0.42910D+04	0.39670D+05	0.26078D+05	0.24077D−01	
		5.090	−0.42258D−02	0.47220D−02	0.19621D−02	−0.42047D+04	0.39584D+05	0.26078D+05	0.24035D−01	
		5.100	−0.42083D−02	0.47044D−02	0.19621D−02	−0.41189D+04	0.39498D+05	0.26078D+05	0.23993D−01	
2	1	5.100	−0.46888D−02	0.47044D−02	0.19621D−02	−0.41189D+04	0.20463D+05	0.40889D+05	0.23993D−01	0.13144D+06
		5.110	−0.46641D−02	0.46861D−02	0.19621D−02	−0.40709D+04	0.20432D+05	0.40834D+05	0.23946D−01	
		5.120	−0.46395D−02	0.46678D−02	0.19621D−02	−0.40230D+04	0.20401D+05	0.40780D+05	0.23899D−01	
		5.130	−0.46151D−02	0.46497D−02	0.19621D−02	−0.39755D+04	0.20371D+05	0.40727D+05	0.23853D−01	
		5.140	−0.45908D−02	0.46317D−02	0.19621D−02	−0.39281D+04	0.20341D+05	0.40673D+05	0.23807D−01	
		5.150	−0.45666D−02	0.46138D−02	0.19621D−02	−0.38810D+04	0.20311D+05	0.40620D+05	0.23761D−01	
		5.160	−0.45425D−02	0.45961D−02	0.19621D−02	−0.38342D+04	0.20281D+05	0.40568D+05	0.23716D−01	
		5.170	−0.45186D−02	0.45784D−02	0.19621D−02	−0.37875D+04	0.20251D+05	0.40516D+05	0.23670D−01	
		5.180	−0.44949D−02	0.45609D−02	0.19621D−02	−0.37412D+04	0.20222D+05	0.40464D+05	0.23625D−01	
		5.190	−0.44712D−02	0.45434D−02	0.19621D−02	−0.36950D+04	0.20193D+05	0.40412D+05	0.23580D−01	
		5.200	−0.44477D−02	0.45261D−02	0.19621D−02	−0.36491D+04	0.20164D+05	0.40361D+05	0.23536D−01	
3	2	5.200	−0.43117D−02	0.45261D−02	0.19621D−02	−0.36491D+04	0.88291D+05	0.55493D+04	0.23536D−01	0.19654D+05
		5.210	−0.42481D−02	0.45092D−02	0.19621D−02	−0.34729D+04	0.88042D+05	0.56322D+04	0.23493D−01	
		5.220	−0.41848D−02	0.44925D−02	0.19621D−02	−0.32978D+04	0.87796D+05	0.57146D+04	0.23451D−01	
		5.230	−0.41221D−02	0.44760D−02	0.19621D−02	−0.31239D+04	0.87553D+05	0.57965D+04	0.23409D−01	
		5.240	−0.40597D−02	0.44596D−02	0.19621D−02	−0.29510D+04	0.87314D+05	0.58779D+04	0.23368D−01	
		5.250	−0.39979D−02	0.44435D−02	0.19621D−02	−0.27793D+04	0.87077D+05	0.59589D+04	0.23328D−01	
		5.260	−0.39364D−02	0.44275D−02	0.19621D−02	−0.26087D+04	0.86843D+05	0.60394D+04	0.23289D−01	
		5.270	−0.38754D−02	0.44117D−02	0.19621D−02	−0.24392D+04	0.86612D+05	0.61194D+04	0.23249D−01	
		5.280	−0.38147D−02	0.43960D−02	0.19621D−02	−0.22708D+04	0.86384D+05	0.61990D+04	0.23211D−01	
		5.290	−0.37546D−02	0.43806D−02	0.19621D−02	−0.21034D+04	0.86159D+05	0.62781D+04	0.23173D−01	
		5.300	−0.36948D−02	0.43653D−02	0.19621D−02	−0.19371D+04	0.85937D+05	0.63568D+04	0.23136D−01	
4	3	5.300	−0.38222D−02	0.43653D−02	0.19621D−02	−0.19371D+04	0.20557D+05	0.40506D+05	0.23136D−01	0.13542D+06
		5.310	−0.38008D−02	0.43499D−02	0.19621D−02	−0.18947D+04	0.20532D+05	0.40462D+05	0.23098D−01	
		5.320	−0.37795D−02	0.43346D−02	0.19621D−02	−0.18526D+04	0.20508D+05	0.40417D+05	0.23060D−01	
		5.330	−0.37583D−02	0.43194D−02	0.19621D−02	−0.18107D+04	0.20483D+05	0.40373D+05	0.23022D−01	
		5.340	−0.37373D−02	0.43043D−02	0.19621D−02	−0.17689D+04	0.20459D+05	0.40329D+05	0.22985D−01	
		5.350	−0.37164D−02	0.42892D−02	0.19621D−02	−0.17274D+04	0.20435D+05	0.40286D+05	0.22947D−01	
		5.360	−0.36956D−02	0.42743D−02	0.19621D−02	−0.16861D+04	0.20411D+05	0.40243D+05	0.22910D−01	
		5.370	−0.36749D−02	0.42595D−02	0.19621D−02	−0.16450D+04	0.20387D+05	0.40200D+05	0.22874D−01	
		5.380	−0.36543D−02	0.42448D−02	0.19621D−02	−0.16040D+04	0.20364D+05	0.40157D+05	0.22837D−01	
		5.390	−0.36338D−02	0.42301D−02	0.19621D−02	−0.15633D+04	0.20340D+05	0.40115D+05	0.22800D−01	
		5.400	−0.36134D−02	0.42156D−02	0.19621D−02	−0.15228D+04	0.20317D+05	0.40073D+05	0.22764D−01	
5	4	5.400	−0.34941D−02	0.42156D−02	0.19621D−02	−0.15228D+04	0.83220D+05	0.64769D+04	0.22764D−01	0.23433D+05
		5.410	−0.34379D−02	0.42014D−02	0.19621D−02	−0.13663D+04	0.83014D+05	0.65510D+04	0.22730D−01	
		5.420	−0.33821D−02	0.41874D−02	0.19621D−02	−0.12108D+04	0.82812D+05	0.66248D+04	0.22695D−01	
		5.430	−0.33267D−02	0.41735D−02	0.19621D−02	−0.10563D+04	0.82611D+05	0.66981D+04	0.22662D−01	
		5.440	−0.32717D−02	0.41597D−02	0.19621D−02	−0.90264D+03	0.82414D+05	0.67710D+04	0.22629D−01	
		5.450	−0.32170D−02	0.41461D−02	0.19621D−02	−0.74995D+03	0.82219D+05	0.68436D+04	0.22596D−01	
		5.460	−0.31627D−02	0.41327D−02	0.19621D−02	−0.59817D+03	0.82026D+05	0.69157D+04	0.22565D−01	
		5.470	−0.31088D−02	0.41194D−02	0.19621D−02	−0.44729D+03	0.81836D+05	0.69875D+04	0.22533D−01	
		5.480	−0.30552D−02	0.41063D−02	0.19621D−02	−0.29731D+03	0.81648D+05	0.70589D+04	0.22502D−01	
		5.490	−0.30019D−02	0.40933D−02	0.19621D−02	−0.14822D+03	0.81463D+05	0.71299D+04	0.22472D−01	
		5.500	−0.29490D−02	0.40804D−02	0.19621D−02	0.82764D−10	0.81280D+05	0.72005D+04	0.22442D−01	

@ 0 psi after auto

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.12851D−02	0.32750D−03	0.14505D−03	−0.16753D−08	−0.13545D+05	−0.67701D+04	0.16375D−02	−0.21482D+05
		5.010	−0.12819D−02	0.32428D−03	0.14505D−03	−0.27008D+02	−0.13518D+05	−0.67701D+04	0.16247D−02	
		5.020	−0.12787D−02	0.32109D−03	0.14505D−03	−0.53856D+02	−0.13491D+05	−0.67701D+04	0.16119D−02	
		5.030	−0.12756D−02	0.31791D−03	0.14505D−03	−0.80543D+02	−0.13464D+05	−0.67701D+04	0.15991D−02	
		5.040	−0.12724D−02	0.31475D−03	0.14505D−03	−0.10707D+03	−0.13438D+05	−0.67701D+04	0.15863D−02	

		5.050	−0.12693D−02	0.31161D−03	0.14505D−03	−0.13344D+03	−0.13411D+05	−0.67701D+04	0.15736D−02	
		5.060	−0.12661D−02	0.30849D−03	0.14505D−03	−0.15966D+03	−0.13385D+05	−0.67701D+04	0.15610D−02	
		5.070	−0.12630D−02	0.30539D−03	0.14505D−03	−0.18572D+03	−0.13359D+05	−0.67701D+04	0.15483D−02	
		5.080	−0.12599D−02	0.30230D−03	0.14505D−03	−0.21162D+03	−0.13333D+05	−0.67701D+04	0.15357D−02	
		5.090	−0.12569D−02	0.29924D−03	0.14505D−03	−0.23738D+03	−0.13307D+05	−0.67701D+04	0.15231D−02	
		5.100	−0.12538D−02	0.29619D−03	0.14505D−03	−0.26298D+03	−0.13282D+05	−0.67701D+04	0.15106D−02	
2	1	5.100	−0.30675D−03	0.29619D−03	0.14505D−03	−0.26298D+03	0.13775D+04	0.28244D+04	0.15106D−02	0.90847D+04
		5.110	−0.30512D−03	0.29501D−03	0.14505D−03	−0.25977D+03	0.13756D+04	0.28210D+04	0.15075D−02	
		5.120	−0.30351D−03	0.29384D−03	0.14505D−03	−0.25658D+03	0.13737D+04	0.28176D+04	0.15045D−02	
		5.130	−0.30190D−03	0.29268D−03	0.14505D−03	−0.25340D+03	0.13718D+04	0.28142D+04	0.15014D−02	
		5.140	−0.30030D−03	0.29152D−03	0.14505D−03	−0.25024D+03	0.13699D+04	0.28108D+04	0.14984D−02	
		5.150	−0.29871D−03	0.29037D−03	0.14505D−03	−0.24710D+03	0.13680D+04	0.28075D+04	0.14954D−02	
		5.160	−0.29713D−03	0.28923D−03	0.14505D−03	−0.24397D+03	0.13662D+04	0.28042D+04	0.14924D−02	
		5.170	−0.29556D−03	0.28810D−03	0.14505D−03	−0.24086D+03	0.13644D+04	0.28009D+04	0.14895D−02	
		5.180	−0.29399D−03	0.28698D−03	0.14505D−03	−0.23776D+03	0.13626D+04	0.27976D+04	0.14865D−02	
		5.190	−0.29244D−03	0.28586D−03	0.14505D−03	−0.23468D+03	0.13608D+04	0.27944D+04	0.14836D−02	
		5.200	−0.29089D−03	0.28475D−03	0.14505D−03	−0.23161D+03	0.13590D+04	0.27911D+04	0.14807D−02	
3	2	5.200	−0.28348D−03	0.28475D−03	0.14505D−03	−0.23161D+03	0.55684D+04	0.39668D+03	0.14807D−02	0.13934D+04
		5.210	−0.27945D−03	0.28366D−03	0.14505D−03	−0.22050D+03	0.55523D+04	0.40190D+03	0.14779D−02	
		5.220	−0.27546D−03	0.28259D−03	0.14505D−03	−0.20945D+03	0.55363D+04	0.40708D+03	0.14751D−02	
		5.230	−0.27149D−03	0.28152D−03	0.14505D−03	−0.19848D+03	0.55206D+04	0.41223D+03	0.14724D−02	
		5.240	−0.26755D−03	0.28047D−03	0.14505D−03	−0.18758D+03	0.55051D+04	0.41735D+03	0.14697D−02	
		5.250	−0.26364D−03	0.27943D−03	0.14505D−03	−0.17675D+03	0.54898D+04	0.42245D+03	0.14670D−02	
		5.260	−0.25975D−03	0.27840D−03	0.14505D−03	−0.16599D+03	0.54746D+04	0.42751D+03	0.14644D−02	
		5.270	−0.25589D−03	0.27739D−03	0.14505D−03	−0.15531D+03	0.54596D+04	0.43254D+03	0.14618D−02	
		5.280	−0.25206D−03	0.27638D−03	0.14505D−03	−0.14469D+03	0.54449D+04	0.43754D+03	0.14593D−02	
		5.290	−0.24826D−03	0.27538D−03	0.14505D−03	−0.13413D+03	0.54303D+04	0.44252D+03	0.14568D−02	
		5.300	−0.24448D−03	0.27440D−03	0.14505D−03	−0.12365D+03	0.54159D+04	0.44746D+03	0.14543D−02	
4	3	5.300	−0.25134D−03	0.27440D−03	0.14505D−03	−0.12365D+03	0.13831D+04	0.27995D+04	0.14543D−02	0.93640D+04
		5.310	−0.24993D−03	0.27341D−03	0.14505D−03	−0.12081D+03	0.13816D+04	0.27967D+04	0.14518D−02	
		5.320	−0.24852D−03	0.27243D−03	0.14505D−03	−0.11799D+03	0.13801D+04	0.27939D+04	0.14493D−02	
		5.330	−0.24713D−03	0.27145D−03	0.14505D−03	−0.11518D+03	0.13785D+04	0.27911D+04	0.14468D−02	
		5.340	−0.24574D−03	0.27048D−03	0.14505D−03	−0.11238D+03	0.13770D+04	0.27883D+04	0.14444D−02	
		5.350	−0.24436D−03	0.26952D−03	0.14505D−03	−0.10960D+03	0.13756D+04	0.27856D+04	0.14419D−02	
		5.360	−0.24299D−03	0.26856D−03	0.14505D−03	−0.10683D+03	0.13741D+04	0.27829D+04	0.14395D−02	
		5.370	−0.24162D−03	0.26761D−03	0.14505D−03	−0.10408D+03	0.13726D+04	0.27802D+04	0.14371D−02	
		5.380	−0.24026D−03	0.26666D−03	0.14505D−03	−0.10133D+03	0.13712D+04	0.27775D+04	0.14347D−02	
		5.390	−0.23891D−03	0.26572D−03	0.14505D−03	−0.98601D+02	0.13697D+04	0.27749D+04	0.14323D−02	
		5.400	−0.23757D−03	0.26479D−03	0.14505D−03	−0.95884D+02	0.13683D+04	0.27722D+04	0.14299D−02	
5	4	5.400	−0.23123D−03	0.26479D−03	0.14505D−03	−0.95884D+02	0.52420D+04	0.45580D+03	0.14299D−02	0.16395D+04
		5.410	−0.22768D−03	0.26388D−03	0.14505D−03	−0.86029D+02	0.52287D+04	0.46045D+03	0.14276D−02	
		5.420	−0.22416D−03	0.26297D−03	0.14505D−03	−0.76236D+02	0.52155D+04	0.46508D+03	0.14253D−02	
		5.430	−0.22066D−03	0.26208D−03	0.14505D−03	−0.66502D+02	0.52025D+04	0.46969D+03	0.14231D−02	
		5.440	−0.21719D−03	0.26120D−03	0.14505D−03	−0.56828D+02	0.51897D+04	0.47427D+03	0.14209D−02	
		5.450	−0.21374D−03	0.26032D−03	0.14505D−03	−0.47213D+02	0.51771D+04	0.47882D+03	0.14188D−02	
		5.460	−0.21031D−03	0.25946D−03	0.14505D−03	−0.37657D+02	0.51646D+04	0.48335D+03	0.14166D−02	
		5.470	−0.20690D−03	0.25860D−03	0.14505D−03	−0.28157D+02	0.51522D+04	0.48786D+03	0.14145D−02	
		5.480	−0.20352D−03	0.25775D−03	0.14505D−03	−0.18715D+02	0.51400D+04	0.49234D+03	0.14125D−02	
		5.490	−0.20016D−03	0.25692D−03	0.14505D−03	−0.93297D+01	0.51280D+04	0.49680D+03	0.14105D−02	
		5.500	−0.19682D−03	0.25609D−03	0.14505D−03	−0.11141D−09	0.51161D+04	0.50123D+03	0.14085D−02	

@ 1000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.19058D−02	0.12389D−02	0.50847D−03	−0.10000D+04	−0.27600D+04	−0.20051D+03	0.61945D−02	−0.63621D+03
		5.010	−0.18995D−02	0.12326D−02	0.50847D−03	−0.10035D+04	−0.27564D+04	−0.20051D+03	0.61754D−02	
		5.020	−0.18933D−02	0.12264D−02	0.50847D−03	−0.10070D+04	−0.27530D+04	−0.20051D+03	0.61565D−02	
		5.030	−0.18871D−02	0.12202D−02	0.50847D−03	−0.10105D+04	−0.27495D+04	−0.20051D+03	0.61376D−02	
		5.040	−0.18809D−02	0.12140D−02	0.50847D−03	−0.10139D+04	−0.27460D+04	−0.20051D+03	0.61187D−02	
		5.050	−0.18748D−02	0.12079D−02	0.50847D−03	−0.10173D+04	−0.27426D+04	−0.20051D+03	0.61000D−02	
		5.060	−0.18687D−02	0.12018D−02	0.50847D−03	−0.10207D+04	−0.27392D+04	−0.20051D+03	0.60812D−02	
		5.070	−0.18627D−02	0.11958D−02	0.50847D−03	−0.10241D+04	−0.27358D+04	−0.20051D+03	0.60626D−02	
		5.080	−0.18566D−02	0.11898D−02	0.50847D−03	−0.10275D+04	−0.27325D+04	−0.20051D+03	0.60440D−02	
		5.090	−0.18507D−02	0.11838D−02	0.50847D−03	−0.10308D+04	−0.27291D+04	−0.20051D+03	0.60254D−02	
		5.100	−0.18447D−02	0.11778D−02	0.50847D−03	−0.10342D+04	−0.27258D+04	−0.20051D+03	0.60070D−02	
2	1	5.100	−0.11832D−02	0.11778D−02	0.50847D−03	−0.10342D+04	0.51945D+04	0.10437D+05	0.60070D−02	0.33556D+05
		5.110	−0.11769D−02	0.11732D−02	0.50847D−03	−0.10220D+04	0.51868D+04	0.10424D+05	0.59952D−02	
		5.120	−0.11707D−02	0.11686D−02	0.50847D−03	−0.10099D+04	0.51792D+04	0.10410D+05	0.59834D−02	
		5.130	−0.11645D−02	0.11641D−02	0.50847D−03	−0.99781D+03	0.51716D+04	0.10397D+05	0.59718D−02	
		5.140	−0.11584D−02	0.11596D−02	0.50847D−03	−0.98582D+03	0.51640D+04	0.10383D+05	0.59601D−02	
		5.150	−0.11523D−02	0.11551D−02	0.50847D−03	−0.97388D+03	0.51566D+04	0.10370D+05	0.59486D−02	
		5.160	−0.11462D−02	0.11506D−02	0.50847D−03	−0.96201D+03	0.51492D+04	0.10357D+05	0.59371D−02	
		5.170	−0.11402D−02	0.11462D−02	0.50847D−03	−0.95020D+03	0.51418D+04	0.10344D+05	0.59257D−02	
		5.180	−0.11342D−02	0.11418D−02	0.50847D−03	−0.93844D+03	0.51345D+04	0.10331D+05	0.59143D−02	
		5.190	−0.11282D−02	0.11374D−02	0.50847D−03	−0.92675D+03	0.51273D+04	0.10318D+05	0.59030D−02	
		5.200	−0.11223D−02	0.11330D−02	0.50847D−03	−0.91511D+03	0.51201D+04	0.10305D+05	0.58917D−02	
3	2	5.200	−0.10891D−02	0.11330D−02	0.50847D−03	−0.91511D+03	0.22113D+05	0.14272D+04	0.58917D−02	0.50455D+04
		5.210	−0.10732D−02	0.11288D−02	0.50847D−03	−0.87097D+03	0.22050D+05	0.14480D+04	0.58809D−02	
		5.220	−0.10573D−02	0.11246D−02	0.50847D−03	−0.82712D+03	0.21988D+05	0.14686D+04	0.58703D−02	
		5.230	−0.10416D−02	0.11204D−02	0.50847D−03	−0.78356D+03	0.21927D+05	0.14891D+04	0.58598D−02	
		5.240	−0.10260D−02	0.11163D−02	0.50847D−03	−0.74027D+03	0.21867D+05	0.15095D+04	0.58494D−02	
		5.250	−0.10105D−02	0.11122D−02	0.50847D−03	−0.69727D+03	0.21807D+05	0.15297D+04	0.58392D−02	
		5.260	−0.99508D−03	0.11082D−02	0.50847D−03	−0.65454D+03	0.21748D+05	0.15499D+04	0.58292D−02	
		5.270	−0.97979D−03	0.11042D−02	0.50847D−03	−0.61209D+03	0.21690D+05	0.15699D+04	0.58193D−02	
		5.280	−0.96460D−03	0.11003D−02	0.50847D−03	−0.56990D+03	0.21633D+05	0.15898D+04	0.58096D−02	
		5.290	−0.94952D−03	0.10964D−02	0.50847D−03	−0.52799D+03	0.21576D+05	0.16096D+04	0.58001D−02	
		5.300	−0.93454D−03	0.10926D−02	0.50847D−03	−0.48633D+03	0.21520D+05	0.16293D+04	0.57906D−02	
4	3	5.300	−0.96550D−03	0.10926D−02	0.50847D−03	−0.48633D+03	0.52179D+04	0.10341D+05	0.57906D−02	0.34576D+05
		5.310	−0.96010D−03	0.10887D−02	0.50847D−03	−0.47560D+03	0.52117D+04	0.10330D+05	0.57810D−02	
		5.320	−0.95472D−03	0.10849D−02	0.50847D−03	−0.46491D+03	0.52056D+04	0.10319D+05	0.57714D−02	
		5.330	−0.94937D−03	0.10810D−02	0.50847D−03	−0.45428D+03	0.51995D+04	0.10308D+05	0.57619D−02	
		5.340	−0.94405D−03	0.10772D−02	0.50847D−03	−0.44370D+03	0.51935D+04	0.10297D+05	0.57524D−02	
		5.350	−0.93877D−03	0.10735D−02	0.50847D−03	−0.43316D+03	0.51874D+04	0.10286D+05	0.57430D−02	
		5.360	−0.93350D−03	0.10697D−02	0.50847D−03	−0.42268D+03	0.51815D+04	0.10275D+05	0.57337D−02	
		5.370	−0.92827D−03	0.10660D−02	0.50847D−03	−0.41225D+03	0.51756D+04	0.10264D+05	0.57244D−02	

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
		5.380	−0.92307D−03	0.10623D−02	0.50847D−03	−0.40187D+03	0.51697D+04	0.10253D+05	0.57151D−02	
		5.390	−0.91789D−03	0.10586D−02	0.50847D−03	−0.39154D+03	0.51639D+04	0.10243D+05	0.57059D−02	
		5.400	−0.91274D−03	0.10550D−02	0.50847D−03	−0.38126D+03	0.51581D+04	0.10232D+05	0.56967D−02	
5	4	5.400	−0.88379D−03	0.10550D−02	0.50847D−03	−0.38126D+03	0.20838D+05	0.16600D+04	0.56967D−02	0.59982D+04
		5.410	−0.86973D−03	0.10514D−02	0.50847D−03	−0.34209D+03	0.20786D+05	0.16786D+04	0.56880D−02	
		5.420	−0.85576D−03	0.10479D−02	0.50847D−03	−0.30315D+03	0.20735D+05	0.16970D+04	0.56794D−02	
		5.430	−0.84188D−03	0.10444D−02	0.50847D−03	−0.26445D+03	0.20684D+05	0.17154D+04	0.56709D−02	
		5.440	−0.82809D−03	0.10409D−02	0.50847D−03	−0.22599D+03	0.20635D+05	0.17336D+04	0.56625D−02	
		5.450	−0.81440D−03	0.10375D−02	0.50847D−03	−0.18776D+03	0.20585D+05	0.17518D+04	0.56543D−02	
		5.460	−0.80079D−03	0.10341D−02	0.50847D−03	−0.14976D+03	0.20537D+05	0.17698D+04	0.56462D−02	
		5.470	−0.78728D−03	0.10308D−02	0.50847D−03	−0.11198D+03	0.20489D+05	0.17878D+04	0.56383D−02	
		5.480	−0.77385D−03	0.10275D−02	0.50847D−03	−0.74434D+02	0.20442D+05	0.18056D+04	0.56305D−02	
		5.490	−0.76051D−03	0.10242D−02	0.50847D−03	−0.37107D+02	0.20395D+05	0.18234D+04	0.56228D−02	
		5.500	−0.74725D−03	0.10210D−02	0.50847D−03	−0.92541D−10	0.20349D+05	0.18411D+04	0.56153D−02	

