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CASKS (Computer Analysis of Storage CasKS): A Microcomputer Based Analysis System for Storage Cask Design Review

User's Manual to Version 1b
(Including Program Reference)

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Abstract

CASKS (Computer Analysis of Storage casKS) is a microcomputer-based system of computer programs and databases developed at the Lawrence Livermore National Laboratory (LLNL) for evaluating safety analysis reports on spent-fuel storage casks. The bulk of the complete program and this user's manual are based upon the SCANS (Shipping Cask ANalysis System) program previously developed at LLNL. A number of enhancements and improvements were added to the original SCANS program to meet requirements unique to storage casks. **CASKS** is an easy-to-use system that calculates global response of storage casks to impact loads, pressure loads and thermal conditions. This provides reviewers with a tool for an independent check on analyses submitted by licensees.

CASKS is based on microcomputers compatible with the IBM-PC family of computers. The system is composed of a series of menus, input programs, cask analysis programs, and output display programs. All data is entered through fill-in-the-blank input screens that contain descriptive data requests.

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Executive Summary

Lawrence Livermore National Laboratory previously developed a microcomputer-based analysis system—SCANS—to assist the Nuclear Regulatory Commission in performing confirmatory analyses for licensing review of radioactive-material shipping cask designs. Because the structure of the shipping cask and the storage cask are similar, we have employed the basic SCANS program to simulate the responses of a storage cask under impact or thermal conditions. A number of enhancements and additions unique to the storage cask were added to the program; however, the overall program layout remains the same. The modified program is named **CASKS**. This volume is the user's manual and program reference which closely follows the format in SCANS Vol. 1—User's Manual to Version 1a. In this volume, we describe the system requirements, installation and operation of **CASKS**, the contents of the **CASKS** distribution diskettes, how **CASKS** is implemented in a DOS environment, and the structure of **CASKS** databases. Theory documents for each analysis module can be found in Volumes 2-5 of SCANS. Appendix G includes the titles and contents for each theory document.

Introduction

CASKS (Computer Analysis of Storage CasKS*) Based on the SCANS System

The U.S. Nuclear Regulatory Commission previously requested that the Lawrence Livermore National Laboratory develop an integrated software system to conduct confirmatory analyses of *shipping casks*. The analyses were to ensure structural integrity under a series of normal operating loads and hypothetical accident loads as specified in Title 10 of the *Code of Federal Regulations* (1983). As a result, **SCANS** Version 1a was produced by LLNL in 1988.

SCANS is a microcomputer-based system of computer programs for evaluating safety analysis reports on spent-fuel shipping casks. The system is easy to use and provides an independent check for reviewing the analyses submitted by licensees. **SCANS** calculates the global response of the shipping casks to impact loads, thermal conditions and pressure loads.

In 1989, the U.S. Nuclear Regulatory Commission requested that LLNL develop a microcomputer-based computer program for evaluating the safety analysis reports on *spent-fuel storage casks* based on the **SCANS** code. Because the structural designs of the two casks are similar, we used the existing framework in the **SCANS** program and made a number of enhancements and modifications to accommodate requirements unique to storage casks. The modified program is named **CASKS**. This user's manual describes the system requirements, installation and operation of **CASKS**.

CASKS System Design

Structured the same way as **SCANS**, the **CASKS** system is composed of a series of menus, input programs, cask-analysis programs and output-display programs. **CASKS** performs the analysis after the user prepares the input data and chooses an appropriate analysis—impact, thermal (heat transfer), thermally-induced stress, or pressure-induced stress. All data is entered through fill-in-the-blank input screens with descriptive data requests. **CASKS** provides default values where possible and always evaluates input data for correctness before it is accepted.

To evaluate impact analyses, **CASKS** uses a one-dimensional dynamic beam model. Each node in the beam model has two translational degrees of freedom and one rotational degree of freedom. The impact code uses an explicit time-history integration scheme in which equilibrium is formulated in terms of the global external forces and internal force resultant. This formulation allows the code to track large, rigid-body motion. Thus, **CASKS** can calculate the oblique impact problem from initial impact through essentially rigid-body rotation to secondary impact, and, if required, lateral pressure due to lead-slump.

CASKS allows the user to analyze cask impact on either an unyielding or a yielding surface. A yielding surface is represented as a series of nonlinear force-deflection relationships. To analyze yielding surface cask impact, CASKS first combines the surface force-deflection relationship with the force-deflection relationships of the cask impact limiter prior to the analysis.

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Introduction

Most of the storage casks do not require impact limiters. However, CASKS code requires the user to specify the impact limiter force-deflection curve before the code can be executed, even when there are no physical impact limiters on the cask. This requirement can be thought of as the relative 'stiffness' or 'flexibility' of the part of the cask that contacts the target on impact. The 'stiffness' of the cask is derived by entering a 'pseudo' force-deflection curve for the cask.

Based on the general geometry description, **CASKS** automatically generates appropriate, two-dimensional finite-element meshes for thermal, thermal-stress, and pressure-stress analyses. **CASKS** allows steady-state or transient thermal analyses, which may include phase change, time- and/or temperature-dependent material properties, time and/or temperature boundary conditions, and internal heat generation. Possible thermal boundary conditions include specified temperature, heat flux, convection, radiation, interface contact resistance, and nonlinear heat transfer to a bulk node. Thermal analyses use 4-node elements. Thermal-stress and pressure-stress analyses are performed using a linear-elastic static structural analysis program which allows temperature-dependent material properties. Stress analyses use 9-node elements.

Users can choose to display or print the graphical output. Graphic displays include: impact force, moment and shear time histories; impact animation; thermal/stress geometry outline; thermal/stress element outlines; temperature distributions as iso-contours or profiles; and temperature-time histories.

CASKS Menu Structure

CASKS uses a series of menus to coordinate input programs, cask analysis programs, output programs, data archive programs and databases. **Figure 1-1** illustrates the menu structure. The menus are ordered according to the stages of analysis.

CASKS requires only the press of a single key to make menu and subtask selections. **CASKS** indicates the available selections on each display screen and describes what action **CASKS** will take. For example, on the Main Menu, **CASKS** indicates that the appropriate keys to press are **1 2 3 4 5 6** and **Q** (where **Q** returns you to DOS).

The user enters data through fill-in-the-blank input screens. Full editing features are available (insert, delete, move cursor, overtype, etc.). The system accepts data items when you move the cursor to another data field.

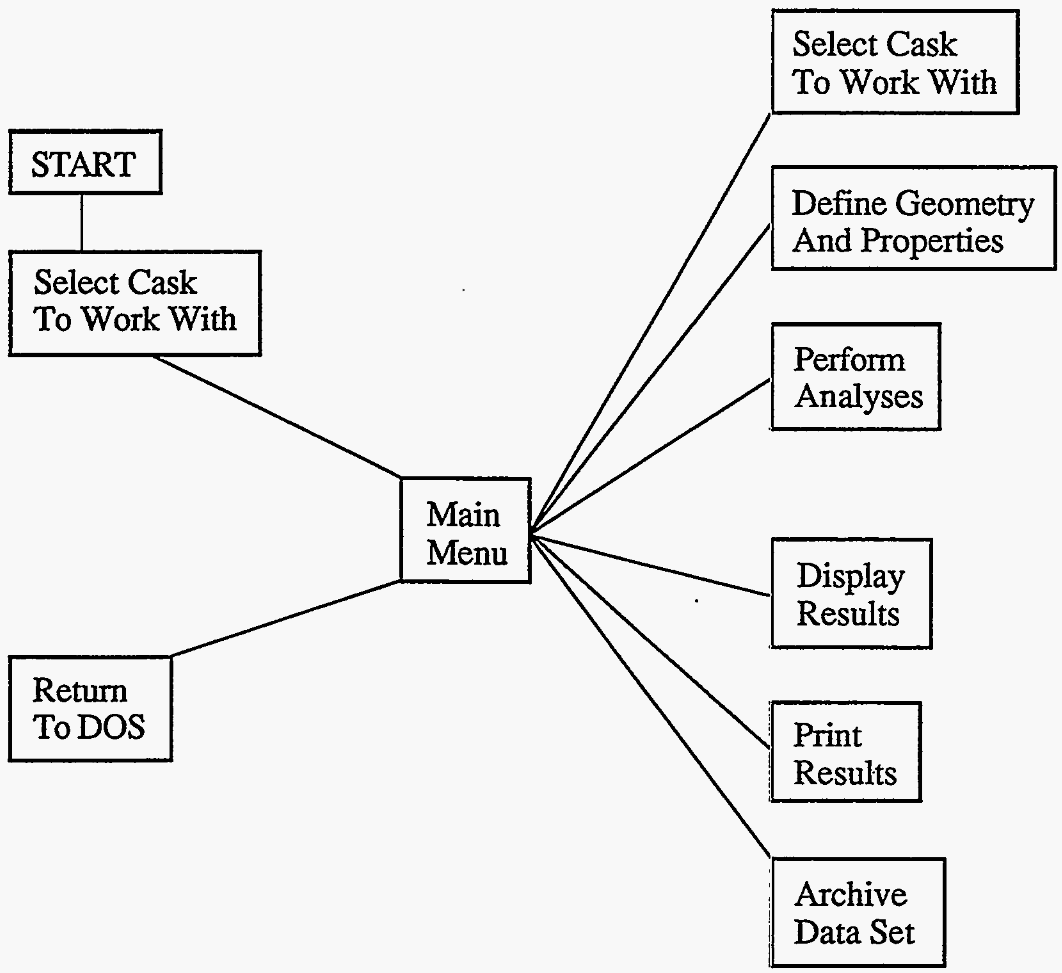


Figure 1-1. CASKS menu structure.

Introduction

Required Hardware and Software

CASKS Required Hardware

CASKS is designed for microcomputers compatible with the IBM-PC family of computers. The minimum required hardware configuration is an IBM "XT" with the following:

10 Mbyte hard disk drive
360 Kbyte floppy disk
640 Kbyte RAM
CGA Board (Color Graphics Adapter)
Color Graphics Monitor
8087 Math co-processor chip
IBM or EPSON Graphics printer

Upgraded Hardware Configuration

CASKS functions on MS-DOS computers including the 80486 class of machines. A typical upgraded configuration is an IBM IBM PS2 Model 80 (80386 processor) with the following:

40 Mbyte hard disk drive
1.44 Mbyte floppy disk (High Density)
360 Kbyte floppy disk (external)
640 Kbyte RAM
VGA Board (Video Graphics Array)
VGA Color Monitor
80387 Math co-processor chip
HP LaserJet, LaserJet+, or LaserJet Series II printer

Required DOS Files

CASKS requires the operating system DOS version 3.1 or later. The DOS command files listed below must be present in the root directory of the *booting* hard disk drive:

AUTOEXEC.BAT
ANSI.SYS
CONFIG.SYS

The following DOS file must be in the root directory of the hard disk drive which will *contain* **CASKS**:

COMMAND.COM

Include the following lines in the **CONFIG.SYS**** file:

DEVICE=ANSI.SYS
BREAK ON
FILES=15
BUFFERS=15

** The files **CONFIG.SYS** and **AUTOEXEC.BAT** and the command **PATH** are described in the DOS reference manual.

Include the following path in the **AUTOEXEC.BAT**** file:

PATH *x*:\ (where *x* is the hard disk drive which contains CASKS)

Required DOS Programs

The DOS programs listed below must be available through the current PATH.

MODE.COM
BACKUP.COM
RESTORE.COM

** The files **CONFIG.SYS** and **AUTOEXEC.BAT** and the command **PATH** are described in the DOS reference manual.

Installing CASKS

The **CASKS** release package contains four, 5-1/4-inch double-density distribution diskettes (or two 5-1/4-inch high-density diskettes for 1.2Mb disk drives). The programs and control files on the distribution diskettes occupy approximately 2.6Mb of disk space and must be installed on a hard disk drive. The following instructions will help you install CASKS. The left hand column lists "user input" and the right hand column describes the system response or additional information you might need.

NOTE: Press **Q** at any time to abandon installation of **CASKS. INSTALL** will ask for verification before terminating the installation.

How to Install **CASKS:**

User input	System response / additional information
(1) Be sure the DOS file **COMMAND.COM** is in the root directory of the hard disk drive which will *contain* **CASKS.**	
(2) Insert diskette number 1 into drive **A:** or **B:**	
(3) If using drive A:, type <u>A:INSTALL</u> If using drive B:, type <u>B:INSTALL</u>	
(4) Press **S** to select the hard disk drive where CASKS will reside *or* Press **Q** to QUIT and return to DOS.	If you press **S, INSTALL** displays the available hard disk drives on your system.
(5) Press the indicated letter to select the drive where **CASKS** will reside *or* Press **Q** to QUIT and return to DOS.	**INSTALL** displays the space remaining on the selected hard disk drive, creates the **CASKS** subdirectory, and prompts for **CASKS** diskette number 1.
(6) Insert each diskette as requested into either drive **A:** or **B:**. Press **A** or **B** as required to install that disk. Repeat for all distribution diskettes.	

Installing CASKS

The program **INSTALL** performs the following installation operations:

- **INSTALL** determines how many hard disk drives exist on the system, lists the hard disk drives, and asks for the drive that will contain **CASKS**.
- **INSTALL** checks the selected hard disk drive for enough space. **CASKS** cannot be partially installed. If there is not enough space, either remove files from the hard disk drive to create room or select a different hard disk drive (if available).
- **INSTALL** creates the subdirectory **\CASKS** on the selected hard disk. If an older version of **CASKS** is already installed, **\CASKS** is renamed to **\CASKSnn** (where **nn** is the previous **CASKS** version number) before **\CASKS** is created. If the same version of **CASKS** is already installed, **INSTALL** asks if you want to reinstall **CASKS**.
- **INSTALL** copies the program and control files from the distribution diskettes. **INSTALL** asks for each **CASKS** diskette in order.
- **INSTALL** unpacks the sample data set and other packed files. This process takes a few minutes to complete.
- **INSTALL** updates the **CASKS** procedure to identify the selected hard disk.

