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**ANALYSIS OF STRESSES IN FILAMENT-WOUND
SPHERICAL PRESSURE VESSELS PRODUCED
BY THE DELTA-AXISYMMETRIC PATTERN**

C. E. Knight, Jr.

August 1975

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ABSTRACT

Spherical pressure vessels may be produced by filament winding the composite material with a delta-axisymmetric pattern. This particular pattern yields a composite with high fiber density and efficient and reproducible structures. The pattern is readily defined mathematically and, thus, eases the analysis problem.

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SUMMARY

Spherical pressure vessels may be produced by filament winding the composite material with a delta-axisymmetric pattern. This particular pattern yields a composite with high fiber density and efficient and reproducible structures. The pattern is readily defined mathematically and, thus, eases the analysis problem.

The finite-element method has been applied to analyze the stresses in the vessels. An existing program has been modified and utilized for the analysis. Modifications involved the program size, orthotropic material properties, and special features associated with the fiber composite material. Several auxiliary data preparation programs provide some of the input data needed to describe the finite-element model.

The stress-analysis capability may be used to evaluate a pattern design or optimize the pattern for a specific application. In this report, analytical and experimental studies for a vessel are described. The vessel was about eight inches in diameter and was constructed of "S" glass with ERL 2258/MPDA epoxy resin. Studies showed good correlation.

INTRODUCTION

Filament-wound spherical pressure vessels may be constructed of properly oriented filament-wound patterns for the load-carrying member and a metal liner for leak-tight containment. Small-diameter fibers in an epoxy-resin matrix make up the filament-wound material. The resulting composite has highly directional elastic and strength properties. The fundamental goal is to achieve a pressure vessel with the best possible strength-to-weight ratio. To aid in this effort, a method for detailed analysis of winding patterns and materials is needed. This method is to be used to evaluate designs and help modify the design to improve efficiency.

A general numerical stress-analysis method of rapidly increasing importance is the finite-element method. This method provides for the analysis of complex problems not generally solved in any other way. The finite-element method was applied to the analysis of axisymmetric filament-wound pressure vessels at the Oak Ridge Y-12 Plant.^(a) An available program for the analysis of axisymmetric solids with special-case orthotropic properties was modified for three-dimensional orthotropy; and, more especially, for filament-wound materials. The size of the program was increased considerably in order to approximate the structure adequately.

Several data-preparation programs were written to provide the input necessary to run the finite-element program. These programs were concerned with modeling the filament-wound pattern from a geometrical standpoint and also to specify the material properties to be used in each element. An analysis procedure was established for using the data-preparation programs to set up the finite-element program for a particular case.

(a) Operated by the Union Carbide Corporation's Nuclear Division for the US Energy Research and Development Administration.

STRESS ANALYSIS IN FILAMENT-WOUND PRESSURE VESSELS

VESSEL DESIGN

General Design Features

Fiber-reinforced composite materials offer the potential of both high performance and low weight in many structural applications. The specific application described here is a spherical pressure vessel. The general design features are indicated in Figure 1.

The structural member of the vessel is a filament-wound shell fabricated from continuous fiber strands and an epoxy-resin matrix. The filament-wound shell is not leaktight to liquids or gases, especially when the shell is pressurized. Therefore, a liner for the vessel is required. This liner serves to contain the charge; the liner material may be polymeric or metal, depending on the application. The fill tube or port provides the inlet and outlet passages for the charge. These tubes are usually relatively small to minimize disturbance in the winding pattern and to keep the axial forces on the fill tube area low. The vessel may have one or two ports on the axis of the winding pattern. If only one port is used, the pattern is adjusted to cover the liner surface at the opposite port location.

Figure 1. GENERAL DESIGN OF THE FILAMENT-WOUND SPHERICAL PRESSURE VESSELS.

Winding Pattern

The winding pattern for the sphere results in a uniform distribution of fiber orientations and uniform total thickness over most of the surface. This pattern is named the "delta-axisymmetric" pattern. Sets of bands are applied equally spaced around the winding or symmetry axis, yielding an incrementally symmetric (thus the term "delta-axisymmetric") pattern. The basic pattern may be defined by considering the geometry of a sphere, as illustrated in Figure 2 where the lines in the sketch represent band edges.

Coordinates are defined with reference to a polar axis and a reference plane through the axis. The coordinates are noted in Figure 3. The poles of the sphere are located where the polar axis intersects the sphere. Longitudinal (meridional) lines run from pole to pole on the sphere surface and lie in a plane passing through the polar axis. Latitudes are circles on the sphere surface with centers lying on the polar axis. A point on the sphere surface may be located by specifying the polar angle (angle between the polar axis and the radius to the point on the longitude) and a circumferential angle (angle measured

Figure 2. DELTA-AXISYMMETRIC PATTERN ON A SPHERE.

in the equatorial plane between a reference plane and the longitudinal plane through the point). As mentioned, sets of bands are applied to the sphere. A band is generated by circumferential winding on a great circle path and parallel paths on both sides of the great circle. The band is actually wound by starting at the specified location of the band edge on one side of the great circle and circumferential winding at the desired lead rate for the fiber being used until the desired band width is established.

The basic pattern is defined by the requirement for total coverage of the sphere surface with the design thickness. The thickness of a single band may be found experimentally for a given fiber, resin system, and set of winding conditions. The design thickness divided by two times the band thickness (each band set gives two layers of coverage) gives the number of band sets required. [For example, if the design thickness is 2.7 mm and the band thickness is 0.15 mm, the number of band sets is $2.7 / (2 \times 0.15) = 9$.] The sets are applied equally spaced along the meridian from the pole to the equator. The bandwidth is equal to the spacing on the surface along the meridian. Equally spaced along the meridian, the bandwidth is $90/9 = 10$ degrees intercept on the surface. The number of bands in each set is calculated to give complete coverage (side-by-side band placement) at the equator. The bands cross the

Figure 3. SPHERICAL COORDINATES.

equator at an angle related to their position along the meridian. The first set of bands are placed so that one edge is tangent to the polar axis, then the opposite edge of the band set lies on a latitude circle at a position along the meridian, one bandwidth away. The central plane of the band is on a great circle of the sphere and makes an angle, γ , with the polar axis equal to one half the bandwidth intercept angle on the sphere surface. The angle between the equator and the central plane is $(\pi/2 - \gamma)$. The length of the equator covered by one band is then equal to the bandwidth divided by $\sin(\pi/2 - \gamma)$. The number of bands in that set is equal to the equator circumference divided by the coverage of one band. In the previous example, γ is 5 degrees, the equator coverage is 10 degrees divided by the sin of 85 degrees (10.04 degrees), and the number of bands is 36 since only an integer number of bands may be applied. The second set of bands is applied with one edge tangent to the latitude circle of the first set and the other edge lying on a latitude circle one band width further away. This set required 35 bands. Similarly, the other band sets are applied progressively along the meridian to the equator. The complete basic pattern yields 100% coverage of the sphere and a uniform total thickness.

The basic pattern is usually altered to meet requirements for a specific design. The most obvious alteration is allowance for the fill-tube opening in the pattern. A fill tube may be applied at one or both poles of the sphere. The pattern is shifted or adjusted to provide the opening. There are many schemes for adjusting the patterns which will be described in a later section.

Winding Process

The winding process applies the fiber and resin by the machine according to the pattern design. The sphere is held in the machine with the reference planes aligned for startup. The band is generated by machine motions. When the first band is completed, the sphere is indexed to the next band position. This sequence is followed until all the bands are applied. Finally, the part is removed from the machine and the resin matrix is cured.

ANALYTICAL METHOD

Numerical Approach

Two major types of numerical analysis methods currently exist for solving solid mechanics problems: (1) the finite-difference method, and (2) the finite-element method. The finite-difference method approximates the governing differential equations by a set of algebraic-difference equations; the finite-element method approximates the continuum by subdivision of the continuum into small elements and solving the governing equations exactly for an assumed behavior of the element. The finite-element method has several distinct advantages for the problem being considered here and, consequently, is used for this analysis. The advantages are: (1) ability to handle nonhomogenous and anisotropic materials easily; (2) ease of applying boundary conditions, and (3) ability to vary the mesh size to obtain better accuracy in areas of expected stress concentration. As stated, the finite-element method approximates the continuum by a set of interconnected elements. The element behavior is approximated usually by a polynomial function which must satisfy the governing equations of elasticity. The elements are assembled and a set of simultaneous algebraic equations result. These equations are solved for the unknowns, yielding the desired solution to the problem.

Element Formulation

The key to successful analysis is the formulation of element behavior. In most cases, the formulation will be based on displacements within the element. The element will be made up of a set of lines defining the element boundary and connected at points called the element nodes. The simplest case is one of straight boundary lines and nodal points at the corners of the element. The simplest element geometry is a triangle. Both these conditions (straight boundaries and corner nodes) are employed here. However, for axisymmetric bodies, the element is a ring with a triangular cross section, as illustrated in Figure 4. In order to have a finite number of degrees of freedom (finite number of algebraic equations), it is assumed that the displacements within the element can be expressed in terms of the displacements of the nodal points through some interpolation functions. The displacement vector anywhere in the element is defined as:

$$\{f\} = \begin{Bmatrix} u \\ v \end{Bmatrix}, \quad (1)$$

where: u represents the r component of displacement and v the z component of displacement.

Figure 4. TRIANGULAR-RING FINITE ELEMENTS.

The nodal-point displacement vector, δ , is given by:

$$\{\delta\}^e = \begin{Bmatrix} \delta_i \\ \delta_j \\ \delta_k \end{Bmatrix} = \begin{Bmatrix} u_i \\ v_i \\ u_j \\ v_j \\ u_k \\ v_k \end{Bmatrix}^e, \quad (2)$$

where: the superscript e refers to a given element, and subscripts i , j , and k denote three nodal points. Assume the displacement field in the element is defined by a linear polynomial, then:

$$\begin{aligned} u &= a_1 + a_2 r + a_3 z \\ v &= a_4 + a_5 r + a_6 z \end{aligned} \quad (3)$$

Since this relation holds anywhere within the element, it must be valid at the nodal points.

Then:

$$\{\delta\}^e = \begin{bmatrix} 1 & r_i & z_i & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & r_i & z_i \\ 1 & r_j & z_j & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & r_j & z_j \\ 1 & r_k & z_k & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & r_k & z_k \end{bmatrix} \begin{Bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \end{Bmatrix} = [A] \{a\} \quad (4)$$

Solving Equation 4 for $\{a\}$:

$$\{a\} = [A]^{-1} \{\delta\}^e, \quad (5)$$

and, substituting into Equation 3:

$$\{f\} = [M] [A]^{-1} \{\delta\}^e = [N] \{\delta\}^e, \quad (6)$$

which expresses the element displacement field in terms of the nodal displacements and their coordinates, where:

$$[N] = [M] [A]^{-1} = \begin{bmatrix} N_i & 0 & : & N_j & 0 & : & N_k & 0 \\ 0 & N_i & : & 0 & N_j & : & 0 & N_k \end{bmatrix}. \quad (7)$$

In this expression:

$$\begin{aligned} N_i &= (b_i + c_i x + d_i y) / 2A, \\ b_i &= r_j z_k - r_k z_j, \\ c_i &= z_j - z_k, \text{ and} \\ d_i &= r_k - r_j. \end{aligned} \quad (7a)$$

A represents the area of the triangle = $1/2 (b_i + b_j + b_k)$ with cyclic permutation of subscripts to obtain N_j and N_k .

It can be shown that this formulation automatically satisfies the compatibility condition (ie, neither gaps nor overlaps develop along element boundaries).

The strain-displacement relations are given by:

$$\{\epsilon\} = \begin{Bmatrix} \epsilon_r \\ \epsilon_\theta \\ \epsilon_z \\ \gamma_{rz} \end{Bmatrix} = \begin{Bmatrix} \frac{\partial u}{\partial r} \\ \frac{u}{r} \\ \frac{\partial v}{\partial z} \\ \frac{\partial u}{\partial z} + \frac{\partial v}{\partial r} \end{Bmatrix}. \quad (8)$$

Using Equation 6:

$$\{\epsilon\} = [B] \{\delta\}^e, \quad (9)$$

where:

$$[B] = [B_i \ B_j \ B_k], \text{ and} \quad (10)$$

$$[B_i] = \frac{1}{2A} \begin{bmatrix} 0 & d_i \\ c_i & 0 \\ b_i & 0 \\ d_i & c_i \end{bmatrix} + c_i + \frac{d_i z}{r} \quad (10a)$$

A, b_i , c_i , and d_i are defined in Equation 7a.

The stress-strain relations are given by Hooke's law as:

$$\{\sigma\} = \begin{bmatrix} \sigma_r \\ \sigma_\theta \\ \sigma_z \\ \tau_{rz} \end{bmatrix} = [D] \{\epsilon\}, \quad (11)$$

where the elasticity matrix, $[D]$, is given by:

$$[D]^{-1} = \begin{bmatrix} \frac{1}{E_r} & -\frac{\nu_{r\theta}}{E_r} & -\frac{\nu_{rz}}{E_r} & 0 \\ -\frac{\nu_{r\theta}}{E_r} & \frac{1}{E_\theta} & -\frac{\nu_{\theta z}}{E_\theta} & 0 \\ -\frac{\nu_{rz}}{E_r} & -\frac{\nu_{\theta z}}{E_\theta} & \frac{1}{E_z} & 0 \\ 0 & 0 & 0 & \frac{1}{G_{rz}} \end{bmatrix} \quad (12)$$

Element Assembly

The solution is obtained by applying the principle of minimum potential energy. The principle states that: "Among all the possible displacement configurations that are compatible with the geometrical constraints, the configuration that satisfies the equations of equilibrium is the one that minimizes the total potential energy"; so, the total potential energy must be a minimum.

The potential energy is made up from two sources: (1) internal strain energy, and (2) concentrated forces acting through surface displacement. Here, body forces are neglected and it is assumed that all loads are distributed as point loads at the nodal points. The potential energy, PE^e , for an element is:

$$PE^e = \iiint_V 1/2 \{\epsilon\}^T \{\sigma\} dv_e - \{R\}^T \{\delta\} , \quad (13)$$

where:

$\{R\}^T$ represents the nodal-point-load matrix.

The potential energy for the system is then the sum of all the element potential energies:

$$PE = \sum_{e=1}^E PE^e , \quad (14)$$

where:

E represents the total number of elements.

The requirement that the total potential energy be a minimum is satisfied by making its "first variation" equal to zero. Since the problem is formulated in terms of displacements, this requirement can be satisfied by expressing the variation in terms of the partial derivatives with respect to the nodal-point displacements. Mathematically, this expression becomes:

$$d(PE) = \frac{\partial(PE)}{\partial u_1} du_1 + \frac{\partial(PE)}{\partial v_1} dv_1 + \frac{\partial(PE)}{\partial u_2} du_2 + \dots \frac{\partial(PE)}{\partial v_m} dv_m = 0 , \quad (15)$$

where:

m represents the total number of nodal points.

Since the $u_1, v_1, u_2, v_2 \dots u_m, v_m$ terms are independent variables, each partial derivative must equal zero, thus:

$$\frac{\partial(PE)}{\partial u_1} = 0 ,$$

$$\frac{\partial(PE)}{\partial v_1} = 0 \dots, \text{ or}$$

$$\frac{\partial(PE)}{\partial \{\delta\}} = \{0\} \quad (16)$$

This expression gives the 2m equations necessary to solve for the 2m nodal-point displacement.

Solution of Equations

Using Equations 9, 11, 13, and 14, along with Equation 16, gives the following result:

$$\frac{\partial(PE)}{\partial \{\delta\}} = \sum_{e=1}^E \frac{\partial}{\partial \{\delta\}} \left(\iiint_{V_e} \frac{1}{2} \{\delta\}^T [B]^T [D] [B] \{\delta\} dv_e \right) - \frac{\partial}{\partial \{\delta\}} R^T \{\delta\} = \{0\} . \quad (17)$$

Since the nodal-point displacements are constants with respect to integration within the element, the displacement matrix can be removed from the integral giving, after taking the partial derivative:

$$\frac{\partial(PE)}{\partial \{\delta\}} = \left(\sum_{e=1}^E \iiint_{V_e} [B]^T [D] [B] dv_e \right) \{\delta\} - \{R\} = \{0\} . \quad (18)$$

Simplifying:

$$\frac{\partial(PE)}{\partial \{\delta\}} = [K] \{\delta\} - \{R\} = \{0\} , \quad (19)$$

where the stiffness matrix for the structure is:

$$[K] = \sum_{e=1}^E \iiint_{V_e} [B]^T [D] [B] dv_e . \quad (20)$$

By applying the boundary conditions, a set of 2m equations for the 2m nodal-point displacements results. If the nodes are numbered and ordered properly, the [K] matrix will be banded and symmetric, resulting in simplification of the solution method.

Approximation for Nonlinear Material

During the pressurization of a vessel, the liner must deform plastically since the strain of the composite is generally higher than the yield strain of the metal. In order to account for this deformation, the liner must be allowed to yield plastically in the analysis. The procedure used in the original program, briefly described in the explanation to follow, is applied: The plasticity theory is a total deformation theory and uses the Von Mises yield function. The stress-strain response of the material is described by a bilinear curve, as shown in Figure 5. The input data required are: the initial modulus, the yield stress, and the ratio of the

Figure 5. APPROXIMATION FOR MATERIAL WITH A BILINEAR STRESS-STRAIN BEHAVIOR.

secondary modulus to the primary modulus. The analysis is an iterative procedure and the number of iterations is an input quantity. As noted in Figure 5, the analysis is first run, using the initial modulus; then, if the calculated stress in an element is higher than the yield stress, as evaluated by the Von Mises criterion, the intersection of the calculated strain with the secondary portion of the curve is found. This intersection point defines a new effective secant modulus for that particular element. This procedure is followed for all the elements in the assembly. The analysis is repeated, using the effective modulus of each element, and the stress is reevaluated.

The number of iterations required depends on the type of problem being solved. (The number should be large enough so that the stresses in each element converge to some value.) For the particular problem being investigated here, four iterations were sufficient.

COMPUTER PROGRAM MODIFICATIONS

Original Program Description

A finite-element computer program, written by Wilson,⁽¹⁾ was obtained which analyzes plane-stress, two-dimensional structures or axisymmetric bodies subjected to various force or displacement boundary conditions. This program is capable of treating two dimensionally orthotropic bodies with thermal as well as mechanical loads. In general, it is well suited for analyzing problems of complex geometries with material properties varying with temperature and/or position. The program is set up with cylindrical coordinates, with the Z axis as the axis of symmetry for the axisymmetric bodies and the R-Z plane as the

cross-sectional plane. The two-dimensional plane-stress bodies are defined in the R-Z plane and the material can be orthotropic in this plane. However, the axisymmetric bodies are required to be isotropic in the R-Z plane and may have different properties in the T (circumferential) direction. This program was written for an IBM Model 7090 computer, but it was run on the IBM 360 with few problems. The program was extensively modified to make it more suitable for use on problems of filament-wound composite materials. Input instructions for the original version are given in Appendix A. The program is an earlier version of the program described by Wilson and Jones.⁽²⁾

Program Modification

The program was modified in several respects, including: the stress-strain relations, the spherical-coordinate components of displacement, the program size, and the stress components displayed in the program output. The plane-stress option was deleted in the modified version to shorten the program. Also, the thermal analysis was deleted. These deletions helped reduce the program storage requirements, allowing an increase in the number of elements and nodal points in the program.

As mentioned earlier, the axisymmetric option in the original version required that the material be isotropic in the R-Z plane, which is inadequate for describing filament-wound composites. In order to analyze filament-wound composites, the material-property matrix must be three dimensionally orthotropic. The property matrix was changed to that shown in Equation 24. The matrix is represented in the program by the subscripted variable, C, and it is defined in Subroutine QUAD of the program. The property matrix is described more fully in the section to follow, entitled: DATA PREPARATION PROGRAMS.

The particular problem under consideration here is that of a spherical shell; therefore, coordinate transformations were installed to give the displacements in the radial and tangential components. Displacement is a vector quantity; therefore, the spherical components of displacement (radial and tangential) are computed by a vector transformation. This computation is accomplished in the program by operating on the subscripted variable, B, which are the R-Z displacement components.

The material properties of a filament-wound composite are most easily defined in a plane that is tangent to the surface of revolution being wound. As described in the section on DATA PREPARATION PROGRAMS, the material properties are defined for integer values of the helix angle between the fiber and circumferential (T) direction. This relationship defines the properties in the N-S-T coordinate system, where N is the radial direction from the origin, S the meridional or tangential direction, and T still the circumferential direction. These properties must then be transformed to the R-Z-T coordinate system before use in the program. Since the property matrix is a fourth-order tensor, it must be transformed by the appropriate equations through an angle rotating about the Z axis. This transformation is accomplished in Subroutine QUAD by operating on the subscripted variable, C, after it is formed in the N-S coordinates.

The program capacity has been approximately doubled by redimensioning the proper variables. The new capacity is 2400 elements, 2500 nodal points, and 96 material types. This size allows a fine subdivision of the thin shell and yet keeps the relative dimensions of the elements reasonable.

The stress components are first solved for in the R-Z-T coordinate system. As far as the fiber-reinforced composite is concerned, these stress components mean very little. The stresses of greatest importance are those parallel and transverse to the fiber direction. To obtain these components, it is first necessary to transform to the N-S coordinates. This transformation is accomplished in Subroutine STRESS by the second-order tensor transformations since stress is a second-order tensor. The N-direction stress is one of the principal transverse-stress components on the composite. Then, to obtain the parallel stress and other transverse stresses on the fiber in the S-T plane, it would seem, at first glance, that another stress transformation would be sufficient. However, this assumption is incorrect because two complementary layers of fibers exist in the element with plus and minus angular orientations. The stresses resulting from the transformations would be average values. The average for the fiber direction is an average between the fiber-direction stress in one layer and the stress at some angle to the fiber in the other direction; and, a similar condition exists for the average transverse stress. So, the averages are not true parallel and transverse stresses. In order to obtain the actual parallel and transverse stresses, it is necessary to compute the strains in the S-T plane and then transform the strains (a second-order tensor) to the fiber direction, since the same state of strain will exist in both the plus and minus angular orientations. The stresses parallel and transverse to the fiber are then found by matrix multiplication of the unidirectional material property matrix with the strain matrix. The stress components are: output as the F Stress (axial stress), E Stress (transverse stress), and F-E Stress (interfiber shear stress in the F-E coordinates). All of these components are composite values. These stresses, combined with the N-direction transverse stress, give the complete three-dimensional state of stress along the principal material axes of the composite for every element in the composite structure.

Description of Input and Output

The input data required for the program may be categorized as: model parameters, material properties, geometrical description, and loads. Much of the input is prepared by other computer programs and these programs will be described later. Input instructions and a Fortran listing of the modified program are given in Appendix B.

Model parameters define the data-control values used to describe the model. These parameters include: a job title, the number of nodal points, number of elements, number of different materials, and the number of boundary pressure cards. Material properties are required for each different material. Three-dimensional orthotropic materials may be described by three moduli of elasticity, three Poisson's ratios, and the shear modulus in the cross-sectional plane. (Since the problem is axisymmetric, the other two shear moduli are not used.)

The geometrical description is supplied on nodal-point and element cards. Each nodal point has a number in sequence through the model. Each nodal-point card has the coordinates of the point and, possibly, a boundary condition descriptor and any nodal-point loads that may be applied. Elements are defined by listing the connected nodal points which form the boundaries of the element. Also, on the element cards are the material type identifier and the material's principal axes orientation angle in that element with respect to the overall coordinate system.

The loading conditions may be described by nodal-point forces or by boundary pressures, or both. As mentioned, nodal-point forces are supplied on the nodal-point cards. Boundary pressures may be applied with one card for each element boundary to be loaded. The card gives the two nodal-point numbers of the boundary and the magnitude of the pressure.

Nodal-point displacements and element stresses are the main output from the program. All of the input data are printed out initially. The nodal-point displacements are given first in the cylindrical R-Z components and then in spherical N-S components (which correspond to radial-tangential components on the sphere).

The element stresses are given for the element centroidal location. The components in the R-Z-T coordinates are given first; the N-S components in the N-S-T coordinates are given next with the T components unchanged. The fiber direction of the composite is in the S-T plane, and the transformation described earlier is applied to give the longitudinal and transverse stresses on the composite. These stresses, along with the N components, give the three-dimensional state of stress on the composite in its principal material coordinates. These transformed components are output as the F-E components.

At present, the program has not incorporated any yield or failure criteria for combined stress states. The primary reason for this incompleteness is that no single criterion for all composites has emerged as being satisfactory. The cases studied to date have been evaluated, based on a maximum fiber stress.

Most of the pressure-vessel patterns will not catastrophically fail when the composite fractures transverse to the fiber. Transverse failure for most of the composites studied generally occurs at a low fraction of the ultimate failure load. This phenomenon is known as "crazing"^(b) in filament-winding technology.

DATA PREPARATION PROGRAMS

The finite-element program requires an enormous amount of data for input. Since preparing the data by hand is an almost impossible task, several data-preparation programs were written to automatically produce the data cards. These programs are written for the delta-axisymmetric pattern on a spherical pressure vessel

Pattern Definition

The first step to be accomplished is that of pattern definition. Several factors go into the selection of a pattern: size of the vessel, fill tube size, desired winding thickness, number of shells, and amount of reinforcement at the stem and winding fabrication sequence. A program exists for using these factors to define the pattern. This program was written on the Com-Share time-sharing computer system. A sample input and output are given in Figure 6. This program specifies the winding fabrication sequence and controls for the operator. One

(b) Cracking parallel to the fiber under a transverse load.

of the outputs available is a list of the coordinate angles for the band positions. These coordinates are indicated in Figure 7; a listing for the pattern designated as the 720A pattern is presented in Figure 8. The variables listed for each band set are: ϕ_1 , $\phi\phi$, NB, NI, and INC, where:

ϕ_1 may be either the polar angle of the band edge nearest the stem (γ_1 , if $\delta = 0$) or the angle to the central plane of the band (γ_2 , if $\delta = 0$) keyed on the value of $\phi\phi$.

$\phi\phi$ is either the polar angle of the band edge nearest the south pole, or zero. (If $\phi\phi = 0$, it is not used to compute any data and $\delta = 0$.)

NB is the number of bands in that set needed to produce full coverage at the equator.

NI is the number of bands to be used in that set. If NI = 0, NI is set equal to NB.

INC is the number of strands per inch of band, if 0 in the input INC is set equal to 100.

Pattern Simulation

Two sets of data which must be input into the finite-element program are: (1) the thickness profile of the wound shell, and (2) the material properties within each element. A pattern-simulation program has been written to satisfy these requirements. In order to specify these data, the program must calculate the thickness buildup for each band set and the fiber orientation angle with respect to the overall spherical coordinates at every point in the composite shell.

INPUT

```
-EXE /PMP/
WHICH PROGRAMS?DLT, BND
ENTERING DLT
PATTERN TYPE - 2
DESIGN NUMBER - 30
STEM ANGLE - 1.79
NUMBER OF REINFORCING BANDS - 30
```

OUTPUT

γ_2	D_o	D_i	NC	NB
5.9	0.285	-.409	69	36
6.9	0.356	0.231	13	30
18.0	0.426	-.426	85	28
30.0	0.434	-.434	87	25
42.0	0.423	-.423	85	22
54.0	0.432	-.432	86	17
66.0	0.421	-.421	84	12
78.0	0.416	-.416	83	6
90.0	0.418	-.418	84	1

Where:

γ_2 represents the polar angle to the band generation plane, D_o and D_i the distance to the planes of the band edges from the sphere center,

NC the number of fiber circuits in the band, and NB the number of bands in the set.

Figure 6. PATTERN DEFINITION PROGRAM INPUT AND OUTPUT.

Figure 7. BAND-LOCATION COORDINATES.

1st Set	ϕI	1.7900
	$\phi\phi$	180.0000
	NB	36
	NI	0
	INC	0
		1.7900
		190.2100
		199
		30
		0
		18.0000
		0.0000
		28
		0
		0
		30.0000
		0.0000
		25
		0
		0
		42.0000
		0.0000
		22
		0
		0
		54.0000
		0.0000
		17
		0
		0
		66.0000
		0.0000
		12
		0
		0
		78.0000
		0.0000
		6
		0
		0
		84.0000
		0.0000
		1
		0
		0

Figure 8. 720A PATTERN DATA.

The calculations are performed by spherical geometry methods. A view of the geometry is provided in Figure 9, looking along the axis of symmetry. (This plane view is for illustrative purposes only.) The concentric circles represent latitudes on the sphere; the straight lines represent the coverage of a single band. The arc length along the latitude covered by the band is calculated. The thickness buildup for a band set at a given latitude then is given by the arc length times the band thickness times the number of bands in the set divided by the circumference of that latitude. By geometry, the helix angle between the fiber direction and the latitude line can be determined at any point across the band, and it will vary across the band. In the program, the bands are subdivided into ten segments. The fiber angle is calculated at each edge of the segment and averaged to determine the fiber angle of the material in that segment. The thickness buildup is calculated for each segment. These calculations are performed for each band set and summed up to obtain the total thickness profile. The resulting data specify completely the fiber angle for all regions of the composite and the total thickness profile for the given pattern. Input instructions for the program are given in Appendix C. The output from the program is a set of cards which specify the material type (which is the fiber angle for the composite) for each element in a 24 x 90 array of elements, and a set of nodal-point cards for the nodes on the outer contour of the composite.

Mesh Generation

In the finite-element program, the coordinates of all nodal points must be specified as well as the nodal-point numbers which are connected to define an element. This operation is accomplished either by supplying boundary nodes and elements and allowing the finite-element program to interpolate for the intermediate points, or by running the mesh-generation program and obtaining data cards for all nodal points and elements. Generation internal to the

finite-element program will be described later; the mesh-generation program will be described in the paragraphs that follow.

The requirement of closely approximating the contour of complex geometries, together with the desirability of a fine mesh size and its attendant high accuracy, make the use of a large number of nodal points and elements desirable. Obviously, the layout and specification of the locations of such a number of points is a tedious job in which the probability of some human error is high. To minimize the effort, a scheme for the machine generation of much of the required data has been incorporated in a mesh-generation program.

To layout a nodal-point system for the body to be analyzed, the region of the R-Z plane intersecting the body is covered with an array of quadrilaterals. Each vertex of the quadrilateral is taken to be a nodal point. Each nodal point is identified by an ordered pair of positive integers [denoted by (I, J) in the I-J plane]. The scheme for mesh generation may be thought of as representing a one-to-one mapping from the I-J plane into the R-Z plane. As illustrated in Figure 10, each quadrilateral in the R-Z plane is a square in the I-J plane and may be identified by the I-J coordinates (or nodal-point number) of its bottom left-hand corner in the I-J plane. (Figure 10 is illustrative only, since curved boundaries are not used in this finite-element program.)