@ 3000 psi (wkg)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.31470D−02	0.30617D−02	0.12353D−02	−0.30000D+04	0.18810D+05	0.12939D+05	0.15308D−01	0.41055D+05
		5.010	−0.31347D−02	0.30493D−02	0.12353D−02	−0.29565D+04	0.18766D+05	0.12939D+05	0.15277D−01	
		5.020	−0.31224D−02	0.30370D−02	0.12353D−02	−0.29133D+04	0.18723D+05	0.12939D+05	0.15246D−01	
		5.030	−0.31101D−02	0.30248D−02	0.12353D−02	−0.28703D+04	0.18680D+05	0.12939D+05	0.15215D−01	
		5.040	−0.30980D−02	0.30126D−02	0.12353D−02	−0.28276D+04	0.18637D+05	0.12939D+05	0.15184D−01	
		5.050	−0.30859D−02	0.30005D−02	0.12353D−02	−0.27851D+04	0.18595D+05	0.12939D+05	0.15153D−01	
		5.060	−0.30739D−02	0.29885D−02	0.12353D−02	−0.27429D+04	0.18553D+05	0.12939D+05	0.15122D−01	
		5.070	−0.30619D−02	0.29765D−02	0.12353D−02	−0.27010D+04	0.18511D+05	0.12939D+05	0.15091D−01	
		5.080	−0.30500D−02	0.29647D−02	0.12353D−02	−0.26592D+04	0.18469D+05	0.12939D+05	0.15061D−01	
		5.090	−0.30382D−02	0.29529D−02	0.12353D−02	−0.26178D+04	0.18427D+05	0.12939D+05	0.15030D−01	
		5.100	−0.30265D−02	0.29411D−02	0.12353D−02	−0.25766D+04	0.18386D+05	0.12939D+05	0.15000D−01	
2	1	5.100	−0.29360D−02	0.29411D−02	0.12353D−02	−0.25766D+04	0.12829D+05	0.25663D+05	0.15000D−01	0.82500D+05
		5.110	−0.29205D−02	0.29296D−02	0.12353D−02	−0.25464D+04	0.12809D+05	0.25629D+05	0.14971D−01	
		5.120	−0.29051D−02	0.29182D−02	0.12353D−02	−0.25165D+04	0.12790D+05	0.25595D+05	0.14941D−01	
		5.130	−0.28898D−02	0.29069D−02	0.12353D−02	−0.24866D+04	0.12771D+05	0.25562D+05	0.14912D−01	
		5.140	−0.28746D−02	0.28956D−02	0.12353D−02	−0.24570D+04	0.12752D+05	0.25528D+05	0.14884D−01	
		5.150	−0.28594D−02	0.28844D−02	0.12353D−02	−0.24275D+04	0.12734D+05	0.25495D+05	0.14855D−01	
		5.160	−0.28444D−02	0.28733D−02	0.12353D−02	−0.23981D+04	0.12715D+05	0.25462D+05	0.14826D−01	
		5.170	−0.28294D−02	0.28623D−02	0.12353D−02	−0.23689D+04	0.12697D+05	0.25430D+05	0.14798D−01	
		5.180	−0.28145D−02	0.28513D−02	0.12353D−02	−0.23398D+04	0.12678D+05	0.25397D+05	0.14770D−01	
		5.190	−0.27997D−02	0.28404D−02	0.12353D−02	−0.23109D+04	0.12660D+05	0.25365D+05	0.14742D−01	
		5.200	−0.27850D−02	0.28296D−02	0.12353D−02	−0.22821D+04	0.12642D+05	0.25333D+05	0.14714D−01	
3	2	5.200	−0.27004D−02	0.28296D−02	0.12353D−02	−0.22821D+04	0.55202D+05	0.34883D+04	0.14714D−01	0.12350D+05
		5.210	−0.26606D−02	0.28190D−02	0.12353D−02	−0.21719D+04	0.55046D+05	0.35401D+04	0.14687D−01	
		5.220	−0.26211D−02	0.28085D−02	0.12353D−02	−0.20625D+04	0.54892D+05	0.35916D+04	0.14661D−01	
		5.230	−0.25818D−02	0.27982D−02	0.12353D−02	−0.19537D+04	0.54740D+05	0.36428D+04	0.14635D−01	
		5.240	−0.25429D−02	0.27880D−02	0.12353D−02	−0.18457D+04	0.54590D+05	0.36937D+04	0.14609D−01	
		5.250	−0.25042D−02	0.27779D−02	0.12353D−02	−0.17383D+04	0.54442D+05	0.37443D+04	0.14584D−01	
		5.260	−0.24657D−02	0.27678D−02	0.12353D−02	−0.16316D+04	0.54296D+05	0.37946D+04	0.14559D−01	
		5.270	−0.24276D−02	0.27580D−02	0.12353D−02	−0.15256D+04	0.54151D+05	0.38447D+04	0.14534D−01	
		5.280	−0.23897D−02	0.27482D−02	0.12353D−02	−0.14203D+04	0.54008D+05	0.38944D+04	0.14510D−01	
		5.290	−0.23520D−02	0.27385D−02	0.12353D−02	−0.13157D+04	0.53868D+05	0.39439D+04	0.14487D−01	
		5.300	−0.23147D−02	0.27289D−02	0.12353D−02	−0.12117D+04	0.53729D+05	0.39931D+04	0.14463D−01	
4	3	5.300	−0.23938D−02	0.27289D−02	0.12353D−02	−0.12117D+04	0.12888D+05	0.25424D+05	0.14463D−01	0.85000D+05
		5.310	−0.23804D−02	0.27193D−02	0.12353D−02	−0.11852D+04	0.12872D+05	0.25396D+05	0.14439D−01	
		5.320	−0.23671D−02	0.27097D−02	0.12353D−02	−0.11588D+04	0.12857D+05	0.25368D+05	0.14416D−01	
		5.330	−0.23539D−02	0.27002D−02	0.12353D−02	−0.11325D+04	0.12841D+05	0.25340D+05	0.14392D−01	
		5.340	−0.23407D−02	0.26907D−02	0.12353D−02	−0.11063D+04	0.12826D+05	0.25313D+05	0.14369D−01	
		5.350	−0.23276D−02	0.26814D−02	0.12353D−02	−0.10803D+04	0.12811D+05	0.25286D+05	0.14345D−01	
		5.360	−0.23145D−02	0.26720D−02	0.12353D−02	−0.10544D+04	0.12796D+05	0.25259D+05	0.14322D−01	
		5.370	−0.23016D−02	0.26627D−02	0.12353D−02	−0.10286D+04	0.12781D+05	0.25232D+05	0.14299D−01	
		5.380	−0.22887D−02	0.26535D−02	0.12353D−02	−0.10030D+04	0.12767D+05	0.25205D+05	0.14276D−01	
		5.390	−0.22758D−02	0.26444D−02	0.12353D−02	−0.97742D+03	0.12752D+05	0.25179D+05	0.14253D−01	
		5.400	−0.22631D−02	0.26353D−02	0.12353D−02	−0.95201D+03	0.12738D+05	0.25153D+05	0.14230D−01	
5	4	5.400	−0.21889D−02	0.26353D−02	0.12353D−02	−0.95201D+03	0.52029D+05	0.40685D+04	0.14230D−01	0.14716D+05
		5.410	−0.21538D−02	0.26264D−02	0.12353D−02	−0.85420D+03	0.51900D+05	0.41148D+04	0.14209D−01	
		5.420	−0.21190D−02	0.26176D−02	0.12353D−02	−0.75698D+03	0.51773D+05	0.41609D+04	0.14187D−01	
		5.430	−0.20843D−02	0.26089D−02	0.12353D−02	−0.66036D+03	0.51648D+05	0.42067D+04	0.14166D−01	
		5.440	−0.20499D−02	0.26003D−02	0.12353D−02	−0.56432D+03	0.51524D+05	0.42523D+04	0.14146D−01	
		5.450	−0.20157D−02	0.25918D−02	0.12353D−02	−0.46885D+03	0.51402D+05	0.42977D+04	0.14125D−01	
		5.460	−0.19818D−02	0.25834D−02	0.12353D−02	−0.37396D+03	0.51281D+05	0.43428D+04	0.14105D−01	
		5.470	−0.19480D−02	0.25751D−02	0.12353D−02	−0.27964D+03	0.51162D+05	0.43876D+04	0.14086D−01	
		5.480	−0.19145D−02	0.25669D−02	0.12353D−02	−0.18587D+03	0.51045D+05	0.44323D+04	0.14066D−01	
		5.490	−0.18812D−02	0.25587D−02	0.12353D−02	−0.92662D+02	0.50929D+05	0.44766D+04	0.14047D−01	
		5.500	−0.18481D−02	0.25507D−02	0.12353D−02	−0.52751D−10	0.50814D+05	0.45208D+04	0.14029D−01	

@ 4500 psi (test)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.40780D−02	0.44288D−02	0.17804D−02	−0.45000D+04	0.34987D+05	0.22793D+05	0.22144D−01	0.72323D+05
		5.010	−0.40610D−02	0.44118D−02	0.17804D−02	−0.44213D+04	0.34908D+05	0.22793D+05	0.22103D−01	
		5.020	−0.40442D−02	0.43949D−02	0.17804D−02	−0.43430D+04	0.34830D+05	0.22793D+05	0.22063D−01	
		5.030	−0.40274D−02	0.43782D−02	0.17804D−02	−0.42652D+04	0.34752D+05	0.22793D+05	0.22022D−01	
		5.040	−0.40107D−02	0.43615D−02	0.17804D−02	−0.41879D+04	0.34675D+05	0.22793D+05	0.21982D−01	
		5.050	−0.39942D−02	0.43450D−02	0.17804D−02	−0.41110D+04	0.34598D+05	0.22793D+05	0.21942D−01	
		5.060	−0.39777D−02	0.43285D−02	0.17804D−02	−0.40346D+04	0.34521D+05	0.22793D+05	0.21902D−01	
		5.070	−0.39614D−02	0.43121D−02	0.17804D−02	−0.39586D+04	0.34445D+05	0.22793D+05	0.21863D−01	
		5.080	−0.39451D−02	0.42959D−02	0.17804D−02	−0.38831D+04	0.34370D+05	0.22793D+05	0.21823D−01	
		5.090	−0.39289D−02	0.42797D−02	0.17804D−02	−0.38080D+04	0.34295D+05	0.22793D+05	0.21784D−01	
		5.100	−0.39128D−02	0.42636D−02	0.17804D−02	−0.37333D+04	0.34220D+05	0.22793D+05	0.21744D−01	
2	1	5.100	−0.42506D−02	0.42636D−02	0.17804D−02	−0.37333D+04	0.18554D+05	0.37082D+05	0.21744D−01	0.11921D+06
		5.110	−0.42282D−02	0.42470D−02	0.17804D−02	−0.36897D+04	0.18526D+05	0.37033D+05	0.21702D−01	
		5.120	−0.42059D−02	0.42304D−02	0.17804D−02	−0.36464D+04	0.18498D+05	0.36984D+05	0.21660D−01	
		5.130	−0.41837D−02	0.42140D−02	0.17804D−02	−0.36032D+04	0.18471D+05	0.36935D+05	0.21618D−01	
		5.140	−0.41617D−02	0.41977D−02	0.17804D−02	−0.35603D+04	0.18444D+05	0.36887D+05	0.21576D−01	
		5.150	−0.41398D−02	0.41815D−02	0.17804D−02	−0.35176D+04	0.18416D+05	0.36839D+05	0.21535D−01	
		5.160	−0.41180D−02	0.41654D−02	0.17804D−02	−0.34751D+04	0.18389D+05	0.36791D+05	0.21493D−01	

		5.170	−0.40963D−02	0.41494D−02	0.17804D−02	−0.34329D+04	0.18363D+05	0.36744D+05	0.21452D−01	
		5.180	−0.40748D−02	0.41335D−02	0.17804D−02	−0.33908D+04	0.18336D+05	0.36697D+05	0.21411D−01	
		5.190	−0.40533D−02	0.41177D−02	0.17804D−02	−0.33490D+04	0.18310D+05	0.36650D+05	0.21371D−01	
		5.200	−0.40320D−02	0.41020D−02	0.17804D−02	−0.33074D+04	0.18284D+05	0.36604D+05	0.21330D−01	
3	2	5.200	−0.39089D−02	0.41020D−02	0.17804D−02	−0.33074D+04	0.80019D+05	0.50341D+04	0.21330D−01	0.17828D+05
		5.210	−0.38512D−02	0.40867D−02	0.17804D−02	−0.31476D+04	0.79793D+05	0.51092D+04	0.21292D−01	
		5.220	−0.37939D−02	0.40715D−02	0.17804D−02	−0.29890D+04	0.79570D+05	0.51839D+04	0.21253D−01	
		5.230	−0.37370D−02	0.40565D−02	0.17804D−02	−0.28313D+04	0.79350D+05	0.52581D+04	0.21216D−01	
		5.240	−0.36805D−02	0.40417D−02	0.17804D−02	−0.26747D+04	0.79133D+05	0.53319D+04	0.21179D−01	
		5.250	−0.36244D−02	0.40271D−02	0.17804D−02	−0.25191D+04	0.78918D+05	0.54053D+04	0.21142D−01	
		5.260	−0.35687D−02	0.40126D−02	0.17804D−02	−0.23645D+04	0.78706D+05	0.54782D+04	0.21106D−01	
		5.270	−0.35134D−02	0.39982D−02	0.17804D−02	−0.22108D+04	0.78497D+05	0.55507D+04	0.21071D−01	
		5.280	−0.34585D−02	0.39841D−02	0.17804D−02	−0.20582D+04	0.78290D+05	0.56228D+04	0.21036D−01	
		5.290	−0.34039D−02	0.39700D−02	0.17804D−02	−0.19065D+04	0.78086D+05	0.56945D+04	0.21002D−01	
		5.300	−0.33497D−02	0.39562D−02	0.17804D−02	−0.17557D+04	0.77885D+05	0.57658D+04	0.20968D−01	
4	3	5.300	−0.34651D−02	0.39562D−02	0.17804D−02	−0.17557D+04	0.18640D+05	0.36736D+05	0.20968D−01	0.12282D+06
		5.310	−0.34457D−02	0.39422D−02	0.17804D−02	−0.17173D+04	0.18617D+05	0.36695D+05	0.20933D−01	
		5.320	−0.34264D−02	0.39284D−02	0.17804D−02	−0.16791D+04	0.18595D+05	0.36655D+05	0.20899D−01	
		5.330	−0.34072D−02	0.39146D−02	0.17804D−02	−0.16411D+04	0.18573D+05	0.36615D+05	0.20865D−01	
		5.340	−0.33882D−02	0.39009D−02	0.17804D−02	−0.16033D+04	0.18551D+05	0.36575D+05	0.20831D−01	
		5.350	−0.33692D−02	0.38873D−02	0.17804D−02	−0.15656D+04	0.18529D+05	0.36536D+05	0.20797D−01	
		5.360	−0.33503D−02	0.38738D−02	0.17804D−02	−0.15282D+04	0.18507D+05	0.36497D+05	0.20763D−01	
		5.370	−0.33315D−02	0.38603D−02	0.17804D−02	−0.14909D+04	0.18486D+05	0.36458D+05	0.20730D−01	
		5.380	−0.33129D−02	0.38470D−02	0.17804D−02	−0.14538D+04	0.18465D+05	0.36419D+05	0.20697D−01	
		5.390	−0.32943D−02	0.38337D−02	0.17804D−02	−0.14168D+04	0.18443D+05	0.36381D+05	0.20664D−01	
		5.400	−0.32758D−02	0.38205D−02	0.17804D−02	−0.13801D+04	0.18422D+05	0.36343D+05	0.20631D−01	
5	4	5.400	−0.31678D−02	0.38205D−02	0.17804D−02	−0.13801D+04	0.75422D+05	0.58748D+04	0.20631D−01	0.21254D+05
		5.410	−0.31169D−02	0.38076D−02	0.17804D−02	−0.12383D+04	0.75236D+05	0.59420D+04	0.20599D−01	
		5.420	−0.30663D−02	0.37949D−02	0.17804D−02	−0.10974D+04	0.75052D+05	0.60088D+04	0.20568D−01	
		5.430	−0.30161D−02	0.37823D−02	0.17804D−02	−0.95728D+03	0.74870D+05	0.60753D+04	0.20538D−01	
		5.440	−0.29663D−02	0.37699D−02	0.17804D−02	−0.81806D+03	0.74691D+05	0.61413D+04	0.20508D−01	
		5.450	−0.29167D−02	0.37576D−02	0.17804D−02	−0.67967D+03	0.74514D+05	0.62071D+04	0.20479D−01	
		5.460	−0.28675D−02	0.37454D−02	0.17804D−02	−0.54212D+03	0.74340D+05	0.62725D+04	0.20450D−01	
		5.470	−0.28186D−02	0.37333D−02	0.17804D−02	−0.40538D+03	0.74167D+05	0.63375D+04	0.20421D−01	
		5.480	−0.27700D−02	0.37214D−02	0.17804D−02	−0.26945D+03	0.73997D+05	0.64022D+04	0.20393D−01	
		5.490	−0.27217D−02	0.37096D−02	0.17804D−02	−0.13433D+03	0.73829D+05	0.64666D+04	0.20366D−01	
		5.500	−0.26738D−02	0.36980D−02	0.17804D−02	0.93223D−10	0.73664D+05	0.65306D+04	0.20339D−01	

@ 5000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.33658D−02	0.50232D−02	0.22760D−02	−0.50000D+04	0.33581D+05	0.20627D+05	0.25116D−01	0.65450D+05
		5.010	−0.33491D−02	0.50065D−02	0.22760D−02	−0.49231D+04	0.33504D+05	0.20627D+05	0.25082D−01	
		5.020	−0.33325D−02	0.49898D−02	0.22760D−02	−0.48466D+04	0.33428D+05	0.20627D+05	0.25049D−01	
		5.030	−0.33160D−02	0.49733D−02	0.22760D−02	−0.47706D+04	0.33352D+05	0.20627D+05	0.25016D−01	
		5.040	−0.32995D−02	0.49569D−02	0.22760D−02	−0.46950D+04	0.33276D+05	0.20627D+05	0.24983D−01	
		5.050	−0.32832D−02	0.49406D−02	0.22760D−02	−0.46199D+04	0.33201D+05	0.20627D+05	0.24950D−01	
		5.060	−0.32670D−02	0.49243D−02	0.22760D−02	−0.45452D+04	0.33127D+05	0.20627D+05	0.24917D−01	
		5.070	−0.32508D−02	0.49082D−02	0.22760D−02	−0.44710D+04	0.33052D+05	0.20627D+05	0.24884D−01	
		5.080	−0.32348D−02	0.48921D−02	0.22760D−02	−0.43972D+04	0.32979D+05	0.20627D+05	0.24852D−01	
		5.090	−0.32188D−02	0.48762D−02	0.22760D−02	−0.43238D+04	0.32905D+05	0.20627D+05	0.24820D−01	
		5.100	−0.32030D−02	0.48603D−02	0.22760D−02	−0.42509D+04	0.32832D+05	0.20627D+05	0.24788D−01	
2	1	5.100	−0.34224D−02	0.48603D−02	0.22760D−02	−0.42509D+04	0.20284D+05	0.43935D+05	0.24788D−01	0.14145D+06
		5.110	−0.33989D−02	0.48441D−02	0.22760D−02	−0.42029D+04	0.20259D+05	0.43890D+05	0.24754D−01	
		5.120	−0.33754D−02	0.48281D−02	0.22760D−02	−0.41552D+04	0.20235D+05	0.43845D+05	0.24720D−01	
		5.130	−0.33521D−02	0.48121D−02	0.22760D−02	−0.41077D+04	0.20211D+05	0.43800D+05	0.24686D−01	
		5.140	−0.33289D−02	0.47962D−02	0.22760D−02	−0.40604D+04	0.20188D+05	0.43756D+05	0.24653D−01	
		5.150	−0.33059D−02	0.47805D−02	0.22760D−02	−0.40133D+04	0.20164D+05	0.43712D+05	0.24619D−01	
		5.160	−0.32829D−02	0.47648D−02	0.22760D−02	−0.39665D+04	0.20141D+05	0.43668D+05	0.24587D−01	
		5.170	−0.32601D−02	0.47493D−02	0.22760D−02	−0.39199D+04	0.20118D+05	0.43625D+05	0.24554D−01	
		5.180	−0.32374D−02	0.47338D−02	0.22760D−02	−0.38735D+04	0.20095D+05	0.43582D+05	0.24521D−01	
		5.190	−0.32149D−02	0.47185D−02	0.22760D−02	−0.38273D+04	0.20072D+05	0.43540D+05	0.24489D−01	
		5.200	−0.31924D−02	0.47033D−02	0.22760D−02	−0.37814D+04	0.20050D+05	0.43497D+05	0.24457D−01	
3	2	5.200	−0.30638D−02	0.47033D−02	0.22760D−02	−0.37814D+04	0.91036D+05	0.40474D+04	0.24457D−01	0.14774D+05
		5.210	−0.29993D−02	0.46884D−02	0.22760D−02	−0.35996D+04	0.90830D+05	0.41347D+04	0.24427D−01	
		5.220	−0.29353D−02	0.46738D−02	0.22760D−02	−0.34189D+04	0.90626D+05	0.42215D+04	0.24397D−01	
		5.230	−0.28717D−02	0.46593D−02	0.22760D−02	−0.32393D+04	0.90426D+05	0.43078D+04	0.24368D−01	
		5.240	−0.28085D−02	0.46450D−02	0.22760D−02	−0.30607D+04	0.90229D+05	0.43937D+04	0.24340D−01	
		5.250	−0.27457D−02	0.46308D−02	0.22760D−02	−0.28832D+04	0.90035D+05	0.44792D+04	0.24312D−01	
		5.260	−0.26833D−02	0.46169D−02	0.22760D−02	−0.27067D+04	0.89843D+05	0.45642D+04	0.24285D−01	
		5.270	−0.26213D−02	0.46031D−02	0.22760D−02	−0.25313D+04	0.89655D+05	0.46487D+04	0.24258D−01	
		5.280	−0.25598D−02	0.45894D−02	0.22760D−02	−0.23569D+04	0.89469D+05	0.47329D+04	0.24232D−01	
		5.290	−0.24986D−02	0.45760D−02	0.22760D−02	−0.21835D+04	0.89286D+05	0.48166D+04	0.24207D−01	
		5.300	−0.24378D−02	0.45627D−02	0.22760D−02	−0.20110D+04	0.89106D+05	0.48999D+04	0.24182D−01	
4	3	5.300	−0.36899D−02	0.45627D−02	0.22760D−02	−0.20110D+04	0.21684D+05	0.43894D+05	0.24182D−01	0.14682D+06
		5.310	−0.36677D−02	0.45472D−02	0.22760D−02	−0.19664D+04	0.21660D+05	0.43850D+05	0.24146D−01	
		5.320	−0.36457D−02	0.45318D−02	0.22760D−02	−0.19221D+04	0.21636D+05	0.43806D+05	0.24109D−01	
		5.330	−0.36237D−02	0.45164D−02	0.22760D−02	−0.18779D+04	0.21613D+05	0.43763D+05	0.24073D−01	
		5.340	−0.36019D−02	0.45012D−02	0.22760D−02	−0.18339D+04	0.21589D+05	0.43720D+05	0.24036D−01	
		5.350	−0.35802D−02	0.44861D−02	0.22760D−02	−0.17901D+04	0.21566D+05	0.43677D+05	0.24001D−01	
		5.360	−0.35586D−02	0.44711D−02	0.22760D−02	−0.17466D+04	0.21543D+05	0.43634D+05	0.23965D−01	
		5.370	−0.35372D−02	0.44561D−02	0.22760D−02	−0.17032D+04	0.21520D+05	0.43592D+05	0.23929D−01	
		5.380	−0.35158D−02	0.44413D−02	0.22760D−02	−0.16601D+04	0.21497D+05	0.43550D+05	0.23894D−01	
		5.390	−0.34946D−02	0.44265D−02	0.22760D−02	−0.16172D+04	0.21475D+05	0.43508D+05	0.23859D−01	
		5.400	−0.34735D−02	0.44119D−02	0.22760D−02	−0.15744D+04	0.21452D+05	0.43467D+05	0.23824D−01	
5	4	5.400	−0.33603D−02	0.44119D−02	0.22760D−02	−0.15744D+04	0.86007D+05	0.66893D+04	0.23824D−01	0.24207D+05
		5.410	−0.33025D−02	0.43976D−02	0.22760D−02	−0.14127D+04	0.85802D+05	0.67662D+04	0.23791D−01	
		5.420	−0.32450D−02	0.43834D−02	0.22760D−02	−0.12520D+04	0.85600D+05	0.68427D+04	0.23758D−01	
		5.430	−0.31879D−02	0.43694D−02	0.22760D−02	−0.10922D+04	0.85400D+05	0.69187D+04	0.23726D−01	
		5.440	−0.31312D−02	0.43556D−02	0.22760D−02	−0.93342D+03	0.85203D+05	0.69943D+04	0.23694D−01	
		5.450	−0.30748D−02	0.43419D−02	0.22760D−02	−0.77555D+03	0.85008D+05	0.70696D+04	0.23663D−01	
		5.460	−0.30188D−02	0.43284D−02	0.22760D−02	−0.61861D+03	0.84816D+05	0.71444D+04	0.23633D−01	
		5.470	−0.29632D−02	0.43150D−02	0.22760D−02	−0.46260D+03	0.84626D+05	0.72189D+04	0.23603D−01	
		5.480	−0.29079D−02	0.43018D−02	0.22760D−02	−0.30750D+03	0.84439D+05	0.72930D+04	0.23574D−01	
		5.490	−0.28530D−02	0.42887D−02	0.22760D−02	−0.15330D+03	0.84254D+05	0.73666D+04	0.23545D−01	