How to Run the **CASKS** Program:

Once installation is complete, start **CASKS** by typing:

CASKS <then press Enter or Return>

CASKS displays the title and disclaimer screen shown in **Figure 1-2.**

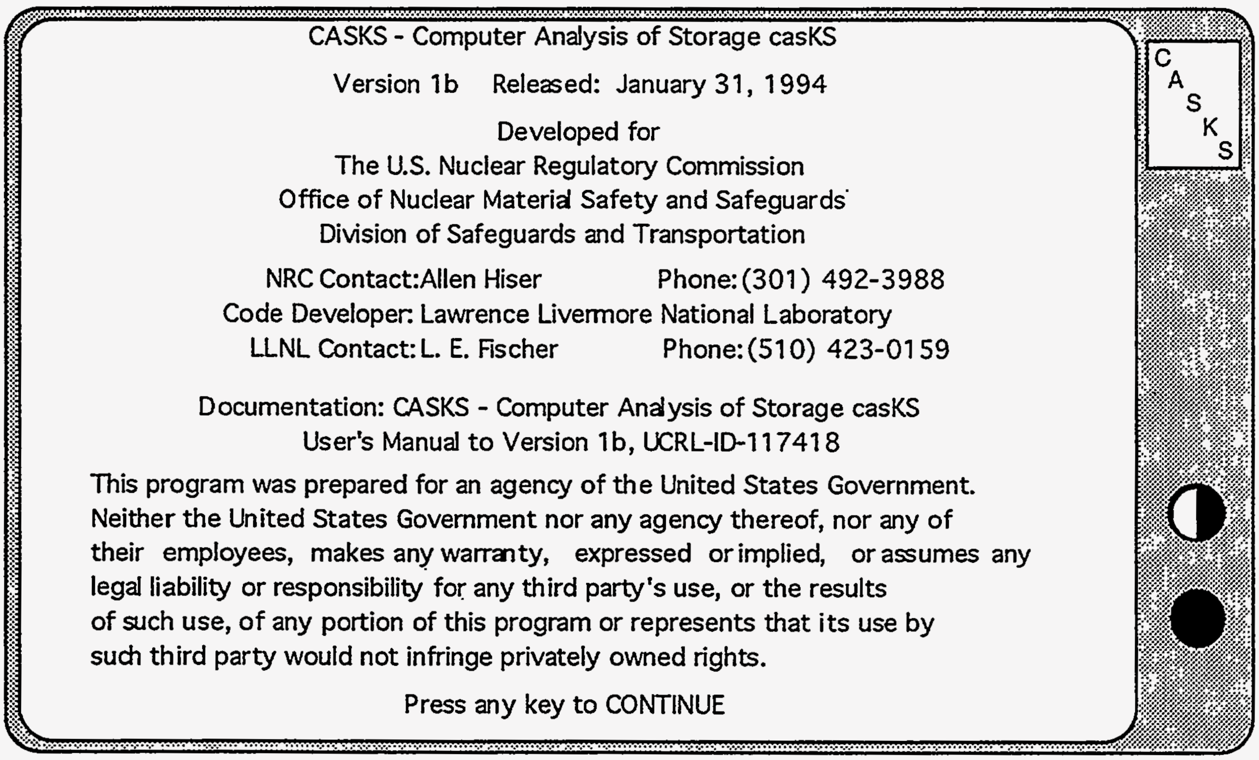


Figure 1-2. Title and disclaimer screen. (Displayed when CASKS is started.)

Press any key to continue.

CASKS automatically initiates the **Select Cask** process and searches for cask data sets that already exist.

The system displays the number of existing data sets. The screen you see will vary depending on whether no data sets exist, only one data set exists, or more than one data set exists.

Press **Q** to Quit
or
Press any other key to continue.

If no data sets exist, enter a new CASKID.

The CASKID is a four-digit number that identifies the cask data set. All four digits are required. For example, to specify a CASKID of 77, enter **0077**. Enter **Q** to QUIT and return to DOS.

or

When only one data set exists, **CASKS** displays a summary of the data set (**Figure 1-3**) and offers three choices:

Press **N**	to select a new CASKID by direct entry
Press **P**	to Proceed with the indicated CASKID (**CASKS** displays the Main Menu)
Press **Q**	to QUIT and return to DOS

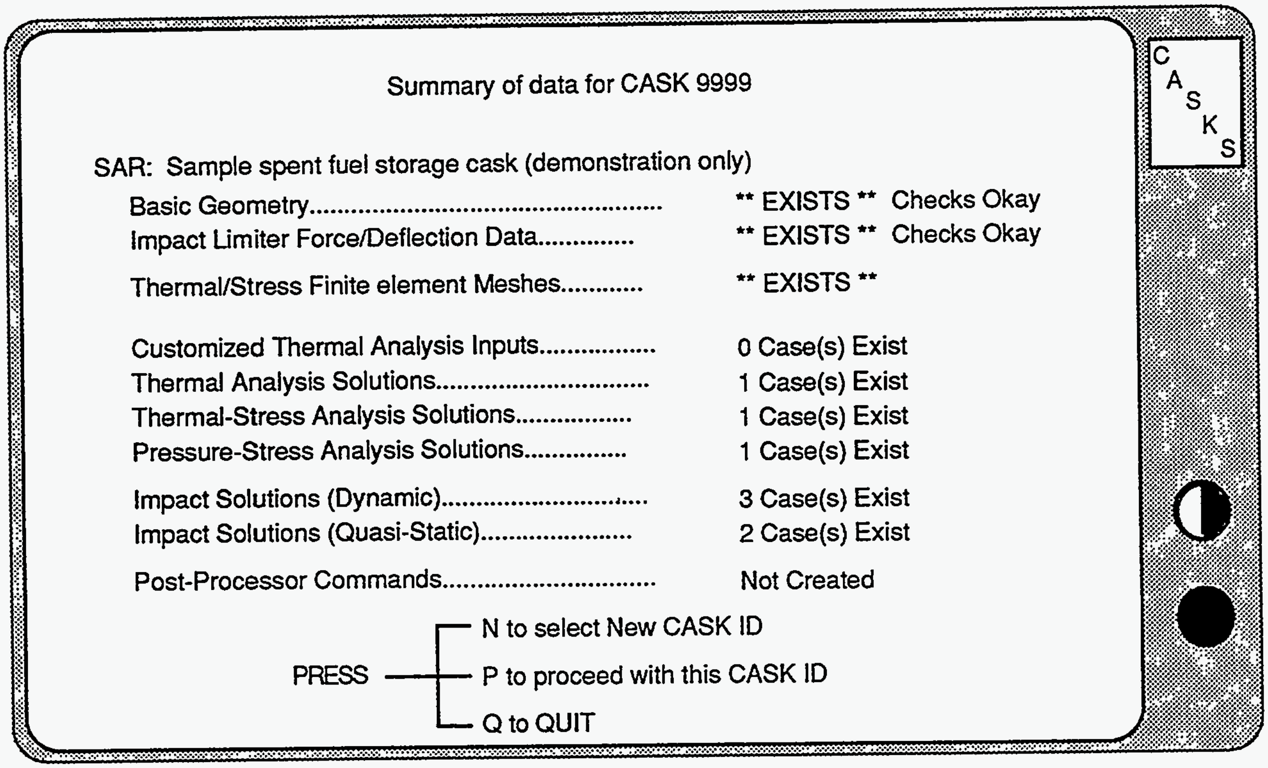


Figure 1-3. Cask data set summary screen.

or

If more than one data set exists, **CASKS** displays a list of CASKIDs and several options:

Press **N** to select a new CASKID by direct entry

Press **S** to select the highlighted CASKID and display data set summary

Press **Q** to QUIT and return to DOS

Press ↑ to highlight the previous CASKID

Press ↓ to highlight the next CASKID

When **S** is pressed, the Summary Screen options are:

Press **S** to select a different CASKID (return to the CASKID list screen)

Press **P** to proceed with the specified CASKID (**CASKS** displays the Main Menu)

Press **Q** to QUIT and return to DOS

After you select a CASKID, **CASKS** displays the Main Menu. The first step for a new data set is to define the basic geometry. Once the geometry definitions exist, CASKS will perform an analysis, display the graphical results (if applicable) and then print the results. You can select each of these operations from the Main Menu.

NOTES:

Main Menu

The Main Menu (**Figure 2-1**) is the central hub of **CASKS**. It provides access to five task menus and the select cask facility. The task menus are connected only through the Main Menu. They cannot call each other directly.

PRESS 1 to Select a new CASK ID

The select cask facility is similar to the select cask process when you start **CASKS**, except that when you press **Q**, you return to the Main Menu instead of leaving **CASKS** and returning to DOS.

PRESS 2 to Create/Modify the CASK geometry model (Geometry Menu)

Select this task first to create a new cask data set. **CASKS** displays the Geometry Menu which provides tasks for: (1) creating new (or modifying previous) basic geometry definitions and impact limiter force-deflection curves; (2) copying basic geometry or limiter curves from a different cask data set; and (3) creating new (or modifying previous) yielding surface user-input force-deflection curves.

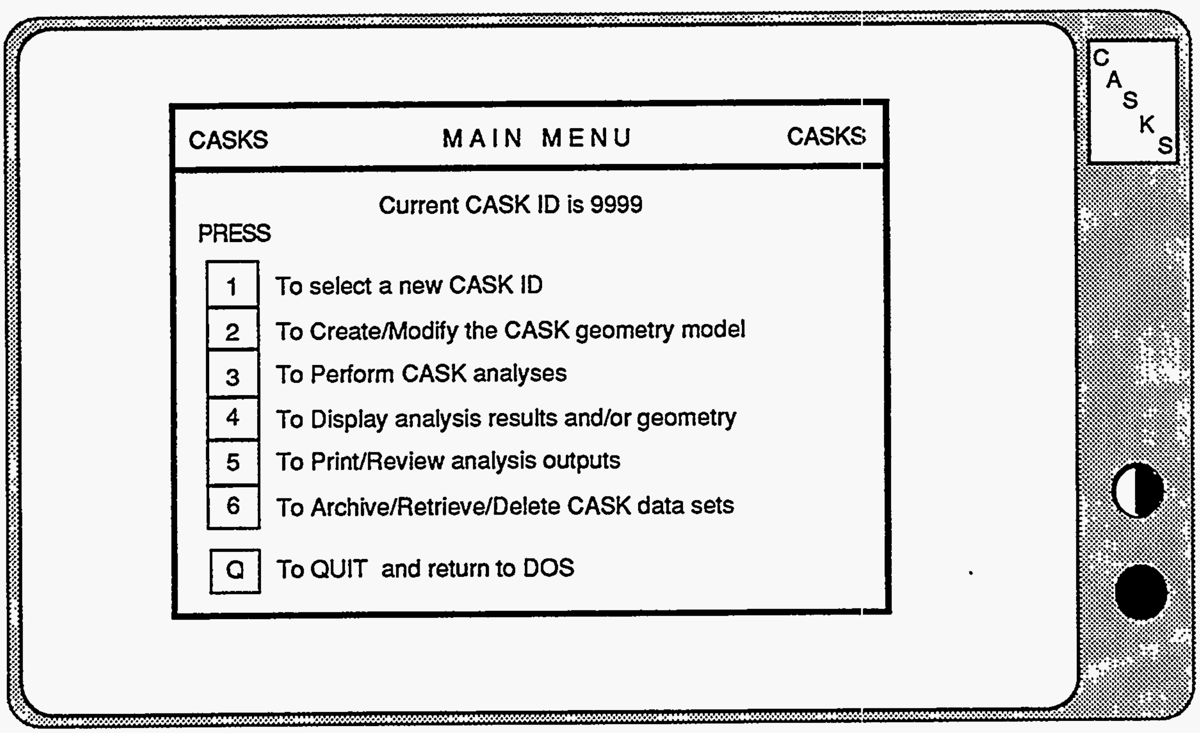


Figure 2-1. CASKS Main Menu.

Main Menu

PRESS 3 to Perform CASK analyses (Analysis Menu)

CASK analyses are performed after defining the cask geometry and, if necessary, the impact limiter force-deflection curves. **CASKS** displays the Analysis Menu, which provides tasks to perform analyses involving impact loads, thermal distributions and stresses, and pressure loads.

PRESS 4 to Display analysis results and/or geometry (Display Menu)

CASKS displays the Display Menu which provides tasks for: (1) plotting dynamic impact time-histories; (2) displaying and printing finite-element meshes used for thermal, thermal-stress and pressure-stress calculations; and (3) plotting thermal distributions as iso-contours, time histories, or thermal profiles. The finite-element meshes can be displayed before any analysis is performed. Results cannot be plotted until the appropriate analysis is performed.

PRESS 5 to Print/Review analysis outputs (Print/Review Menu)

CASKS displays the Print/Review Menu, which provides tasks for printing or reviewing all printable outputs (analysis results or the cask summary and data check). Printing an output sends it to the printer; reviewing an output displays it on the screen.

PRESS 6 to Archive/Retrieve/Delete CASK data sets (Archive Menu)

CASKS displays the Archive Menu which provides tasks for: (1) archiving cask data sets; (2) retrieving previously archived data sets; and (3) deleting cask data sets (complete data sets or just the output) from the hard disk.