Figure 9. THICKNESS CALCULATION METHOD. (Plane View)

The mesh generation is accomplished in the following manner: A data card, containing (among other things) the values of I and J and the R and Z coordinates, is input for each node whose coordinates are to be specified. The specified nodes must at least include all nodes on the boundary of the region. As many other interior nodes as desired may also be specified, but no others are necessary. The calculation, or mapping, of coordinates is achieved by solving twice the finite-difference analog of Laplace's equation on the lattice points in the I-J plane. First, the R coordinates of the boundary points and any specified internal nodes are used as boundary values of the unknown harmonic function, and the functional values obtained on the interior points are taken as the R coordinates of the points in the R-Z plane. A similar procedure yields the Z coordinates. In general, this method tends to yield nodal points that are uniformly spaced. If this approach is not desirable, some of the internal nodal-point coordinates may be specified in order to control the distribution.

Figure 10. I-J to R-Z MAPPING FOR MESH GENERATION.

The program calculates the location of each point and assigns a nodal-point number. After the output of this information, the program forms quadrilateral or triangular elements by assigning proper nodal-point numbers to the corners of the elements. Output from the program is printed and/or punched onto cards for use in the finite-element program. Input instructions are given in Appendix D.

Material Property Set

As mentioned before, the material type within any given element is given a number corresponding to its angle (in integer degrees) between the fiber direction and a latitude (the circumferential direction) on the sphere. This angle lies in a plane which is tangent to the sphere surface at the specific point of interest. Therefore, there are 90 material types to represent the composite material—one for each integer degree of angle. These properties are specified in an N-S-T coordinate system, where T represents the circumferential direction, S the meridional direction, and N the radial direction. S and T lie in the plane tangent to the surface. The relation between the fiber direction and the S-T directions in the tangent plane is illustrated in Figure 11, View a; the relation between the N-S and R-Z coordinates is indicated in Figure 11, View b.

Figure 11. RELATION BETWEEN PAIRS OF COORDINATES.

The stress-strain relation for three dimensionally orthotropic materials is, in index notation:

$$\sigma_{ij} = C_{ijkl} e_{kl} \quad , \text{ or:} \quad (21)$$

$$e_{ij} = S_{ijkl} \sigma_{kl} \quad , \quad (22)$$

where:

σ_{ij} represents the second-order stress tensor,

e_{ij} the second-order strain tensor,

C_{ijkl} the fourth-order stiffness tensor, and

S_{ijkl} the fourth-order compliance tensor.

The stiffness and compliance tensors are related.

In matrix notation:

$$[C] = [S]^{-1} \quad (23)$$

The compliance tensor, S_{ijkl} , may be written out in terms of common engineering constants for the case of the Z axis being an axis of symmetry. Equation 22 in the N-S-T coordinate system becomes:

$$\begin{bmatrix} e_{nn} \\ e_{ss} \\ e_{tt} \\ e_{ns} \end{bmatrix} = \begin{bmatrix} \frac{1}{E_n} & \frac{-\nu_{ns}}{E_n} & \frac{-\nu_{nt}}{E_n} & 0 \\ \frac{-\nu_{ns}}{E_n} & \frac{1}{E_s} & \frac{-\nu_{st}}{E_s} & 0 \\ \frac{-\nu_{nt}}{E_n} & \frac{-\nu_{st}}{E_s} & \frac{1}{E_t} & 0 \\ 0 & 0 & 0 & \frac{1}{G_{ns}} \end{bmatrix} \begin{bmatrix} \sigma_{nn} \\ \sigma_{ss} \\ \sigma_{tt} \\ \nu_{ns} \end{bmatrix} \quad (24)$$

and the S matrix may be inverted to obtain [C]. For a composite made from continuous unidirectional fibers, the composite properties along the fiber direction and transverse to it may be measured experimentally or determined analytically, and the composite is generally considered to be transversely isotropic. For this case, if β in Figure 11, View a is zero, then T corresponds to the fiber direction and S and N are both transverse directions. In this application to wound vessels, N will always be a transverse direction. When β is not zero, the N-S-T properties must be found by use of the transformation equations for a fourth-order tensor. Tsai⁽³⁾ has tabulated these for the stiffness and compliance matrices.

The property transformations may be made two different ways. One approach involves transforming the S matrix directly. When the matrix is transformed, terms will appear in the present matrix of Equation 2 where now there are zeros. These terms are known as "shear coupling" terms and will have opposite signs when transformed through a plus or minus Angle β . By assuming that the state of stress in the plus- β layer is the same as in the minus- β layer, the two equations (same as Equation 22) obtained for plus and minus β can be averaged to derive the stress-strain relations for a composite consisting of a mixture of the plus and minus- β layers. The effect of this averaging is to cancel the shear-coupling terms and, in this case, the state of strain is such as to allow "scissoring" of the plus and minus layers to occur. The properties which derive from this approach are called "free" elastic properties.

In the second approach, the stress-strain relations in the form of Equation 21 are used. The S matrix is inverted to obtain [C]. Zeros will appear in the same locations as in [S]. Again, when the transformation is made, the terms will appear with plus and minus signs on the shear-coupling terms for the two layers. In this case it is assumed that the same state of strain exists in both layers and the two equations are averaged. This step cancels the shear-coupling terms and the composite behaves as if the two layers were rigidly bonded together (no scissoring occurs). The properties which are derived from this approach are called "restrained" elastic properties. The "restrained" properties are used in most cases since they more likely represent the real composite. Layers in a filament-wound composite are generally well bonded, so this action seems justified. The resulting C matrix is inverted to obtain [S] so that the moduli and Poisson's ratios may be easily obtained. Input instructions are given in Appendix E.

ANALYSIS PROCEDURE

Definition of the Problem

The problem to be investigated is that of a filament-wound, spherical pressure vessel which was wound using the delta-axisymmetric winding pattern. The first assumption is that the problem is axisymmetric with respect to loading, geometry, and material. It is further assumed that the material in a given layer is uniformly distributed around the axis of symmetry. This axis of symmetry is taken to be through the center of the sphere and passing through the center of the fill tube. Furthermore, it is assumed to be symmetric with respect to the equator so that each hemisphere can be considered independently. Even though there may be a fill tube in only one of the hemispheres, the pattern is still very similar on each hemisphere, justifying the separation. This last assumption is not necessary, but it keeps the program size more reasonable.

The finite-element mesh for the hemisphere is seen in Figure 12. In this mesh, starting from the pole, the first two columns of elements represent the fill tube and are assigned elastic properties of the fill-tube material. The third column is a set of interface elements between the tube and composite. These interface elements may have properties which either bond the two materials together or decouple them. (Decoupling is probably more realistic in this case.) Starting from the inside surface of the sphere, the first three elements in each column are used for the liner material. The liner material may be described by a bilinear stress-strain curve to allow the liner to yield plastically. The fourth element in each column is an interface element which may have properties of an adhesive or of the liner to show a bonded condition, or it may have low-modulus, incompressible material properties to allow normal pressure transmission without shear stress, thus modeling the no-bond condition. In the remaining 87 columns of the 90×24 element array, 20 elements of each column describe the composite material.

Typically the element length along the meridian will vary to allow a finer mesh in the fill-tube region. The elements nearest the tube have lengths corresponding to one-half degree increments along the meridian. This relationship applies out to 10 degrees, polar angle, from the axis of symmetry. The next group of elements have a length of a one-degree increment out to 70 degrees, polar angle. The last group are two-degree lengths and run to the equator. The total number of elements in this case is then $90 \times 24 = 2160$ elements. These element lengths may be allocated differently, but the overall number of elements should remain the same in order for the various data preparation programs to be compatible. Also, the finite-element program is only dimensioned at 2400 elements.

Loading is provided by a set of pressure cards along the loaded boundary. The pressure acts along the ID of the sphere and tube, and a surface tension acts on the outside of the tube in the axial direction. The resultant of this surface tension is equal to the resultant of the internal pressure acting on the bore cross-sectional area of the tube. The internal pressure listed on the cards is 1000 psi. A multiplier card is added in the program deck to adjust the pressure for the actual pressure to be analyzed.

Figure 12. FINITE-ELEMENT MESH FOR THE FILL-TUBE HEMISPHERE OF THE 720A PATTERN.

Run Data Preparation Programs

The programs described in the DATA PREPARATION PROGRAMS section are now used to model the vessel. First, the pattern-design options must be selected. The pattern-definition program, also described in the DATA PREPARATION PROGRAMS section, has three subprograms: DLT, BND, and CHK. Subprogram DLT generates the angular coordinates of the band edges and the number of bands in each set. This information must be generated before running Subprograms BND and CHK. Subprogram BND organizes the

DLT data into a fabrication sequence and control data for the machine operator. Subprogram CHK computes the check-point information for the use of the machine operator.

After starting the pattern-definition program, the computer prompts for the needed input. The first input in the DLT subprogram is the pattern type. The response is a number corresponding to a cataloged pattern design. For example, Type 1 is a basic pattern with an adjustment for the stem (fill tube) angle. The bands of the first band set are reduced in width to fit between the stem and the normal first latitude of the basic pattern. The number of bands is increased to give side-by-side laydown at the equator. Pattern Type 2 is the same as Type 1 except that the narrow reinforcing bands with a band width equal to the stem angle are applied adjacent to the stem as the second set of bands.

After the pattern type, the next input is the design number. The design number is calculated by dividing the design thickness of one complete basic pattern by the thickness of a single band. The band thickness is determined experimentally for the specific composite material being used. The design thickness of one complete basic pattern is equal to the total design thickness divided by the number of complete patterns in the shell.

The stem angle is requested; and, if the pattern type is Type 2 or any type which uses reinforcing bands, the number of reinforcing bands is requested. The number of bands may be any number desired, but it is normally taken equal to the design number. The DLT subprogram produces a file of pattern data, as was illustrated in Figure 7.

Subprogram BND uses the DLT-produced file and other input data to produce the fabrication data. The radius of the surface to be wound, the number of band sets, and a sequence number is requested. If "1" is the number, the sequence will be such that the band sets are applied progressively from the pole to the equator—commonly called a "downwind". If "2" is the number, the sets are applied from the equator to the pole—"upwind". Normally, a vessel would have a downwind followed by an upwind to produce a balanced laminate shell. Both the downwind and upwind are complete patterns.

When the Subprogram DLT file is created, the pattern-simulation program uses these data to compute the shell-thickness profile and the material orientations in the shell. Control data for the pattern-simulation program are similar to the BND subprograms of the pattern-definition program. The radius of the sphere, the band thickness, and number of band sets in the part are input. The number of angular increments (number of elements along the meridian) are specified.

Additional information and options are input to further refine the modeling technique. A material-stacking sequence locates the radial position of the material in a segment. The segment nearest the axis of symmetry may be located either at the smallest or largest radial position in its band-set layer. The other nine segments are then progressively positioned toward the largest or smallest radial position. The lengths of elements along the meridian may be specified with up to five different regions. This sequence allows finer grids in areas of likely stress concentrations. Following all this input, the data file created by DLT is input. The data are entered in the order of the winding sequence.

The program has two output options: Option (IOPT) 0 gives the helix angles (angle between the fiber and latitude in the tangent plane) at the band segment edges and the average thickness contributed by that segment at all calculating positions on the sphere; Option 1 produces an array of material types representative of the material orientations in the shell. The helix angles in a segment are averaged as well as the values for each segment represented in an element, weighted by their thickness fraction to give the computed material orientation for that element. The orientation angle is rounded to the nearest integer and used as the material-type identifier. The array of material types is formatted for a 24-element thick-shell model, with three of these elements for the mandrel and one for the interface. Also, with Option 1, the shell total-thickness profile is computed and a list of the outer-surface nodal points and their coordinates is printed. Thus, Option 1 is selected for production of data cards needed by the finite-element program.

The actual finite-element mesh may be generated by the mesh-generation program, or by hand. When a large number of nodal points and elements are used, hand generation becomes impractical. Portions of the mesh may also be generated internally in the finite-element program. This internal generation is limited to equal spacing between given nodal points. The outer-surface nodal points generated by the pattern-simulation program may be used as input to the mesh-generation program. They may also be direct inputs to the finite-element program, utilizing the internal program node and element generation. The approach used in this study starts with the complete mesh produced by the mesh-generation program. The finite-element program is run with this mesh. If the design needs to be altered, the pattern is changed. Then, all the nodal-point cards in the old mesh for the composite material are removed. These cards are replaced by the outer-contour nodal-point set for the new pattern and the interior nodes are program generated. In this way, redesigned cases may be examined with a minimized effort.

Properties for the composite material types in the material array are found by transformation in the T-S plane. Nine properties of the composite material are required in its principal material directions—three are moduli of elasticity, three are Poisson's ratios, and three are shear moduli of elasticity. The transformed properties are computed at every integer degree between 0 to 90 degrees. A data set of cards is punched in the format required for input to the finite-element program.

Editing the Assembled Data Set

It remains to assemble the data sets that have been prepared by running these computer programs, prepare other needed data cards by hand, and edit the complete set for any required corrections. The data sets are assembled in the sequence required for input to the finite-element program. The title card and first control card, giving the number of nodal points, elements, materials, and boundary pressure cards, are prepared by hand. The material cards for the composite are generated in the set, but those cards for the liner, fill tube, interface regions, and any void or resin-filled regions must be prepared by hand. The nodal-point cards are normally computer generated, but may require editing to apply the proper boundary conditions or alter the position of some points. All element cards are computer generated. The material type of each element is generated in the pattern-simulation array. To locate materials, as desired, the array may be edited. Orientation of the N-S coordinates of each element with respect to the R-Z coordinates is

prepared by hand. All the inner-boundary elements are loaded by the internal pressure. The fill tube is usually terminated in the model, flush with the outer contour adjacent to the tube. An additional tension force on the tube due to the bore pressure acts in the axial direction. This force is added as a negative pressure on the terminated boundary of the tube. After all the cards are prepared and assembled, the finite-element program is now ready to run.

Evaluation of the Results

The computer run is made and the results may be evaluated. If a vessel pattern design is needed, several runs may be made to check the effects of pattern alterations. A pattern for the part is chosen and the first run analyzes this pattern. Structurally deficient areas may then be recognized and the pattern modified for proper compensation. This process continues until an acceptable pattern is reached. If the other design constraints on the vessel (such as wall thickness or fill-tube diameter) are such that only one pattern may be used, then the results are predicted. In either case, experimental tests follow to assess the accuracy of the analysis.

CASE STUDY OF AN EIGHT-INCH-DIAMETER VESSEL

Vessel Description and Input Data

The program was used to analyze an eight-inch-diameter pressure vessel. The vessel is spherical and has a Type 5083-0 aluminum liner that is 0.080 inch thick. There is one fill tube, 0.250 inch in diameter and made from Type 5083-H231 aluminum. The winding pattern is identified as the "720A" pattern. The composite structure is wound with single-end "S" glass yarn and ERL 2258/MPDA epoxy resin. The composite thickness averages 0.180 inch.

The 720A pattern is described in Figure 8. The band width is nominally 12 degrees arc coverage and the band thickness is 0.0056 inch. The 720A pattern was produced by the following input to the pattern definition program: pattern type, 2; design number, 30; stem angle, 1.79 degrees; number of reinforcing bands, 30. When Subprogram DLT is completed, the pattern description may be used in Subprogram BND to calculate the operation control data given in Figure 6.

The pattern description is fed into the pattern-simulation program to calculate the thickness profile and material type (orientation) in each element. The thickness profile is identified in the mesh of Figure 12; the material array is reported in Table 1. The following input data produced these results: radius, 4 inches; thickness factor, 0.0056 inch; number of band sets, 18; number of meridian-angle increments, 90; output option, 1. The first nine band sets are in a downwind sequence, the second nine sets are in an upwind sequence. The material stacking sequence is specified as 1 for the downwind and 2 for the upwind. The size of the meridian-angle increment is 1/2 degree for the first 10 degrees along the meridian, 1-degree increments for the next 60 degrees, and 2-degree increments for the last 20 degrees. Editing of the material array is needed to correctly model this particular design. In the illustrated array, horizontal lines (rows) go through the vessel wall with the inside surface of the vessel on the right; vertical lines (columns) go along the vessel meridian. As mentioned, the first

MATERIAL ARRAY FOR 720A PATTERN

[illegible]

two rows of the array represent the fill tube, so all the material-type numbers in these rows should be Number 95. The third row represents the tube-composite interface (bonded or free) up to the liner outside surface. These material numbers should be Number 94. The fill tube is fabricated from a forging and machined with a 0.750-inch-diameter flange. The liner is welded to the flange. Since the fill tube material is a strain-hardened version of the same aluminum in the liner, it has a different yield strength and is, thus, identified as a different material. The last three elements in each row represent the liner or fill-tube flange. Then, in the first 10 rows (to the flange edge) the last three elements are Material Number 95. Liner material is Number 92, so the remainder of the rows are correct. The fourth row begins the filament-wound composite material. As mentioned, the composite material is numbered correlatively with the fiber orientation in the tangent plane. All the material types from 1 to 90 are oriented composite. Material Number 91 is the epoxy-resin component of the wound structure and is used to model any fiber voids which might occur in the pattern. These fiber voids are filled with the epoxy resin. The illustrated array shows 11 elements in the fourth row, 5 in the fifth row, and 2 in the sixth row that are resin filled. In this case, for a downwind followed by an upwind, the filling would be between the two winds. Therefore, the fourth, fifth, and sixth rows are edited to move the filled elements midway between the composite elements of the row.

The thickness profile is fed into the mesh-generation program along with other data to produce the node and element cards which describe the mesh. The polar section of the generated mesh for the first 20 rows of composite elements is illustrated in Figure 13. This drawing provides a closer view of the same general model shown earlier in Figure 12.

Figure 13. POLAR REGION OF THE 720A PATTERN MESH.

The composite-material property cards are generated in the transformation program. Material types from 1 to 90 are calculated and a set of cards are punched for input to the finite-element program. The composite material is "S" glass/epoxy resin with the following principal N-S-T direction properties when the fiber is in the T direction (property values in

parentheses denote values used for an analysis of a "crazed" vessel): moduli of elasticity, $E_N = 3.15 \times 10^6$ psi, $E_S = 3.15 \times 10^6$ psi (1×10^3 psi for "crazed" material), and $E_T = 8.60 \times 10^6$ psi. Poisson's ratios are: $\nu_{NS} = 0.245(0.0)$, $\nu_{NT} = 0.090$ (0.090), and $\nu_{ST} = 0.090$ (0.0); all shear moduli (G_{NS} , G_{NT} , and G_{ST}), 0.95×10^6 psi.

Additional material cards are prepared by hand, including: the epoxy resin material, Type 91; the liner material, Type 92; the liner/composite interface material (bonded or incompressible fluid sliding), Type 93; the fill tube/composite interface (uncoupled), Type 94; and the fill tube material, Type 95.

The boundaries of all elements on the inside of the vessel are loaded with a pressure of 15 kpsi; the outside elements of the fill tube are loaded with a negative pressure of 4.894 kpsi. These pressures balance the axial thrust on the tube due to bore pressure, as described earlier.

The title card is prepared with the title: "Axisymmetric Shell - 90 degr. segment - 1.79 degr. opng. - 720A pattern". The control card specifies 2275 nodal points, 2160 elements, 95 materials, 116 boundary pressure cards, and 4 nonlinear material approximations. A partial listing of the program output is given in Appendix F. Where node or element numbers are not in sequence, the data have been omitted.

Experimental and Analytical Results

Stresses and deformations are computed for this eight-inch vessel based on "crazed" properties. The output from the program and results from experimental tests are compared.

In studying the finite-element results, the fiber-stress values are checked for peak values. As mentioned before, no combined stress-failure criteria have been incorporated in the program. Therefore, maximum stress or maximum strain values are the most practical method of assessment of the ultimate structural capability. In this case, the "crazed" material simulates a transversely failed condition, so the maximum fiber stresses are evaluated. This model has peak fiber stresses on the composite inner surface located at meridian angles from the polar axis of approximately 3, 24, and 90 degrees. The highest fiber stress occurs at the 3 degree location.

Using an ultimate fiber strength of 320 kpsi, the pressure capacity of this vessel is estimated. By linear interpolation, using the peak stress of 360 kpsi at a 15-kpsi internal pressure, the calculated burst pressure is 13.3 kpsi. This value compares very well with the experimental value. Several experimental vessels were pressure tested to failure. These tests gave an average burst pressure for this design of 13.850 kpsi.

In addition, the failure location in the experimental units may be discussed. In general, a post-failure observation does not indicate a precise location of the initial failure (sometimes not even an imprecise location). The majority of failed units did indicate failure near the fill-tube pole. This observation concurs with the maximum fiber-stress location.

The nodal-point displacements in the R-Z coordinate system are transformed to the N-S components. This transformation is shown in the partial program output listing in Appendix F. The N component is in the radial direction of the sphere.

Radial displacement is measured experimentally by a sweep-type gage operated at incremental values of internal pressure. The sweep gage rotates an arm around the part along a meridian from the fill tube. The arm carries a calibrated linear potentiometer which measures the radial displacement. The sweep data are compensated for any center shift of the unit on its mount during pressurization. The data are then reduced to a displacement profile. The experimental and analytical results for this vessel are plotted in Figure 14. As can be seen, the agreement is good and well within the range of variation of elastic-property values.

Figure 14. EXPERIMENTAL AND THEORETICAL RADIAL DISPLACEMENTS AT A 9000-psi INTERNAL PRESSURE.

Additional results from the analysis reveal some interesting facts about the fill tube/composite interaction. The internal pressure is transmitted to the composite through the interface between the fill-tube-flange liner and the composite. The pressure is uniform over most of the sphere until the fill tube is approached. Near the fill-tube-flange outer diameter the pressure decreases and then increases again just across the flange/liner joint. The pressure builds up to approximately 20 kpsi adjacent to the fill tube when the internal pressure is 15 kpsi. The pressure distribution is indicated in Figure 15.

One of the important considerations in fabricating a vessel is the liner-to-composite bond. The purpose of the bond is to use the composite to prevent any defects in the liner from allowing local yielding and failure of the liner. This provision is especially important for thin liners. The analysis shows no significant stress on the bond over most of the sphere due to known discontinuities. The fill-tube flange area again has a different response. The shear stress builds up over this area to an elastic stress value of 10 kpsi which, obviously, the adhesive cannot hold. Therefore, the fill-tube-flange area is most likely unbonded in all cases.

Conclusions

The following conclusions can be stated as a result of this study:

1. The finite-element method is well suited for an analysis of orthotropic composite material structures. The analytical results are reasonable even though the material properties vary greatly from element to element in a filament-wound structure.

Figure 15. INTERFACE PRESSURE AS A FUNCTION OF THE POSITION. (At $P = 15$ kpsi).

2. The material transformation producing "restrained" elastic properties correlates the data best for the case studied here. This observation indicates that even though the composite "crazes" (cracks parallel to the fiber under a transverse load), the layers remain bonded, thus preventing a "scissoring" of the layers.
3. Mathematical description of the pattern yields models which adequately describe the resulting structure with respect to layer thickness and fiber orientations.
4. Fiberglass-epoxy vessels may be analyzed by this program and produce reliable evaluations of a design. Pattern design could probably be optimized for a specific vessel although the case studied here was not optimized. An optimization of this case would likely result in less than a 10% increase in efficiency.

REFERENCES

- (1) Wilson, E. L.; "Structural Analysis of Axisymmetric Solids", *AIAA Journal*, 3, (12) pp 2269 - 2274; December 1965.
- (2) Wilson, E. L. and Jones R. M.; *Finite Element Stress Analysis of Axisymmetric Solids*, Aerospace Corporation Report TR-0158, Air Force Report BSD-TR-67-228; September 1967.
- (3) Tsai, S. W.; *Mechanics of Composite Materials, Part II - Theoretical Aspects*, Technical Report AFML-TR-66-149; Air Force Materials Laboratory; November 1966.

APPENDIX A

APPENDIX A

ORIGINAL PROGRAM INPUT INSTRUCTIONS

IDENTIFICATION:

ANALYSIS OF PLANE STRESS AND AXISYMMETRIC SOLIDS

(Programmed by E. L. Wilson, University of California, February 1967)

PURPOSE:

The purpose of this computer program is to determine deformations and stresses within axisymmetric structures of arbitrary shape. The effects of displacement or stress boundary condition, concentrated loads, gravity forces and temperature changes are included. In addition, non-linear material properties are included by a successive approximation technique.

COMPUTER PROGRAM INPUT:

The first step in the structural analysis of an axisymmetric solid is to select a finite element representation of the two-dimensional cross-section of the body. Elements and nodal points are then numbered in two numerical sequences each starting with one. The following group of punched cards numerically define the two-dimensional structure to be analyzed.

A. IDENTIFICATION CARD - (72H)

Columns 1 to 72 of this card contain information to be printed with results.

B. CONTROL CARD - (4I5, 3F10.2, I5)

Columns 1 - 5 Number of nodal points (900 maximum)

6 - 10 Number of elements (800 maximum)

11 - 15 Number of different materials (12 maximum)

16 - 20 Number of boundary pressure cards (200 maximum)

21 - 30 Axial acceleration in the Z-direction

31 - 40 Angular velocity

41 - 50 Reference temperature (stress free temperature)

51 - 55 Number of approximations

56 - 60 NPP { 0 Axisymmetric Prob.
 1 Plane Stress Structure }

C. MATERIAL PROPERTY INFORMATION

The following group of cards must be supplied for each different material:

First Card - (2I5, 2F10.0)

Columns 1 - 5 Materials identification - any number from 1 to 12
 6 - 10 Number of different temperatures for which properties are given - 8 maximum
 11 - 20 Mass density of material
 21 - 30 Ratio of plastic modulus to elastic modulus

Following Cards - One card for each temperature
 Axisymmetric property (plane stress property)

Columns 1 - 10 Temperature
 11 - 20 Modulus of elasticity - E_r and E_z (E_r)
 21 - 30 Poisson's ratio - ν_{rz} (ν_{rz})
 31 - 40 Modulus of elasticity - E_θ (E_z)
 41 - 50 Poisson's ratio - $\nu_{\theta r}$ and $\nu_{\theta z}$ (G_{rz})
 51 - 60 Coefficient of thermal expansion - α_r and α_z (α_r)
 61 - 70 Coefficient of thermal expansion - α_θ (α_z)
 71 - 80 Yield stress - σ_y

D. NODAL POINT CARDS - (2I5, 5F10.0)

One card for each nodal point with the following information:

Columns 1 - 5 Nodal point number
 6 - 10 Number which indicates if displacements or forces are to be specified
 11 - 20 R - ordinate
 21 - 30 Z - ordinate
 31 - 40 XR
 41 - 50 XZ
 51 - 60 Temperature

If the number in column 10 is

- 0 XR is the specified R-load and
XZ is the specified Z-load.
- 1 XR is the specified R-displacement and
XZ is the specified Z-load.
- 2 XR is the specified R-load and
XZ is the specified Z-displacement.
- 3 XR is the specified R-displacement and
XZ is the specified Z-displacement.

All loads are considered to be total forces acting on a one radian segment.

Nodal point cards must be in numerical sequence. If cards are omitted, the omitted nodal points are generated at equal intervals along a straight line between the defined nodal points. The necessary temperatures are determined by linear interpolation. The boundary code (column 10), XR and XZ are set equal to zero.

E. ELEMENT CARDS - (615)

One card for each element

Columns	1 - 5	Element number	1. Order nodal points counter-clockwise around element.
	6 - 10	Nodal Point I	
	11 - 15	Nodal Point J	2. Maximum difference between nodal point I.D. must be less than 27.
	16 - 20	Nodal Point K	
	21 - 25	Nodal Point L	
	26 - 30	Material Identification	

Element cards must be in element number sequence. If element cards are omitted, the program automatically generates the omitted information by incrementing by one the preceding I, J, K and L. The material identification code for the generated cards is set equal to the value given on the last card. The last element card must always be supplied.

Triangular elements are also permissible, and are identified by repeating the last nodal point number (i.e., I, J, K, K).

F. PRESSURE CARDS - (2I5, 1F10.0)

One card for each boundary element which is subjected to a normal pressure.

Columns 1 - 5 Nodal Point I
 6 - 10 Nodal Point J
 11 - 20 Normal Pressure

As shown above, the boundary element must be on the left as one progresses from I to J. Surface tensile force is input as a negative pressure.

ADDITIONAL REMARKS ON USE OF THE PROGRAM:

The previous section contains a schematic description of the program input. The purpose of this section is to explain in greater detail the various options of the program.

A. OUTPUT INFORMATION

The following information is developed and printed by the program:

1. Reprint of input data
2. Nodal point displacements
3. Stresses at the center of each element
4. An approximate fundamental frequency. (The displacements for the given load condition are used as an approximate mode shape in the calculation of a frequency by Raleigh's procedure. A considerable amount of engineering judgment must be used in the interpretation of this frequency.)

APPENDIX B

APPENDIX B

MODIFIED COMPUTER PROGRAM INSTRUCTIONS

IDENTIFICATION:

ANALYSIS OF AXISYMMETRIC SOLIDS

(Programmed by E. L. Wilson, University of California, February 1967;
Modified Version 4, July 8, 1971, C. E. Knight, Jr.)

PURPOSE:

The purpose of this program is to determine the deformations and stresses within a solid of revolution that is loaded axisymmetrically and has an arbitrary cross-section and general axisymmetric material properties. The program includes the effects of displacement, force, or pressure boundary conditions.

INPUT DATA:

The two-dimensional cross-section of the solid is subdivided, by means of a network of straight lines, into a number of quadrilateral (or triangular) elements. The elements and their associated (corner) nodal points are numbered in two numerical sequences each starting with one. The following cards define the problem to be analyzed.

A. IDENTIFICATION CARD - (72H)

Columns 1 to 72 contain the problem title and other information to be presented with the results.

B. CONTROL CARD - (5I5)

Columns 1 - 5 Number of nodal points (2500 max)

6 - 10 Number of elements (2400 max)

11 - 15 Number of different materials (96 max)

16 - 20 Number of boundary pressure cards (200 max)

21 - 25 Number of approximations

C. MATERIAL CARDS (15, 3F10.0, 3F5.0, 3F10.0)

One card must be supplied for each different material. The cards do not have to be in order.

Columns 1 - 5 Material identification number
 6 - 15 Modulus of Elasticity, E_n
 16 - 25 Modulus of Elasticity, E_s
 26 - 35 Modulus of Elasticity, E_θ
 36 - 40 Poisson's ratio, ν_{ns}
 41 - 45 Poisson's ratio, $\nu_{n\theta}$
 46 - 50 Poisson's ratio, $\nu_{s\theta}$
 51 - 60 Shear Modulus, G_{ns}
 61 - 70 Yield Stress
 71 - 80 Modulus Ratio

D. ELEMENT MATERIAL TYPES (2413)

Columns 1 - 3 Material type for Element 1
 4 - 6 Material type for Element 2
 .
 .
 .
 .
 69 - 72 Material type for Element 24
 next card

. . . Material type for Element NUMEL .

Material types are supplied for the elements in an array 24 wide. The number of cards needed is then NUMEL/24 rounded up to the nearest whole number. If the material type for Element I is omitted then IX(I,5) is set equal to IX(I-1,5).

E. ELEMENT MATERIAL TRANSFORMATION ANGLES (24F3.1)

Columns 1 - 3 Angle to element material coord.(tenth degr.)
for Element 1

3 - 6 for Element 2

•
•
•
•

69 - 72 for Element 24

next card

•
•
•
•

. . . for Element NUMEL

Transformation angles are supplied for the elements in an array 24 wide. The number of cards needed is the NUMEL/24 rounded up to the nearest whole number. If the angle for Element I is omitted then WANG(I) is set equal to WANG(I-1).

