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**FLX: A Shell Code for Coupled Fluid-Structure
Analysis of Core Barrel Dynamics**

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FLX: A SHELL CODE FOR COUPLED FLUID-STRUCTURE ANALYSIS OF CORE BARREL DYNAMICS

by

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ABSTRACT

The coupled fluid-structure dynamics of a light water reactor core support barrel can be calculated by the K-FIX(3D,FLX) and SOLA-FLX codes. The fluid dynamics is described by the three-dimensional, two-fluid code K-FIX(3D) or the two-dimensional, drift-flux code SOLA-DF. The structural dynamics is described by the three-dimensional, elastic shell code FLX. FLX, which uses an explicit finite-difference solution algorithm to solve the shell equations, is explicitly coupled to the fluid-dynamics codes. Motion may be induced by blowdown, prescribed displacement, or seismic action. A sample calculation is provided for verification.

I. INTRODUCTION

Many engineering problems involve the coupled dynamics of fluid and solid materials. Considerable theory has been developed for such problems where the coupling is weak or the fluid behavior can be simply represented.¹ However, for strongly coupled fluid-structure systems, relatively few tools are available with which to make any kind of theoretical analysis.

The nuclear power industry provides various complicated fluid-structure interactions that must be understood in detail. For example, for a postulated break of a cold water pipe (LOCA) in a pressurized water reactor, large pressure transients are transmitted to the internal structures of the reactor pressure vessel. The most critical internal structures are the fuel rod bundles, which are surrounded by a cylindrical core support barrel. The barrel is separated from the pressure vessel wall by a relatively narrow annulus through which depressurization waves must pass. Because the annulus is narrow, any motion of the core support barrel produces large relative volume changes in the annulus and, hence, generates large pressure responses in the fluid located in the annulus. This, then, is a strongly coupled fluid-structure problem.^{2,3} It is also a problem of practical importance because the integrity of the fuel rod bundles must be maintained to control a reactor should a LOCA-type accident occur.

Section II presents a finite-difference numerical model suitable for describing the dynamics of a core barrel. The model is contained in the FLX code, which is listed in the Appendix. FLX was

coupled to two different algorithms for computing the dynamic behavior of two-phase fluid mixtures. In one case, FLX was coupled to a three-dimensional version of the K-FIX code,⁴ which treats a two-phase fluid mixture using a complete set of conservation equations for each phase. The combined code is referred to as K-FIX(3D,FLX). In the second case, FLX was coupled to the two-dimensional SOLA-DF code.⁵ Because SOLA-DF approximates a two-phase mixture with a reduced set of conservation equations, it is not as general as the K-FIX code. The coupled SOLA-DF and FLX codes are referred to as SOLA-FLX. The coupling procedures for both cases are described in Sec. III.

Although several test problems have been investigated with the coupled codes, their comprehensive test—to predict accurately the dynamics of a core support barrel under accident conditions—must be provided by comparisons with experimental data. The large-scale Heisdampfreaktor (HDR) tests^{6,7} by Kernforschungszentrum, Karlsruhe, Germany, offer an ideal opportunity for checking both theoretical and numerical models. Section IV describes the specific boundary conditions and other special considerations needed to represent accurately the HDR system. Sections V and VI contain an input data description and a sample HDR calculation performed with the K-FIX(3D, FLX) code. The sample calculation corresponds to a typical "snapback" test, in which the lower end of the core barrel is displaced to an equilibrium configuration and suddenly released. To verify implementation of the code at other facilities, we have provided listings of the computed results.

II. DESCRIPTION OF FLX CODE

A. Three-Dimensional, Linear-Elastic, Shell Equations

FLX solves the three-dimensional, linear-elastic, shell equations⁸

$$\begin{aligned} \rho h \ddot{U} &= N_{\phi}^0 + N_{\phi z}^1 - M_{\phi}^0/a + M_{z\phi}^1/a + \rho h(\ddot{x} \sin \phi - \ddot{y} \cos \phi) \quad , \\ \rho h \ddot{V} &= N_z^1 + N_{\phi z}^0 - \rho h \ddot{z} \quad , \end{aligned}$$

and

$$\rho h \ddot{W} = q - M_z'' + 2M_{z\phi}^0' - M_{\phi}^{00} - N_{\phi}/a - \rho h(\ddot{x} \cos \phi + \ddot{y} \sin \phi) \quad , \quad (2.1)$$

where

$$\begin{aligned} N_z &= C(V^1 + \nu U^0 + \nu W/a) \quad , \\ N_{\phi} &= C(U^0 + W/a + \nu V^1) \quad , \\ N_{\phi z} &= C(1 - \nu)(V^0 + U^1)/2 \quad , \\ M_z &= D(W'' + \nu W^{00} - \nu U^0/a) \quad , \\ M_{\phi} &= D(W^{00} + \nu W'' - U^0/a) \quad , \\ M_{z\phi} &= -D(1 - \nu)(W^{01} - U^1/a) \quad , \end{aligned} \quad (2.2)$$

and

$$C = Eh/(1 - \nu^2) \quad , \quad D = Eh^3/12(1 - \nu^2) \quad . \quad (2.3)$$

In these equations, U , V , and W are the circumferential, axial, and radial displacements, respectively; ρ is density; h is thickness; a is middle surface radius; ν is Poisson's ratio; q is differential pressure between the inside and outside of the core barrel (pressure inside minus pressure outside); and E is Young's modulus. The superscripts prime, zero, and dot denote differentiation with respect to the axial coordinate z , the circumferential coordinate $a\phi$, and time t , respectively. The \ddot{x} and \ddot{y} terms describe two horizontal acceleration components, and the \ddot{z} term describes the vertical component of a seismic disturbance. The \ddot{x} component lies in the $\phi = 0^\circ$ plane and the \ddot{y} component lies in the $\phi = 90^\circ$ plane. Both are positive outward in their respective planes. The vertical component \ddot{z} is positive upward. The coordinate directions coincide with those used to describe the three-dimensional fluid dynamics; that is, the positive directions are counter-clockwise, upward, and radially outward.

The accelerations \ddot{U} , \ddot{V} , and \ddot{W} in Eq. (2.1) determine the new velocity and displacement fields from the kinematic relations

$$\begin{aligned} \dot{U} &= \int \ddot{U} dt \quad , \quad U = \int \dot{U} dt \quad , \\ \dot{V} &= \int \ddot{V} dt \quad , \quad V = \int \dot{V} dt \quad , \end{aligned}$$

and

$$\dot{W} = \int \ddot{W} dt \quad , \quad W = \int \dot{W} dt \quad . \quad (2.4)$$

B. Stress Relations

Stresses are determined from the forces and moments per unit length in Eq. (2.2) as

$$\begin{aligned} \sigma_{zm} &= N_z/h \quad , \quad \sigma_{zb} = 6M_z/h^2 \quad , \\ \sigma_{\phi m} &= N_\phi/h \quad , \quad \sigma_{\phi b} = 6M_\phi/h^2 \quad , \end{aligned}$$

and

$$\sigma_{\phi zm} = N_{\phi z}/h \quad , \quad \sigma_{z\phi b} = 6M_{z\phi}/h^2 \quad . \quad (2.5)$$

The stresses with m subscripts are membrane stresses. These represent average stress values across the shell thickness, in accordance with the definitions.

$$N_z \equiv \int_{-h/2}^{h/2} \sigma_z(\eta, z, \phi) d\eta \quad ,$$

$$N_\phi \equiv \int_{-h/2}^{h/2} \sigma_\phi(\eta, z, \phi) d\eta \quad ,$$

and

$$N_{\phi z} \equiv \int_{-h/2}^{h/2} \tau_{\phi z}(\eta, z, \phi) d\eta \quad ,$$

where σ_z , σ_ϕ , and $\tau_{\phi z}$ are local tensile and shear stresses. The stresses with b subscripts are bending stresses and provide information on the antisymmetric character of the stresses σ_z , σ_ϕ , and $\tau_{\phi z}$ through the definitions

$$M_z \equiv \int_{-h/2}^{h/2} \eta \sigma_z(\eta, z, \phi) d\eta ,$$

$$M_\phi \equiv \int_{-h/2}^{h/2} \eta \sigma_\phi(\eta, z, \phi) d\eta ,$$

and

$$M_{z\phi} \equiv - \int_{-h/2}^{h/2} \eta \tau_{\phi z}(\eta, z, \phi) d\eta .$$

If, for example, we write the antisymmetric part of σ_z as $\sigma_z = 2\eta\sigma_{zb}/h$, we obtain from the definition of M_z that $\sigma_{zb} = 6M_z/h^2$, as given in Eq. (2.5). The total stress at any position across the core barrel thickness is the sum of the membrane and bending stresses.

C. Boundary Conditions

The top of the core barrel is modeled mathematically as a clamped or built-in boundary on which we require (see Ref. 8, pp. 89-99) that

$$U = V = W = W' = 0 . \quad (2.6)$$

The bottom of the core barrel is a free boundary on which forces and moments vanish. This boundary condition is described mathematically by

$$N_z = N_{\phi z} = M_z = 0 ,$$

and

$$M_z' - 2M_{z\phi}^0 = 0 . \quad (2.7)$$

Equation (2.7) reduces to the classical Kirchhoff boundary conditions for the free edge of a plate where N_z and $N_{\phi z}$ are identically zero and only lateral deflections (W displacements) are considered.

D. Numerical Solution Procedure

The shell equations, Eqs. (2.1)-(2.4), are solved numerically by explicitly integrating a system of finite-difference equations. The middle surface of radius a is divided into many computational cells that collectively form the computing mesh. The circumferential dimension of each cell $\delta s = a\delta\phi$ is constant, but the axial dimension δz can vary from one row of cells to the next. Figure 1 shows that the quantities W , N_z , N_ϕ , M_z , and M_ϕ are located at the cell center, U is located at the

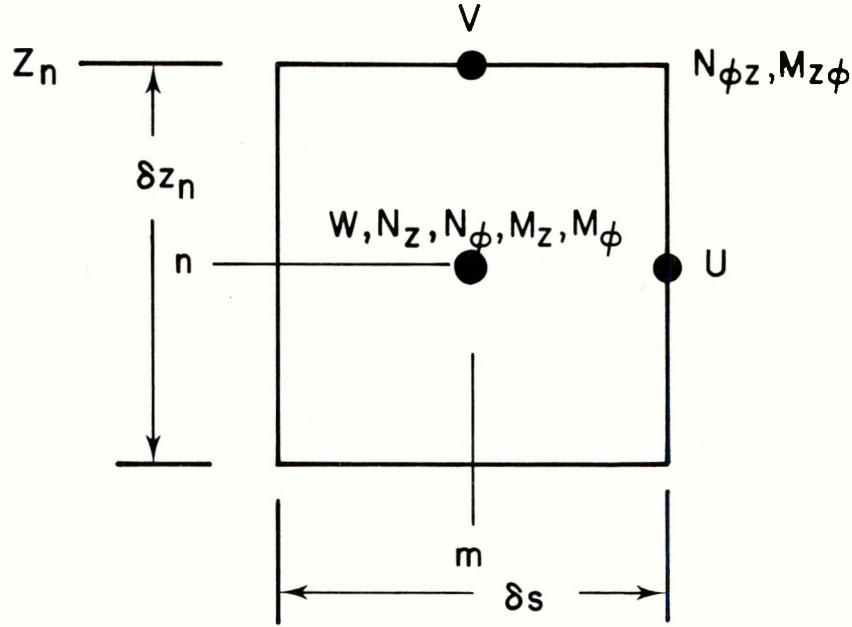


Fig. 1.
Locations of variables for computational cell (m,n) .

center of the right boundary, V is located at the center of the top boundary, and $N_{\phi z}$ and $M_{z\phi}$ are located at the upper right corner.

The finite-difference calculation begins by computing the forces and moments per unit length from the following finite-difference approximations to Eq. (2.2).

$$(N_z)_{m,n} = C \left[(v_{m,n} - v_{m,n-1})/\delta z_n + \nu (u_{m,n} - u_{m-1,n})/\delta s + \nu w_{m,n}/a \right] ,$$

$$(N_\phi)_{m,n} = -C \left[(u_{m,n} - u_{m-1,n})/\delta s + w_{m,n}/a + \nu (v_{m,n} - v_{m,n-1})/\delta z_n \right] ,$$

$$(N_{\phi z})_{m+\frac{1}{2},n+\frac{1}{2}} = C(1-\nu) \left[(v_{m+1,n} - v_{m,n})/2\delta s + (u_{m,n+1} - u_{m,n})/(\delta z_n + \delta z_{n+1}) \right] ,$$

$$(M_z)_{m,n} = D \left\{ 2 \left[(w_{m,n+1} - w_{m,n})/(\delta z_n + \delta z_{n+1}) - (w_{m,n} - w_{m,n-1})/(\delta z_n + \delta z_{n-1}) \right] / \delta z_n + \nu (w_{m+1,n} - 2w_{m,n} + w_{m-1,n})/\delta s^2 - \nu (u_{m,n} - u_{m-1,n})/a\delta s \right\} ,$$

$$(M_\phi)_{m,n} = D \left\{ (w_{m+1,n} - 2w_{m,n} + w_{m-1,n})/\delta s^2 + 2\nu \left[(w_{m,n+1} - w_{m,n})/(\delta z_n + \delta z_{n+1}) - (w_{m,n} - w_{m,n-1})/(\delta z_n + \delta z_{n-1}) \right] / \delta z_n - (u_{m,n} - u_{m-1,n})/a\delta s \right\} ,$$

$$(M_{z\phi})_{m+\frac{1}{2},n+\frac{1}{2}} = -2D(1-\nu) \left\{ (w_{m+1,n+1} - w_{m,n+1})/\delta s - (w_{m+1,n} - w_{m,n})/\delta s - (u_{m,n+1} - u_{m,n})/a \right\} / (\delta z_n + \delta z_{n+1}) .$$

All the displacements in these expressions are known from the solution at the previous cycle. Accelerations are computed from the following finite-difference approximations to Eq. (2.1).

$$\begin{aligned}
\ddot{U}_{m,n} &= (1/\rho h) \left\{ \left[(N_\phi)_{m+1,n} - (N_\phi)_{m,n} \right] / \delta s + \left[(N_{\phi z})_{m,n} - (N_{\phi z})_{m,n-1} \right] / \delta z_n \right. \\
&\quad \left. - \left[(M_\phi)_{m+1,n} - (M_\phi)_{m,n} \right] / a \delta s + \left[(M_{z\phi})_{m,n} - (M_{z\phi})_{m,n-1} \right] / a \delta z_n \right\} \\
&\quad + \ddot{x} \sin \phi - \ddot{y} \cos \phi \quad , \\
\ddot{V}_{m,n} &= (1/\rho h) \left\{ 2 \left[(N_z)_{m,n+1} - (N_z)_{m,n} \right] / (\delta z_n + \delta z_{n+1}) + \left[(N_{\phi z})_{m,n} \right. \right. \\
&\quad \left. \left. - (N_{\phi z})_{m-1,n} \right] / \delta s \right\} - \ddot{z} \quad , \\
\ddot{W}_{m,n} &= (1/\rho h) \left(q_{m,n} - 2 \left\{ \left[(M_z)_{m,n+1} - (M_z)_{m,n} \right] / (\delta z_n + \delta z_{n+1}) \right. \right. \\
&\quad \left. \left. - \left[(M_z)_{m,n} - (M_z)_{m,n-1} \right] / (\delta z_n + \delta z_{n-1}) \right\} / \delta z_n + 2 \left\{ \left[(M_{z\phi})_{m,n} \right. \right. \right. \\
&\quad \left. \left. - (M_{z\phi})_{m-1,n} \right] / \delta s - \left[(M_{z\phi})_{m,n-1} - (M_{z\phi})_{m-1,n-1} \right] / \delta s \right\} / \delta z_n - \left[(M_\phi)_{m+1,n} \right. \\
&\quad \left. - 2(M_\phi)_{m,n} + (M_\phi)_{m-1,n} \right] / \delta s^2 - (N_\phi)_{m,n} / a \quad - \ddot{x} \cos \phi - \ddot{y} \sin \phi \quad . \tag{2.8}
\end{aligned}$$

New velocities and then new displacements are computed from the kinematic relations in Eq. (2.4) as

$$\dot{U}_{m,n} = \dot{U}_{m,n} + \delta t_s \ddot{U}_{m,n} \quad , \quad U_{m,n} = U_{m,n} + \delta t_s \dot{U}_{m,n} \quad ,$$

$$\dot{V}_{m,n} = \dot{V}_{m,n} + \delta t_s \ddot{V}_{m,n} \quad , \quad V_{m,n} = V_{m,n} + \delta t_s \dot{V}_{m,n} \quad ,$$

and

$$\dot{W}_{m,n} = \dot{W}_{m,n} + \delta t_s \ddot{W}_{m,n} \quad , \quad W_{m,n} = W_{m,n} + \delta t_s \dot{W}_{m,n} \quad ,$$

where δt_s is the integration time step for the shell equations.

To enforce the boundary conditions in Eq. (2.6) in the computing mesh, we set

$$U_{m,NB2} = -U_{m,NB1} \quad ,$$

$$V_{m,NB1} = 0 \quad ,$$

and

$$W_{m,NB1} = W_{m,NB2} = 0 \quad , \quad (2.9)$$

where $n = NB1$ refers to the row of cells around the top of the core barrel and $n = NB2$ refers to the row of cells above $NB1$, which are fictitious and used only for setting boundary conditions. Such fictitious cells surround the entire perimeter of the mesh. Equation (2.9) reflects our choice of $\delta z_{NB2} = \delta z_{NB1}$ in that the value of U at the core barrel top, obtained by arithmetic average, is zero.

The first three conditions in Eq. (2.7) are enforced in the computing mesh by setting the U , V , and W displacements in the fictitious row $n = 1$ below the core barrel bottom. From the condition that $N_z = 0$, we obtain

$$V_{m,1} = V_{m,2} + \delta z_2 \nu \left[(U_{m,2} - U_{m-1,2})/\delta s + W_{m,2}/a \right] \quad , \quad (2.10)$$

from $N_{\phi z} = 0$, we obtain

$$U_{m,1} = U_{m,2} + \delta z_2 (V_{m+1,1} - V_{m,1})/\delta s \quad , \quad (2.11)$$

and from $M_z = 0$, we obtain

$$\begin{aligned} W_{m,1} = & W_{m,2} - 2\delta z_2 (W_{m,3} - W_{m,2})/(\delta z_2 + \delta z_3) \\ & - \nu (\delta z_2)^2 \left[(W_{m+1,2} - 2W_{m,2} + W_{m-1,2})/(\delta s)^2 \right. \\ & \left. - (U_{m,2} - U_{m-1,2})/a\delta s \right] \quad . \end{aligned} \quad (2.12)$$

Equations (2.10)-(2.12) reflect our choice of $\delta z_1 = \delta z_2$, which simplifies the equations. The final condition in Eq. (2.7) is satisfied by specifying $(M_z)_{m,1}$ through the relation

$$(M_z)_{m,1} = -2\delta z_2 \left[(M_{z\phi})_{m,1} - (M_{z\phi})_{m-1,1} \right] / \delta s \quad (2.13)$$

where we used $(M_z)_{m,2} = 0$. We evaluate $M_{z\phi}$ at $n = 1$ using the displacements determined by Eqs. (2.11) and (2.12).

The maximum value of δt_s is determined from a linear stability analysis, the results of which are expressed by the inequality conditions

$$\begin{aligned} \delta t_s & < \delta z \left\{ \rho(1 - \nu^2)/E \left[1 - \nu + 2(\delta z/\delta s)^2 \right] \right\}^{1/2} \quad , \\ \delta t_s & < \delta z \left\{ \rho(1 - \nu^2)/E \left[2 + (1 - \nu)(\delta z/\delta s)^2 \right] \right\}^{1/2} \quad , \end{aligned} \quad (2.14)$$

and a third condition that depends on the treatment of the bottom mass ring that is used in conjunction with the HDR tests, which are discussed in Sec. IV.A. The first condition is derived for the circumferential acceleration equation and the second, for the axial acceleration equation. Stability of the radial acceleration equation is controlled by the stiffness of the bottom mass ring.