PRESS Q to QUIT and return to DOS

CASKS terminates the session and returns to DOS in the root directory of the hard disk which contains **CASKS**.

Geometry Menu

The Geometry Menu (**Figure 3-1**) provides tasks for creating new (or modifying previous) basic geometry definitions: impact limiter force-deflection curves, yielding surface force-deflection curves, and modifying material data set.

PRESS 1 to Create/Modify basic geometry

If the basic geometry definition data set exists, editing is initiated. If the basic geometry data does not exist, **CASKS** creates a new data set with default values, and editing is initiated. When the basic geometry is saved, **CASKS** automatically performs a data check. Basic geometry definitions must be completed and pass the data check before **CASKS** will perform an analysis.

PRESS 2 to Create/Modify impact limiter F/D curves

If the impact limiter force-deflection curve data set exists, editing is initiated. If the limiter curve data does not exist, **CASKS** creates a new data set with default values, and editing is initiated. When the limiter curve data is saved, **CASKS** automatically performs a data check. Limiter force-deflection curves must be defined and pass the data check before **CASKS** will perform an impact analysis.

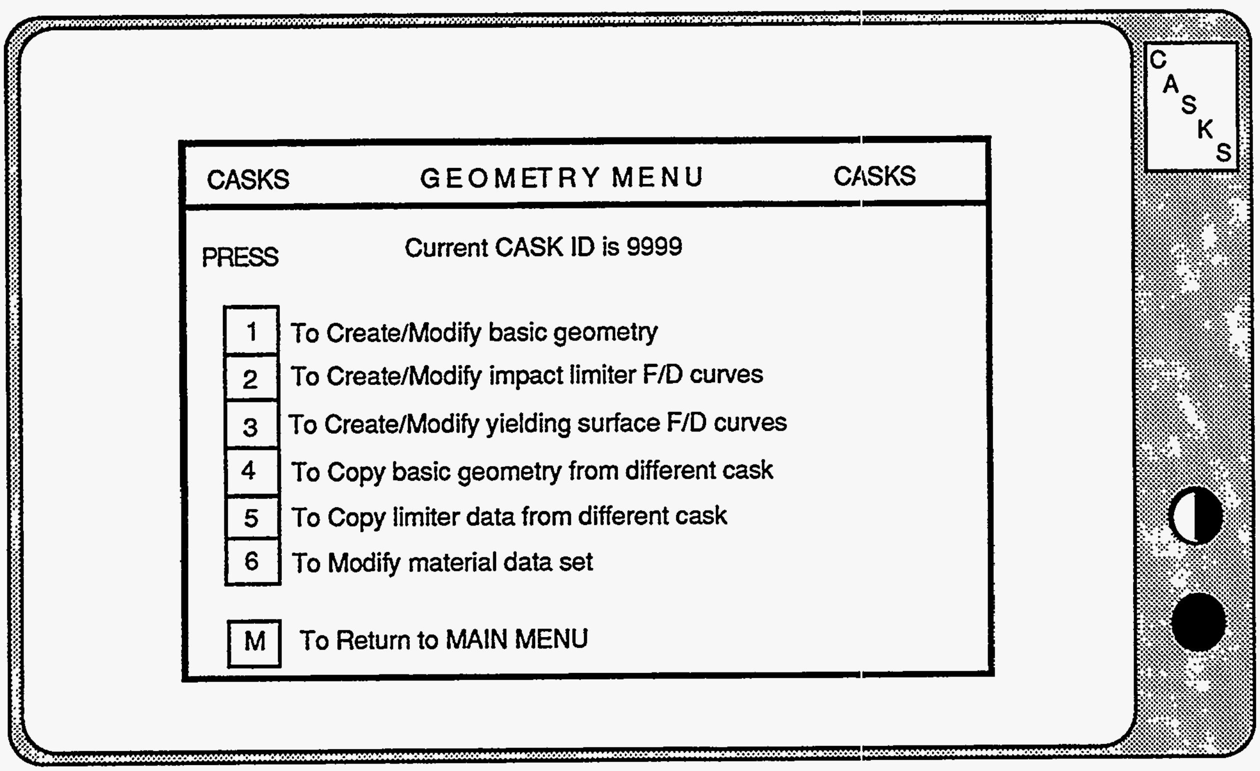


Figure 3-1. CASKS Geometry Menu.

Geometry Menu

PRESS 3 to Create/Modify yielding surface F/D curves

Editing is initiated with previously created cases, if any. A total of nine different surface F/D curves (cases) can be created and/or modified. When the surface curve data is saved, **CASKS** automatically performs a data check before returning to the Geometry Menu.

PRESS 4 to Copy basic geometry from different cask

Use this feature to create the basic geometry definition data set by copying it from the existing data set for a different cask. Then, modify the data set to resolve any differences between the casks.

CASKS lists the available basic geometry definition data sets from other casks. Use the cursor keys to highlight the data set to copy, then press **S**. If a basic geometry data set already exists for the current cask, **CASKS** asks for confirmation before copying the selected data set over the current one.

PRESS 5 to Copy limiter data from different cask

Use this feature to create the impact limiter force-deflection curve data set by copying it from the existing data set for a different cask. Then, modify the data set to resolve any differences between the casks.

CASKS lists the available limiter curve data sets from other casks. Use the cursor keys to highlight the data set to copy, then press **S**. If a limiter curve data set already exists for the current cask, **CASKS** asks for confirmation before copying the selected data set over the current one.

PRESS 6 to Modify material data set

Use this feature to create/modify a material data set. Locked files may not be edited. A new material data set may be created using the C (copy) option to copy an existing material file then input all necessary data pertaining to this material.

PRESS M to Return to MAIN MENU

CASKS returns to the Main Menu display.

CASKS uses a general purpose fill-in-the-blank type editor to enter data for the basic geometry definition, the impact limiter and yielding surface force-deflection curve definitions. Appendix A has a complete description of the editor features, displays, and usage. A condensed description of how to use the editor is included here.

The editor title screen indicates the status of the data set. To abandon editing at this point, press **Q** to quit and return to the Geometry Menu. If the data set does not exist, press any other key to create the data set using default values. If the data exists, press **D** to delete the data set and create a new one or press any other key to edit the existing data set. When **D** is selected, **CASKS** asks for confirmation before proceeding.

The editor reads a template which describes the editor screens and, if creating a new data set, identifies each editor page as it is created with the appropriate default values. The editor then displays the first editor page. Each page contains related data, and each data field has a descriptive label indicating what to enter (units are indicated if appropriate).

IMPORTANT: All fields displayed in light blue are required inputs. Fields displayed in green have default values which can be changed or accepted as is.

On each page display, in the upper left hand corner, the editor displays the number of pages which must be accessed. These pages have fields that must be filled in before the data set is considered complete. The page list display also identifies these pages. *Be sure to move to each field that is labeled in light blue.* If necessary, enter the appropriate data.

Use the following keys to edit a field:

Characters, numbers and special symbols to enter the appropriate data
(Typing in the first character position clears the field)
Keypad left and right arrow keys to position the cursor
DEL and backspace keys to delete characters
INS key to toggle between insert and overtype modes

Use the following keys to accept a field and go to another:

Keypad up and down arrow keys or **ENTER** to move to previous or next field on current page.
Keypad **PgUp** and **PgDn** to move to first field on previous or next page.

Use the following keys for help, redefaulting and special control:

ESC to display help relating to the current field and a description of all the editing keys.

F1 to display a list of all the pages in the data set. Use the keypad up and down arrow keys to highlight the desired page and then press **F1** again to move to the indicated page. The page list screen indicates which pages have data fields that must be filled in.

F2 saves the data set, terminates the editor, and returns to the current menu.

F3 abandons editing. **CASKS** asks for confirmation before proceeding.

F4 saves the data set and continues editing.

F5 prints the displayed page on the printer. Make sure the printer is on-line.

F6 resets the current field to its default value.

F7 resets all fields on the current page to their default values.

If the entered data is invalid for the specified field, the editor displays an error message at the bottom of the screen and indicates any restrictions on the data item. Press **ENTER** to clear the error message and return to editing.

See Appendix A for a more complete description of the editor and its features.

CASKS uses a simplified cask model comprised of seven components: (1) cask cavity, (2) shell, (3) top end cap, (4) bottom end cap, (5) top impact limiter, (6) bottom impact limiter, and (7) neutron shield and water jacket. The general form of this cask model is shown in **Figure 3-2.** The shell and end caps can be either solid (single layer) or laminated (two or three layers). The cavity, shell and end caps must be defined for each analysis. Impact limiters are optional but are required for impact calculations. The neutron shield/water jacket is optional and, if included, used only for thermal analyses. Mesh division values are used to generate two-dimensional finite-element meshes for thermal, thermal-stress and pressure-stress analyses. The geometry definition is described in the context of the editor pages that follow.

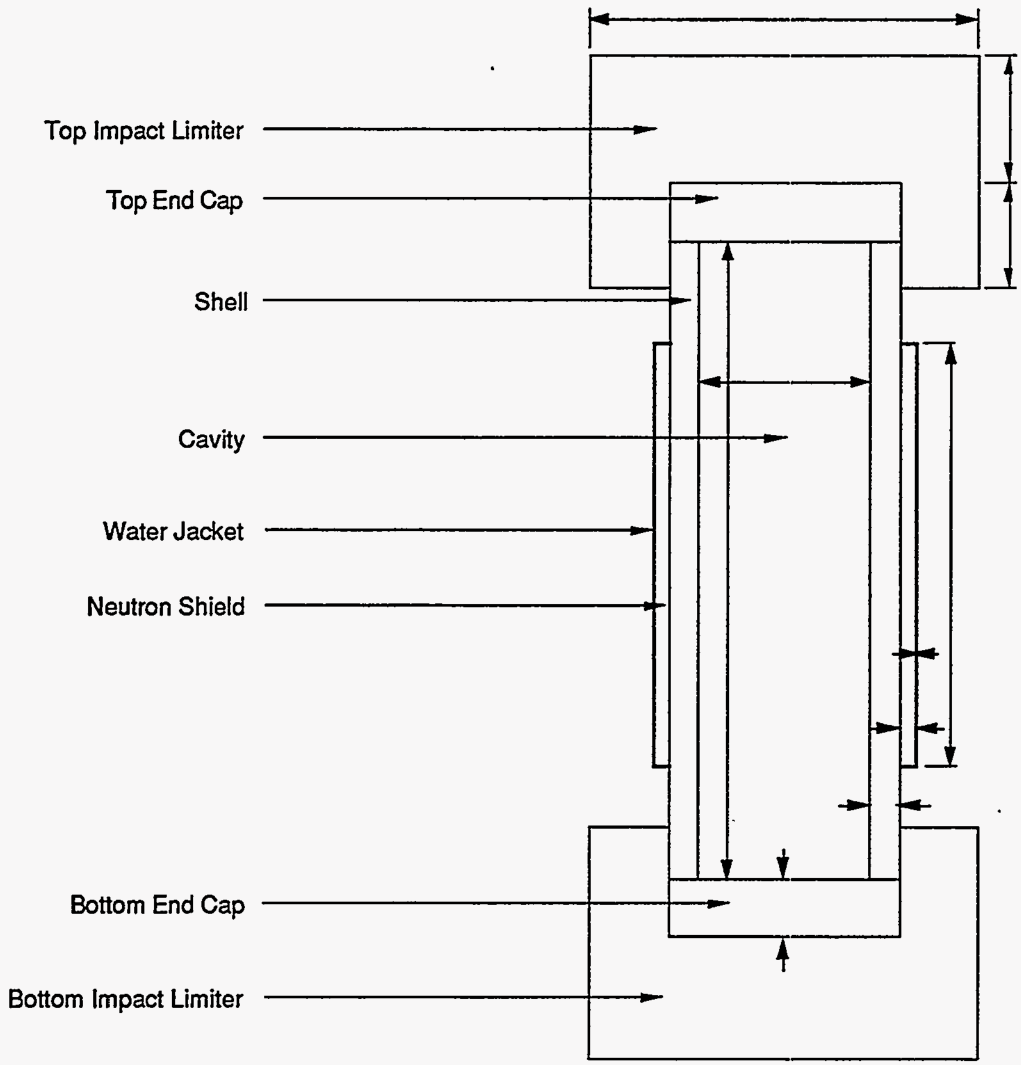


Figure 3-2. CASKS simplified cask model.

Geometry Menu
Defining the Geometry

Basic Geometry PAGE 1 General SAR Information

The SAR title is required. Four fields are provided for other SAR information, three fields are provided for additional information, and three for the submitting company's address. All fields on this page are character type and are not checked for validity.

Basic Geometry PAGE 2 Reviewer Information

There is no required data on this page. It is provided to document the persons involved in the cask evaluation. All fields are character type and are not checked for validity.

Basic Geometry PAGE 3 Cask Cavity/Contents Specifications

The cavity dimensions and the weight specifications are required for all analyses. The maximum heat generation rate is required for thermal and thermal-stress analyses.

Field Name	Description
Cavity Inner Radius	Required Positive. Must be less than 2000.
Cavity length (in.)	Required Positive. Must be less than 2000.
Gross weight of package (lbs.)	Required Positive Includes the cask body, impact limiters, internal structures, and spent-fuel contents.
Weight of spent-fuel contents and internal structures (lbs.)	Required Positive
Maximum heat generation rate of the spent fuel contents (Btu/min).	Positive Used for thermal and thermal-stress analyses.

Basic Geometry PAGE 3 Cask Cavity/Contents Specifications (con't.)