F. NODAL POINT CARDS (I5, F5.0, 4F10.0)

The nodal point cards must be numbered such that the maximum difference between the node numbers of any element is less than or equal to 26 (the maximum half band width).

The nodal point cards must be in numerical sequence. If nodal point cards are omitted the omitted points are generated at equal intervals along a straight line between the defined nodal points. For the generated nodal points CODE (N), XR, and XZ (discussed below) are set equal to zero. The first and last nodal points must be supplied.

One card is supplied for each nodal point input to the program. The card contains

Columns 1 - 5 Nodal point number
6 - 10 Boundary condition code
11 - 20 R-coordinate of point
21 - 30 Z-coordinate of point
31 - 40 XR
41 - 50 XZ

If the number in Column 10 is:

- 0 then X_R = specified R load
 X_Z = specified Z load
- 1 then X_R = specified R displacement
 X_Z = specified Z load
- 2 then X_R = specified R load
 X_Z = specified Z displacement
- 3 then X_R = specified R displacement
 X_Z = specified Z displacement

If the number in columns 6 - 10 of the nodal point card is negative it is interpreted as the magnitude of an angle in degrees. The angle of the skew boundary is shown above. The other parameters are then interpreted as follows:

X_R is the specified load in the 1-direction.
 X_Z is the specified displacement in the 2-direction.

(The output on the skew boundaries are interpreted as follows:

U_R is the displacement in the 1-direction.

U_Z is the displacement in the 2-direction.)

Note: The specified boundary conditions must eliminate the possibility of a rigid body motion in the Z direction.

The load data are interpreted to be the total forces acting on a one-radian segment of the solid.

G. ELEMENT CARDS (5I5)

Element cards must be in numerical sequence. If any element cards are omitted the omitted data are generated by incrementing the preceding values of I, J, K, and L by one. The material number and angle assigned to the generated elements is the same as that of the last element preceding the missing data.

An element is defined by listing its nodal point numbers in an order obtained by proceeding around the element in a counter-clockwise direction (for a right-handed coordinate system). A triangular element is denoted by repeating the last nodal point number (ie, I, J, K, K).

The first and last element must be supplied. The element card contains:

Columns	1 - 5	Element Number
	6 - 10	Nodal point I
	11 - 15	Nodal point J
	16 - 20	Nodal point K
	21 - 25	Nodal point L

H. PRESSURE CARDS (2I5, F10.0)

One card must be supplied for each element edge which is subjected to a uniform normal pressure. The pressure is assumed to act on the edge of the element (which must be on the left as one progresses along the edge) from nodal point I to nodal point J. A suction is input as a negative pressure.

The edge pressure card contains:

Columns	1 - 5	Nodal point I
	6 - 10	Nodal point J
	11 - 20	Normal pressure

MODIFIED PROGRAM FORTRAN LISTING

LEVEL 21.6 (DEC 72)

OS/360 FORTRAN H

DATE 74.248/04.43.58

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COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0300K,
SOURCE,EB,DIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
C      AXISYMMETRIC SOLIDS      VERSION 4
C      VERSION 4      DATED 7-8-71
C
ISN 0002      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0003      COMMON NUMNP,NUMEL,NUMMAT,NUMPC,ACELZ,ANGFO,MBAND,MTYPE,TEMP,Q,
              IHED(12),EI(9,96),XD,XXNN,X(2500),Z(2500),UR(2500),U7(2500),
              2WANG(2500),CODE(2500),T(BC(200),JBC(200),PR(200),ANGLE(4),
              3SIG(13),FANG(2500),NP,NNN
ISN 0004      COMMON /ARG /RRR(5),ZZZ(5),S(10,10),P(10),TT,LM(4),DD(3,3),
              1 MH(6,10),RR(4),ZZ(4),C(4,4),H(6,10),D(6,6),F(6,10),TP(6),XI(10)
              2 ,EE(9),IX(2400,5),EPS(2400)
ISN 0005      COMMON /BANARG/ MBAN,NUMBLK,B(108),A(108,93)
ISN 0006      DIMENSION THETA(2500), URAD(2500), UTANG(2500), THETD(2500)
C
ISN 0007      REAL*4 CLASS(3)
ISN 0008      REAL*4 BUFF(5000)
ISN 0009      40 CALL ZERO
ISN 0010      LENGTH=5000
ISN 0011      CALL PLOTS (BUFF,LENGTH)
C*****
C      READ AND PRINT OF CONTROL INFORMATION AND MATERIAL PROPERTIES
C*****
ISN 0012      50 READ (5,1000) HE,NUMNP,NUMEL,NUMMAT,NUMPC, NP,ICHECK,MSHPLT
ISN 0013      WRITE (6,2000) HE,NUMNP,NUMEL,NUMMAT,NUMPC, NP,ICHECK,MSHPLT
ISN 0014      XXNN=1.0
ISN 0015      TT=0.0
ISN 0016      RD=0.0
ISN 0017      NUMTC=1
ISN 0018      T=0.0
ISN 0019      ACELZ=0.0
ISN 0020      ANGFO=0.0
ISN 0021      Q=0.0
ISN 0022      TEMP=0.0
ISN 0023      WRITE(6,2010)
ISN 0024      56 DO 58 M=1,NUMMAT
ISN 0025      READ (5,1005) MTYPE,((J,MTYPE),J=1,9)
ISN 0026      DO 57 K = 4,6
ISN 0027      57 IF(E(K,MTYPE) .EQ. 0.5) E(K,MTYPE) = 0.49999
ISN 0029      58 CONTINUE
ISN 0030      DO 59 M=1,NUMMAT
ISN 0031      WRITE (6,2013) ((J,M),J=1,9) , M
ISN 0032      59 CONTINUE
C*****
C      READ ELEMENT MATERIAL TYPES AND MATL TRANSFORMATION ANGLE
C*****
ISN 0033      READ(5,1006) (IX(I,5), I=1,NUMEL)
ISN 0034      READ(5,1007) (WANG(I), I=1,NUMEL)
ISN 0035      DO 120 I= 1,NUMEL
ISN 0036      IF(IX(I,5) .EQ. 0) IX(I,5) = IX(I-1,5)
ISN 0038      120 IF(WANG(I) .EQ. 0.) WANG(I) = WANG(I-1)
C
C*****
C      READ AND PRINT OF NODAL POINT DATA
C*****
ISN 0040      WRITE(6,2004)
ISN 0041      L=0
ISN 0042      60 READ (5,1002) N,DOE(N),R(N),Z(N),UR(N),UZ(N)
ISN 0043      NL=L+1
ISN 0044      IF( N.EQ.1 ) GO TO 70
ISN 0046      ZX=N-L
ISN 0047      DR=(R(N)-R(L))/ZX
ISN 0048      DZ=(Z(N)-Z(L))/ZX
ISN 0049      70 L=L+1
ISN 0050      IF(N-L) 100,90,80
ISN 0051      80 CODE(L)= CODE(L-1)
ISN 0052      R(L)=R(L-1)+DR
ISN 0053      Z(L)=Z(L-1)+DZ
ISN 0054      UR(L)=0.0
ISN 0055      UZ(L)=0.0
ISN 0056      GO TO 70
ISN 0057      90 WRITE(6,2002) (K,DOE(K),R(K),Z(K),UR(K),UZ(K),K=NL,N)
ISN 0058      IF(NUMNP-N) 100,110,60
ISN 0059      100 WRITE(6,2009) N
ISN 0060      CALL EXIT
ISN 0061      110 CONTINUE
C*****
C      READ AND PRINT OF ELEMENT PROPERTIES
C*****
ISN 0062      WRITE(6,2001)
ISN 0063      N=0
ISN 0064      130 READ(5,1003) M,((IX(M,I),I=1,4)
ISN 0065      FANG(M) = IX(M,5)
ISN 0066      IF( IX(M,5) .EQ. 90) FANG(M) = 0.
ISN 0068      140 N=N+1
ISN 0069      IF(M-N) 170,170,150
ISN 0070      150 IX(N,1)=IX(N-1,1)+1
ISN 0071      IX(N,2)=IX(N-1,2)+1
ISN 0072      IX(N,3)=IX(N-1,3)+1
ISN 0073      IX(N,4)=IX(N-1,4)+1
ISN 0074      FANG(N) = IX(N,5)
ISN 0075      170 WRITE(6,2003) N,((IX(N,I),I=1,5),WANG(N)
ISN 0076      IF(M-N)180,180,140
ISN 0077      180 IF ( NUMEL - N ) 189,190,130
ISN 0078      189 WRITE ( 6,2012 ) N
ISN 0079      CALL EXIT
ISN 0080      190 CONTINUE
C*****
C      READ AND PRINT OF PRESSURE BOUNDARY CONDITIONS
C*****

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TSN 0081      IF(NUMPC)290,310,290
TSN 0082      290 WRITE(6,2005)
TSN 0083      DO 300 L=1,NUMPC
TSN 0084      READ (5,1004) I8(L),J8(L),PR(L)
TSN 0085      PR(L) = 15.*PR(L)
TSN 0086      300 WRITE(6,2007) I8(L),J8(L),PR(L)
TSN 0087      310 CONTINUE

C
C*****
C      PLOT A MESH.PLOT OF THE GEOMETRY, IF REQUESTED.
C*****
C
C      (N1,N2) ARE FIRST AND LAST ELEMENTS NUMBERS TO BE PLOTTED
C      SCALE IS FACTOR TO MAKE VERTICAL DIMENSION .LE. 10.0 INCHES
C      (XD,YD) ARE COORDINATES OF ORIGIN ON PAPER (YD .GE. 0.5 )
C      CLASS CONTAINS 0-12 HOLLERITH CHARACTERS. WRITTEN ON LEFT EDGE.
TSN 0088      IF (MSHPLT.LE.0) GO TO 346
TSN 0090      DO 345 M=1,MSHPLT
TSN 0091      READ (5,1008) N1,N2,SCALE,XD,YD,CLASS
TSN 0092      CALL GROPLT (NUMNP,NUMEL,N1,N2,SCALE,XD,YD,HED,CLASS,IX,R,Z)
TSN 0093      345 CONTINUE
TSN 0094      346 IF (ICHECK.NE.0) GO TO 50

C
C*****
C      DETERMINE BAND WIDTH
C*****
TSN 0096      J=0
TSN 0097      DO 340 N=1,NUMEL
TSN 0098      DO 340 I=1,4
TSN 0099      DO 325 L=1,4
TSN 0100      KK=IABS(LX(N,I)-LX(N,L))
TSN 0101      IF(KK-J)325,325,320
TSN 0102      320 J=KK
TSN 0103      325 CONTINUE
TSN 0104      340 CONTINUE
TSN 0105      MBAND=2*J+2
TSN 0106      MBAND = MBAND

C*****
C      SOLVE NON-LINEAR STRUCTURE BY SUCCESSIVE APPROXIMATIONS
C*****
TSN 0107      DO 350 N=1,NUMEL
TSN 0108      350 EPS(N)=0.0

C
C      IF ( NP.EQ.0 ) NP = 1
TSN 0109      DO 500 NNN=1,NP
TSN 0111

C
C      FORM STIFFNESS MATRIX
C
TSN 0112      CALL STIFF

C
C      SOLVE FOR DISPLACEMENTS
C
TSN 0113      CALL BANSOL

C
C      IF(NNN .NE. NP) GO TO 401
TSN 0114      DO 400 I = 1,NUMNP
TSN 0116      THETA(I) = DATAN2(Z(I),R(I))
TSN 0117      THETA(I) = THETA(I)*57.29578
TSN 0118      URAD(I) = B(2*I-1)*CCOS(THETA(I)) + B(2*I)*DSIN(THETA(I))
TSN 0119      UTANG(I) = B(2*I-1)*USIN(THETA(I)) - B(2*I)*DCOS(THETA(I))
TSN 0120      400 WRITE (6,2006) (N,B(2*N-1),B(2*N),THETA(N),URAD(N),UTANG(N),N=1,
TSN 0121      NUMNP)
TSN 0122      401 CONTINUE

C
C      COMPUTE STRESSES
C
TSN 0123      CALL STRESS

C
C      500 CONTINUE
TSN 0124

C
C      GO TO 40
TSN 0125

C*****
C*****
1000 FORMAT (12A6/7I5)
1002 FORMAT (15,F5.0,4F10.0)
1003 FORMAT (5I5)
1004 FORMAT (2I5,F10.0)
1005 FORMAT (15, 3F10.0, 3F5.0, 3F10.0)
1006 FORMAT(24I3)
1007 FORMAT(24F3.1)
1008 FORMAT(2I5, 3F10.0, 3A4)
2000 FORMAT (14I1 12A6/
1 30H0 NUMBER OF NODAL POINTS----- 14 /
2 30H0 NUMBER OF ELEMENTS----- 14 /
3 30H0 NUMBER OF DIFF. MATERIALS----- 13 /
4 30H0 NUMBER OF PRESSURE CARDS----- 13 /
5 30H0 NUMBER OF APPROXIMATIONS----- 13 /
6 30H0 DATA CHECK ONLY (0=NO)----- 13 /
7 30H0 NUMBER OF PLOTS----- 13 //)

TSN 0135      2001 FORMAT (58H1ELEMENT NO.      I      J      K      L      MATERIAL      AN
1GLE)
TSN 0136      2002 FORMAT (11I2,F12.2,2F12.3,2E24.7)
TSN 0137      2003 FORMAT ( 1I3, 4I6, 1I2, F9.1)
TSN 0138      2004 FORMAT ( 97H1NODAL POINT      TYPE R-ORDINATE Z-ORDINATE R LO
1AD OR DISPLACEMENT Z LOAD OR DISPLACEMENT )
TSN 0139      2005 FORMAT (29H0PRESSURE BOUNDARY CONDITIONS/ 24H      I      J      PRESS
1URE )
TSN 0140      2006 FORMAT (12H1N.P. NUMBER 18X 2HUR 18X 2HUZ 15X 5HANGLE 16X 4HURAD
115X 5HUTANG / (11I2, 5E20.6))
TSN 0141      2007 FORMAT (2I6,F12.3)
TSN 0142      2009 FORMAT (26H0NODAL POINT CARD ERROR N= 15)
TSN 0143      2010 FORMAT ( 4X, 5H E(N), 8X, 4H E(S), 8X, 4H E(T), 8X, 6HNU(NS), 6X,
1 6HNU(NT),6X, 6HNU(ST), 6X, 5H G(NS), 5X, 10HYIELD STR, 12H MOD R
2ATIO, 10H MATERIAL //)

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ISN 0144      2011 FORMAT (17HOMATERIAL NUMBER= 13)
ISN 0145      2012 FORMAT ( 2HOLEMENT ERROR FOR N= , 15 )
ISN 0146      2013 FORMAT(9E12.3, 6X, 14)
C
ISN 0147      END

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LEVEL 21.6 (DEC 72)

OS/360 FORTRAN H

DATE 74.248/04.44.11

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COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,E3=DIC,NQLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
ISN 0002      SUBROUTINE STIFF
C
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      COMMON NUMNP,NUMEL,NUMMAT,NUMPC,ACELZ,ANGFQ,MBAND,MTYPE,TEMP,Q,
1HED(12),E(9,96),IO,XXN, R(2500),Z(2500),UR(2500),UZ(2500),
2WANG(2500),CODE(2500),T,IBC(200),JBC(200),PR(200),ANGLE(4),
3SIG(13),FANG(2500),NP,NNN
ISN 0005      COMMON/ARG/RKK(5),ZZZ(5),S(10,10),P(10),TT,LM(4),DD(3,3),
1HH(6,10),RR(4),ZZ(4),C(4,4),H(6,10),D(6,6),F(6,10),TP(6),XII(10)
2,EE(9),IX(2400,5),EPS(2400)
ISN 0006      COMMON /BANARG/ MBAN,NUMBLK,B(108),A(108,93)
C
C*****
C      INITIALIZATION
C*****
ISN 0007      REWIND 2
ISN 0008      NB=27
ISN 0009      ND=2*NB
ISN 0010      ND2=2*ND
ISN 0011      STOP=0.0
ISN 0012      NUMBLK=0
C
ISN 0013      DO 50 N=1,ND2
ISN 0014      B(N)=0.0
ISN 0015      DO 50 M=1,93
ISN 0016      50 A(N,M)=0.0
C*****
C      FORM STIFFNESS MATRIX IN BLOCKS
C*****
ISN 0017      60 NUMBLK=NUMBLK+1
ISN 0018      NH=NB*(NUMBLK+1)
ISN 0019      NM=NH-NB
ISN 0020      NL=NM-NB+1
ISN 0021      KSHIFT=2*NL-2
C
ISN 0022      DO 210 N=1,NUMEL
C
ISN 0023      IF(IX(N,5)) 210,210.65
ISN 0024      65 DO 80 I=1,4
ISN 0025      IF(IX(N,I)-NL) 80,70,70
ISN 0026      70 IF(IX(N,I)-NM) 90,90,80
ISN 0027      80 CONTINUE
ISN 0028      GO TO 210
C
ISN 0029      90 CALL QUAD(N,VOL)
C
ISN 0030      IF(VOL) 142,142,144
ISN 0031      142 WRITE(6,2003) N
ISN 0032      STOP=1.0
ISN 0033      144 IF(IX(N,3)-IX(N,4)) 145,145,145
ISN 0034      145 DO 150 II=1,9
ISN 0035      CC=S(II,10)/S(10,10)
ISN 0036      P(II)=P(II)-CC*P(10)
ISN 0037      DO 150 JJ=1,9
ISN 0038      150 S(II,JJ)=S(II,JJ)-CC*S(10,JJ)
C
ISN 0039      DO 160 II=1,8
ISN 0040      CC=S(II,9)/S(9,9)
ISN 0041      P(II)=P(II)-CC*P(9)
ISN 0042      DO 160 JJ=1,8
ISN 0043      160 S(II,JJ)=S(II,JJ)-CC*S(9,JJ)
C
C      ADD ELEMENT STIFFNESS TO TOTAL STIFFNESS
C
ISN 0044      165 DO 166 I=1,4
ISN 0045      166 LM(I)=2*IX(N,I)-2
C
ISN 0046      DO 200 I=1,4
ISN 0047      DO 200 K=1,2
ISN 0048      II=LM(I)+K-KSHIFT
ISN 0049      KK=2*I-2+K
ISN 0050      B(II)=B(II)+P(KK)
ISN 0051      DO 200 J=1,4
ISN 0052      DO 200 L=1,2
ISN 0053      JJ=LM(J)+L-II+1-KSHIFT
ISN 0054      LL=2*J-2+L
ISN 0055      IF(JJ) 200,200,175
ISN 0056      175 IF(ND-JJ) 180,195,195
ISN 0057      180 WRITE(6,2004) N
ISN 0058      STOP=1.0
ISN 0059      GO TO 210
ISN 0060      195 A(II,JJ)=A(II,JJ)+S(KK,LL)

```

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ISN 0061      200 CONTINUE
ISN 0062      210 CONTINUE
C
C      ADD CONCENTRATED FORCES WITHIN BLOCK
C
ISN 0063      DO 250 N=NL,NM
ISN 0064      K=2*N-KSHIFT
ISN 0065      B(K)=B(K)+UZ(N)
ISN 0066      250 B(K-1)=B(K-1)+UR(N)
C
C      BOUNDARY CONDITIONS
C
C      1. PRESSURE B.C.
C
ISN 0067      IF(NUMPC) 260,310,260
ISN 0068      260 DO 300 L=1,NUMPC
ISN 0069      I=IBC(L)
ISN 0070      J=JBC(L)
ISN 0071      PP=PR(L)/6.
ISN 0072      DZ=(Z(I)-Z(J))*PP
ISN 0073      OR=(R(J)-R(I))*PP
ISN 0074      RX=2.0*RI(J)+R(I)
ISN 0075      ZX=R(I)+2.0*R(J)
ISN 0076      264 II=2*I-KSHIFT
ISN 0077      JJ=2*J-KSHIFT
ISN 0078      IF(II) 280,280,265
ISN 0079      265 IF(II-ND) 270,270,280
ISN 0080      270 SINA=0.0
ISN 0081      COSA=1.0
ISN 0082      IF(CODE(I)) 271,272,272
ISN 0083      271 SINA=DSIN(CODE(I))/57.295779513082321
ISN 0084      COSA=DCOS(CODE(I))/57.295779513082321
ISN 0085      272 B(II-1)=B(II-1)+RX*(COSA*DZ+SINA*OR)
ISN 0086      B(II)=B(II)-RX*(SINA*DZ-COSA*OR)
ISN 0087      280 IF(JJ) 300,300,285
ISN 0088      285 IF(JJ-ND) 290,290,300
ISN 0089      290 SINA=0.0
ISN 0090      COSA=1.0
ISN 0091      IF(CODE(J)) 291,292,292
ISN 0092      291 SINA=DSIN(CODE(J))/57.295779513082321
ISN 0093      COSA=DCOS(CODE(J))/57.295779513082321
ISN 0094      292 B(JJ-1)=B(JJ-1)+ZX*(COSA*DZ+SINA*DR)
ISN 0095      R(JJ)=B(JJ)-ZX*(SINA*DZ-COSA*DR)
ISN 0096      300 CONTINUE
C
C      2. DISPLACEMENT B.C.
C
ISN 0097      310 DO 400 M=NL,NM
ISN 0098      IF(M=NUMNP) 315,315,400
ISN 0099      315 U=UR(M)
ISN 0100      N=2*M-1-KSHIFT
ISN 0101      IF(CODE(M)) 390,400,316
ISN 0102      316 IF(CODE(M)-1.) 317,370,317
ISN 0103      317 IF(CODE(M)-2.) 318,390,318
ISN 0104      318 IF(CODE(M)-3.) 390,380,390
ISN 0105      370 CALL MODIFY(A,B,ND2,MBAND,N,U)
ISN 0106      GO TO 400
ISN 0107      380 CALL MODIFY(A,B,ND2,MBAND,N,U)
ISN 0108      390 U=UZ(M)
ISN 0109      N=N+1
ISN 0110      CALL MODIFY(A,B,ND2,MBAND,N,U)
ISN 0111      400 CONTINUE
C
C      WRITE BLOCK OF EQUATIONS ON TAPE AND SHIFT UP LOWER BLOCK
C
ISN 0112      WRITE(2) (B(N), (A(N,M), M=1,MBAND), N=1,ND)
C
ISN 0113      DO 420 N=1,ND
ISN 0114      K=N+ND
ISN 0115      B(N)=B(K)
ISN 0116      B(K)=0.0
ISN 0117      DO 420 M=1,ND
ISN 0118      A(N,M)=A(K,M)
ISN 0119      420 A(K,M)=0.0
C
C      CHECK FOR LAST BLOCK
C
ISN 0120      IF(NM=NUMNP) 60,480,480
ISN 0121      480 CONTINUE
C*****
ISN 0122      IF(STOP) 490,500,490
ISN 0123      490 CALL EXIT
ISN 0124      500 RETURN
C
ISN 0125      2003 FORMAT (26HNEGATIVE AREA ELEMENT NO. 14)
ISN 0126      2004 FORMAT (29HOBAND WIDTH EXCEEDS ALLOWABLE 14)
ISN 0127      END

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ISN 0002      SUBROUTINE QUAD(N,VOL)
C
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      COMMON NUMNP,NUMEL,NUMMAT,NUMPC,ACELZ,ANGFO,MBAND,MTYPE,TEMP,Q,
1HEDI(12),EI(9,96),RO,XXNN,R(2500),Z(2500),UR(2500),UZ(2500),
2WANG(2500),CODE(2500),T,IBC(200),JBC(200),PR(200),ANGLE(4),
3SIG(13),FANG(2500),NP,NNN
ISN 0005      COMMON/ARG/RRR(5),ZZZ(5),S(10,10),P(10),TT,LM(4),DD(3,3),
1HME(6,10),RR(4),ZZ(4),C(4,4),H(6,10),D(6,6),F(6,10),TP(6),XI(10)
2EE(9),IX(2400,5),EPS(2400)
ISN 0006      COMMON /BANARG/ ND,NUMBLK,B(108),A(108,93)
C
ISN 0007      I=IX(N,1)
ISN 0008      J=IX(N,2)
ISN 0009      K=IX(N,3)
ISN 0010      L=IX(N,4)
ISN 0011      MTYPE=IX(N,5)
ISN 0012      IX(N,5)=IX(N,5)
ISN 0013      TEMP=0.0
ISN 0014      71 DO 105 KK=1,9
ISN 0015      105 EE(KK)=E(KK,MTYPE)
ISN 0016      IF(EE(8).EQ. 0.) GO TO 108
ISN 0017      EPSR = EE(8)/EE(1)
ISN 0018      IF(EPSR - EPS(N)) 106,108,108
ISN 0019      106 RATIO = (EE(8)/(EPS(N)*EE(1)))*(1.0 - EE(9)) + EE(9)
ISN 0020      EE(1) = EE(1)*RATIO
ISN 0021      EE(2) = EE(2)*RATIO
ISN 0022      EE(3) = EE(3)*RATIO
ISN 0023      EE(7) = EE(1)/(2.*(1. + EE(4)))
ISN 0024      108 CONTINUE
C
ISN 0025      NU SUB I,J IS THE CHANGE IN THE J-DIP. DUE TO TENSION IN I-DIR.
C      FOR EXAMPLE SEE ***ANI SOTROPIC PLATES*** BY LEKNITSKII
C
C      FORM STRESS-STRAIN TRANSFORMATION IN N-S-T SYSTEM
C
ISN 0026      86 C(1,1)= 1.0/EE(1)
ISN 0027      C(1,2)= -EE(4)/EE(1)
ISN 0028      C(1,3)= -EE(5)/EE(1)
ISN 0029      C(1,4)= 0.0
ISN 0030      C(2,1)= C(1,2)
ISN 0031      C(2,2)= 1.0/EE(2)
ISN 0032      C(2,3)= -EE(6)/EE(2)
ISN 0033      C(2,4)= 0.0
ISN 0034      C(3,1)= C(1,3)
ISN 0035      C(3,2)= C(2,3)
ISN 0036      C(3,3)= 1.0/EE(3)
ISN 0037      C(3,4)= 0.0
ISN 0038      C(4,1)= 0.0
ISN 0039      C(4,2)= 0.0
ISN 0040      C(4,3)= 0.0
ISN 0041      C(4,4)= EE(7)
C
ISN 0042      CALL SYMINV (C,3)
C
C      ROTATE MATERIAL PROPERTIES TO R-Z-T SYSTEM
C
ISN 0043      SS= DSIN(WANG(N)/57.29577951308232)
ISN 0044      CC= DCOS(WANG(N)/57.29577951308232)
ISN 0045      S2= SS*SS
ISN 0046      C2= CC*CC
ISN 0047      SC= SS*CC
C
ISN 0048      D(1,1)=C2
ISN 0049      D(1,2)=S2
ISN 0050      D(1,3)=0.0
ISN 0051      D(1,4)=SC
ISN 0052      D(2,1)=S2
ISN 0053      D(2,2)=C2
ISN 0054      D(2,3)=0.0
ISN 0055      D(2,4)=-SC
ISN 0056      D(3,1)=0.0
ISN 0057      D(3,2)=0.0
ISN 0058      D(3,3)=1.0
ISN 0059      D(3,4)=0.0
ISN 0060      D(4,1)=-2.*SC
ISN 0061      D(4,2)=2.*SC
ISN 0062      D(4,3)=0.0
ISN 0063      D(4,4)=C2-S2
C
ISN 0064      DO 88 II=1,4
ISN 0065      DO 88 JJ=1,4
ISN 0066      H(II,JJ)=0.0
ISN 0067      DO 88 KK=1,4
ISN 0068      88 H(II,JJ)=H(II,JJ) + C(II,KK)*D(KK,JJ)
C
ISN 0069      DO 87 II=1,4
ISN 0070      DO 87 JJ=1,4
ISN 0071      C(II,JJ)=0.0
ISN 0072      DO 87 KK=1,4
ISN 0073      87 C(II,JJ)=C(II,JJ) + D(KK,II)*H(KK,JJ)
ISN 0074      TT=0.0
C
C      FORM QUADRILATERAL STIFFNESS MATRIX
C
ISN 0075      RRR(5)=(R(1)+R(J)+R(K)+R(L))/4.0
ISN 0076      ZZZ(5)=(Z(1)+Z(J)+Z(K)+Z(L))/4.0
ISN 0077      DO 94 M=1,4
ISN 0078      MM=IX(N,M)
ISN 0079      89 IF(R(MM))93,91,93
ISN 0080      91 R(MM)=.01*RRR(5)
ISN 0081      IF(CODE(MM))93,92,93
ISN 0082      92 CODE(MM)=1.0
ISN 0083      93 RRR(M)=R(MM)

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ISN 0084      94 ZZZ(M)=Z(MM)
C
ISN 0085      DO 100 II=1,10
ISN 0086      PI(II)=0.0
ISN 0087      DO 95 JJ=1,6
ISN 0088      95 HH(JJ,II)=0.0
ISN 0089      DO 100 JJ=1,10
ISN 0090      100 SI(II,JJ)=0.0
ISN 0091      DO 119 II=1,4
ISN 0092      JJ=IX(N,II)
ISN 0093      119 ANGLE(II)=CODE(JJ)/57.29577951308232
ISN 0094      VOL=0.0
ISN 0095      IF(K-L)125,120,125
ISN 0096      120 CALL TRISTF(1,2,3)
ISN 0097      RRR(5)=(RRR(1)+RRR(2)+RRR(3))/3.0
ISN 0098      ZZZ(5)=(ZZZ(1)+ZZZ(2)+ZZZ(3))/3.0
ISN 0099      VOL=XI(1)
ISN 0100      GO TO 130
ISN 0101      125 VOL=0.0
ISN 0102      CALL TRISTF(4,1,5)
ISN 0103      VOL=VOL+XI(1)
ISN 0104      CALL TRISTF(1,2,5)
ISN 0105      VOL=VOL+XI(1)
ISN 0106      CALL TRISTF(2,3,5)
ISN 0107      VOL=VOL+XI(1)
ISN 0108      CALL TRISTF(3,4,5)
ISN 0109      VOL=VOL+XI(1)
C
ISN 0110      DO 140 II=1,6
ISN 0111      DO 140 JJ=1,10
ISN 0112      140 HH(II,JJ)=HH(II,JJ)/4.0
ISN 0113      130 RETURN
ISN 0114      END

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LEVEL 21.6 (DEC 72)

OS/360 FORTRAN H

DATE 74.248/04.44.37

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINENCT=60,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,NODECK,LCAD,M&P,NOEDIT,NOID,NOXREF

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ISN 0002      SUBROUTINE TRISTF(II,JJ,KK)
C
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      COMMON NUMNP,NUMEL,NUMMAT,NUMPC,ACELZ,ANGFO,MBAND,MTYPE,TEMP,Q,
1MEO(12),EI(9,96),RO,XXNN,R(2500),Z(2500),UR(2500),UZ(2500),
2WANGI(2500),CODE(2500),T,IBC(200),JBC(200),PRI(200),ANGLE(4),
3SIG(13),FANG(2500),NP,NNN
ISN 0005      COMMON/ARG/RRR(5),ZZZ(5),SI(10,10),PI(10),TT,LM(4),DD(3,3),
1HH(6,10),RK(4),ZZ(4),C(4,4),H(6,10),D(6,6),F(6,10),TP(6),XI(10)
2,EE(9),IX(2400,5),EPS(2400)
C
C      1. INITIALIZATION
C
ISN 0006      LM(1)=II
ISN 0007      LM(2)=JJ
ISN 0008      LM(3)=KK
C
ISN 0009      RRI(1)=RRR(II)
ISN 0010      RRI(2)=RRR(JJ)
ISN 0011      RRI(3)=RRR(KK)
ISN 0012      RRI(4)=RRR(II)
ISN 0013      ZZI(1)=ZZZ(II)
ISN 0014      ZZI(2)=ZZZ(JJ)
ISN 0015      ZZI(3)=ZZZ(KK)
ISN 0016      ZZI(4)=ZZZ(II)
C
ISN 0017      85 DO 100 I=1,6
ISN 0018      DO 90 J=1,10
ISN 0019      FI(I,J)=0.0
ISN 0020      90 HI(I,J)=0.0
ISN 0021      DO 100 J=1,6
ISN 0022      100 DI(I,J)=0.0
C
C      3. FORM INTEGRAL(G)T*(C)*(G)
C
ISN 0023      CALL INTER(XI,RR,ZZ)
C
ISN 0024      106 DI(1,1)=XI(3)*C(3,3)
ISN 0025      DI(1,2)=XI(2)*(C(1,3)+C(3,3))
ISN 0026      DI(1,3)=XI(5)*C(3,3)+XI(2)*C(3,4)
ISN 0027      DI(1,4)=0.0
ISN 0028      DI(1,5)=XI(2)*C(3,4)
ISN 0029      DI(1,6)=XI(2)*C(2,3)
ISN 0030      DI(2,2)=XI(1)*(C(1,1)+2.0*C(1,3)+C(3,3))
ISN 0031      DI(2,3)=XI(4)*(C(1,3)+C(3,3))+XI(1)*(C(1,4)+C(3,4))
ISN 0032      DI(2,4)=0.0
ISN 0033      DI(2,5)=XI(1)*(C(1,4)+C(3,4))
ISN 0034      DI(2,6)=XI(1)*(C(1,2)+C(2,3))
ISN 0035      DI(3,3)=XI(6)*C(3,3)+XI(1)*C(4,4)+2.*XI(4)*C(3,4)
ISN 0036      DI(3,4)=0.0
ISN 0037      DI(3,5)=XI(1)*C(4,4)+XI(4)*C(3,4)
ISN 0038      DI(3,6)=XI(4)*C(2,3)+XI(1)*C(2,4)
ISN 0039      DI(4,4)=0.0

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ISN 0040      D(4,5)=0.0
ISN 0041      D(4,6)=0.0
ISN 0042      D(5,5)=X(1)*C(4,4)
ISN 0043      D(5,6)=X(1)*C(2,4)
ISN 0044      D(6,6)=X(1)*C(2,2)

C
ISN 0045      108 DO 110 I=1,6
ISN 0046      DO 110 J=1,6
ISN 0047      110 D(I,J)=D(I,J)

C
C      4. FORM COEFFICIENT-DISPLACEMENT TRANSFORMATION MATRIX
C
ISN 0048      COMM=RR(2)*(ZZ(1)-ZZ(11))+RR(1)*(ZZ(2)-ZZ(3))+RR(3)*(ZZ(1)-ZZ(2))
ISN 0049      DD(1,1)=(RR(2)*ZZ(3)-RR(3)*ZZ(2))/COMM
ISN 0050      DD(1,2)=(RR(3)*ZZ(1)-RR(1)*ZZ(3))/COMM
ISN 0051      DD(1,3)=(RR(1)*ZZ(2)-RR(2)*ZZ(1))/COMM
ISN 0052      DD(2,1)=(ZZ(2)-ZZ(3))/COMM
ISN 0053      DD(2,2)=(ZZ(3)-ZZ(1))/COMM
ISN 0054      DD(2,3)=(ZZ(1)-ZZ(2))/COMM
ISN 0055      DD(3,1)=(RR(3)-RR(2))/COMM
ISN 0056      DD(3,2)=(RR(1)-RR(3))/COMM
ISN 0057      DD(3,3)=(RR(2)-RR(1))/COMM

C
ISN 0058      DO 120 I=1,3
ISN 0059      J=2*LM(I)-1
ISN 0060      H(1,J)=DD(1,1)
ISN 0061      H(2,J)=DD(2,1)
ISN 0062      H(3,J)=DD(3,1)
ISN 0063      H(4,J+1)=DD(1,1)
ISN 0064      H(5,J+1)=DD(2,1)
ISN 0065      120 H(6,J+1)=DD(3,1)

C
C      ROTATE UNKNOWNNS IF REQUIRED
C
ISN 0066      DO 125 J=1,2
ISN 0067      I=LM(J)
ISN 0068      IF(ANGLE(I))122,125,125
ISN 0069      122 SINA=DSIN(ANGLE(I))
ISN 0070      COSA=DCOS(ANGLE(I))
ISN 0071      IJ=2*I
ISN 0072      DO 124 K=1,6
ISN 0073      TEM=H(K,IJ-1)
ISN 0074      H(K,IJ-1)=TEM*COSA+H(K,IJ)*SINA
ISN 0075      124 H(K,IJ)=-TEM*SINA+H(K,IJ)*COSA
ISN 0076      125 CONTINUE

C
C      5. FORM ELEMENT STIFFNESS MATRIX (HIT*(D)*H)
C
ISN 0077      DO 130 J=1,10
ISN 0078      DO 130 K=1,6
ISN 0079      IF(H(K,J))128,130,128
ISN 0080      128 DO 129 I=1,6
ISN 0081      129 F(I,J)=F(I,J)+D(I,K)*H(K,J)
ISN 0082      130 CONTINUE

C
ISN 0083      DO 140 I=1,10
ISN 0084      DO 140 K=1,6
ISN 0085      IF(H(K,I))138,140,138
ISN 0086      138 DO 139 J=1,10
ISN 0087      139 S(I,J)=S(I,J)+H(K,I)*F(K,J)
ISN 0088      140 CONTINUE

C
ISN 0089      FORM STRAIN TRANSFORMATION MATRIX
ISN 0090      400 DO 410 I=1,6
ISN 0091      DO 410 J=1,10
ISN 0092      410 HH(I,J)=HH(I,J)+I(I,J)
ISN 0093      RETURN
END

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LEVEL 21.6 (DEC 72)

05/360 FORTRAN H

DATE 74.248/04.44.49

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE STRESS

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ISN 0002      C
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      COMMON NUMNP,NUMEL,NUMMAT,NUMPC,ACELZ,ANGFQ,MBAND,MTYPE,TEMP,Q,
1HED(12),EI(9,96),RO,XXNN,R(2500),Z(2500),UR(2500),UZ(2500),
2WANG(2500),CODE(2500),T,IBC(200),JBC(200),PR(200),ANGLE(4),
3SIG(13),FANG(2500),NP,NNN
ISN 0005      COMMON/ARG/RR(5),ZZ(5),S(10,10),P(10),TT,LM(4),DD(3,3),
1 HH(6,10),RR(4),ZZ(4),C(6,6),H(6,10),D(6,6),F(6,10),I(6),X(10)
2 ,EE(9),IX(2400),EPS(2400)
ISN 0006      COMMON /BANARG/ ND,NUMBLK,8(108),A(108,93)
C*****
C      COMPUTE ELEMENT STRESSES
C*****
ISN 0007      XCE=0.0
ISN 0008      XPF=0.0
ISN 0009      MPRINT=0

C
ISN 0010      DO 300 M=1,NUMEL

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C
ISN 0011      N=M
ISN 0012      IX(N,5)=IABS(IX(N,5))
ISN 0013      MTYPE=IX(N,5)
ISN 0014      CALL QUAD(N,VOL)
ISN 0015      IX(N,5)=MTYPE

C
ISN 0016      DO 120 I=1,4
ISN 0017      II=2*I
ISN 0018      JJ=2*IX(N,I)
ISN 0019      P(II-1)=B(JJ-1)
ISN 0020      120 P(II)=B(JJ)

C
ISN 0021      DO 150 I=1,2
ISN 0022      RR(I)=P(I+8)
ISN 0023      DO 150 K=1,8
ISN 0024      150 RR(I)=RR(I)-S(I+8,K)*P(K)

C
ISN 0025      COMM=S(9,9)*S(10,10)-S(9,10)*S(10,9)
ISN 0026      IF(COMM)155,160,155
ISN 0027      155 P(9)=(S(10,10)*RR(11)-S(9,10)*RR(21))/COMM
ISN 0028      P(10)=(-S(10,9)*RR(11)+S(9,9)*RR(21))/COMM
ISN 0029      160 DO 170 I=1,6
ISN 0030      TP(I)=0.0
ISN 0031      DO 170 K=1,10
ISN 0032      170 TP(I)=TP(I)+HH(I,K)*P(K)

C
ISN 0033      RR(1)=TP(2)
ISN 0034      RR(2)=TP(6)
ISN 0035      RR(3)=(TP(11)+TP(21)*RRR(51)+TP(31)*ZZZ(511)/RRR(51)
ISN 0036      RR(4)=TP(31)+TP(51)

C
ISN 0037      176 DO 180 I=1,4
ISN 0038      SIG(I)=-TY
ISN 0039      DO 180 K=1,4
ISN 0040      180 SIG(I)=SIG(I)+C(I,K)*RR(K)

C
C      CALCULATE EFFECTIVE STRAIN
C
ISN 0041      CC=(RR(1)+RR(2))/2.0
ISN 0042      CR=DSORT((RR(2)-RR(1))/2.0)**2+(RR(4)/2.0)**2)
ISN 0043      RR1=CC+CR
ISN 0044      RR2=CC-CR
ISN 0045      EPSN=DSORT((RR1-RR2)**2+(RR1-RR(3))**2+(RR2-
      1 RR(3))**2)*.707/(1.0+EE(4))

C
C*****
C      OUTPUT STRESSES
C*****
C
C      CALCULATE PRINCIPAL STRESSES
C
ISN 0046      CC=(SIG(1)+SIG(2))/2.0
ISN 0047      BB=(SIG(1)-SIG(2))/2.0
ISN 0048      CR=DSORT(BB**2+SIG(4)**2)
ISN 0049      SIG(5)=CC+CR
ISN 0050      SIG(6)=CC-CR
ISN 0051      SIG(7)=28.648*DATAN2(SIG(4),BB)

C
C      CALCULATE STRESSES IN N-S SYSTEM
C
ISN 0052      ANG=WANG(M)/28.6478897565*116
ISN 0053      SIN2A=DSIN(ANG)
ISN 0054      COS2A=DCOS(ANG)
ISN 0055      CX=.5*(SIG(1)-SIG(2))
ISN 0056      SIG(8)=CX*COS2A+SIG(4)*SIN2A+CC
ISN 0057      SIG(9)=2.*CC-SIG(8)
ISN 0058      SIG(10)=-CX*SIN2A+SIG(4)*COS2A

C
C      CALCULATE STRAINS IN N-S SYSTEM
C
ISN 0059      ANGP=WANG(M)/57.2957795
ISN 0060      COSAP=DCOS(ANGP)
ISN 0061      SINAP=DSIN(ANGP)
ISN 0062      EPSN=COSAP**2*RR(1)+SINAP**2*RR(2)+SINAP*COSAP*RR(4)
ISN 0063      EPSS=COSAP**2*RR(2)+SINAP**2*RR(1)-SINAP*COSAP*RR(4)
ISN 0064      EPST=RR(3)
ISN 0065      EPSNS=2.*(RR(2)-RR(1))*SINAP*COSAP+(COSAP**2-SINAP**2)*RR(4)

C
C      CALCULATE STRAINS IN F-E SYSTEM
C
ISN 0066      ANGL=FANG(M)/57.2957795
ISN 0067      COSAL=DCOS(ANGL)
ISN 0068      SINAL=DSIN(ANGL)
ISN 0069      EPSF=COSAL**2*EPST+SINAL**2*EPSS
ISN 0070      EPSE=COSAL**2*EPSS+SINAL**2*EPST
ISN 0071      EPSFE=2.*(EPSS-EPST)*SINAL*COSAL

C
C      CALCULATE STRESSES IN F-E SYSTEM
C
ISN 0072      MAT=90
ISN 0073      IF(E(1,MAT).EQ.0.)GO TO 190
ISN 0075      DO 185 KK=1,7
ISN 0076      185 EE(KK)=E(KK,MAT)
ISN 0077      C(1,1)=1.0/EE(1)
ISN 0078      C(1,2)=-EE(4)/EE(1)
ISN 0079      C(1,3)=-EE(5)/EE(1)
ISN 0080      C(1,4)=0.0
ISN 0081      C(2,1)=C(1,2)
ISN 0082      C(2,2)=1.0/EE(2)
ISN 0083      C(2,3)=-EE(6)/EE(2)
ISN 0084      C(2,4)=0.0