III. FLUID-STRUCTURE COUPLING

The fluid and structure codes are coupled together explicitly. For each calculation cycle, we use the fluid pressure field to determine the differential pressure array that drives the shell motion through the radial acceleration equation. The shell equations often are integrated several time steps per fluid time step because of their more restrictive stability criteria. After integration, through a fluid time step, the shell radial motion is assigned as a boundary condition to the fluid.

In FLX, the subroutine FLXFTOS couples the fluid to the structure by calculating the differential pressure array. Conversely, the subroutine FLXSTOF couples the structure to the fluid by assigning the shell radial motion to the fluid. These coupling routines are the communication links between FLX and any fluid-dynamics code. The explicit coupling procedure is stable for a compressible fluid when the fluid time step δt satisfies the criterion

$$\delta t < 2 \left(r_I \delta r_I \rho_l h/a \rho_l \right)^{1/2} / C_l \quad ,$$

where r_I is the radius to the center of the downcomer gap, δr_I is the gap width, and ρ_l and C_l are the liquid density and sound speed, respectively.

A. Coupling with K-FIX(3D)

Pressure differences across the core barrel are computed at the axial and circumferential locations of the fluid cell centers. Linear interpolation between values at these locations is used to obtain values at the locations of the structure cell centers. The reverse of this interpolation is used to transfer the radial velocity components of the structure to the radial velocity component array for the fluid. The core barrel motion causes a fractional change in volume $\delta \text{VOL}/\text{VOL}$ for the fluid cells adjacent to the core barrel and a corresponding density change

$$\delta \rho_l = - \rho_l \delta \text{VOL}/\text{VOL} \quad .$$

With a single cell across the downcomer gap, the density in the downcomer cells changes according to

$$\begin{aligned} (\delta \rho_l)_{I,j,k} = & - \delta t \left[\langle \rho_l v_l \rangle_{I,j,k} / \delta z + \langle \rho_l w_l \rangle_{I,j,k} / (r_I \delta \theta) \right] \\ & + \delta t (\rho_l)_{I,j,k} (u_l)_{I-\frac{1}{2},j,k} r_{I-\frac{1}{2}} / (r_I \delta r) \quad , \end{aligned}$$

where I is the radial index of cells in the downcomer gap; j and k are the axial (z) and circumferential (θ) indexes, respectively; $\langle \rho_l v_l \rangle$ and $\langle \rho_l w_l \rangle$ are the mass fluxes in the axial and circumferential directions, respectively; and u_l , v_l , and w_l are the radial, axial, and circumferential velocities of the fluid, respectively. The last term accounts for the effect of

volume change where $r_{I-1/2}$ is the radial coordinate of the cell's inner boundary, which coincides with the outer boundary of the core barrel. Also, the last term has the form of a radial flux term for donor cell differencing, except that the density used does not depend on the algebraic sign of $(u_\ell)_{I-1/2,j,k}$. The flux on the cell's outer boundary is zero because the vessel is considered rigid. A similar expression describes the density change for cells $(I-1,j,k)$ in the core region adjacent to the core barrel. For these cells

$$\begin{aligned}
(\delta\rho_\ell)_{I-1,j,k} = & -\delta t \left[\langle \rho_\ell v_\ell \rangle_{I-1,j,k} / \delta z + \langle \rho_\ell w_\ell \rangle_{I-1,j,k} / (r_{I-1} \delta\theta) \right] \\
& - \delta t \left\{ (\rho_\ell)_{I-1,j,k} (u_\ell)_{I-3/2,j,k} r_{I-3/2} - (u_\ell)_{I-3/2,j,k} r_{I-3/2} \right. \\
& \left. [(\rho_\ell)_{I-1,j,k} \text{ or } (\rho_\ell)_{I-2,j,k}] \right\} / r_{I-1} \delta r,
\end{aligned}$$

where, for donor cell differencing, $(\rho_\ell)_{I-1,j,k}$ is used for the radial flux if $(u_\ell)_{I-3/2,j,k}$ is negative and $(\rho_\ell)_{I-2,j,k}$ is used if $(u_\ell)_{I-3/2,j,k}$ is positive. The flux on the outer boundary of this cell uses $(\rho_\ell)_{I-1,j,k}$ to account for the effect of volume change.

Certain momentum fluxes also are modified to account for the moving core barrel. These are the radial fluxes of axial and circumferential momentum for the cells adjacent to the core barrel. The modified fluxes are given by

$$(\rho_\ell u_\ell v_\ell r)_{I-1/2,j+1/2,k} = (\rho_\ell)_{I,j+1/2,k} (u_\ell)_{I-1/2,j+1/2,k} (v_\ell)_{I,j+1/2,k} r_{I-1/2}$$

and

$$(\rho_\ell u_\ell w_\ell r)_{I-1/2,j,k+1/2} = (\rho_\ell)_{I,j,k+1/2} (u_\ell)_{I-1/2,j,k+1/2} (w_\ell)_{I,j,k+1/2} r_{I-1/2},$$

for the cells in the downcomer gap, and by

$$(\rho_\ell u_\ell v_\ell r)_{I-1/2,j+1/2,k} = (\rho_\ell)_{I-1,j+1/2,k} (u_\ell)_{I-1/2,j+1/2,k} (v_\ell)_{I-1,j+1/2,k} r_{I-1/2}$$

and

$$(\rho_\ell u_\ell w_\ell r)_{I-1/2,j,k+1/2} = (\rho_\ell)_{I-1,j,k+1/2} (u_\ell)_{I-1/2,j,k+1/2} (w_\ell)_{I-1,j,k+1/2} r_{I-1/2},$$

for the cells in the core adjacent to the core barrel.

The radial velocity component $(u_\ell)_{I-1/2,j,k}$ is not calculated as part of the fluid solution because it is determined by solution of the shell equations.

The radial fluxes of internal energy density are modified for the moving core barrel in the same manner as the mass fluxes.

This coupling technique has been used successfully with one-, two-, and three-dimensional fluid-dynamic simulations. The results with one-dimensional fluid dynamics that exhibit axial, circumferential, and radial motion separately have been compared with analytic solutions for structure frequency, displacement, and added mass effects.

B. Coupling with SOLA-DF

Although it is basically a two-dimensional code, SOLA-DF can treat two-dimensional regions of variable thickness A. For example, in Cartesian coordinates, a mesh cell of area $\delta x \delta y$ has

volume $A\delta x\delta y$, where A may vary from cell to cell. SOLA-DF assumes A to be time-independent. For fluid-structure coupling, we extend this formulation to account for time-dependent thicknesses as follows.

The two-dimensional region spanned by the SOLA-DF mesh is the annulus between the core support barrel and the pressure vessel wall, with x corresponding to the azimuthal coordinate and y to the axial coordinate. Thickness A corresponds to the annulus gap size and is directly related to the radial motion of the core barrel, that is,

$$A = A_0 - w$$

and

$$\dot{A} = -\dot{w}(r/r_m) \quad , \quad (3.1)$$

where A_0 is the initial annulus thickness, r is the radius to the outer boundary of the core barrel, and r_m is the mean radius of the annulus.

Thickness A appears in the fluid conservation equations in the generic form

$$\frac{\partial \rho A Q}{\partial t} + \nabla \cdot \rho A \underline{u} Q \quad , \quad (3.2)$$

where ρQ is the mass, momentum, or energy density. The operator (3.2) may be written in two forms, after division by A , as

$$\frac{\partial \rho Q}{\partial t} + \frac{1}{A} \nabla \cdot \rho A \underline{u} Q + \frac{\rho Q}{A} \frac{\partial A}{\partial t} \quad (3.2a)$$

or

$$\rho \frac{\partial Q}{\partial t} + \rho \underline{u} \cdot \nabla Q + Q \left[\frac{\partial \rho}{\partial t} + \frac{1}{A} \nabla \cdot \rho A \underline{u} + \frac{\rho}{A} \frac{\partial A}{\partial t} \right] \quad . \quad (3.2b)$$

The bracket term in operator (3.2b) vanishes identically because it is the mass conservation equation ($Q = 1$). Operator (3.2b) is used in SOLA-DF for the momentum equations ($Q = \underline{u}$) and, hence, needs no modification for a time-dependent thickness. The mass conservation and internal energy density equations use the first two terms in operator (3.2a) and, hence, require addition of the third term.

For the present application, \dot{A} is expressed in terms of \dot{W} from Eq. (3.1), but for more general cases it is useful to add an extra array $AN(i,j)$ to retain values of A from the previous computational cycle so that \dot{A} can be approximated directly from the change in A . The new value of A is calculated in subroutine FLXSTOF from the core barrel velocity. Accordingly, in SOLA-FLX, the difference equation for mass conservation is supplemented with the term $\rho(i,j)[A(i,j) - AN(i,j)]/A(i,j)$, and a similar term is added to the energy density equation with ρ replaced by ρI .

IV. APPLICATION TO HDR

To calculate the coupled, fluid-structure dynamics of the HDR core support barrel (Fig. 2), the FLX code contains a special feature to account for the mass and stiffness of the bottom ring. The fluid-dynamics codes K-FIX(3D) and SOLA-DF must be modified to treat the geometry accurately and to include the appropriate equation-of-state properties for water.

The HDR tests are separated into three categories: (1) snapback tests, in which the core barrel is displaced mechanically and then suddenly released to vibrate in either a water- or air-filled vessel; (2) seismic tests, in which the vessel is shaken; and (3) blowdown tests, in which the vessel water flashes to steam through a broken inlet water pipe. The FLX code input data have been specialized to the calculation of these tests.

A. Mass Ring Treatment

The geometry of the HDR bottom mass ring is shown in Fig. 3. The FLX code includes a model of the ring that accounts for its location, mass, and stiffness. The three-dimensional, fluid-dynamics code K-FIX includes a model of the ring volume, which obstructs flow around the bottom of the core barrel. Because the two-dimensional, fluid-dynamics code SOLA-DF treats only the flow in the annular gap between the core barrel and the vessel, no model for ring volume can be included.

The axial location of the mass ring centroid is 7.385 cm above the core barrel bottom. Because the mass ring is modeled by the bottom ($n = 2$) row of cells, we specify $\delta z = 14.77$ cm to place the centroid at the midplane of this row. The mass and stiffness of the ring are modeled by specifying the shell thickness and density in this row. The radial coordinate of the ring centroid R_r and the area moment of inertia about this centroid I_r are 99.38 cm and 3.706×10 cm⁴, respectively. Classical theory⁹ gives the ring stiffness S_r for a diametrically compressed ring as

$$S_r = 7.3 E I_r R_r^{-3} ,$$

for which the above values and $E = 1.95 \times 10^{12}$ dyn/cm² yield $S_r = 5.37 \times 10^{12}$ dyn/cm. In FLX the ring stiffness is modeled by the increased shell thickness h_r , where $R_r = a$ and $I_r = (\delta z_2) h_r^3 / 12$. The h_r value is calculated to match the actual ring stiffness, which yields

$$h_r = A(1.644 S_r / E \delta z_2)^{1/3} .$$

This h_r value is used to calculate the shell stiffness coefficients C and D for the bottom row of cells. To ensure that the correct ring mass is included in FLX, the density ρ_r in the bottom row of cells is calculated as

$$\rho_r = M_r / (2\pi a h_r \delta z_2) ,$$

where M_r is the ring mass.

The stability condition on the structure time step for the radial displacement equation is controlled by the h_r and ρ_r values through the relation

$$\delta t_s \leq (\delta s^2 / h_r) (3\rho_r / 2E)^{1/2} .$$

This condition is generally more restrictive than those in Eq. (2.14).

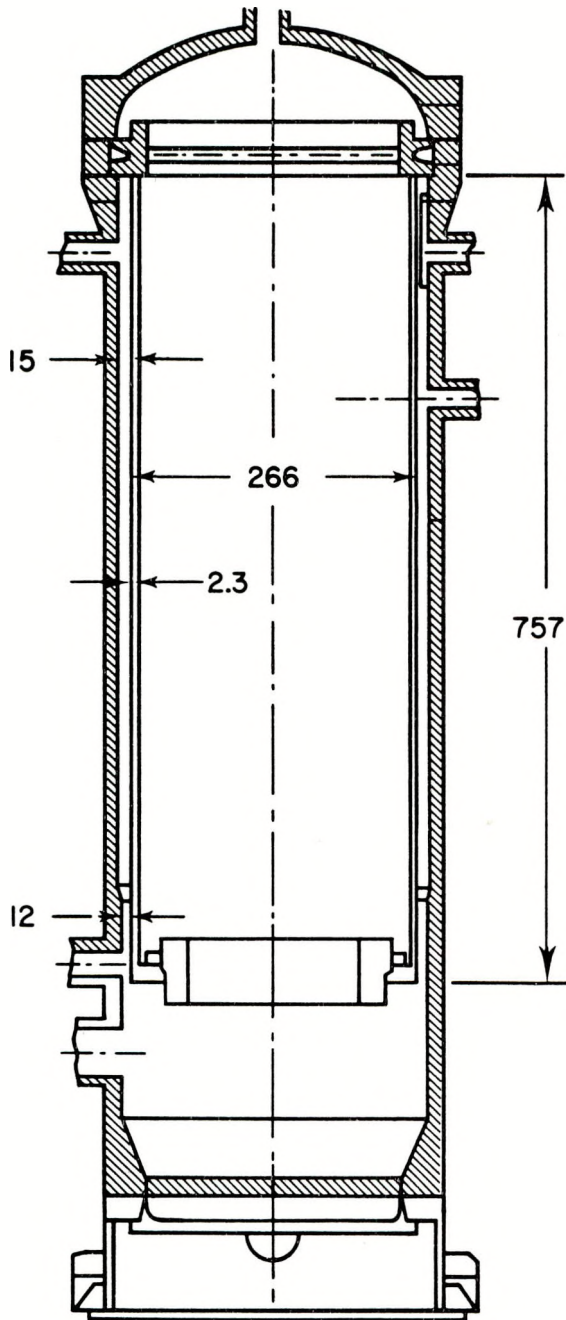


Fig. 2.
Geometry of HDR vessel (dimensions are in centimeters).

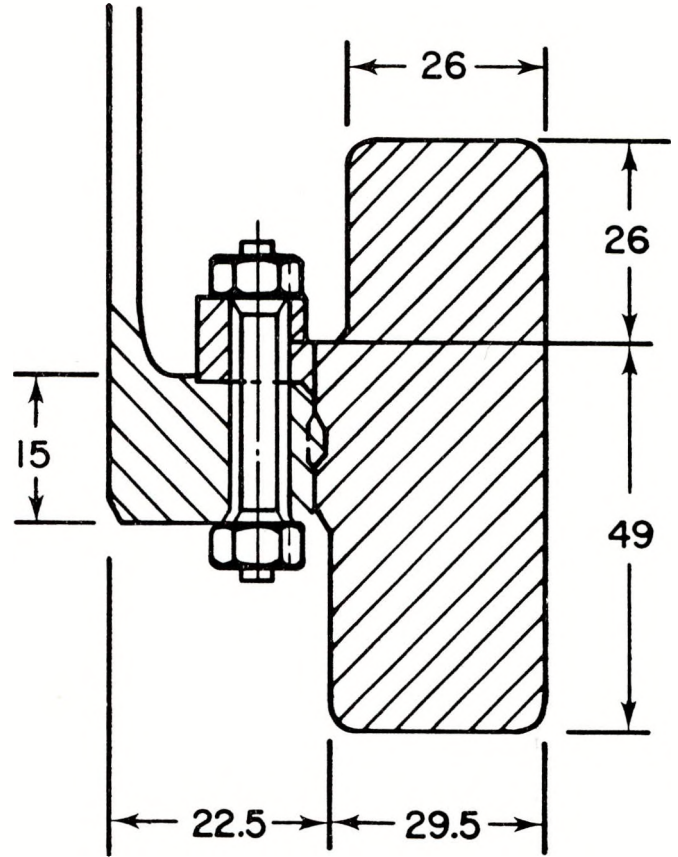


Fig. 3.
Geometry of HDR bottom mass ring (dimensions are in centimeters).

B. Additions to K-FIX(3D)

Here we present the additions to K-FIX that describe the HDR geometry, water properties, effects of seismic-induced accelerations, and fluid-structure coupling. The additions are listed in UPDATE notation with reference to statements contained in the three-dimensional K-FIX code

report (Ref. 4). In UPDATE notation *I,KFIXCC.# means to insert the following statements after statement KFIXCC.#; *D,KFIXCC.# means to delete the statement KFIXCC.#; and *B,KFIXCC.# means to insert the following statements before statement KFIXCC.#. The additions are listed in Table I for each subroutine affected, and the affected subroutines are listed in alphabetical order.

Additions that relate to geometry are made (1) to allow a change in the radial cell dimension to a smaller value in the downcomer gap than in the core and lower plenum regions, (2) to describe the core barrel boundary without the actual use of obstacle cells, and (3) to model the ring volume by an internal obstacle that is one cell instead of the required two cells thick in the radial direction. The affected subroutines are BETAS, SETUP, ULMOMF, VEL5, VLMOMF, and WLMOMF.

The state equation and physical properties of the water and the absence of gas are specified by additions to the subroutines CONVERT, EOSG, EOSL, KDRAGS, RHEATS, SAT, and SETC. A snapback test in air is actually calculated as a test in vacuum by using only the FLX code.

The effects of seismic-induced accelerations on the fluid are included by additions to subroutine TILDE.

The fluid-structure coupling is implemented in K-FIX by additions to subroutines ITER, MASFL, and VEL5.

C. Additions to SOLA-DF

Very few changes to SOLA-DF are required for HDR applications. The downcomer gap width and mean radius are specified in the main program. The state equation and physical properties of the water are specified through the input data.

For seismic accelerations, the body accelerations must be modified to have spatial and temporal dependences. These modifications are made in the main program and subroutine BCSPEC.

Additions for a time-dependent thickness array $A(i,j)$ for fluid-structure coupling are made in the main program and subroutines BC and PITER.

V. FLX INPUT DATA

The input data for FLX are read following the input data for the fluid-dynamics codes K-FIX(3D) or SOLA-DF. Six read statements are used to specify the FLX input.

Card No. 1. MB, NB, ML1, ML2, ML3 (Format 616)

MB = number of circumferential real cells. The fluid code also must have this number of circumferential real cells so that the coupling routines perform correctly.

NB = number of axial real cells.

ML1 = m-value of the first radial displacement limiting lug at the core barrel bottom.

ML2 = m-value of the second radial displacement limiting lug at the core barrel bottom.

ML3 = m-value of the third radial displacement limiting lug at the core barrel bottom.

If the lugs are to be ignored, the value of FPL on Card No. 2 is set to a larger value than the downcomer gap width.

Card No. 2. RAD, AL, DZBOT, DZTOP, FPL, HN (Format 6E12.5)

RAD = midplane radius of the core barrel.

AL = length of the core barrel.

DZBOT = axial dimension of cells in the bottom row ($n = 2$).

DZTOP = axial dimension of cells in the top row ($n = NB1$). The axial dimensions of cells between $n = 2$ and $NB1$ are calculated automatically from the values of NB, DZBOT, and DZTOP.

FPL = distance between the core barrel lugs and the inner wall of the vessel.

HN = core barrel thickness.

Card No. 3. ANU, YM, RHO, WMAX (Format 6E12.5)

ANU = Poisson's ratio.

YM = Young's modulus.

RHO = core barrel density.

WMAX = maximum forced displacement for snapback tests. WMAX is positive for an outward displacement.

Card No. 4. TSTART, TEND, TFILM, TPRINT, DTFILM, DTPRINT (Format 6E12.5)

TSTART = starting time for FLX program. For snapback calculations, TSTART is generally -150 ms and the core barrel is released at time TFLX = 0.

TEND = ending time for the calculation using only the FLX code. For a snapback calculation in water, TEND = 0. For a snapback calculation in vacuum (air), TEND > 0.

TFILM = time to start printing output on film.

TPRINT = time to start printing output on paper.

DTFILM = time interval for output on film.

DTPRINT = time interval for output on paper.