Field Name	Description
Temperature defining stress free condition (degrees F).	Must be greater than or equal to -100°F. Used for thermal-stress analyses. May be changed during specification of the thermal-stress analysis.
Number of mesh divisions along cavity inner radius and along cavity half length.	Must be even and between 2 and 30. Specific mesh divisions along the half length of the cavity, not the full length.
Initial cavity charge pressure (psia) and temperature (degrees F).	Pressure must be positive, and temperature must be greater than or equal to -100°F. Used during thermal analyses to estimate the change in internal pressure as a result of thermal loads.
Maximum normal operating pressure (psia).	Must be positive. Used as one of the regulatory pressure-stress loading conditions.

Basic Geometry PAGE 4 Cask Component Configurations

The default cask configuration has a solid shell and solid end caps. It includes top and bottom impact limiters, neutron shield, and water jacket. Enter **L** to specify a laminated shell or end caps. Enter **N** to exclude either limiter or the neutron shield and water jacket. **Figure 3-3** shows several possible configurations.

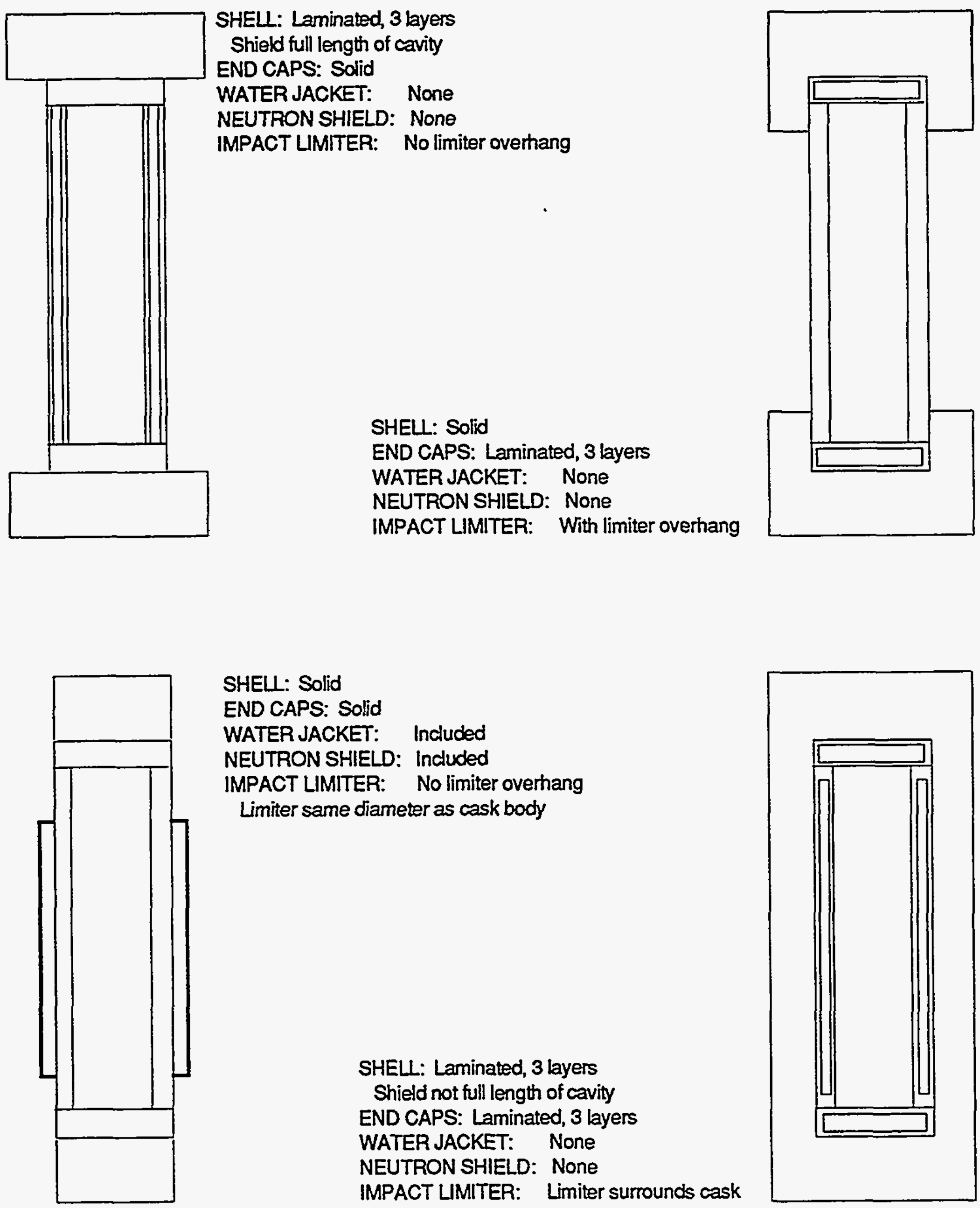


Figure 3-3. Sample cask configurations.

Basic Geometry Pages 5a and 5b Cask Shell Specifications

CASKS displays Page 5a for a solid shell and page 5b for a laminated shell.

Solid Shell

Field Name	Description
Shell thickness (inches)	Required Must be positive and less than 2000. Total thickness of the shell.
Shell material name	Select from the displayed list of materials
Number of mesh divisions through shell	Must be even and between 2 and 10. Used to generate a two-dimensional finite-element mesh for thermal, thermal-stress and pressure-stress analyses.

Laminated Shell

Field Name	Description
Shell inner layer thickness (inches)	Required Must be non-negative and less than 2000. Set to 0.0 to eliminate the inner layer.
Additional thickness of inner layer in vicinity of the end caps (inches).	Must be non-negative and less than 2000. Set to 0.0 if inner shell is not thickened. Used for impact analyses with unbonded lead shielding.
Shell inner layer material name	Select from the displayed list of materials.
Shell shield layer thickness (inches)	Required Must be non-negative and less than 2000. Set to 0.0 to eliminate the shield layer.

Laminated Shell (con't.)

Field Name	Description
Shell shield length (inches)	Required Must be non-negative and less than 2000. Set to 0.0 to eliminate the shield layer. May be larger than the cavity length but should not exceed the cask body length (cavity length plus thickness of both end caps). **Figure 3-4** shows the effects of various shell shield lengths. NOTE: Impact analyses assume shield length is same as cavity length.
Shell shield layer material name.	Select from the displayed list of materials.
Shell outer layer thickness (inches)	Required Must be positive and less than 2000.
Additional thickness of outer layer in vicinity of the end caps (inches).	Must be non-negative and less than 2000. Set to 0.0 if outer shell is not thickened. Used for impact analyses with unbonded lead shielding.
Shell outer layer material name.	Select from the displayed list of materials.
Number of mesh divisions through inner layer, shield layer and outer layer of the shell.	Must be even and between 2 and 10. If inner layer or shield layer is eliminated, number of mesh divisions is ignored.

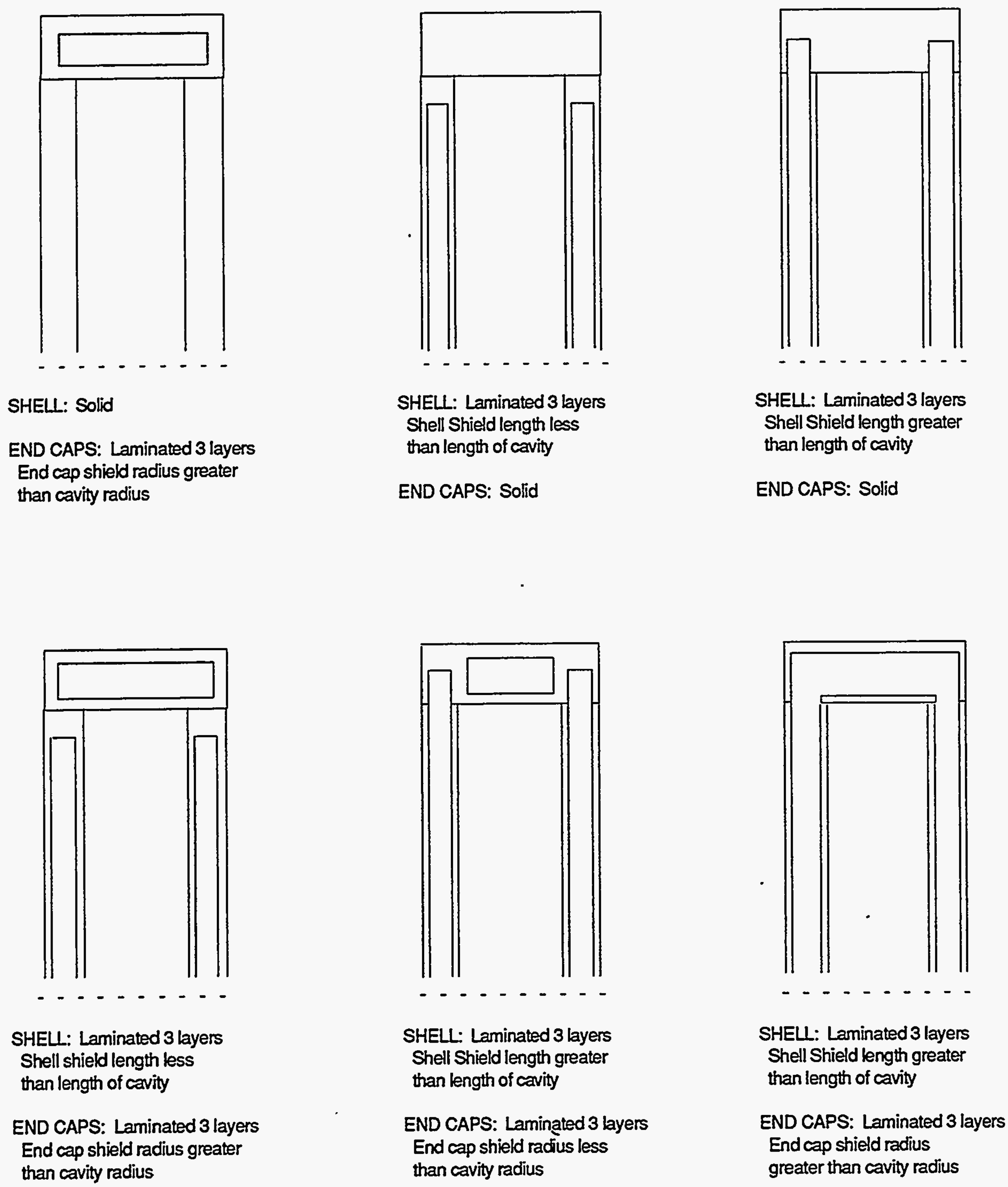


Figure 3-4. Possible shield configurations.

Basic Geometry Pages 6-7 Cask End Cap Specifications

Page 6a is displayed when a solid top end cap is specified. Page 6b is displayed when a laminated top end cap is specified. Pages 7a and 7b are for solid and laminated bottom end caps; these pages are identical to pages 6a and 6b.

Solid End Cap

Field Name	Description
End cap thickness (inches)	Required Must be positive and less than 2000. Total thickness of the end cap.
End cap material name.	Select from the displayed list of materials.
Number of mesh divisions through end cap.	Must be even and between 2 and 10.

Laminated End Cap

Field Name	Description
End cap inner layer thickness (inches)	Required Must be non-negative and less than 2000. Set to 0.0 to eliminate the inner layer.
End cap inner layer material name.	Select from the displayed list of materials.
End cap shield layer thickness (inches)	Required Must be non- negative and less than 2000. Set to 0.0 to eliminate the shield layer.
End cap shield radius (inches)	Required Must be non-negative and less than 2000. Set to 0.0 to eliminate the shield layer. Must be larger than the cavity radius and should not exceed the cask body outer radius (cavity radius plus shell thickness). **Figure 3-4** shows the effects of various end cap shield lengths.
End cap shield layer material name.	Select from the displayed list of materials.

Laminated End Cap (con't.)

Field Name	Description
End cap outer layer thickness (inches)	Required Must be positive and less than 2000.
End cap outer layer material name.	Select from the displayed list of materials.
Number of mesh divisions through inner layer, shield layer, and outer layer of the end cap.	Must be even and between 2 and 10. If inner layer or shield layer is eliminated, number of mesh divisions is ignored.

Basic Geometry Page 8 Cask Closure Bolts Information

Field Name	Description
Number of closure bolts	Required Must be positive and less than 100.
Diameter of closure bolts (inches)	Required Must be positive and less than or equal to 10.
Closure bolt circle radius (inches)	Required Must be positive and less than 2000. Should be greater than the cavity radius and less than the cask body outer radius (cavity radius plus shell thickness).

Basic Geometry Page 9 Cask Neutron Shield / Water Jacket Specifications

The neutron shield and water jacket are not included in impact, thermal-stress and pressure-stress analyses. They may be included in thermal analyses if they affect heat transfer.

Field Name	Description
Neutron shield and water jacket length (inches)	Required Must be non-negative and less than 2000. Should be less than the cavity length. Set to 0.0 to eliminate the neutron shield and water jacket (same as specifying on Page 4 that they are not included).
Neutron shield thickness (inches)	Required Must be non-negative and less than 2000. Set to 0.0 to eliminate the neutron shield.

Basic Geometry Page 9 Cask Neutron Shield / Water Jacket Specifications (con't.)

Neutron shield material name.	Select from the displayed list of materials.
Water jacket thickness (inches)	Must be non-negative and less than 2000. Set to 0.0 to eliminate the water jacket.
Water jacket material name.	Select from the displayed list of materials.
Number of mesh divisions through neutron shield and water jacket.	Must be between 1 and 3. If neutron shield or water jacket is eliminated, number of mesh divisions is ignored.