		5.500	−0.27985D−02	0.42757D−02	0.22760D−02	0.32742D−10	0.84072D+05	0.74400D+04	0.23517D−01	

@ 5500 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.46986D−02	0.53402D−02	0.21438D−02	−0.55000D+04	0.45772D+05	0.29363D+05	0.26701D−01	0.93168D+05
		5.010	−0.46786D−02	0.53201D−02	0.21438D−02	−0.53978D+04	0.45669D+05	0.29363D+05	0.26654D−01	
		5.020	−0.46587D−02	0.53002D−02	0.21438D−02	−0.52961D+04	0.45568D+05	0.29363D+05	0.26607D−01	
		5.030	−0.46389D−02	0.52805D−02	0.21438D−02	−0.51951D+04	0.45467D+05	0.29363D+05	0.26561D−01	
		5.040	−0.46193D−02	0.52608D−02	0.21438D−02	−0.50947D+04	0.45366D+05	0.29363D+05	0.26514D−01	
		5.050	−0.45997D−02	0.52413D−02	0.21438D−02	−0.49949D+04	0.45267D+05	0.29363D+05	0.26468D−01	
		5.060	−0.45803D−02	0.52218D−02	0.21438D−02	−0.48956D+04	0.45167D+05	0.29363D+05	0.26422D−01	
		5.070	−0.45610D−02	0.52025D−02	0.21438D−02	−0.47970D+04	0.45069D+05	0.29363D+05	0.26377D−01	
		5.080	−0.45418D−02	0.51833D−02	0.21438D−02	−0.46989D+04	0.44971D+05	0.29363D+05	0.26331D−01	
		5.090	−0.45227D−02	0.51642D−02	0.21438D−02	−0.46014D+04	0.44873D+05	0.29363D+05	0.26286D−01	
		5.100	−0.45037D−02	0.51453D−02	0.21438D−02	−0.45045D+04	0.44776D+05	0.29363D+05	0.26241D−01	
2	1	5.100	−0.51270D−02	0.51453D−02	0.21438D−02	−0.45045D+04	0.22371D+05	0.44695D+05	0.26241D−01	0.14368D+06
		5.110	−0.51000D−02	0.51252D−02	0.21438D−02	−0.44520D+04	0.22337D+05	0.44636D+05	0.26190D−01	
		5.120	−0.50731D−02	0.51052D−02	0.21438D−02	−0.43997D+04	0.22304D+05	0.44577D+05	0.26139D−01	
		5.130	−0.50464D−02	0.50854D−02	0.21438D−02	−0.43477D+04	0.22271D+05	0.44518D+05	0.26088D−01	
		5.140	−0.50198D−02	0.50657D−02	0.21438D−02	−0.42959D+04	0.22238D+05	0.44459D+05	0.26038D−01	
		5.150	−0.49934D−02	0.50462D−02	0.21438D−02	−0.42444D+04	0.22205D+05	0.44402D+05	0.25988D−01	
		5.160	−0.49671D−02	0.50267D−02	0.21438D−02	−0.41932D+04	0.22172D+05	0.44344D+05	0.25938D−01	
		5.170	−0.49409D−02	0.50074D−02	0.21438D−02	−0.41422D+04	0.22140D+05	0.44287D+05	0.25888D−01	
		5.180	−0.49149D−02	0.49883D−02	0.21438D−02	−0.40915D+04	0.22108D+05	0.44230D+05	0.25839D−01	
		5.190	−0.48891D−02	0.49692D−02	0.21438D−02	−0.40411D+04	0.22076D+05	0.44174D+05	0.25790D−01	
		5.200	−0.48634D−02	0.49503D−02	0.21438D−02	−0.39909D+04	0.22045D+05	0.44118D+05	0.25741D−01	
3	2	5.200	−0.47145D−02	0.49503D−02	0.21438D−02	−0.39909D+04	0.96564D+05	0.60646D+04	0.25741D−01	0.21480D+05
		5.210	−0.46449D−02	0.49318D−02	0.21438D−02	−0.37981D+04	0.96291D+05	0.61552D+04	0.25695D−01	
		5.220	−0.45758D−02	0.49135D−02	0.21438D−02	−0.36066D+04	0.96022D+05	0.62454D+04	0.25649D−01	
		5.230	−0.45071D−02	0.48954D−02	0.21438D−02	−0.34164D+04	0.95757D+05	0.63349D+04	0.25603D−01	
		5.240	−0.44390D−02	0.48775D−02	0.21438D−02	−0.32274D+04	0.95494D+05	0.64240D+04	0.25558D−01	
		5.250	−0.43713D−02	0.48599D−02	0.21438D−02	−0.30396D+04	0.95235D+05	0.65125D+04	0.25514D−01	
		5.260	−0.43041D−02	0.48424D−02	0.21438D−02	−0.28530D+04	0.94980D+05	0.66006D+04	0.25471D−01	
		5.270	−0.42373D−02	0.48251D−02	0.21438D−02	−0.26676D+04	0.94727D+05	0.66881D+04	0.25428D−01	
		5.280	−0.41710D−02	0.48080D−02	0.21438D−02	−0.24834D+04	0.94478D+05	0.67751D+04	0.25386D−01	
		5.290	−0.41052D−02	0.47911D−02	0.21438D−02	−0.23003D+04	0.94232D+05	0.68617D+04	0.25345D−01	
		5.300	−0.40398D−02	0.47744D−02	0.21438D−02	−0.21184D+04	0.93989D+05	0.69477D+04	0.25304D−01	
4	3	5.300	−0.41792D−02	0.47744D−02	0.21438D−02	−0.21184D+04	0.22475D+05	0.44277D+05	0.25304D−01	0.14803D+06
		5.310	−0.41559D−02	0.47575D−02	0.21438D−02	−0.20721D+04	0.22448D+05	0.44228D+05	0.25262D−01	
		5.320	−0.41326D−02	0.47408D−02	0.21438D−02	−0.20261D+04	0.22421D+05	0.44180D+05	0.25221D−01	
		5.330	−0.41095D−02	0.47242D−02	0.21438D−02	−0.19802D+04	0.22394D+05	0.44131D+05	0.25180D−01	
		5.340	−0.40865D−02	0.47076D−02	0.21438D−02	−0.19346D+04	0.22367D+05	0.44084D+05	0.25139D−01	
		5.350	−0.40636D−02	0.46912D−02	0.21438D−02	−0.18892D+04	0.22341D+05	0.44036D+05	0.25098D−01	
		5.360	−0.40408D−02	0.46749D−02	0.21438D−02	−0.18440D+04	0.22315D+05	0.43989D+05	0.25057D−01	
		5.370	−0.40182D−02	0.46587D−02	0.21438D−02	−0.17991D+04	0.22289D+05	0.43942D+05	0.25017D−01	
		5.380	−0.39957D−02	0.46426D−02	0.21438D−02	−0.17543D+04	0.22263D+05	0.43895D+05	0.24977D−01	
		5.390	−0.39733D−02	0.46266D−02	0.21438D−02	−0.17098D+04	0.22238D+05	0.43849D+05	0.24937D−01	
		5.400	−0.39510D−02	0.46107D−02	0.21438D−02	−0.16654D+04	0.22212D+05	0.43803D+05	0.24898D−01	
5	4	5.400	−0.38203D−02	0.46107D−02	0.21438D−02	−0.16654D+04	0.91018D+05	0.70790D+04	0.24898D−01	0.25612D+05
		5.410	−0.37589D−02	0.45952D−02	0.21438D−02	−0.14943D+04	0.90793D+05	0.71601D+04	0.24860D−01	
		5.420	−0.36979D−02	0.45798D−02	0.21438D−02	−0.13243D+04	0.90571D+05	0.72407D+04	0.24822D−01	
		5.430	−0.36374D−02	0.45646D−02	0.21438D−02	−0.11552D+04	0.90352D+05	0.73209D+04	0.24786D−01	
		5.440	−0.35772D−02	0.45496D−02	0.21438D−02	−0.98722D+03	0.90136D+05	0.74007D+04	0.24750D−01	
		5.450	−0.35174D−02	0.45347D−02	0.21438D−02	−0.82022D+03	0.89923D+05	0.74800D+04	0.24714D−01	
		5.460	−0.34580D−02	0.45200D−02	0.21438D−02	−0.65422D+03	0.89712D+05	0.75589D+04	0.24679D−01	
		5.470	−0.33990D−02	0.45055D−02	0.21438D−02	−0.48920D+03	0.89504D+05	0.76374D+04	0.24645D−01	
		5.480	−0.33403D−02	0.44911D−02	0.21438D−02	−0.32517D+03	0.89299D+05	0.77155D+04	0.24611D−01	
		5.490	−0.32821D−02	0.44769D−02	0.21438D−02	−0.16211D+03	0.89096D+05	0.77932D+04	0.24578D−01	
		5.500	−0.32242D−02	0.44629D−02	0.21438D−02	0.18645D−09	0.88896D+05	0.78704D+04	0.24546D−01	

@ 7500 psi (min burst)

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	5	5.000	−0.59399D−02	0.71630D−02	0.28707D−02	−0.75000D+04	0.67341D+05	0.42502D+05	0.35815D−01	0.13486D+06
		5.010	−0.59138D−02	0.71368D−02	0.28707D−02	−0.73508D+04	0.67192D+05	0.42502D+05	0.35755D−01	
		5.020	−0.58878D−02	0.71109D−02	0.28707D−02	−0.72024D+04	0.67044D+05	0.42502D+05	0.35696D−01	
		5.030	−0.58620D−02	0.70850D−02	0.28707D−02	−0.70550D+04	0.66896D+05	0.42502D+05	0.35638D−01	
		5.040	−0.58363D−02	0.70594D−02	0.28707D−02	−0.69084D+04	0.66750D+05	0.42502D+05	0.35579D−01	
		5.050	−0.58108D−02	0.70339D−02	0.28707D−02	−0.67627D+04	0.66604D+05	0.42502D+05	0.35521D−01	
		5.060	−0.57854D−02	0.70085D−02	0.28707D−02	−0.66178D+04	0.66459D+05	0.42502D+05	0.35463D−01	
		5.070	−0.57602D−02	0.69833D−02	0.28707D−02	−0.64738D+04	0.66315D+05	0.42502D+05	0.35405D−01	
		5.080	−0.57352D−02	0.69582D−02	0.28707D−02	−0.63307D+04	0.66172D+05	0.42502D+05	0.35348D−01	
		5.090	−0.57103D−02	0.69333D−02	0.28707D−02	−0.61884D+04	0.66030D+05	0.42502D+05	0.35291D−01	
		5.100	−0.56855D−02	0.69086D−02	0.28707D−02	−0.60469D+04	0.65888D+05	0.42502D+05	0.35234D−01	
2	1	5.100	−0.68799D−02	0.69086D−02	0.28707D−02	−0.60469D+04	0.30005D+05	0.59921D+05	0.35234D−01	0.19262D+06
		5.110	−0.68436D−02	0.68816D−02	0.28707D−02	−0.59764D+04	0.29960D+05	0.59841D+05	0.35165D−01	
		5.120	−0.68075D−02	0.68548D−02	0.28707D−02	−0.59063D+04	0.29915D+05	0.59762D+05	0.35097D−01	
		5.130	−0.67716D−02	0.68282D−02	0.28707D−02	−0.58365D+04	0.29870D+05	0.59683D+05	0.35029D−01	
		5.140	−0.67360D−02	0.68018D−02	0.28707D−02	−0.57670D+04	0.29826D+05	0.59604D+05	0.34961D−01	
		5.150	−0.67005D−02	0.67756D−02	0.28707D−02	−0.56980D+04	0.29782D+05	0.59527D+05	0.34894D−01	
		5.160	−0.66652D−02	0.67495D−02	0.28707D−02	−0.56293D+04	0.29738D+05	0.59450D+05	0.34827D−01	
		5.170	−0.66302D−02	0.67236D−02	0.28707D−02	−0.55609D+04	0.29695D+05	0.59373D+05	0.34761D−01	
		5.180	−0.65953D−02	0.66978D−02	0.28707D−02	−0.54929D+04	0.29652D+05	0.59297D+05	0.34695D−01	
		5.190	−0.65606D−02	0.66722D−02	0.28707D−02	−0.54252D+04	0.29609D+05	0.59221D+05	0.34629D−01	
		5.200	−0.65261D−02	0.66468D−02	0.28707D−02	−0.53579D+04	0.29567D+05	0.59146D+05	0.34563D−01	
3	2	5.200	−0.63258D−02	0.66468D−02	0.28707D−02	−0.53579D+04	0.12965D+06	0.81257D+04	0.34563D−01	0.28785D+05
		5.210	−0.62324D−02	0.66220D−02	0.28707D−02	−0.50991D+04	0.12929D+06	0.82474D+04	0.34501D−01	
		5.220	−0.61395D−02	0.65975D−02	0.28707D−02	−0.48420D+04	0.12893D+06	0.83684D+04	0.34439D−01	
		5.230	−0.60474D−02	0.65732D−02	0.28707D−02	−0.45866D+04	0.12857D+06	0.84887D+04	0.34378D−01	
		5.240	−0.59558D−02	0.65492D−02	0.28707D−02	−0.43328D+04	0.12822D+06	0.86082D+04	0.34318D−01	
		5.250	−0.58650D−02	0.65255D−02	0.28707D−02	−0.40806D+04	0.12787D+06	0.87271D+04	0.34259D−01	
		5.260	−0.57747D−02	0.65020D−02	0.28707D−02	−0.38301D+04	0.12753D+06	0.88453D+04	0.34201D−01	
		5.270	−0.56851D−02	0.64788D−02	0.28707D−02	−0.35812D+04	0.12719D+06	0.89629D+04	0.34143D−01	
		5.280	−0.55961D−02	0.64558D−02	0.28707D−02	−0.33338D+04	0.12685D+06	0.90797D+04	0.34087D−01	

		5.290	−0.55077D−02	0.64331D−02	0.28707D−02	−0.30880D+04	0.12652D+06	0.91959D+04	0.34031D−01	
		5.300	−0.54199D−02	0.64107D−02	0.28707D−02	−0.28438D+04	0.12620D+06	0.93114D+04	0.33977D−01	
4	3	5.300	−0.56076D−02	0.64107D−02	0.28707D−02	−0.28438D+04	0.30144D+05	0.59360D+05	0.33977D−01	0.19845D+06
		5.310	−0.55762D−02	0.63881D−02	0.28707D−02	−0.27817D+04	0.30108D+05	0.59294D+05	0.33921D−01	
		5.320	−0.55450D−02	0.63656D−02	0.28707D−02	−0.27199D+04	0.30072D+05	0.59229D+05	0.33865D−01	
		5.330	−0.55140D−02	0.63433D−02	0.28707D−02	−0.26584D+04	0.30036D+05	0.59164D+05	0.33810D−01	
		5.340	−0.54831D−02	0.63211D−02	0.28707D−02	−0.25972D+04	0.30000D+05	0.59100D+05	0.33755D−01	
		5.350	−0.54524D−02	0.62991D−02	0.28707D−02	−0.25363D+04	0.29965D+05	0.59036D+05	0.33700D−01	
		5.360	−0.54219D−02	0.62772D−02	0.28707D−02	−0.24757D+04	0.29930D+05	0.58973D+05	0.33646D−01	
		5.370	−0.53915D−02	0.62555D−02	0.28707D−02	−0.24154D+04	0.29895D+05	0.58910D+05	0.33592D−01	
		5.380	−0.53613D−02	0.62338D−02	0.28707D−02	−0.23554D+04	0.29860D+05	0.58847D+05	0.33538D−01	
		5.390	−0.53312D−02	0.62124D−02	0.28707D−02	−0.22956D+04	0.29826D+05	0.58785D+05	0.33485D−01	
		5.400	−0.53013D−02	0.61910D−02	0.28707D−02	−0.22362D+04	0.29792D+05	0.58724D+05	0.33431D−01	
5	4	5.400	−0.51255D−02	0.61910D−02	0.28707D−02	−0.22362D+04	0.12221D+06	0.94875D+04	0.33431D−01	0.34330D+05
		5.410	−0.50430D−02	0.61702D−02	0.28707D−02	−0.20064D+04	0.12191D+06	0.95963D+04	0.33381D−01	
		5.420	−0.49611D−02	0.61495D−02	0.28707D−02	−0.17781D+04	0.12161D+06	0.97046D+04	0.33331D−01	
		5.430	−0.48798D−02	0.61292D−02	0.28707D−02	−0.15511D+04	0.12132D+06	0.98123D+04	0.33281D−01	
		5.440	−0.47990D−02	0.61090D−02	0.28707D−02	−0.13255D+04	0.12103D+06	0.99194D+04	0.33233D−01	
		5.450	−0.47187D−02	0.60891D−02	0.28707D−02	−0.11013D+04	0.12074D+06	0.10026D+05	0.33185D−01	
		5.460	−0.46389D−02	0.60693D−02	0.28707D−02	−0.87842D+03	0.12046D+06	0.10132D+05	0.33139D−01	
		5.470	−0.45597D−02	0.60498D−02	0.28707D−02	−0.65686D+03	0.12018D+06	0.10237D+05	0.33093D−01	
		5.480	−0.44810D−02	0.60305D−02	0.28707D−02	−0.43661D+03	0.11990D+06	0.10342D+05	0.33047D−01	
		5.490	−0.44028D−02	0.60115D−02	0.28707D−02	−0.21766D+03	0.11963D+06	0.10446D+05	0.33003D−01	
		5.500	−0.43251D−02	0.59926D−02	0.28707D−02	0.35425D−09	0.11936D+06	0.10550D+05	0.32959D−01	

STEP	DESCRIPTION	STRESS RATIO
1	1000 psi	7.935
2	5000 psi autofrettag	1.466
3	0 psi after auto	21.783
4	1000 psi	5.776
5	3000 psi (wkg)	2.339
6	4500 psi (test)	1.617
7	5000 psi	1.479
8	5500 psi	1.341
9	7500 psi (min burst)	1.000

```
Ver7 - pressure + temp, metal lined
5.,5,5,9,9,0
1,1
5.81d6,1.508d6,2.411d6,1.393,-.239,.3436
-4.96D-6,19.5D-6,23.1D-6
2,1
2.228d6,19.38d6,2.228d6,.03481,.5195,.3029
20.D-6,0.2D-6,20.D-6
3,4
32.d6,32.d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5.0d-6,5.0d-6
30,.6,.03
4,4
32.0d6,32.0d6,.32,.32,.5d6,.5d6
.5d6,.35,.186d6
1.1d-6,5d-6,5d-6
90,.6,.03
5,2
3
.0028,28000
.0054,40000
.0318,48000
13.1d-6
1,5,0.1
2,1,0.1
3,2,0.1
4,3,0.1
5,4,0.1
1000 psi
1000.,0.
10,10,10,10,10,10
5000 psi autofrettage
5000.,0.
0,0,0,0,0,0
0 psi after auto
0000.,0.
0,0,0,0,0,0
1000 psi
1000.,0,
0,0,0,0,0,0
3000 psi (wkg)
3000.,0.
0,0,0,0,0,0
4500 psi (test)
4500.,0.
0,0,0,0,0,0
5000 psi
5000.,0.
50,50,50,50,50,50
```

5500 psi
5500.,0.
0,0,0,0,0,0
7500 psi (min burst)
7500.,0.
0,0,0,0,0,0

Verification 8: composite cylinder with pressure, compare with prior computer program

A composite cylinder with metal liner and an internal pressure step.

The following page contains the results of the NewCAP analysis of the cylinder, followed by a page containing the comparable results from the program TDCYL2, which was previously verified. Note that:

- The results are the same between the two programs

-->NewCAP<-- LAST MODIFIED 3JAN2020 VERSION 1a
COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020

Ver8 - pressure - compare w/TDCYL2

RI= 1.5800   NL= 5   NMT= 3   NLS= 1   ISPL= 3   IPO= 0

* MATERIAL MODEL 1 - GENERAL PROPERTIES

MT	EM	EH	ER	PRMH	PRMR	PRHR	PRHM	PRRM	PRRH	N
1	0.3000D+08	0.3000D+08	0.3000D+08	0.3000D+00	0.3000D+00	0.3000D+00	0.3000D+00	0.3000D+00	0.3000D+00	0.1000D+01
2	0.1713D+07	0.3383D+08	0.1713D+07	0.2107D-01	0.4884D+00	0.2919D+00	0.4161D+00	0.4884D+00	0.1478D-01	0.3895D+01
3	0.2374D+08	0.1713D+07	0.1713D+07	0.2919D+00	0.2919D+00	0.4884D+00	0.2106D-01	0.2106D-01	0.4884D+00	0.1000D+01

MT	ALPM	ALPH	ALPR
1	0.0000D+00	0.0000D+00	0.0000D+00
2	0.0000D+00	0.0000D+00	0.0000D+00
3	0.0000D+00	0.0000D+00	0.0000D+00

LN	MT	TL	NODE	TEMP
1	1	0.2500	1	0.00
2	2	0.0600	2	0.00
3	3	0.0200	3	0.00
4	2	0.0600	4	0.00
5	3	0.0200	5	0.00
			6	0.00

STEP DESCRIPTION	PI	PO
10000 psi	10000.000	0.000

@ 10000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	1.580	-0.10953D-02	0.14894D-02	0.48863D-03	-0.10000D+05	0.49647D+05	0.26553D+05	0.23532D-02	0.71115D+05
		1.643	-0.99885D-03	0.13929D-02	0.48863D-03	-0.77735D+04	0.47421D+05	0.26553D+05	0.22878D-02	
		1.705	-0.91279D-03	0.13068D-02	0.48863D-03	-0.57873D+04	0.45434D+05	0.26553D+05	0.22281D-02	
		1.768	-0.83569D-03	0.12297D-02	0.48863D-03	-0.40081D+04	0.43655D+05	0.26553D+05	0.21735D-02	
		1.830	-0.76635D-03	0.11604D-02	0.48863D-03	-0.24081D+04	0.42055D+05	0.26553D+05	0.21235D-02	
2	2	1.830	-0.18763D-02	0.11604D-02	0.48863D-03	-0.24081D+04	0.38752D+05	0.47742D+03	0.21235D-02	0.53926D+03
		1.845	-0.17191D-02	0.11363D-02	0.48863D-03	-0.20762D+04	0.38097D+05	0.62574D+03	0.20965D-02	
		1.860	-0.15674D-02	0.11139D-02	0.48863D-03	-0.17547D+04	0.37492D+05	0.77002D+03	0.20719D-02	
		1.875	-0.14207D-02	0.10931D-02	0.48863D-03	-0.14429D+04	0.36936D+05	0.91055D+03	0.20495D-02	
		1.890	-0.12787D-02	0.10737D-02	0.48863D-03	-0.11404D+04	0.36426D+05	0.10476D+04	0.20293D-02	
3	3	1.890	-0.12457D-02	0.10737D-02	0.48863D-03	-0.11404D+04	0.15290D+04	0.11714D+05	0.20293D-02	0.27968D+04
		1.895	-0.12396D-02	0.10676D-02	0.48863D-03	-0.11334D+04	0.15219D+04	0.11714D+05	0.20231D-02	
		1.900	-0.12335D-02	0.10615D-02	0.48863D-03	-0.11264D+04	0.15150D+04	0.11714D+05	0.20169D-02	
		1.905	-0.12275D-02	0.10555D-02	0.48863D-03	-0.11195D+04	0.15080D+04	0.11714D+05	0.20107D-02	
		1.910	-0.12215D-02	0.10495D-02	0.48863D-03	-0.11126D+04	0.15012D+04	0.11714D+05	0.20046D-02	
4	2	1.910	-0.12545D-02	0.10495D-02	0.48863D-03	-0.11126D+04	0.35615D+05	0.10441D+04	0.20046D-02	0.95025D+03
		1.925	-0.11214D-02	0.10321D-02	0.48863D-03	-0.82819D+03	0.35162D+05	0.11734D+04	0.19868D-02	
		1.940	-0.99240D-03	0.10159D-02	0.48863D-03	-0.55153D+03	0.34749D+05	0.12998D+04	0.19709D-02	
		1.955	-0.86716D-03	0.10010D-02	0.48863D-03	-0.28214D+03	0.34374D+05	0.14235D+04	0.19570D-02	
		1.970	-0.74549D-03	0.98726D-03	0.48863D-03	-0.19573D+02	0.34036D+05	0.15446D+04	0.19449D-02	
5	3	1.970	-0.71342D-03	0.98726D-03	0.48863D-03	-0.19573D+02	0.19377D+04	0.12160D+05	0.19449D-02	0.30256D+04
		1.975	-0.70912D-03	0.98296D-03	0.48863D-03	-0.14624D+02	0.19328D+04	0.12160D+05	0.19413D-02	
		1.980	-0.70485D-03	0.97869D-03	0.48863D-03	-0.97122D+01	0.19279D+04	0.12160D+05	0.19378D-02	
		1.985	-0.70062D-03	0.97445D-03	0.48863D-03	-0.48377D+01	0.19230D+04	0.12160D+05	0.19343D-02	
		1.990	-0.69641D-03	0.97025D-03	0.48863D-03	0.92086D-11	0.19182D+04	0.12160D+05	0.19308D-02	

STEP	DESCRIPTION	STRESS RATIO
1	10000 psi	1.000

```
Ver8 - pressure - compare w/TDCYL2
1.58,5,3,1,3,0
1,1
30.d6,30.d6,30.d6,.3,.3,.3
0,0,0
2,1
1.713d6,33.83d6,1.713d6,.02107,.4884,.2919
0,0,0
3,1
23.74d6,1.713d6,1.713d6,.2919,.2919,.4884
0,0,0
1,1,.25
2,2,.06
3,3,.02
4,2,.06
5,3,.02
10000 psi
10000.,0.
0,0,0,0,0,0
```

```
Last login: Sun Feb  2 20:26:23 on ttys000
/Applications/Absoft11.5/bin/absvars.csh: No such file or directory.
[iMac:~] norm% /Volumes/HD2/Fortran/TDCYL2/TDCYL2 ; exit;
TDCYL2 Test Run - pressure
1.58,5,3,3,2,1,0
1,30.d6,30.d6,30.d6,.3,.3,.3
0,0,0,0,0,0,0
2,1.713d6,33.83d6,1.713d6,.02107,.4884,.2919
0,0,0,0,0,0,0
3,23.74d6,1.713d6,1.713d6,.2919,.2919,.4884
0,0,0,0,0,0,0
1,1,.25
2,2,.06
3,3,.02
4,2,.06
5,3,.02
10000.,0,0
10,11,13,16,20,25
0,0,0,0,0,0
78426.7

   -->TDCYL2<--  LAST MODIFIED 7/21/82   VERSION *1*



 TDCYL2 Test Run - pressure



 RI=  1.5800     NL=  5     NMT=  3     ISPL=  3     ISS= 2     IBC= 1     IPO= 0


 MT       EM           EH           ER          PRMH         PRMR         PRHR         PRHM         PRRM         PRRH           N

  1   0.3000D+08   0.3000D+08   0.3000D+08   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.1000D+01
  2   0.1713D+07   0.3383D+08   0.1713D+07   0.2107D-01   0.4884D+00   0.2919D+00   0.4161D+00   0.4884D+00   0.1478D-01   0.3895D+01
  3   0.2374D+08   0.1713D+07   0.1713D+07   0.2919D+00   0.2919D+00   0.4884D+00   0.2106D-01   0.2106D-01   0.4884D+00   0.1000D+01



   MT      GAMA         ALPM         ALPH         ALPR         BETM         BETH         BETR

    1   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
    2   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
    3   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
1  LN  MT   TL        NODE    TEMP       MOIST

    1   1   0.2500       1     10.00    0.000000
    2   2   0.0600       2     11.00    0.000000
    3   3   0.0200       3     13.00    0.000000
    4   2   0.0600       4     16.00    0.000000
    5   3   0.0200       5     20.00    0.000000
                         6     25.00    0.000000

 PI=   10000.000     PO=       0.000     OMEGA=      0.00

 AF=    0.78427D+05
1  LN  MT    R         EPR           EPH           EPM           SR            SH            SM             U            AF

    1   1  1.580  -0.10953D-02   0.14894D-02   0.48863D-03  -0.10000D+05   0.49647D+05   0.26553D+05   0.23532D-02   0.71115D+05
           1.643  -0.99885D-03   0.13929D-02   0.48863D-03  -0.77735D+04   0.47421D+05   0.26553D+05   0.22878D-02
           1.705  -0.91279D-03   0.13068D-02   0.48863D-03  -0.57874D+04   0.45434D+05   0.26553D+05   0.22281D-02
           1.768  -0.83569D-03   0.12297D-02   0.48863D-03  -0.40081D+04   0.43655D+05   0.26553D+05   0.21735D-02
           1.830  -0.76635D-03   0.11604D-02   0.48863D-03  -0.24081D+04   0.42055D+05   0.26553D+05   0.21235D-02

    2   2  1.830  -0.18763D-02   0.11604D-02   0.48863D-03  -0.24081D+04   0.38752D+05   0.47742D+03   0.21235D-02   0.53926D+03
           1.845  -0.17191D-02   0.11363D-02   0.48863D-03  -0.20762D+04   0.38097D+05   0.62573D+03   0.20965D-02
           1.860  -0.15674D-02   0.11139D-02   0.48863D-03  -0.17547D+04   0.37492D+05   0.77002D+03   0.20719D-02
           1.875  -0.14207D-02   0.10931D-02   0.48863D-03  -0.14429D+04   0.36936D+05   0.91055D+03   0.20495D-02
           1.890  -0.12787D-02   0.10737D-02   0.48863D-03  -0.11404D+04   0.36426D+05   0.10476D+04   0.20293D-02

    3   3  1.890  -0.12457D-02   0.10737D-02   0.48863D-03  -0.11404D+04   0.15290D+04   0.11714D+05   0.20293D-02   0.27968D+04
           1.895  -0.12396D-02   0.10676D-02   0.48863D-03  -0.11334D+04   0.15219D+04   0.11714D+05   0.20231D-02
           1.900  -0.12335D-02   0.10615D-02   0.48863D-03  -0.11264D+04   0.15150D+04   0.11714D+05   0.20169D-02
           1.905  -0.12275D-02   0.10555D-02   0.48863D-03  -0.11195D+04   0.15080D+04   0.11714D+05   0.20107D-02
           1.910  -0.12215D-02   0.10495D-02   0.48863D-03  -0.11126D+04   0.15012D+04   0.11714D+05   0.20046D-02

    4   2  1.910  -0.12545D-02   0.10495D-02   0.48863D-03  -0.11126D+04   0.35615D+05   0.10441D+04   0.20046D-02   0.95025D+03
           1.925  -0.11214D-02   0.10321D-02   0.48863D-03  -0.82819D+03   0.35162D+05   0.11734D+04   0.19868D-02
           1.940  -0.99240D-03   0.10159D-02   0.48863D-03  -0.55153D+03   0.34749D+05   0.12998D+04   0.19709D-02
           1.955  -0.86716D-03   0.10010D-02   0.48863D-03  -0.28214D+03   0.34374D+05   0.14235D+04   0.19570D-02
           1.970  -0.74549D-03   0.98726D-03   0.48863D-03  -0.19573D+02   0.34036D+05   0.15446D+04   0.19449D-02

    5   3  1.970  -0.71342D-03   0.98726D-03   0.48863D-03  -0.19573D+02   0.19377D+04   0.12160D+05   0.19449D-02   0.30256D+04
           1.975  -0.70912D-03   0.98296D-03   0.48863D-03  -0.14624D+02   0.19328D+04   0.12160D+05   0.19413D-02
           1.980  -0.70485D-03   0.97869D-03   0.48863D-03  -0.97122D+01   0.19279D+04   0.12160D+05   0.19378D-02
           1.985  -0.70062D-03   0.97445D-03   0.48863D-03  -0.48377D+01   0.19230D+04   0.12160D+05   0.19343D-02
           1.990  -0.69641D-03   0.97025D-03   0.48863D-03   0.32969D-10   0.19182D+04   0.12160D+05   0.19308D-02
logout

[Process completed]
```

Verification 9: composite cylinder with temperature change, compare with prior computer program

A composite cylinder with metal liner and a temperature change.