Card No. 5. THIST, DTHIST (Format 6E12.5)

THIST = time to start printing output to obtain the time history of a particular variable.

DTHIST = time interval for these prints.

Card No. 6. COUPLE, FLXONLY, PUSH, SEISMIC, SNAP, SYM, RING (Format 7L6)

The seven quantities on this card are logical variables, that is, they are either true T or false F.

COUPLE = T for a coupled fluid-structure calculation; F otherwise.

FLXONLY = T for a structure calculation without fluid dynamics, such as for a snapback calculation in vacuum; F otherwise.

PUSH = T if the core barrel is initially deflected by pushing on the mass ring; F otherwise.

SEISMIC = T if the vessel is to be shaken by a seismic disturbance; F otherwise.

SNAP = T for a snapback calculation; F otherwise.

SYM = T for a problem with circumferential symmetry; F otherwise.

RING = T to include the mass ring description with $M_r = 1.2 \times 10^7$ g; F otherwise.

VI. SAMPLE CALCULATION

A sample calculation of a typical snapback test demonstrates the K-FIX(3D,FLX) code. Sufficient output is provided to verify proper implementation of the code at computing facilities other than the Los Alamos Scientific Laboratory.

For this calculation, the core barrel is displaced 0.35 cm at the bottom by pushing on the mass ring. The displacement rate is such that the maximum displacement is reached in 50 ms. Additional time is used to relax vibrations to achieve a static equilibrium. To assist the relaxation, a constant damping is applied to the core barrel by adjusting the accelerations in Eq. (2.8) to be

$$\ddot{U}_{m,n} = \ddot{U}_{m,n} - d \dot{U}_{m,n} ,$$

$$\ddot{V}_{m,n} = \ddot{V}_{m,n} - d \dot{V}_{m,n} ,$$

and

$$\ddot{W}_{m,n} = \ddot{W}_{m,n} - d \dot{W}_{m,n} ,$$

where $d = (10^4/\rho h)s^{-1}$. The magnitude of d , based on an estimate of the critical damping, has been empirically shown to be adequate.

The calculation begins at $t = -150$ ms, which provides a 100-ms relaxation time. The structural damping stops at $t = -1$ ms, at which time the core barrel is generally very close to static equilibrium. We compute the force required to hold the core barrel in its displaced position using three different procedures: (1) a free-body force balance, (2) a free-body moment balance, and (3) an action-reaction balance made by evaluating the (mass) \times (acceleration) product $\rho h \delta z \delta s \ddot{W}$ associated with internal stresses at the point where the external force is applied.

The calculation from $t = -150$ ms to $t = 0$ involves only the FLX code. The FLX input data are listed in Table II. The force is applied in cell (2,2) so that the problem is symmetric. The FLX solution at $t = 0$, which corresponds to the static solution, is given in Table III for column $m = 2$. The three independent procedures for calculating the applied force yield 0.69×10^{11} dyn, 0.67×10^{11} dyn, and 0.67×10^{11} dyn, respectively. The differences largely arise from the treatment of the bottom boundary condition and the uncertainties of computing high-order derivatives in the bottom row of cells. The differences are less when the force is applied away from the bottom.

At $t = 0$ the coupled fluid-structure calculation begins. The K-FIX(3D) input data are listed in Table IV. The solution at 5 ms after the core barrel is released is listed in Table V. The radial index $I = 5$ corresponds to the downcomer gap. The first circumferential fluid column $k = 2$ is aligned with the column $m = 2$ for the core barrel. The axial index J spans the entire range from the bottom of the lower plenum $J = 2$ to the core barrel top $J = 33$. The solution for the core barrel is given for column $m = 2$.

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TABLE I

ADDITIONS TO K-FIX(3D) FOR HDR SNAPBACK TESTS

*IDENT	HDRS	1
*D,KFIXCC.270		
C	HDRS	2
C ADDITIONS TO SUBROUTINE BETAS	HDRS	3
C	HDRS	4
DATA EPSG,EPST / 1.E-7, 1.E-7 /	HDRS	5
*B,KFIXCC.289		
JLP=C(9)	HDRS	6
IF(1.EQ.IB.AND.J.GT.JLP) NFLR=2	HDRS	7
IF(1.EQ.IB1.AND.J.GT.JLP) NFLL=2	HDRS	8
*I,KFIXCC.317		
IF(1.EQ.IB) CS(4)=CS(4)*DR/(0.5*(DR+C(10)))	HDRS	9
*I,KFIXCC.321		
IF(1.EQ.IB1) CS(5)=CS(5)*DR/(0.5*(DR+C(10)))	HDRS	10
*I,KFIXCC.617		
C	HDRS	11
C ADDITIONS TO SUBROUTINE CONVERT	HDRS	12
DIMENSION CI(4)	HDRS	13
CI(1)=P(IJ)	HDRS	14
CI(2)=TG(IJ)	HDRS	15
CI(3)=TH(IJ)	HDRS	16
CI(4)=TL(IJ)	HDRS	17
ROG(IJ)=C(1)	HDRS	18
RGP(IJ)=ROG(IJ)*CI(3)	HDRS	19
RL(IJ)=C(2)+(P(IJ)-C(3))*C(8)	HDRS	20
RLP(IJ)=RL(IJ)*(1.-CI(3))	HDRS	21
CG(IJ)=C(1)	HDRS	22
SIEG(IJ)=C(1)	HDRS	23
CL(IJ)=C(5)	HDRS	24
SIEL(IJ)=(CI(4)-C(6))*CL(IJ)+C(7)	HDRS	25
*I,KFIXCC.672		
C	HDRS	26
C ADDITIONS TO SUBROUTINE EOSG	HDRS	27
C	HDRS	28
IF(NC.GT.0) CG(IJ)=C(1)	HDRS	29
IF(NT.GT.0) TG(IJ)=C(1)	HDRS	30
IF(NR.GT.0) ROG(IJ)=C(1)	HDRS	31
IF(NC.GT.1) RAGS=C(1)	HDRS	32
*I,KFIXCC.682		
C	HDRS	33
C ADDITIONS TO SUBROUTINE EOSL	HDRS	34
C	HDRS	35
IF(NC.GT.0) CL(IJ)=C(5)	HDRS	36
IF(NT.GT.0) TL(IJ)=C(6)+(SIEL(IJ)-C(7))/CL(IJ)	HDRS	37
IF(NR.GT.0) RL(IJ)=C(2)+(P(IJ)-C(3))*C(8)	HDRS	38
IF(NC.GT.1) RALS=C(8)	HDRS	39
*I,FLX.455		
C	HDRS	40
C ADDITIONS TO SUBROUTINE FLXDELT	HDRS	41
C	HDRS	42
DTSMX=1.25E-5	HDRS	43
*D,KFIXCC.1121		
C	HDRS	44
C ADDITIONS TO SUBROUTINE ITER	HDRS	45
C	HDRS	46
DATA LMAX,OMEGA / 5, 1.0 /	HDRS	47
*I,KFIXCC.1138		
JLPP=C(9)+1	HDRS	47

TABLE I (cont)

IF (1.EQ.1B.AND.J.GE.JLPP) RLFR(IJ)=UL(IJ)*RLPN(IJ)*RB(I)	HDRS	48
IF (1.EQ.1B1.AND.J.GE.JLPP) RLFR(IMJ)=UL(IMJ)*RLPN(IJ)*RB(I-1)	HDRS	49
*1,KFIXCC.1244		
C	HDRS	50
C ADDITIONS TO SUBROUTINE KDRAGS	HDRS	51
C	HDRS	52
KDRAG(IJ)=1.0E10	HDRS	53
*1,KFIXCC.1273		
C	HDRS	54
C ADDITIONS TO SUBROUTINE MASFL	HDRS	55
C	HDRS	56
JLPP=C(9)+1	HDRS	57
IF (1.EQ.1B1.AND.J.GE.JLPP) RLFR(IMJ)=UL(IMJ)*RLPN(IJ)*RB(I-1)	HDRS	58
*1,KFIXCC.1280		
IF (1.EQ.1B.AND.J.GE.JLPP) RLFR(IJ)=UL(IJ)*RLPN(IJ)*RB(I)	HDRS	59
*1,KFIXCC.1550		
C	HDRS	60
C ADDITIONS TO SUBROUTINE RHEATS	HDRS	61
C	HDRS	62
RHEAT(IJ)=1.E20	HDRS	63
*1,KFIXCC.1578		
C	HDRS	64
C ADDITIONS TO SUBROUTINE SAT	HDRS	65
C	HDRS	66
TS(IJ)=C(1)	HDRS	67
IF (NL.GT.0) LHEAT(IJ)=C(1)	HDRS	68
*1,KFIXCC.1638		
C	HDRS	69
C ADDITIONS TO SUBROUTINE SETC TO SET CONSTANTS	HDRS	70
C	HDRS	71
C(1)=1.0	HDRS	72
C(2)=0.9992	HDRS	73
C(3)=2.E7	HDRS	74
C(4)=1.48E5	HDRS	75
C(5)=4.182E7	HDRS	76
C(6)=293.15	HDRS	77
C(7)=0.0837E10	HDRS	78
C(8)=0.4565E-10	HDRS	79
C(9)=FLOAT(JB1)-757.0/(DZ*SCALE(1))+0.1	HDRS	80
C(10)=15.0	HDRS	81
C(2)=C(2)/SCALE(3)	HDRS	82
C(3)=C(3)/(SCALE(3)*SCALE(2)**2)	HDRS	83
C(4)=C(4)/SCALE(2)	HDRS	84
C(5)=C(5)*SCALE(4)/SCALE(2)**2	HDRS	85
C(6)=C(6)/SCALE(4)	HDRS	86
C(7)=C(7)/SCALE(2)**2	HDRS	87
C(8)=C(8)*SCALE(2)**2	HDRS	88
C(10)=C(10)/SCALE(1)	HDRS	89
C C(1)= CONSTANT	HDRS	90
C C(2)= MICROSCOPIC LIQUID DENSITY AT REFERENCE CONDITIONS	HDRS	91
C C(3)= REFERENCE PRESSURE	HDRS	92
C C(4)= LIQUID SOUND SPEED	HDRS	93
C C(5)= LIQUID SPECIFIC HEAT	HDRS	94
C C(6)= REFERENCE TEMPERATURE	HDRS	95
C C(7)= LIQUID SPECIFIC INTERNAL ENERGY AT REFERENCE TEMPERATURE	HDRS	96
C C(8)= SQUARE OF RECIPROCAL LIQUID SOUND SPEED	HDRS	97
C C(9)= CELL INDEX J AT TOP OF LOWER PLENUM	HDRS	98
C C(10)= DOWNCOMER GAP WIDTH	HDRS	99

TABLE I (cont)

*I,KFIXCC.1668		
C		HDRS 100
C	ADDITIONS TO SUBROUTINE SETUP	HDRS 101
C		HDRS 102
	IF(1.EQ.IB1) R(IB1)=RB(IB1)+0.5*C(10)	HDRS 103
	IF(1.EQ.IB1) RB(IB1)=R(IB1)+0.5*C(10)	HDRS 104
*B,KFIXCC.1673		
	IF(1.GE.IB1) DTORDR(1)=DTORDR(1)*DR/C(10)	HDRS 105
	IF(1.EQ.IB) DTORBD(1)=DTORBD(1)*DR*RB(1)*2./((R(1)+RB(1)+	HDRS 106
	1 0.5*C(10))*(.5*(DR+C(10))))	HDRS 107
	IF(1.EQ.IB) DTORBD(1)=DTORBD(1)*RB(1)*2./(R(1)+RB(1)+0.5*C(10))	HDRS 108
*D,KFIXCC.1756,1759		
*I,KFIXCC.1818		
C		HDRS 109
C	ADDITIONS TO SUBROUTINE SIELF	HDRS 110
C		HDRS 111
	JLPP=C(9)+1	HDRS 112
	IF(1.EQ.IB.AND.J.GE.JLPP) ELFR=RLPN(IJ)*SIELN(IJ)*UL(IJ)*RB(1)	HDRS 113
*I,KFIXCC.1821		
	IF(1.EQ.IB1.AND.J.GE.JLPP) GO TO 1	HDRS 114
*I,KFIXCC.1826		
	IF(1.EQ.IB1.AND.J.GE.JLPP.AND.UL(IMJ).GE.0.) ELFL=RLPN(IJ)*	HDRS 115
	1 SIELN(IJ)*UL(IMJ)*RB(I-1)	HDRS 116
*I,KFIXCC.1945		
C		HDRS 117
C	ADDITIONS TO SUBROUTINE TILDE	HDRS 118
C		HDRS 119
	DIMENSION PSINU(17), PCOSU(17), PSINW(17), PCOSW(17)	HDRS 120
C		HDRS 121
	IF(TIME.GT.0.) GO TO 4	HDRS 122
	PSINU(1)=0.	HDRS 123
	PSINW(1)=0.	HDRS 124
	PCOSU(1)=0.	HDRS 125
	PCOSW(1)=0.	HDRS 126
	DO 2 K=2,KB1	HDRS 127
	PSINU(K)=SIN((FLOAT(K)-1.5)*DPH)	HDRS 128
	PSINW(K)=SIN((FLOAT(K)-1.0)*DPH)	HDRS 129
	PCOSU(K)=COS((FLOAT(K)-1.5)*DPH)	HDRS 130
	PCOSW(K)=COS((FLOAT(K)-1.0)*DPH)	HDRS 131
	2 CONTINUE	HDRS 132
	4 CALL FLXSHAK(TIME,SXDDN,SYDDN,SZDDN)	HDRS 133
*I,THREED.309		
	GU=(-PCOSU(K)*SXDDN-PSINU(K)*SYDDN)*DT	HDRS 134
	GW=(PSINW(K)*SXDDN-PCOSW(K)*SYDDN)*DT	HDRS 135
	GV=-SZDDN*DT	HDRS 136
*I,THREED.331		
	3 +0.5*(RGP(IJ)+RGP(IJR))*GU	HDRS 137
*I,THREED.341		
	3 +0.5*(RLP(IJ)+RLP(IJR))*GU	HDRS 138
*I,THREED.337		
	3 +0.5*(RGP(IJ)+RGP(IJA))*GW	HDRS 139
*I,THREED.347		
	3 +0.5*(RLP(IJ)+RLP(IJA))*GW	HDRS 140
*I,THREED.333		
	2 +0.5*(RGP(IJ)+RGP(IJT))*GV	HDRS 141
*I,THREED.343		
	2 +0.5*(RLP(IJ)+RLP(IJT))*GV	HDRS 142
*I,KFIXCC.2074		

TABLE I (cont)

C		HDRS	143
C	ADDITIONS TO SUBROUTINE ULMOMF	HDRS	144
C		HDRS	145
	JLP=C(9)	HDRS	146
	IF(1.EQ.IB-1.AND.J.GE.JLP+2.AND.CS(1).LT.0.)	HDRS	147
	1 ULFR=RLP(IJR)*UL(IPJ)*CS(1)*R(I+1)	HDRS	148
	*1,KFIXCC.2137		
C		HDRS	149
C	ADDITIONS TO SUBROUTINE VELS	HDRS	150
C		HDRS	151
	JLP=C(9)	HDRS	152
	IF(1.EQ.IB1.AND.J.GT.JLP) GO TO 1	HDRS	153
	*1,KFIXCC.2142		
	IF(1.EQ.IB1) PGRAD=PGRAD*DR/(0.5*(DR+C(10)))	HDRS	154
	*1,KFIXCC.2170		
	JLP=C(9)	HDRS	155
	IF(1.EQ.IB.AND.J.GT.JLP) GO TO 3	HDRS	156
	*1,KFIXCC.2175		
	IF(1.EQ.IB) PGRAD=PGRAD*DR/(0.5*(DR+C(10)))	HDRS	157
	*1,KFIXCC.2281		
C		HDRS	158
C	ADDITIONS TO VLMOMF	HDRS	159
C		HDRS	160
	JLP=C(9)	HDRS	161
	IF(1.EQ.IB.AND.J.GE.JLP+2.AND.CS(2).LT.0.) VLFR=0.5*(RLP(IJ)+	HDRS	162
	1 RLP(IJT))*CS(2)*RB(1)*VL(IJ)	HDRS	163
	IF(1.EQ.IB-1.AND.J.EQ.JLP.AND.CS(2).LT.0.) VLFR=0.5*(RLP(IJ)+	HDRS	164
	1 RLP(IJT))*CS(2)*RB(1)*VL(IJ)	HDRS	165
	IF(1.EQ.IB-1.AND.J.EQ.JLP+1) VLFR=0.25*(RLP(IJ)+RLP(IJT))*UL(IJ)*	HDRS	166
	1 RB(1)*VL(IJ)	HDRS	167
	IF(1.EQ.IB-1.AND.J.EQ.JLP+1.AND.UL(IJP).GE.0.) VLFR=VLFR+0.25*	HDRS	168
	1 (RLP(IJ)+RLP(IJT))*UL(IJP)*RB(1)*VL(IJ)	HDRS	169
	*1,KFIXCC.2282		
	IF(1.EQ.IB1.AND.J.GE.JLP) GO TO 1	HDRS	170
	*1,KFIXCC.2288		
	IF(1.EQ.IB1.AND.J.GE.JLP.AND.CS(3).GE.0.) VLFL=0.5*(RLP(IJ) +	HDRS	171
	1 RLP(IJT))*CS(3)*VL(IJ)*RB(I-1)	HDRS	172
	*1,THREED.485		
C		HDRS	173
C	ADDITIONS TO SUBROUTINE WLMOMF	HDRS	174
C		HDRS	175
	JLP=C(9)	HDRS	176
	IF(1.EQ.IB.AND.J.GE.JLP+2.AND.CS(3).LT.0.) WLFR=0.5*(RLP(IJ)+	HDRS	177
	1 RLP(IJA))*CS(3)*WL(IJ)*RB(1)	HDRS	178
	IF(1.EQ.IB-1.AND.J.EQ.JLP+1.AND.CS(3).LT.0.) WLFR=0.5*(RLP(IJ)+	HDRS	179
	1 RLP(IJA))*CS(3)*WL(IJ)*RB(1)	HDRS	180
	*1,THREED.486		
	IF(1.EQ.IB1.AND.J.GE.JLP+1) GO TO 1	HDRS	181
	*1,THREED.492		
	IF(1.EQ.IB1.AND.J.GE.JLP+1.AND.CS(4).GE.0.) WLFL=0.5*(RLP(IJ)+	HDRS	182
	1 RLP(IJA))*CS(4)*WL(IJ)*RB(I-1)	HDRS	183

TABLE II
FLX INPUT DATA

INITIAL VALUES FOR STRUCTURE CALCULATION

AL = 7.57000E+02
 ANU = 3.00000E-01
 COUPLE = T
 DS = 2.76146E+01
 DTSMX = 1.25000E-05
 DTFILM = 5.00000E-03
 DTHIST = 2.00000E-04
 DTPRINT = 5.00000E-03
 DZBOT = 1.47700E+01
 DZTOP = 1.35000E+01
 FLXONLY = F
 FPL = 1.00000E+02
 HB = 8.89142E+01
 HN = 2.30000E+00
 MB = 15
 NB = 34
 PUSHR = T
 RAD = 1.31850E+02
 RHO = 7.90000E+00
 RING = T
 SEISMIC = F
 SNAP = T
 SYM = T
 TEND = 0.
 TFILM = -1.50000E-01
 THIST = 1.00000E+00
 TPRINT = -1.50000E-01
 TSTART = -1.50000E-01
 WMAX = -3.50000E-01
 YM = 1.95000E+12