Basic Geometry Pages 10-11 Cask Impact Limiter Specifications

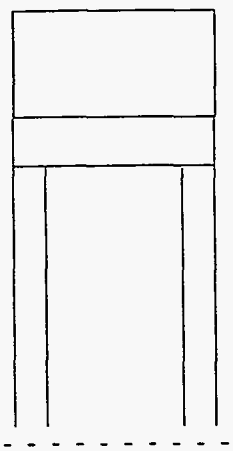
Page 10 is displayed when a top impact limiter is included in the cask model. Page 11 is displayed when a bottom impact limiter is included*. Top and bottom impact limiters are specified in a similar manner. Impact limiters are included in impact and thermal analyses. **Figure 3-5** shows possible impact limiter configurations.

Field Name	Description
Impact limiter radius (inches)	Required Must be positive and less than 2000. Should be greater than or equal to the cask body outer radius (cavity radius plus shell thickness).
Impact limiter centerline thickness above the end cap (inches)	Required Must be positive and less than 2000.

*Note that most of the storage casks do not require impact limiters. However, CASKS code requires the user to specify the impact limiter force-deflection curve before the code can be executed, even when there are not physical impact limiters on the cask. This requirement can be thought of as the relative 'stiffness' or 'flexibility' of the part of the cask that contacts the target on impact. The 'stiffness' of the cask is derived by entering a 'pseudo' force-deflection curve for the cask.

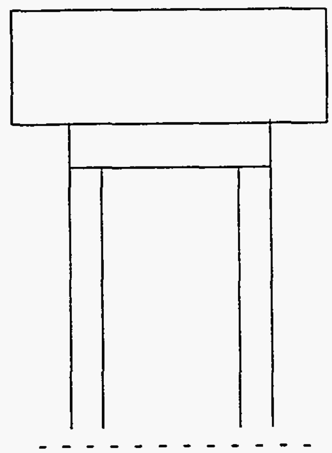
Basic Geometry Pages 10-11 Cask Impact Limiter Specifications (con't.)

Impact limiter overhang thickness below the end cap (inches)	Required Must be non-negative and less than 2000. Should be less than or equal to half the cask body length (cavity length plus thickness of both end caps). Set to 0.0 for no overhang. Set greater than half cask body length to surround the cask with the impact limiter. If the impact limiter radius is less than or equal to the cask body outer radius, the overhang thickness is ignored.
Impact limiter material name	Select from the displayed material list.
Number of mesh divisions through limiter centerline thickness and overhang width (impact limiter radius minus cask body outer radius)	Must be between 1 and 10.



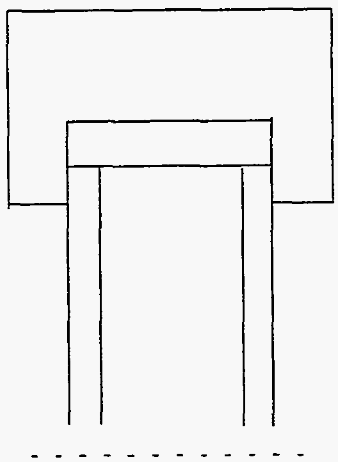
Limiter RADIUS: Equal to cask body

Limiter OVERHANG: None



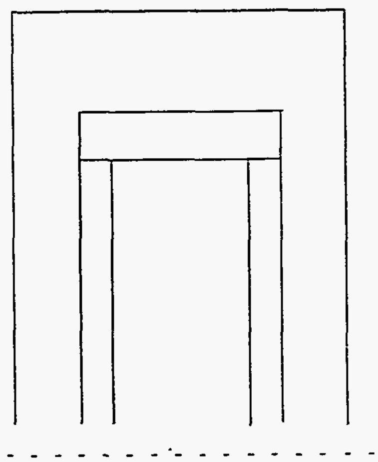
Limiter Radius: Greater than cask body

Limiter OVERHANG: None



RADIUS: Greater than cask body

OVERHANG: Included



RADIUS: Greater than cask body

OVERHANG: Included, exceeds body half length
(Limiter surrounds the cask body)

Figure 3-5. Possible impact limiter configurations.

Basic Geometry Page 12 Cask Impact Model Specifications

Define these values for impact analyses. They are not used for any other analysis.

Field Name	Description
Number of elements for the one-dimensional beam impact model.	Must be between 3 and 20. Accuracy generally improves with increased number of elements. However, the more elements used, the higher the possibility of capturing unnecessary high frequency modes. The integration time step is inversely proportional to the maximum frequency of the model. Thus, high frequencies require small time steps which causes the computation time to lengthen. The number of elements also specifies where force and stress information is output. Set to 3 for output at third points. Set to 4 for output at quarter points. Set to 6 for 1/6th points. Set to 12 for quarter and third points (plus a few more).
Top impact limiter weight (lbs.)	Set to 0.0 to calculate top impact limiter weight based on limiter dimensions and density.
Bottom impact limiter weight (lbs.)	Set to 0.0 to calculate bottom impact limiter weight based on limiter dimensions and density.
Define impact model with user specified properties? [Y/N]. Specify **N** to use shell, end caps, and impact limiter dimensions for impact analyses. Specify **Y** to input the following impact model properties directly.	These properties are described in Volume 2, *SCANS Impact Analysis Theory Manual*, in the section discussing the theory of impact. The weight of the contents and internal structures must be specified on the basic geometry editor page 3 (cask cavity/contents specifications).

The following properties must all be positive:

Shell translational mass (lb-sec**2/inch).
Shell rotational mass (lb-sec**2-inch).
Shell inside length (inches).
Shell E*I (composite Young's Modulus *x* Moment of Inertia) (lb-inch**2).
Shell A*E (composite Young's Modulus *x* Area) (lbs).
Shell composite Poisson's Ratio.
Top end translational mass (lb-sec**2/inch).
Top end rotational mass (lb-sec**2-inch).
Bottom end translational mass (lb-sec**2/inch).
Bottom end rotational mass (lb-sec**2-inch).
Characteristic cross-section width (inches).

Geometry Menu
Defining the Limiter F/D Curves

CASKS has eight predefined oblique angles for defining force-deflection curves: 0 degrees (side drop); 15; 30; 45; 60; 75; 90 (end-on drop); and CG (center-of-gravity drop). Force-deflection curves are related to the angle of impact because crush forces are based on the contact footprint. Define any or all of the curves; there are eight possible curves for the top impact and eight for the bottom impact. If curves are only defined for one end, **CASKS** will not allow side drop analyses, secondary impact analyses, or analyses specifying the end without an impact curve as the primary impact end.

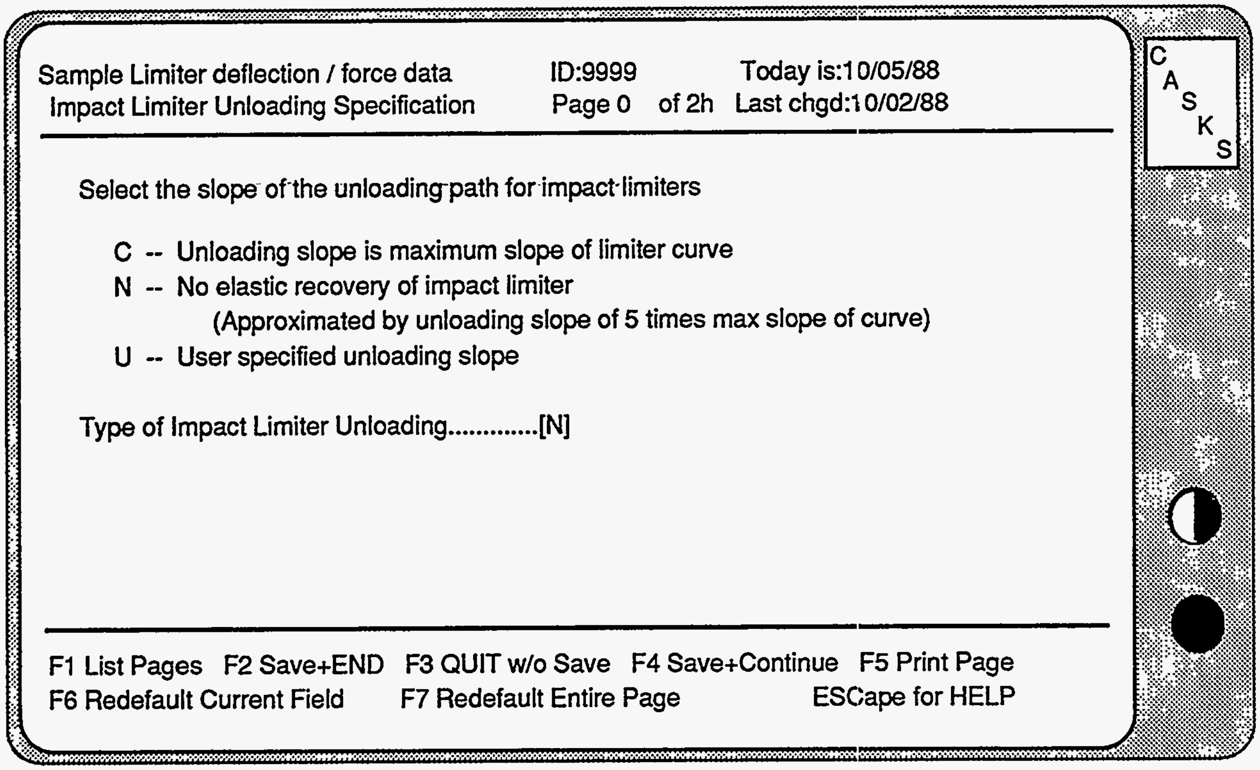
Defining the Limiter F/D Curves:

The impact force-deflection data set has 17 editor pages. Page 0 specifies the slope of the unloading path for the impact (**Figure 3-6**). This slope relates the force unloaded with the amount of elastic recovery of the impact. **CASKS** allows three choices:

C selects the maximum slope of the force-deflection curve as the unloading slope.

N selects no elastic recovery of the impact (for dynamic stability this is approximated by an unloading slope that is five times the maximum slope of the force-deflection curve).

U selects a user specified unloading slope (in terms of kips of unloading force per inch of elastic recover).



Sample Limiter deflection / force data   ID:9999   Today is:10/05/88
Impact Limiter Unloading Specification   Page 0 of 2h   Last chgd:10/02/88

Select the slope of the unloading path for impact limiters

C -- Unloading slope is maximum slope of limiter curve
N -- No elastic recovery of impact limiter
(Approximated by unloading slope of 5 times max slope of curve)
U -- User specified unloading slope

Type of Impact Limiter Unloading.............[N]

F1 List Pages F2 Save+END F3 QUIT w/o Save F4 Save+Continue F5 Print Page
F6 Redefault Current Field   F7 Redefault Entire Page   ESCape for HELP

Figure 3-6. Impact limiter unloading specification.

Each of the remaining pages specifies a force-deflection curve at a specific impact angle. Pages 1a-1h define force-deflection curves for the bottom impact, and pages 2a-2h define curves for the top impact.

(1) Use the keypad **PgUp** or **PgDn** keys to display the page with the desired limiter and impact angle (or use the page list function key **F1** to select the page).

The impact end and orientation angle are identified in the upper left corner of the screen.

(2) Type **Y** and press **ENTER** to activate the curve data.

(3) Fill in up to ten curve points. Enter deflections in **inches** and forces in **kips**. **NOTE:** the first two points are required.

If there are less than ten curve points, leave the remaining curve points 0.0.

Data page 1c, which specifies the bottom impact limiter for a 30-degree impact, is shown in **Figure 3-7.**

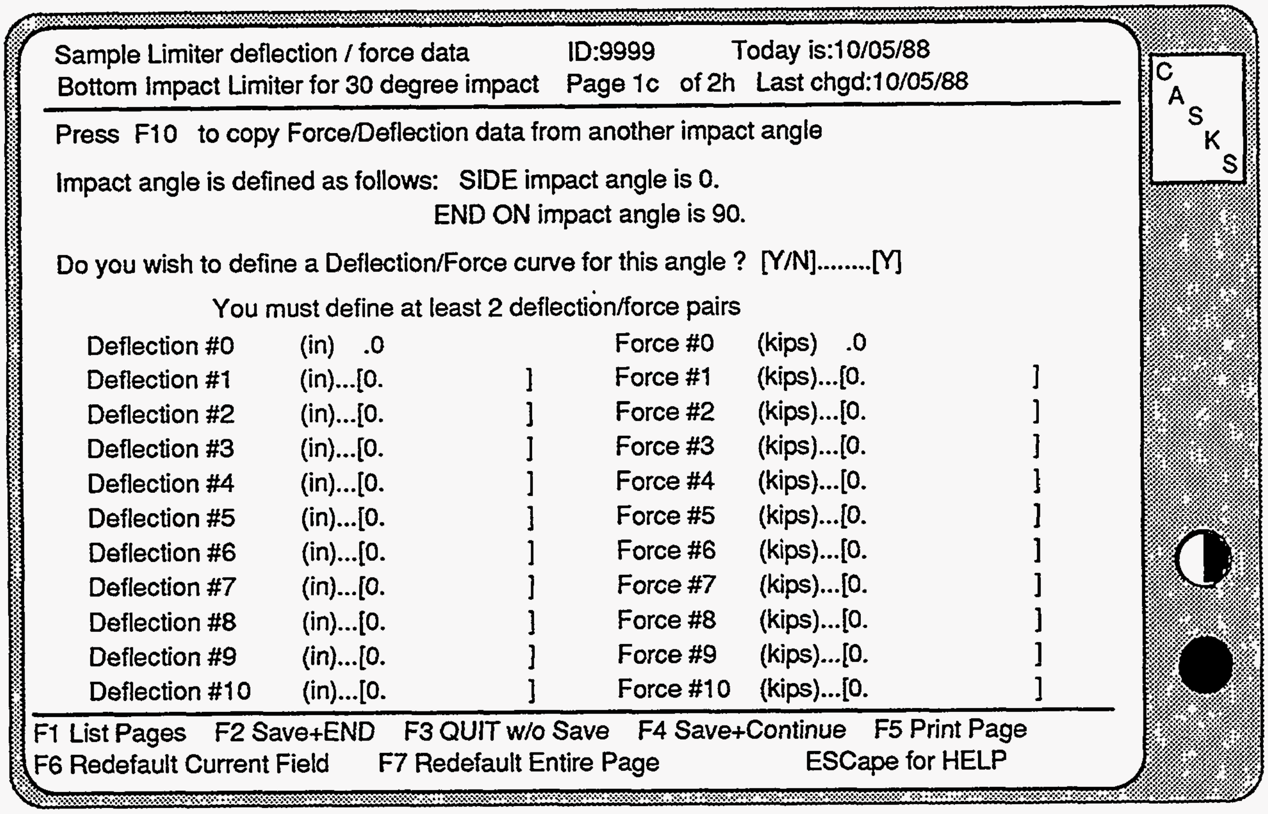


Figure 3-7. Sample impact limiter data page.