```



```

ISN 0085      C(3,1) = C(1,3)
ISN 0086      C(3,2) = C(2,3)
ISN 0087      C(3,3) = 1.0/EE(3)
ISN 0088      C(3,4) = 0.0
ISN 0089      C(4,1) = 0.0
ISN 0090      C(4,2) = 0.0
ISN 0091      C(4,3) = 0.0
ISN 0092      C(4,4) = 950000.

C
ISN 0093      CALL SYMINV(C,3)

C
ISN 0094      190 SIG(11) = C(3,1)*EPSN + C(3,2)*EPSE + C(3,3)*EPSF
ISN 0095      SIG(12) = C(2,1)*EPSN + C(2,2)*EPSE + C(2,3)*EPSF
ISN 0096      SIG(13) = C(4,4)*EPSFE

C
ISN 0097      IF(INNN .NE. NP) GO TO 300
ISN 0099      104 IF(MPRINT) 110,105,110
ISN 0100      105 WRITE(6,2000)
ISN 0101      MPRINT=48
ISN 0102      110 MPRINT=MPRINT-1

C
ISN 0103      305 WRITE(6,2001)N,RRR(5),ZZZ(5),(SIG(I),I=1,4),(SIG(I),I=8,13)
ISN 0104      300 CONTINUE
ISN 0105      320 RETURN
ISN 0106      2000 FORMAT (7H1EL.NO. 7X 14R 7X 1HZ 4X 8HR-STRESS 4X 8HZ-STRESS 4X
1 8HT-STRESS 3X 9HRZ-STRESS 10H N-STRESS 10H S-STRESS
2 10H NS-STRESS 10H F-STRESS 10H E-STRESS 10H SHEAR )
ISN 0107      2001 FORMAT (17,2F8.2,1P4E12.4,1P6E10.2)
ISN 0108      END

```

LEVEL 21.6 (DEC 72)

DS/360 FORTRAN H

DATE 74.248/04.45.03

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF

```

ISN 0002      SUBROUTINE SYMINV(A,NMAX)

C
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      DIMENSION A(4,4)
ISN 0005      DO 200 N=1,NMAX
ISN 0006      O=A(N,N)
ISN 0007      DO 100 J=1,NMAX
ISN 0008      100 A(N,J)=-A(N,J)/O

C
ISN 0009      DO 150 I=1,NMAX
ISN 0010      IF(N-I) 110,150,110
ISN 0011      110 DO 140 J=1,NMAX
ISN 0012      IF(N-J) 120,140,120
ISN 0013      120 A(I,J)=A(I,J)+A(I,N)*A(N,J)
ISN 0014      140 CONTINUE
ISN 0015      150 A(I,N)=A(I,N)/O
ISN 0016      A(N,N)=1./O
ISN 0017      200 CONTINUE
ISN 0018      RETURN
ISN 0019      END

```

LEVEL 21.6 (DEC 72)

DS/360 FORTRAN H

DATE 74.248/04.45.11

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF

```

ISN 0002      SUBROUTINE INTER(XI,RR,ZZ)

C
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      DIMENSION RR(1),ZZ(1),XI(1),XM(6),R(6),Z(6),XX(6)
ISN 0005      DATA XX/3*1.000,3*3.000/

C
ISN 0006      COMM=RR(2)*(ZZ(3)-ZZ(1))+RR(1)*(ZZ(2)-ZZ(3))+RR(3)*(ZZ(1)-ZZ(2))
ISN 0007      COMM=COMM/24.0
ISN 0008      R(1)=RR(1)
ISN 0009      R(2)=RR(2)
ISN 0010      R(3)=RR(3)
ISN 0011      R(4)=(R(1)+R(2))/2.
ISN 0012      R(5)=(R(2)+R(3))/2.
ISN 0013      R(6)=(R(3)+R(1))/2.
ISN 0014      Z(1)=ZZ(1)
ISN 0015      Z(2)=ZZ(2)
ISN 0016      Z(3)=ZZ(3)
ISN 0017      Z(4)=(Z(1)+Z(2))/2.
ISN 0018      Z(5)=(Z(2)+Z(3))/2.
ISN 0019      Z(6)=(Z(3)+Z(1))/2.
ISN 0020      30 DO 35 I=1,6
ISN 0021      35 XM(I)=XX(I)*R(I)

C

```

```

ISN 0022      40 DD 50 I=1.10
ISN 0023      50 XI(1)=0.0
ISN 0024      C
ISN 0025      DD 100 I=1.6
ISN 0026      XI(1)=XI(1)+XM(1)
ISN 0027      XI(2)=XI(2)+XM(1)/R(1)
ISN 0028      XI(3)=XI(3)+XM(1)/(R(1)**2)
ISN 0029      XI(4)=XI(4)+XM(1)*Z(1)/R(1)
ISN 0030      XI(5)=XI(5)+XM(1)*Z(1)/(R(1)**2)
ISN 0031      XI(6)=XI(6)+XM(1)*Z(1)**2/(R(1)**2)
ISN 0032      XI(7)=XI(7)+XM(1)*R(1)
ISN 0033      XI(8)=XI(8)+XM(1)*Z(1)
ISN 0034      XI(9)=XI(9)+XM(1)*R(1)**2
ISN 0035      XI(10)=XI(10)+XM(1)*R(1)*Z(1)
ISN 0036      100 CONTINUE
ISN 0037      DD 150 I=1.10
ISN 0038      150 XI(1)=XI(1)*COMM
ISN 0039      RETURN
ISN 0039      END

```

LEVEL 21.6 (DEC 72)

OS/360 FORTRAN H

DATE 74.248/04.45.20

```

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,EB=01C,NOLIST,NODECK,LGAD,MAP,NOEDIT,NOID,NOXREF
ISN 0002      SUBROUTINE MODIFY(A,B,NEQ,MBAND,N,U)
ISN 0003      C
ISN 0004      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      DIMENSION A(108,93),B(108)
ISN 0005      C
ISN 0006      DD 250 M=2,MBAND
ISN 0007      K=N-M+1
ISN 0008      IF(K)235,235,230
ISN 0009      230 B(K)=B(K)-A(K,M)*U
ISN 0010      A(K,M)=0.0
ISN 0011      235 K=N-M-1
ISN 0012      IF(NEQ-K)250,240,240
ISN 0013      240 B(K)=B(K)-A(N,M)*U
ISN 0014      A(N,M)=0.0
ISN 0015      250 CONTINUE
ISN 0016      A(N,1)=1.0
ISN 0017      B(N)=U
ISN 0018      RETURN
ISN 0018      END

```

LEVEL 21.6 (DEC 72)

OS/360 FORTRAN H

DATE 74.248/04.45.27

```

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,EB=01C,NOLIST,NODECK,LGAD,MAP,NOEDIT,NOID,NOXREF
ISN 0002      SUBROUTINE BANSOL
ISN 0003      C
ISN 0004      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0005      COMMON /BANARG/ MM,NUMBLK,B(108),A(108,93)
ISN 0006      NN=54
ISN 0007      NL=NN+1
ISN 0008      NH=NN+NN
ISN 0009      REWIND 1
ISN 0010      REWIND 2
ISN 0011      NB=0
ISN 0011      GO TO 150
ISN 0012      C*****
ISN 0013      C REDUCE EQUATIONS BY BLOCKS
ISN 0014      C*****
ISN 0015      C
ISN 0016      C 1. SHIFT BLOCK OF EQUATIONS
ISN 0017      C
ISN 0018      100 NB=NB+1
ISN 0019      DD 125 N=1,NN
ISN 0020      NH=NN+NH
ISN 0021      B(N)=B(NM)
ISN 0022      B(NM)=0.0
ISN 0023      DD 125 M=1,MM
ISN 0024      A(N,M)=A(NM,M)
ISN 0025      125 A(NM,M)=0.0
ISN 0026      C
ISN 0027      C 2. READ NEXT BLOCK OF EQUATIONS INTO CORE
ISN 0028      C
ISN 0029      IF(NUMBLK-NB)150,200,150
ISN 0030      150 READ(2)(B(N),A(N,M),M=1,MM),N=NL,NH
ISN 0031      IF(NB)200,100,200
ISN 0032      C
ISN 0033      C 3. REDUCE BLOCK OF EQUATIONS
ISN 0034      C
ISN 0035      200 DD 300 N=1,NN

```

```

ISN 0024      IF(A(N,1)1225,300,225
ISN 0025      225 B(N)=B(N)/A(N,1)
ISN 0026      DO 275 L=2,MM
ISN 0027      IF(A(N,L)1230,275,230
ISN 0028      230 C=A(N,L)/A(N,1)
ISN 0029      I=N+L-1
ISN 0030      J=0
ISN 0031      DO 250 K=L,MM
ISN 0032      J=J+1
ISN 0033      250 A(I,J)=A(I,J)-C*A(N,K)
ISN 0034      B(I)=B(I)-A(N,L)*B(N)
ISN 0035      A(N,L)=C
ISN 0036      275 CONTINUE
ISN 0037      300 CONTINUE

C
C      4. WRITE BLOCK OF REDUCED EQUATIONS ON TAPE 2
C
ISN 0038      IF(NUMBLK-NB)375,400,375
ISN 0039      375 WRITE(1)(B(N),(A(N,M),M=2,MM),N=1,NN)
ISN 0040      GO TO 100
C*****
C      BACK-SUBSTITUTION
C*****
ISN 0041      400 DO 450 M=1,NN
ISN 0042      N=NN+1-M
ISN 0043      DO 425 K=2,MM
ISN 0044      L=N+K-1
ISN 0045      425 B(N)=B(N)-A(N,K)*B(L)
ISN 0046      NM=N+NN
ISN 0047      B(NM)=B(N)
ISN 0048      450 A(NM,NB)=B(N)
ISN 0049      NB=NB-1
ISN 0050      IF(NB)475,500,475
ISN 0051      475 BACKSPACE 1
ISN 0052      READ(1)(B(N),(A(N,M),M=2,MM),N=1,NN)
ISN 0053      BACKSPACE 1
ISN 0054      GO TO 400
C*****
C      ORDER UNKNOWN IN B ARRAY
C*****
ISN 0055      500 K=0
ISN 0056      DO 600 NB=1,NUMBLK
ISN 0057      DO 600 N=1,NN
ISN 0058      NM=N+NN
ISN 0059      K=K+1
ISN 0060      600 B(K)=A(NM,NB)
ISN 0061      RETURN
ISN 0062      END

```

LEVEL 21.0 (DEC 72)

06/360 FORTRAN-M

DATE 74.248/04.45.37

```

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0300K,
SOURCE,ERR-DIC,NOLIST,NODECK,LCAD,MAP,NOEDIT,NOID,NOXREF
ISN 0002      SUBROUTINE GROPLT (NN,NE,N1,N2,SCALE,XD,YD,HED,CLASS,IX,R,Z)
C
C**** ROUTINE TO PLOT THE FINITE ELEMENT GRID FOR WILSON'S CODE.
C
ISN 0003      REAL*8 R(2500),Z(2500),SCALE,XD,YD
C
ISN 0004      DIMENSION IX(2400,5),HED(20),END(4),CLASS(3),DATE(2)
C
C
ISN 0005      MAXDIF=0
ISN 0006      WRITE (4,50) N1,N2,SCALE,XD,YD,CLASS
ISN 0007      50 FORMAT('MESH PLOT REQUESTED FOR ELEMENTS',I5,' TO ',I5/
1          'OSCALE=',F10,F10.6/
2          ' XD=',F10,F10.6/
3          ' YD=',F10,F10.6/
4          ' CLASS=',F10,3A4)
C
C**** PLOT ONLY THE ELEMENTS BETWEEN N1 AND N2, INCLUSIVE.
C
ISN 0008      N1=MAX0(N1,1)
ISN 0009      N2=MIN0(N2,NE)
C
C**** FIND MINIMUM COORDINATES.
C
ISN 0010      XMIN=1.E75
ISN 0011      YMIN=XMIN
ISN 0012      DO 100 M=N1,N2
ISN 0013      DO 75 I=1,4
ISN 0014      K=IX(M,I)
ISN 0015      IF (K.LT.1 .OR. K.GT.NN) GO TO 75
ISN 0017      XMIN=AMIN1(XMIN,SNG1(R(K)))
ISN 0018      YMIN=AMIN1(YMIN,SNG1(Z(K)))
ISN 0019      75 CONTINUE
ISN 0020      100 CONTINUE
ISN 0021      WRITE (6,600) XMIN,YMIN
ISN 0022      600 FORMAT('MINIMUM COORDINATES ARE',2E15.6)
C
C**** WRITE TITLES ON PLOT
C

```

```

ISN 0023      CALL SYMBOL(-1.0,4.0,0.105,CLASS(1),90.0,12)
ISN 0024      CALL IDAY(DATE)
ISN 0025      CALL SYMBOL(-1.0,6.0,0.105,DATE(1),90.0,8)
ISN 0026      CALL SYMBOL (0.0,0.5,0.105,HED(1),0.0,72)
C
C**** PLOT THE ELEMENTS.
C
ISN 0027      DO 200 M=N1,N2
ISN 0028        I=IX(M,1)
ISN 0029        J=IX(M,2)
ISN 0030        K=IX(M,3)
ISN 0031        L=IX(M,4)
ISN 0032        MAXDIF=MAX(MAXDIF,IABS(I-J),IABS(I-K),IABS(I-L),
1              IABS(J-K),IABS(J-L),IABS(K-L))
ISN 0033        L=4
ISN 0034        IF (IX(M,4).EQ.IX(M,3)) L=3
ISN 0035        K=IX(M,L)
ISN 0037        IF (K.LT.1 .OR. K.GT.NN) GO TO 200
ISN 0039        XP=SCALE*(R(K)-XMIN)+XD
ISN 0040        YP=SCALE*(Z(K)-YMIN)+YD
ISN 0041        CALL PLOT (XP,YP,3)
ISN 0042        DO 150 I=1,L
ISN 0043          K=IX(M,I)
ISN 0044          IF (K.LT.1 .OR. K.GT.NN) GO TO 200
ISN 0046          XP=SCALE*(R(K)-XMIN)+XD
ISN 0047          YP=SCALE*(Z(K)-YMIN)+YD
ISN 0048          CALL PLOT (XP,YP,2)
ISN 0049        150 CONTINUE
ISN 0050        200 CONTINUE
ISN 0051        WRITE (6,2000) MAXDIF
ISN 0052        2000 FORMAT('OGRID PLOT FINISHED.  MAXIMUM NODE DIFFERENCE WAS',I3)
ISN 0053        CALL PLOT (17.0,0.0,-3)
ISN 0054        RETURN
ISN 0055        END

```

LEVEL 21.6 (DEC 72)

OS/360 FORTRAN H

DATE 74.248/04.45.46

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,EB=01C,NOLIST,NODECK,LCAD,MAP,NOEDIT,NOID,NOXREF

```

ISN 0002      SUBROUTINE ZERO
ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)
ISN 0004      COMMON ZERO1(18805)
ISN 0005      COMMON/ARG/ZERO2(8797)
ISN 0006      COMMON/BANARG/ZERO3(10153)
ISN 0007      DO 1 I= 1,18805
ISN 0008        1 ZERO1(I) = 0.0
ISN 0009      DO 2 I= 1,8797
ISN 0010        2 ZERO2(I) = 0.0
ISN 0011      DO 3 I= 1,10153
ISN 0012        3 ZERO3(I) = 0.0
ISN 0013      RETURN
ISN 0014      END

```

APPENDIX C

DELTA PATTERN SIMULATION

This program computes the helix angles and thickness for a delta-axisymmetric pattern. The band width is subdivided into 10 segments and the helix angles at the edge of each segment are computed along with the average thickness of coverage for each band segment as a function of meridional position. These data are used to determine the average helix angle of the material which is included in each element of a 20-element division of the total thickness. This set of 20 angles for each meridional position stimulates a complete shell produced by the delta-axisymmetric pattern. The order of the band data is the same as the fabrication sequence, thus providing the proper model for the shell. The program input and output is described below.

Input

I. Control data

First Card

Field (type)	Variable	Definition
1 - 10 (F)	R	Radius
11 - 20 (F)	TF	Thickness factor = thickness for one band
21 - 25 (I)	NBS	Number of band sets in the pattern to the limiting meridional position
26 - 30 (I)	MM	Number of increments of meridional angle to the limiting meridional position. ($20 \leq MM \leq 90$)
31 - 35 (I)	IOPT	Option on program output = 0 gives helix angles on edges and thicknesses for each band segment. = 1 computes average helix angle and thickness for each segment and determines element average helix angle in each element. A material array is generated for a 24-element thick shell. Four elements per position are used to describe the mandrel and interface.

Second Card

Field (type)	Variable	Definition
1 - 5 (I)	IB	BAND SET NUMBER
6 - 10 (I)	ISS	Material stacking sequence within a segmented band = 1, Material in band segment closest to axis of symmetry lies nearest the inside radius. = 2, Material in band segment closest to axis of symmetry lies farthest from the inside radius.

Additional cards as needed

These cards specify the stacking sequence for all band sets between the previous IB and the current IB. Normally ISS = 1 for downwinds and ISS = 2 for upwinds. IB on the last card must equal NBS.

Third Card

1 - 5 (I)	IP(1)	Integer value of position along the meridian.
6 - 10 (I)	M(1)	180/M gives the value of the meridional angular increment in degrees for the region up through IP(1)
0		
0		
0		
0		
41 - 45 (I)	IP(5)	Integer value of final position along the meridian. Must equal MM.
46 - 50 (I)	M(5)	180/M gives the value to the meridional angular increment in degrees for the region between the preceding IP(4) and IP(5).

This third card specifies the element length in degrees along the meridian coordinate for regions along the meridian. Any of the five IP values may be equal to MM and the remaining data omitted if five regions are not needed. This allows a finer element grid in areas where desired.

II. Band data

One card for each band set in order of wind sequence.

Field (type)	Variable	Definition
1 - 6 (F)	OI	Angle between part axis and inner edge of band set in north hemisphere. If 00 = 0 : OI = angle between part axis and center of band. If NB = 1: OI = one half the band width angle.
7 - 12 (F)	00	Angle between part axis and inner edge of band set in south hemisphere.
13 - 15 (I)	NB	Number of bands for full coverage of the equator.
16 - 18 (I)	NI	Number of bands used in this band set. (If equal to NB does not need to be input.)

Output

I. Control data is printed out.

II. Band set output (one set for each band set)

A. Band data

B. If IOPT = 0

1. Helix angles at each segment edge and average thickness coverage of each segment normalized to a total unit thickness for each meridional position.