AXIAL NODING

N= 1	ZS = 0.	DZS = 1.4770000E+01
N= 2	ZS = 1.4770000E+01	DZS = 1.4770000E+01
N= 3	ZS = 3.0979643E+01	DZS = 1.6209643E+01
N= 4	ZS = 4.8536547E+01	DZS = 1.7556904E+01
N= 5	ZS = 6.7348329E+01	DZS = 1.8811781E+01
N= 6	ZS = 8.7322605E+01	DZS = 1.9974276E+01
N= 7	ZS = 1.0836699E+02	DZS = 2.1044387E+01
N= 8	ZS = 1.3038911E+02	DZS = 2.2022116E+01
N= 9	ZS = 1.5329657E+02	DZS = 2.2907461E+01
N= 10	ZS = 1.7699699E+02	DZS = 2.3700423E+01
N= 11	ZS = 2.0139799E+02	DZS = 2.4401003E+01
N= 12	ZS = 2.2640719E+02	DZS = 2.5009199E+01
N= 13	ZS = 2.5193221E+02	DZS = 2.5525012E+01
N= 14	ZS = 2.7788065E+02	DZS = 2.5948443E+01
N= 15	ZS = 3.0416014E+02	DZS = 2.6279490E+01
N= 16	ZS = 3.3067829E+02	DZS = 2.6518154E+01
N= 17	ZS = 3.5734273E+02	DZS = 2.6664435E+01
N= 18	ZS = 3.8406106E+02	DZS = 2.6718333E+01
N= 19	ZS = 4.1074091E+02	DZS = 2.6679848E+01
N= 20	ZS = 4.3728989E+02	DZS = 2.6548981E+01
N= 21	ZS = 4.6361562E+02	DZS = 2.6325730E+01
N= 22	ZS = 4.8962572E+02	DZS = 2.6010096E+01
N= 23	ZS = 5.1522779E+02	DZS = 2.5602079E+01
N= 24	ZS = 5.4032947E+02	DZS = 2.5101679E+01
N= 25	ZS = 5.6483837E+02	DZS = 2.4508896E+01
N= 26	ZS = 5.8866210E+02	DZS = 2.3823730E+01
N= 27	ZS = 6.1170828E+02	DZS = 2.3046181E+01
N= 28	ZS = 6.3388453E+02	DZS = 2.2176249E+01
N= 29	ZS = 6.5509846E+02	DZS = 2.1213934E+01
N= 30	ZS = 6.7525770E+02	DZS = 2.0159236E+01
N= 31	ZS = 6.9426985E+02	DZS = 1.9012155E+01
N= 32	ZS = 7.1204254E+02	DZS = 1.7772691E+01
N= 33	ZS = 7.2848339E+02	DZS = 1.6440843E+01
N= 34	ZS = 7.4350000E+02	DZS = 1.5016613E+01
N= 35	ZS = 7.5700000E+02	DZS = 1.3500000E+01
N= 36	ZS = 7.7050000E+02	DZS = 1.3500000E+01

TABLE III
FLX SOLUTION AT T = 0

TIME = -3.92656E-13 DTS = 1.00000E-05 DTFL = 5.00000E-05 NDT5 = 1 TOTAL CYCLES = 15000

M = 2 N	U	V	W	PD	STRESSES					
					Z MBRN	Z BNDG	F MBRN	F BNDG	ZF MBRN	ZF BNDG
1	7.697E-02	-7.574E-02	-3.527E-01	0.	0.	1.564E+06	0.	0.	0.	-1.462E+06
2	7.518E-02	-7.604E-02	-3.500E-01	0.	-8.829E-06	5.209E-04	1.324E+08	1.396E+09	-1.540E+07	-1.851E+06
3	7.297E-02	-7.602E-02	-3.472E-01	0.	8.640E+06	5.885E+07	2.043E+07	5.406E+07	-1.442E+07	-2.054E+05
4	7.058E-02	-7.585E-02	-3.377E-01	0.	1.746E+07	1.585E+07	-4.544E+06	4.019E+07	-1.456E+07	2.396E+05
5	6.802E-02	-7.558E-02	-3.255E-01	0.	2.705E+07	6.602E+04	-2.083E+06	3.404E+07	-1.465E+07	2.027E+05
6	6.529E-02	-7.520E-02	-3.125E-01	0.	3.733E+07	-6.689E+05	-3.648E+04	3.234E+07	-1.464E+07	1.437E+05
7	6.242E-02	-7.468E-02	-2.990E-01	0.	4.821E+07	-1.338E+05	1.827E+05	3.100E+07	-1.464E+07	1.126E+05
8	5.942E-02	-7.401E-02	-2.849E-01	0.	5.962E+07	-1.525E+05	1.222E+05	2.946E+07	-1.463E+07	9.191E+04
9	5.632E-02	-7.317E-02	-2.704E-01	0.	7.152E+07	-3.016E+05	9.934E+04	2.785E+07	-1.463E+07	7.570E+04
10	5.314E-02	-7.215E-02	-2.554E-01	0.	8.387E+07	-4.477E+05	9.148E+04	2.622E+07	-1.463E+07	6.269E+04
11	4.990E-02	-7.094E-02	-2.402E-01	0.	9.661E+07	-5.901E+05	8.458E+04	2.457E+07	-1.462E+07	5.209E+04
12	4.661E-02	-6.953E-02	-2.248E-01	0.	1.097E+08	-7.328E+05	7.775E+04	2.291E+07	-1.462E+07	4.329E+04
13	4.331E-02	-6.792E-02	-2.093E-01	0.	1.231E+08	-8.758E+05	7.120E+04	2.125E+07	-1.462E+07	3.582E+04
14	4.002E-02	-6.610E-02	-1.938E-01	0.	1.367E+08	-1.019E+06	6.495E+04	1.960E+07	-1.462E+07	2.936E+04
15	3.675E-02	-6.407E-02	-1.785E-01	0.	1.505E+08	-1.162E+06	5.896E+04	1.798E+07	-1.462E+07	2.369E+04
16	3.354E-02	-6.184E-02	-1.635E-01	0.	1.645E+08	-1.304E+06	5.322E+04	1.638E+07	-1.462E+07	1.865E+04
17	3.039E-02	-5.940E-02	-1.487E-01	0.	1.786E+08	-1.446E+06	4.775E+04	1.482E+07	-1.462E+07	1.410E+04
18	2.734E-02	-5.676E-02	-1.345E-01	0.	1.927E+08	-1.586E+06	4.254E+04	1.332E+07	-1.462E+07	9.953E+03
19	2.441E-02	-5.393E-02	-1.207E-01	0.	2.068E+08	-1.725E+06	3.761E+04	1.187E+07	-1.462E+07	6.141E+03
20	2.160E-02	-5.092E-02	-1.076E-01	0.	2.209E+08	-1.862E+06	3.297E+04	1.049E+07	-1.462E+07	2.608E+03
21	1.893E-02	-4.775E-02	-9.517E-02	0.	2.349E+08	-1.997E+06	2.863E+04	9.189E+06	-1.462E+07	-6.883E+02
22	1.643E-02	-4.443E-02	-8.350E-02	0.	2.488E+08	-2.129E+06	2.460E+04	7.965E+06	-1.462E+07	-3.778E+03
23	1.410E-02	-4.098E-02	-7.265E-02	0.	2.625E+08	-2.257E+06	2.089E+04	6.826E+06	-1.462E+07	-6.685E+03
24	1.195E-02	-3.743E-02	-6.265E-02	0.	2.759E+08	-2.383E+06	1.751E+04	5.778E+06	-1.462E+07	-9.425E+03
25	9.986E-03	-3.380E-02	-5.354E-02	0.	2.890E+08	-2.505E+06	1.445E+04	4.822E+06	-1.462E+07	-1.201E+04
26	8.213E-03	-3.011E-02	-4.533E-02	0.	3.018E+08	-2.623E+06	1.161E+04	3.960E+06	-1.462E+07	-1.445E+04
27	6.631E-03	-2.640E-02	-3.804E-02	0.	3.142E+08	-2.735E+06	8.769E+03	3.193E+06	-1.462E+07	-1.673E+04
28	5.239E-03	-2.269E-02	-3.163E-02	0.	3.262E+08	-2.837E+06	9.319E+03	2.521E+06	-1.462E+07	-1.869E+04
29	4.032E-03	-1.901E-02	-2.610E-02	0.	3.377E+08	-2.954E+06	3.212E+04	1.933E+06	-1.462E+07	-2.083E+04
30	3.002E-03	-1.541E-02	-2.140E-02	0.	3.486E+08	-3.297E+06	4.013E+04	1.362E+06	-1.462E+07	-2.833E+04
31	2.139E-03	-1.191E-02	-1.753E-02	0.	3.590E+08	-3.915E+06	-5.449E+05	7.943E+05	-1.464E+07	-4.678E+04
32	1.431E-03	-8.541E-03	-1.450E-02	0.	3.687E+08	-7.322E+05	-2.748E+06	1.454E+06	-1.471E+07	-3.719E+02
33	8.630E-04	-5.354E-03	-1.181E-02	0.	3.779E+08	1.884E+07	-3.598E+05	7.057E+06	-1.472E+07	4.036E+05
34	4.200E-04	-2.464E-03	-7.393E-03	0.	3.862E+08	3.924E+07	3.619E+07	1.267E+07	-1.386E+07	1.131E+06
35	1.005E-04	0.	0.	0.	3.934E+08	-9.467E+07	1.251E+08	-2.842E+07	-1.117E+07	-1.848E+05
36	-1.005E-04	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE IV
K-FIX(3D) INPUT DATA

CODE NAME - KFIX PROBLEM IDENTIFIER - SAMPLE CALCULATION HDR - SNAPBACK 6/18/79
 SCALING LENGTH(CM)=1.00E+00 VELOCITY(CM/SEC)=1.00E+00 DENSITY(GM/CC)=1.00E+00 TEMPERATURE(DEG.K)=1.00E+00
 GEOMETRY

1. COORDINATES (CART=0, CYLIND=1, SPHERE=2) = 1
 2. MESH SIZE, IB2= 6 JB2= 34 KB2= 17
 3. CELL SIZE, DR= 4.3950E+01 DZ= 2.9115E+01 DPH= 2.0944E-01
 4. INFLOW OPENINGS
 A. BOTTOM 0. 0. 0. 0.
 0. 0. 0. 0.
 B. LEFT 0. 0. 0. 0.
 0. 0. 0. 0.
 5. OUTFLOW OPENINGS
 A. TOP 0. 0. 0. 0.
 0. 0. 0. 0.
 B. RIGHT 0. 0. 0. 0.
 0. 0. 0. 0.
 6. BOUNDARIES, (FREE-SLIP=0 NO-SLIP=1)
 BOTTOM= 0 LEFT= 0 TOP= 0 RIGHT= 0 FORE= 0 AFT= 0
 7. OBSTACLES, NO= 2
 SLIP -----COORDINATES-----
 0 1.3185E+02 1.3185E+02 1.7469E+02 9.3169E+02 0. 3.1416E+00
 0 8.7900E+01 1.3185E+02 1.4558E+02 2.0381E+02 0. 3.1416E+00
 8. GRAVITY, GRAV= 0.

INITIAL DATA GAS AND LIQUID

1. UO= 0. VO= 0. WO= 0. PO= 2.0000E+07 THO= 0. TO= 2.9300E+02

INFLOW DATA

1. BOTTOM
 UINL= 0. VINL= 0. WINL= 0. PINL= 0. THINL= 0. TEMPINL= 0.
 UINR= 0. VINR= 0. WINR= 0. PINR= 0. THINR= 0. TEMPINR= 0.
 2. LEFT
 UINB= 0. VINB= 0. WINB= 0. PINB= 0. THINB= 0. TEMPINB= 0.
 UINT= 0. VINT= 0. WINT= 0. PINT= 0. THINT= 0. TEMPINT= 0.

CONTROL

TABLE IV (cont)

1. DUMP AND RESTART, ITD= 0 NTD= 0 NSDMP= 0 NFILE= 0 NNDMP= 0

2. TIME AND CYCLE TSTART= 0. TSTOP= 5.1000E-03 DT= 5.0000E-05 CYCLE= 0.

3. PRINTING AND PLOTTING, LPR= 3 TPR= 5.0000E-03 TPL= 5.0000E-03 TPLD= 5.0000E-03

PRINT LIMITS I1= 5 I2= 5 J1= 2 J2= 33 K1= 2 K2= 2

4. CONTOUR PLOT FLAGS

	RGP	RLP	TH	P	TG	TL	TS	IG	IL	G	K.
IJPLOT FOR K = 2	0	0	0	1	0	0	0	0	0	0	0
IJPLOT FOR K = 9	0	0	0	1	0	0	0	0	0	0	0
IJPLOT FOR K =16	0	0	0	1	0	0	0	0	0	0	0
IJPLOT FOR K = 0	0	0	0	0	0	0	0	0	0	0	0
IJPLOT FOR K = 0	0	0	0	0	0	0	0	0	0	0	0
IKPLOT FOR J = 4	0	0	0	1	0	0	0	0	0	0	0
IKPLOT FOR J = 7	0	0	0	1	0	0	0	0	0	0	0
IKPLOT FOR J =15	0	0	0	1	0	0	0	0	0	0	0
IKPLOT FOR J =25	0	0	0	1	0	0	0	0	0	0	0
IKPLOT FOR J =31	0	0	0	1	0	0	0	0	0	0	0
JKPLOT FOR I = 4	0	0	0	1	0	0	0	0	0	0	0
JKPLOT FOR I = 5	0	0	0	1	0	0	0	0	0	0	0
JKPLOT FOR I = 0	0	0	0	0	0	0	0	0	0	0	0
JKPLOT FOR I = 0	0	0	0	0	0	0	0	0	0	0	0
JKPLOT FOR I = 0	0	0	0	0	0	0	0	0	0	0	0

TABLE V

SOLUTION AT 5 ms AFTER CORE BARREL RELEASE

CYCLE= 100 TIME= .00500000 DT= .00005000 SAMPLE CALCULATION HDR-SNAPBACK 06/19/79											
I	J	K	FL	TH	UG	VG	SIEG	RGP	KDRAG	HG	CG
				ROL	UL	VL	SIEL	RLP	R-EAT	HL	CL
				ROG	ERATE	CRATE	ASURF	TS	TL	TG	P
5	2	2	1	0.	0.	-1.06941E+00	4.73050E+04	0.	1.00000E+10	1.45646E-01	1.00000E+00
				9.99200E-01	0.	-1.06941E+00	8.30726E+08	9.99200E-01	1.00000E+20	1.45646E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.00107E+07
5	3	2	1	0.	0.	-2.36992E+00	4.84730E+04	0.	1.00000E+10	2.08540E-01	1.00000E+00
				9.99201E-01	0.	-2.36992E+00	8.30727E+08	9.99201E-01	1.00000E+20	2.08540E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.00147E+07
5	4	2	1	0.	0.	-4.62568E+00	4.99330E+04	0.	1.00000E+10	3.38061E-01	1.00000E+00
				9.99201E-01	0.	-4.62568E+00	8.30727E+08	9.99201E-01	1.00000E+20	3.38061E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.00235E+07
5	5	2	1	0.	0.	-1.02038E+01	5.13930E+04	0.	1.00000E+10	5.92376E-01	1.00000E+00
				9.99202E-01	0.	-1.02038E+01	8.30726E+08	9.99202E-01	1.00000E+20	5.92376E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.00344E+07
5	6	2	1	0.	0.	-2.86222E+01	5.43130E+04	0.	1.00000E+10	1.17165E+00	1.00000E+00
				9.99202E-01	0.	-2.86222E+01	8.30727E+08	9.99202E-01	1.00000E+20	1.17165E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.00446E+07
5	7	2	1	0.	0.	-3.00283E+01	5.72330E+04	0.	1.00000E+10	2.78964E+00	1.00000E+00
				9.99204E-01	0.	-3.00283E+01	8.30726E+08	9.99204E-01	1.00000E+20	2.78964E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.00803E+07
5	8	2	1	0.	0.	-1.86992E+01	5.75250E+04	0.	1.00000E+10	4.27830E+00	1.00000E+00
				9.99206E-01	0.	-1.86992E+01	8.30727E+08	9.99206E-01	1.00000E+20	4.27830E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.01377E+07
5	9	2	1	0.	0.	-6.36157E+00	5.72330E+04	0.	1.00000E+10	5.06816E+00	1.00000E+00
				9.99225E-01	0.	-6.36157E+00	8.30729E+08	9.99225E-01	1.00000E+20	5.06816E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.05409E+07
5	10	2	1	0.	0.	2.14613E+00	5.69410E+04	0.	1.00000E+10	4.78964E+00	1.00000E+00
				9.99226E-01	0.	2.14613E+00	8.30727E+08	9.99226E-01	1.00000E+20	4.78964E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.06236E+07
5	11	2	1	0.	0.	4.91695E+00	5.60650E+04	0.	1.00000E+10	4.27126E+00	1.00000E+00
				9.99227E-01	0.	4.91695E+00	8.30727E+08	9.99227E-01	1.00000E+20	4.27126E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.05953E+07
5	12	2	1	0.	0.	9.53189E+00	5.51890E+04	0.	1.00000E+10	4.74143E+00	1.00000E+00
				9.99224E-01	0.	9.53189E+00	8.30729E+08	9.99224E-01	1.00000E+20	4.74143E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.05310E+07
5	13	2	1	0.	0.	1.84531E+01	5.46050E+04	0.	1.00000E+10	5.04278E+00	1.00000E+00
				9.99231E-01	0.	1.84531E+01	8.30729E+08	9.99231E-01	1.00000E+20	5.04278E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.06794E+07
5	14	2	1	0.	0.	2.31695E+01	5.25610E+04	0.	1.00000E+10	4.52928E+00	1.00000E+00
				9.99244E-01	0.	2.31695E+01	8.30730E+08	9.99244E-01	1.00000E+20	4.52928E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.09682E+07

TABLE V (cont)

CYCLE= 100		TIME= .00500000	DT= .00005000	SAMPLE CALCULATION				HDR=SNAPBACK	06/19/79		
I	J	K	FL	TH	UG	VG	SIEG	ROP	KDRAG	WG	CG
				ROL	UL	VL	SIEL	RLP	RHEAT	WL	CL
				ROG	ERATE	CRATE	ASURF	TS	TL	TG	P
5	15	2	1	0.	0.	2.05442E+01	5.25610E+04	0.	1.00000E+10	2.87063E+00	1.00000E+00
				9.99241E-01	0.	2.05442E+01	8.30730E+08	9.99241E-01	1.00000E+20	2.87063E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.08964E+07
5	16	2	1	0.	0.	1.55276E+01	5.13930E+04	0.	1.00000E+10	1.32914E+00	1.00000E+00
				9.99229E-01	0.	1.55276E+01	8.30729E+08	9.99229E-01	1.00000E+20	1.32914E+00	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.06431E+07
5	17	2	1	0.	0.	1.06169E+01	5.02250E+04	0.	1.00000E+10	3.00144E-01	1.00000E+00
				9.99217E-01	0.	1.06169E+01	8.30728E+08	9.99217E-01	1.00000E+20	3.00144E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.01433E+07
5	18	2	1	0.	0.	6.78693E+00	5.05170E+04	0.	1.00000E+10	-2.70114E-01	1.00000E+00
				9.99207E-01	0.	6.78693E+00	8.30727E+08	9.99207E-01	1.00000E+20	-2.70114E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	2.01433E+07
5	19	2	1	0.	0.	4.05847E+00	4.96410E+04	0.	1.00000E+10	-5.48683E-01	1.00000E+00
				9.99199E-01	0.	4.05847E+00	8.30727E+08	9.99199E-01	1.00000E+20	-5.48683E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.99830E+07
5	20	2	1	0.	0.	2.19007E+00	4.87650E+04	0.	1.00000E+10	-6.54898E-01	1.00000E+00
				9.99195E-01	0.	2.19007E+00	8.30727E+08	9.99195E-01	1.00000E+20	-6.54898E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98804E+07
5	21	2	1	0.	0.	9.15257E-01	4.84730E+04	0.	1.00000E+10	-6.77676E-01	1.00000E+00
				9.99192E-01	0.	9.15257E-01	8.30726E+08	9.99192E-01	1.00000E+20	-6.77676E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98208E+07
5	22	2	1	0.	0.	5.58869E-02	4.75870E+04	0.	1.00000E+10	-6.54200E-01	1.00000E+00
				9.99191E-01	0.	5.58869E-02	8.30726E+08	9.99191E-01	1.00000E+20	-6.54200E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.97939E+07
5	23	2	1	0.	0.	-5.01737E-01	4.64290E+04	0.	1.00000E+10	-6.02189E-01	1.00000E+00
				9.99191E-01	0.	-5.01737E-01	8.30726E+08	9.99191E-01	1.00000E+20	-6.02189E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.97928E+07
5	24	2	1	0.	0.	-8.71741E-01	4.49690E+04	0.	1.00000E+10	-5.47966E-01	1.00000E+00
				9.99191E-01	0.	-8.71741E-01	8.30726E+08	9.99191E-01	1.00000E+20	-5.47966E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98051E+07
5	25	2	1	0.	0.	-1.11503E+00	4.67210E+04	0.	1.00000E+10	-4.93919E-01	1.00000E+00
				9.99192E-01	0.	-1.11503E+00	8.30726E+08	9.99192E-01	1.00000E+20	-4.93919E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98205E+07
5	26	2	1	0.	0.	-1.23346E+00	4.38010E+04	0.	1.00000E+10	-4.20656E-01	1.00000E+00
				9.99193E-01	0.	-1.23346E+00	8.30726E+08	9.99193E-01	1.00000E+20	-4.20656E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98386E+07
5	27	2	1	0.	0.	-1.24682E+00	4.52610E+04	0.	1.00000E+10	-3.40751E-01	1.00000E+00
				9.99194E-01	0.	-1.24682E+00	8.30727E+08	9.99194E-01	1.00000E+20	-3.40751E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98589E+07