The following page contains the results of the NewCAP analysis of the cylinder, followed by a page containing the comparable results from the program TDCYL2, which was previously verified. Note that:

- The results are the same between the two programs

```
  -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
             COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020



Ver9 - temperature - compare w/TDCYL2


RI=  1.5800     NL=  5     NMT=  3     NLS=  1     ISPL=  3     IPO= 0



* MATERIAL MODEL 1 - GENERAL PROPERTIES
MT       EM           EH           ER          PRMH         PRMR         PRHR         PRHM         PRRM         PRRH           N

 1   0.3000D+08   0.3000D+08   0.3000D+08   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.1000D+01
 2   0.1713D+07   0.3383D+08   0.1713D+07   0.2107D-01   0.4884D+00   0.2919D+00   0.4161D+00   0.4884D+00   0.1478D-01   0.3895D+01
 3   0.2374D+08   0.1713D+07   0.1713D+07   0.2919D+00   0.2919D+00   0.4884D+00   0.2106D-01   0.2106D-01   0.4884D+00   0.1000D+01

  MT      ALPM         ALPH         ALPR

   1   0.6600D-05   0.6600D-05   0.6600D-05
   2   0.4000D-05   0.1000D-05   0.4000D-05
   3   0.2000D-05   0.4000D-05   0.4000D-05


  LN  MT   TL        NODE    TEMP

   1   1   0.2500       1 50.00
   2   2   0.0600       2 60.00
   3   3   0.0200       3 70.00
   4   2   0.0600       4 80.00
   5   3   0.0200       5 90.00
                        6100.00

STEP DESCRIPTION          PI          PO
Temperature gradient       0.000       0.000


@ Temperature gradient
  LN  MT    R         EPR           EPH           EPM           SR            SH            SM            U            AF

   1   1  1.580   0.34410D-03   0.26021D-03   0.36689D-03   0.54570D-11  -0.19357D+04   0.52604D+03   0.41114D-03  -0.24715D+04
          1.643   0.37103D-03   0.26392D-03   0.36689D-03  -0.85540D+02  -0.25573D+04  -0.18111D+03   0.43349D-03
          1.705   0.39727D-03   0.26833D-03   0.36689D-03  -0.18729D+03  -0.31627D+04  -0.88825D+03   0.45750D-03
          1.768   0.42290D-03   0.27334D-03   0.36689D-03  -0.30300D+03  -0.37542D+04  -0.15954D+04   0.48314D-03
          1.830   0.44800D-03   0.27888D-03   0.36689D-03  -0.43079D+03  -0.43335D+04  -0.23025D+04   0.51035D-03

   2   2  1.830  -0.12099D-03   0.27888D-03   0.36689D-03  -0.43079D+03   0.73464D+04   0.16175D+03   0.51035D-03   0.12644D+03
          1.845  -0.75875D-04   0.27582D-03   0.36689D-03  -0.36825D+03   0.71804D+04   0.17168D+03   0.50888D-03
          1.860  -0.31967D-04   0.27316D-03   0.36689D-03  -0.30800D+03   0.70273D+04   0.18074D+03   0.50807D-03
          1.875   0.10811D-04   0.27089D-03   0.36689D-03  -0.24989D+03   0.68863D+04   0.18903D+03   0.50792D-03
          1.890   0.52531D-04   0.26899D-03   0.36689D-03  -0.19377D+03   0.67571D+04   0.19658D+03   0.50839D-03

   3   3  1.890   0.10171D-03   0.26899D-03   0.36689D-03  -0.19377D+03  -0.12447D+01   0.53295D+04   0.50839D-03   0.12129D+04
          1.895   0.11929D-03   0.26857D-03   0.36689D-03  -0.19329D+03  -0.21478D+02   0.52050D+04   0.50894D-03
          1.900   0.13682D-03   0.26820D-03   0.36689D-03  -0.19286D+03  -0.41655D+02   0.50806D+04   0.50958D-03
          1.905   0.15430D-03   0.26788D-03   0.36689D-03  -0.19249D+03  -0.61777D+02   0.49561D+04   0.51031D-03
          1.910   0.17174D-03   0.26761D-03   0.36689D-03  -0.19218D+03  -0.81844D+02   0.48316D+04   0.51113D-03

   4   2  1.910   0.11887D-03   0.26761D-03   0.36689D-03  -0.19218D+03   0.63406D+04   0.12006D+03   0.51113D-03   0.95099D+02
          1.925   0.15769D-03   0.26660D-03   0.36689D-03  -0.14168D+03   0.62389D+04   0.12546D+03   0.51320D-03
          1.940   0.19569D-03   0.26590D-03   0.36689D-03  -0.92702D+02   0.61472D+04   0.13031D+03   0.51585D-03
          1.955   0.23292D-03   0.26551D-03   0.36689D-03  -0.45148D+02   0.60649D+04   0.13467D+03   0.51907D-03
          1.970   0.26942D-03   0.26540D-03   0.36689D-03   0.10914D+01   0.59918D+04   0.13859D+03   0.52284D-03

   5   3  1.970   0.32585D-03   0.26540D-03   0.36689D-03   0.10914D+01  -0.68481D+02   0.44171D+04   0.52284D-03   0.10370D+04
          1.975   0.34284D-03   0.26557D-03   0.36689D-03   0.89050D+00  -0.88031D+02   0.42927D+04   0.52451D-03
          1.980   0.35978D-03   0.26579D-03   0.36689D-03   0.64131D+00  -0.10753D+03   0.41682D+04   0.52627D-03
          1.985   0.37669D-03   0.26605D-03   0.36689D-03   0.34432D+00  -0.12699D+03   0.40438D+04   0.52811D-03
          1.990   0.39355D-03   0.26635D-03   0.36689D-03   0.81002D-11  -0.14640D+03   0.39193D+04   0.53003D-03
  STEP  DESCRIPTION          STRESS RATIO
    1    Temperature gradient     0.000
```

```
Ver9 - temperature - compare w/TDCYL2
1.58,5,3,1,3,0
1,1
30.d6,30.d6,30.d6,.3,.3,.3
6.6d-6,6.6d-6,6.6d-6
2,1
1.713d6,33.83d6,1.713d6,.02107,.4884,.2919
4.d-6,1.d-6,4.d-6
3,1
23.74d6,1.713d6,1.713d6,.2919,.2919,.4884
2.d-6,4.d-6,4.d-6
1,1,.25
2,2,.06
3,3,.02
4,2,.06
5,3,.02
Temperature gradient
0.,0.
50,60,70,80,90,100
```

```
Last login: Sun Feb  2 20:41:03 on ttys000
/Applications/Absoft11.5/bin/absvars.csh: No such file or directory.
[iMac:~] norm% /Volumes/HD2/Fortran/TDCYL2/TDCYL2 ; exit;
TDCYL2 Test Run - Temperature
1.58,5,3,3,2,1,0
1,30.d6,30.d6,30.d6,.3,.3,.3
.286,6.6d-6,6.6d-6,6.6d-6,0,0,0
2,1.713d6,33.83d6,1.713d6,.02107,.4884,.2919
0,4.d-6,1.d-6,4.d-6,0,0,0
3,23.74d6,1.713d6,1.713d6,.2919,.2919,.4884
0,2.d-6,4.d-6,4.d-6,0,0,0
1,1,.25
2,2,.06
3,3,.02
4,2,.06
5,3,.02
0,0,0
50,60,70,80,90,100
0,0,0,0,0,0
0

   -->TDCYL2<--  LAST MODIFIED 7/21/82   VERSION *1*



 TDCYL2 Test Run - Temperature



 RI=  1.5800     NL=  5     NMT=  3     ISPL=  3     ISS= 2     IBC= 1     IPO= 0


 MT       EM           EH           ER           PRMH         PRMR         PRHR         PRHM         PRRM         PRRH           N

  1   0.3000D+08   0.3000D+08   0.3000D+08   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.3000D+00   0.1000D+01
  2   0.1713D+07   0.3383D+08   0.1713D+07   0.2107D-01   0.4884D+00   0.2919D+00   0.4161D+00   0.4884D+00   0.1478D-01   0.3895D+01
  3   0.2374D+08   0.1713D+07   0.1713D+07   0.2919D+00   0.2919D+00   0.4884D+00   0.2106D-01   0.2106D-01   0.4884D+00   0.1000D+01



   MT      GAMA         ALPM         ALPH         ALPR         BETM         BETH         BETR

    1   0.2860D+00   0.6600D-05   0.6600D-05   0.6600D-05   0.0000D+00   0.0000D+00   0.0000D+00
    2   0.0000D+00   0.4000D-05   0.1000D-05   0.4000D-05   0.0000D+00   0.0000D+00   0.0000D+00
    3   0.0000D+00   0.2000D-05   0.4000D-05   0.4000D-05   0.0000D+00   0.0000D+00   0.0000D+00
1  LN  MT   TL        NODE    TEMP       MOIST

    1   1   0.2500       1     50.00    0.000000
    2   2   0.0600       2     60.00    0.000000
    3   3   0.0200       3     70.00    0.000000
    4   2   0.0600       4     80.00    0.000000
    5   3   0.0200       5     90.00    0.000000
                         6    100.00    0.000000

 PI=       0.000     PO=       0.000     OMEGA=      0.00

 AF=    0.00000D+00
1  LN  MT    R         EPR           EPH           EPM            SR            SH            SM             U             AF

    1   1  1.580   0.34410D-03   0.26021D-03   0.36689D-03   0.54570D-11  -0.19357D+04   0.52604D+03   0.41114D-03  -0.24715D+04
           1.643   0.37103D-03   0.26392D-03   0.36689D-03  -0.85540D+02  -0.25573D+04  -0.18111D+03   0.43349D-03
           1.705   0.39727D-03   0.26833D-03   0.36689D-03  -0.18729D+03  -0.31627D+04  -0.88825D+03   0.45750D-03
           1.768   0.42290D-03   0.27334D-03   0.36689D-03  -0.30300D+03  -0.37542D+04  -0.15954D+04   0.48314D-03
           1.830   0.44800D-03   0.27888D-03   0.36689D-03  -0.43079D+03  -0.43335D+04  -0.23025D+04   0.51035D-03

    2   2  1.830  -0.12099D-03   0.27888D-03   0.36689D-03  -0.43079D+03   0.73464D+04   0.16175D+03   0.51035D-03   0.12644D+03
           1.845  -0.75875D-04   0.27582D-03   0.36689D-03  -0.36825D+03   0.71804D+04   0.17168D+03   0.50888D-03
           1.860  -0.31967D-04   0.27316D-03   0.36689D-03  -0.30800D+03   0.70273D+04   0.18074D+03   0.50807D-03
           1.875   0.10811D-04   0.27089D-03   0.36689D-03  -0.24989D+03   0.68863D+04   0.18903D+03   0.50792D-03
           1.890   0.52531D-04   0.26899D-03   0.36689D-03  -0.19377D+03   0.67571D+04   0.19658D+03   0.50839D-03

    3   3  1.890   0.10171D-03   0.26899D-03   0.36689D-03  -0.19377D+03  -0.12447D+01   0.53295D+04   0.50839D-03   0.12129D+04
           1.895   0.11929D-03   0.26857D-03   0.36689D-03  -0.19329D+03  -0.21478D+02   0.52050D+04   0.50894D-03
           1.900   0.13682D-03   0.26820D-03   0.36689D-03  -0.19286D+03  -0.41655D+02   0.50806D+04   0.50958D-03
           1.905   0.15430D-03   0.26788D-03   0.36689D-03  -0.19249D+03  -0.61777D+02   0.49561D+04   0.51031D-03
           1.910   0.17174D-03   0.26761D-03   0.36689D-03  -0.19218D+03  -0.81844D+02   0.48316D+04   0.51113D-03

    4   2  1.910   0.11887D-03   0.26761D-03   0.36689D-03  -0.19218D+03   0.63406D+04   0.12006D+03   0.51113D-03   0.95099D+02
           1.925   0.15769D-03   0.26660D-03   0.36689D-03  -0.14168D+03   0.62389D+04   0.12546D+03   0.51320D-03
           1.940   0.19569D-03   0.26590D-03   0.36689D-03  -0.92702D+02   0.61472D+04   0.13031D+03   0.51585D-03
           1.955   0.23292D-03   0.26551D-03   0.36689D-03  -0.45148D+02   0.60649D+04   0.13467D+03   0.51907D-03
           1.970   0.26942D-03   0.26540D-03   0.36689D-03   0.10914D+01   0.59918D+04   0.13859D+03   0.52284D-03

    5   3  1.970   0.32585D-03   0.26540D-03   0.36689D-03   0.10914D+01  -0.68481D+02   0.44171D+04   0.52284D-03   0.10370D+04
           1.975   0.34284D-03   0.26557D-03   0.36689D-03   0.89050D+00  -0.88031D+02   0.42927D+04   0.52451D-03
           1.980   0.35978D-03   0.26579D-03   0.36689D-03   0.64131D+00  -0.10753D+03   0.41682D+04   0.52627D-03
           1.985   0.37669D-03   0.26605D-03   0.36689D-03   0.34432D+00  -0.12699D+03   0.40438D+04   0.52811D-03
           1.990   0.39355D-03   0.26635D-03   0.36689D-03   0.81002D-11  -0.14640D+03   0.39193D+04   0.53003D-03
logout

[Process completed]
```

Verification 10: metal lined composite cylinder, compare three runs addressing a correlation factor

A composite cylinder with metal liner and internal pressure steps.

The prediction of composite properties generally includes a “correlation factor” to match predictions with measured properties. This may account for factors such as small undulation in the laminate as one ply of the laminate is wound over previously applied plies.

The laminate analysis included in NewCAP permits the use of a correlation factor. It is currently coded into the program as having a value of “4”. Future updates of NewCAP may allow entry of a correlation factor. A decision on this may be based on results of subsequent validation testing, where test results will be compared with predictions.

The first computer output uses a correlation factor of 4.0. The second computer output uses a correlation factor of 3.0. The third computer output uses a correlation factor of 5.0.

The following page contains the results of the NewCAP analysis of the cylinder. Note that:

- Changing the correlation factor from 4.0 to 3.0 increases the laminate stiffness by about 1.7%, resulting in slight decreases in strains
- Changing the correlation factor from 4.0 to 5.0 decreases the laminate stiffness by about 1.2%, resulting in slight increases in strains

```
  -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
             COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020


Ver10a - Pressure (C=4.0)


RI=  4.0000     NL=  5     NMT=  3     NLS=  1     ISPL=  9     IPO= 0


* MATERIAL MODEL 2 - MULTI-LINEAR STRESS/STRAIN
MT    STRAIN1      STRESS1      STRAIN2      STRESS2      STRAIN3      STRESS3      STRAIN4      STRESS4      STRAIN5      STRESS5

 1   0.2800D-02   0.2800D+05   0.5400D-02   0.4000D+05   0.3180D-01   0.4800D+05   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
  MT
 1   0.1000D-04


* MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES
MT        EF1          EF2          VF12         VF23         GF12         GF23          EM           VF           GM

 2   0.3200D+08   0.1000D+07   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1800D+06
 3   0.3200D+08   0.1000D+07   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1800D+06

MT      ALP1         ALP2         ALP3         WA           FVF          VVF

 2   0.1100D-05   0.5000D-05   0.5000D-05   0.3000D+02   0.6000D+00   0.3000D-01
 3   0.1100D-05   0.5000D-05   0.5000D-05   0.9000D+02   0.6000D+00   0.3000D-01


  LN  MT   TL        NODE    TEMP

   1   1   0.1000       1  0.00
   2   2   0.2000       2  0.00
   3   3   0.1000       3  0.00
   4   2   0.2000       4  0.00
   5   3   0.1000       5  0.00
                        6  0.00

STEP DESCRIPTION          PI          PO
1000 psi               1000.000       0.000


@ 1000 psi
 LN  MT    R         EPR           EPH           EPM            SR            SH            SM            U            AF

   1   1  4.000  -0.47040D-03   0.80458D-03   0.11970D-03  -0.10000D+04   0.88075D+04   0.35393D+04   0.32183D-02   0.90063D+04
          4.010  -0.46723D-03   0.80140D-03   0.11970D-03  -0.97557D+03   0.87831D+04   0.35393D+04   0.32136D-02
          4.020  -0.46408D-03   0.79825D-03   0.11970D-03  -0.95133D+03   0.87589D+04   0.35393D+04   0.32090D-02
          4.030  -0.46095D-03   0.79512D-03   0.11970D-03  -0.92726D+03   0.87348D+04   0.35393D+04   0.32043D-02
          4.040  -0.45784D-03   0.79201D-03   0.11970D-03  -0.90338D+03   0.87109D+04   0.35393D+04   0.31997D-02
          4.050  -0.45476D-03   0.78893D-03   0.11970D-03  -0.87967D+03   0.86872D+04   0.35393D+04   0.31952D-02
          4.060  -0.45170D-03   0.78587D-03   0.11970D-03  -0.85613D+03   0.86637D+04   0.35393D+04   0.31906D-02
          4.070  -0.44866D-03   0.78284D-03   0.11970D-03  -0.83277D+03   0.86403D+04   0.35393D+04   0.31861D-02
          4.080  -0.44565D-03   0.77982D-03   0.11970D-03  -0.80958D+03   0.86171D+04   0.35393D+04   0.31817D-02
          4.090  -0.44266D-03   0.77683D-03   0.11970D-03  -0.78656D+03   0.85941D+04   0.35393D+04   0.31772D-02
          4.100  -0.43969D-03   0.77386D-03   0.11970D-03  -0.76371D+03   0.85712D+04   0.35393D+04   0.31728D-02

   2   2  4.100  -0.10458D-02   0.77386D-03   0.11970D-03  -0.76371D+03   0.17843D+04   0.39209D+04   0.31728D-02   0.19998D+05
          4.120  -0.10313D-02   0.76506D-03   0.11970D-03  -0.75137D+03   0.17706D+04   0.38933D+04   0.31520D-02
          4.140  -0.10170D-02   0.75642D-03   0.11970D-03  -0.73922D+03   0.17572D+04   0.38663D+04   0.31316D-02
          4.160  -0.10029D-02   0.74792D-03   0.11970D-03  -0.72725D+03   0.17440D+04   0.38398D+04   0.31114D-02
          4.180  -0.98902D-03   0.73958D-03   0.11970D-03  -0.71546D+03   0.17310D+04   0.38137D+04   0.30914D-02
          4.200  -0.97536D-03   0.73138D-03   0.11970D-03  -0.70384D+03   0.17183D+04   0.37882D+04   0.30718D-02
          4.220  -0.96190D-03   0.72333D-03   0.11970D-03  -0.69239D+03   0.17058D+04   0.37630D+04   0.30524D-02
          4.240  -0.94866D-03   0.71541D-03   0.11970D-03  -0.68111D+03   0.16935D+04   0.37384D+04   0.30333D-02
          4.260  -0.93561D-03   0.70763D-03   0.11970D-03  -0.66999D+03   0.16815D+04   0.37141D+04   0.30145D-02
          4.280  -0.92276D-03   0.69998D-03   0.11970D-03  -0.65903D+03   0.16697D+04   0.36903D+04   0.29959D-02
          4.300  -0.91010D-03   0.69246D-03   0.11970D-03  -0.64822D+03   0.16581D+04   0.36669D+04   0.29776D-02

   3   3  4.300  -0.91735D-03   0.69246D-03   0.11970D-03  -0.64822D+03   0.13240D+05   0.44302D+02   0.29776D-02   0.28416D+03
          4.310  -0.88737D-03   0.68876D-03   0.11970D-03  -0.61607D+03   0.13182D+05   0.56438D+02   0.29685D-02
          4.320  -0.85768D-03   0.68514D-03   0.11970D-03  -0.58419D+03   0.13125D+05   0.68483D+02   0.29598D-02
          4.330  -0.82826D-03   0.68162D-03   0.11970D-03  -0.55259D+03   0.13070D+05   0.80439D+02   0.29514D-02
          4.340  -0.79912D-03   0.67817D-03   0.11970D-03  -0.52127D+03   0.13016D+05   0.92307D+02   0.29433D-02
          4.350  -0.77026D-03   0.67481D-03   0.11970D-03  -0.49021D+03   0.12964D+05   0.10409D+03   0.29354D-02
          4.360  -0.74165D-03   0.67153D-03   0.11970D-03  -0.45941D+03   0.12913D+05   0.11579D+03   0.29279D-02
          4.370  -0.71331D-03   0.66832D-03   0.11970D-03  -0.42886D+03   0.12864D+05   0.12741D+03   0.29206D-02
          4.380  -0.68522D-03   0.66520D-03   0.11970D-03  -0.39857D+03   0.12816D+05   0.13894D+03   0.29136D-02
          4.390  -0.65738D-03   0.66216D-03   0.11970D-03  -0.36852D+03   0.12770D+05   0.15040D+03   0.29069D-02
          4.400  -0.62979D-03   0.65919D-03   0.11970D-03  -0.33871D+03   0.12725D+05   0.16178D+03   0.29004D-02

   4   2  4.400  -0.62296D-03   0.65919D-03   0.11970D-03  -0.33871D+03   0.17152D+04   0.36740D+04   0.29004D-02   0.20300D+05
          4.420  -0.61237D-03   0.65341D-03   0.11970D-03  -0.32944D+03   0.17066D+04   0.36564D+04   0.28881D-02
          4.440  -0.60194D-03   0.64773D-03   0.11970D-03  -0.32028D+03   0.16983D+04   0.36392D+04   0.28759D-02
          4.460  -0.59165D-03   0.64215D-03   0.11970D-03  -0.31125D+03   0.16901D+04   0.36223D+04   0.28640D-02
          4.480  -0.58150D-03   0.63667D-03   0.11970D-03  -0.30233D+03   0.16821D+04   0.36056D+04   0.28523D-02
          4.500  -0.57149D-03   0.63128D-03   0.11970D-03  -0.29353D+03   0.16742D+04   0.35893D+04   0.28407D-02
          4.520  -0.56162D-03   0.62598D-03   0.11970D-03  -0.28484D+03   0.16664D+04   0.35732D+04   0.28294D-02
          4.540  -0.55188D-03   0.62077D-03   0.11970D-03  -0.27626D+03   0.16588D+04   0.35575D+04   0.28183D-02
          4.560  -0.54228D-03   0.61564D-03   0.11970D-03  -0.26779D+03   0.16514D+04   0.35420D+04   0.28073D-02
          4.580  -0.53280D-03   0.61061D-03   0.11970D-03  -0.25943D+03   0.16441D+04   0.35268D+04   0.27966D-02
          4.600  -0.52346D-03   0.60566D-03   0.11970D-03  -0.25117D+03   0.16369D+04   0.35119D+04   0.27860D-02

   5   3  4.600  -0.52960D-03   0.60566D-03   0.11970D-03  -0.25117D+03   0.11720D+05   0.18243D+03   0.27860D-02   0.67634D+03
          4.610  -0.50566D-03   0.60322D-03   0.11970D-03  -0.22524D+03   0.11683D+05   0.19237D+03   0.27808D-02
          4.620  -0.48192D-03   0.60085D-03   0.11970D-03  -0.19950D+03   0.11648D+05   0.20225D+03   0.27759D-02
          4.630  -0.45836D-03   0.59853D-03   0.11970D-03  -0.17395D+03   0.11614D+05   0.21207D+03   0.27712D-02
          4.640  -0.43500D-03   0.59628D-03   0.11970D-03  -0.14858D+03   0.11581D+05   0.22184D+03   0.27667D-02
          4.650  -0.41181D-03   0.59409D-03   0.11970D-03  -0.12339D+03   0.11549D+05   0.23155D+03   0.27625D-02
          4.660  -0.38881D-03   0.59195D-03   0.11970D-03  -0.98373D+02   0.11518D+05   0.24120D+03   0.27585D-02
          4.670  -0.36598D-03   0.58988D-03   0.11970D-03  -0.73530D+02   0.11488D+05   0.25080D+03   0.27547D-02
          4.680  -0.34333D-03   0.58786D-03   0.11970D-03  -0.48855D+02   0.11460D+05   0.26035D+03   0.27512D-02
          4.690  -0.32084D-03   0.58590D-03   0.11970D-03  -0.24347D+02   0.11432D+05   0.26984D+03   0.27479D-02
          4.700  -0.29853D-03   0.58399D-03   0.11970D-03  -0.81428D-11   0.11405D+05   0.27928D+03   0.27448D-02
 STEP  DESCRIPTION          STRESS RATIO
    1    1000 psi                1.000
```

-->NewCAP<-- LAST MODIFIED 3JAN2020 VERSION 1a

Ver10b - Pressure (C=3.0)

RI= 4.0000 NL= 5 NMT= 3 NLS= 1 ISPL= 9 IPO= 0

* MATERIAL MODEL 2 - MULTI-LINEAR STRESS/STRAIN

MT	STRAIN1	STRESS1	STRAIN2	STRESS2	STRAIN3	STRESS3	STRAIN4	STRESS4	STRAIN5	STRESS5
1	0.2800D-02	0.2800D+05	0.5400D-02	0.4000D+05	0.3180D-01	0.4800D+05	0.0000D+00	0.0000D+00	0.0000D+00	0.0000D+00