C. If IOPT = 1

1. Average helix angle for the material within the region of each element of a 20-element thickness for each meridional position. If the computed thickness does not cover all the elements, the remaining elements have material set at 91.

III. Pattern simulation

A deck of cards is punched of the final material array, MATL (MM,24), after all band sets have been applied. This deck is used as input for the mesh generation program. Material types in columns 21 - 24 are used for the mandrel and interface elements.

APPENDIX D

MESH GENERATION PROGRAM

I. Input Data

1. Total number of problems (I5)
2. The following set of data are used for each problem to be run.

A. Title, or description of problem (72H)

B. Problem codes (9B15)

Column	1 - 5	Number of nodal point data cards	fixed
	6 - 10	Maximum number of rows in I-J plane, J max	
	11 - 15	Maximum number of columns in I-J plane, I max	
	20	Code for output of nodal points	
		= 0	print
		= 1	print and punch
	25	Code for output of quadrilateral elements	
		= 0	print
		= 1	print and punch
	30	Code for output of triangular elements	
		= 0	print
		= 1	print and punch
	35	Restriction of element type	
		= 0	calculate both if col. 40 zero
		= 1	calculate quadrilateral elements only
	40	Restriction of element type	
		= 0	calculate both if col. 35 zero
		= 1	calculate triangular elements only
	45	linear = 1	gives eq. spaced mesh

C. Nodal Point Input Data (I1, I2, I2, 2F10.0, F5.0, I2, 2F10.0, I2, 2F10.0). One card for each specified nodal point.

Column	1 -	INTEST
	2 - 3	I - coordinate
	4 - 5	J - coordinate
	6 - 15	R
	16 - 25	Z
	26 - 30	CODE
	31 - 32	KDELTA
	33 - 42	RNEXT
	43 - 52	ZNEXT
	53 - 54	POLAR
	55 - 64	RSUBO
	65 - 74	ZSUBO

POLAR = 0 implies rectangular coordinates, so R = cylindrical radius.

Z = axial coordinates (RSUBO, ZSUBO are not used).

POLAR = 1 implies polar coordinates relative to a circle whose center is at (RSUBO, ZSUBO). R is the radius of the circle and Z is the angle (in degrees) that a line from the center of the circle to the point in question makes with the R-axis.

II. Program Output

1. Problem number, and listing of input data.
2. Nodal Point Output - The program calculates the rectangular coordinates of every point and assigns a nodal number to each point.

A. Printed

Number of iterations required for given accuracy.

The following data is printed for each node: I, J-coords; R, Z-coords; nodal point number.

The above set ends with a statement giving the total number of nodal points.

B. Punched (if so desired)

The nodal points are punched in a format so that they can be directly used in Wilson's finite element code. The following data are punched for each nodal point:

Column	1 - 5	nodal point number (I5)
	10	0 (note, this is a boundary code)
	11 - 20	R - coord. (F10.4)
	21 - 30	Z - coord. (F10.4)
	38 - 40	0.0

48 - 50 0.0
58 - 60 0.0

3. Element Output Data - The following data are the output for the quadrilateral and/or triangular shaped elements.

A. The program prints the type of element, then lists (one line for each element) the element number, the I, J, K, and L nodal point numbers, and sets the MATERIAL equal to one.

B. The punched data (if used) is as follows (one card for each element):

Column	1 - 5	Element number
	6 - 10	I
	11 - 15	J
	16 - 20	K
	21 - 25	L
	30	1

APPENDIX E

ORIENTED FILAMENT-WOUND COMPOSITE MATERIAL PROPERTIES SET

This program produces a data set for oriented orthotropic material with the material type identified by the integer values of the orientation angle. Properties of the unidirectional material are input. The transformation occurs around the N axis by angle beta from the T axis in the T-S plane.

INPUT

1 card - unidirectional properties (3F10.0, 3F5.0, 3F10.0, I5)

Columns	1-10 Modulus of Elasticity, E_{11} (fiber direction)
	11 - 20 Modulus of Elasticity, E_{22} (transverse direction in tangent plane)
	21 - 30 Modulus of Elasticity, E_{33} (transverse radial direction)
	31 - 35 Poisson's ratio, ν_{12}
	36 - 40 Poisson's ratio, ν_{13}
	41 - 45 Poisson's ratio, ν_{23}
	46 - 55 Shear Modulus, G_{12}
	56 - 65 Shear Modulus, G_{13}
	66 - 75 Shear Modulus, G_{23}
	76 - 80 IOPT = 0 "Restrained" Elastic properties
	= 1 "Free" Elastic Properties

OUTPUT

- I. Input Data
- II. Listing of the transformed data set
- III. Punched data set for finite element program input

APPENDIX F

PARTIAL PROGRAM OUTPUT

AXISYMMETRIC SHELL - 90 DEGR SEGMENT - 1.79 DEGR OPNG - 720A PATTERN

NUMBER OF NODAL POINTS-----2275

NUMBER OF ELEMENTS-----2160

NUMBER OF DIFF. MATERIALS--- 95

NUMBER OF PRESSURE CARDS----116

NUMBER OF APPROXIMATIONS---- 4

DATA CHECK ONLY (O=NO)----- 0

NUMBER OF PLOTS----- 0

E(N)	E(S)	E(T)	NU(NS)	NU(NT)	NU(ST)	G(NS)	YIELD STR	MOD RATIO	MATERIAL
0.3150 07	0.1260 04	0.8590 07	0.8300-01	0.9000-01	0.0	0.9500 06	0.0	0.0	1
0.3150 07	0.4730 04	0.8580 07	0.8800-01	0.9000-01	0.1000-02	0.9500 06	0.0	0.0	2
0.3150 07	0.1050 05	0.8550 07	0.8900-01	0.9000-01	0.2030-02	0.9500 06	0.0	0.0	3
0.3150 07	0.1860 05	0.8510 07	0.8900-01	0.9000-01	0.3030-02	0.9500 06	0.0	0.0	4
0.3150 07	0.2910 05	0.8450 07	0.8900-01	0.9000-01	0.4030-02	0.9500 06	0.0	0.0	5
0.3150 07	0.4190 05	0.8390 07	0.9000-01	0.9000-01	0.6000-02	0.9500 06	0.0	0.0	6
0.3150 07	0.5700 05	0.8320 07	0.9000-01	0.9000-01	0.8000-02	0.9500 06	0.0	0.0	7
0.3150 07	0.7450 05	0.8230 07	0.9000-01	0.9000-01	0.1100-01	0.9500 06	0.0	0.0	8
0.3150 07	0.9440 05	0.8140 07	0.9000-01	0.9000-01	0.1430-01	0.9500 06	0.0	0.0	9
0.3150 07	0.1170 06	0.8030 07	0.9000-01	0.9000-01	0.1700-01	0.9500 06	0.0	0.0	10
0.3150 07	0.1410 06	0.7920 07	0.9000-01	0.9000-01	0.2130-01	0.9500 06	0.0	0.0	11
0.3150 07	0.1680 06	0.7800 07	0.9000-01	0.9000-01	0.2500-01	0.9500 06	0.0	0.0	12
0.3150 07	0.1980 06	0.7670 07	0.9000-01	0.9000-01	0.2930-01	0.9500 06	0.0	0.0	13
0.3150 07	0.2300 06	0.7540 07	0.9000-01	0.9000-01	0.3430-01	0.9500 06	0.0	0.0	14
0.3150 07	0.2650 06	0.7400 07	0.9000-01	0.9000-01	0.3930-01	0.9500 06	0.0	0.0	15
0.3150 07	0.3020 06	0.7250 07	0.9000-01	0.9000-01	0.4400-01	0.9500 06	0.0	0.0	16
0.3150 07	0.3410 06	0.7100 07	0.9000-01	0.9000-01	0.5030-01	0.9500 06	0.0	0.0	17
0.3150 07	0.3830 06	0.6940 07	0.9000-01	0.9000-01	0.5630-01	0.9500 06	0.0	0.0	18
0.3150 07	0.4280 06	0.6780 07	0.9000-01	0.9000-01	0.6300-01	0.9500 06	0.0	0.0	19
0.3150 07	0.4760 06	0.6620 07	0.9000-01	0.9000-01	0.7000-01	0.9500 06	0.0	0.0	20
0.3150 07	0.5260 06	0.6450 07	0.9000-01	0.9000-01	0.7700-01	0.9500 06	0.0	0.0	21
0.3150 07	0.5790 06	0.6280 07	0.9000-01	0.9000-01	0.8500-01	0.9500 06	0.0	0.0	22
0.3150 07	0.6340 06	0.6110 07	0.9000-01	0.9000-01	0.9300-01	0.9500 06	0.0	0.0	23
0.3150 07	0.6930 06	0.5940 07	0.9000-01	0.9000-01	0.1020 00	0.9500 06	0.0	0.0	24
0.3150 07	0.7540 06	0.5760 07	0.9000-01	0.9000-01	0.1110 00	0.9500 06	0.0	0.0	25
0.3150 07	0.8180 06	0.5590 07	0.9000-01	0.9000-01	0.1200 00	0.9500 06	0.0	0.0	26
0.3150 07	0.8850 06	0.5420 07	0.9000-01	0.9000-01	0.1300 00	0.9500 06	0.0	0.0	27
0.3150 07	0.9550 06	0.5240 07	0.9000-01	0.9000-01	0.1400 00	0.9500 06	0.0	0.0	28
0.3150 07	0.1030 07	0.5070 07	0.9000-01	0.9000-01	0.1510 00	0.9500 06	0.0	0.0	29
0.3150 07	0.1100 07	0.4900 07	0.9000-01	0.9000-01	0.1620 00	0.9500 06	0.0	0.0	30
0.3150 07	0.1180 07	0.4730 07	0.9000-01	0.9000-01	0.1740 00	0.9500 06	0.0	0.0	31
0.3150 07	0.1270 07	0.4570 07	0.9000-01	0.9000-01	0.1850 00	0.9500 06	0.0	0.0	32
0.3150 07	0.1350 07	0.4400 07	0.9000-01	0.9000-01	0.1980 00	0.9500 06	0.0	0.0	33
0.3150 07	0.1440 07	0.4240 07	0.9000-01	0.9000-01	0.2110 00	0.9500 06	0.0	0.0	34
0.3150 07	0.1530 07	0.4080 07	0.9000-01	0.9000-01	0.2250 00	0.9500 06	0.0	0.0	35
0.3150 07	0.1630 07	0.3920 07	0.9000-01	0.9000-01	0.2390 00	0.9500 06	0.0	0.0	36
0.3150 07	0.1730 07	0.3760 07	0.9000-01	0.9000-01	0.2530 00	0.9500 06	0.0	0.0	37
0.3150 07	0.1830 07	0.3610 07	0.9000-01	0.9000-01	0.2680 00	0.9500 06	0.0	0.0	38
0.3150 07	0.1930 07	0.3460 07	0.9000-01	0.9000-01	0.2840 00	0.9500 06	0.0	0.0	39
0.3150 07	0.2040 07	0.3320 07	0.9000-01	0.9000-01	0.3000 00	0.9500 06	0.0	0.0	40
0.3150 07	0.2150 07	0.3170 07	0.9000-01	0.9000-01	0.3160 00	0.9500 06	0.0	0.0	41
0.3150 07	0.2270 07	0.3030 07	0.9000-01	0.9000-01	0.3330 00	0.9500 06	0.0	0.0	42
0.3150 07	0.2390 07	0.2900 07	0.9000-01	0.9000-01	0.3510 00	0.9500 06	0.0	0.0	43
0.3150 07	0.2510 07	0.2760 07	0.9000-01	0.9000-01	0.3690 00	0.9500 06	0.0	0.0	44
0.3150 07	0.2640 07	0.2640 07	0.9000-01	0.9000-01	0.3870 00	0.9500 06	0.0	0.0	45
0.3150 07	0.2760 07	0.2510 07	0.9000-01	0.9000-01	0.4060 00	0.9500 06	0.0	0.0	46
0.3150 07	0.2900 07	0.2390 07	0.9000-01	0.9000-01	0.4250 00	0.9500 06	0.0	0.0	47
0.3150 07	0.3030 07	0.2270 07	0.9000-01	0.9000-01	0.4450 00	0.9500 06	0.0	0.0	48
0.3150 07	0.3170 07	0.2150 07	0.9000-01	0.9000-01	0.4650 00	0.9500 06	0.0	0.0	49
0.3150 07	0.3320 07	0.2040 07	0.9000-01	0.9000-01	0.4870 00	0.9500 06	0.0	0.0	50
0.3150 07	0.3460 07	0.1930 07	0.9000-01	0.9000-01	0.5090 00	0.9500 06	0.0	0.0	51
0.3150 07	0.3610 07	0.1830 07	0.9000-01	0.9000-01	0.5300 00	0.9500 06	0.0	0.0	52
0.3150 07	0.3760 07	0.1730 07	0.9000-01	0.9000-01	0.5530 00	0.9500 06	0.0	0.0	53
0.3150 07	0.3920 07	0.1630 07	0.9000-01	0.9000-01	0.5750 00	0.9500 06	0.0	0.0	54
0.3150 07	0.4080 07	0.1530 07	0.9000-01	0.9000-01	0.5990 00	0.9500 06	0.0	0.0	55
0.3150 07	0.4240 07	0.1440 07	0.9000-01	0.9000-01	0.6220 00	0.9500 06	0.0	0.0	56
0.3150 07	0.4400 07	0.1350 07	0.9000-01	0.9000-01	0.6460 00	0.9500 06	0.0	0.0	57
0.3150 07	0.4570 07	0.1270 07	0.9000-01	0.9000-01	0.6710 00	0.9500 06	0.0	0.0	58
0.3150 07	0.4730 07	0.1180 07	0.9000-01	0.9000-01	0.6950 00	0.9500 06	0.0	0.0	59
0.3150 07	0.4900 07	0.1100 07	0.9000-01	0.9000-01	0.7230 00	0.9500 06	0.0	0.0	60
0.3150 07	0.5070 07	0.1030 07	0.9000-01	0.9000-01	0.7450 00	0.9500 06	0.0	0.0	61
0.3150 07	0.5240 07	0.9550 06	0.9000-01	0.9000-01	0.7700 00	0.9500 06	0.0	0.0	62
0.3150 07	0.5420 07	0.8850 06	0.9000-01	0.9000-01	0.7950 00	0.9500 06	0.0	0.0	63
0.3150 07	0.5590 07	0.8180 06	0.9000-01	0.9000-01	0.8210 00	0.9500 06	0.0	0.0	64
0.3150 07	0.5760 07	0.7540 06	0.9000-01	0.9000-01	0.8470 00	0.9500 06	0.0	0.0	65
0.3150 07	0.5940 07	0.6930 06	0.9000-01	0.9000-01	0.8720 00	0.9500 06	0.0	0.0	66
0.3150 07	0.6110 07	0.6340 06	0.9000-01	0.9000-01	0.8970 00	0.9500 06	0.0	0.0	67
0.3150 07	0.6280 07	0.5790 06	0.9000-01	0.9000-01	0.9220 00	0.9500 06	0.0	0.0	68
0.3150 07	0.6450 07	0.5260 06	0.9000-01	0.9000-01	0.9470 00	0.9500 06	0.0	0.0	69
0.3150 07	0.6620 07	0.4760 06	0.9000-01	0.9000-01	0.9720 00	0.9500 06	0.0	0.0	70
0.3150 07	0.6780 07	0.4280 06	0.9000-01	0.9000-01	0.9960 00	0.9500 06	0.0	0.0	71
0.3150 07	0.6940 07	0.3830 06	0.9000-01	0.9000-01	0.1020 01	0.9500 06	0.0	0.0	72
0.3150 07	0.7100 07	0.3410 06	0.9000-01	0.9000-01	0.1040 01	0.9500 06	0.0	0.0	73
0.3150 07	0.7250 07	0.3020 06	0.9000-01	0.9000-01	0.1070 01	0.9500 06	0.0	0.0	74
0.3150 07	0.7400 07	0.2650 06	0.9000-01	0.9000-01	0.1090 01	0.9500 06	0.0	0.0	75
0.3150 07	0.7540 07	0.2300 06	0.9000-01	0.9000-01	0.1110 01	0.9500 06	0.0	0.0	76
0.3150 07	0.7670 07	0.1980 06	0.9000-01	0.9000-01	0.1130 01	0.9500 06	0.0	0.0	77
0.3150 07	0.7800 07	0.1680 06	0.9000-01	0.9000-01	0.1150 01	0.9500 06	0.0	0.0	78
0.3150 07	0.7920 07	0.1410 06	0.9000-01	0.9000-01	0.1160 01	0.9500 06	0.0	0.0	79
0.3150 07	0.8030 07	0.1170 06	0.9000-01	0.9000-01	0.1180 01	0.9500 06	0.0	0.0	80
0.3150 07	0.8140 07	0.9440 05	0.9000-01	0.9000-01	0.1190 01	0.9500 06	0.0	0.0	81
0.3150 07	0.8230 07	0.7450 05	0.9000-01	0.9000-01	0.1210 01	0.9500 06	0.0	0.0	82
0.3150 07	0.8320 07	0.5700 05	0.9000-01	0.9000-01	0.1220 01	0.9500 06	0.0	0.0	83

0.3150 07	0.8390 07	0.4190 05	0.9000-01	0.9000-01	0.1230 01	0.9500 06	0.0	0.0	84
0.3150 07	0.8450 07	0.2910 05	0.9000-01	0.8900-01	0.1240 01	0.9500 06	0.0	0.0	85
0.3150 07	0.8510 07	0.1860 05	0.9000-01	0.8900-01	0.1240 01	0.9500 06	0.0	0.0	86
0.3150 07	0.8550 07	0.1050 05	0.9000-01	0.8900-01	0.1240 01	0.9500 06	0.0	0.0	87
0.3150 07	0.8580 07	0.4730 04	0.9000-01	0.8800-01	0.1230 01	0.9500 06	0.0	0.0	88
0.3150 07	0.8590 07	0.1260 04	0.9000-01	0.8300-01	0.1150 01	0.9500 06	0.0	0.0	89
0.3150 07	0.1000 03	0.8600 07	0.0	0.9000-01	0.0	0.9500 06	0.0	0.0	90
0.5000 06	0.5000 06	0.5000 06	0.3500 00	0.3500 00	0.3500 00	0.1850 06	0.0	0.0	91
0.1000 08	0.1000 08	0.1000 08	0.3300 00	0.3300 00	0.3300 00	0.3760 07	0.2100 05	0.9640-02	92
0.1000 03	0.1000 03	0.1000 03	0.5000 00	0.5000 00	0.5000 00	0.3330 02	0.0	0.0	93
0.1000 02	0.1000 02	0.1000 02	0.0	0.0	0.0	0.5000 01	0.0	0.0	94
0.1000 08	0.1000 08	0.1000 08	0.3300 00	0.3300 00	0.3300 00	0.3760 07	0.3600 05	0.9640-02	95

NODAL POINT	TYPE	R-ORDINATE	Z-ORDINATE	R LOAD OR DISPLACEMENT	Z LOAD OR DISPLACEMENT
1	0.0	0.062	4.237	0.0	0.0
2	0.0	0.062	4.225	0.0	0.0
3	0.0	0.062	4.213	0.0	0.0
4	0.0	0.062	4.201	0.0	0.0
5	0.0	0.062	4.190	0.0	0.0
6	0.0	0.062	4.178	0.0	0.0
7	0.0	0.062	4.166	0.0	0.0
8	0.0	0.062	4.154	0.0	0.0
9	0.0	0.062	4.142	0.0	0.0
10	0.0	0.062	4.130	0.0	0.0
11	0.0	0.062	4.118	0.0	0.0
12	0.0	0.062	4.107	0.0	0.0
13	0.0	0.062	4.095	0.0	0.0
14	0.0	0.062	4.083	0.0	0.0
15	0.0	0.062	4.071	0.0	0.0
16	0.0	0.062	4.059	0.0	0.0
17	0.0	0.062	4.047	0.0	0.0
18	0.0	0.062	4.036	0.0	0.0
19	0.0	0.062	4.024	0.0	0.0
20	0.0	0.062	4.012	0.0	0.0
21	0.0	0.062	4.000	0.0	0.0
22	0.0	0.062	3.995	0.0	0.0
23	0.0	0.062	3.965	0.0	0.0
24	0.0	0.062	3.934	0.0	0.0
25	0.0	0.062	3.904	0.0	0.0
26	0.0	0.094	4.237	0.0	0.0
27	0.0	0.094	4.225	0.0	0.0
28	0.0	0.094	4.213	0.0	0.0
29	0.0	0.094	4.201	0.0	0.0
30	0.0	0.094	4.190	0.0	0.0
31	0.0	0.094	4.178	0.0	0.0
32	0.0	0.094	4.166	0.0	0.0
33	0.0	0.094	4.154	0.0	0.0
34	0.0	0.094	4.142	0.0	0.0
35	0.0	0.094	4.130	0.0	0.0
36	0.0	0.094	4.118	0.0	0.0
37	0.0	0.094	4.107	0.0	0.0
38	0.0	0.094	4.095	0.0	0.0
39	0.0	0.094	4.083	0.0	0.0
40	0.0	0.094	4.071	0.0	0.0
41	0.0	0.094	4.059	0.0	0.0
42	0.0	0.094	4.047	0.0	0.0
43	0.0	0.094	4.036	0.0	0.0
44	0.0	0.094	4.024	0.0	0.0
45	0.0	0.094	4.012	0.0	0.0
46	0.0	0.094	4.000	0.0	0.0
47	0.0	0.094	3.995	0.0	0.0
48	0.0	0.094	3.965	0.0	0.0
49	0.0	0.094	3.934	0.0	0.0
50	0.0	0.094	3.904	0.0	0.0
51	0.0	0.125	4.237	0.0	0.0
52	0.0	0.125	4.225	0.0	0.0
53	0.0	0.125	4.213	0.0	0.0
54	0.0	0.125	4.201	0.0	0.0
55	0.0	0.125	4.190	0.0	0.0
56	0.0	0.125	4.178	0.0	0.0
57	0.0	0.125	4.166	0.0	0.0
58	0.0	0.125	4.154	0.0	0.0
59	0.0	0.125	4.142	0.0	0.0
60	0.0	0.125	4.130	0.0	0.0
61	0.0	0.125	4.118	0.0	0.0
62	0.0	0.125	4.107	0.0	0.0
63	0.0	0.125	4.095	0.0	0.0
64	0.0	0.125	4.083	0.0	0.0
65	0.0	0.125	4.071	0.0	0.0
66	0.0	0.125	4.059	0.0	0.0
67	0.0	0.125	4.047	0.0	0.0
68	0.0	0.125	4.036	0.0	0.0
69	0.0	0.125	4.024	0.0	0.0
70	0.0	0.125	4.012	0.0	0.0
71	0.0	0.125	4.000	0.0	0.0
72	0.0	0.125	3.995	0.0	0.0
73	0.0	0.125	3.965	0.0	0.0
74	0.0	0.125	3.934	0.0	0.0
75	0.0	0.125	3.904	0.0	0.0
76	0.0	0.130	4.237	0.0	0.0
77	0.0	0.130	4.225	0.0	0.0
78	0.0	0.130	4.213	0.0	0.0
79	0.0	0.130	4.201	0.0	0.0
80	0.0	0.130	4.190	0.0	0.0
81	0.0	0.130	4.178	0.0	0.0
82	0.0	0.130	4.166	0.0	0.0
83	0.0	0.130	4.154	0.0	0.0
84	0.0	0.130	4.142	0.0	0.0
85	0.0	0.130	4.130	0.0	0.0
86	0.0	0.130	4.118	0.0	0.0
87	0.0	0.130	4.107	0.0	0.0
88	0.0	0.130	4.095	0.0	0.0

89	0.0	0.130	4.084	0.0	0.0
90	0.0	0.130	4.071	0.0	0.0
91	0.0	0.130	4.059	0.0	0.0
92	0.0	0.130	4.047	0.0	0.0
93	0.0	0.130	4.036	0.0	0.0
94	0.0	0.130	4.024	0.0	0.0
95	0.0	0.130	4.012	0.0	0.0
96	0.0	0.130	4.000	0.0	0.0
97	0.0	0.130	3.995	0.0	0.0
98	0.0	0.130	3.965	0.0	0.0
99	0.0	0.130	3.934	0.0	0.0
100	0.0	0.130	3.904	0.0	0.0
101	0.0	0.167	4.238	0.0	0.0
102	0.0	0.166	4.226	0.0	0.0
103	0.0	0.166	4.214	0.0	0.0
104	0.0	0.165	4.201	0.0	0.0
105	0.0	0.165	4.189	0.0	0.0
106	0.0	0.164	4.177	0.0	0.0
107	0.0	0.164	4.165	0.0	0.0
108	0.0	0.163	4.153	0.0	0.0
109	0.0	0.163	4.141	0.0	0.0
110	0.0	0.162	4.129	0.0	0.0
111	0.0	0.162	4.117	0.0	0.0
112	0.0	0.161	4.105	0.0	0.0
113	0.0	0.161	4.093	0.0	0.0
114	0.0	0.160	4.081	0.0	0.0
115	0.0	0.160	4.069	0.0	0.0
116	0.0	0.159	4.057	0.0	0.0
117	0.0	0.159	4.045	0.0	0.0
118	0.0	0.158	4.033	0.0	0.0
119	0.0	0.158	4.021	0.0	0.0
120	0.0	0.157	4.009	0.0	0.0
121	0.0	0.157	3.997	0.0	0.0
122	0.0	0.157	3.992	0.0	0.0
123	0.0	0.156	3.982	0.0	0.0
124	0.0	0.155	3.973	0.0	0.0
125	0.0	0.154	3.964	0.0	0.0
126	0.0	0.204	4.238	0.0	0.0
127	0.0	0.203	4.226	0.0	0.0
128	0.0	0.202	4.214	0.0	0.0
2175	0.0	3.891	0.478	0.0	0.0
2176	0.0	4.152	0.363	0.0	0.0
2177	0.0	4.144	0.363	0.0	0.0
2178	0.0	4.135	0.362	0.0	0.0
2179	0.0	4.127	0.361	0.0	0.0
2180	0.0	4.119	0.360	0.0	0.0
2181	0.0	4.110	0.360	0.0	0.0
2182	0.0	4.102	0.359	0.0	0.0
2183	0.0	4.094	0.358	0.0	0.0
2184	0.0	4.085	0.357	0.0	0.0
2185	0.0	4.077	0.357	0.0	0.0
2186	0.0	4.068	0.356	0.0	0.0
2187	0.0	4.060	0.355	0.0	0.0
2188	0.0	4.052	0.354	0.0	0.0
2189	0.0	4.043	0.354	0.0	0.0
2190	0.0	4.035	0.353	0.0	0.0
2191	0.0	4.027	0.352	0.0	0.0
2192	0.0	4.018	0.352	0.0	0.0
2193	0.0	4.010	0.351	0.0	0.0
2194	0.0	4.002	0.350	0.0	0.0
2195	0.0	3.993	0.349	0.0	0.0
2196	0.0	3.985	0.349	0.0	0.0
2197	0.0	3.980	0.348	0.0	0.0
2198	0.0	3.975	0.348	0.0	0.0
2199	0.0	3.970	0.347	0.0	0.0
2200	0.0	3.965	0.342	0.0	0.0
2201	0.0	4.160	0.218	0.0	0.0
2202	0.0	4.151	0.218	0.0	0.0
2203	0.0	4.143	0.217	0.0	0.0
2204	0.0	4.135	0.217	0.0	0.0
2205	0.0	4.127	0.216	0.0	0.0
2206	0.0	4.118	0.216	0.0	0.0
2207	0.0	4.110	0.215	0.0	0.0
2208	0.0	4.102	0.215	0.0	0.0
2209	0.0	4.094	0.215	0.0	0.0
2210	0.0	4.085	0.214	0.0	0.0
2211	0.0	4.077	0.214	0.0	0.0
2212	0.0	4.069	0.213	0.0	0.0
2213	0.0	4.061	0.213	0.0	0.0
2214	0.0	4.052	0.212	0.0	0.0
2215	0.0	4.044	0.212	0.0	0.0
2216	0.0	4.036	0.211	0.0	0.0
2217	0.0	4.028	0.211	0.0	0.0
2218	0.0	4.019	0.211	0.0	0.0
2219	0.0	4.011	0.210	0.0	0.0
2220	0.0	4.003	0.210	0.0	0.0
2221	0.0	3.995	0.209	0.0	0.0
2222	0.0	3.990	0.209	0.0	0.0
2223	0.0	3.965	0.208	0.0	0.0
2224	0.0	3.940	0.207	0.0	0.0
2225	0.0	3.915	0.205	0.0	0.0
2226	0.0	4.164	0.073	0.0	0.0
2227	0.0	4.156	0.073	0.0	0.0
2228	0.0	4.147	0.072	0.0	0.0
2229	0.0	4.139	0.072	0.0	0.0
2230	0.0	4.131	0.072	0.0	0.0
2231	0.0	4.123	0.072	0.0	0.0
2232	0.0	4.115	0.072	0.0	0.0
2233	0.0	4.106	0.072	0.0	0.0
2234	0.0	4.098	0.072	0.0	0.0
2235	0.0	4.090	0.071	0.0	0.0
2236	0.0	4.082	0.071	0.0	0.0
2237	0.0	4.073	0.071	0.0	0.0
2238	0.0	4.065	0.071	0.0	0.0
2239	0.0	4.057	0.071	0.0	0.0
2240	0.0	4.049	0.071	0.0	0.0
2241	0.0	4.041	0.071	0.0	0.0
2242	0.0	4.032	0.070	0.0	0.0
2243	0.0	4.024	0.070	0.0	0.0
2244	0.0	4.016	0.070	0.0	0.0
2245	0.0	4.008	0.070	0.0	0.0
2246	0.0	3.999	0.070	0.0	0.0