TABLE V (cont)

CYCLE= 100 TIME= .00500000 DT= .00005000 SAMPLE CALCULATION HDR-SNAPBACK 06/19/79

I	J	K	FL	TH	UG	VG	SIEG	RGP	KDRAG	WG	CG
				ROL	UL	VL	SIEL	RLP	RHEAT	HL	CL
				ROG	ERATE	CRATE	ASURF	TS	TL	TG	P
5	28	2	1	0.	0.	-1.17093E+00	4.36810E+04	0.	1.00000E+10	-2.70304E-01	1.00000E+00
				9.99194E-01	0.	-1.17093E+00	8.30727E+08	9.99194E-01	1.00000E+20	-2.70304E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98935E+07
5	29	2	1	0.	0.	-1.00267E+00	4.46770E+04	0.	1.00000E+10	-2.19817E-01	1.00000E+00
				9.99195E-01	0.	-1.00267E+00	8.30727E+08	9.99195E-01	1.00000E+20	-2.19817E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.98935E+07
5	30	2	1	0.	0.	-7.75206E-01	4.55530E+04	0.	1.00000E+10	-1.85391E-01	1.00000E+00
				9.99196E-01	0.	-7.75206E-01	8.30727E+08	9.99196E-01	1.00000E+20	-1.85391E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.99037E+07
5	31	2	1	0.	J.	-4.96641E-01	4.40930E+04	0.	1.00000E+10	-1.53130E-01	1.00000E+00
				9.99196E-01	0.	-4.96641E-01	8.30727E+08	9.99196E-01	1.00000E+20	-1.53130E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.99179E+07
5	32	2	1	0.	0.	-1.10702E-01	4.26330E+04	0.	1.00000E+10	-1.37659E-01	1.00000E+00
				9.99196E-01	0.	-1.10702E-01	8.30727E+08	9.99196E-01	1.00000E+20	-1.37659E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.99221E+07
5	33	2	1	0.	0.	0.	4.00050E+04	0.	1.00000E+10	-1.38285E-01	1.00000E+00
				9.99197E-01	0.	0.	8.30727E+08	9.99197E-01	1.00000E+20	-1.38285E-01	4.18200E+07
				1.00000E+00	0.	0.	0.	1.00000E+00	2.93000E+02	1.00000E+00	1.99371E+07

TIME= 5.00000E-03 DTS= 1.00000E-05 DTFL= 5.00000E-05 NDT5= 5 TOTAL CYCLES = 15500

M = 3

N	U	V	W	PD	-----STRESSES-----					
					Z MBRN	Z BNDG	F MBRN	F BNDG	ZF MBRN	ZF BNDG
1	6.936E-02	-6.179E-02	-3.133E-01	0.	0.	2.530E+06	0.	0.	0.	-2.365E+06
2	6.801E-02	-6.210E-02	-3.156E-01	-1.643E+05	-1.510E-05	5.655E-04	1.350E+08	1.177E+09	5.296E+05	-2.331E+06
3	6.659E-02	-6.225E-02	-3.180E-01	-3.200E+05	-1.992E+07	6.991E+07	-7.702E+06	5.244E+07	-8.888E+05	-6.073E+05
4	6.501E-02	-6.232E-02	-3.129E-01	-6.340E+05	-2.073E+07	2.862E+07	-4.451E+07	3.978E+07	-4.085E+06	7.806E+03
5	6.321E-02	-6.240E-02	-3.038E-01	-7.132E+05	-1.882E+07	-5.395E+06	-3.512E+07	2.872E+07	-6.393E+06	-2.301E+05
6	6.123E-02	-6.243E-02	-2.948E-01	-7.019E+05	-1.494E+07	6.667E+06	-4.159E+07	3.161E+07	-9.801E+06	6.781E+05
7	5.904E-02	-6.239E-02	-2.843E-01	-6.210E+05	-7.898E+06	2.855E+06	-3.874E+07	2.877E+07	-1.073E+07	7.088E+05
8	5.670E-02	-6.229E-02	-2.727E-01	-5.657E+05	-2.232E+05	-6.506E+06	-2.961E+07	2.414E+07	-8.624E+06	-4.615E+05
9	5.434E-02	-6.211E-02	-2.619E-01	-6.286E+05	5.320E+06	-2.586E+06	-3.473E+07	2.469E+07	-7.946E+06	-3.007E+05
10	5.190E-02	-6.180E-02	-2.512E-01	-8.476E+05	1.096E+07	-3.837E+06	-4.716E+07	2.348E+07	-7.331E+06	-1.443E+06
11	4.938E-02	-6.132E-02	-2.410E-01	-1.177E+06	1.738E+07	1.146E+07	-7.290E+07	2.851E+07	-1.104E+07	-6.576E+05
12	4.667E-02	-6.070E-02	-2.280E-01	-1.095E+06	2.803E+07	6.726E+06	-6.764E+07	2.657E+07	-1.609E+07	1.732E+05
13	4.373E-02	-5.994E-02	-2.131E-01	-8.472E+05	4.370E+07	2.713E+06	-4.980E+07	2.377E+07	-1.974E+07	4.161E+05
14	4.064E-02	-5.899E-02	-1.974E-01	-5.449E+05	6.226E+07	3.190E+05	-3.010E+07	2.108E+07	-2.168E+07	3.611E+05
15	3.747E-02	-5.782E-02	-1.815E-01	-2.637E+05	8.251E+07	-1.058E+06	-1.333E+07	1.872E+07	-2.246E+07	2.332E+05
16	3.426E-02	-5.640E-02	-1.658E-01	-4.081E+04	1.043E+08	-1.636E+06	-1.942E+06	1.674E+07	-2.202E+07	1.425E+05
17	3.110E-02	-5.470E-02	-1.507E-01	1.143E+05	1.256E+08	-1.824E+06	5.790E+06	1.501E+07	-2.129E+07	8.154E+04
18	2.801E-02	-5.273E-02	-1.360E-01	2.074E+05	1.467E+08	-1.909E+06	1.035E+07	1.341E+07	-2.061E+07	3.526E+04
19	2.501E-02	-5.049E-02	-1.220E-01	2.528E+05	1.676E+08	-1.975E+06	1.231E+07	1.193E+07	-1.994E+07	1.576E+04
20	2.215E-02	-4.799E-02	-1.086E-01	2.627E+05	1.872E+08	-2.071E+06	1.338E+07	1.052E+07	-1.965E+07	6.455E+03
21	1.943E-02	-4.527E-02	-9.603E-02	2.493E+05	2.056E+08	-2.189E+06	1.341E+07	9.193E+06	-1.918E+07	-6.147E+03
22	1.687E-02	-4.234E-02	-8.422E-02	2.316E+05	2.234E+08	-2.288E+06	1.272E+07	7.959E+06	-1.882E+07	-3.221E+04
23	1.448E-02	-3.922E-02	-7.326E-02	2.143E+05	2.414E+08	-2.363E+06	1.099E+07	6.840E+06	-1.848E+07	-2.334E+04
24	1.227E-02	-3.593E-02	-6.317E-02	1.915E+05	2.583E+08	-2.457E+06	9.302E+06	5.793E+06	-1.786E+07	-1.310E+03
25	1.028E-02	-3.253E-02	-5.398E-02	1.649E+05	2.728E+08	-2.568E+06	8.976E+06	4.818E+06	-1.727E+07	-2.941E+03
26	8.487E-03	-2.907E-02	-4.571E-02	1.391E+05	2.861E+08	-2.676E+06	9.073E+06	3.942E+06	-1.706E+07	-2.320E+04
27	6.872E-03	-2.555E-02	-3.834E-02	1.184E+05	3.000E+08	-2.744E+06	8.093E+06	3.182E+06	-1.667E+07	-3.092E+04
28	5.447E-03	-2.201E-02	-3.187E-02	1.074E+05	3.135E+08	-2.788E+06	7.201E+06	2.526E+06	-1.644E+07	-2.444E+04
29	4.209E-03	-1.849E-02	-2.625E-02	1.014E+05	3.263E+08	-2.966E+06	6.843E+06	1.911E+06	-1.637E+07	-2.497E+04
30	3.154E-03	-1.501E-02	-2.147E-02	9.375E+04	3.382E+08	-3.399E+06	6.525E+06	1.305E+06	-1.605E+07	-2.933E+04
31	2.269E-03	-1.163E-02	-1.753E-02	8.410E+04	3.490E+08	-3.479E+06	5.708E+06	8.904E+05	-1.604E+07	-5.048E+04
32	1.533E-03	-8.361E-03	-1.436E-02	8.571E+04	3.596E+08	-1.186E+06	3.670E+06	1.273E+06	-1.613E+07	-3.042E+04
33	9.277E-04	-5.253E-03	-1.160E-02	8.334E+04	3.700E+08	1.776E+07	4.899E+06	6.694E+06	-1.589E+07	3.669E+05
34	4.575E-04	-2.423E-03	-7.233E-03	7.595E+04	3.793E+08	3.789E+07	3.900E+07	1.224E+07	-1.508E+07	1.079E+06
35	1.117E-04	0.	0.	7.292E+04	3.873E+08	-9.263E+07	1.240E+08	-2.780E+07	-1.229E+07	-2.145E+05
36	-1.117E-04	0.	0.	0.	0.	0.	0.	0.	0.	0.

APPENDIX

FLX CODE LISTING

Below is a FORTRAN listing of the FLX code. This FLX code listing, the K-FIX(3D) listing in Ref. 4, and the additions enumerated in Sec. IV of this report provide the K-FIX(3D,FLX) listing. FLX is inserted in K-FIX(3D) at location KFIXCC.800, as indicated in statement FLX. 1.

LASL Identification

No. LP-1073

- IDENT.COMFLX
- I,ARRAYS.40
- COMDECK.COMFLX

COMMON / FLX1 /							COMFLX	1		
1	AL.	ANU.	COUPLE.	DN.	DS.	DTFILM.	COMFLX	2		
2	DTFL.	DTHIST.	DTPRINT.	DTS.	DTSMX.	DZBOT.	COMFLX	3		
3	DZTOP.	FLXONLY.	FPL.	HB.	HN.	MB.	COMFLX	4		
4	MB1.	MB2.	ML1.	ML2.	ML3.	NB.	COMFLX	5		
5	NB1.	NB2.	NCYC.	NDTS.	NPUSH.	PUSH.	COMFLX	6		
6	RAD.	RHO.	RING.	RINGM.	RRH.	RRHV.	COMFLX	7		
7	SNAP.	SYM.	TEND.	TFLX.	TFILM.	THIST.	COMFLX	8		
8	TPRINT.	TSTART.	UDDS.	VDDS.	WDDS.	WMAX.	COMFLX	9		
9	YM						COMFLX	10		
	LEVEL 2.						COMFLX	11		
1	AMF.	AMZ.	AMZF.	ANF.	ANFZ.	ANZ.	DZS.	QS.	COMFLX	12
2	PCOSW.	PSINU.	RADZ.	RDZS.	UDS.	US.	VDD.	VDS.	COMFLX	13
3	VS.	WDD.	WDS.	WS.	ZS				COMFLX	14
	COMMON / FLX2 /							COMFLX	15	
1	AMF (18,36).		AMZ (18,36).		AMZF (18,36).		ANF (18,36).		COMFLX	16
2	ANFZ (18,36).		ANZ (18,36).		QS (18,36).		UDS (18,36).		COMFLX	17
3	US (18,36).		VDD (18,36).		VDS (18,36).		VS (18,36).		COMFLX	18
4	WDD (18,36).		WDS (18,36).		WS (18,36).		DZS (36).		COMFLX	19
5	RADZ (36).		RDZS (36).		ZS (36).		PSINU (18).		COMFLX	20
6	PCOSW (18)							COMFLX	21	

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*IDENT FLX
*I,KF]XCC.800
  SUBROUTINE FLX
C
C
*CALL COMFLX
  DIMENSION PCOSU(18), PSINW(18)
C
  LOGICAL COUPLE, FLXONLY, SEISMIC, SNAP, SYM, PUSHR, RING
C
C
C  AL      LENGTH OF SHELL
C  ANU     POISSON RATIO
C  COUPLE  COUPLE = TRUE TO COUPLE STRUCTURE AND FLUID CALCULATIONS
C  DTFILM  INTERVAL BETWEEN OUTPUT FILM
C  DTHIST  DATA STORAGE INTERVAL FOR HISTORIES
C  DTPRINT INTERVAL BETWEEN OUTPUT PRINTS
C  DZBOT   MESH SPACING AT BOTTOM OF CORE BARREL
C  DZTOP   MESH SPACING AT TOP OF CORE BARREL
C  FLXONLY FLXONLY = TRUE TO PERFORM ONLY STRUCTURE CALCULATION
C  FPL     DISTANCE BETWEEN LUGS AND VESSEL
C  HB      THICKNESS OF SHELL BOTTOM (MASS RING)
C  HN      NORMAL THICKNESS OF SHELL
C  MB      NUMBER OF CIRCUMFERENTIAL CELLS FOR CORE BARREL
C  ML1     CIRCUMFERENTIAL NODE NUMBER FOR LUG 1
C  ML2     CIRCUMFERENTIAL NODE NUMBER FOR LUG 2
C  ML3     CIRCUMFERENTIAL NODE NUMBER FOR LUG 3
C  NB      NUMBER OF AXIAL CELLS FOR CORE BARREL
C  PUSHR   PUSHR=TRUE TO PUSH AT T(RING)
C          PUSHR=FALSE TO PUSH AT A2(UPPER POSITION)
C  RAD     RADIUS OF STRUCTURAL SHELL
C  RHO     SHELL DENSITY
C  RING    RING = TRUE  INCLUDE MASS RING IN STRUCTURE
C  SEISMIC SEISMIC = TRUE TO INCLUDE SEISMIC SHAKING
C  SNAP    SNAP = TRUE TO PERFORM SNAPBACK CALCULATIONS
C  SYM     SYM = TRUE FOR SYMMETRY
C  TEND    TIME TO END INDEPENDENT CALCULATION OF STRUCTURE
C  TFILM   TIME FOR NEXT FILM OUTPUT
C  THIST   TIME OF NEXT DATA STORAGE FOR HISTORIES
C  TPRINT  TIME FOR NEXT PAPER OUTPUT
C  TSTART  STARTING TIME FOR STRUCTURE CALCULATION
C  WMAX    INITIAL INWARD DISPLACEMENT FOR SNAPBACK TESTS
C  YM      YOUNGS MODULUS
C
  NCYC=0
  PI=3.141592654
C ***** READ THE INPUT DATA FOR STRUCTURE*****
  READ (10,500) MB,NB,ML1,ML2,ML3
  READ (10,510) RAD,AL,DZBOT,DZTOP,FPL,HN
  READ (10,510) ANU,YM,RHO,WMAX
  READ (10,510) TSTART,TEND,TFILM,TPRINT,DTFILM,DTPRINT
  READ (10,510) THIST,DTHIST
  READ (10,520) COUPLE,FLXONLY,PUSHR,SEISMIC,SNAP,SYM,RING
C
  TFLX=TSTART
C***** DERIVED PARAMETERS *****
  CN=YM*HN/(1.0-ANU**2)
  DN=YM*HN**3/12.0/(1.0-ANU**2)
  DS=2.*PI*RAD/FLOAT(MB)
  IF (SYM) DS=0.5*DS

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RDS=1./DS	FLX	57
NB1=NB+1	FLX	58
NB2=NB+2	FLX	59
MB1=MB+1	FLX	60
MB2=MB+2	FLX	61
RRAD=1./RAD	FLX	62
RRN=1.0/RHO/HN	FLX	63
C	FLX	64
C ***** DEFINE THE STRUCTURAL MESH *****	FLX	65
C SUBROUTINE FLXMESH RETURNS TABLE OF ZS(N)	FLX	66
C CALL FLXMESH	FLX	67
C	FLX	68
C FIND NPUSH	FLX	69
C ZPUSH=600.0	FLX	70
C IF (PUSHR) ZPUSH=0.5*DZBOT	FLX	71
C DZS(1)=DZBOT	FLX	72
C DZS(NB2)=DZ*OP	FLX	73
C DO 10 N=2,NB1	FLX	74
C DZS(N)=ZS(N)-ZS(N-1)	FLX	75
C FIND AXIAL CELL LEVEL N OF PUSH PISTON	FLX	76
C IF (ZS(N-1).LE.ZPUSH.AND.ZS(N).GE.ZPUSH) NPUSH=N	FLX	77
C 10 CONTINUE	FLX	78
C	FLX	79
C DO 20 N=1,NB1	FLX	80
C RDZS(N)=1.0/DZS(N)	FLX	81
C RADZ(N)=2.0/(DZS(N)+DZS(N+1))	FLX	82
C 20 CONTINUE	FLX	83
C	FLX	84
C ***** MORE DERIVED PARAMETERS *****	FLX	85
C RINGM, RINGI, RINGCG ARE THE MASS, MOMENT OF INERTIA, AND	FLX	86
C RADIAL CENTROID FOR THE RING	FLX	87
C RINGM=12.0E6	FLX	88
C RINGI=3.706E5	FLX	89
C RINGCG=99.39	FLX	90
C HB=HN	FLX	91
C RRB=RRN	FLX	92
C IF (RING) HB=(RAD/RINGCG)*(12.0*RINGI/DZBOT)**0.333333	FLX	93
C IF (RING) RRB=(DZBOT*2.0*PI*RAD)/RINGM	FLX	94
C CB=YM*HB/(1.0-ANU**2)	FLX	95
C DB=YM*HB**3/12.0/(1.0-ANU**2)	FLX	96
C RRBV=(DZS(2)+DZS(3))/(DZS(2)/RRB+DZS(3)/RRN)	FLX	97
C ***** ZERO THE ARRAYS *****	FLX	98
C DO 30 M=1,MB2	FLX	99
C DO 30 N=1,NB2	FLX	100
C ANZ(M,N)=0.	FLX	101
C ANF(M,N)=0.	FLX	102
C ANFZ(M,N)=0.	FLX	103
C AMZ(M,N)=0.	FLX	104
C AMF(M,N)=0.	FLX	105
C AMZF(M,N)=0.	FLX	106
C US(M,N)=0.	FLX	107
C VS(M,N)=0.	FLX	108
C WS(M,N)=0.	FLX	109
C UDS(M,N)=0.	FLX	110
C VDS(M,N)=0.	FLX	111
C WDS(M,N)=0.	FLX	112
C QS(M,N)=0.0	FLX	113
C 30 CONTINUE	FLX	114