MT	
1	0.1000D-04

* MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES

MT	EF1	EF2	VF12	VF23	GF12	GF23	EM	VF	GM
2	0.3200D+08	0.1000D+07	0.3200D+00	0.3200D+00	0.5000D+06	0.5000D+06	0.5000D+06	0.3500D+00	0.1800D+06
3	0.3200D+08	0.1000D+07	0.3200D+00	0.3200D+00	0.5000D+06	0.5000D+06	0.5000D+06	0.3500D+00	0.1800D+06

MT	ALP1	ALP2	ALP3	WA	FVF	VVF
2	0.1100D-05	0.5000D-05	0.5000D-05	0.3000D+02	0.6000D+00	0.3000D-01
3	0.1100D-05	0.5000D-05	0.5000D-05	0.9000D+02	0.6000D+00	0.3000D-01

LN	MT	TL	NODE	TEMP
1	1	0.1000	1	0.00
2	2	0.2000	2	0.00
3	3	0.1000	3	0.00
4	2	0.2000	4	0.00
5	3	0.1000	5	0.00
			6	0.00

STEP DESCRIPTION	PI	PO
1000 psi	1000.000	0.000

@ 1000 psi

LN	MT	R	EPR	EPH	EPM	SR	SH	SM	U	AF
1	1	4.000	-0.46785D-03	0.79827D-03	0.12004D-03	-0.10000D+04	0.87394D+04	0.35222D+04	0.31931D-02	0.89629D+04
		4.010	-0.46469D-03	0.79512D-03	0.12004D-03	-0.97574D+03	0.87151D+04	0.35222D+04	0.31884D-02	
		4.020	-0.46156D-03	0.79199D-03	0.12004D-03	-0.95167D+03	0.86911D+04	0.35222D+04	0.31838D-02	
		4.030	-0.45846D-03	0.78888D-03	0.12004D-03	-0.92777D+03	0.86672D+04	0.35222D+04	0.31792D-02	
		4.040	-0.45537D-03	0.78580D-03	0.12004D-03	-0.90405D+03	0.86434D+04	0.35222D+04	0.31746D-02	
		4.050	-0.45231D-03	0.78274D-03	0.12004D-03	-0.88050D+03	0.86199D+04	0.35222D+04	0.31701D-02	
		4.060	-0.44928D-03	0.77970D-03	0.12004D-03	-0.85713D+03	0.85965D+04	0.35222D+04	0.31656D-02	
		4.070	-0.44626D-03	0.77668D-03	0.12004D-03	-0.83393D+03	0.85733D+04	0.35222D+04	0.31611D-02	
		4.080	-0.44327D-03	0.77369D-03	0.12004D-03	-0.81090D+03	0.85503D+04	0.35222D+04	0.31567D-02	
		4.090	-0.44029D-03	0.77072D-03	0.12004D-03	-0.78804D+03	0.85274D+04	0.35222D+04	0.31522D-02	
		4.100	-0.43734D-03	0.76777D-03	0.12004D-03	-0.76535D+03	0.85047D+04	0.35222D+04	0.31479D-02	
2	2	4.100	-0.10009D-02	0.76777D-03	0.12004D-03	-0.76535D+03	0.18252D+04	0.39100D+04	0.31479D-02	0.19963D+05
		4.120	-0.98691D-03	0.75922D-03	0.12004D-03	-0.75281D+03	0.18115D+04	0.38833D+04	0.31280D-02	
		4.140	-0.97316D-03	0.75082D-03	0.12004D-03	-0.74045D+03	0.17980D+04	0.38572D+04	0.31084D-02	
		4.160	-0.95963D-03	0.74256D-03	0.12004D-03	-0.72828D+03	0.17848D+04	0.38315D+04	0.30890D-02	
		4.180	-0.94630D-03	0.73445D-03	0.12004D-03	-0.71629D+03	0.17718D+04	0.38063D+04	0.30700D-02	
		4.200	-0.93318D-03	0.72647D-03	0.12004D-03	-0.70447D+03	0.17590D+04	0.37816D+04	0.30512D-02	
		4.220	-0.92026D-03	0.71864D-03	0.12004D-03	-0.69282D+03	0.17465D+04	0.37573D+04	0.30327D-02	
		4.240	-0.90753D-03	0.71094D-03	0.12004D-03	-0.68135D+03	0.17342D+04	0.37334D+04	0.30144D-02	
		4.260	-0.89500D-03	0.70337D-03	0.12004D-03	-0.67004D+03	0.17221D+04	0.37099D+04	0.29964D-02	
		4.280	-0.88265D-03	0.69593D-03	0.12004D-03	-0.65888D+03	0.17103D+04	0.36869D+04	0.29786D-02	
		4.300	-0.87049D-03	0.68862D-03	0.12004D-03	-0.64789D+03	0.16986D+04	0.36642D+04	0.29611D-02	
3	3	4.300	-0.87526D-03	0.68862D-03	0.12004D-03	-0.64789D+03	0.13176D+05	0.62938D+02	0.29611D-02	0.33074D+03
		4.310	-0.84697D-03	0.68502D-03	0.12004D-03	-0.61588D+03	0.13120D+05	0.74748D+02	0.29524D-02	
		4.320	-0.81896D-03	0.68151D-03	0.12004D-03	-0.58415D+03	0.13064D+05	0.86469D+02	0.29441D-02	
		4.330	-0.79120D-03	0.67807D-03	0.12004D-03	-0.55269D+03	0.13010D+05	0.98106D+02	0.29361D-02	
		4.340	-0.76370D-03	0.67472D-03	0.12004D-03	-0.52150D+03	0.12958D+05	0.10966D+03	0.29283D-02	
		4.350	-0.73646D-03	0.67144D-03	0.12004D-03	-0.49057D+03	0.12907D+05	0.12113D+03	0.29208D-02	
		4.360	-0.70946D-03	0.66825D-03	0.12004D-03	-0.45990D+03	0.12857D+05	0.13252D+03	0.29136D-02	
		4.370	-0.68270D-03	0.66512D-03	0.12004D-03	-0.42948D+03	0.12809D+05	0.14383D+03	0.29066D-02	
		4.380	-0.65619D-03	0.66208D-03	0.12004D-03	-0.39931D+03	0.12762D+05	0.15506D+03	0.28999D-02	
		4.390	-0.62990D-03	0.65910D-03	0.12004D-03	-0.36938D+03	0.12717D+05	0.16622D+03	0.28935D-02	
		4.400	-0.60385D-03	0.65620D-03	0.12004D-03	-0.33969D+03	0.12673D+05	0.17730D+03	0.28873D-02	
4	2	4.400	-0.59935D-03	0.65620D-03	0.12004D-03	-0.33969D+03	0.17521D+04	0.36703D+04	0.28873D-02	0.20291D+05
		4.420	-0.58915D-03	0.65055D-03	0.12004D-03	-0.33025D+03	0.17435D+04	0.36532D+04	0.28754D-02	
		4.440	-0.57910D-03	0.64499D-03	0.12004D-03	-0.32093D+03	0.17350D+04	0.36364D+04	0.28637D-02	
		4.460	-0.56918D-03	0.63952D-03	0.12004D-03	-0.31172D+03	0.17267D+04	0.36199D+04	0.28523D-02	
		4.480	-0.55940D-03	0.63414D-03	0.12004D-03	-0.30264D+03	0.17186D+04	0.36036D+04	0.28410D-02	
		4.500	-0.54976D-03	0.62886D-03	0.12004D-03	-0.29368D+03	0.17106D+04	0.35877D+04	0.28299D-02	
		4.520	-0.54024D-03	0.62367D-03	0.12004D-03	-0.28483D+03	0.17027D+04	0.35720D+04	0.28190D-02	
		4.540	-0.53086D-03	0.61856D-03	0.12004D-03	-0.27609D+03	0.16950D+04	0.35566D+04	0.28083D-02	
		4.560	-0.52160D-03	0.61354D-03	0.12004D-03	-0.26746D+03	0.16875D+04	0.35415D+04	0.27977D-02	
		4.580	-0.51247D-03	0.60860D-03	0.12004D-03	-0.25894D+03	0.16801D+04	0.35267D+04	0.27874D-02	
		4.600	-0.50346D-03	0.60375D-03	0.12004D-03	-0.25052D+03	0.16728D+04	0.35121D+04	0.27772D-02	
5	3	4.600	-0.50752D-03	0.60375D-03	0.12004D-03	-0.25052D+03	0.11688D+05	0.19767D+03	0.27772D-02	0.71731D+03
		4.610	-0.48488D-03	0.60136D-03	0.12004D-03	-0.22466D+03	0.11652D+05	0.20737D+03	0.27723D-02	
		4.620	-0.46243D-03	0.59904D-03	0.12004D-03	-0.19899D+03	0.11618D+05	0.21700D+03	0.27675D-02	
		4.630	-0.44016D-03	0.59677D-03	0.12004D-03	-0.17351D+03	0.11584D+05	0.22658D+03	0.27630D-02	
		4.640	-0.41806D-03	0.59456D-03	0.12004D-03	-0.14821D+03	0.11551D+05	0.23610D+03	0.27587D-02	
		4.650	-0.39614D-03	0.59240D-03	0.12004D-03	-0.12308D+03	0.11520D+05	0.24557D+03	0.27547D-02	
		4.660	-0.37438D-03	0.59030D-03	0.12004D-03	-0.98128D+02	0.11489D+05	0.25498D+03	0.27508D-02	
		4.670	-0.35279D-03	0.58826D-03	0.12004D-03	-0.73347D+02	0.11460D+05	0.26434D+03	0.27472D-02	
		4.680	-0.33136D-03	0.58627D-03	0.12004D-03	-0.48734D+02	0.11431D+05	0.27365D+03	0.27438D-02	
		4.690	-0.31010D-03	0.58434D-03	0.12004D-03	-0.24286D+02	0.11404D+05	0.28291D+03	0.27406D-02	
		4.700	-0.28899D-03	0.58246D-03	0.12004D-03	-0.11227D-10	0.11377D+05	0.29212D+03	0.27376D-02	

STEP	DESCRIPTION	STRESS RATIO
1	1000 psi	1.000

```
   -->NewCAP<-- LAST MODIFIED 3JAN2020  VERSION 1a
               COPYRIGHT NEWHOUSE TECHNOLOGY LLC 1984, 2020



 Ver10c - Pressure (C=5.0)



 RI=  4.0000     NL=  5     NMT=  3     NLS=  1     ISPL=  9     IPO= 0



 * MATERIAL MODEL 2 - MULTI-LINEAR STRESS/STRAIN
 MT    STRAIN1      STRESS1      STRAIN2      STRESS2      STRAIN3      STRESS3      STRAIN4      STRESS4      STRAIN5      STRESS5

  1   0.2800D-02   0.2800D+05   0.5400D-02   0.4000D+05   0.3180D-01   0.4800D+05   0.0000D+00   0.0000D+00   0.0000D+00   0.0000D+00
   MT
  1   0.1000D-04


 * MATERIAL MODEL 4 - FIBER/RESIN PROPERTIES
 MT        EF1          EF2          VF12         VF23         GF12         GF23          EM           VF           GM

  2   0.3200D+08   0.1000D+07   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1800D+06
  3   0.3200D+08   0.1000D+07   0.3200D+00   0.3200D+00   0.5000D+06   0.5000D+06   0.5000D+06   0.3500D+00   0.1800D+06

 MT      ALP1         ALP2         ALP3         WA           FVF          VVF

  2   0.1100D-05   0.5000D-05   0.5000D-05   0.3000D+02   0.6000D+00   0.3000D-01
  3   0.1100D-05   0.5000D-05   0.5000D-05   0.9000D+02   0.6000D+00   0.3000D-01


   LN  MT   TL        NODE    TEMP

    1   1   0.1000       1  0.00
    2   2   0.2000       2  0.00
    3   3   0.1000       3  0.00
    4   2   0.2000       4  0.00
    5   3   0.1000       5  0.00
                         6  0.00

 STEP DESCRIPTION          PI          PO
 1000 psi               1000.000       0.000


@ 1000 psi
  LN  MT    R         EPR           EPH           EPM           SR            SH            SM            U             AF

    1   1  4.000  -0.47205D-03   0.80859D-03   0.11952D-03  -0.10000D+04   0.88511D+04   0.35505D+04   0.32344D-02   0.90350D+04
           4.010  -0.46886D-03   0.80540D-03   0.11952D-03  -0.97546D+03   0.88266D+04   0.35505D+04   0.32297D-02
           4.020  -0.46569D-03   0.80224D-03   0.11952D-03  -0.95111D+03   0.88022D+04   0.35505D+04   0.32250D-02
           4.030  -0.46255D-03   0.79910D-03   0.11952D-03  -0.92694D+03   0.87780D+04   0.35505D+04   0.32204D-02
           4.040  -0.45943D-03   0.79598D-03   0.11952D-03  -0.90295D+03   0.87540D+04   0.35505D+04   0.32157D-02
           4.050  -0.45634D-03   0.79288D-03   0.11952D-03  -0.87913D+03   0.87302D+04   0.35505D+04   0.32112D-02
           4.060  -0.45326D-03   0.78981D-03   0.11952D-03  -0.85549D+03   0.87066D+04   0.35505D+04   0.32066D-02
           4.070  -0.45021D-03   0.78676D-03   0.11952D-03  -0.83203D+03   0.86831D+04   0.35505D+04   0.32021D-02
           4.080  -0.44718D-03   0.78373D-03   0.11952D-03  -0.80873D+03   0.86598D+04   0.35505D+04   0.31976D-02
           4.090  -0.44418D-03   0.78072D-03   0.11952D-03  -0.78561D+03   0.86367D+04   0.35505D+04   0.31932D-02
           4.100  -0.44119D-03   0.77774D-03   0.11952D-03  -0.76266D+03   0.86138D+04   0.35505D+04   0.31887D-02

    2   2  4.100  -0.10759D-02   0.77774D-03   0.11952D-03  -0.76266D+03   0.17593D+04   0.39278D+04   0.31887D-02   0.20020D+05
           4.120  -0.10610D-02   0.76878D-03   0.11952D-03  -0.75045D+03   0.17456D+04   0.38997D+04   0.31674D-02
           4.140  -0.10463D-02   0.75997D-03   0.11952D-03  -0.73843D+03   0.17321D+04   0.38721D+04   0.31463D-02
           4.160  -0.10318D-02   0.75132D-03   0.11952D-03  -0.72658D+03   0.17189D+04   0.38450D+04   0.31255D-02
           4.180  -0.10176D-02   0.74283D-03   0.11952D-03  -0.71491D+03   0.17060D+04   0.38184D+04   0.31050D-02
           4.200  -0.10035D-02   0.73448D-03   0.11952D-03  -0.70341D+03   0.16932D+04   0.37923D+04   0.30848D-02
           4.220  -0.98972D-03   0.72627D-03   0.11952D-03  -0.69208D+03   0.16808D+04   0.37666D+04   0.30649D-02
           4.240  -0.97612D-03   0.71821D-03   0.11952D-03  -0.68092D+03   0.16685D+04   0.37414D+04   0.30452D-02
           4.260  -0.96273D-03   0.71029D-03   0.11952D-03  -0.66992D+03   0.16565D+04   0.37166D+04   0.30258D-02
           4.280  -0.94954D-03   0.70250D-03   0.11952D-03  -0.65907D+03   0.16447D+04   0.36923D+04   0.30067D-02
           4.300  -0.93655D-03   0.69485D-03   0.11952D-03  -0.64839D+03   0.16331D+04   0.36684D+04   0.29878D-02

    3   3  4.300  -0.94548D-03   0.69485D-03   0.11952D-03  -0.64839D+03   0.13280D+05   0.32632D+02   0.29878D-02   0.25497D+03
           4.310  -0.91435D-03   0.69108D-03   0.11952D-03  -0.61614D+03   0.13221D+05   0.44971D+02   0.29785D-02
           4.320  -0.88352D-03   0.68740D-03   0.11952D-03  -0.58418D+03   0.13163D+05   0.57217D+02   0.29696D-02
           4.330  -0.85298D-03   0.68381D-03   0.11952D-03  -0.55249D+03   0.13107D+05   0.69372D+02   0.29609D-02
           4.340  -0.82273D-03   0.68030D-03   0.11952D-03  -0.52108D+03   0.13052D+05   0.81436D+02   0.29525D-02
           4.350  -0.79276D-03   0.67688D-03   0.11952D-03  -0.48994D+03   0.12999D+05   0.93414D+02   0.29444D-02
           4.360  -0.76306D-03   0.67354D-03   0.11952D-03  -0.45906D+03   0.12948D+05   0.10531D+03   0.29366D-02
           4.370  -0.73364D-03   0.67029D-03   0.11952D-03  -0.42844D+03   0.12898D+05   0.11711D+03   0.29292D-02
           4.380  -0.70449D-03   0.66712D-03   0.11952D-03  -0.39807D+03   0.12849D+05   0.12884D+03   0.29220D-02
           4.390  -0.67559D-03   0.66402D-03   0.11952D-03  -0.36795D+03   0.12802D+05   0.14049D+03   0.29151D-02
           4.400  -0.64695D-03   0.66101D-03   0.11952D-03  -0.33807D+03   0.12756D+05   0.15205D+03   0.29085D-02

    4   2  4.400  -0.63854D-03   0.66101D-03   0.11952D-03  -0.33807D+03   0.16924D+04   0.36761D+04   0.29085D-02   0.20305D+05
           4.420  -0.62770D-03   0.65516D-03   0.11952D-03  -0.32890D+03   0.16839D+04   0.36583D+04   0.28958D-02
           4.440  -0.61700D-03   0.64940D-03   0.11952D-03  -0.31985D+03   0.16756D+04   0.36407D+04   0.28833D-02
           4.460  -0.60646D-03   0.64375D-03   0.11952D-03  -0.31092D+03   0.16675D+04   0.36235D+04   0.28711D-02
           4.480  -0.59606D-03   0.63819D-03   0.11952D-03  -0.30211D+03   0.16595D+04   0.36066D+04   0.28591D-02
           4.500  -0.58581D-03   0.63273D-03   0.11952D-03  -0.29341D+03   0.16517D+04   0.35901D+04   0.28473D-02
           4.520  -0.57570D-03   0.62736D-03   0.11952D-03  -0.28482D+03   0.16440D+04   0.35738D+04   0.28357D-02
           4.540  -0.56572D-03   0.62208D-03   0.11952D-03  -0.27634D+03   0.16365D+04   0.35578D+04   0.28242D-02
           4.560  -0.55588D-03   0.61689D-03   0.11952D-03  -0.26797D+03   0.16291D+04   0.35421D+04   0.28130D-02
           4.580  -0.54618D-03   0.61179D-03   0.11952D-03  -0.25970D+03   0.16219D+04   0.35266D+04   0.28020D-02
           4.600  -0.53660D-03   0.60678D-03   0.11952D-03  -0.25153D+03   0.16148D+04   0.35115D+04   0.27912D-02

    5   3  4.600  -0.54417D-03   0.60678D-03   0.11952D-03  -0.25153D+03   0.11738D+05   0.17287D+03   0.27912D-02   0.65060D+03
           4.610  -0.51935D-03   0.60431D-03   0.11952D-03  -0.22556D+03   0.11701D+05   0.18296D+03   0.27859D-02
           4.620  -0.49473D-03   0.60190D-03   0.11952D-03  -0.19979D+03   0.11666D+05   0.19299D+03   0.27808D-02
           4.630  -0.47030D-03   0.59956D-03   0.11952D-03  -0.17420D+03   0.11631D+05   0.20297D+03   0.27760D-02
           4.640  -0.44608D-03   0.59728D-03   0.11952D-03  -0.14879D+03   0.11598D+05   0.21288D+03   0.27714D-02
           4.650  -0.42204D-03   0.59506D-03   0.11952D-03  -0.12356D+03   0.11566D+05   0.22274D+03   0.27670D-02
           4.660  -0.39819D-03   0.59291D-03   0.11952D-03  -0.98511D+02   0.11535D+05   0.23254D+03   0.27629D-02
           4.670  -0.37452D-03   0.59081D-03   0.11952D-03  -0.73633D+02   0.11505D+05   0.24229D+03   0.27591D-02
           4.680  -0.35104D-03   0.58877D-03   0.11952D-03  -0.48924D+02   0.11476D+05   0.25198D+03   0.27554D-02
           4.690  -0.32773D-03   0.58679D-03   0.11952D-03  -0.24381D+02   0.11448D+05   0.26162D+03   0.27521D-02
           4.700  -0.30460D-03   0.58487D-03   0.11952D-03  -0.16982D-11   0.11421D+05   0.27120D+03   0.27489D-02
  STEP  DESCRIPTION          STRESS RATIO
    1    1000 psi                 1.000
```

```
Ver10c - Pressure (C=5.0)
4.,5,3,1,9,0
1,2
3
0.0028,28000.
0.0054,40000.
0.0318,48000.
10.0d-6
2,4
32.d6,1.d6,.32,.32,.5d6,.5d6
.5d6,.35,.18d6
1.1d-6,5d-6,5d-6
30,.6,.03
3,4
32.d6,1.d6,.32,.32,.5d6,.5d6
.5d6,.35,.18d6
1.1d-6,5d-6,5d-6
90,.6,.03
1,1,.1
2,2,.2
3,3,.1
4,2,.2
5,3,.1
1000 psi
1000.,0.
0,0,0,0,0,0
```

Annex E. Verification using Finite Element Analysis

Report – Task 2.2 Verification – Comparison with finite element analysis

Project Title: Composite Cylinder Stress Analysis Software Development and Validation

Project Period: 30 September 2018 – 29 September 2020

Date of Report: 9 June 2020

Contract Number: 693JK318C000008
Contractor: Newhouse Technology, LLC
Norman L. Newhouse, Ph.D., P.E.
Cell: 402-432-8700
6521 Perry Circle, Lincoln, NE 68516
newhousetech@windstream.net

Contract Specialist: Mr. Ben Patterson; Ben.Patterson@dot.gov
Contracting Officer's Representative: Ms. Andrea Smith; andrea.smith@dot.gov

Discussion: This report discusses comparison of NewCAP analysis vs. Finite Element Analysis (FEA) examples used to verify NewCAP. The analyses and review were conducted by Jim Harris, Managing Director of Hexagon MasterWorks, Inc., as a subcontractor to Newhouse Technology, LLC. The program ABAQUS was used for finite element analysis. The report from Jim Harris follows this discussion.

The analysis addresses a Type 3 cylinder, having a yielding metal liner, with a pressure load sequence, and a Type 4 cylinder, having a non-metallic liner, with a pressure loading sequence and a thermal loading.

A preliminary report of FEA verification was made at the Project Review for Tasks 1 and 2 held at DOT-PHMSA on 4 March 2020. At that time, it was noted that there were two anomalies to be addressed, and consideration was to be given to non-linear geometric analysis.

The first anomaly related to a "bookkeeping" error when dealing with sequential temperature levels when pressure was not applied. To address this, load steps were specifically identified, and the baseline for temperature loading was adjusted. Subsequent analysis confirmed the anomaly has been fixed.

The second anomaly related to a problem with the baseline condition at zero pressure after autofrettage. The problem was identified, and corrections made. Subsequent analysis confirmed that the anomaly has been fixed.

The results of NewCAP matched FEA results when linear geometric analysis was used. FEA also has the capability to do non-linear geometric analysis, accounting for added loading that occurs when the surface subjected to pressure load moves due to strain. The difference between linear and non-linear geometric analysis is small, particularly for the carbon fiber reinforced cylinders most commonly used in transportation service.

A methodology to address non-linear geometric analysis was incorporated, increasing the diameter as strain occurred, and iterating until convergence was achieved. This methodology did correctly calculate the resultant deflection, but it resulted in calculation of an incorrect internal pressure, and therefore incorrect radial stresses, when the deflections were substituted back into the computer solution. Therefore, to correctly address non-linear geometric analysis, a change to the fundamental model is required, which is outside the scope of the project.

An alternate approach will be considered for geometric nonlinearity, but continuing forward with a linear geometric model is appropriate at this time. There is some merit in using a linear geometric analysis, as this is how stresses are addressed in national and international standards. That is, stress ratios and burst ratios are defined in the standards, which are based on linear geometric analysis.

The attached report prepared by Jim Harris provides background information and explanation of the models. It provides comparative results between the NewCAP analysis and Finite Element Analysis.

The background and objectives are discussed on page 5, with description of the cylinders and load cases to be evaluated, and the general inputs to the models. Definitions are given on page 7.

Details of the NewCAP and FEA model definition are given on pages 9 through 13. Geometry, loading, and material properties are given. Details of the FEA model are also provided. The NewCAP and FEA results are presented on pages 16 through 20.

Case 1 is presented on page 16. This analysis is for a T4 cylinder with internal pressure load. The hoop strain difference was a maximum of 0.18%. The meridional strain difference was a maximum of 0.01%.

Case 2 is presented on page 17. This analysis is for a T4 cylinder with thermal load. The hoop strain difference was a maximum of 0.17%. The meridional strain difference was a maximum of 0.97%.

Case 3 is presented on pages 18 through 20. The hoop and meridional strains showed less than 1% difference between NewCAP and the FEA results at autofrettage, zero, service, proof, minimum burst, and rupture pressures. The graphs of liner hoop and meridional strain vs. pressure are plotted on pate 20. In the preliminary evaluation, the NewCAP analysis diverged from the FEA solution when increasing pressure from zero after autofrettage, essentially having an extended linear region before exhibiting yielding. The cause of the extended linear region was identified and corrected. The graphs on page 20 show that the NewCAP and FEA solutions now are consistent over the entire pressure cycle.

A summary and potential improvement are provided on page 22. In summary, it was noted that the structural analyses of the Type 3 and Type 4 cylinders using NewCAP and FEA differed by less than 1%, and therefore, NewCAP can be effectively used to design (and analyze) Type 3 and Type 4 cylinders. The potential improvement was to add capability for non-linear geometric effects. As discussed above, adding this capability would require reformulation of the solution, which is outside the scope of the project, and there are advantages to using a linear analysis.

Conclusion: Results from NewCAP have been verified by matching its results to that of a commercially available Finite Element Analysis program, ABAQUS. This leads to the conclusion that the NewCAP software program is accurate and running as expected.

NN NewCap
DOT Composite Tank Closed Form Solution vs FEA Review

HEXAGON

Hexagon MasterWorks, Inc.
Jim Harris
May 30, 2020

Revision log

Rev	Description	Date
A	Initial Release	All`
B	Updated NewCap results for Type III Case 3 analyses using a non-linear metallic material model for the liner	18-20, 22

Table of Contents

Table of Contents

Background & Objectives

Background:

- The NewCap software is a new Type III and Type IV composite pressure vessel tool based on a closed-form solid mechanics of materials solution. The graphical user interface is MS Excel which allows for ease of inputting the model definition, solving the model, and reviewing tabulated results.
- The Type III and Type IV model definition have the following inputs.
- The output results are tabulated for each load step and layer which are displacement, strain, and stress. In addition, the plotting graphical interface allows displaying strain and stress as a function of layer number, layer thickness, or radial location.