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1	0.1306510-03	0.1068890 00	0.8916160 02	0.1068790 00	-0.1433300-02
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5	0.1366460-03	0.1068710 00	0.8915220 02	0.1068610 00	-0.1444730-02
6	0.1370790-03	0.1068630 00	0.8914980 02	0.1068530 00	-0.1448680-02
7	0.1386120-03	0.1068520 00	0.8914730 02	0.1068420 00	-0.1451480-02
8	0.1423240-03	0.1068380 00	0.8914490 02	0.1068290 00	-0.1452100-02
9	0.1495420-03	0.1068220 00	0.8914250 02	0.1068120 00	-0.1449190-02
10	0.1618830-03	0.1068020 00	0.8914000 02	0.1067920 00	-0.1441140-02
11	0.1813240-03	0.1067790 00	0.8913750 02	0.1067700 00	-0.1425970-02
12	0.2103630-03	0.1067550 00	0.8913500 02	0.1067460 00	-0.1401200-02
13	0.2527430-03	0.1067290 00	0.8913250 02	0.1067200 00	-0.1363100-02
14	0.3122940-03	0.1067000 00	0.8913000 02	0.1066930 00	-0.1307810-02
15	0.3929810-03	0.1066670 00	0.8912750 02	0.1066610 00	-0.1231340-02
16	0.4993630-03	0.1066290 00	0.8912490 02	0.1066240 00	-0.1129130-02
17	0.6381230-03	0.1065890 00	0.8912240 02	0.1065870 00	-0.9995460-03
18	0.8155910-03	0.1065530 00	0.8911980 02	0.1065530 00	-0.8213320-03
19	0.1035070-02	0.1065310 00	0.8911720 02	0.1065350 00	-0.6063740-03
20	0.1287690-02	0.1065440 00	0.8911460 02	0.1065510 00	-0.3588280-03
21	0.1548970-02	0.1066090 00	0.8911220 02	0.1066210 00	-0.1034640-03
22	0.1660470-02	0.1066560 00	0.8911030 02	0.1066690 00	-0.3226290-05
23	0.2177160-02	0.1070630 00	0.8910600 02	0.1070840 00	0.5027760-03
24	0.2426490-02	0.1076610 00	0.8909710 02	0.1076880 00	0.7296490-03
25	0.2486770-02	0.1083030 00	0.8909010 02	0.1083290 00	0.7665250-03
26	0.8780110-04	0.1069000 00	0.8873580 02	0.1068760 00	-0.2270660-02
27	0.9033580-04	0.1068960 00	0.8873230 02	0.1068720 00	-0.2274660-02
28	0.9138540-04	0.1068930 00	0.8872870 02	0.1068690 00	-0.2280180-02
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31	0.8973670-04	0.1068820 00	0.8871790 02	0.1068580 00	-0.2301770-02
32	0.8966300-04	0.1068790 00	0.8871430 02	0.1068540 00	-0.2308560-02
33	0.9131020-04	0.1068750 00	0.8871060 02	0.1068500 00	-0.2313660-02
34	0.9589800-04	0.1068710 00	0.8870690 02	0.1068460 00	-0.2315860-02
35	0.1049070-03	0.1068670 00	0.8870320 02	0.1068420 00	-0.2313690-02
36	0.1200980-03	0.1068640 00	0.8869950 02	0.1068390 00	-0.2305380-02
37	0.1434860-03	0.1068610 00	0.8869570 02	0.1068370 00	-0.2288930-02
38	0.1769990-03	0.1068590 00	0.8869190 02	0.1068350 00	-0.2262410-02
39	0.2225820-03	0.1068560 00	0.8868810 02	0.1068340 00	-0.2223860-02
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47	0.1456500-02	0.1069790 00	0.8865930 02	0.1069830 00	-0.1046970-02
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52	0.7106790-04	0.1069040 00	0.8830540 02	0.1068590 00	-0.3090310-02
53	0.7240990-04	0.1069010 00	0.8830060 02	0.1068560 00	-0.3097760-02
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58	0.7832420-04	0.1069060 00	0.8827640 02	0.1068600 00	-0.3137180-02
59	0.8440460-04	0.1069140 00	0.8827150 02	0.1068680 00	-0.3140530-02
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61	0.1104930-03	0.1069390 00	0.8826160 02	0.1068930 00	-0.3133750-02
62	0.1334190-03	0.1069570 00	0.8825650 02	0.1069110 00	-0.3120730-02
63	0.1650340-03	0.1069780 00	0.8825150 02	0.1069330 00	-0.3099190-02
64	0.2074640-03	0.1070030 00	0.8824640 02	0.1069590 00	-0.3067010-02
65	0.2635670-03	0.1070320 00	0.8824130 02	0.1069900 00	-0.3021350-02
66	0.3368280-03	0.1070640 00	0.8823620 02	0.1070240 00	-0.2958680-02
67	0.4315720-03	0.1070990 00	0.8823130 02	0.1070620 00	-0.2874720-02
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73	0.1888410-02	0.1072950 00	0.8819410 02	0.1073010 00	-0.1493820-02
74	0.2141620-02	0.1077070 00	0.8818010 02	0.1077210 00	-0.1280000-02
75	0.2197720-02	0.1082350 00	0.8816590 02	0.1082500 00	-0.1268090-02
76	0.1063980-02	0.1004960 00	0.8824260 02	0.1004810 00	-0.2018490-02
77	0.1544480-02	0.1005180 00	0.8823770 02	0.1005180 00	-0.1547540-02
78	0.2036780-02	0.1005440 00	0.8823270 02	0.1005590 00	-0.1064980-02
79	0.2520360-02	0.1005790 00	0.8822770 02	0.1006090 00	-0.5914450-03
80	0.3035280-02	0.1006370 00	0.8822270 02	0.1006820 00	-0.8735350-04
81	0.3900950-02	0.1010010 00	0.8821770 02	0.1010740 00	0.7577050-03
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85	0.5238220-02	0.1024680 00	0.8819720 02	0.1025820 00	0.2012130-02
86	0.5398860-02	0.1029300 00	0.8819210 02	0.1030490 00	0.2148810-02
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88	0.5462020-02	0.1037630 00	0.8818160 02	0.1038840 00	0.2166710-02
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91	0.4326960-02	0.1053180 00	0.8816570 02	0.1054020 00	0.9536060-03
92	0.3902800-02	0.1054360 00	0.8816030 02	0.1055070 00	0.5159960-03
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158	0.6496970-02	0.1037880 00	0.8674940 02	0.1039890 00	0.6011680-03
159	0.6775220-02	0.1038930 00	0.8674940 02	0.1041100 00	0.8732770-03
160	0.6841980-02	0.1040700 00	0.8674940 02	0.1042900 00	0.9299230-03
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164	0.7566580-02	0.1048210 00	0.8674950 02	0.1050810 00	0.1610870-02
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166	0.7976520-02	0.1049790 00	0.8674950 02	0.1052630 00	0.2011240-02
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168	0.8115170-02	0.1052820 00	0.8674960 02	0.1055730 00	0.2132580-02
169	0.8535770-02	0.1054140 00	0.8674960 02	0.1057280 00	0.2545070-02
170	0.9151630-02	0.1055430 00	0.8674960 02	0.1058920 00	0.3152650-02
171	0.9468110-02	0.1057050 00	0.8674960 02	0.1060720 00	0.3459470-02
172	0.2778130-02	0.1063730 00	0.8674980 02	0.1063590 00	-0.3257190-02
173	0.3124700-02	0.1068870 00	0.8674730 02	0.1068920 00	-0.2945080-02
174	0.3370690-02	0.1075180 00	0.8674470 02	0.1075360 00	-0.2740080-02
175	0.3575430-02	0.1082450 00	0.8674210 02	0.1082740 00	-0.2581910-02
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184	0.8827870-02	0.1047740 00	0.8625040 02	0.1051270 00	0.1957080-02
185	0.9241250-02	0.1048380 00	0.8625040 02	0.1052180 00	0.2365380-02
186	0.9393580-02	0.1049450 00	0.8625030 02	0.1053340 00	0.2510380-02
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189	0.8923440-02	0.1054080 00	0.8625030 02	0.1057660 00	0.2010870-02
190	0.8665170-02	0.1055440 00	0.8625030 02	0.1058850 00	0.1744180-02
191	0.9018590-02	0.1055980 00	0.8625020 02	0.1059620 00	0.2093260-02
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193	0.9981520-02	0.1057610 00	0.8625020 02	0.1061880 00	0.3043410-02
194	0.1027970-01	0.1058940 00	0.8625020 02	0.1063400 00	0.3332210-02
195	0.1060880-01	0.1060230 00	0.8625020 02	0.1064890 00	0.3652220-02
196	0.1085750-01	0.1061500 00	0.8625010 02	0.1066330 00	0.3891990-02
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198	0.3505800-02	0.1073870 00	0.8624720 02	0.1073860 00	-0.3530380-02
199	0.3912040-02	0.1079440 00	0.8624460 02	0.1079690 00	-0.3166300-02
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207	0.9172660-02	0.1054760 00	0.8574980 02	0.1058660 00	0.1330300-02
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217	0.1092000-01	0.1061860 00	0.8575030 02	0.1067020 00	0.3021340-02
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1487	0.1182110 00	0.9444950-01	0.4050000 02	0.1512280 00	0.4951860-02
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1489	0.1183930 00	0.9453370-01	0.4050010 02	0.1514220 00	0.5006710-02
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1492	0.1186820 00	0.9467460-01	0.4050020 02	0.1517320 00	0.5087170-02
1493	0.1187840 00	0.9471960-01	0.4050020 02	0.1518410 00	0.5120490-02
1494	0.1188930 00	0.9476340-01	0.4050020 02	0.1519510 00	0.5156920-02
1495	0.1190030 00	0.9480780-01	0.4050030 02	0.1520630 00	0.5194500-02
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1497	0.1186650 00	0.94803580-01	0.4049970 02	0.1526040 00	0.4040120-02
1498	0.1199390 00	0.9495990-01	0.4050000 02	0.1541730 00	0.4165470-02
1499	0.1212450 00	0.9791320-01	0.4050030 02	0.1557850 00	0.4289350-02
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2197	0.1580070	00	0.1337080	-01	0.5000180	01	0.1585710	00	0.4518400	-03
2198	0.1596160	00	0.1320070	-01	0.4999870	01	0.1601590	00	0.7605810	-03
2199	0.1612640	00	0.1303570	-01	0.4999560	01	0.1617870	00	0.1067740	-02
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2204	0.1579350	00	0.8100740	-02	0.2999970	01	0.1581420	00	0.1759450	-03
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2212	0.1586400	00	0.7611370	-02	0.2999700	01	0.1588200	00	0.7007720	-03
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2218	0.1592520	00	0.7270410	-02	0.2999490	01	0.1594140	00	0.1072730	-02
2219	0.1593570	00	0.7211500	-02	0.2999460	01	0.1595160	00	0.1136980	-02
2220	0.1594640	00	0.7149400	-02	0.2999420	01	0.1596200	00	0.1204480	-02
2221	0.1595720	00	0.7083710	-02	0.2999390	01	0.1597240	00	0.1275660	-02
2222	0.1596780	00	0.8145500	-02	0.3000270	01	0.1601550	00	0.2374490	-03
2223	0.1615560	00	0.8003340	-02	0.3000350	01	0.1617530	00	0.4637740	-03
2224	0.1637000	00	0.7860610	-02	0.3000500	01	0.1633880	00	0.6928140	-03
2225	0.1648760	00	0.7718210	-02	0.3000650	01	0.1650540	00	0.9231730	-03
2226	0.1587480	00	0.2852630	-02	0.1000260	01	0.1587740	00	-0.8092890	-04
2227	0.1588270	00	0.2808220	-02	0.1000240	01	0.1588520	00	-0.3521310	-04
2228	0.1589070	00	0.2770950	-02	0.1000220	01	0.1589310	00	0.3394120	-05
2229	0.1589880	00	0.2739470	-02	0.1000200	01	0.1590110	00	0.3651930	-04
2230	0.1590700	00	0.2712090	-02	0.1000180	01	0.1590930	00	0.6498170	-04
2231	0.1591540	00	0.2686640	-02	0.1000160	01	0.1591760	00	0.9184050	-04
2232	0.1592400	00	0.2659950	-02	0.1000140	01	0.1592620	00	0.1199660	-03
2233	0.1593280	00	0.2635460	-02	0.1000120	01	0.1593490	00	0.1459350	-03
2234	0.1594180	00	0.2613240	-02	0.1000100	01	0.1594390	00	0.1696740	-03
2235	0.1595110	00	0.2592500	-02	0.1000080	01	0.1595320	00	0.1919890	-03
2236	0.1596060	00	0.2572550	-02	0.1000060	01	0.1596270	00	0.2135320	-03
2237	0.1597040	00	0.2554290	-02	0.1000040	01	0.1597240	00	0.2334330	-03
2238	0.1598030	00	0.2535760	-02	0.1000020	01	0.1598230	00	0.2536410	-03
2239	0.1599030	00	0.2515240	-02	0.1000000	01	0.1599230	00	0.2758510	-03
2240	0.1600040	00	0.2493070	-02	0.9999830	00	0.1600230	00	0.2997260	-03
2241	0.1601060	00	0.2470260	-02	0.9999630	00	0.1601240	00	0.3242440	-03
2242	0.1602080	00	0.2447500	-02	0.9999420	00	0.1602270	00	0.3487290	-03
2243	0.1603100	00	0.2423420	-02	0.9999220	00	0.1603280	00	0.3745320	-03
2244	0.1604130	00	0.2397860	-02	0.9999010	00	0.1604300	00	0.4018140	-03
2245	0.1605150	00	0.2370510	-02	0.9998810	00	0.1605320	00	0.4308770	-03
2246	0.1606190	00	0.2340420	-02	0.9998600	00	0.1606360	00	0.4627350	-03
2247	0.1610420	00	0.2755760	-02	0.9996770	00	0.1610660	00	0.5432780	-04
2248	0.1626570	00	0.2689940	-02	0.1000230	01	0.1626790	00	0.1497920	-03
2249	0.1642970	00	0.2621980	-02	0.9992770	00	0.1643180	00	0.2437220	-03
2250	0.1659610	00	0.2555480	-02	0.9998040	00	0.1659800	00	0.3407560	-03
2251	0.1589050	00	0.0	0.0	0.0	0.0	0.1589050	00	0.0	0.0
2252	0.1589840	00	0.0	0.0	0.0	0.0	0.1589840	00	0.0	0.0
2253	0.1590640	00	0.0	0.0	0.0	0.0	0.1590640	00	0.0	0.0
2254	0.1591440	00	0.0	0.0	0.0	0.0	0.1591440	00	0.0	0.0
2255	0.1592250	00	0.0	0.0	0.0	0.0	0.1592250	00	0.0	0.0
2256	0.1593080	00	0.0	0.0	0.0	0.0	0.1593080	00	0.0	0.0
2257	0.1593920	00	0.0	0.0	0.0	0.0	0.1593920	00	0.0	0.0
2258	0.1594790	00	0.0	0.0	0.0	0.0	0.1594790	00	0.0	0.0
2259	0.1595680	00	0.0	0.0	0.0	0.0	0.1595680	00	0.0	0.0
2260	0.1596600	00	0.0	0.0	0.0	0.0	0.1596600	00	0.0	0.0
2261	0.1597550	00	0.0	0.0	0.0	0.0	0.1597550	00	0.0	0.0
2262	0.1598510	00	0.0	0.0	0.0	0.0	0.1598510	00	0.0	0.0
2263	0.1599500	00	0.0	0.0	0.0	0.0	0.1599500	00	0.0	0.0
2264	0.1600500	00	0.0	0.0	0.0	0.0	0.1600500	00	0.0	0.0
2265	0.1601510	00	0.0	0.0	0.0	0.0	0.1601510	00	0.0	0.0
2266	0.1602520	00	0.0	0.0	0.0	0.0	0.1602520	00	0.0	0.0
2267	0.1603540	00	0.0	0.0	0.0	0.0	0.1603540	00	0.0	0.0
2268	0.1604560	00	0.0	0.0	0.0	0.0	0.1604560	00	0.0	0.0
2269	0.1605580	00	0.0	0.0	0.0	0.0	0.1605580	00	0.0	0.0
2270	0.1606600	00	0.0	0.0	0.0	0.0	0.1606600	00	0.0	0.0
2271	0.1607620	00	0.0	0.0	0.0	0.0	0.1607620	00	0.0	0.0
2272	0.1611870	00	0.0	0.0	0.0	0.0	0.1611870	00	0.0	0.0
2273	0.1628110	00	0.0	0.0	0.0	0.0	0.1628110	00	0.0	0.0
2274	0.1644520	00	0.0	0.0	0.0	0.0	0.1644520	00	0.0	0.0
2275	0.1661110	00	0.0	0.0	0.0	0.0	0.1661110	00	0.0	0.0

 > 320 ksi Fiber Stress

EL.NO.	R	Z	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	NS-STRESS	F-STRESS	E-STRESS	SHEAR
1	0.08	4.23	-8.11590 03	4.31992 03	1.27260 04	3.6030 02	4.330 03	-8.120 03	-2.520 02	-1.170 04	1.380 -01	4.570 02
2	0.08	4.22	-8.15230 03	4.61050 03	1.30680 04	8.3300 02	4.620 03	-8.170 03	-7.220 02	-1.190 04	1.400 -01	4.660 02
3	0.08	4.21	-8.10740 03	5.15950 03	1.33430 04	2.2643 03	5.180 03	-8.130 03	-1.150 03	-1.210 04	1.410 -01	4.710 02
4	0.08	4.20	-8.03260 03	5.95630 03	1.35930 04	1.6888 03	5.980 03	-8.060 03	-1.570 03	-1.220 04	1.410 -01	4.750 02
5	0.08	4.18	-7.93990 03	6.99640 03	1.38900 04	2.1143 03	7.030 03	-7.980 03	-1.980 03	-1.250 04	1.400 -01	4.800 02
6	0.08	4.17	-7.82540 03	8.27580 03	1.43270 04	2.5338 03	8.320 03	-7.870 03	-2.390 03	-1.280 04	1.400 -01	4.870 02
7	0.08	4.16	-7.68100 03	9.78450 03	1.50220 04	2.9273 03	9.830 03	-7.730 03	-2.770 03	-1.320 04	1.410 -01	4.990 02
8	0.08	4.15	-7.49890 03	1.14980 04	1.61180 04	3.2583 03	1.160 04	-7.550 03	-3.090 03	-1.380 04	1.460 -01	5.190 02
9	0.08	4.14	-7.27900 03	1.33680 04	1.77820 04	3.4678 03	1.340 04	-7.340 03	-3.290 03	-1.450 04	1.550 -01	5.510 02
10	0.08	4.12	-7.04420 03	1.53100 04	2.02000 04	3.46220 03	1.540 04	-7.100 03	-3.270 03	-1.550 04	1.720 -01	5.990 02
11	0.08	4.11	-6.88810 03	1.71800 04	2.35640 04	3.08760 03	1.720 04	-6.940 03	-2.880 03	-1.670 04	1.990 -01	6.490 02
12	0.08	4.10	-7.21880 03	1.87310 04	2.79950 04	2.06530 03	1.880 04	-7.250 03	-1.840 03	-1.870 04	2.380 -01	7.730 02
13	0.08	4.09	-6.95480 03	1.60090 04	3.11130 04	3.48950 02	1.960 04	-6.960 03	-1.170 02	-2.170 04	2.940 -01	9.260 02

SL-NO.	R	Z	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	NS-STRESS	F-STRESS	E-STRESS	SHEAR				
14	0.08	4.08	-6.13040	03	1.94950	04	-1.48500	03	1.95004	-6.1003	1.7103	-2.6104	3.700-01	1.1403		
15	0.08	4.07	-5.90610	03	1.82550	04	-3.05220	03	1.82004	-5.8503	3.2603	-3.2004	4.720-01	1.4303		
16	0.08	4.05	-5.97970	03	1.62070	04	-4.50840	03	1.61004	-5.9003	4.7003	-3.9704	6.070-01	1.8003		
17	0.08	4.04	-6.10640	03	1.33600	04	-6.02570	03	1.33004	-6.0003	6.1903	-4.9004	7.840-01	2.2703		
18	0.08	4.03	-6.01550	03	9.49640	03	-7.44710	03	9.3703	-5.8803	7.5803	-5.8604	1.0100	2.8203		
19	0.08	4.02	-5.22890	03	4.67350	03	-2.77620	04	4.5203	-5.0803	8.5703	-6.5104	1.3000	3.4003		
20	0.08	4.01	-3.92920	03	-1.43170	03	-2.66060	04	-8.36760	-1.5803	8.3903	-6.4504	1.6400	3.8903		
21	0.08	4.00	-3.75700	03	-6.89290	03	2.50010	04	-7.04810	-7.0203	7.0203	-6.2604	1.9000	4.2403		
22	0.08	3.98	-4.37150	03	-8.94560	03	2.50240	04	-3.35920	-9.0003	4.3103	-7.2704	2.2400	4.9603		
23	0.08	3.95	-6.12750	03	-1.25810	04	2.24290	04	-8.75000	-1.2604	6.1103	8.1902	-6.9704	2.7000	5.9803	
24	0.08	3.92	-7.21390	03	-1.43460	04	2.06080	04	-5.30560	-1.4304	-7.2103	-9.1800	-9.8204	2.8700	6.3803	
25	0.11	4.23	-1.60550	03	5.10760	03	8.36140	03	1.34470	02	5.1103	-1.6103	-7.5801	-5.0103	7.110-02	2.1902
26	0.11	4.22	-1.66580	03	4.91160	03	8.43560	03	5.58480	02	4.9203	-1.6803	-5.0102	-5.0503	7.260-02	2.2202
27	0.11	4.21	-1.64440	03	4.55090	03	8.37940	03	9.70200	02	4.5703	-1.6603	-9.1602	-4.9403	7.320-02	2.2002
28	0.11	4.20	-1.59840	03	4.03110	03	8.20590	03	1.36510	03	4.0503	-1.6203	-1.3203	-4.7503	7.300-02	2.1602
29	0.11	4.18	-1.54020	03	3.35380	03	7.95740	03	1.74670	03	3.3803	-1.5703	-1.7003	-4.4903	7.260-02	2.0902
30	0.11	4.17	-1.46590	03	2.52040	03	7.69580	03	2.11310	03	2.5603	-1.5103	-2.0803	-4.1803	7.260-02	2.0202
31	0.11	4.16	-1.38470	03	1.53560	03	7.50120	03	2.45160	03	1.5803	-1.4303	-2.4303	-3.8403	7.360-02	1.9602
32	0.11	4.15	-1.28260	03	4.13030	02	7.47500	03	2.73650	03	4.6102	-1.3303	-2.7203	-3.5203	7.670-02	1.9302
33	0.11	4.14	-1.16760	03	-8.18610	02	7.74160	03	2.92810	03	-7.6802	-1.2203	-2.9203	-3.2503	8.310-02	1.9702
34	0.11	4.12	-1.05970	03	-2.10710	03	8.44860	03	2.97630	03	-2.0603	-1.1103	-2.9803	-3.1003	9.400-02	2.1002
35	0.11	4.11	-1.01140	03	-3.36450	03	9.71680	03	2.83340	03	-3.3103	-1.0603	-2.8503	-3.2003	1.110-01	2.3702
36	0.11	4.10	-1.03550	03	-4.42870	03	1.18880	04	2.49730	03	-4.3803	-1.0803	-2.5303	-3.6403	1.360-01	2.9502
37	0.11	4.09	-0.57840	02	-5.01920	03	1.51430	04	1.91450	03	-4.9903	-9.9202	-1.9503	-4.4403	1.700-01	3.5602
38	0.11	4.08	-6.75130	02	-4.90710	03	1.98810	04	7.52800	02	-4.8903	-6.8902	-7.9002	-5.6603	2.150-01	4.5102
39	0.11	4.07	-2.97870	02	-4.04490	03	2.64300	04	-1.26330	03	-4.0703	-2.7602	1.2303	-7.5003	2.760-01	5.8602
40	0.11	4.05	-3.27460	02	-2.69600	03	2.98910	04	-3.87750	03	-2.7603	-2.6002	3.8603	-1.0304	3.550-01	7.6902
41	0.11	4.04	-5.96870	02	-8.76140	02	2.90880	04	-6.47660	03	-9.8902	-4.8402	6.4703	-1.4404	4.600-01	1.0203
42	0.11	4.03	-6.38370	02	1.58300	03	2.80510	04	-8.86840	03	1.4303	-4.8302	8.8903	-2.0404	5.990-01	1.3703
43	0.11	4.02	1.76840	02	4.65740	03	2.68460	04	-1.11950	04	4.4603	3.7302	1.1204	-2.8004	7.860-01	1.8303
44	0.11	4.01	5.18790	03	8.66700	03	2.64290	04	-1.39550	04	8.4203	5.4303	1.4004	-2.5704	1.0500	2.2303
45	0.11	4.00	1.23080	04	1.23700	04	2.57360	04	-1.66340	04	1.2104	1.2604	1.6604	1.2803	1.2700	2.1003
46	0.11	3.98	1.05340	04	-1.67490	03	3.00870	04	-7.74840	03	-1.8103	1.0704	7.6403	8.0402	1.5400	2.4403
47	0.11	3.95	4.10130	03	-1.08170	04	2.39060	04	-6.69110	03	-1.0904	4.1803	4.5603	-1.0604	1.8200	3.0303
48	0.11	3.92	2.79620	03	-1.47820	04	2.10400	04	-1.75280	03	-1.4804	2.8303	1.6003	-7.5003	1.9500	3.1303
49	0.13	4.23	2.46850	00	-8.08590-03	03	5.43620-02	-6.50050-03	-1.210-01	2.5800	6.4800	6.4800	6.4800	6.4800	6.4800	6.4800
50	0.13	4.22	3.43780	00	-9.85980-03	03	7.37150-02	-6.47550-03	-1.230-01	3.5500	6.4400	6.4400	6.4400	6.4400	6.4400	6.4400
51	0.13	4.21	4.41170	00	-1.38330-02	03	9.30840-02	-6.44040-03	-1.260-01	4.5200	6.4000	6.4000	6.4000	6.4000	6.4000	6.4000
52	0.13	4.20	5.40930	00	-2.38530-02	03	1.12830-01	-6.39930-03	-1.350-01	5.5200	6.3500	6.3500	6.3500	6.3500	6.3500	6.3500
53	0.13	4.18	6.78520	00	-1.56180-01	03	1.39070-01	-6.26210-03	-2.630-01	6.9000	6.2000	6.2000	6.2000	6.2000	6.2000	6.2000
54	0.13	4.17	8.15510	00	-1.42660-01	03	1.66360-01	-5.83710-03	-2.440-01	8.2600	5.7600	5.7600	5.7600	5.7600	5.7600	5.7600
55	0.13	4.16	8.97130	00	-1.52920-01	03	1.82650-01	-5.45600-03	-2.470-01	9.0700	5.3800	5.3800	5.3800	5.3800	5.3800	5.3800
56	0.13	4.15	9.53150	00	-1.48850-01	03	1.94190-01	-5.09740-03	-2.370-01	9.6200	5.0100	5.0100	5.0100	5.0100	5.0100	5.0100
57	0.13	4.14	1.00320	01	-1.85180-01	03	2.04450-01	-4.72410-03	-2.670-01	1.0101	4.6300	4.6300	4.6300	4.6300	4.6300	4.6300
58	0.13	4.12	1.04320	01	-2.01150-01	03	2.13290-01	-4.27030-03	-2.750-01	1.0501	4.1800	4.1800	4.1800	4.1800	4.1800	4.1800
59	0.13	4.11	1.05710	01	-2.03610-01	03	2.17580-01	-3.79380-03	-2.690-01	1.0601	3.7000	3.7000	3.7000	3.7000	3.7000	3.7000
60	0.13	4.10	1.05800	01	-1.64290-01	03	2.20270-01	-3.40480-03	-2.230-01	1.0601	3.3100	3.3100	3.3100	3.3100	3.3100	3.3100
61	0.13	4.09	1.05650	01	-1.84260-01	03	2.22720-01	-3.03360-03	-2.360-01	1.0601	2.9400	2.9400	2.9400	2.9400	2.9400	2.9400
62	0.13	4.08	1.03040	01	-1.99860-01	03	2.21310-01	-2.59570-03	-2.440-01	1.0301	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
63	0.13	4.07	9.02660	00	-3.08100-01	03	2.00080-01	-1.88970-03	-3.400-01	9.0600	1.8100	1.8100	1.8100	1.8100	1.8100	1.8100
64	0.13	4.05	7.46140	00	-6.49060-02	03	1.77830-01	-1.63540-03	-9.290-02	7.4900	1.5700	1.5700	1.5700	1.5700	1.5700	1.5700
65	0.13	4.04	6.69410	00	-6.54370-02	03	1.71190-01	-1.62430-03	-9.230-02	6.7200	1.5700	1.5700	1.5700	1.5700	1.5700	1.5700
66	0.13	4.03	8.05490	00	-7.03740-02	03	1.69540-01	-1.52140-03	-9.650-02	6.0800	1.4700	1.4700	1.4700	1.4700	1.4700	1.4700
67	0.13	4.02	5.12370	00	-6.45700-02	03	1.48590-01	-1.39930-03	-9.040-02	5.1900	1.3500	1.3500	1.3500	1.3500	1.3500	1.3500
68	0.13	4.01	3.98810	00	-5.14200-02	03	1.64290-01	-1.27120-03	-9.330-02	4.0100	1.2400	1.2400	1.2400	1.2400	1.2400	1.2400
69	0.13	4.00	1.79370	00	-6.83310-01	03	1.39540-01	-2.34550-03	-6.870-01	1.8000	2.1300	2.1300	2.1300	2.1300	2.1300	2.1300
70	0.13	3.98	1.93090	04	8.63270	02	2.06030	04	-2.07060	04	5.0302	1.9704	2.0504	9.8604	1.3500	1.9902
71	0.13	3.95	9.76610	03	-9.73820	03	2.36730	04	-8.08700	03	-9.8803	9.9103	7.9203	2.1304	1.5800	2.0203
72	0.13	3.92	7.13390	03	-1.45370	04	2.08820	04	-2.56590	03	-1.4604	7.1803	2.3803	1.9904	1.7000	2.2003
73	0.15	4.23	7.80790	03	1.07330	04	9.78220	04	2.18000	03	1.7202	7.6503	-2.4503	1.0605	2.3600	5.2803
74	0.15	4.22	1.41740	04	1.13050	03	1.14350	05	8.13760	02	1.2003	1.4104	-1.2703	1.2905	1.9500	3.1603
75	0.15	4.21	1.40500	04	1.24240	03	1.34880	05	-1.48730	03	1.1503	1.4204	1.0403	1.4905	1.7300	4.3801
76	0.15	4.20	1.17340	04	-2.22180	02	1.62220	05	-6.16270	03	-6.3802	1.2104	5.7303	1.7505	1.6900	2.0003
77	0.15	4.18	1.01290	04	-6.63980	02	1.58290	04	-3.91940	03	-9.2402	1.0404	3.5303	7.5004	2.5000	4.8702
78	0.15	4.17	3.40320	03	-3.36220	03	1.42190	04	-1.19390	03	-3.4403	3.4803	9.5502	-2.0404	2.8400	9.6102
79	0.15	4.16	1.56510	03	-4.31200	03	1.44950	04	-1.92600	03	-4.4403	1.6903	1.7203	-4.8004	3.0900	1.1503
80	0.15	4.15	1.28880	03	-9.75030	03	1.35540	04	-2.98230	03	-9.9403	1.4803	2.5903	-2.0104	3.3000	1.0803
81	0.15	4.14	3.26660	03	-1.02900	04	1.31960	04	-1.36060	03	-1.0404	3.3403	8.8502	2.4103	3.5300	1.0603
82	0.15	4.12	3.18550	03	-9.99810	03	1.60120	04	-1.68470	02	-9.9903	3.1903	-2.9202	-7.3003	3.6800	1.1503
83	0.15	4.11	3.52070	03	-1.01970	04	1.63910	04	-4.899							