C		FLX	115
C	***** ** ESTABLISH MAXIMUM TIME STEP *****	FLX	116
	CALL FLXMAXT	FLX	117
C	***** OUTPUT THE INITIAL VALUES *****	FLX	118
	WRITE (9,160)	FLX	119
	WRITE (9,180) AL	FLX	120
	WRITE (9,190) ANU	FLX	121
	WRITE (9,390) COUPLE	FLX	122
	WRITE (9,240) DS	FLX	123
	WRITE (9,200) DTSMX	FLX	124
	WRITE (9,220) DTFILM	FLX	125
	WRITE (9,430) DTHIST	FLX	126
	WRITE (9,210) DTPRINT	FLX	127
	WRITE (9,410) DZBOT	FLX	128
	WRITE (9,420) DZTOP	FLX	129
	WRITE (9,350) FLXONLY	FLX	130
	WRITE (9,250) FPL	FLX	131
	WRITE (9,270) HB	FLX	132
	WRITE (9,280) HN	FLX	133
	WRITE (9,290) MB	FLX	134
	WRITE (9,300) NB	FLX	135
	WRITE (9,440) PUSHR	FLX	136
	WRITE (9,170) RAD	FLX	137
	WRITE (9,310) RHO	FLX	138
	WRITE (9,460) RING	FLX	139
	WRITE (9,260) SEISMIC	FLX	140
	WRITE (9,470) SNAP	FLX	141
	WRITE (9,320) SYM	FLX	142
	WRITE (9,360) TEND	FLX	143
	WRITE (9,330) TFILM	FLX	144
	WRITE (9,480) THIST	FLX	145
	WRITE (9,340) TPRINT	FLX	146
	WRITE (9,400) TSTART	FLX	147
	WRITE (9,450) WMAX	FLX	148
	WRITE (9,230) YM	FLX	149
C		FLX	150
	WRITE (12,160)	FLX	151
	WRITE (12,180) AL	FLX	152
	WRITE (12,190) ANU	FLX	153
	WRITE (12,390) COUPLE	FLX	154
	WRITE (12,240) DS	FLX	155
	WRITE (12,200) DTSMX	FLX	156
	WRITE (12,220) DTFILM	FLX	157
	WRITE (12,430) DTHIST	FLX	158
	WRITE (12,210) DTPRINT	FLX	159
	WRITE (12,410) DZBOT	FLX	160
	WRITE (12,420) DZTOP	FLX	161
	WRITE (12,350) FLXONLY	FLX	162
	WRITE (12,250) FPL	FLX	163
	WRITE (12,270) HB	FLX	164
	WRITE (12,280) HN	FLX	165
	WRITE (12,290) MB	FLX	166
	WRITE (12,300) NB	FLX	167
	WRITE (12,440) PUSHR	FLX	168
	WRITE (12,170) RAD	FLX	169
	WRITE (12,310) RHO	FLX	170
	WRITE (12,460) RING	FLX	171
	WRITE (12,260) SEISMIC	FLX	172

WRITE (12,470) SNAP	FLX	173
WRITE (12,320) SYM	FLX	174
WRITE (12,360) TEND	FLX	175
WRITE (12,330) TFILM	FLX	176
WRITE (12,480) THIST	FLX	177
WRITE (12,340) TPRINT	FLX	178
WRITE (12,400) TSTART	FLX	179
WRITE (12,450) WMAX	FLX	180
WRITE (12,230) YM	FLX	181
WRITE (9,370)	FLX	182
WRITE (12,370)	FLX	183
WRITE (12,380) (N,ZS(N),DZS(N),N=1,NB2)	FLX	184
WRITE (9,380) (N,ZS(N),DZS(N),N=1,NB2)	FLX	185
C	FLX	186
C ***** CALC TABLES FOR SEISMIC SHAKE COMPONENTS *****	FLX	187
DPH=DS/RAD	FLX	188
PSINU(1)=0.	FLX	189
PCOSU(1)=0.	FLX	190
PSINW(1)=0.	FLX	191
PCOSW(1)=0.	FLX	192
DO 40 M=2,MB1	FLX	193
PSINU(M)=SIN((FLOAT(M)-1.0)*DPH)	FLX	194
PCOSU(M)=COS((FLOAT(M)-1.0)*DPH)	FLX	195
PSINW(M)=SIN((FLOAT(M)-1.5)*DPH)	FLX	196
PCOSW(M)=COS((FLOAT(M)-1.5)*DPH)	FLX	197
40 CONTINUE	FLX	198
C	FLX	199
RETURN	FLX	200
C	FLX	201
ENTRY FLXA	FLX	202
50 CONTINUE	FLX	203
C	FLX	204
CALL SSWTCH (1,ISW)	FLX	205
CALL GETTR (TREM)	FLX	206
IF (TREM.LT.120.) ISW=1	FLX	207
IF (ISW.EQ.1) RETURN	FLX	208
C ***** FLXFTOS PROVIDES PRESSURE DIFFERENCES TO THE SHELL CALC***	FLX	209
IF (.NOT.FLXONLY) CALL FLXFTOS	FLX	210
C *****DETERMINE FLX TIME INCREMENT *****	FLX	211
CALL FLXDELT	FLX	212
C	FLX	213
C ***** NDT5 IS THE NUMBER OF STRUCTURE SUBCYCLES *****	FLX	214
DO 150 IBX=1,NDT5	FLX	215
TFLX=TFLX+DTS	FLX	216
C *****GET THE SEISMIC SHAKE ACCELERATIONS *****	FLX	217
IF (SEISMIC) CALL FLXSHAK (TFLX,SXDDN,SYDDN,SZDDN)	FLX	218
C	FLX	219
C ***** COMPUTE FORCES AND MOMENTS *****	FLX	220
C	FLX	221
DE=DB	FLX	222
CE=CB	FLX	223
DO 80 N=2,NB1	FLX	224
IF (N.NE.3) GO TO 60	FLX	225
DE=DN	FLX	226
CE=CN	FLX	227
60 DO 70 M=2,MB1	FLX	228
UO=(US(M,N)-US(M-1,N))*RDS	FLX	229
VP=(VS(M,N)-VS(M,N-1))*RDZS(N)	FLX	230

	UP=(US(M,N+1)-US(M,N))*RADZ(N)	FLX	231
	V0=(VS(M+1,N)-VS(M,N))*RDS	FLX	232
	WPP=((WS(M,N+1)-WS(M,N))*RADZ(N)-(WS(M,N)-WS(M,N-1))*RADZ(N-1))	FLX	233
	1 *RDZS(N)	FLX	234
	W00=(WS(M+1,N)-2.*WS(M,N)+WS(M-1,N))*RDS*RDS	FLX	235
	WOP=((WS(M+1,N+1)-WS(M,N+1))-(WS(M+1,N)-WS(M,N)))*RDS*RADZ(N)	FLX	236
	ANZ(M,N)=CE*(VP+ANU*(U0+WS(M,N)*RRAD))	FLX	237
	ANF(M,N)=CE*(U0+WS(M,N)*RRAD+ANU*VP)	FLX	238
	ANFZ(M,N)=CN*(1.-ANU)*(V0+UP)*0.5	FLX	239
	AMZ(M,N)=DE*(WPP+ANU*(W00-U0*RRAD))	FLX	240
	AMF(M,N)=DE*(W00+ANU*(WPP-U0*RRAD))	FLX	241
	AMZF(M,N)=-DN*(1.-ANU)*(WOP-UP*RRAD)	FLX	242
	70 CONTINUE	FLX	243
	80 CONTINUE	FLX	244
C		FLX	245
C	***** SET CIRCUMFERENTIAL FORCE AND MOMENT BOUNDARY CONDITIONS ***	FLX	246
	CALL FLXBC	FLX	247
C	***** EQUATIONS OF MOTION *****	FLX	248
	RRHV=RRBV	FLX	249
	RRH=RRB	FLX	250
	DO 140 N=2,NB1	FLX	251
	IF (N.NE.3) GO TO 90	FLX	252
	RRH=RRN	FLX	253
	RRHV=RRN	FLX	254
	90 DO 130 M=2,MB1	FLX	255
	VDDS=RRHV*((ANZ(M,N+1)-ANZ(M,N))*RADZ(N)+(ANFZ(M,N)-ANFZ(M-1,N))	FLX	256
	1 *RDS)-SZDDN	FLX	257
	UDDS=RRH*((ANF(M+1,N)-ANF(M,N))*RDS+(ANFZ(M,N)-ANFZ(M,N-1))*RDZS(N)	FLX	258
	1)-(AMF(M+1,N)-AMF(M,N))*RDS*RRAD+(AMZF(M,N)-AMZF(M,N-1))*RDZS(N)	FLX	259
	2 *RRAD)+SXDDN*PSINU(M)-SYDDN*PCOSU(M)	FLX	260
	WDDS=RRH*(QS(M,N)-((AMZ(M,N+1)-AMZ(M,N))*RADZ(N)-(AMZ(M,N)-AMZ(M,N-1))	FLX	261
	1-1))*RADZ(N-1))*RDZS(N)+2.*((AMZF(M,N)-AMZF(M-1,N))-AMZF(M,N-1)	FLX	262
	2-AMZF(M-1,N-1))*RDS*RDZS(N)-(AMF(M+1,N)-2.*AMF(M,N)+AMF(M-1,N))	FLX	263
	3 *RDS*RDS-ANF(M,N)*RRAD)-SXDDN*PCOSW(M)-SYDDN*PSINW(M)	FLX	264
	WDD(M,N)=WDDS	FLX	265
	VDD(M,N)=VDDS	FLX	266
C		FLX	267
C	***** COMPUTE FORCE FROM ACTION-REACTION PRINCIPLE *****	FLX	268
	IF (.NOT.SNAP) GO TO 110	FLX	269
	IF (TFLX.LT.-0.0005.OR.TFLX.GT.0.) GO TO 100	FLX	270
	IF (M.NE.2.OR.N.NE.NPUSH) GO TO 100	FLX	271
	PUSH=-WDDS*PCOSW(2)*DS*DZS(NPUSH)/RRH	FLX	272
	IF (SYM) PUSH=2.*PUSH	FLX	273
C		FLX	274
C	***** COMPUTE DAMPING TERMS IF REQUIRED *****	FLX	275
	100 CALL FLXDAMP (M,N)	FLX	276
C		FLX	277
C	***** COMPUTE VELOCITIES AND DISPLACEMENTS *****	FLX	278
	110 UDS(M,N)=UDS(M,N)+UDDS*DTS	FLX	279
	VDS(M,N)=VDS(M,N)+VDDS*DTS	FLX	280
	WDS(M,N)=WDS(M,N)+WDDS*DTS	FLX	281
	US(M,N)=US(M,N)+UDS(M,N)*DTS	FLX	282
	VS(M,N)=VS(M,N)+VDS(M,N)*DTS	FLX	283
	WS(M,N)=WS(M,N)+WDS(M,N)*DTS	FLX	284
	130 CONTINUE	FLX	285
	140 CONTINUE	FLX	286
C		FLX	287
C	***** SET CIRCUMFERENTIAL DISPLACEMENT BOUNDARY CONDITION	FLX	288

CALL FLXBBCD	FLX	289
150 CONTINUE	FLX	290
C	FLX	291
C ***** SUBROUTINE FLXOUT IS THE OUTPUT SUBROUTINE	FLX	292
CALL FLXOUT	FLX	293
C	FLX	294
C ***** FLXSTOF PROVIDES SHELL VELOCITIES TO THE FLUID CALC *****	FLX	295
IF (COUPLE) CALL FLXSTOF	FLX	296
C	FLX	297
IF (TFLX+0.1*DTS.LT.TEND) GO TO 50	FLX	298
IF (FLXONLY) STOP	FLX	299
IF (TFLX+0.1*DTS.LT.DTFL) GO TO 50	FLX	300
RETURN	FLX	301
C	FLX	302
160 FORMAT (1H1,45H INITIAL VALUES FOR STRUCTURE CALCULATION)	FLX	303
170 FORMAT (15X,5HRAD =,1PE12.5)	FLX	304
180 FORMAT (15X,4HAL =,1PE12.5)	FLX	305
190 FORMAT (15X,5HANU =,1PE12.5)	FLX	306
200 FORMAT (15X,7HDTSMX =,1PE12.5)	FLX	307
210 FORMAT (15X,9HDTPRINT =,1PE12.5)	FLX	308
220 FORMAT (15X,8HDTFILM =,1PE12.5)	FLX	309
230 FORMAT (15X,4HYM =,1PE12.5)	FLX	310
240 FORMAT (15X,4HDS =,1PE12.5)	FLX	311
250 FORMAT (15X,5HFPL =,1PE12.5)	FLX	312
260 FORMAT (15X,9HSEISMIC =,L3)	FLX	313
270 FORMAT (15X,4HNB =,1PE12.5)	FLX	314
280 FORMAT (15X,4HNN =,1PE12.5)	FLX	315
290 FORMAT (15X,4HNB =,15)	FLX	316
300 FORMAT (15X,4HNB =,15)	FLX	317
310 FORMAT (15X,5HRHO =,1PE12.5)	FLX	318
320 FORMAT (15X,5HSYM =,L3)	FLX	319
330 FORMAT (15X,7HTFILM =,1PE12.5)	FLX	320
340 FORMAT (15X,8HTPRINT =,1PE12.5)	FLX	321
350 FORMAT (15X,9HFLXONLY =,L3)	FLX	322
360 FORMAT (15X,6HTEND =,1PE12.5)	FLX	323
370 FORMAT (1H1,10X,13HAXIAL NODING /)	FLX	324
380 FORMAT (2X,2HN=,13,2X,4HZS =,1PE14.7,2X,5HDZS =,1PE14.7)	FLX	325
390 FORMAT (15X,8HCOUPLE =,L3)	FLX	326
400 FORMAT (15X,8HTSTART =,1PE12.5)	FLX	327
410 FORMAT (15X,7HDZBOT =,1PE12.5)	FLX	328
420 FORMAT (15X,7HDZTOP =,1PE12.5)	FLX	329
430 FORMAT (15X,8HDTHIST =,1PE12.5)	FLX	330
440 FORMAT (15X,7HPUSHR =,L3)	FLX	331
450 FORMAT (15X,6HWMAX =,1PE12.5)	FLX	332
460 FORMAT (15X,6HRING =,L3)	FLX	333
470 FORMAT (15X,6HSNAP =,L3)	FLX	334
480 FORMAT (15X,7HTHIST =,1PE12.5)	FLX	335
500 FORMAT (6I6)	FLX	336
510 FORMAT (6E12.5)	FLX	337
520 FORMAT (7L6)	FLX	338
END	FLX	339
= = = = = // = = = = =		
SUBROUTINE FLXBC	FLX	340

C		FLX	341
	*CALL COMFLX	FLX	342
	LOGICAL SNAP, SYM	FLX	343
C	THIS ROUTINE SETS CIRCUMFERENTIAL DISPLACEMENT BOUNDARY CONDITIONS	FLX	344
C	PLUS CIRCUMFERENTIAL FORCE AND MOMENT BOUNDARY CONDITIONS	FLX	345
C		FLX	346
	DATA KTRAN /1/	FLX	347
C		FLX	348
	GO TO (10,20), KTRAN	FLX	349
10	KTRAN=2	FLX	350
	M1=1	FLX	351
	M2=2	FLX	352
	M3=MB1	FLX	353
	M4=MB2	FLX	354
	IF (SYM) GO TO 20	FLX	355
	M2=MB1	FLX	356
	M3=2	FLX	357
20	DO 30 N=2,NB1	FLX	358
	ANF (M4,N)=ANF (M3,N)	FLX	359
	AMF (M4,N)=AMF (M3,N)	FLX	360
	AMF (M1,N)=AMF (M2,N)	FLX	361
	IF (SYM) GO TO 30	FLX	362
	ANFZ (M1,N)=ANFZ (M2,N)	FLX	363
	AMZF (M1,N)=AMZF (M2,N)	FLX	364
30	CONTINUE	FLX	365
	DO 35 M=2,MB1	FLX	366
	AMZF (M,1)=-DN*(1.-ANU)*ROZS(2)*((WS(M+1,2)-WS(M,2)-WS(M+1,1)+	FLX	367
1	WS(M,1))/DS-(US(M,2)-US(M,1))/RAD)	FLX	368
	AMZ(M,1)=-2.0*DZS(2)*(AMZF(M,1)-AMZF(M-1,1))/DS	FLX	369
35	CONTINUE	FLX	370
	RETURN	FLX	371
C		FLX	372
	ENTRY FLXBCD	FLX	373
	IF(SNAP) CALL FLXWDIS	FLX	374
	DO 40 M=1,MB2	FLX	375
	VS(M,NB1)=0.	FLX	376
	WS(M,NB1)=0.	FLX	377
	WDS(M,NB1)=0.	FLX	378
	IF (M.NE.ML1.AND.M.NE.ML2.AND.M.NE.ML3) GO TO 40	FLX	379
	IF (WS(M,2).LE.FPL) GO TO 40	FLX	380
	WDS(M,2)=0.	FLX	381
	WS(M,2)=FPL	FLX	382
40	CONTINUE	FLX	383
	IF (SYM) GO TO 60	FLX	384
	DO 50 N=2,NB1	FLX	385
	US(1,N)=US(MB1,N)	FLX	386
50	CONTINUE	FLX	387
60	DO 70 M=2,MB1	FLX	388
	VS(M,1)=VS(M,2)+DZS(2)*ANU*((US(M,2)-US(M-1,2))/DS+WS(M,2)/RAD)	FLX	389
	VS(M+1,1)=VS(M+1,2)+DZS(2)*ANU*((US(M+1,2)-US(M,2))/DS+WS(M+1,2)	FLX	390
1	/RAD)	FLX	391
	MP=M+1	FLX	392
	MM=M-1	FLX	393
	IF (M.EQ.2) MM=M2	FLX	394
	IF (M.EQ.MB1) MP=M3	FLX	395
	WS(M,1)=WS(M,2)-DZS(2)*RADZ(2)*(WS(M,3)-WS(M,2))-ANU*DZS(2)*	FLX	396
1	DZS(2)*((WS(MP,2)-2.0*WS(M,2)+WS(MM,2))/(DS*DS)-(US(M,2)-	FLX	397
2	US(M-1,2))/(DS*RAD))	FLX	398

US(M,1)=US(M,2)+DZS(2)*(VS(MP,1)-VS(M,1))/DS	FLX	399
US(M,NB2)=-US(M,NB1)	FLX	400
70 CONTINUE	FLX	401
DO 80 N=1,NB1	FLX	402
WS(M1,N)=WS(M2,N)	FLX	403
WS(M4,N)=WS(M3,N)	FLX	404
VS(M4,N)=VS(M3,N)	FLX	405
80 CONTINUE	FLX	406
RETURN	FLX	407
END	FLX	408

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SUBROUTINE FLXDAMP (M,N)	FLX	409
C	FLX	410
*CALL COMFLX	FLX	411
C THIS ROUTINE DAMPS THE ACCELERATIONS DURING INITIALIZATION	FLX	412
C OF SNAP-BACK PROBLEM	FLX	413
C	FLX	414
DATA CDAMP, KTRAN /1.E+4,1/	FLX	415
C END DAMPING 1 MS BEFORE RELEASE IN SNAPBACK PROBLEMS	FLX	416
C	FLX	417
IF (TFLX.GT.-.001) RETURN	FLX	418
GO TO (10,20), KTRAN	FLX	419
10 KTRAN=2	FLX	420
FAC1=CDAMP/(RHO*HN)	FLX	421
20 UDDS=UDDS-FAC1*UDS(M,N)	FLX	422
VDDS=VDDS-FAC1*VDS(M,N)	FLX	423
WDDS=WDDS-FAC1*WDS(M,N)	FLX	424
RETURN	FLX	425
END	FLX	426

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SUBROUTINE FLXDELT	FLX	427
C	FLX	428
*CALL COMFLX	FLX	429
LOGICAL FLXONLY, RING	FLX	430
C DETERMINE FLX TIME INCREMENT	FLX	431
C	FLX	432
C DTFL IS THE FLUID CALCULATION TIME STEP SET IN FLXFTOS	FLX	433
IF (FLXONLY) DTFL=DTSMX	FLX	434
IF (DTSMX.GE.DTFL) GO TO 10	FLX	435
IDT=INT(DTFL/DTSMX)	FLX	436
NDTS=IDT+1	FLX	437
DTS=DTFL/FLOAT(NDTS)	FLX	438
IF (TFLX+0.1*DTS.LT.0.) NDTS=1	FLX	439
GO TO 20	FLX	440
10 DTS=DTFL	FLX	441
NDTS=1	FLX	442
20 CONTINUE	FLX	443
RETURN	FLX	444