Type III & Type IV Model Definition Inputs
File Name
Number of Layers
Number of Material Types
Number of Load Steps
Intermediate Points per Layer
Material Definition per Layer
Thickness per Layer
Pressure Load and Thermal Load per Load Step

Objectives:

- Analyze a T3 composite pressure vessel and compare the results against a FEA model using an equivalent model definition with a pressure load.
- Analyze a T4 composite pressure vessel and compare the results against a FEA model using an equivalent model definition with a pressure load and a thermal load.

Table of Contents

Design Definitions

Definitions:

- Pressures:
  - Service Pressure: Operating Pressure
  - Proof/Test Pressure: Design proof pressure for the COPV
  - Autofrettage Pressure: Pressure at which COPV is autofrettaged
  - Minimum Burst Pressure: Minimum design COPV burst pressure
  - Rupture Pressure: Arbitrary pressure which is beyond burst pressure for determining the structural margin of safety for the estimated nominal burst pressure
  - AFR: Autofrettage Ratio, Ratio above cylinder proof pressure to reach autofrettage
  - BSF: Burst Safety Factor, multiplier of service pressure defining the minimum design burst pressure
  - PSF: Proof Safety Factor, multiplier of service pressure defining the proof pressure
- Applied Loads:
  - Internal Pressure and Thermal Temperature
- Material Models:
  - Metallic liner uses a piece-wise linear curve to define the non-linear elastic and plastic response
  - Composite material uses lamina layer properties which are transversely isotropic based on a hexagonal periodic structure formulation
- Strain and Stress Results
  - Radial, hoop, and meridional results are provided for each orthogonal direction
- Initial geometric inputs use a netting analysis to estimate the hoop and low angle helical thicknesses to be analyzed using the NewCap and FEA methods

Table of Contents

NEWCAP & FEA Model Definition

- The NewCap and FEA models assume a inner liner diameter, minimum liner thickness, liner minimum material properties, minimum lamina composite overwrap properties as a function of layer angle, and minimum composite layer thickness.

Input Data	Type III	Type IV
Liner Inner Radius (in)	3.312	3.312
Number of Layers	5	4
Number of Materials	3	2
Number of Intermediate Points	3	3
Material Definition & Thickness per Layer	Layer 1: Metallic, 0.032 in Layer 2: Composite 1, 0.015 in Layer 3: Composite 2, 0.020 in Layer 4: Composite 2, 0.020 in Layer 5: Composite 1, 0.015 in	Layer 1: Composite 1, 0.015 in Layer 2: Composite 2, 0.020 in Layer 3: Composite 2, 0.020 in Layer 4: Composite 1, 0.015 in
Pressure Load	Load Step 1: 4000 psi (autofrettage) Load Step 2: 0 psi Load Step 3: 2745 psi (service pressure) Load Step 4: 3431 psi (proof/test pressure) Load Step 5: 4400 psi (min burst pressure) Load Step 6: 6000 psi (rupture pressure)	Load Step 1: 3431 psi (proof/test pressure) Load Step 2: 0 psi Load Step 3: 2745 psi (service pressure) Load Step 4: 3431 psi (proof/test pressure) Load Step 5: 4400 psi (min burst pressure) Load Step 6: 6000 psi (rupture pressure)
Thermal Load (applied to the entire laminate)	Not Applicable	Load Step 1: 100 F Load Step 2: -100 F

NEWCAP & FEA Model Definition

HEXAGON

Metallic Liner and Composite Material Properties

- Al 6061-T6 Aluminum
  - 38.0ksi = sigma(yield), 44ksi = sigma(ultimate), 12% elongation
  - 10Msi = modulus, 0.33 = poisson's ratio
  - Piece-wise linear material response cure

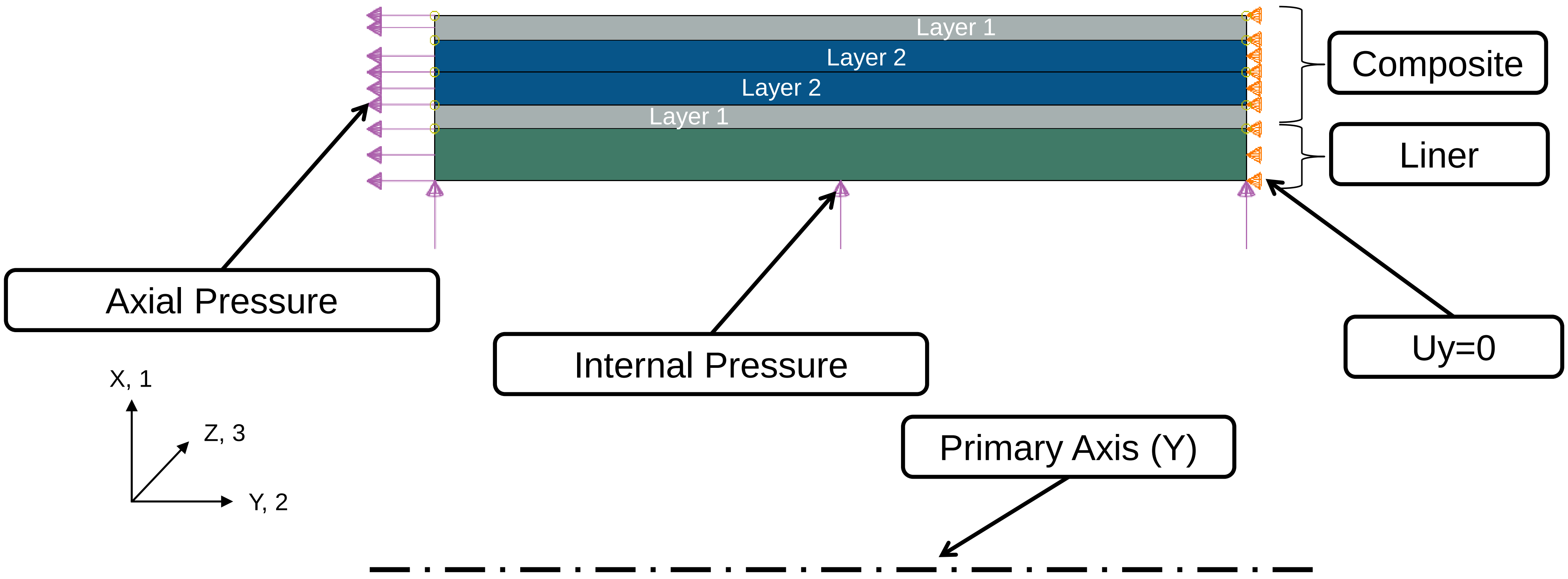
Data Point	Strain (in/in)	Stress (psi)
1	0.0038	38,000
2	0.1200	44,000

- Carbon Fiber/Epoxy
  - Layer 1, 90 degrees: 1.55Msi=E1, 1.55Msi=E2, 29.98Msi=E3, 0.014=Nu12, 0.014=Nu13, 0.404=Nu23, 8.73E-7 in/in=Alpha1, 5.10E-6 in/in=Alpha2, 4.88E-6 in/in=Alpha3
  - Layer 2, 11 degrees: 25.12Msi=E1, 1.57Msi=E2, 1.54Msi=E3, 0.031=Nu12, 0.395=Nu13, 0.819=Nu23, 5.00E-6 in/in=Alpha1, 5.00E-6 in/in=Alpha2, 1.10E-6 in/in=Alpha3

NEWCAP & FEA Model Definition

Type III Model Laminate

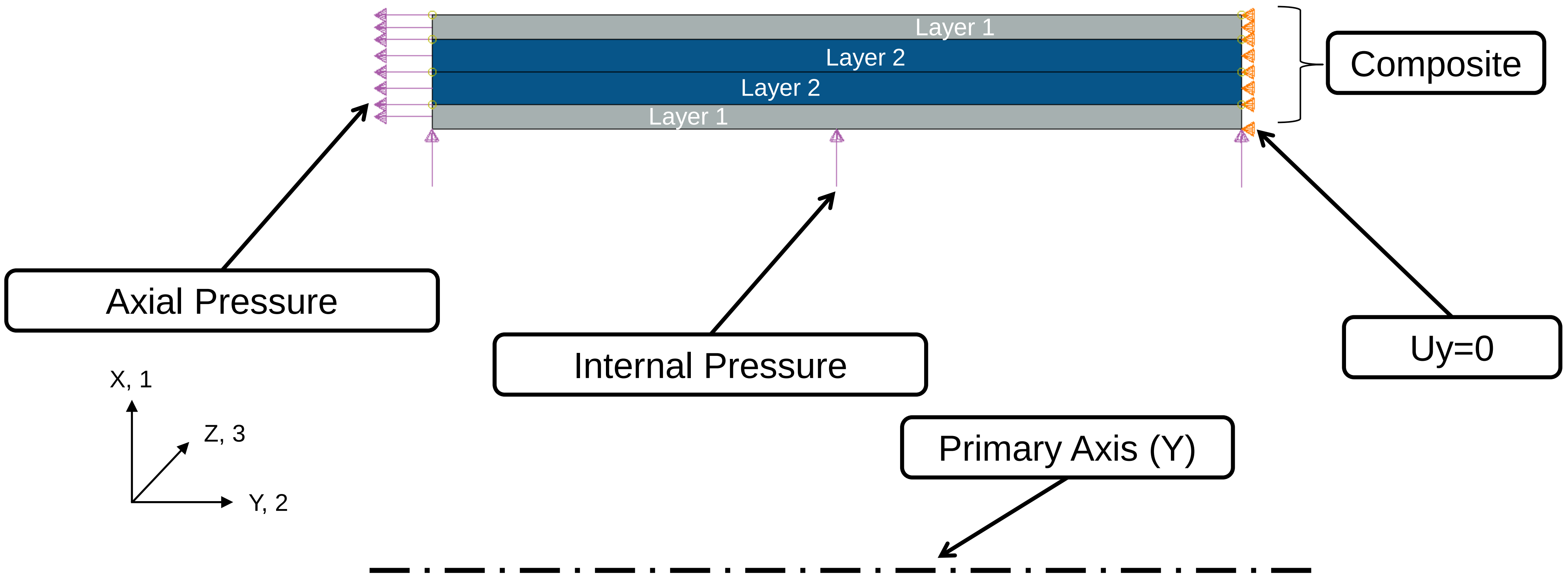
- Liner and Composite as one part instance
- Axisymmetric Model about the primary Y axis
- BC's: Uy constrained along the secondary axis of the sidewall thickness
- Loads: Internal pressure applied to the ID surface and axial pressure applied to the sidewall thickness



NEWCAP & FEA Model Definition

Type IV Model Laminate

- Composite as one part instance
- Axisymmetric Model about the primary Y axis
- BC's: Uy constrained along the secondary axis of the sidewall thickness
- Loads: Internal pressure applied to the ID surface and axial pressure applied to the sidewall thickness



NEWCAP & FEA Model Definition

Detailed FEA Model Definition

- ABAQUS finite element software used to compare result versus the NewCap software
- CAX4R element type (4-node bilinear axisymmetric quadrilateral, reduced integration, hourglass control) was used for both the Type III and Type IV composite pressure vessels
- Direct Sparse Solver used with linear displacement theory, material non-linearity, and without non-linear solver stabilization
- Number of elements is approximately 915 using a refined dense mesh (H-element) to accurately capture the stress and strain response .
- Analysis convergence was intrinsically verified using the Direct Sparse Solver without automatic stabilization.

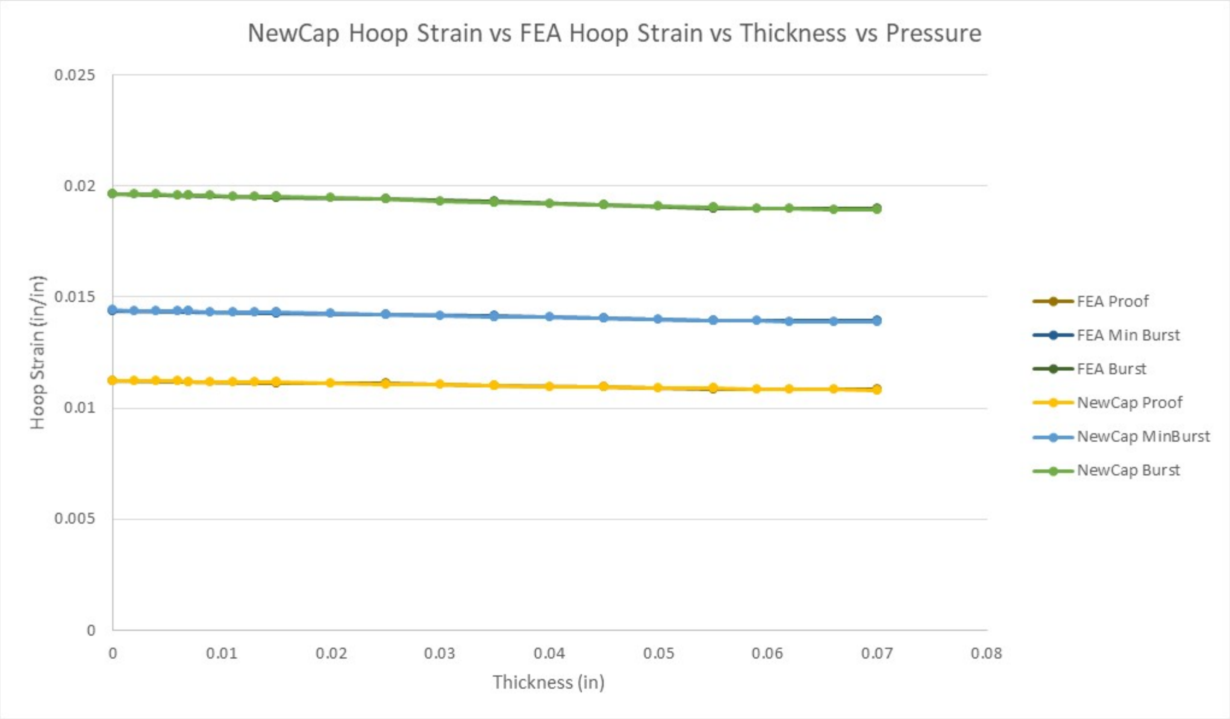
Table of Contents

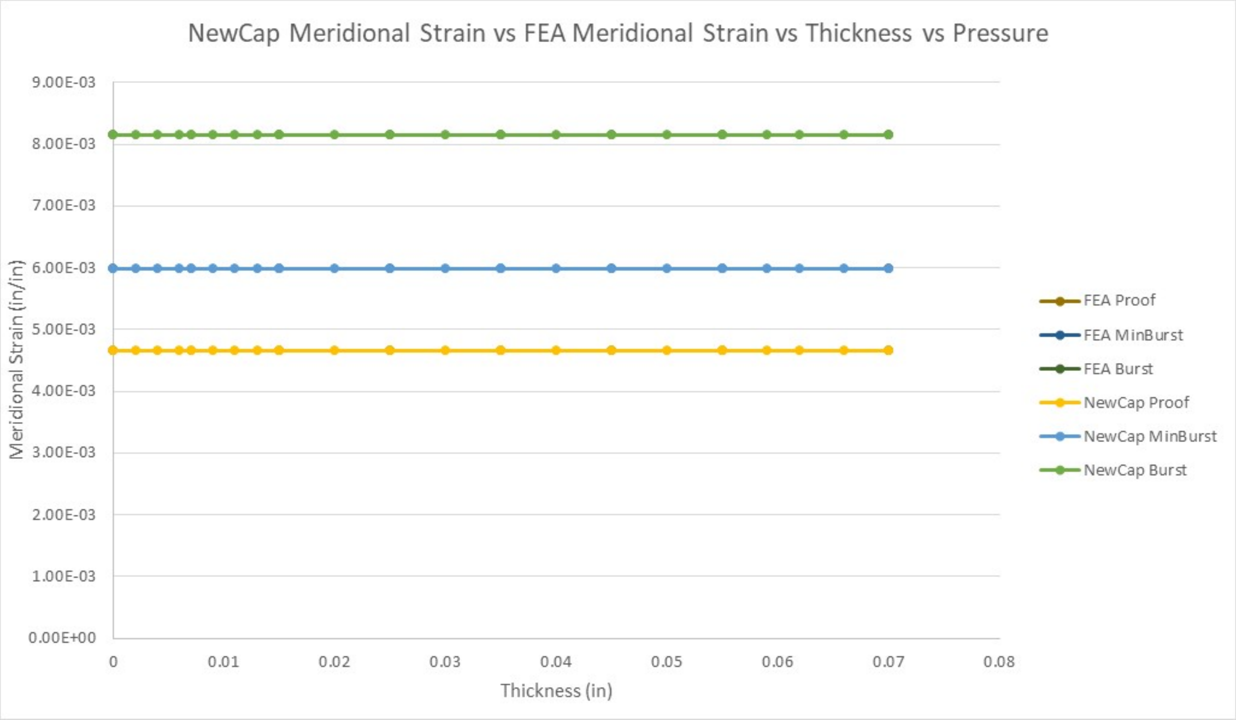
NEWCAP & FEA Results

- A total of 3 analysis cases were analyzed
    - Case 1: Type IV composite pressure vessel with an applied pressure load
    - Case 2: Type IV composite pressure vessel with an applied thermal load
    - Case 3: Type III composite pressure vessel with an applied pressure load

NEWCAP & FEA Results

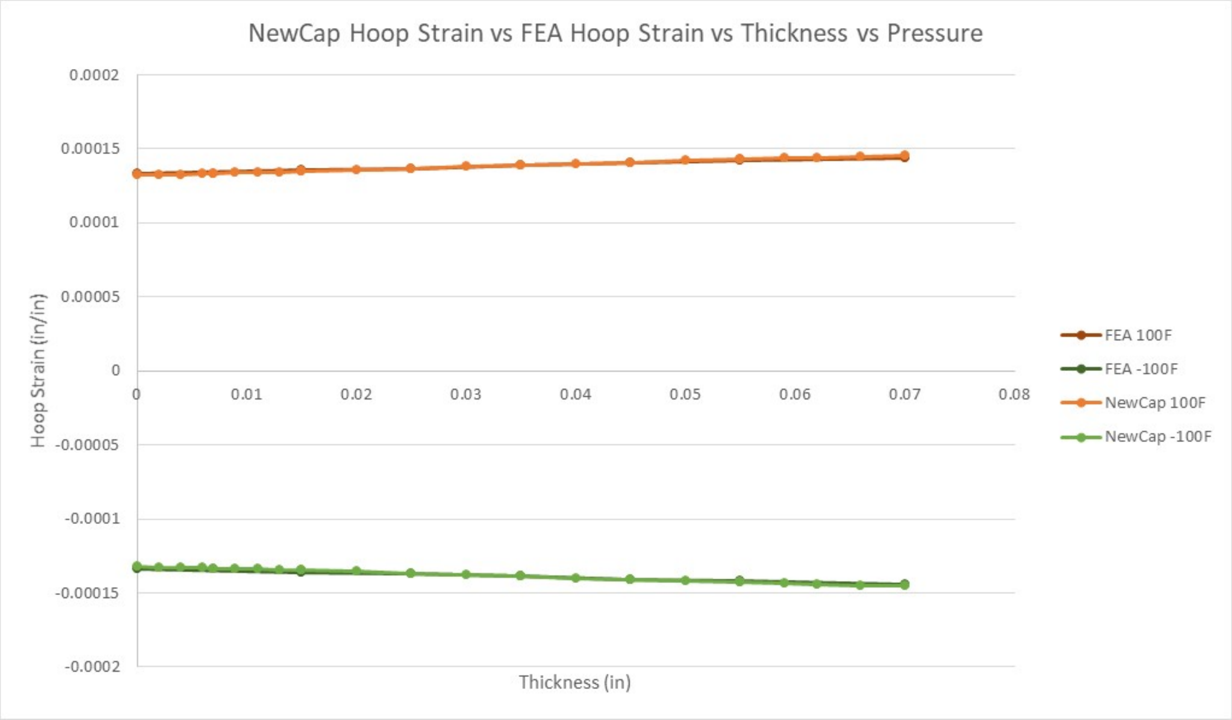
- CASE 1: NEWCAP vs FEA Results, T4 Tank Design with pressure load
  - The Hoop strain maximum percent difference at each of the pressures is 0.18%.
  - The Meridional strain maximum percent difference at each of the pressures is 0.01%.

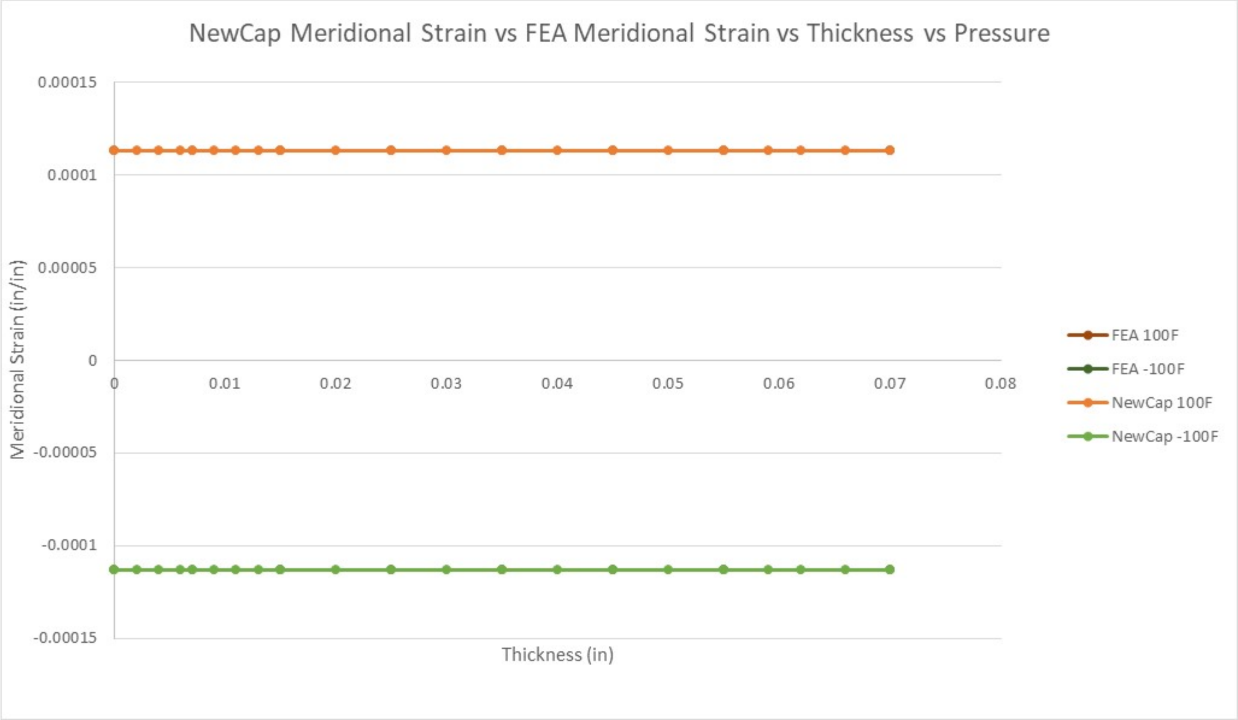




NEWCAP & FEA Results

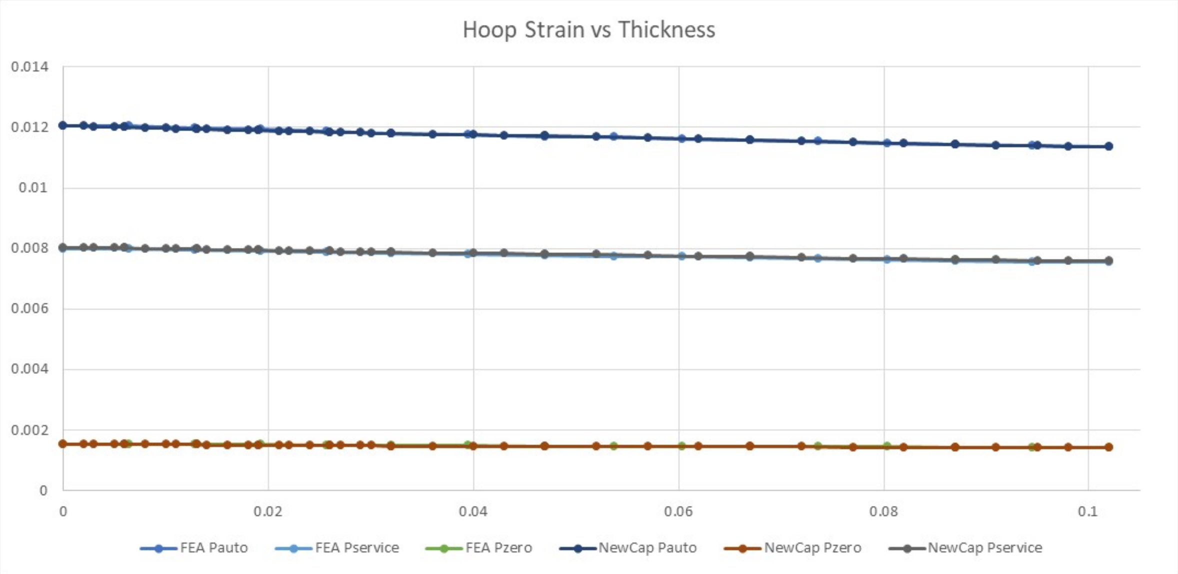
- CASE 2: NEWCAP vs FEA Results, T4 Tank Design with thermal load
  - The Hoop strain maximum percent difference at each of the pressures is 0.17%.
  - The Meridional strain maximum percent difference at each of the pressures is 0.97%.