EL.NO.	R	Z	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	NS-STRESS	F-STRESS	E-STRESS	SHEAR
125	0.22	4.18	4.64550	03 -5.39260	1.85910	05 -8.74110	03 -6.28003	5.530	03 8.170	03 1.910	05 3.100	00 2.650
126	0.22	4.17	1.12900	05 5.06610	1.14030	05 -1.80810	04 -1.08003	1.140	05 1.210	04 2.800	05 4.210	03 0.000
127	0.22	4.16	6.65180	04 -3.62420	1.69970	05 -3.56460	03 -3.80003	6.670	04 -1.210	02 2.370	05 3.010	00 4.420
128	0.22	4.15	2.13840	04 -1.60230	2.16560	05 -6.50020	03 -1.52004	2.060	04 -8.420	02 2.370	05 3.640	00 4.960
129	0.22	4.13	6.11230	03 -1.83970	2.33820	05 7.15860	03 -1.76004	5.300	03 -8.400	03 2.390	05 3.690	00 2.340
130	0.22	4.12	2.13660	04 1.40480	2.20280	04 2.28400	03 4.37002	2.110	04 -3.380	03 2.090	05 2.900	00 8.580
131	0.22	4.11	1.90850	04 1.22413	2.18340	04 1.83660	03 1.46003	1.880	04 -2.760	03 1.680	05 2.940	00 2.680
132	0.21	4.10	4.01290	03 -1.26390	2.50230	05 -7.40420	03 -1.34004	4.740	03 6.490	03 2.550	05 2.710	00 -7.850
133	0.21	4.09	2.71620	04 -7.41290	2.41520	05 -1.40370	04 -8.79003	2.850	04 1.220	04 2.700	05 3.140	00 -1.850
134	0.21	4.07	8.26630	04 -5.29410	1.99220	05 -8.93340	03 -5.99003	8.340	04 4.290	03 2.830	05 3.280	00 -4.780
135	0.21	4.06	1.63510	05 -1.72480	1.45020	05 4.96930	03 -7.53002	1.630	05 -1.360	04 3.080	05 3.570	00 3.390
136	0.21	4.05	1.14040	04 -7.76110	2.81560	05 1.33970	04 -6.31003	9.950	03 -1.430	04 2.920	05 4.410	00 3.470
137	0.21	4.04	1.09330	04 -9.63720	2.84710	05 -8.71610	03 -1.05004	1.180	04 7.590	03 2.960	05 4.120	00 2.460
138	0.21	4.02	1.01420	05 -9.46300	2.01540	05 -2.81680	04 -1.21004	1.040	05 2.220	04 3.060	05 3.530	00 -1.610
139	0.21	4.01	1.18830	05 -1.31380	2.03160	05 -2.98840	04 -1.59004	1.220	05 2.280	04 3.250	05 3.780	00 -1.540
140	0.21	4.00	1.34640	05 -1.80300	2.17050	05 -1.41700	04 -1.91004	1.360	05 6.110	03 3.530	05 4.210	00 2.070
141	0.21	3.99	2.16300	04 -2.16440	-2.16340	04 4.02040	01 -2.16004	-2.160	04 -4.070	01 1.690	05 2.720	00 2.150
142	0.21	3.98	1.10900	04 -1.90360	1.45680	04 -4.42730	02 -1.90004	1.110	04 -1.130	03 6.920	04 1.340	00 6.020
143	0.21	3.95	1.65980	04 -1.71400	1.69500	04 -1.04730	03 -1.72004	1.660	04 -7.220	02 1.060	05 1.450	00 6.230
144	0.21	3.92	2.12370	04 -1.52000	1.91900	04 -7.12630	02 -1.52004	2.120	04 -1.200	03 1.360	05 1.940	00 -3.970
145	0.26	4.22	7.76610	04 1.79450	7.20570	04 -3.53250	04 1.39004	8.170	04 3.140	04 1.540	05 1.780	00 -3.210
146	0.26	4.20	1.10780	05 1.10930	8.89040	04 -3.18040	07 7.59003	1.140	05 2.550	04 2.030	05 2.320	00 2.080
147	0.26	4.19	3.87210	04 -1.38950	1.95510	05 1.04670	04 -1.24004	3.720	04 -1.360	04 2.330	05 5.490	00 2.040
148	0.26	4.18	3.55810	04 -1.32820	1.95930	05 1.19450	04 -1.16004	3.390	04 -1.480	04 2.300	05 4.800	00 1.550
149	0.25	4.17	5.81290	04 -8.81440	1.78490	05 9.84410	03 -7.37003	5.670	04 -1.390	04 2.350	05 3.530	00 1.010
150	0.25	4.16	1.00580	05 2.15563	6.26640	04 -1.24990	04 1.00003	1.020	05 6.400	03 1.640	05 2.260	00 -9.130
151	0.25	4.15	7.18080	04 4.72610	1.01670	05 -1.99410	04 2.55003	7.400	04 1.570	04 1.760	05 2.040	00 -1.380
152	0.25	4.14	6.19550	04 2.76850	1.78780	05 -2.19080	04 3.19002	6.440	04 1.810	04 2.430	05 2.600	00 -4.330
153	0.25	4.12	4.04430	04 -1.08610	2.44750	05 -3.27580	03 -1.11004	4.070	04 1.250	02 2.850	05 4.760	00 1.130
154	0.25	4.11	7.98870	03 -3.38700	2.64760	05 1.37950	04 -3.20004	6.150	03 -1.620	02 2.710	05 7.110	00 9.140
155	0.25	4.10	7.16260	03 -2.71450	2.67060	05 6.86240	03 -2.62004	6.200	03 -8.900	03 2.740	05 7.140	00 9.200
156	0.25	4.09	4.65380	04 -1.16780	2.57910	05 -6.81100	02 -1.15004	4.640	04 -3.070	03 3.040	05 5.670	00 1.670
157	0.25	4.08	9.89010	04 -1.08890	2.15440	05 4.75540	03 -9.90003	9.790	04 -1.140	04 3.130	05 4.240	00 1.100
158	0.25	4.07	1.35330	05 -7.03070	1.39140	05 8.72290	03 -5.44003	1.340	05 -1.730	04 2.730	05 3.190	00 -2.700
159	0.25	4.06	1.30860	05 -2.58590	7.61660	04 -1.28790	03 -3.66003	1.320	05 4.650	03 2.080	05 2.940	00 -1.200
160	0.25	4.04	2.82870	04 -5.34880	2.64290	05 -1.02030	04 -6.47003	2.940	04 8.080	03 2.940	05 3.050	00 -2.860
161	0.25	4.03	3.48180	04 -1.07200	2.77990	05 -1.02580	04 -1.18004	3.590	04 7.410	03 3.140	05 4.250	00 4.220
162	0.25	4.02	3.62420	04 -1.09840	2.89410	05 -1.75420	04 -1.29004	3.820	04 1.450	04 3.270	05 4.600	00 5.600
163	0.25	4.01	1.91030	05 -8.41550	1.53410	05 -3.58720	04 -1.20004	1.950	05 2.130	03 3.480	05 4.050	00 2.450
164	0.24	4.00	1.85110	05 1.19530	1.54400	05 -2.02070	04 -1.37004	1.870	05 8.050	03 3.410	05 4.020	00 -1.620
165	0.24	3.99	1.23360	04 -1.23540	-1.23420	04 6.83290	01 -1.23004	-1.230	04 -4.900	01 1.780	05 2.620	00 6.300
166	0.24	3.97	1.27670	04 -1.50430	1.75420	05 -1.63460	02 -1.50004	1.270	04 -1.530	03 5.940	04 1.280	00 7.470
167	0.24	3.95	1.69020	04 -1.53450	1.82410	04 1.57190	02 -1.52004	1.680	04 -2.120	03 9.570	04 1.440	00 2.640
168	0.24	3.92	2.10910	04 -1.50780	1.92250	04 1.44920	02 -1.49004	2.090	04 -2.350	03 1.370	05 1.580	00 -3.440
169	0.29	4.19	1.80230	05 1.83670	8.00010	04 -4.40030	04 1.30004	1.860	05 3.230	04 2.660	05 2.750	00 7.850
170	0.29	4.18	1.42650	05 1.27980	9.29830	04 -2.76800	04 9.58003	1.460	05 1.840	04 2.390	05 2.710	00 1.660
171	0.29	4.17	7.51110	04 -3.75540	1.73460	05 9.16360	03 -2.10003	7.350	04 -1.640	04 2.470	05 3.110	00 4.570
172	0.29	4.16	8.48660	04 -7.26050	1.79890	05 1.44380	04 -4.80003	8.240	04 -2.070	04 2.620	05 3.560	00 9.730
173	0.29	4.15	5.77030	04 -6.87960	2.05560	05 9.87700	03 -5.19003	5.600	04 -1.430	04 2.610	05 4.120	00 1.210
174	0.29	4.14	8.12840	03 2.63573	2.37580	05 -6.62760	03 1.74003	9.020	03 6.180	03 2.470	05 4.230	00 6.710
175	0.29	4.13	1.64400	03 9.85543	2.51710	05 -1.64790	04 7.52003	3.980	03 1.690	04 2.560	05 3.420	00 1.090
176	0.29	4.12	1.33810	05 1.35990	8.45350	04 -3.62160	04 9.14003	1.380	05 2.750	04 2.230	05 2.840	00 -7.940
177	0.29	4.11	8.96860	04 3.07370	1.34650	05 -1.75240	04 1.06003	9.170	04 1.130	04 2.260	05 2.530	00 -1.360
178	0.29	4.10	6.14670	04 -4.04440	1.95480	05 -1.84630	02 -3.84003	1.070	04 -3.680	03 2.570	05 2.380	00 -1.200
179	0.29	4.09	6.93620	04 -9.68180	2.01160	05 9.76760	03 -7.94003	6.760	04 -1.520	04 2.690	05 2.700	00 -8.760
180	0.29	4.08	1.24810	05 -1.05880	1.51390	05 1.00810	04 -8.53003	1.230	05 -1.940	04 2.740	05 3.170	00 -4.770
181	0.28	4.07	2.12560	05 -7.79110	1.05930	05 7.24280	03 -5.71003	2.110	05 -2.250	04 3.170	05 3.570	00 3.720
182	0.28	4.06	1.15450	04 -1.20920	2.85190	05 2.02040	04 -9.17003	8.620	03 -2.170	04 2.940	05 4.890	00 4.480
183	0.28	4.05	9.82880	03 -5.95000	2.86520	05 -5.35640	03 -6.62003	1.050	04 4.210	03 2.970	05 4.800	00 4.580
184	0.28	4.04	5.52100	04 -4.73120	2.52670	05 -2.31250	04 -7.66003	5.810	04 1.870	04 3.110	05 3.930	00 3.370
185	0.28	4.03	8.41860	04 -6.94940	2.26740	05 -2.89990	04 -1.05004	8.780	04 2.240	04 3.140	05 3.650	00 -6.180
186	0.28	4.02	8.86020	04 -1.12030	2.35140	05 -2.04010	04 -1.36004	9.100	04 1.330	04 3.260	05 3.790	00 -7.010
187	0.28	4.01	1.96910	05 -1.10990	1.32820	05 -2.59330	04 -1.37004	2.000	05 1.120	04 3.320	05 3.930	00 -1.220
188	0.28	4.00	2.18070	05 -1.14220	1.11500	05 -2.10420	04 -1.32004	2.200	05 4.870	03 3.310	05 3.990	00 -2.630
189	0.28	3.99	1.39880	04 -1.40090	-1.39950	04 5.54130	01 -1.40004	-1.400	04 -5.630	01 1.440	05 2.620	00 4.850
190	0.28	3.97	1.49330	04 -1.37360	1.80660	04 -1.62340	03 -1.38004	1.500	04 -3.870	02 7.040	04 1.240	00 4.690
191	0.28	3.94	1.78190	04 -1.42830	1.88490	04 -5.68960	02 -1.42004	1.770	04 -1.670	03 9.840	04 1.430	00 1.960
192	0.27	3.92	2.08640	04 -1.48910	1.93020	05 -1.64630	02 -1.44004	2.070	04 -3.680	03 1.360	05 1.610	00 -2.830
193	0.33	4.19	1.98660	05 5.88530	6.66040	04 -1.13880	04 2.16003	2.030	05 1.590	04 2.690	05 2.820	00 5.470
194	0.33	4.18	1.63430	05 5.82960	8.94330	04 -1.89340	04 3.64003	1.650	05 6.370	03 2.540	05 2.660	00 2.990
195	0.33	4.17	1.15470	03 3.08480	1.36850	05 -4.27830	03 3.11003	1.150	05 -4.560	03 2.520	05 2.950	00 2.500
196	0.33	4.16	8.20850	04 -4.45970	1.71360	05 1.35860	03 2.75002	8.140	04 -7.800	03 2.530	05 3.050	00 2.540
197	0.33	4.15	2.00350	04 -2.30700	2.29680	05 4.26530	03 -1.50003	1.920	04 -5.960	03 2.490	05 3.020	00 6.980
198	0.33	4.14	1.89100	04 -2.34850	2.31440	05 5.34400	03 -1.38003	1.790	04 -6.940	03 2.500	05 2.600	00 -1.800
199	0.32	4.12	2.77120	04 1.25070	2.17850	05 2.33000	03 6.59002	2.720	04 -4.460	03 2.450	05 2.110	00 -6.370
200	0.32	4.11	1.19620	05 5.93020	4.66360	04 -2.7805						

EL-NO.	R	Z	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	NS-STRESS	F-STRESS	E-STRESS	SHEAR										
237	0.35	3.98	1.57180	04	-1.57480	04	-1.57300	04	6.63550	01	-1.570	04	2.200	05	2.580	00	-3.920	02				
238	0.35	3.97	1.86470	04	-1.75990	04	1.48170	04	-2.10100	03	-1.770	04	1.870	04	-1.080	03	1.310	05	-7.530	02		
239	0.34	3.94	1.89210	04	-1.84260	04	1.53630	04	-7.61970	02	-1.830	04	1.880	04	-2.490	03	1.440	05	1.460	00	-7.170	02
240	0.34	3.92	2.19930	04	-1.81090	04	1.65290	04	-4.01030	02	-1.790	04	2.180	04	-3.090	03	1.890	05	1.690	00	-1.270	03
625	1.22	3.99	2.66120	05	2.67150	04	1.09410	04	-8.45670	04	-1.100	02	2.930	05	3.170	03	3.040	05	3.450	00	3.380	02
626	1.22	3.98	2.50920	05	2.36780	04	2.87840	04	-7.82290	04	-6.430	02	2.750	05	1.320	03	3.040	05	3.480	00	4.210	02
627	1.22	3.98	2.27640	05	1.99350	04	5.84370	04	-6.93840	04	-1.110	03	2.490	05	-5.520	02	3.070	05	3.510	00	7.410	02
628	1.21	3.97	1.99580	05	1.58360	04	9.64280	04	-5.90860	04	-1.500	03	2.170	05	-2.390	03	3.130	05	3.580	00	1.670	03
629	1.21	3.96	1.79250	05	1.02510	04	1.29670	05	-4.73270	04	-1.760	03	1.910	05	-8.030	03	3.210	05	3.680	00	3.110	03
630	1.21	3.95	1.33990	05	5.16840	03	1.78560	05	-3.27070	04	-2.110	03	1.410	05	-8.900	03	3.200	05	3.800	00	3.650	03
631	1.20	3.94	9.01440	04	1.73940	03	2.18740	05	-2.33590	04	-3.770	03	9.560	04	-5.350	03	3.150	05	3.790	00	2.650	03
632	1.20	3.93	4.67700	04	-3.22140	03	2.62600	05	-1.06480	04	-4.900	03	4.850	04	-5.150	03	3.110	05	3.770	00	1.370	03
633	1.20	3.92	2.33690	04	-5.25510	03	2.86960	05	-5.35000	03	-5.800	03	2.390	04	-3.570	03	3.110	05	3.750	00	6.750	02
634	1.20	3.92	2.41150	03	-6.68730	03	3.09670	05	-1.23240	03	-6.600	03	2.320	03	-1.520	03	3.120	05	3.750	00	1.590	02
635	1.19	3.91	1.38490	03	-6.40050	03	3.11720	05	-2.87220	03	-7.340	03	2.330	03	2.040	02	3.140	05	3.730	00	8.650	01
636	1.19	3.90	1.98330	04	-3.83120	03	2.92320	05	-1.10130	04	-7.970	03	2.400	04	2.510	03	3.170	05	3.710	00	5.710	00
637	1.19	3.89	4.11060	04	-9.91080	02	2.70150	05	-1.96940	04	-8.410	03	4.850	04	4.560	03	3.190	05	3.720	00	-1.490	02
638	1.19	3.88	8.32840	04	3.34050	03	2.26060	05	-3.36100	04	-8.620	03	9.520	04	5.510	03	3.220	05	3.760	00	-3.820	01
639	1.18	3.87	1.26400	05	1.04550	04	1.79140	05	-5.09310	04	-8.110	03	1.450	05	9.810	03	3.240	05	3.790	00	-1.460	02
640	1.18	3.86	1.59410	05	1.19200	04	1.39180	05	-6.10560	04	-9.610	03	1.810	05	9.380	03	3.200	05	3.770	00	-1.410	03
641	1.18	3.86	1.87720	05	1.01850	04	9.94010	04	-6.51460	04	-1.110	04	2.090	05	4.370	03	3.080	05	3.760	00	-3.210	03
642	1.18	3.85	2.12030	05	1.09550	04	5.98480	04	-7.16090	04	-1.190	04	2.350	05	3.150	03	2.950	05	3.800	00	-4.070	03
643	1.17	3.84	2.30690	05	1.11390	04	2.92560	04	-7.62000	04	-1.270	04	2.550	05	1.790	03	2.840	05	3.870	00	-3.670	03
644	1.17	3.83	2.41730	05	1.06630	04	1.10560	04	-7.83390	04	-1.340	04	2.660	05	3.400	02	2.770	05	3.930	00	-2.600	03
645	1.17	3.82	-1.39590	04	-1.40460	04	-1.40190	04	-2.83810	01	-1.400	04	-1.400	04	-3.680	01	2.460	05	3.730	00	2.090	02
646	1.16	3.81	1.26050	04	-1.16340	04	1.44630	04	-8.05080	03	-1.410	04	1.500	04	-1.030	02	2.860	05	3.600	00	-1.280	02
647	1.16	3.78	1.21800	04	-1.19930	04	1.44600	04	-8.06100	03	-1.440	04	1.460	04	-7.590	01	2.830	05	3.710	00	-4.120	01
648	1.15	3.76	1.17540	04	-1.23520	04	1.44120	04	-8.07970	03	-1.480	04	1.420	04	-4.160	01	2.800	05	3.820	00	4.630	01
649	1.29	3.97	2.58280	05	2.82250	04	8.97300	03	-8.59810	04	-3.450	02	2.870	05	1.950	03	2.960	05	3.480	00	-1.460	02
650	1.29	3.96	2.39780	05	2.49820	04	2.83970	04	-7.90120	04	-9.480	02	2.660	05	7.930	02	2.940	05	3.500	00	-5.310	02
651	1.28	3.95	2.15870	05	2.13140	04	5.30640	04	-7.07330	04	-1.680	03	2.390	05	4.560	01	2.920	05	3.500	00	-1.190	03
652	1.28	3.94	1.82020	05	1.68270	04	8.78990	04	-5.99050	04	-2.610	03	2.010	05	-8.320	01	2.890	05	3.480	00	-2.270	03
653	1.28	3.94	2.45050	05	2.06480	04	8.77660	03	-7.81700	04	-3.870	03	2.700	05	-2.710	03	2.780	05	3.570	00	-1.110	03
654	1.28	3.93	1.20350	05	4.02470	03	1.66210	05	-3.33650	04	-4.480	03	1.290	05	-7.190	03	2.550	05	3.410	00	-3.270	03
655	1.27	3.92	8.64130	04	2.56830	02	2.09600	05	-2.27150	04	-4.870	03	9.150	04	-6.940	03	3.010	05	3.400	00	-2.800	03
656	1.27	3.91	4.39710	04	-3.91650	03	2.62010	05	-1.02190	04	-5.350	03	4.540	04	-5.810	03	3.080	05	3.380	00	-2.090	03
657	1.27	3.90	2.78810	03	-6.75720	03	3.03210	05	-1.40510	03	-6.400	03	9.030	03	-3.720	03	3.120	05	3.350	00	-2.050	03
658	1.27	3.89	8.37220	03	-6.02770	03	3.04870	05	-3.46000	03	-6.690	03	9.030	03	-1.430	03	3.140	05	3.330	00	-1.180	03
659	1.26	3.88	7.34960	03	-5.71060	03	3.06660	05	-5.00070	03	-7.400	03	9.040	03	2.070	02	3.160	05	3.320	00	-1.310	03
660	1.26	3.88	5.87800	03	-5.00380	03	3.08560	05	-7.17720	03	-8.180	03	9.060	03	2.610	03	3.180	05	3.300	00	-1.430	03
661	1.26	3.87	3.72390	04	-8.06140	02	2.68820	05	-2.02000	04	-9.050	03	4.550	04	5.160	03	3.140	05	3.330	00	-3.450	03
662	1.25	3.86	7.73470	04	3.65740	03	2.15870	05	-5.33000	04	-1.010	04	9.110	04	6.900	03	3.070	05	3.380	00	-5.270	03
663	1.25	3.85	1.13450	05	7.12450	03	1.65850	05	-4.83640	04	-1.120	04	1.320	05	7.880	03	2.970	05	3.440	00	-6.710	03
664	1.25	3.84	2.28220	05	1.65770	04	5.65000	03	-8.30560	04	-1.200	04	2.570	05	4.990	03	2.620	05	3.830	00	-2.040	03
665	1.25	3.83	1.72650	05	8.91440	03	9.02500	04	-6.18210	04	-1.180	04	1.930	05	1.890	03	2.840	05	3.650	00	-6.710	03
666	1.24	3.82	2.00980	05	1.16590	04	5.40760	04	-7.14880	04	-1.230	04	2.250	05	2.200	03	2.790	05	3.770	00	-5.530	03
667	1.24	3.82	2.19760	05	1.28330	04	2.87370	04	-7.73620	04	-1.290	04	2.450	05	1.770	03	2.740	05	3.850	00	-4.340	03
668	1.24	3.81	2.33150	05	1.30010	04	9.01420	03	-8.10400	04	-1.360	04	2.600	05	8.640	02	2.690	05	3.930	00	-2.650	03
669	1.24	3.80	-1.40850	04	-1.41310	04	-1.41040	04	-2.53600	01	-1.410	04	-1.410	04	-3.410	01	2.400	05	3.760	00	3.060	02
670	1.23	3.79	1.22050	04	-1.12590	04	1.46030	04	-8.55280	03	-1.400	04	1.500	04	2.340	01	2.840	05	3.650	00	-8.760	01
671	1.22	3.76	1.17750	04	-1.15530	04	1.45410	04	-8.54790	03	-1.440	04	1.460	04	2.890	01	2.810	05	3.750	00	-5.770	02
672	1.22	3.74	1.13680	04	-1.20640	04	1.44840	04	-8.54360	03	-1.480	04	1.420	04	3.200	01	2.790	05	3.860	00	7.650	01
673	1.36	3.95	2.52790	03	3.07930	04	8.96130	03	-8.87910	04	-3.410	02	2.840	05	1.630	03	2.930	05	3.510	00	-3.700	02
674	1.36	3.94	2.36960	05	2.72220	04	2.53410	04	-8.17540	04	-8.790	02	2.650	05	-1.420	02	2.900	05	3.520	00	-9.240	02
675	1.35	3.93	2.12240	05	2.29370	04	5.29990	04	-7.18530	04	-1.230	03	2.360	05	-1.650	03	2.890	05	3.520	00	-1.690	03
676	1.35	3.92	1.82070	05	1.85100	04	8.83290	04	-6.02940	04	-1.270	03	2.020	05	-2.840	03	2.900	05	3.490	00	-2.470	03
677	1.35	3.91	2.45330	05	2.55060	04	8.85030	03	-8.13660	04	-1.290	03	2.720	05	-3.550	03	2.810	05	3.590	00	-1.100	03
678	1.34	3.90	1.22200	05	9.00540	03	1.61430	05	-3.76580	04	-2.180	03	1.330	05	-5.170	03	2.550	05	3.400	00	-3.750	03
679	1.34	3.90	8.30240	04	3.74560	03	2.09480	05	-2.48790	04	-3.170	03	8.990	04	-4.800	03						

EL.NO.	R	Z	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	M-STRESS	F-STRESS	E-STRESS	SHEAR
1395	3.13	2.72	1.05590 05	1.48950 05	4.32050 04	-1.26560 05	-1.070 03	2.560 05	3.660 03	2.990 05	3.680 00	-1.830 03
1396	3.13	2.72	9.47790 04	1.32930 05	6.77700 04	-1.14360 05	-2.050 03	2.300 05	2.980 03	2.980 05	3.650 00	-2.650 03
1397	3.12	2.71	7.13160 04	9.90640 04	1.28070 05	-8.69670 04	-2.860 03	1.730 05	1.640 03	3.010 05	3.580 00	-3.630 03
1398	3.11	2.71	5.64060 04	7.76290 04	1.67010 05	-6.97810 04	-3.560 03	1.380 05	7.960 02	3.040 05	3.520 00	-4.100 03
1399	3.11	2.70	3.27640 04	4.25160 04	2.32750 05	-4.14880 04	-4.120 03	7.940 04	-9.450 02	3.120 05	3.420 00	-3.880 03
1400	3.10	2.70	1.91930 04	2.21220 04	2.70920 05	-2.54600 04	-4.760 03	4.610 04	-2.090 03	3.170 05	3.380 00	-3.190 03
1401	3.09	2.69	8.11870 03	6.48073 03	3.04140 05	-1.20530 04	-5.380 03	1.800 04	-3.480 03	3.220 05	3.360 00	-1.990 03
1402	3.09	2.68	1.17240 03	-5.12980 03	3.21880 05	-4.73000 03	-6.220 03	2.270 03	-3.780 03	3.250 05	3.390 00	-6.770 02
1403	3.08	2.68	3.53300 01	-4.79880 03	3.22610 05	-5.04990 03	-7.050 03	2.280 03	-3.100 03	3.250 05	3.430 00	-6.170 02
1404	3.07	2.67	6.41960 03	4.07493 03	3.06470 05	-1.34160 04	-7.870 03	1.840 04	-3.030 03	3.250 05	3.500 00	-1.500 03
1405	3.07	2.67	1.86610 04	2.03143 04	2.75040 05	-2.84580 04	-8.810 03	4.780 04	-3.140 03	3.230 05	3.570 00	-2.060 03
1406	3.06	2.66	3.32520 04	4.05623 04	2.38400 05	-4.64450 04	-9.590 03	8.340 04	-2.840 03	3.220 05	3.640 00	-2.240 03
1407	3.05	2.66	5.91340 04	7.65990 04	1.72910 05	-7.77550 04	-1.030 04	1.460 05	-2.170 03	3.190 05	3.720 00	-2.300 03
1408	3.05	2.65	7.48690 04	9.85260 04	1.33410 05	-9.70120 04	-1.100 04	1.840 05	-1.790 03	3.180 05	3.770 00	-2.120 03
1409	3.04	2.64	9.96600 04	1.33430 05	7.09790 04	-1.27050 05	-1.160 04	2.450 05	-6.620 02	3.160 05	3.820 00	-1.690 03
1410	3.04	2.64	1.09980 05	1.48303 05	4.52510 04	-1.40040 05	-1.220 04	2.700 05	-5.130 02	3.160 05	3.850 00	-1.360 03
1411	3.03	2.63	1.22650 05	1.65943 05	1.39500 04	-1.55630 05	-1.280 04	3.010 05	-2.230 02	3.150 05	3.890 00	-7.750 02
1412	3.02	2.63	1.26250 05	1.71433 05	4.80650 04	-1.60780 05	-1.350 04	3.110 05	-3.770 00	3.160 05	3.900 00	-4.540 02
1413	3.02	2.62	-1.38990 04	-1.39140 04	-1.39020 04	-5.14080 00	-1.390 04	-1.390 04	-8.030 00	2.660 05	3.910 00	1.830 02
1414	3.01	2.61	-1.69070 03	2.31630 03	1.52720 04	-1.42480 04	-1.410 04	1.470 04	1.050 00	2.790 05	3.940 00	1.310 02
1415	2.99	2.60	-1.93780 03	2.05933 03	1.50830 04	-1.43620 04	-1.440 04	1.460 04	-1.970 01	2.850 05	4.000 00	1.220 02
1416	2.97	2.58	-2.21350 03	1.82340 03	1.48940 04	-1.44750 04	-1.480 04	1.440 04	-1.570 01	2.910 05	4.070 00	1.130 02
1417	3.19	2.68	1.20450 05	1.78330 05	4.60980 03	-1.46960 05	-3.620 02	2.990 05	2.980 03	3.040 05	3.700 00	-3.940 02
1418	3.19	2.67	1.16950 05	1.73333 05	1.12740 04	-1.42750 05	-3.410 02	2.910 05	2.980 03	3.020 05	3.710 00	-7.430 02
1419	3.18	2.67	1.04070 05	1.53403 05	4.34580 04	-1.26950 05	-5.750 02	2.580 05	2.250 03	3.020 05	3.690 00	-1.660 03
1420	3.17	2.66	9.45220 04	1.37583 05	6.83130 04	-1.14980 05	-9.170 02	2.330 05	1.240 03	3.010 05	3.670 00	-2.290 03
1421	3.17	2.66	7.19620 04	1.02403 05	1.29000 05	-8.72250 04	-1.360 03	1.760 05	-1.600 02	3.050 05	3.610 00	-3.140 03
1422	3.16	2.65	5.97410 04	8.26900 04	1.62330 05	-7.21870 04	-1.870 03	1.440 05	-1.230 03	3.060 05	3.550 00	-3.670 03
1423	3.15	2.65	3.56120 04	4.65270 04	2.28300 05	-4.31470 04	-2.370 03	8.450 04	-2.120 03	3.130 05	3.450 00	-3.720 03
1424	3.15	2.64	2.13850 04	2.56890 04	2.67370 05	-2.65130 04	-2.950 03	5.000 04	-2.480 03	3.170 05	3.370 00	-3.410 03
1425	3.14	2.63	1.06420 04	1.15470 04	2.94910 05	-1.49150 04	-3.670 03	2.590 04	-2.140 03	3.210 05	3.310 00	-2.750 03
1426	3.13	2.63	-1.05140 02	-2.04270 03	3.22500 05	-3.53330 03	-4.390 03	2.240 03	-1.570 03	3.250 05	3.270 00	-8.690 02
1427	3.13	2.62	-1.10560 03	-1.92240 03	3.23220 05	-3.88800 03	-5.270 03	2.240 03	-1.080 03	3.260 05	3.290 00	-8.620 02
1428	3.12	2.62	7.45830 03	1.23583 04	2.96940 05	-1.59940 04	-6.270 03	2.610 04	-3.650 02	3.230 05	3.360 00	-2.690 03
1429	3.11	2.61	1.65840 04	2.68900 04	2.70500 05	-2.85290 04	-7.250 03	5.070 04	1.210 02	3.210 05	3.440 00	-3.310 03
1430	3.11	2.61	3.05270 04	4.72830 04	2.32120 05	-4.65160 04	-8.360 03	8.620 04	1.730 02	3.180 05	3.540 00	-3.590 03
1431	3.11	2.60	5.56490 04	8.30513 04	1.64940 05	-7.74730 04	-4.420 03	1.480 05	1.090 02	3.140 05	3.660 00	-3.540 02
1432	3.09	2.60	6.87650 04	1.01750 05	1.24740 05	-4.16240 04	-1.030 04	1.810 05	-1.060 02	3.130 05	3.730 00	-3.060 03
1433	3.09	2.59	9.29540 04	1.35943 05	7.03900 04	-1.23820 05	-1.120 04	2.400 05	-3.340 02	3.110 05	3.810 00	-2.360 03
1434	3.08	2.58	1.02920 05	1.50300 05	4.48380 04	-1.36630 05	-1.210 04	2.650 05	-3.960 02	3.100 05	3.850 00	-1.900 03
1435	3.07	2.58	1.15590 05	1.68720 05	1.16240 04	-1.52690 05	-1.280 04	2.970 05	-3.500 02	3.090 05	3.890 00	-1.010 03
1436	3.07	2.57	1.18140 05	1.72773 05	4.75290 04	-1.56660 05	-1.360 04	3.040 05	-3.040 02	3.090 05	3.910 00	-6.480 02
1437	3.06	2.57	-1.39390 04	-1.39530 04	-1.39420 04	-5.34480 00	-1.390 04	-1.390 04	-7.850 00	2.580 05	3.910 00	2.220 02
1438	3.05	2.56	-2.11320 03	2.82923 03	1.52780 04	-1.42090 04	-1.410 04	1.480 04	-3.370 01	2.820 05	3.940 00	1.150 02
1439	3.03	2.54	-2.40870 03	2.55243 03	1.50970 04	-1.42930 04	-1.440 04	1.460 04	-3.900 01	2.850 05	4.010 00	1.220 02
1440	3.01	2.53	-2.72500 03	2.28653 03	1.49140 04	-1.43780 04	-1.480 04	1.440 04	-2.900 01	2.890 05	4.080 00	1.290 02
1441	3.24	2.62	1.16270 05	1.80663 05	4.59650 03	-1.45190 05	-2.420 02	2.970 05	1.310 03	3.020 05	3.700 00	-4.600 02
1442	3.23	2.62	1.13650 05	1.75723 05	1.12690 04	-1.42080 05	-7.420 02	2.900 05	8.180 02	3.010 05	3.710 00	-7.790 02
1443	3.23	2.61	1.01770 05	1.56180 05	4.35630 04	-1.27260 05	-1.160 03	2.590 05	1.540 02	3.030 05	3.690 00	-1.570 03
1444	3.22	2.61	9.44570 04	1.43550 05	6.42020 05	-1.18040 05	-1.560 03	2.400 05	-5.310 02	3.040 05	3.690 00	-1.950 03
1445	3.21	2.60	7.30030 04	1.09220 05	1.24630 05	-9.12970 04	-1.950 03	1.840 05	-1.270 03	3.090 05	3.650 00	-2.370 03
1446	3.21	2.60	5.93310 04	8.69923 04	1.64190 05	-7.43530 04	-2.440 03	1.490 05	-1.930 03	3.130 05	3.640 00	-2.260 03
1447	3.20	2.59	3.51110 04	4.94253 04	2.30520 05	-4.98700 04	-3.200 03	8.780 04	-2.350 03	3.180 05	3.620 00	-1.810 03
1448	3.19	2.58	2.05210 04	2.77570 04	2.69390 05	-2.80390 04	-4.040 03	5.230 04	-2.290 03	3.210 05	3.630 00	-1.280 03
1449	3.19	2.58	4.32020 03	4.64823 03	3.10610 05	-9.54940 04	-4.890 03	1.390 04	-1.820 03	3.240 05	3.640 00	-6.070 02
1450	3.18	2.57	-1.52530 03	-1.89240 03	3.22570 05	-4.84100 03	-5.760 03	2.350 03	-1.050 03	3.250 05	3.650 00	-2.560 02
1451	3.17	2.57	-2.50360 03	-1.65673 03	3.23320 05	-4.43760 03	-6.510 03	2.350 03	-5.080 02	3.260 05	3.650 00	-2.720 02
1452	3.17	2.56	1.69500 03	7.26723 03	3.09900 05	-1.13370 04	-7.190 03	1.610 04	3.680 02	3.260 05	3.650 00	-7.650 02
1453	3.16	2.56	1.49290 04	2.98683 04	2.72280 05	-2.93500 04	-7.860 03	5.270 04	1.200 03	3.250 05	3.650 00	-1.540 03
1454	3.15	2.55	2.83600 04	5.17650 04	2.33920 05	-4.71780 04	-8.520 03	8.860 04	1.640 03	3.220 05	3.660 00	-2.170 03
1455	3.15	2.55	5.25290 04	8.89253 04	1.67150 05	-7.78490 04	-9.200 03	1.510 05	1.610 03	3.180 05	3.710 00	-2.710 03
1456	3.14	2.54	6.67380 04	1.10070 05	1.27280 05	-6.61180 04	-1.010 04	1.870 05	1.210 03	3.140 05	3.750 00	-2.900 03
1457	3.13	2.54	8.87640 04	1.43420 05	6.56960 04	-1.24140 05	-1.100 04	2.430 05	9.180 02	3.090 05	3.810 00	-2.500 03
1458	3.13	2.53	9.64510 04	1.54670 05	4.46700 04	-1.34330 05	-1.190 04	2.630 05	5.470 02	3.080 05	3.850 00	-2.150 03
1459	3.12	2.53	1.08430 05	1.72740 05	1.15630 05	-1.49490 05	-1.270 04	2.940 05	2.840 02	3.050 05	3.890 00	-1.170 03
1460	3.11	2.52	1.10740 05	1.76233 05	4.72160 03	-1.53540 05	-1.350 04	3.000 05	1.070 02	3.050 05	3.910 00	-7.660 02
1461	3.11	2.52	-1.38130 04	-1.38250 04	-1.38150 04	-4.98220 00	-1.380 04	-1.380 04	-7.250 00	2.560 05	3.920 00	2.460 02
1462	3.09	2.51	-2.60440 03	3.36353 03	1.52940 04	-1.41200 04	-1.410 04	1.480 04	-1.710 01	2.830 05	3.950 00	1.110 02
1463	3.08	2.49	-2.92290 02	3.07133 03	1.51140 04	-1.41890 04	-1.440 04	1.460 04	-1.790 01	2.850 05	4.020 00	1.270 02
1464	3.06	2.47	-3.25370 03	2.79123 03	1.49390 04	-1.42600 05	-1.480 04	1.430 04	-8.340 00	2.880 05	4.090 00	1.420 02
1465	3.28	2.57	1.12120 05	1.85183 05	4.60240 03	-1.44420 05	-3.200 02	2.980 05	5.050 02	3.020 05	3.710 00	-4.570 02
1466	3.28	2.56	1.09740 05	1.79853 05	1.12810 04	-1.41400 05	-8.830 02	2.900 05	-1.970 02	3.020 05	3.710 00	-7.7