(4) Press **F10** to copy curve data from a different impact angle or cask end.

CASKS displays the list of all impact angles.

(5) Use the **UpArrow** and **DnArrow** keys to indicate the data to copy from and then press **C** to perform the copy.

NOTE: Each force-deflection curve must be single valued and in increasing order. That is, each deflection point must be larger than the previous one.

The impact force-deflection model is described in Volume 2 of *SCANS Impact Analysis Theory Manual.*

Defining the Yielding Surface F/D Curves

CASKS allows the user to define how yielding surface behaves under cask impact via the use of yielding surface F/D curves. Yielding surface F/D curves inputs are structured the same way as inputs to the cask limiter F/D curves. User may input up to 9 different surface F/D curves (cases). Each surface force-deflection curve must be input as single valued and in increasing order.

Appendix F provides user with a means to estimate the yielding surface F/D curve for a given concrete slab/subgrade soil combination. Users are encouraged to use a more accurate yielding surface F/D curve whenever possible.

NOTES:

Analysis Menu

The Analysis Menu (**Figure 4-1**) provides tasks to perform analyses involving impact loads, thermal distributions and stresses, and pressure loads. The basic geometry model definitions must be completed before **CASKS** can perform any analysis.

PRESS 1 to Perform Impact analysis

CASKS determines forces and stresses resulting from impact loads. Impact force-deflection curves must be defined before **CASKS** can perform an impact analysis. Users have the option of selecting cask impact on either an unyielding surface or a yielding surface. The impact condition is specified by drop height, impact type, analysis type, shell/shield interface type, impact end, and impact angle.

PRESS 2 to Perform Thermal analysis

CASKS performs any of seven predefined regulatory thermal analyses. These analyses include various ambient temperatures, solar effects, contents heat loads, and fire loads.

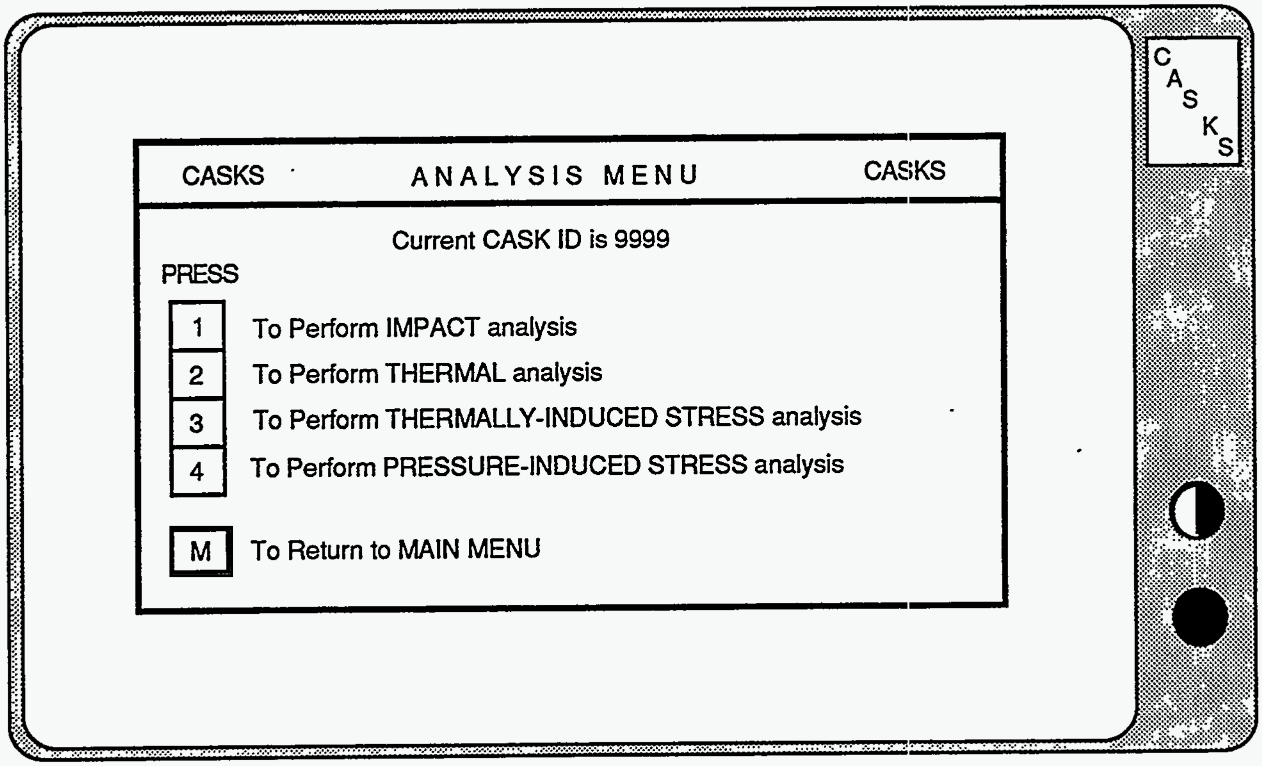


Figure 4-1. CASKS Analysis Menu

Analysis Menu

PRESS 3 to Perform Thermally-Induced Stress analysis

CASKS determines stresses resulting from previously analyzed thermal conditions. After selecting the thermal case, specify the stress-free temperature and, for the transient case, specify the time state.

PRESS 4 to Perform Pressure-Induced Stress analysis

CASKS determines stresses resulting from the pressure difference between cavity pressure and external pressures defined by regulations.

PRESS M to Return to MAIN MENU

CASKS returns to the Main Menu display.

Selecting the Impact Surface Type:

CASKS allows the user to choose between cask impact on either an unyielding surface or a yielding surface.

(1) When you press **1** to perform Impact Analysis, the User Selected CASK Impact Options Screen appears.

See **Figure 4-2**, below.

(2) Select the cask input surface type from the screen.

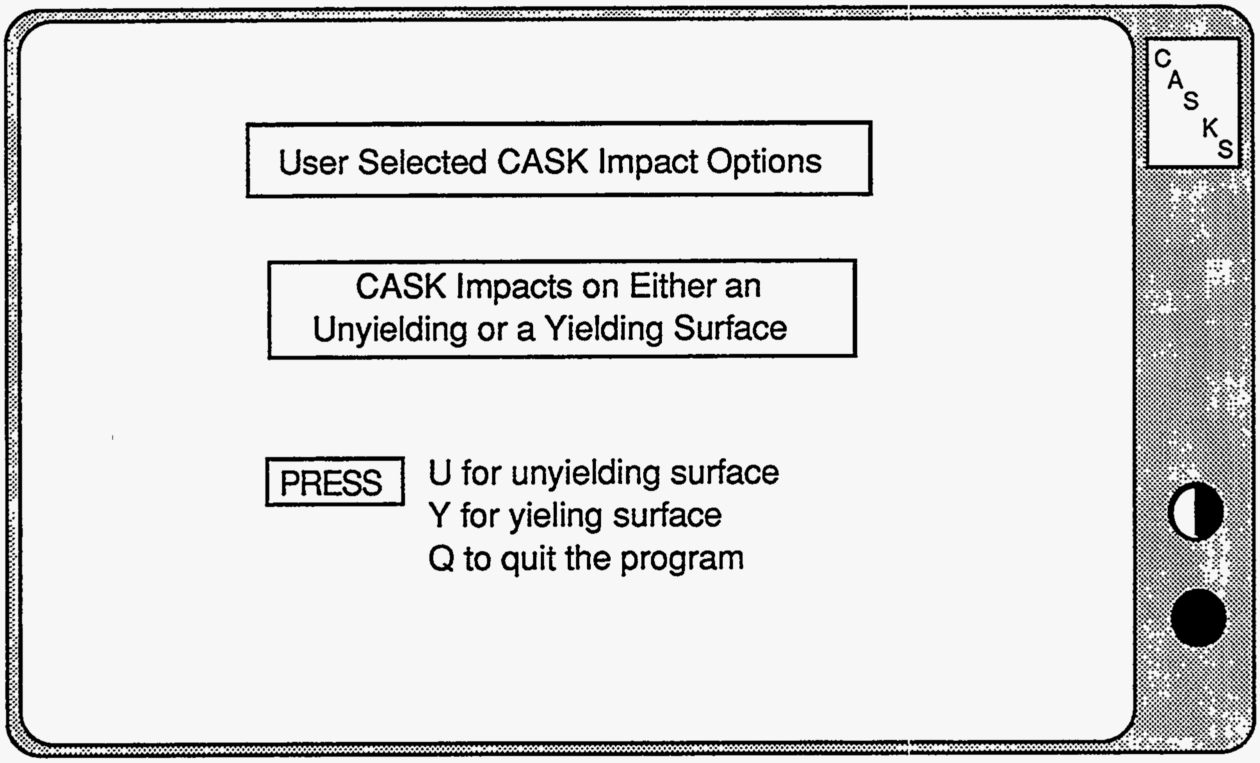


Figure 4-2. Select Impact Surface Type Screen

Analysis Menu

Select Impact Surface Type

(3) Press **U** if an unyielding surface impact option is desired.

Press **Y** if a yielding surface input option is desired.

Press **Q** to **QUIT** and return to the Analysis Menu.

When **U** (unyielding surface option) is selected, **CASKS** proceeds to perform Impact analysis by displaying the impact analysis parameters input screen as shown in Figure 4-7.

The yielding surface uses a non-linear force-deflection approximation. After a proper yielding surface F/D curve is defined, it then combines with the cask limiter F/D curves before performing an impact analysis.

When **Y** (yielding surface option) is selected, CASKS then asks whether the user wishes to use the built-in surface force-deflection curves or to input his/her own pair of surface force-deflection values (**Figure 4-3**).

(4) If **Y** is selected:

Press **1** for built-in curve.

Press **2** for user-defined curve.

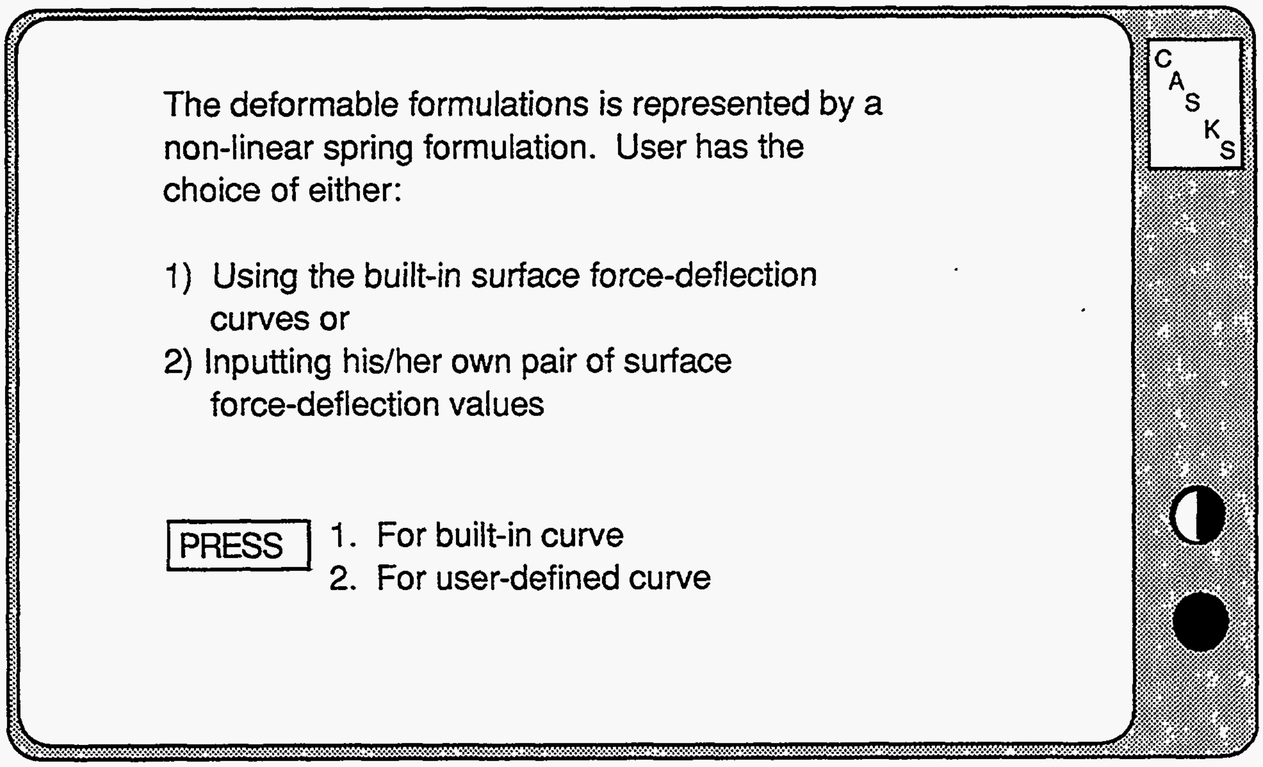


Figure 4-3. Select Proper Surface F/D Curve Screen

CASKS does *not* provide a set of build-in surface F/D curves at this time (this option is reserved for future code expansion).