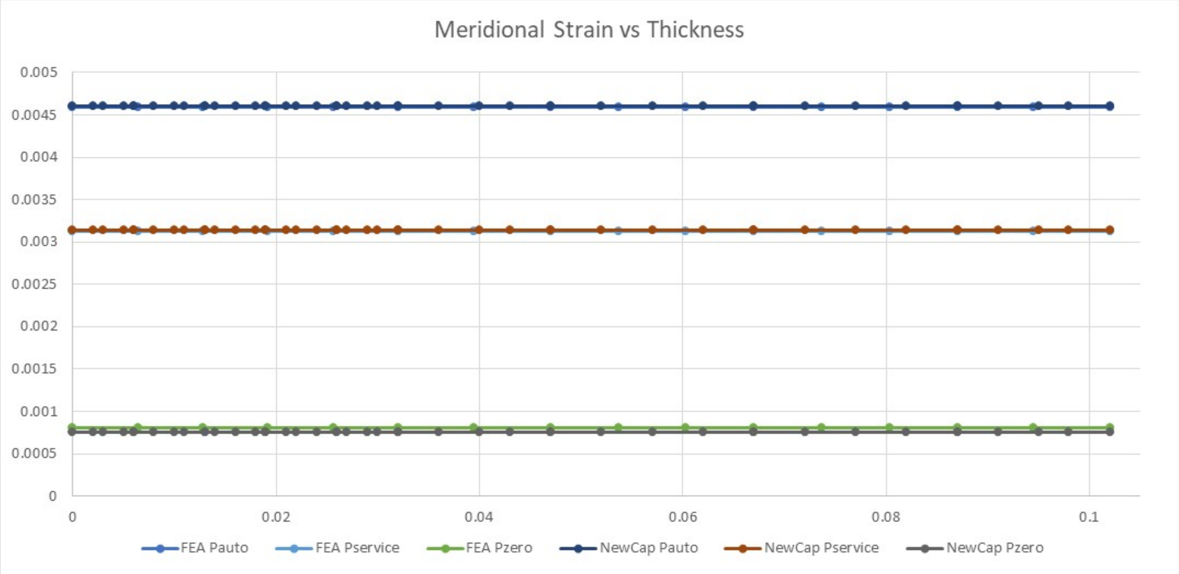




NEWCAP & FEA Results

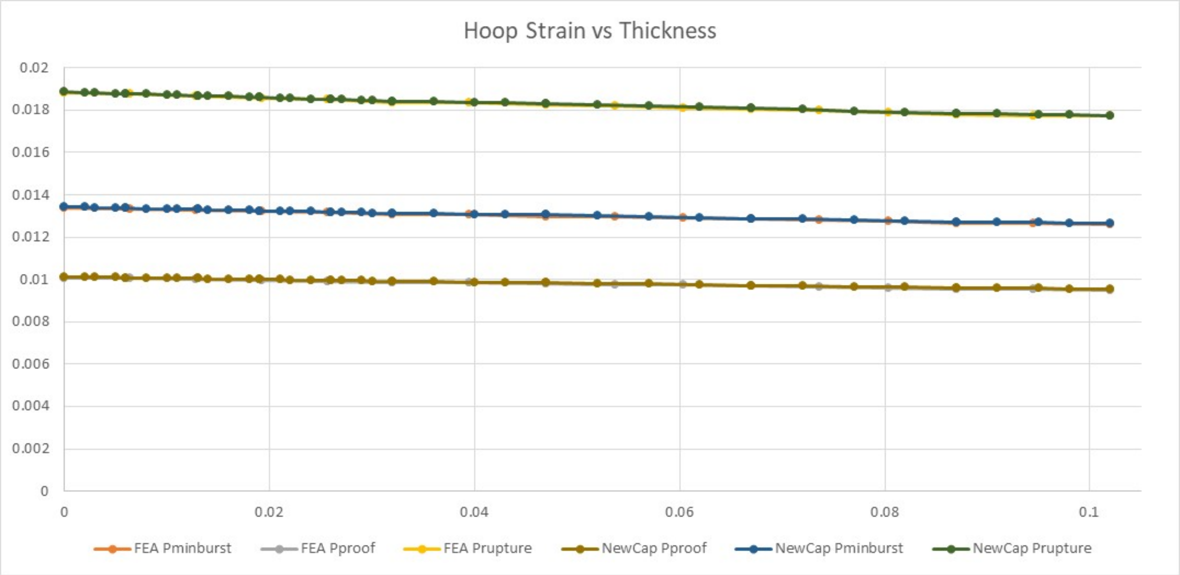
- CASE 3: NEWCAP vs FEA Results, T3 Tank Design with pressure load (Pauto, Pzero, and Pservice)
  - The Hoop strain maximum percent difference at each of the pressures is <1%.
  - The Meridional strain maximum percent difference at each of the pressures is <1%.

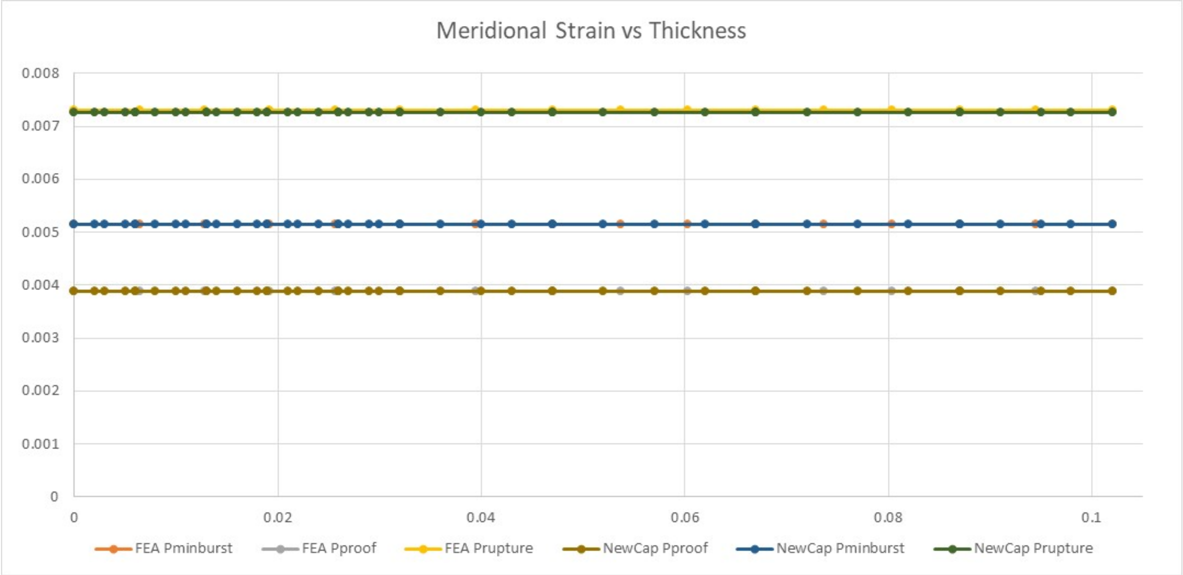




NEWCAP & FEA Results

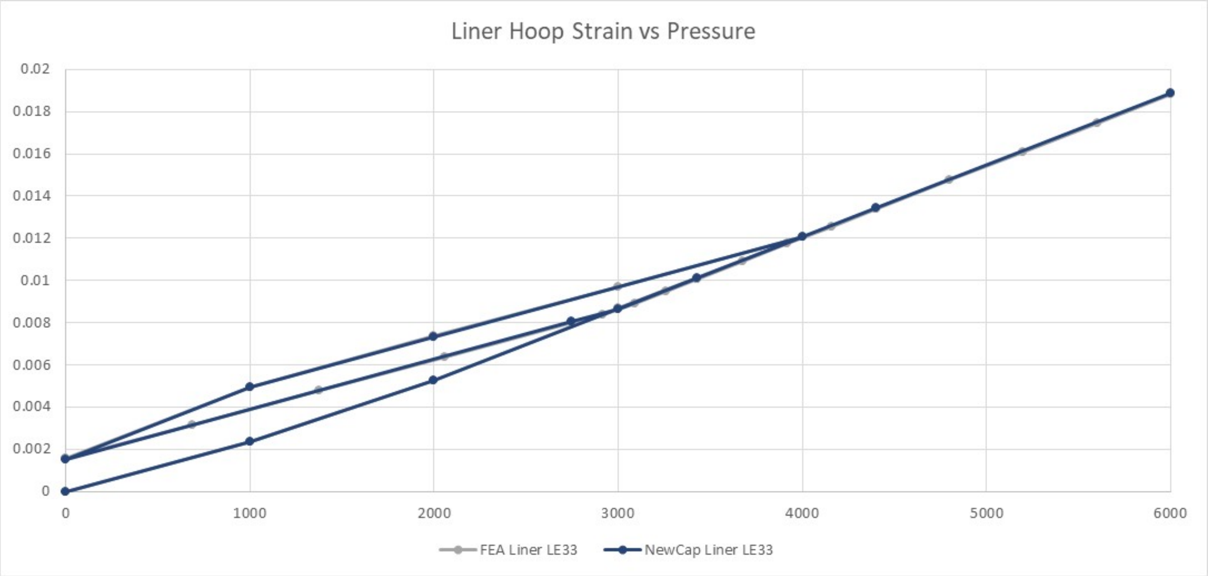
- CASE 3: NEWCAP vs FEA Results, T3 Tank Design with pressure load (Pproof, Pminburst, and Prupture)
  - The Hoop strain maximum percent difference at each of the pressures is <1%.
  - The Meridional strain maximum percent difference at each of the pressures is <1%.





NEWCAP & FEA Results

- CASE 3: NEWCAP vs FEA Results, T3 Tank Design with pressure load (entire load histogram)
  - The Hoop strain maximum percent difference at each of the pressures is <1%.
  - The Meridional strain maximum percent difference at each of the pressures is <1%.



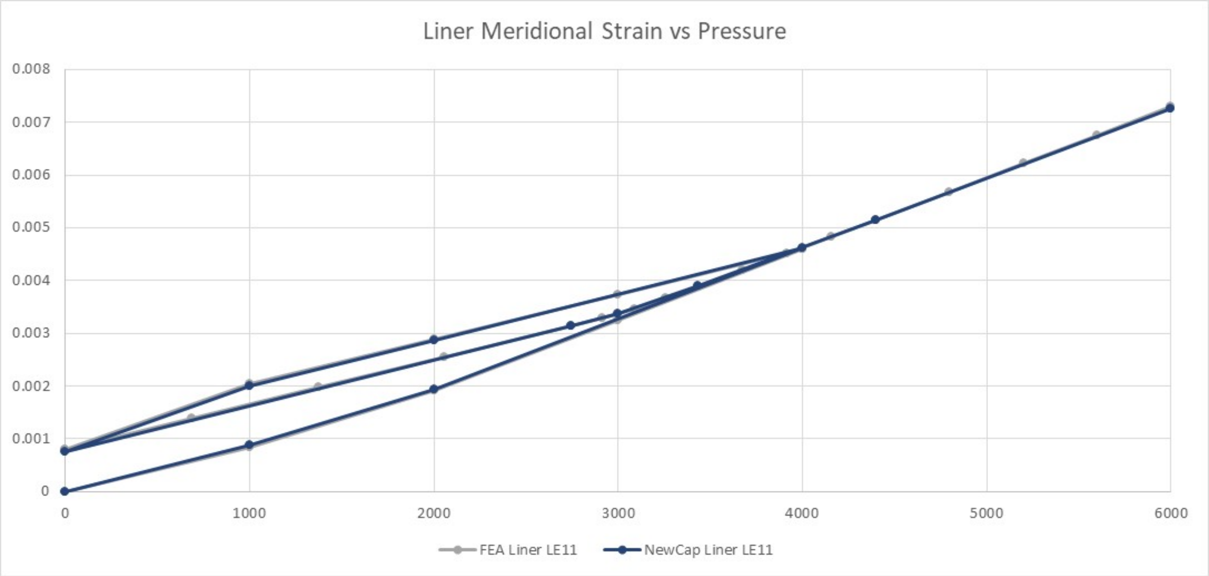


Table of Contents

Summary & Improvements

HEXAGON

Summary:

- The Type IV NewCap structural analyses (Case 1 pressure & Case 2 thermal) have less than a 1% difference relative to the FEA results. This demonstrates the NewCap linear elastic composite analyses can be effectively used to design Type IV composite pressure vessels.
- The Type III NewCap structural analyses (Case 3 pressure) have less than a 1% difference relative to the FEA results. This demonstrates the NewCap non-linear elastic-plastic liner material model and linear elastic composite material model can be effectively used to design Type III composite pressure vessels.

Improvements:

- Add the capability to account for non-linear geometric effects (ie large displacements). Rationale: Non-linear geometric effects will more accurately represent the strain and stress fields within the composite pressure vessel.

THANK YOU

Jim Harris

HEXAGON

Annex F. Validation

Report – Task 3 Validation

Project Title: Composite Cylinder Stress Analysis Software Development and Validation

Project Period: 30 September 2018 – 29 September 2020

Date of Report: 8 July 2020

Contract Number: 693JK318C000008
Contractor: Newhouse Technology, LLC
Norman L. Newhouse, Ph.D., P.E.
Cell: 402-432-8700
6521 Perry Circle, Lincoln, NE 68516
newhousetech@windstream.net

Contract Specialist: Mr. Ben Patterson; Ben.Patterson@dot.gov
Contracting Officer's Representative: Ms. Andrea Smith; andrea.smith@dot.gov

Discussion: This report discusses comparison of NewCAP analysis vs. strain gage measurements used to validate NewCAP. The analyses and measurements were conducted by, or under the direction of, Jim Harris, Managing Director of Hexagon MasterWorks, Inc., as a subcontractor to Newhouse Technology, LLC. The report from Jim Harris follows this discussion.

Five vessel designs were analyzed and tested. The vessels included two Type 3 cylinder designs with aluminum liners and three Type 4 cylinder designs with non-loadsharing liners. Details of these designs are in the attached report.

There are multiple hoop and axial strain gages used on each cylinder, located at different points on the cylinder. The different strain gages may give somewhat different measurements. This may reflect slight differences in the installation of the gages, such as precise orientation, slight differences in the local laminate quality, which could be due to localized fiber waviness, or differences in local strains, such as could result from thickness differences in a loadsharing liner or location near the juncture with the dome, which would induce bending discontinuities.

At some point, a gage may fail due to delaminating from the composite or exceeding the strain capability of the gage, particularly if the gage is installed perpendicular to the fiber direction of the outermost composite layer.

The liner material may respond somewhat differently than modeled by the analysis. There may be differences in the yield stress due to processing and heat treat of the liner. There may be kinematic or isotropic hardening of the liner, particularly if the liner had not been properly heat treated. However, most liners are a heat treatable material and are properly heat treated. It may be appropriate to adjust the yield point of the liner material properties to match the strain gage readings. This would be true whether NewCAP or Finite Element Analysis were used to analyze the design.

The first design is a Type 3 cylinder, with design definition and pressure loading up to 6000 psi detailed on slide 9. Slide 16 presents the strain gage measurements and predicted strains. The liner material model uses two linear segments to approximate the stress-strain curve. The analysis gives generally good correlation with the data for this design.

The hoop strains are well modelled up to the autofrettage pressure, and from autofrettage pressure to burst pressure. There is some divergence between autofrettage pressure and zero pressure, but the analysis results and strain gage measurements converge as they approach the service and autofrettage pressures. This shows that overall, the analysis of the yielding liner is consistent with the measured strain results. The analysis shows somewhat higher axial strains than strain gage measurements. Adjustment of the liner material model might improve correlation.

The second design is a Type 3 cylinder, with design definition and pressure loading up to 35,000 psi detailed on slide 10. Slide 17 presents the strain gage measurements and predicted strains. There is very good correlation between the NewCAP analysis and strain gage measurements for this model. The NewCAP analysis for hoop strain tracks very well with the strain gage measurements, particularly the hoop 1 gage. The analysis for axial strain tracks very well with the strain gage measurements, particularly the axial 2 gage, although this gage began to deteriorate above 15,000 psi.

The third design is a Type 4 cylinder, with design definition and pressure loading up to 5,500 psi detailed on slide 11. Slide 18 presents the strain gage measurements and predicted strains. The NewCAP analysis for both hoop and axial strains match very well with the strain gage measurements. It is noted that the hoop 1 gage shows some change in performance at 4000 psi, and the axial 2 gage began to deteriorate just below 2000 psi.

The fourth design is a Type 4 cylinder, with design definition and pressure loading up to 11,000 psi detailed on slide 12. Slide 19 presents the strain gage measurements and predicted strains. The NewCAP analysis for both hoop and axial strains match very well with the strain gage measurements. It is noted that the three axial strain gages show change in performance above about 5,500 psi.

The fifth design is a Type 4 cylinder with carbon and glass reinforcement, with design definition and pressure loading up to 5,500 psi detailed on slide 13. Slide 20 presents the strain gage measurements and predicted strains. Two cylinders were tested for this configuration, with two hoop and two axial strain gages on each cylinder. The NewCAP analysis for both hoop and axial strains match very well with the strain gage measurements.

Having strain measurements for two cylinders shows directly the benefits of testing multiple cylinders, and the benefits of using a verified and validated analysis. The NewCAP analysis calculates strains that are consistent with the hoop and axial strain measurements. Note that analysis matches very well with the hoop 1 gage on Test Unit 1, and with the hoop 2 and axial 1 gages on Test Unit 2. The other strain results are close, but different. The analysis, when validated against the average of multiple measures from multiple cylinders, will give more consistent results than gages on a single cylinder.

Conclusion: Results from NewCAP have been validated by comparing its calculation results to strain gage measurements and getting good correlation. This leads to the conclusion, particularly given the successful verification using closed form and finite element analysis, that the NewCAP software program is accurate and running as expected, and will be of benefit to DOT-PHMSA and the cylinder industry as a means to determine the stresses in a composite cylinder and verify that stress and stress ratio requirements have been met.

NN NewCap
DOT Composite Tank Closed Form Solution vs As-Built Test Data Review

HEXAGON

Hexagon MasterWorks, Inc.
Jim Harris
June 30, 2020

Revision log

Rev	Description	Date
A	Initial Release	All
B	Added the Type IV Hybrid Composite Strain Gage Results vs NewCap Results	13, 20 ,22

Table of Contents

Table of Contents

Background & Objectives

Background:

- The NewCap software is a new Type III and Type IV composite pressure vessel tool based on a closed-form solid mechanics of materials solution. The graphical user interface is MS Excel which allows for ease of inputting the model definition, solving the model, and reviewing tabulated results.
- The Type III and Type IV model definition have the following inputs.
- The output results are tabulated for each load step and layer which are displacement, strain, and stress. In addition, the plotting graphical interface allows displaying strain and stress as a function of layer number, layer thickness, or radial location.

Type III & Type IV Model Definition Inputs
File Name
Number of Layers
Number of Material Types
Number of Load Steps
Intermediate Points per Layer
Material Definition per Layer
Thickness per Layer
Pressure Load and Thermal Load per Load Step

Objectives:

- Analyze a T3 composite pressure vessel and compare the results against as-built strain gage data due to an autofrettage pressure load.
- Analyze a T4 composite pressure vessel and compare the results against as-built strain gage data due to a proof pressure load.
- Analyze a T4 hybrid composite pressure vessel and compare the results against as-built strain gage data due to a proof pressure load.

Table of Contents

Design Definitions

Definitions:

- Pressures:
  - Service Pressure: Operating Pressure
  - Proof/Test Pressure: Design proof pressure for the COPV
  - Autofrettage Pressure: Pressure at which COPV is autofrettaged
  - Minimum Burst Pressure: Minimum design COPV burst pressure
  - Rupture Pressure: Arbitrary pressure which is beyond burst pressure for determining the structural margin of safety for the estimated nominal burst pressure
  - AFR: Autofrettage Ratio, Ratio above cylinder proof pressure to reach autofrettage
  - BSF: Burst Safety Factor, multiplier of service pressure defining the minimum design burst pressure
  - PSF: Proof Safety Factor, multiplier of service pressure defining the proof pressure
- Applied Loads:
  - Internal Pressure
- Material Models:
  - Metallic liner uses a piece-wise linear curve to define the non-linear elastic and plastic response
  - Composite material uses lamina layer properties which are transversely isotropic based on a hexagonal periodic structure formulation
- Strain and Stress Results
  - Radial, hoop, and meridional results are provided for each orthogonal direction
- Initial geometric inputs use a netting analysis to estimate the hoop and low angle helical thicknesses to be analyzed using the NewCap and FEA methods
- The NewCap models assume a inner liner diameter, minimum liner thickness, liner minimum material properties, minimum lamina composite overwrap properties as a function of layer angle, and minimum composite layer thickness.

Design Definitions

- A total of 5 analysis models were created

Analysis Case	Description
1	Type III, Seamless Aluminum 6061-T6 Liner, 2745 psig operating pressure, 6.8” OD, All Carbon Composite Pressure Vessel
2	Type III, Seamless Aluminum 6061-T6 Liner, 10,000 psig operating pressure, 7.5” OD, All Carbon Composite Pressure Vessel
3	Type IV, Plastic Lined, 3600 psig operating pressure, 9.9” OD, All Carbon Composite Pressure Vessel
4	Type IV, Plastic Lined, 10,000 psig operating pressure, 27.7” OD, All Carbon Composite Pressure Vessel
5	Type IV, Plastic Lined, 3600 psig operating pressure, 13.7” OD, Hybrid Carbon & Eglass Composite Pressure Vessel

Design Definitions

HEXAGON

1. Type III, Seamless Aluminum 6061-T6 Liner, All Carbon Composite Pressure Vessel

Input Data	Type III (All Carbon Composite)
Liner Inner Radius (in)	3.312
Number of Layers	5
Number of Materials	3
Number of Intermediate Points	3
Material Definition & Thickness per Layer	Layer 1: Metallic, 0.032 in Layer 2: Composite 1, 0.015 in Layer 3: Composite 2, 0.020 in Layer 4: Composite 2, 0.020 in Layer 5: Composite 1, 0.015 in
Pressure Load	Load Step 1: 4000 psi (autofrettage) Load Step 2: 0 psi Load Step 3: 2745 psi (service pressure) Load Step 4: 3431 psi (proof/test pressure) Load Step 5: 4400 psi (min burst pressure) Load Step 6: 6000 psi (rupture pressure)

Metallic Liner and Composite Material Properties:

- Al 6061-T6 Aluminum
  - 38.0ksi = sigma(yield), 44ksi = sigma(ultimate), 12% elongation
  - 10Msi = modulus, 0.33 = poisson's ratio
  - Piece-wise linear material response cure

Data Point	Strain (in/in)	Stress (psi)
1	0.0038	38,000
2	0.1200	44,000

- Carbon Fiber/Epoxy
  - Layer 1, 90 degrees: 1.55Msi=E1, 1.55Msi=E2, 29.98Msi=E3, 0.014=Nu12, 0.014=Nu13, 0.404=Nu23
  - Layer 2, 11 degrees: 25.12Msi=E1, 1.57Msi=E2, 1.54Msi=E3, 0.031=Nu12, 0.395=Nu13, 0.819=Nu23

Design Definitions

2. Type III, Seamless Aluminum 6061-T6 Liner, All Carbon Composite Pressure Vessel

Input Data	Type III (All Carbon Composite)
Liner Inner Radius (in)	3.145
Number of Layers	22
Number of Materials	15
Number of Intermediate Points	3
Material Definition & Thickness per Layer	See Tabulated Data
Pressure Load	Load Step 1: 3500 psi Load Step 2: 7000 psi Load Step 3: 10,500 psi Load Step 4: 14,000 psi Load Step 5: 17,500 psi Load Step 6: 21,000 psi Load Step 7: 24,500 psi Load Step 8: 28,000 psi Load Step 9: 31,500 psi Load Step 10: 35,000 psi

Layer Number (LN)	Material Number (MT)	Material Description	Layer Thickness (TL) [inch]
1	1	Material 1, Liner	0.0160
2	2	Material 2, Liner	0.0160
3	3	Material 3, Liner	0.0160
4	4	Material 4, Liner	0.0160
5	5	Material 5, Liner	0.0160
6	6	Material 6, WA 90	0.0328
7	8	Material 8, WA 14.1	0.0317
8	7	Material 7, WA 80	0.0348
9	9	Material 9, WA 13.8	0.0320
10	7	Material 7, WA 80	0.0332
11	10	Material 10, WA 26.5	0.0321
12	7	Material 7, WA 80	0.0331
13	11	Material 11, WA 13.3	0.0316
14	7	Material 7, WA 80	0.0317
15	12	Material 12, WA 13	0.0319
16	7	Material 7, WA 80	0.0314
17	13	Material 13, WA 24.9	0.0318
18	7	Material 7, WA 80	0.0357
19	14	Material 14, WA 12.5	0.0316
20	7	Material 7, WA 80	0.0352
21	15	Material 15, WA 12.3	0.0319
22	6	Material 6, WA 90	0.0164

Metallic Liner and Composite Material Properties:

- Al 6061-T6 Aluminum
  - 38.0ksi = sigma(yield), 44ksi = sigma(ultimate), 12% elongation
  - 10Msi = modulus, 0.33 = poisson's ratio
  - Piece-wise linear material response cure

Data Point	Strain (in/in)	Stress (psi)
1	0.0038	38,000
2	0.1200	44,000

- Carbon Fiber
  - 33.4Msi=EF11, 2.23Msi=EF22, 0.22=Nu12, 0.91Msi=GF1, 0.58=VF
- Epoxy
  - 0.46Msi=EM, 0.35=NuM

Design Definitions

HEXAGON

3. Type IV, Plastic Lined, All Carbon Composite Pressure Vessel

Input Data	Type IV (All Carbon Composite)
Liner Inner Radius (in)	4.700
Number of Layers	13
Number of Materials	13
Number of Intermediate Points	3
Material Definition & Thickness per Layer	See Tabulated Data
Pressure Load	Load Step 1: 500 psi Load Step 2: 1000 psi Load Step 3: 1500 psi Load Step 4: 2000 psi Load Step 5: 2500 psi Load Step 6: 3000 psi Load Step 7: 3500 psi Load Step 8: 4000 psi Load Step 9: 4500 psi Load Step 10: 5000 psi Load Step 11: 5500 psi

Layer Number (LN)	Material Number (MT)	Material Description	Layer Thickness (TL) [inch]
1	1	Material 1, WA 77.2	0.0165
2	2	Material 2, WA 74.2	0.0165
3	3	Material 3, WA 15.3	0.0206
4	4	Material 4, WA 71.6	0.0165
5	5	Material 5, WA 15.1	0.0206
6	6	Material 6, WA 74.5	0.0165
7	7	Material 7, WA 25.8	0.0206
8	8	Material 8, WA 77.6	0.0165
9	9	Material 9, WA 14.9	0.0206
10	10	Material 10, WA 81.2	0.0165
11	11	Material 11, WA 14.8	0.0206
12	12	Material 12, WA 82	0.0165
13	13	Material 13, WA 88.3	0.0165

Composite Material Properties:

- Carbon Fiber
  - 33.4Msi=EF11, 2.23Msi=EF22, 0.22=Nu12, 0.91Msi=GF12, 0.58=VF
- Epoxy
  - 0.46Msi=EM, 0.35=NuM

Design Definitions

4. Type IV, Plastic Lined, All Carbon Composite Pressure Vessel

Input Data	Type IV (All Carbon Composite)
Liner Inner Radius (in)	12.200
Number of Layers	47
Number of Materials	20
Number of Intermediate Points	3
Material Definition & Thickness per Layer	See Tabulated Data
Pressure Load	Load Step 1: 100 psi Load Step 2: 2000 psi Load Step 3: 3000 psi Load Step 4: 4000 psi Load Step 5: 5000 psi Load Step 6: 6000 psi Load Step 7: 7000 psi Load Step 8: 8000 psi Load Step 9: 9000 psi Load Step 10: 10,000 psi Load Step 11: 11,000 psi