EL.NO.	R	2	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	NS-STRESS	F-STRESS	E-STRESS	SHEAR
1983	3.93	0.98	-3.95640	0.2	1.44740	0.5	1.60020	0.5	-3.77730	0.4	-9.480	0.3
1984	3.92	0.98	-3.44640	0.2	1.58450	0.5	1.49390	0.5	-4.10240	0.4	-1.030	0.4
1985	3.91	0.97	-2.62530	0.3	2.17600	0.5	8.50550	0.4	-5.61890	0.4	-1.120	0.4
1986	3.90	0.97	-4.69600	0.3	2.62150	0.5	3.75550	0.4	-6.76510	0.4	-1.200	0.4
1987	3.89	0.97	-6.05070	0.3	2.94580	0.5	3.51860	0.3	-7.61210	0.4	-1.280	0.4
1988	3.88	0.97	-5.53810	0.3	2.96000	0.5	3.53270	0.4	-7.69030	0.4	-1.360	0.4
1989	3.88	0.97	-1.39170	0.4	-1.39100	0.4	-1.39090	0.4	-2.11900	0.0	-1.390	0.4
1990	3.86	0.96	-1.23890	0.4	1.30730	0.4	1.52000	0.4	-6.74250	0.3	-1.410	0.4
1991	3.84	0.96	-1.27500	0.4	1.29280	0.4	1.49940	0.4	-6.79720	0.3	-1.440	0.4
1992	3.82	0.95	-1.31140	0.4	1.27770	0.5	1.47890	0.4	-6.85810	0.3	-1.480	0.4
1993	4.08	0.87	1.32980	0.4	2.71120	0.5	3.27940	0.3	-6.07140	0.4	-2.520	0.2
1994	4.07	0.86	1.28080	0.4	2.71070	0.5	4.46880	0.4	-6.08850	0.4	-7.920	0.2
1995	4.06	0.86	1.11210	0.4	2.47850	0.5	3.21050	0.4	-5.59080	0.4	-1.390	0.3
1996	4.05	0.86	8.50120	0.3	2.05750	0.5	8.11300	0.4	-4.67440	0.4	-1.980	0.3
1997	4.04	0.86	5.28530	0.3	1.51560	0.5	1.44030	0.5	-3.49280	0.4	-2.600	0.3
1998	4.04	0.86	3.81120	0.3	1.42700	0.5	1.55450	0.5	-3.21320	0.4	-3.250	0.3
1999	4.03	0.86	2.33110	0.2	8.61090	0.4	2.21190	0.5	-1.90460	0.4	-3.800	0.3
2000	4.02	0.85	-2.57370	0.3	4.13370	0.4	2.73140	0.5	-9.42110	0.3	-4.510	0.3
2001	4.01	0.85	-5.09370	0.3	5.92710	0.3	3.13760	0.3	-1.49220	0.5	-5.220	0.3
2002	4.00	0.85	-6.27860	0.3	1.25850	0.3	3.20450	0.5	-1.94750	0.2	-6.030	0.3
2003	3.99	0.85	-7.05140	0.3	1.29270	0.3	3.21180	0.5	-2.06260	0.2	-6.770	0.3
2004	3.98	0.85	-7.59330	0.3	7.86700	0.3	3.14320	0.5	-1.40450	0.3	-7.500	0.3
2005	3.98	0.85	-7.01700	0.3	3.91470	0.4	2.80400	0.5	-8.07580	0.3	-8.310	0.3
2006	3.97	0.84	-5.34510	0.3	8.95420	0.4	2.25770	0.5	-1.91900	0.4	-9.050	0.3
2007	3.96	0.84	-3.53670	0.3	1.50900	0.3	1.60250	0.5	-3.17440	0.4	-9.770	0.3
2008	3.95	0.84	-3.66010	0.3	1.67830	0.5	1.44020	0.5	-3.49810	0.4	-1.050	0.4
2009	3.94	0.84	-1.61970	0.3	2.23710	0.5	8.53970	0.4	-4.75740	0.4	-1.120	0.4
2010	3.93	0.84	2.06170	0.1	2.70170	0.5	3.77930	0.4	-5.81990	0.4	-1.200	0.4
2011	3.92	0.83	1.07130	0.3	3.03000	0.5	4.81920	0.5	-6.60290	0.4	-1.270	0.4
2012	3.92	0.83	7.31720	0.2	3.05970	0.5	3.56480	0.3	-6.74690	0.4	-1.350	0.4
2013	3.91	0.83	-1.38670	0.4	-1.38600	0.4	-1.38600	0.4	-2.83410	0.0	-1.390	0.4
2014	3.89	0.83	-1.28240	0.4	1.34800	0.4	1.52190	0.4	-5.82430	0.3	-1.410	0.4
2015	3.87	0.82	-1.31940	0.4	1.33870	0.4	1.49980	0.4	-5.87630	0.3	-1.440	0.4
2016	3.85	0.82	-1.35570	0.4	1.32910	0.4	1.47820	0.4	-5.94430	0.3	-1.480	0.4
2017	4.11	0.72	9.56890	0.3	2.71510	0.5	3.26100	0.3	-5.17150	0.4	-2.200	0.2
2018	4.10	0.72	8.52490	0.3	2.73220	0.5	4.45630	0.3	-5.16830	0.4	-1.100	0.3
2019	4.09	0.72	6.94310	0.3	2.52210	0.5	3.21660	0.4	-4.73580	0.4	-1.860	0.3
2020	4.08	0.72	4.80340	0.3	2.11280	0.5	8.16100	0.3	-3.99160	0.4	-2.620	0.3
2021	4.07	0.72	2.24960	0.3	1.56850	0.5	1.45180	0.5	-2.99430	0.4	-3.330	0.3
2022	4.06	0.72	-7.05740	0.2	9.81890	0.4	2.11700	0.5	-1.83720	0.4	-4.010	0.3
2023	4.06	0.72	-1.96430	0.3	9.60430	0.4	2.17400	0.5	-1.69430	0.4	-4.860	0.3
2024	4.05	0.71	-4.36060	0.3	4.28010	0.4	2.74070	0.5	-7.57300	0.3	-5.530	0.3
2025	4.04	0.71	-6.21820	0.3	7.80230	0.3	3.12690	0.5	-1.15750	0.3	-6.190	0.3
2026	4.03	0.71	-7.06560	0.3	1.27430	0.3	3.20970	0.5	-3.77800	0.6	-8.820	0.3
2027	4.02	0.71	-7.75220	0.3	1.30700	0.3	3.21740	0.5	-1.49260	0.1	-7.470	0.3
2028	4.01	0.71	-8.12130	0.3	9.62060	0.3	3.12890	0.5	-1.57730	0.3	-8.130	0.3
2029	4.00	0.71	-7.52830	0.3	4.39950	0.4	2.78010	0.5	-8.02260	0.3	-8.720	0.3
2030	4.00	0.70	-6.43680	0.3	9.30160	0.4	2.78850	0.5	-1.72020	0.4	-9.320	0.3
2031	3.99	0.70	-4.77640	0.3	1.09300	0.5	2.29770	0.5	-1.95810	0.4	-9.970	0.3
2032	3.98	0.70	-5.58950	0.3	1.75360	0.5	1.46170	0.5	-3.08580	0.4	-1.070	0.4
2033	3.97	0.70	-4.28040	0.3	2.33360	0.5	8.67460	0.4	-4.16250	0.4	-1.140	0.4
2034	3.96	0.70	-3.16450	0.3	2.84540	0.5	3.47710	0.4	-5.13670	0.4	-1.210	0.4
2035	3.95	0.70	-2.82280	0.3	3.15020	0.5	4.89320	0.4	-5.70470	0.4	-1.270	0.4
2036	3.94	0.70	-3.36860	0.3	3.18630	0.5	3.62170	0.3	-5.79840	0.4	-1.350	0.4
2037	3.94	0.69	-1.39150	0.4	-1.39090	0.4	-1.39080	0.4	-4.64170	0.0	-1.390	0.4
2038	3.92	0.69	-1.32540	0.4	1.37710	0.4	1.52180	0.4	-4.86700	0.3	-1.410	0.4
2039	3.90	0.69	-1.35900	0.4	1.37720	0.4	1.50080	0.4	-4.92200	0.3	-1.440	0.4
2040	3.87	0.68	-1.39290	0.4	1.37650	0.4	1.48010	0.4	-4.98970	0.3	-1.480	0.4
2041	4.13	0.58	3.91250	0.3	2.67450	0.5	3.21130	0.3	-3.49420	0.4	-6.140	0.2
2042	4.12	0.58	2.81910	0.3	2.54790	0.5	2.87290	0.4	-3.36770	0.4	-1.580	0.3
2043	4.11	0.58	1.92200	0.3	2.58490	0.5	3.23970	0.4	-3.44750	0.4	-2.600	0.3
2044	4.11	0.58	4.23650	0.2	2.18460	0.5	8.24760	0.4	-2.99110	0.4	-3.600	0.3
2045	4.10	0.58	-1.36930	0.3	1.62040	0.5	1.46590	0.5	-2.31920	0.4	-4.400	0.3
2046	4.09	0.57	-3.19920	0.3	1.00700	0.5	2.13270	0.5	-1.54320	0.4	-5.440	0.3
2047	4.08	0.57	-3.82650	0.3	9.61790	0.4	2.19070	0.5	-1.50400	0.4	-6.030	0.3
2048	4.07	0.57	-5.36850	0.3	4.32860	0.4	2.75810	0.5	-8.11330	0.3	-6.660	0.3
2049	4.06	0.57	-6.56260	0.3	7.22160	0.3	3.14370	0.5	-3.30320	0.3	-7.210	0.3
2050	4.05	0.57	-7.23330	0.3	-1.05170	0.2	3.23000	0.5	-2.34960	0.3	-7.740	0.3
2051	4.04	0.57	-7.73690	0.3	5.31840	0.2	3.23500	0.5	-2.40850	0.3	-8.240	0.3
2052	4.04	0.57	-8.11190	0.3	9.02370	0.3	3.14620	0.5	-3.53660	0.3	-8.750	0.3
2053	4.03	0.57	-8.03730	0.3	4.39680	0.4	2.79410	0.5	-8.28770	0.3	-9.310	0.3
2054	4.02	0.56	-7.59200	0.3	9.85510	0.4	2.23420	0.5	-1.59230	0.4	-9.930	0.3
2055	4.01	0.56	-7.89990	0.3	1.09610	0.5	2.13660	0.5	-1.76740	0.4	-1.050	0.4
2056	4.00	0.56	-7.07180	0.3	1.76560	0.5	1.46690	0.5	-2.70650	0.4	-1.100	0.4
2057	3.99	0.56	-6.35610	0.3	2.36810	0.5	8.72870	0.4	-3.57160	0.4	-1.150	0.4
2058	3.98	0.56	-5.76600	0.3	2.91090	0.5	3.51210	0.4	-4.36100	0.4	-1.200	0.4
2059	3.97	0.56	-6.38620	0.3	2.97350	0.5	3.18280	0.4	-4.48170	0.4	-1.270	0.4
2060	3.96	0.56	-6.54800	0.3	3.28480	0.5	3.67220	0.3	-4.81960	0.4	-1.330	0.4
2061	3.96	0.56	-1.40030	0.4	-1.39990	0.4	-1.39970	0.4	-7.50130	0.0	-1.400	0.4
2062	3.94	0.55	-1.35720	0.4	1.40290	0.4	1.52380	0.4	-4.00260	0.3	-1.410	0.4
2063	3.92	0.55	-1.38820	0.4	1.40520	0.4	1.50530	0.4	-4.05520	0.3	-1.450	0.4
2064	3.89	0.55	-1.42010	0.4	1.40740	0.4	1.48710	0.4	-4.09690	0.3	-1.480	0.4
2065	4.15	0.44	1.14790	0.3	2.96020	0.5	3.38300	0.4	-1.96960	0.4	-2.750	0.2
2066	4.14	0.43	6.74770	0.2	2.75660	0.5	2.98980	0.4	-2.02800	0.4	-5.370	0.2
2067	4.13	0.43	2.32240	0.2	2.75850	0.5	3.34690	0.4	-2.17870	0.4	-1.290	0.3
2068	4.12	0.43	-5.50620	0.2	2.35010	0.5	7.97590	0.4	-1.95920	0.4	-2.050	0.3
2069	4.11	0.43	-1.55120	0.3	1.70170	0.5	1.49890	0.5	-1.53430	0.4	-2.870	0.3
2070	4.10	0.43	-2.49810	0.3	1.05450	0.5	2.17420	0.5	-1.16070	0.4	-3.730	0.3
2071	4.09	0.43	-3.19920	0.3	1.00380	0.5	2.23140	0.5	-1.24530	0.4	-4.660	0.3
2072	4.09	0.43	-4.30970	0.3	4.47120	0.4	2.79860	0.5	-8.41390	0.3	-5.520	0.3
2073	4.08	0.43	-5.28520	0.3	8.79310	0.3	3.16050	0.5	-5.84080	0.3	-6.350	0.3
2074	4.07	0.43	-5.95390	0.3	6.49310	0.2	3.25440	0.5	-5.37280	0.3	-7.000	0.3
2075	4.06	0.43	-6.56820	0.3	6.08980	0.2	3.26190	0.5	-5.61380	0.3	-7.460	0.3
2076	4.05	0.43	-7.10550	0.3	8.73530	0.3	3.18260	0.5	-6.49920	0.3	-8.280	0.3
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EL.NO.	R	Z	R-STRESS	Z-STRESS	T-STRESS	RZ-STRESS	N-STRESS	S-STRESS	NS-STRESS	F-STRESS	E-STRESS	SHEAR										
2095	4.10	0.29	-2.73830	03	1.01030	05	2.16810	05	-8.62170	03	-3.430	03	1.020	05	-1.320	03	3.180	05	3.590	00	-3.270	03
2096	4.09	0.29	-3.38430	03	5.10650	04	2.72680	05	-6.36420	03	-4.010	03	5.170	04	-2.510	03	3.240	05	3.520	00	-2.720	03
2097	4.09	0.29	-4.11610	03	1.10130	04	3.17850	05	-6.32650	03	-4.640	03	1.150	04	-3.230	03	3.230	05	3.470	00	-1.410	03
2098	4.08	0.29	-4.89590	03	7.22503	03	3.22550	05	-4.34720	03	-5.450	03	7.770	03	-3.460	03	3.300	05	3.470	00	-1.180	03
2099	4.07	0.28	-5.68680	03	7.20240	03	3.23220	05	-4.62960	03	-6.270	03	7.780	03	-3.690	03	3.310	05	3.480	00	-1.180	03
2100	4.06	0.28	-6.49090	03	1.31390	04	3.17440	05	-5.18620	03	-7.120	03	1.380	04	-3.770	03	3.310	05	3.500	00	-1.560	03
2101	4.05	0.28	-7.27660	03	5.13430	04	2.75440	05	-7.64480	03	-8.060	03	5.210	04	-3.490	03	3.270	05	3.560	00	-2.850	03
2102	4.04	0.28	-8.01080	03	1.01620	05	2.19620	05	-1.08370	04	-8.990	03	1.030	05	-3.100	03	3.220	05	3.630	00	-3.640	03
2103	4.04	0.28	-8.50130	03	1.63670	05	1.50740	05	-1.59330	04	-9.880	03	1.650	05	-3.800	03	3.160	05	3.730	00	-3.870	03
2104	4.03	0.28	-9.16570	03	1.69480	05	1.45390	05	-1.67620	04	-1.060	04	1.710	05	-4.170	03	3.160	05	3.750	00	-3.770	03
2105	4.02	0.28	-9.85860	03	2.28403	05	8.04190	04	-2.00160	04	-1.150	04	2.300	05	-3.240	03	3.100	05	3.840	00	-3.240	03
2106	4.01	0.28	-1.05930	04	2.70320	05	3.38670	04	-2.20190	04	-1.230	04	2.720	05	-2.260	03	3.060	05	3.910	00	-2.360	03
2107	4.00	0.28	-1.13160	04	2.95970	05	4.72410	03	-2.32970	04	-1.310	04	2.980	05	-1.690	03	3.020	05	3.950	00	-9.460	02
2108	3.99	0.28	-1.21360	04	2.96680	05	3.47770	03	-2.27080	04	-1.380	04	2.980	05	-9.970	02	3.020	05	3.970	00	-8.420	02
2109	3.99	0.28	-1.38540	04	-1.38480	04	-1.38470	04	-9.04920	00	-1.390	04	-1.380	04	-8.570	00	2.580	05	3.980	00	-2.850	02
2110	3.97	0.28	-1.38660	04	1.47780	04	1.54540	04	-2.09760	03	-1.400	04	1.490	04	-8.390	01	2.870	05	4.020	00	1.220	02
2111	3.95	0.28	-1.42690	04	1.44310	04	1.52690	04	-2.11100	03	-1.440	04	1.460	04	-9.330	01	2.870	05	4.090	00	1.620	02
2112	3.92	0.27	-1.46780	04	1.40910	04	1.50860	04	-2.09970	03	-1.480	04	1.420	04	-7.730	01	2.860	05	4.160	00	2.020	02
2113	4.16	0.15	-1.55520	02	3.22710	05	3.57610	03	-8.99700	03	-3.900	02	3.230	05	-2.290	03	3.270	05	3.810	00	-1.740	01
2114	4.15	0.14	-4.70820	02	3.19240	05	4.84430	03	-9.18740	03	-7.220	02	3.190	05	-1.990	03	3.240	05	3.820	00	-9.920	01
2115	4.14	0.14	-8.40970	02	2.91103	05	3.10530	04	-8.84080	03	-1.100	03	2.910	05	-1.360	03	3.220	05	3.820	00	-4.510	02
2116	4.13	0.14	-1.28230	03	2.40313	05	8.13080	04	-7.84400	03	-1.540	03	2.410	05	-6.010	02	3.220	05	3.810	00	-9.670	02
2117	4.12	0.14	-1.82850	03	1.76830	05	1.46120	05	-6.24030	03	-2.050	03	1.770	05	-6.180	00	3.230	05	3.780	00	-1.430	03
2118	4.12	0.14	-2.40860	03	1.76110	05	1.46060	05	-6.24190	03	-2.630	03	1.760	05	-2.640	-01	3.220	05	3.770	00	-1.720	03
2119	4.11	0.14	-3.15620	03	1.10430	05	2.14740	05	-4.63070	03	-3.340	03	1.110	05	-6.580	02	3.250	05	3.730	00	-1.900	03
2120	4.10	0.14	-3.98610	03	4.88990	04	2.79880	05	-2.86240	03	-4.120	03	4.900	04	-1.010	03	3.290	05	3.670	00	-1.610	03
2121	4.09	0.14	-4.83590	03	1.17330	04	3.20550	05	-1.69610	03	-4.930	03	1.180	04	-1.110	03	3.320	05	3.630	00	-9.290	02
2122	4.08	0.14	-5.63670	03	9.57630	03	3.22920	05	-1.70950	03	-5.740	03	9.680	03	-1.170	03	3.330	05	3.620	00	-9.360	02
2123	4.08	0.14	-6.42660	03	9.55430	03	3.23550	05	-1.85570	03	-6.540	03	9.660	03	-1.290	03	3.330	05	3.600	00	-1.030	03
2124	4.07	0.14	-7.21150	03	1.38620	04	3.20010	05	-2.02720	03	-7.330	03	1.400	04	-1.290	03	3.340	05	3.590	00	-1.330	03
2125	4.06	0.14	-7.95460	03	5.26290	04	2.77810	05	-3.24540	03	-8.110	03	5.280	04	-1.120	03	3.300	05	3.610	00	-2.630	03
2126	4.05	0.14	-8.66430	03	1.08450	05	2.15810	05	-5.21500	03	-8.890	03	1.090	05	-1.120	03	3.240	05	3.670	00	-3.620	03
2127	4.04	0.14	-9.39370	03	1.65540	05	1.51740	05	-7.07020	03	-9.670	03	1.660	05	-5.520	02	3.170	05	3.750	00	-4.050	03
2128	4.03	0.14	-1.02390	04	1.70080	05	1.45880	05	-7.20340	03	-1.050	04	1.700	05	-8.970	02	3.160	05	3.750	00	-4.310	03
2129	4.03	0.14	-1.09910	04	2.26603	05	8.02550	04	-9.15660	03	-1.130	04	2.270	05	-8.480	02	3.070	05	3.850	00	-3.980	03
2130	4.02	0.14	-1.17240	04	2.65810	05	3.36310	04	-1.04400	04	-1.210	04	2.660	05	-7.350	02	3.000	05	3.920	00	-2.990	03
2131	4.01	0.14	-1.24550	04	2.89110	05	4.67270	03	-1.09900	04	-1.290	04	2.900	05	-4.450	02	2.940	05	3.980	00	-1.240	03
2132	4.00	0.14	-1.31940	04	2.88510	05	3.43220	03	-1.06160	04	-1.360	04	2.890	05	-6.730	01	2.920	05	3.990	00	-1.120	03
2133	3.99	0.14	-1.38240	04	-1.38170	04	-1.38160	04	-5.30270	00	-1.380	04	-1.380	04	-5.030	00	2.540	05	4.010	00	3.580	02
2134	3.98	0.14	-1.40080	04	1.49410	04	1.54810	04	-1.02610	03	-1.400	04	1.500	04	-1.390	01	2.900	05	4.050	00	1.190	02
2135	3.95	0.14	-1.43860	04	1.45303	04	1.53390	04	-1.03180	03	-1.440	04	1.460	04	-2.080	01	2.860	05	4.120	00	1.830	02
2136	3.93	0.14	-1.47720	04	1.41160	04	1.51920	04	-1.02160	03	-1.480	04	1.420	04	-1.150	01	2.830	05	4.190	00	2.490	02
2137	4.16	0.04	-8.76760	01	3.31410	05	3.63370	03	-1.91490	03	-9.590	01	3.310	05	9.780	02	3.350	05	3.820	00	1.540	02
2138	4.15	0.04	-6.62400	02	3.25890	05	4.90510	03	-2.29660	03	-6.780	02	3.260	05	5.530	02	3.310	05	3.830	00	4.670	01
2139	4.14	0.04	-1.27260	03	2.96103	05	3.13660	04	-2.36280	03	-1.290	03	2.960	05	2.320	02	3.280	05	3.840	00	-1.610	02
2140	4.14	0.04	-1.92840	03	2.43830	05	8.19670	04	-2.18040	03	-1.950	03	2.440	05	-3.550	01	3.260	05	3.830	00	-5.870	02
2141	4.13	0.04	-2.62350	03	1.73430	05	1.52780	05	-1.65970	03	-2.640	03	1.730	05	-1.230	02	3.260	05	3.810	00	-1.040	03
2142	4.12	0.04	-3.31740	03	1.78019	05	1.46860	05	-1.62530	03	-3.330	03	1.780	05	-4.270	01	3.250	05	3.800	00	-1.400	03
2143	4.11	0.04	-4.01380	03	1.11360	05	2.15600	05	-1.16500	03	-4.030	03	1.110	05	-1.580	02	3.270	05	3.760	00	-1.680	03
2144	4.10	0.04	-4.73450	03	4.92650	04	2.80750	05	-7.48510	02	-4.740	03	4.930	04	-2.770	02	3.300	05	3.700	00	-1.510	03
2145	4.09	0.04	-5.47410	03	1.18690	04	3.21470	05	-5.02570	02	-5.480	03	1.190	04	-3.510	02	3.330	05	3.650	00	-9.030	02
2146	4.09	0.04	-6.22380	03	1.18490	04	3.22080	05	-5.48470	02	-6.230	03	1.190	04	-3.910	02	3.340	05	3.630	00	-1.010	03
2147	4.08	0.04	-6.99640	03	1.18290	04	3.22690	05	-6.48690	02	-7.010	03	1.180	04	-4.840	02	3.340	05	3.610	00	-1.120	03
2148	4.07	0.04	-7.79120	03	1.18130	04	3.23310	05	-6.39510	02	-7.800	03	1.180	04	-4.680	02	3.350	05	3.600	00	-1.220	03
2149	4.06	0.04	-8.58090	03	5.29220	04	2.78590	05	-8.93880	02	-8.590	03	5.290	04	-3.570	02	3.310	05	3.630	00	-2.640	03
2150	4.05	0.04	-9.34930	03	1.08860	05	2.16360	05	-1.29880	03	-9.360	03	1.090	05	-2.660	02	3.250	05	3.680	00	-3.680	03
2151	4.04	0.04	-1.00970	04	1.65790	05	1.52010	05	-1.76990	03	-1.010	04	1.660	05	-2.350	02	3.180	05	3.750	00	-4.190	03
2152	4.04	0.04	-1.08220	04	1.70110	05	1.46060	05	-1.82200	03	-1.080	04	1.700	05	-2.430	02	3.160	05	3.760	00	-4.520	03
2153	4.03	0.04	-1.15480	04																		

Distribution**Energy Research and Development
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