IMPORTANT: *User is warned that CASKS will give erroneous impact results if option 1 (build-in curve) is accidently selected.*

(5) Select **2** to input a site-specific surface F/D curve.

A screen appears and prompts the user to decide whether to use a previously input case or to input a new case **(Figure 4-4)**.

A total of 9 different surface F/D curves (CASES) may be input through the yielding surface template.

NOTE: New cases may ONLY be input using option 3 (to Create/Modify yielding surface F/D curves) under the GEOMETRY MENU.

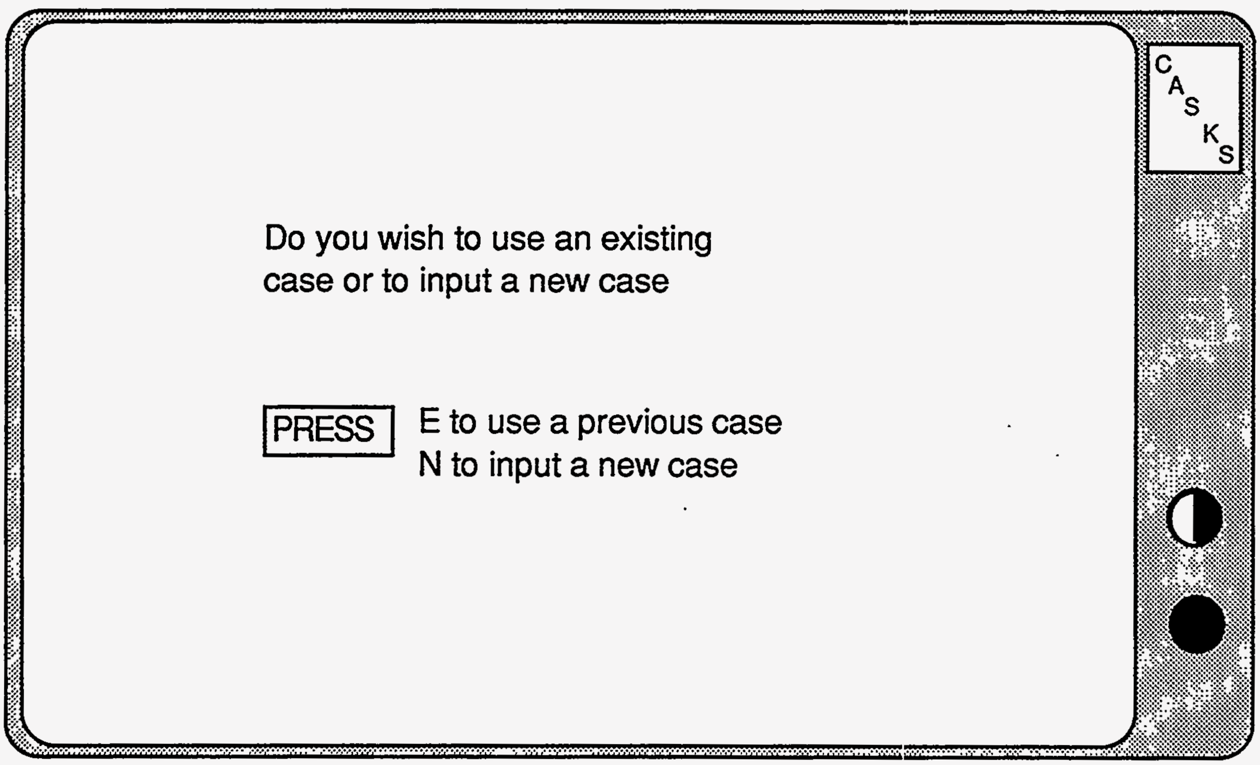


Figure 4-4. User Input Surface F/D Options

Analysis Menu

Select Impact Surface Type

(6) Press **E** to use a previous case.

CASKS asks the user to indicate which case to use (**Figure 4-5**).

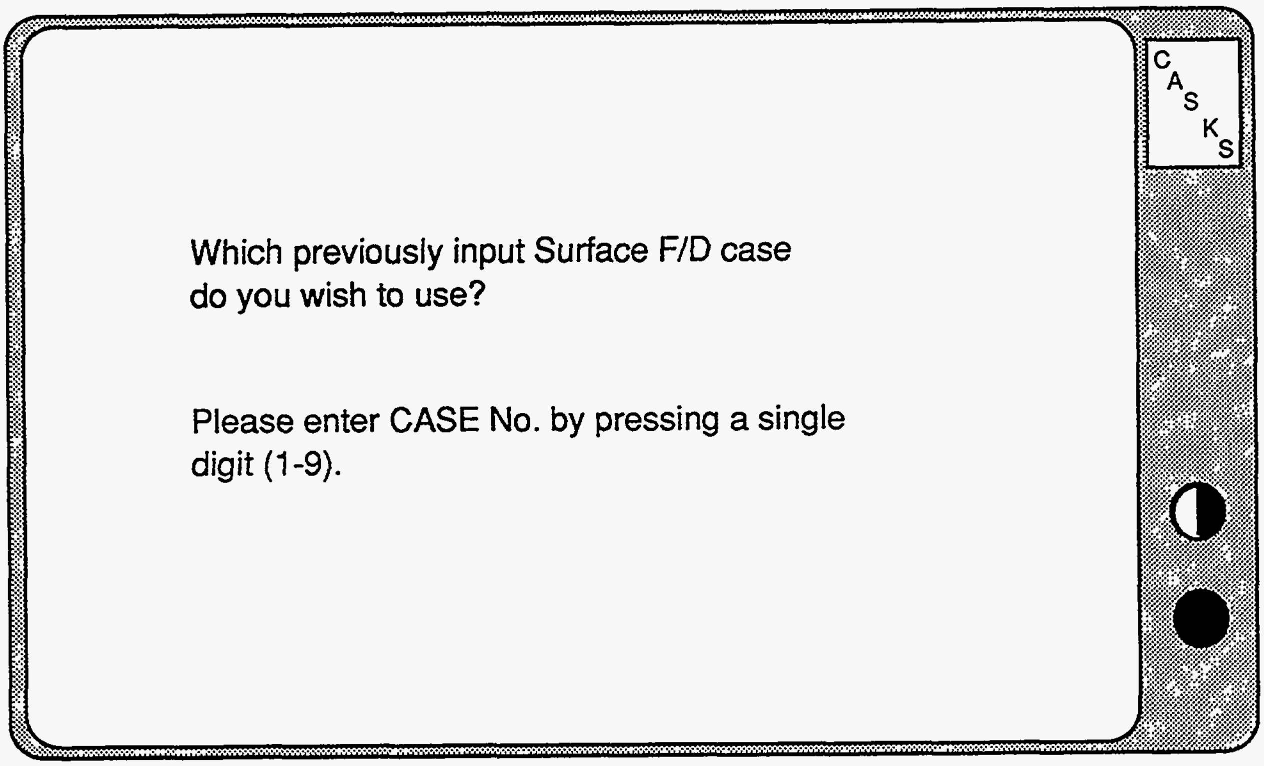


Figure 4-5. Users Specifies Which Previously Defined Surface F/D Curve to Use

Enter a CASE No.

The user will be prompted with a message signaling the completion of combining the surface F/D curves just selected with that of the cask limiter F/D curve. CASKS then performs impact analysis by displaying **Figure 4-7.**

or

(7) Press **N** to input a new surface F/D curve.

CASKS will instruct the user to first exit the analysis module and enter the GEOMETRY MENU. New cases can ONLY be entered this way.

Select option **3** (Create/Modify surface F/D curve) to input a new surface F/D curve (**Figure 4-6**).

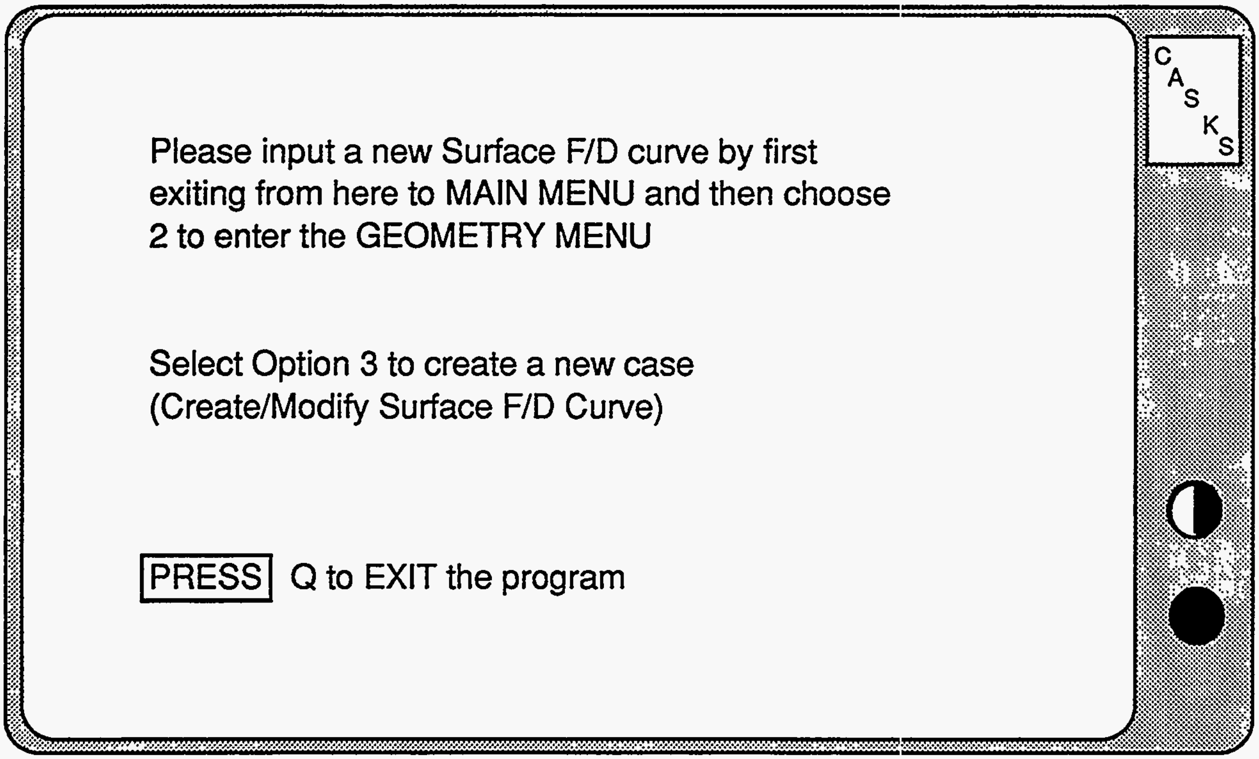


Figure 4-6. CASKS Instructs the User on How to Input/Modify a Surface F/D Curve

Analysis Menu

Perform Impact Analysis

CASKS assumes beam-column behavior for impact analyses and determines forces and stresses for both primary and secondary impacts. **CASKS** can perform impact analyses for oblique angles between 0 degrees (side drop) and 90 degrees (end-on drop).

Both the basic geometry and the impact force-deflection curves must be defined and complete before **CASKS** can perform an impact analysis (see Geometry Menu). The basic geometry must include at least one set of impact force-deflection curves. The Impact Analysis Title Screen indicates any missing information required before an impact analysis can be performed.

(9) From the *Select Impact Analysis Parameters Screen*, press **Q** to QUIT and return to the Main Menu, or press any other key to specify the six impact analysis parameters.

The six impact analysis parameters are: drop height; impact type; analysis type; shell/shield interface type; primary impact end; and impact angle (**Figure 4-7**).