C	ENTRY FLXMAXT	FLX	445
C	CALCULATE THE MAXIMUM TIME STEP ALLOWABLE FOR THE SHELL MESH	FLX	446
C		FLX	447
	DTS1=DS*DS*SQRT(0.2387*RINGM/(RAD*HB*DZBOT*YM))/HB	FLX	448
	DZMIN=AMINI(DZBOT,DZTOP)	FLX	449
	DTS2=DZMIN*SQRT(RHO*(1.-ANU**2)/(YM*(2.+(1.-ANU)*(DZMIN/DS)**2)))	FLX	450
	DTSMX=0.7*DTS2	FLX	451
	IF (RING) DTSMX=0.7*AMINI(DTS1,DTS2)	FLX	452
	NCYCL=-TSTART/DTSMX	FLX	453
	IF (TSTART.LT.0.) DTSMX=-TSTART/(1.+FLOAT(NCYCL))	FLX	454
	RETURN	FLX	455
	END	FLX	456

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	SUBROUTINE FLXFILB	FLX	458
C		FLX	459
	*CALL COMFLX	FLX	460
	LOGICAL COUPLE,SYM	FLX	461
	DIMENSION HEADER(8),EXPTIM(9),COMMENT(16),NAME(15)	FLX	462
	DIMENSION NBT(15),MBT(15),DNB(15),CS(15),DMB(15)	FLX	463
	DIMENSION DTRAN(15), ATRAN(15)	FLX	464
	DATA (ATLAN(1),1=1,15) / 180., 0., 0., 0., 0., 180., 0., 180.,	FLX	465
	1 0., 0., 0., 0., 0., 30., 30. /	FLX	466
	DATA (DTRAN(1),1=1,15) / 50.,210.,355.,578.,30.,30.,740.,740.,	FLX	467
	1 30.,30.,210.,355.,578.,641.,355. /	FLX	468
	DATA KTRAN / 1 /	FLX	469
	GO TO (10,50),KTRAN	FLX	470
10	KTRAN=2	FLX	471
	DPH=360./FLOAT(MB)	FLX	472
	IF (SYM) DPH=0.5*DPH	FLX	473
	RH1=1./(HN*YM)	FLX	474
	RH2=6./(HN**2*YM)	FLX	475
	DO 40 L=1,15	FLX	476
	DIST1=DTRAN(L)	FLX	477
	DO 20 N=2,NB2	FLX	478
	DIST2=ZS(N)-0.5*DZS(N)	FLX	479
	IF (L.EQ.5.OR.L.EQ.6) DIST2=ZS(N)	FLX	480
	IF (DIST2.GT.1.0001*DIST1) GO TO 25	FLX	481
20	CONTINUE	FLX	482
25	N=N-1	FLX	483
	NBT(L)=N	FLX	484
	DNB(L)=DIST1-ZS(N)+0.5*DZS(N)	FLX	485
	IF (L.EQ.5.OR.L.EQ.6) DNB(L)=DIST1-ZS(N)	FLX	486
	IF (NBT(L).EQ.1.OR.NBT(L).EQ.NB1) DNB(L)=0.	FLX	487
	IF (NBT(L).EQ.1) NBT(L)=2	FLX	488
	IF (L.NE.5.AND.L.NE.6) DNB(L)=DNB(L)*RADZ(NBT(L))	FLX	489
	IF (L.EQ.5.OR.L.EQ.6) DNB(L)=DNB(L)*RDZS(NBT(L)+1)	FLX	490
C		FLX	491
	ANGL1=ATLAN(L)	FLX	492
	DO 30 M=1,MB2	FLX	493
	ANGL2=(FLOAT(M-1)-0.5)*DPH	FLX	494
	IF (ANGL2.GT.1.0001*ANGL1) GO TO 35	FLX	495
30	CONTINUE	FLX	496

35	MBT(L)=M-1	FLX	497
	DMB(L)=(ANGL1-ANGL2+DPH)/DPH	FLX	498
	IF (MBT(L).EQ.1.OR.MBT(L).EQ.MB1) DMB(L)=0.	FLX	499
	IF (MBT(L).EQ.1) MBT(L)=2	FLX	500
40	CONTINUE	FLX	501
C		FLX	502
	HEADER(1)=10HIDENTIFI	FLX	503
	HEADER(2)=10HKATION	FLX	504
	PROGNAM=8HK-FIX	FLX	505
	PROGVER=4HFLX	FLX	506
	CALL DATEH(DAY)	FLX	507
	CALL TIMEH(CLOCK)	FLX	508
	CASE=4H59.3	FLX	509
	IF (COUPLE) CASE=4H59.4	FLX	510
	NUMEXP=59	FLX	511
	EXPTIM(1)=8HHR-SNAP	FLX	512
	EXPTIM(2)=8HBACK-EXP	FLX	513
	EXPTIM(3)=8HERIMENT	FLX	514
	COMMENT(1)=8HRUN WITH	FLX	515
	COMMENT(2)=8H RELEASE	FLX	516
	COMMENT(3)=8HD VERSIO	FLX	517
	COMMENT(4)=8HN	FLX	518
	NUMTRS=15	FLX	519
	NUMTIMS=551	FLX	520
	HEADER(3)=8HNAMEN	FLX	521
	HEADER(4)=8H	FLX	522
	NAME(1)=6HKS1241	FLX	523
	NAME(2)=6HKS1028	FLX	524
	NAME(3)=6HKS1024	FLX	525
	NAME(4)=6HKS1010	FLX	526
	NAME(5)=6HKS3334	FLX	527
	NAME(6)=6HKS3335	FLX	528
	NAME(7)=6HK13261	FLX	529
	NAME(8)=6HK13262	FLX	530
	NAME(9)=6HKS1232	FLX	531
	NAME(10)=6HKP0251	FLX	532
	NAME(11)=6HKP0252	FLX	533
	NAME(12)=6HKP0253	FLX	534
	NAME(13)=6HKP0254	FLX	535
	NAME(14)=6HKP0018	FLX	536
	NAME(15)=6HKP0032	FLX	537
	HEADER(5)=8HWERTE	FLX	538
	HEADER(6)=8H	FLX	539
	WRITE(12,900) (NAME(L),ATRAN(L),DTRAN(L),MBT(L),NBT(L),DMB(L),	FLX	540
	1 DNB(L),L=1,15)	FLX	541
900	FORMAT(1H1,10X,30HPARAMETERS FOR HDR TRANSDUCERS, //14X,	FLX	542
	1 10HTRANSDUCER,16X,1HM,4X,1HN,6X,13HINTERPOLATION, //3X,3HNO.,	FLX	543
	2 8X,5HANGLE,8X,6HHEIGHT,4X,6HBEFORE,2X,5HBELOW,2X,5HANGLE,8X,	FLX	544
	3 6HHEIGHT, //(3X,A6,1P2E14.5,2I5,1P2E14.5))	FLX	545
	WRITE(2,1000) HEADER(1),HEADER(2),PROGNAM,PROGVER,DAY,CLOCK,CASE,	FLX	546
	1 NUMEXP,(EXPTIM(I),I=1,9),(COMMENT(I),I=1,16),NUMTRS,NUMTIMS,	FLX	547
	2 HEADER(3),HEADER(4),(NAME(I),I=1,15)	FLX	548
1000	FORMAT(A8,A8/A8/A4/A6/A10/A4/12/9(A8)/9(A8)/7(A8)/15/15/A8,A8,	FLX	549
	1 15(/A6))	FLX	550
C		FLX	551
50	DO 200 L=1,15	FLX	552
	N=NBT(L)	FLX	553
	M=MBT(L)	FLX	554

IF(L.GT.4) GO TO 60	FLX	555
WSL=WS(M,N)+(WS(M,N+1)-WS(M,N))*DNB(L)	FLX	556
WSR=WS(M+1,N)+(WS(M+1,N+1)-WS(M+1,N))*DNB(L)	FLX	557
CS(L)=WSL+(WSR-WSL)*DMB(L)	FLX	558
CS(L)=10.*CS(L)	FLX	559
GO TO 200	FLX	560
60 IF(L.GT.6) GO TO 70	FLX	561
VSL=VS(M,N)+(VS(M,N+1)-VS(M,N))*DNB(L)	FLX	562
VSR=VS(M+1,N)+(VS(M+1,N+1)-VS(M+1,N))*DNB(L)	FLX	563
CS(L)=VSL+(VSR-VSL)*DMB(L)	FLX	564
CS(L)=10.*CS(L)	FLX	565
GO TO 200	FLX	566
70 IF(L.GT.8) GO TO 90	FLX	567
STRNB=RH1*(ANZ(M,N)-ANU*ANF(M,N))+RH2*(AMZ(M,N)-ANU*AMF(M,N))	FLX	568
STRNA=RH1*(ANZ(M,N+1)-ANU*ANF(M,N+1))+RH2*(AMZ(M,N+1)-ANU*	FLX	569
1 AMF(M,N+1))	FLX	570
STRNL=STRNB-(STRNA-STRNB)*DNB(L)	FLX	571
STRNB=RH1*(ANZ(M+1,N)-ANU*ANF(M+1,N))+RH2*(AMZ(M+1,N)-ANU*	FLX	572
1 AMF(M+1,N))	FLX	573
STRNA=RH1*(ANZ(M+1,N+1)-ANU*ANF(M+1,N+1))+RH2*(AMZ(M+1,N+1)-	FLX	574
1 ANU*AMF(M+1,N+1))	FLX	575
STRNR=STRNB+(STRNA-STRNB)*DNB(L)	FLX	576
CS(L)=STRNL+(STRNR-STRNL)*DMB(L)	FLX	577
CS(L)=1000.*CS(L)	FLX	578
GO TO 200	FLX	579
90 IF(L.GT.9) GO TO 100	FLX	580
WDDL=WDD(M,N)+(WDD(M,N+1)-WDD(M,N))*DNB(L)	FLX	581
WDDR=WDD(M+1,N)+(WDD(M+1,N+1)-WDD(M+1,N))*DNB(L)	FLX	582
CS(L)=WDDL+(WDDR-WDDL)*DMB(L)	FLX	583
CS(L)=0.01*CS(L)	FLX	584
GO TO 200	FLX	585
100 QSL=QS(M,N)+(QS(M,N+1)-QS(M,N))*DNB(L)	FLX	586
QSR=QS(M+1,N)+(QS(M+1,N+1)-QS(M+1,N))*DNB(L)	FLX	587
CS(L)=QSL+(QSR-QSL)*DMB(L)	FLX	588
CS(L)=-1.E-6*CS(L)	FLX	589
200 CONTINUE	FLX	590
TIME=1000.0*FLX	FLX	591
C	FLX	592
WRITE(2,110) HEADER(5),HEADER(6),TIME,(CS(I),I=1,15)	FLX	593
110 FORMAT(A8,A8,/E12.4,/ (6E12.4))	FLX	594
RETURN	FLX	595
END	FLX	596

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SUBROUTINE FLXFILT	FLX	597
C	FLX	598
*CALL COMFLX	FLX	599
LOGICAL COUPLE,SYM	FLX	600
DIMENSION HEADER(8),EXPTIM(9),COMMENT(16),NAME(37)	FLX	601
DIMENSION NBT(37),MBT(37),DNB(37),DMB(37),CS(37)	FLX	602
DIMENSION DTRAN(37), ATRAN(37)	FLX	603
DATA (ATRAN(I),I=1,37) / 0.,90.,180.,0.,0.,0.,0.,170.,10.,10.,	FLX	604
1 10.,0.,6.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,15.,30.,60.,	FLX	605
2 90.,135.,180.,10.,0.,20.,20. /	FLX	606

DATA (DTRAN(1),1=1.37) / 600.,600.,600.,540.,375.,0.,660.,	FLX	607
1 30.,210.,355.,578.,616.,600.,0.,75.,150.,225.,300.,375.,450.,	FLX	608
2 510.,540.,570.,600.,630.,660.,705.,600.,600.,600.,600.,600.,	FLX	609
3 600.,30.,600.,641.,355. /	FLX	610
DATA KTRAN / 1 /	FLX	611
GO TO (10,50),KTRAN	FLX	612
10 KTRAN=2	FLX	613
DPH=360./FLOAT(MB)	FLX	614
IF (SYM) DPH=0.5*DPH	FLX	615
RH1=1./(HN*YM)	FLX	616
RH2=6./(HN*2*YM)	FLX	617
DO 40 L=1,37	FLX	618
DIST1=DTRAN(L)	FLX	619
DO 20 N=2,NB2	FLX	620
DIST2=ZS(N)-0.5*DZS(N)	FLX	621
IF (L.EQ.34) DIST2=ZS(N)	FLX	622
IF (DIST2.GT.1.0001*DIST1) GO TO 25	FLX	623
20 CONTINUE	FLX	624
25 N=N-1	FLX	625
NBT(L)=N	FLX	626
DNB(L)=DIST1-ZS(N)+0.5*DZS(N)	FLX	627
IF (L.EQ.34) DNB(L)=DIST1-ZS(N)	FLX	628
IF (NBT(L).EQ.1.OR.NBT(L).EQ.NB1) DNB(L)=0.	FLX	629
IF (NBT(L).EQ.1) NBT(L)=2	FLX	630
IF (L.NE.34) DNB(L)=DNB(L)*RADZ(NBT(L))	FLX	631
IF (L.EQ.34) DNB(L)=DNB(L)*RDZS(NBT(L)+1)	FLX	632
C	FLX	633
ANGL1=ATRAN(L)	FLX	634
DO 30 M=1,MB2	FLX	635
ANGL2=(FLOAT(M-1)-0.5)*DPH	FLX	636
IF (ANGL2.GT.1.0001*ANGL1) GO TO 35	FLX	637
30 CONTINUE	FLX	638
35 MBT(L)=M-1	FLX	639
DMB(L)=(ANGL1-ANGL2+DPH)/DPH	FLX	640
IF (MBT(L).EQ.1.OR.MBT(L).EQ.MB1) DMB(L)=0.	FLX	641
IF (MBT(L).EQ.1) MBT(L)=2	FLX	642
40 CONTINUE	FLX	643
C	FLX	644
HEADER(1)=10HIDENTIFI	FLX	645
HEADER(2)=10HKATION	FLX	646
PROGNAM=8HK-FIX	FLX	647
PROGVER=4HFLX	FLX	648
CALL DATEH(DAY)	FLX	649
CALL TIMEH(CLOCK)	FLX	650
CASE=4H59.7	FLX	651
IF (COUPLE) CASE=4H59.8	FLX	652
NUMEXP=59	FLX	653
EXPTIM(1)=8HHDR-SNAP	FLX	654
EXPTIM(2)=8HBACK-EXP	FLX	655
EXPTIM(3)=8HERIMENT	FLX	656
COMMENT(1)=8HRUN WITH	FLX	657
COMMENT(2)=8H RELEASE	FLX	658
COMMENT(3)=8HD VERSIO	FLX	659
COMMENT(4)=8HN	FLX	660
NUMTRS=37	FLX	661
NUMTMS=551	FLX	662
HEADER(3)=8HNAMEN	FLX	663
HEADER(4)=8H	FLX	664

NAME (1)=6HKS1311	FLX	665
NAME (2)=6HKS1318	FLX	666
NAME (3)=6HKS1320	FLX	667
NAME (4)=6HKS1309	FLX	668
NAME (5)=6HKS1306	FLX	669
NAME (6)=6HKS1301	FLX	670
NAME (7)=6HKS1313	FLX	671
NAME (8)=6HKS1241	FLX	672
NAME (9)=6HKS1028	FLX	673
NAME (10)=6HKS1024	FLX	674
NAME (11)=6HKS1010	FLX	675
NAME (12)=6HK13263	FLX	676
NAME (13)=6HK12264	FLX	677
NAME (14)=6HKS1201	FLX	678
NAME (15)=6HKS1202	FLX	679
NAME (16)=6HKS1203	FLX	680
NAME (17)=6HKS1204	FLX	681
NAME (18)=6HKS1205	FLX	682
NAME (19)=6HKS1206	FLX	683
NAME (20)=6HKS1207	FLX	684
NAME (21)=6HKS1208	FLX	685
NAME (22)=6HKS1209	FLX	686
NAME (23)=6HKS1210	FLX	687
NAME (24)=6HKS1211	FLX	688
NAME (25)=6HKS1212	FLX	689
NAME (26)=6HKS1213	FLX	690
NAME (27)=6HKS1214	FLX	691
NAME (28)=6HKS1215	FLX	692
NAME (29)=6HKS1216	FLX	693
NAME (30)=6HKS1217	FLX	694
NAME (31)=6HKS1218	FLX	695
NAME (32)=6HKS1219	FLX	696
NAME (33)=6HKS1220	FLX	697
NAME (34)=6HKS3224	FLX	698
NAME (35)=6HKP0255	FLX	699
NAME (36)=6HKP0018	FLX	700
NAME (37)=6HKP0032	FLX	701
HEADER(5)=8HWERTE	FLX	702
HEADER(6)=8H	FLX	703
WRITE(12,900) (NAME(L),ATRA(L),DTRA(L),MBT(L),NBT(L),DMB(L),	FLX	704
1 DNB(L),L=1,37)	FLX	705
900 FORMAT(1H1,10X,30HPARAMETERS FOR HDR TRANSDUCERS, //14X,	FLX	706
1 10HTRANSDUCER,16X,1HM,4X,1HN,6X,13HINTERPOLATION, //3X,3HNO.,	FLX	707
2 8X,5HANGLE,8X,6HHEIGHT,4X,6HBEFORE,2X,5HBELOW,2X,5HANGLE,8X,	FLX	708
3 6HHEIGHT, //(3X,A6,1P2E14.5,215,1P2E14.5)	FLX	709
WRITE(2,1000) HEADER(1),HEADER(2),PROGNAM,PROGVER,DAY,CLOCK,CASE,	FLX	710
1 NUMEXP,(EXPTIM(I),I=1,9),(COMMENT(I),I=1,16),NUMTRS,NUMTMS,	FLX	711
2 HEADER(3),HEADER(4),(NAME(I),I=1,37)	FLX	712
1000 FORMAT(A8,A8/A8/A4/A6/A10/A4/12/9(A8)/9(A8)/7(A8)/15/15/A8,A8,	FLX	713
1 37(/A6))	FLX	714
C	FLX	715
50 DO 200 L=1,37	FLX	716
N=NBT(L)	FLX	717
M=MBT(L)	FLX	718
IF(L.GT.11) GO TO 60	FLX	719
WSL=WS(M,N)+(WS(M,N+1)-WS(M,N))*DNB(L)	FLX	720
WSR=WS(M+1,N)+(WS(M+1,N+1)-WS(M+1,N))*DNB(L)	FLX	721
CS(L)=WSL+(WSR-WSL)*DMB(L)	FLX	722