Layer Number (LN)	Material Number (MT)	Material Description	Layer Thickness (TL) [inch]
1	1	Material 1	0.0386
2	2	Material 2	0.0385
3	3	Material 3	0.0375
4	4	Material 4	0.0377
5	5	Material 5	0.0349
6	6	Material 6	0.0347
7	7	Material 7	0.0349
8	8	Material 8	0.0348
9	9	Material 9	0.0347
10	10	Material 10	0.0348
11	11	Material 11	0.0375
12	12	Material 12	0.0378
13	13	Material 13	0.0349
14	14	Material 14	0.0349
15	15	Material 15	0.0348
16	16	Material 16	0.0348
17	17	Material 17	0.0348
18	10	Material 10	0.0348
19	18	Material 18	0.0379
20	19	Material 19	0.0381
21	20	Material 20	0.0347
22	21	Material 21	0.0348
23	22	Material 22	0.0348
24	23	Material 23	0.0347
25	24	Material 24	0.0348
26	10	Material 10	0.0174
27	25	Material 25	0.0374
28	26	Material 26	0.0374
29	27	Material 27	0.0349
30	27	Material 27	0.0348
31	27	Material 27	0.0347
32	28	Material 28	0.0350
33	29	Material 29	0.0348
34	10	Material 10	0.0175
35	30	Material 30	0.0374
36	31	Material 31	0.0375
37	32	Material 32	0.0348
38	32	Material 32	0.0347
39	33	Material 33	0.0349
40	34	Material 34	0.0347
41	35	Material 35	0.0349
42	36	Material 36	0.0375
43	37	Material 37	0.0373
44	38	Material 38	0.0380
45	39	Material 39	0.0382
46	40	Material 40	0.0378
47	35	Material 35	0.0349

Composite Material Properties:

- Carbon Fiber
  - 33.4Msi=EF11, 2.23Msi=EF22, 0.22=Nu12, 0.91Msi=GF12, 0.58=VF
- Epoxy
  - 0.46Msi=EM, 0.35=NuM

Design Definitions

HEXAGON

4. Type IV, Plastic Lined, Hybrid Carbon & Eglass Composite Pressure Vessel

Input Data	Type IV (Hybrid Carbon & Eglass Composite)
Liner Inner Radius (in)	6.305
Number of Layers	19
Number of Materials	10
Number of Intermediate Points	3
Material Definition & Thickness per Layer	See Tabulated Data
Pressure Load	Load Step 1: 500 psi Load Step 2: 1000 psi Load Step 3: 1500 psi Load Step 4: 2000 psi Load Step 5: 2500 psi Load Step 6: 3000 psi Load Step 7: 3500 psi Load Step 8: 4000 psi Load Step 9: 4500 psi Load Step 10: 5000 psi Load Step 11: 5500 psi

Layer Number (LN)	Material Number (MT)	Material Description	Layer Thickness (TL) [inch]
1	1	Layer 1 CF/GL	0.0292
2	1	Layer 1 CF/GL	0.0290
3	2	Layer 2 CF/GL	0.0292
4	1	Layer 1 CF/GL	0.0288
5	2	Layer 2 CF/GL	0.0289
6	1	Layer 1 CF/GL	0.0285
7	3	Layer 3 CF/GL	0.0293
8	4	Layer 4 CF/GL	0.0286
9	5	Layer 5 CF/GL	0.0295
10	4	Layer 4 CF/GL	0.0283
11	2	Layer 2 CF/GL	0.0293
12	1	Layer 1 CF/GL	0.0278
13	6	Layer 6 CF/GL	0.0299
14	1	Layer 1 CF/GL	0.0275
15	2	Layer 2 CF/GL	0.0288
16	7	Layer 7 CF/GL	0.0137
17	8	Layer 8 GL	0.0288
18	9	Layer 9 GL	0.0292
19	10	Layer 10 GL	0.0261

Composite Material Properties:

- Carbon & Eglass Fiber
  - 26.6Msi=EF11, 3.01Msi=EF22, 0.21=Nu12, 1.70Msi=GF12, 0.58=VF
- Eglass Fiber
  - 1.2Msi=EF11=EF22, 0.22=Nu12 4.93Msi=GF12, 0.58=VF
- Epoxy
  - 0.46Msi=EM, 0.35=NuM

Table of Contents

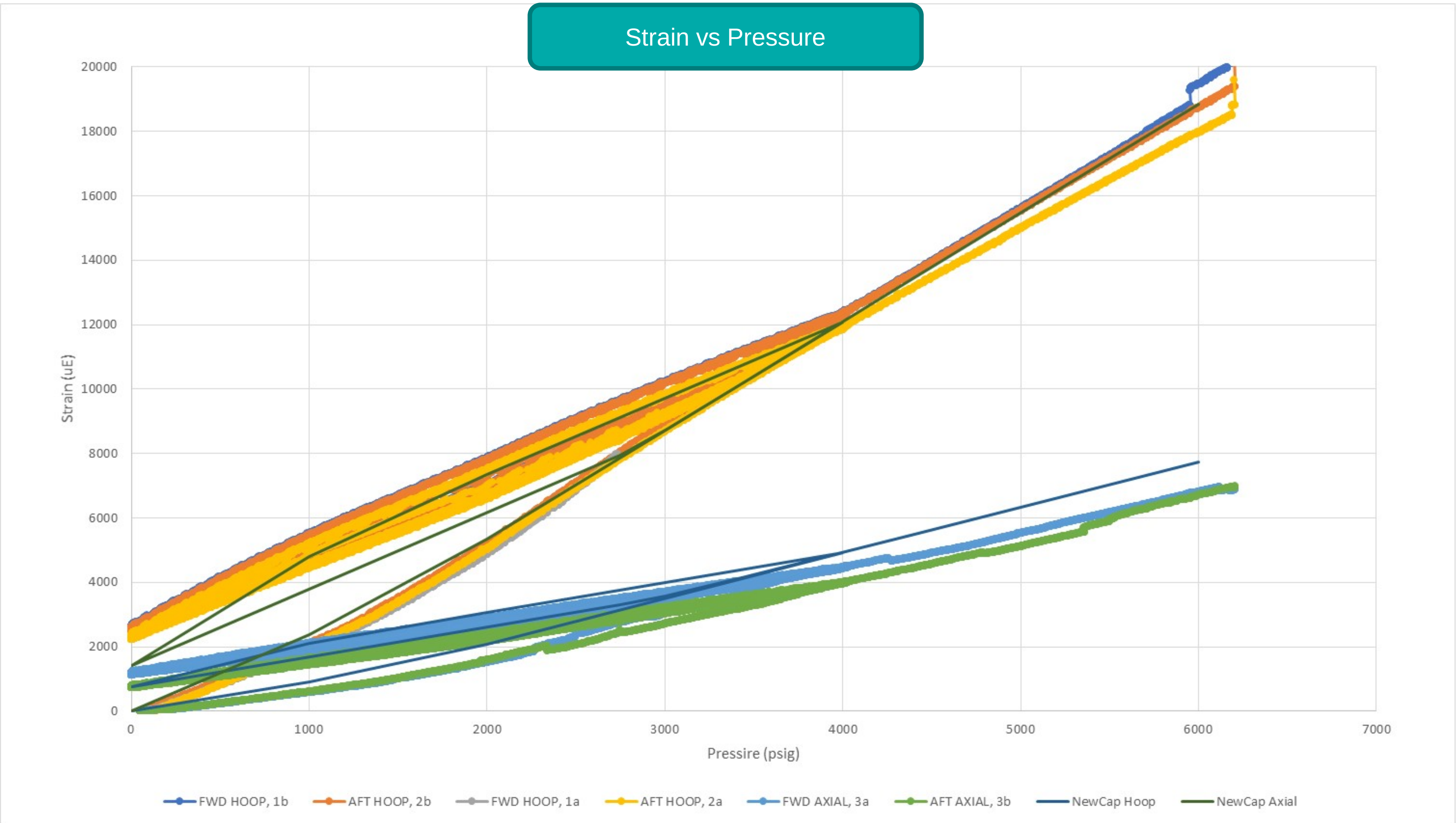
NEWCAP & FEA Results

- A total of 5 analysis cases were analyzed

Analysis Case	Description
1	Type III, Seamless Aluminum 6061-T6 Liner, 2745 psig operating pressure, 6.8” OD, All Carbon Composite Pressure Vessel
2	Type III, Seamless Aluminum 6061-T6 Liner, 10,000 psig operating pressure, 7.5” OD, All Carbon Composite Pressure Vessel
3	Type IV, Plastic Lined, 3600 psig operating pressure, 9.9” OD, All Carbon Composite Pressure Vessel
4	Type IV, Plastic Lined, 10,000 psig operating pressure, 27.7” OD, All Carbon Composite Pressure Vessel
5	Type IV, Plastic Lined, 3600 psig operating pressure, 13.7” OD, Hybrid Carbon & Eglass Composite Pressure Vessel

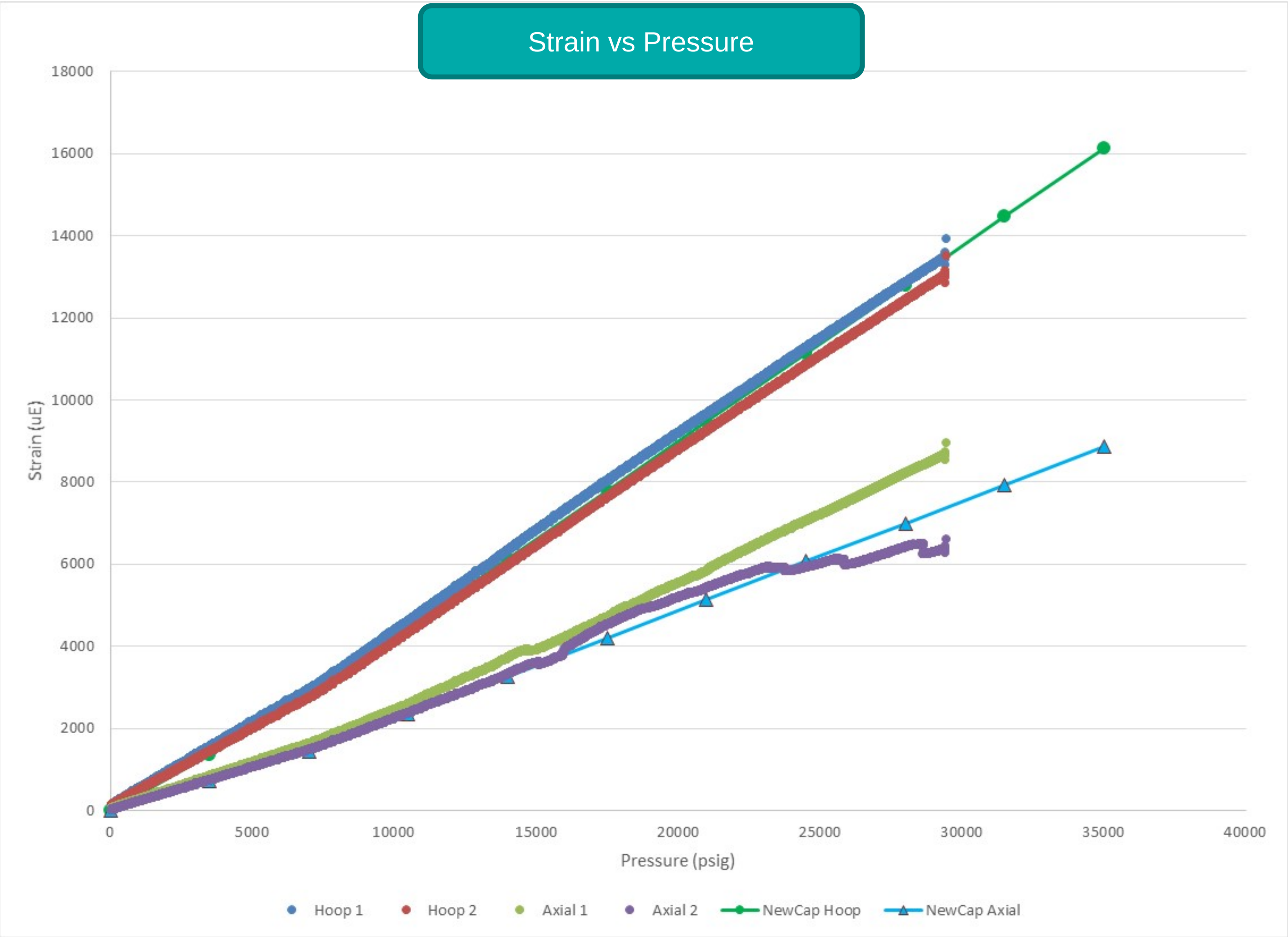
NEWCAP vs As-Built Test Data Results

CASE 1: Type III, Seamless Aluminum 6061-T6 Liner, 2745 psig operating pressure, 6.8” OD, All Carbon Composite Pressure Vessel



NEWCAP vs As-Built Test Data Results

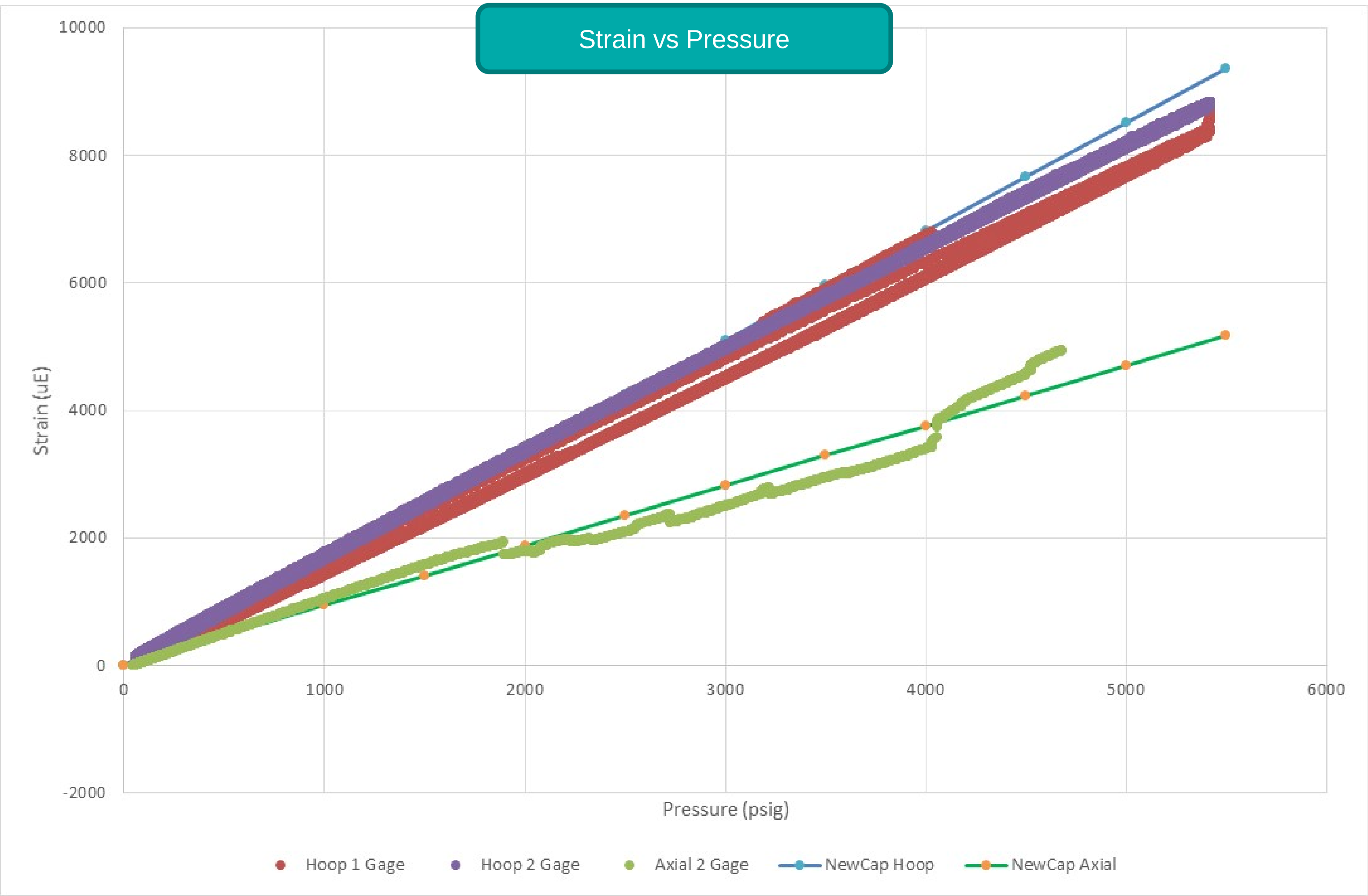
CASE 2: Type III, Seamless Aluminum 6061-T6 Liner, 10,000 psig operating pressure, 7.5” OD, All Carbon Composite Pressure Vessel



NEWCAP vs As-Built Test Data Results

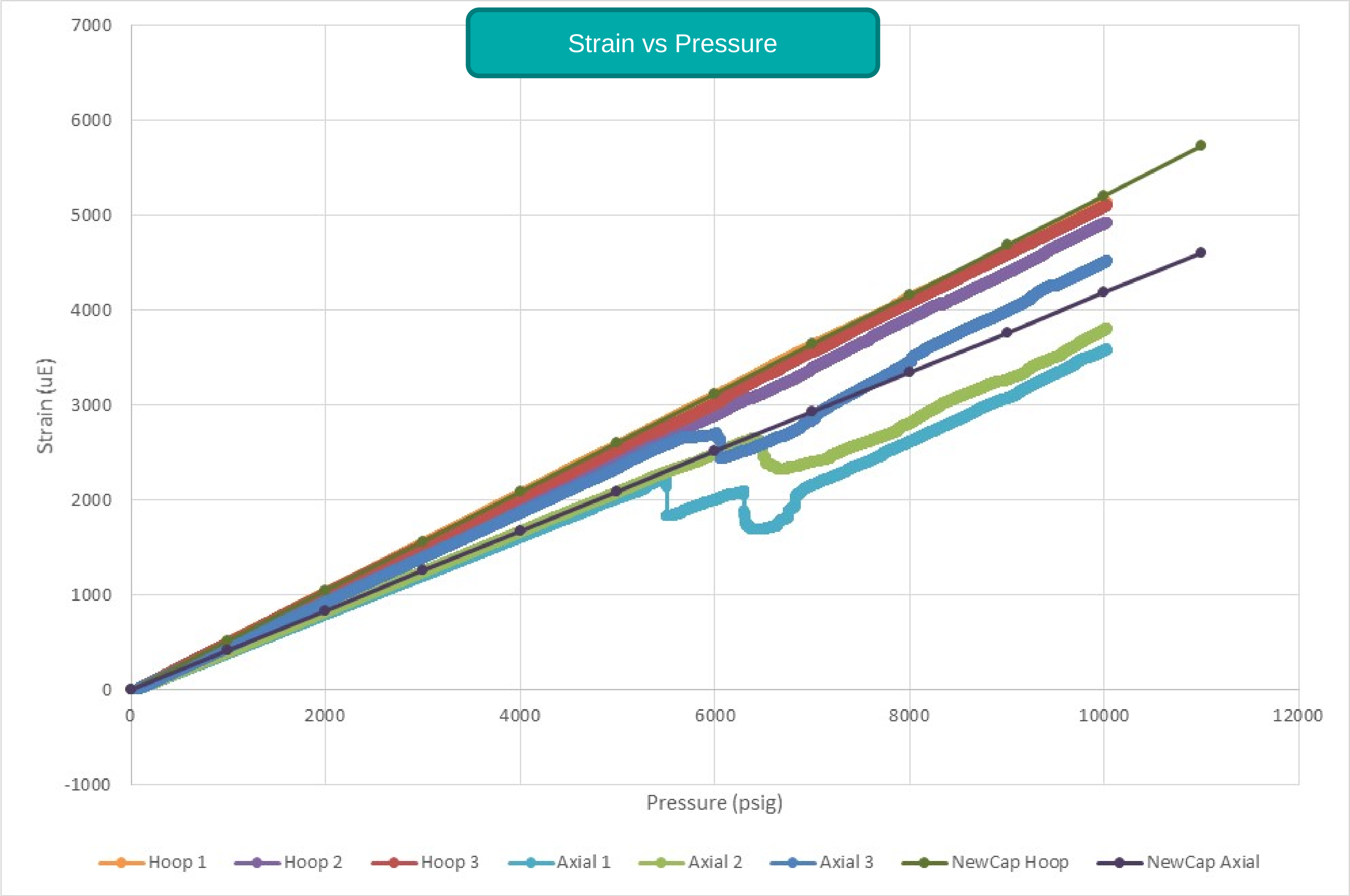
HEXAGON

CASE 3: Type IV, Plastic Lined, 3600 psig operating pressure, 9.9” OD, All Carbon Composite Pressure Vessel



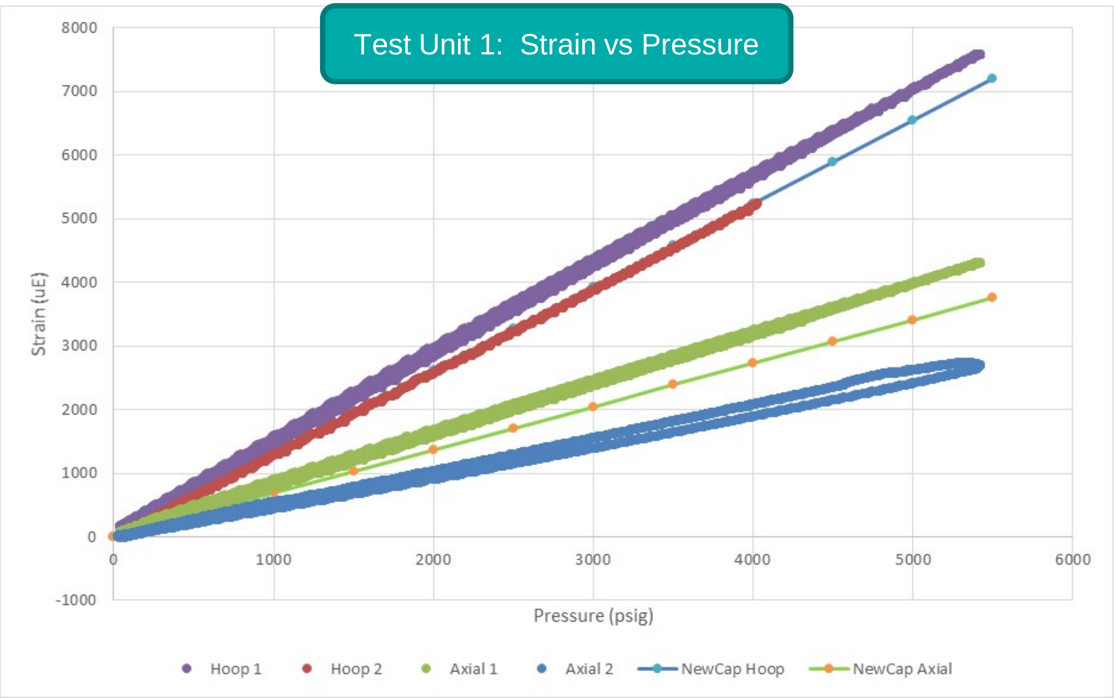
NEWCAP vs As-Built Test Data Results

CASE 4: Type IV, Plastic Lined, 10,000 psig operating pressure, 27.7” OD, All Carbon Composite Pressure Vessel



NEWCAP vs As-Built Test Data Results

CASE 5: Type IV, Plastic Lined, 3600 psig operating pressure, 13.7” OD, Hybrid Carbon & Eglass Composite Pressure Vessel



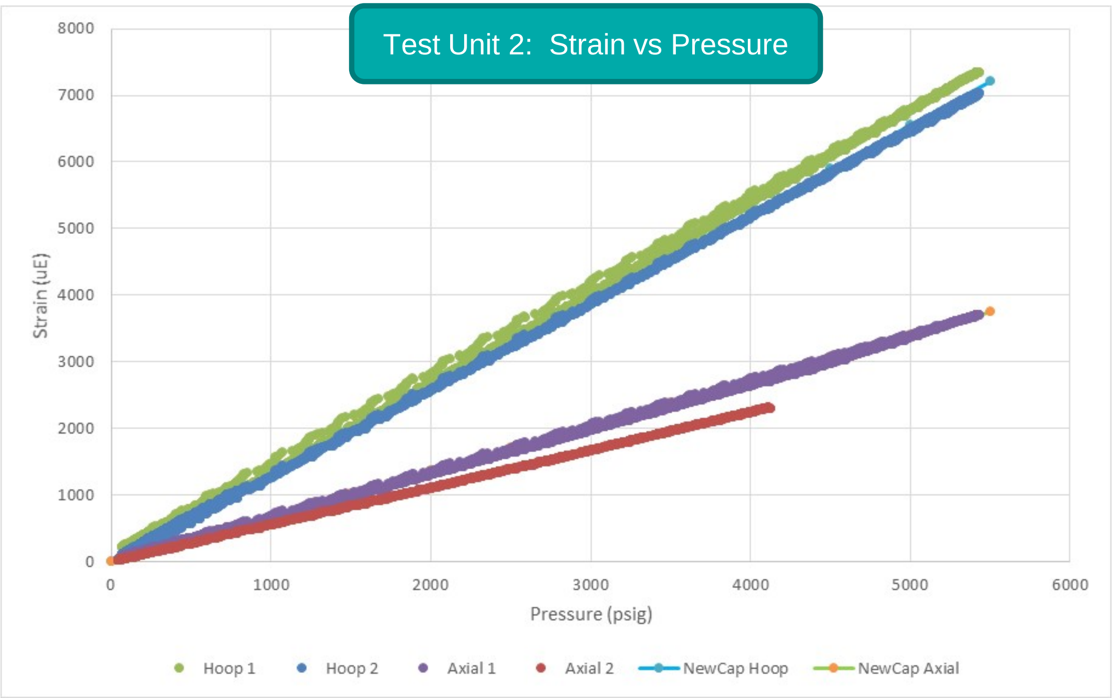


Table of Contents

Summary & Improvements

HEXAGON

Summary:

- Both Type III All Carbon Fiber NewCap structural analyses vs As-Built Strain Data correlate well with the overall strain-pressure response. This demonstrates the NewCap non-linear elastic-plastic liner material model and linear elastic composite material model can be effectively used to design Type III composite pressure vessels.
- Both Type IV All Carbon Fiber NewCap structural analyses vs As-Built Strain Data correlate well with the overall strain-pressure response. This demonstrates the NewCap linear elastic composite analyses can be effectively used to design Type IV composite pressure vessels.
- The Type IV Hybrid Carbon & Eglass Fiber NewCap structural analyses vs As-Built Strain Data correlate well with the overall strain-pressure response. This demonstrates the NewCap linear elastic composite analyses can be effectively used to design Type IV hybrid composite pressure vessels.

THANK YOU

Jim Harris

HEXAGON