CS(L)=10.*CS(L)	FLX	723
GO TO 200	FLX	724
60 IF(L.GT.12) GO TO 70	FLX	725
STRNB=RH1*(ANZ(M,N)-ANU*ANF(M,N))+RH2*(AMZ(M,N)-ANU*AMF(M,N))	FLX	726
STRNA=RH1*(ANZ(M,N+1)-ANU*ANF(M,N+1))+RH2*(AMZ(M,N+1)-ANU*	FLX	727
1 AMF(M,N+1))	FLX	728
STRNL=STRNB+(STRNA-STRNB)*DNB(L)	FLX	729
STRNB=RH1*(ANZ(M+1,N)-ANU*ANF(M+1,N))+RH2*(AMZ(M+1,N)-	FLX	730
1 ANU*AMF(M+1,N))	FLX	731
STRNA=RH1*(ANZ(M+1,N+1)-ANU*ANF(M+1,N+1))+RH2*(AMZ(M+1,N+1)-	FLX	732
1 ANU*AMF(M+1,N+1))	FLX	733
STRNR=STRNB+(STRNA-STRNB)*DNB(L)	FLX	734
CS(L)=STRNL+(STRNR-STRNL)*DMB(L)	FLX	735
CS(L)=1000.*CS(L)	FLX	736
GO TO 200	FLX	737
70 IF(L.GT.13) GO TO 80	FLX	738
STRNB=RH1*(ANF(M,N)-ANU*ANZ(M,N))+RH2*(AMF(M,N)-ANU*AMZ(M,N))	FLX	739
STRNA=RH1*(ANF(M,N+1)-ANU*ANZ(M,N+1))+RH2*(AMF(M,N+1)-ANU*	FLX	740
1 AMZ(M,N+1))	FLX	741
STRNL=STRNB+(STRNA-STRNB)*DNB(L)	FLX	742
STRNB=RH1*(ANF(M+1,N)-ANU*ANZ(M+1,N))+RH2*(AMF(M+1,N)-	FLX	743
1 ANU*AMZ(M+1,N))	FLX	744
STRNA=RH1*(ANF(M+1,N+1)-ANU*ANZ(M+1,N+1))+RH2*(AMF(M+1,N+1)-	FLX	745
1 ANU*AMZ(M+1,N+1))	FLX	746
STRNR=STRNB+(STRNA-STRNB)*DNB(L)	FLX	747
CS(L)=STRNL+(STRNR-STRNL)*DMB(L)	FLX	748
CS(L)=1000.*CS(L)	FLX	749
GO TO 200	FLX	750
80 IF(L.GT.33) GO TO 90	FLX	751
WDDL=WDD(M,N)+(WDD(M,N+1)-WDD(M,N))*DNB(L)	FLX	752
WDDR=WDD(M+1,N)+(WDD(M+1,N+1)-WDD(M+1,N))*DNB(L)	FLX	753
CS(L)=WDDL+(WDDR-WDDL)*DMB(L)	FLX	754
CS(L)=0.01*CS(L)	FLX	755
GO TO 200	FLX	756
90 IF(L.GT.34) GO TO 100	FLX	757
VDDL=VDD(M,N)+(VDD(M,N+1)-VDD(M,N))*DNB(L)	FLX	758
VDDR=VDD(M+1,N)+(VDD(M+1,N+1)-VDD(M+1,N))*DNB(L)	FLX	759
CS(L)=VDDL+(VDDR-VDDL)*DMB(L)	FLX	760
CS(L)=0.01*CS(L)	FLX	761
GO TO 200	FLX	762
100 QSL=QS(M,N)+(QS(M,N+1)-QS(M,N))*DNB(L)	FLX	763
QSR=QS(M+1,N)+(QS(M+1,N+1)-QS(M+1,N))*DNB(L)	FLX	764
CS(L)=QSL+(QSR-QSL)*DMB(L)	FLX	765
CS(L)=-1.E-6*CS(L)	FLX	766
200 CONTINUE	FLX	767
TIME=1000.0*TFLX	FLX	768
C	FLX	769
WRITE(2,110) HEADER(5),HEADER(6),TIME,(CS(I),I=1,37)	FLX	770
110 FORMAT(A8,A8,/E12.4,/ (6E12.4))	FLX	771
C	FLX	772
RETURN	FLX	773
END	FLX	774

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SUBROUTINE FLXFTOS FLX 775

C		FLX	776
	*CALL GCOM1	FLX	777
	*CALL GCOM2	FLX	778
	*CALL COMFLX	FLX	779
	DIMENSION DNJ(36), JBN(36)	FLX	780
	DATA KTRAN /1/	FLX	781
C		FLX	782
C	THIS ROUTINE INTERPOLATES PRESSURE DIFFERENCES FROM THE FLUID	FLX	783
C	MESH TO THE STRUCTURE MESH	FLX	784
C	***** NOTE- FOR THE EXAMPLE PROBLEM THE RELATION BETWEEN THE	FLX	785
C	TWO COMPUTING MESHES IS AS FOLLOWS	FLX	786
C	THE FLX CIRCUMFERENTIAL CELL BOUNDARIES COINCIDE WITH	FLX	787
C	THE FLUID CELL AZMUTHAL BOUNDARIES	FLX	788
C	IB1 = 1 INDEX IN FLUID MESH OF THE THE HDR DOWNCOMER REGION	FLX	789
C	JB = NUMBER OF AXIAL CELLS IN FLUID MESH	FLX	790
C	JB1 = JB+1	FLX	791
C	C(9) = J INDEX OF K-FIX FLUID CELL AT LOWER PLENUM TOP	FLX	792
C		FLX	793
C	SET THE FLUID TIME STEP INTO DTFL	FLX	794
	DTFL=DT	FLX	795
	IF (TFLX+0.1*DTS.LT.0.0) RETURN	FLX	796
C		FLX	797
	GO TO (10,50), KTRAN	FLX	798
10	KTRAN=2	FLX	799
	JBOT=C(9)+1.	FLX	800
	JTOP=JB2	FLX	801
	DO 40 N=2,NB1	FLX	802
	DIST=ZS(N)-0.5*DZS(N)	FLX	803
	DO 20 J=JBOT,JTOP	FLX	804
	IF (DIST.LT.(FLOAT(J-JBOT)+0.5)*DZ) GO TO 30	FLX	805
20	CONTINUE	FLX	806
30	JBN(N)=J-1	FLX	807
	DNJ(N)=DIST-(FLOAT(JBN(N)-JBOT)+0.5)*DZ	FLX	808
	IF (JBN(N).EQ.JB1) DNJ(N)=0.	FLX	809
40	CONTINUE	FLX	810
C		FLX	811
50	CONTINUE	FLX	812
	DO 60 M=2,MB1	FLX	813
	K=M	FLX	814
	DO 60 N=2,NB1	FLX	815
	IJ=IB1+JBN(N)*IB2+(K-1)*IB2XJB2	FLX	816
	IJM=IJ-IB2	FLX	817
	IMJ=IJ-1	FLX	818
	PGA=P(IJ)	FLX	819
	PGB=P(IJM)	FLX	820
	PGAP=PGB+(PGA-PGB)*DNJ(N)*RDZ	FLX	821
	PCA=P(IMJ)	FLX	822
	IF (FL(IMJ).EQ.2.OR.FL(IMJ).EQ.3) PCA=P(IMJ-1)	FLX	823
	PCB=P(IJM-1)	FLX	824
	IF (FL(IJM-1).EQ.2.OR.FL(IJM-1).EQ.3) PCB=P(IJM-2)	FLX	825
	PCOR=PCB+(PCA-PCB)*DNJ(N)*RDZ	FLX	826
	QS(M,N)=PCOR-PGAP	FLX	827
60	CONTINUE	FLX	828
	RETURN	FLX	829
	END	FLX	830

```

=====
SUBROUTINE FLXMESH
C
C      *CALL COMFLX
C      RETURNS TABLE OF ZS(N) - THE AXIAL CELL SPACING OF SHELL
C
C      DZTOP = MESH SPACING AT TOP OF CORE BARREL
C      DZBOT = MESH SPACING AT BOTTOM OF CORE BARREL
C
      FNB=FLOAT(NB)
      ZDCF=(DZTOP+DZBOT-2.0*AL/FNB)/((FNB-1.0)*(FNB-2.0))
      ZCCF=(AL/FNB-DZBOT)/(FNB-1.0)-(FNB+1.0)*ZDCF
      ZBCF=DZBOT-ZCCF-ZDCF
      ZS(1)=0.
      DO 10 N=2,NB1
      ZN=FLOAT(N-1)
      ZS(N)=ZS(1)+ZBCF*ZN+ZCCF*ZN**2+ZDCF*ZN**3
10 CONTINUE
      ZS(NB2)=ZS(NB1)+DZTOP
      RETURN
      END

```

FLX	831
FLX	832
FLX	833
FLX	834
FLX	835
FLX	836
FLX	837
FLX	838
FLX	839
FLX	840
FLX	841
FLX	842
FLX	843
FLX	844
FLX	845
FLX	846
FLX	847
FLX	848
FLX	849
FLX	850

```

=====
SUBROUTINE FLXOUT
C
C      *CALL COMFLX
C      OUTPUT ROUTINE FOR STRUCTURE CALCULATION
C
C      LOGICAL SNAP, SYM
C      DATA KTRAN /1/
C
      GO TO (5,10),KTRAN
5 KTRAN=2
  RH1=1./HB
  SRHS1=6./HB**2
  RH2=1./HN
  SRHS2=6./HN**2
10 NCYC=NCYC+NDTS
  IPRT=0
  IF (TFLX+0.1*DTS.LT.TPRINT) GO TO 20
  IPRT=1
  TPRINT=TPRINT+DTPRINT
20 IFLM=0
  IF (TFLX+0.1*DTS.LT.TFILM) GO TO 30
  IFLM=1
  TFILM=TFILM+DTFILM
30 CONTINUE
  IF (IPRT.EQ.1) WRITE (9,130) TFLX,DTS,DTFL,NDTS,NCYC
  IF (IFLM.EQ.1) WRITE (12,130) TFLX,DTS,DTFL,NDTS,NCYC
  DO 60 M=1,MB2
  RH=RH1

```

FLX	851
FLX	852
FLX	853
FLX	854
FLX	855
FLX	856
FLX	857
FLX	858
FLX	859
FLX	860
FLX	861
FLX	862
FLX	863
FLX	864
FLX	865
FLX	866
FLX	867
FLX	868
FLX	869
FLX	870
FLX	871
FLX	872
FLX	873
FLX	874
FLX	875
FLX	876
FLX	877
FLX	878

SRHS=SRHS1	FLX	879
IF (IPRT.EQ.1) WRITE (9,140) M	FLX	880
IF (IFLM.EQ.1) WRITE (12,140) M	FLX	881
IF (IPRT.EQ.1) WRITE (9,150)	FLX	882
IF (IFLM.EQ.1) WRITE (12,150)	FLX	883
DO 50 N=1,NB2	FLX	884
IF (N.NE.3) GO TO 40	FLX	885
RH=RH2	FLX	886
SRHS=SRHS2	FLX	887
40 SMZ=ANZ(M,N)*RH	FLX	888
SMF=ANF(M,N)*RH	FLX	889
SMFZ=ANFZ(M,N)*RH2	FLX	890
SBZ=AMZ(M,N)*SRHS	FLX	891
IF (N.EQ.1) SBZ=AMZ(M,N)*SRHS2	FLX	892
SBF=AMF(M,N)*SRHS	FLX	893
SBZF=AMZF(M,N)*SRHS2	FLX	894
IF (IPRT.EQ.1) WRITE (9,160) N,US(M,N),VS(M,N),WS(M,N),QS(M,N),	FLX	895
1 SMZ,SBZ,SMF,SBF,SMFZ,SBZF	FLX	896
IF (IFLM.EQ.1) WRITE (12,160) N,US(M,N),VS(M,N),WS(M,N),QS(M,N),	FLX	897
1 ,SMZ,SBZ,SMF,SBF,SMFZ,SBZF	FLX	898
50 CONTINUE	FLX	899
60 CONTINUE	FLX	900
IF (.NOT.SNAP) GO TO 90	FLX	901
IF (TFLX.LT.-0.0005.OR.TFLX.GT.0.0) GO TO 90	FLX	902
NS=(NPUSH+NB1)/2	FLX	903
SUM1=0.	FLX	904
SUM2=0.	FLX	905
DO 70 M=2,MB1	FLX	906
SUM1=SUM1+ANFZ(M,NS)*PSINU(M)	FLX	907
SUM2=SUM2*(RAD*ANZ(M,NS)+AMZ(M,NS)-AMZ(M,1))*PCOSW(M)	FLX	908
70 CONTINUE	FLX	909
IF (.NOT.SYM) GO TO 80	FLX	910
SUM1=2.*SUM1	FLX	911
SUM2=2.*SUM2	FLX	912
80 FFB=DS*SUM1	FLX	913
FMB=-DS*SUM2/(ZS(NS)-ZS(NPUSH)+0.5*(DZS(NPUSH)-DZS(NS)))	FLX	914
WRITE (12,170) TFLX,NCYC,PUSH,FFB,FMB	FLX	915
90 CONTINUE	FLX	916
IF (TFLX+0.1*DTS.LT.THIST) GO TO 100	FLX	917
THIST=THIST+DTHIST	FLX	918
WRITE (12,120) TFLX,NCYC,WS(2,2)	FLX	919
IF (NPUSH.NE.2) GO TO 95	FLX	920
CALL FLXFILB	FLX	921
RETURN	FLX	922
95 CALL FLXFILT	FLX	923
100 CONTINUE	FLX	924
RETURN	FLX	925
C	FLX	926
110 FORMAT (3X,3HEOH,1PE12.5,15,1PBE12.5)	FLX	927
120 FORMAT (3X,6HTFLX =,1PE12.5,3X,6HNCYC =,16,3X,9HWS(2,2) =,1PE12.5)	FLX	928
130 FORMAT (1H1,5X,7H TIME=,1PE12.5,6H DTS=,1PE12.5,7H DTFL=,1PE12.	FLX	929
1 5,7H NDT=,13,16H TOTAL CYCLES =,16)	FLX	930
140 FORMAT (1H0,2X,3HM =,13)	FLX	931
150 FORMAT (3X,1HN,6X,1HU,10X,1HV,10X,1HW,9X,2HPD,5X,6H-----,23H-----	FLX	932
1-----,8HSTRESSES,23H-----,6H-----,	FLX	933
2 /52X,6HZ MBRN,5X,6HZ BNDG,5X,6HF MBRN,5X,6HF BNDG,5X,7HZF MBRN,4X	FLX	934
3 ,7HZF BNDG/)	FLX	935
160 FORMAT (1X,13,10(1X,1PE10.3))	FLX	936

170	FORMAT (3X,6HTFLX =.1PE12.5,3X,6HNCYC =.16,3X,6HPUSH =.1PE12.5,3X,	FLX	937
	1 5HFFB =.1PE12.5,3X,5HFMB =.1PE12.5)	FLX	938
	END	FLX	939

===== // =====

	SUBROUTINE FLXREST (KTRAN)	FLX	940
C		FLX	941
	*CALL COMFLX	FLX	942
C	THIS ROUTINE R/W FLX DATA ARRAYS ON TAPE5 FOLLOWING THE K-FIX	FLX	943
C	DATA ARRAYS FOR RESTARTING LONG RUNNING PROBLEMS	FLX	944
C		FLX	945
	GO TO (10,20,30), KTRAN	FLX	946
C		FLX	947
C	THIS IS NOT THE RESTART TIME - SKIP A DUMP	FLX	948
	10 READ (5)	FLX	949
	RETURN	FLX	950
C		FLX	951
C	READ THIS FILE TO FLX DATA ARRAYS	FLX	952
	20 CALL FLX	FLX	953
	READ (5) TFLX,TFILM,TPRINT,((US(M,N),VS(M,N),WS(M,N),UDS(M,N),VDS	FLX	954
	1 (M,N),WDS(M,N),M=1,MB2),N=1,NB2)	FLX	955
	RETURN	FLX	956
C		FLX	957
C	WRITE FLX DATA ARRAYS TO TAPE5 FOLLOWING THE K-FIX(3D) DATA ARRAYS	FLX	958
C		FLX	959
	30 WRITE (5) TFLX,TFILM,TPRINT,((US(M,N),VS(M,N),WS(M,N),UDS(M,N),VDS	FLX	960
	1 (M,N),WDS(M,N),M=1,MB2),N=1,NB2)	FLX	961
	RETURN	FLX	962
	END	FLX	963

===== // =====

	SUBROUTINE FLXSHAK (TFLX,SXDDN,SYDDN,SZDDN)	FLX	964
C		FLX	965
C	PROVIDES THE SEISMIC SHAKE ACCELERATIONS	FLX	966
C		FLX	967
C		FLX	968
	IF (TFLX+0.1*DTS.LT.0.) RETURN	FLX	969
	SXDDN=0.	FLX	970
	SYDDN=0.	FLX	971
	SZDDN=0.	FLX	972
	RETURN	FLX	973
	END	FLX	974

===== // =====

	SUBROUTINE FLXSTOF	FLX	975
C		FLX	976

*CALL GCOM1	FLX	977
*CALL GCOM2	FLX	978
*CALL COMFLX	FLX	979
DIMENSION DNJ(34), NBJ(34)	FLX	980
DATA KTRAN /1/	FLX	981
C	FLX	982
C THIS ROUTINE INTERPOLATES RADIAL VELOCITIES FROM THE SHELL	FLX	983
C MESH TO THE FLUID MESH	FLX	984
C	FLX	985
C IB IS THE K-FIX(3D) I INDEX FOR THE FLUID CELL IN THE CORE	FLX	986
C ADJACENT TO THE CORE BARREL WALL	FLX	987
C	FLX	988
IF (TFLX+0.1*DTS.LT.0.) RETURN	FLX	989
GO TO (10,50), KTRAN	FLX	990
10 KTRAN=2	FLX	991
JBOT=C(9)+1.	FLX	992
JTOP=JB1	FLX	993
DO 40 J=JBOT,JTOP	FLX	994
DISTJ=(FLOAT(J-JBOT)+0.5)*DZ	FLX	995
DO 20 N=1,NB2	FLX	996
DISTN=ZS(N)-0.5*DZS(N)	FLX	997
IF (DISTN.GT.DISTJ) GO TO 30	FLX	998
20 CONTINUE	FLX	999
30 NBJ(J)=N-1	FLX	1000
DNJ(J)=DISTJ-(ZS(N-1)-0.5*DZS(N-1))	FLX	1001
40 CONTINUE	FLX	1002
C	FLX	1003
50 DO 70 K=2,KB1	FLX	1004
M=K	FLX	1005
DO 60 J=JBOT,JTOP	FLX	1006
N=NBJ(J)	FLX	1007
IJ=IB+(J-1)*IB2+(K-1)*IB2XJB2	FLX	1008
WDA=WDS(M,N+1)	FLX	1009
WDB=WDS(M,N)	FLX	1010
UL(IJ)=WDB+(WDA-WDB)*DNJ(J)*RADZ(N)	FLX	1011
IF (N.EQ.1) UL(IJ)=WDA	FLX	1012
UG(IJ)=UL(IJ)	FLX	1013
IF (J.NE.JBOT) GO TO 60	FLX	1014
UL(IJ-1)=UL(IJ)	FLX	1015
UG(IJ-1)=UL(IJ)	FLX	1016
60 CONTINUE	FLX	1017
70 CONTINUE	FLX	1018
RETURN	FLX	1019
END	FLX	1020

..... // // // //

SUBROUTINE FLXWDIS	FLX	1021
C	FLX	1022
*CALL COMFLX	FLX	1023
C COMPUTE DISPLACEMENT AND VELOCITY OF STRUCTURE NODE(S)	FLX	1024
C DURING INITIALIZATION OF SNAP-BACK PROBLEM	FLX	1025
C	FLX	1026
IF (TFLX+0.1*DTS.GT.0.) RETURN	FLX	1027
WS(2,NPUSH)=WMAX	FLX	1028

WDS(2,NPUSH)=0.	FLX	1029
IF (TFLX.GT.TSTART+0.050) RETURN	FLX	1030
WDS(2,NPUSH)=20.*WMAX	FLX	1031
WS(2,NPUSH)=WDS(2,NPUSH)*(TFLX-TSTART)	FLX	1032
RETURN	FLX	1033
END	FLX	1034

----- //-----

*B,KFIXCC.1504		
C ADDITION TO SUBROUTINE PROG TO IMPLIMENT FLX RESTART	FLX	1035
C CALL FLXREST (3)	FLX	1036
*I,KFIXCC.1562		
C CALL FLXREST (1)	FLX	1037
C ADDITION TO SUBROUTINE RTAPES TO IMPLIMENT FLX RESTART	FLX	1038
CALL FLXREST (1)	FLX	1039
*B,KFIXCC.1567		
CALL FLXREST (2)	FLX	1040
*I,KFIXCC.1988		
C CALL FLXREST (2)	FLX	1041
C ADDITION TO SUBROUTINE TILDE TO IMPLIMENT STRUCTURE CALCULATION	FLX	1042
IF (CYCLE.EQ.0) CALL FLX	FLX	1043
CALL FLXA	FLX	1044
	FLX	1045

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