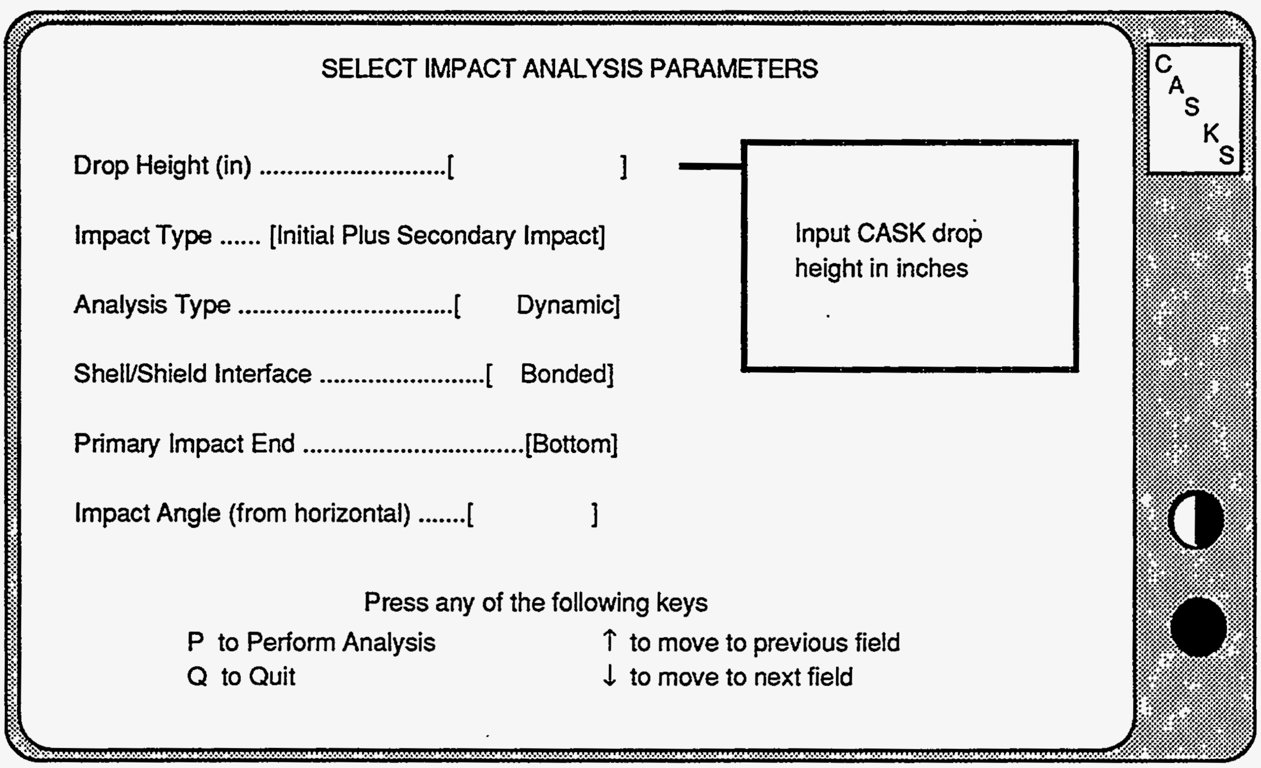


Figure 4-7. Select Impact Analysis Parameters Screen

CASKS displays the default values for four of the six parameters.

(10) Press **P** to proceed and perform the analysis with the parameters as displayed, press **Q** to QUIT and return to the Analysis Menu or modify any of the parameters before performing the analysis.

To modify a parameter, use the keypad up or down arrow keys to highlight the desired field and then press the function key that selects the desired value.

Selecting the Drop Height:

(1) Input the *Drop Height* field in inches and press return.

The program then asks the user to input either a digit (0-9) or a character (a-z) to uniquely identify this case.

(2) Input a single digit or a character, then press the return key twice.

Selecting the Impact Type:

Two impact types are available: impact of one end (primary impact); and impact of one end followed by rotation of the cask and impact of the other end (secondary impact). Impact limiter geometry and force-deflection curves must be defined for both ends of the cask to perform secondary impact calculations. An impact angle of 0 degrees is always a primary and secondary impact (both ends impact at the same time). Impact angles greater than or equal to the CG angle and unbonded shell/shield interface analyses are always primary impact only.

(1) Highlight the *Impact Type* field and press one of the indicated function keys to change the type of impact:

F1 for initial plus secondary impact

F2 for initial impact only

Selecting the Analysis Type:

Two analysis types can be selected: a dynamic, lumped parameter approach that accounts for the dynamic response of the cask and rigid body motion associated with oblique impact; and a quasi-static approach that treats the cask as a slender rigid bar which does not capture dynamic response. Both types are one-dimensional techniques and assume elastic response.

(1) Highlight the *Analysis Type* field and press one of the indicated function keys to change the type of analysis:

F1 for a Dynamic analysis

F2 for a Quasi-static analysis

Selecting the Shell-Shield Interface Type:

The default shell/shield interface is bonded. That is, the shield is prevented from slumping. An unbonded interface may be selected if the impact angle is greater than 0 and if the cask has a three-layer laminated shell comprised of STEEL, LEAD, and STEEL. An unbonded interface allows the lead shield to slump and contribute radial forces to the steel shells.

NOTE: unbonded shell/shield interface analyses are always primary impact only.

(1) Highlight the *Shell/Shield Interface Type* field and press one of the indicated function keys to change the type of shell/shield interface:

F1 for a bonded interface

F2 for an unbonded interface

Analysis Menu
Perform Impact Analysis

Selecting the Primary Impact End:

(1) Highlight the *Primary Impact End* field and press one of the indicated function keys to change the primary impact end.

F1 for primary impact on bottom of cask

F2 for primary impact on top of cask

The primary impact end can only be changed if the alternate end has at least one force-deflection curve defined.

Selecting the Impact Angle:

(1) Input the *Impact Angle* and press return.

The input angles must be less or equal to 90 degrees. The program then asks the user to input either a digit (0-9) or a character (a-z) to uniquely identify this case.

(2) Input a single digit or character, then press the return key twice.

A 0-degree angle is a side drop, and a 90-degree impact angle is an end-on drop. Side-drop analyses are always a primary and secondary impact with a bonded shell/shield interface. Impact angles greater than or equal to the CG angle are always primary impact only.

Performing the Analysis:

After all analysis parameters are selected, **CASKS** indicates whether a solution exists for this case.

(1) Press **P** to perform the analysis.

NOTE: **P** must NOT be pressed where an input is sought, e.g., Drop Height or Impact Angle. **P** is accepted in any other field—Impact Type, Analysis Type, Shell/Shield Interface or Primary Impact End. See Fig. 4-7.)

When the analysis is complete, **CASKS** displays the maximum impact force and acceleration for both primary impact and secondary impact (if included) and lists two options.

(2) Press **P** to perform another impact analysis (with different parameter selections)

NOTE: The user can Press **F3** to halt the analysis at any point (results are complete up to the point the analysis is halted).

or

Press **Q** to QUIT and return to the Analysis Menu

During dynamic analyses, **CASKS** displays the current simulation time, cask orientation, and analysis status.

If the impact angle does not correspond to any of the predefined oblique angles with available F/D curves, **CASKS** selects the F/D curve that is nearest the next higher impact angle.

During primary impact, the analysis status indicates **"Calculating PRIMARY impact."**

When the primary impact analysis is complete, the status is changed to **"Primary impact complete."**

When a secondary impact is initiated, the analysis status indicates **"Calculating SECONDARY impact"** and displays both the cask orientation at secondary impact and the impact force-deflection data set angle used for the secondary impact end.

CASKS selects the F/D curve that is nearest to the actual secondary impact angle.

When the secondary impact analysis is complete, the status is changed to **"Secondary impact complete."**

Dynamic impact analyses may indicate one of the error messages listed below:

Time limit reached
The analysis could not be completed. Probable cause is a very soft impact limiter that does not absorb all the impact energy.

Secondary impact reached, only primary requested
The secondary end of the cask impacts before the primary impact analysis is complete. Message appears only if the impact type was restricted to primary only.

Chord rotation in element "i" is too large
Indicates a numerical instability. Probable cause is a geometry or weight error.

Quasi-Static impact analyses may indicate the error message listed below:

Force becomes negative before impact energy can be dissipated
The Force/deflection curve defined for this configuration does not absorb all the impact energy. Probable cause is an F/D curve that ends with a negative slope.

Generating Finite-Element Meshes:

Thermal, thermal-stress, and pressure-stress analyses require two-dimensional finite element meshes. The first time one of these analyses is requested for a cask, **CASKS** automatically generates the F.E. meshes based on the dimensions and mesh gradings in the geometry definition (see Geometry Menu). The generated F.E. meshes are used automatically until any geometry definition is updated.

When a pressure-stress or thermal analysis is selected after the geometry definition is updated, **CASKS** indicates that the F.E. mesh predates the current version of the basic geometry. **CASKS** displays the date and time for both the geometry definition and F.E. mesh and lists several options:

Press **C** to Continue (the analysis) with the current F.E. mesh

Press **G** to Generate a new F.E. mesh based on the current geometry

Press **Q** to QUIT and return to the analysis menu

CASKS displays the thermal and stress meshes after generation is complete. The thermal mesh uses 4-node elements and includes all specified cask components. The stress mesh uses 9-node elements (each 9-node element is equivalent to four, 4-node elements) and includes only the cask shell and end caps. The impact limiters, neutron shield, and water jacket are low-strength components which do not affect stress distributions. After displaying the meshes, **CASKS** lists several options.

Press **T** to print the Thermal mesh as a node/element map

Press **S** to print the Stress mesh as a node/element map

The thermal and stress mesh node/element maps are useful for reviewing results from thermal and stress analyses. These maps can also be generated from the Display Menu.

Press **C** to Continue with the analysis

NOTE: the video display type and printer type are selected from the Display Menu.

Press **Q** to QUIT and return to the Analysis Menu
(Allows abort if display indicates a potential problem)

Performing Thermal Analysis:

The basic geometry must be defined and complete before **CASKS** can perform a thermal analysis (see Geometry Menu). The Thermal Analysis Title Screen indicates any missing information required before an analysis can be performed.

(1) Press **Q** to QUIT and return to the Analysis Menu.

or

Press any other key to display the list of available thermal analysis cases **(Figure 4-8)**.

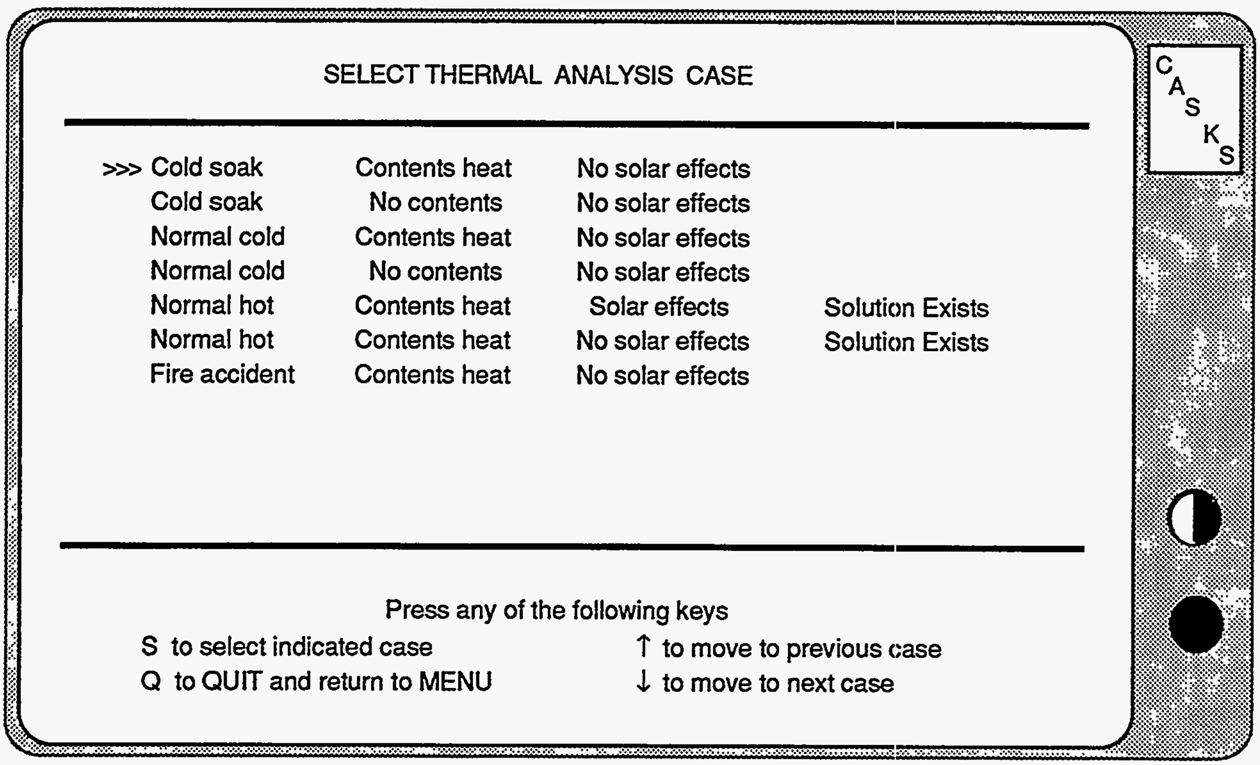


Figure 4-8. Select Thermal Analysis Case

The case list also indicates whether a solution exists for each case.

(2) Use the keypad up or down arrow keys to highlight the desired case and press **S** to select and perform the analysis.

The thermal cases are described on the next page. All cases, except the fire accident, include convection and radiation heat transfer to the environment. The fire accident case excludes convection heat transfer during the fire and reinstates it after the fire.

CASKS automatically generates the necessary finite element mesh if one has not been previously generated (see Generating Finite Element Meshes).

Cold Soak, Contents Heat, No Solar Effects

Ambient temperature: -40°F
Contents Heat: As specified in the geometry definition
Solar effects: None
Analysis type: Steady State

Cold Soak, No Contents, No Solar Effects

Ambient temperature: -40°F
Contents Heat: None
Solar effects: None
Analysis type: Steady State

Normal Cold, Contents Heat, No Solar Effects

Ambient temperature: -20°F
Contents Heat: As specified in the geometry definition
Solar effects: None
Analysis type: Steady State

Normal Cold, No Contents, No Solar Effects

Ambient temperature: -20°F
Contents Heat: None
Solar effects: None
Analysis type: Steady State

Normal Hot, Contents Heat, Solar Effects

Ambient temperature: 100°F
Contents Heat: As specified in the geometry definition
Solar effects: Included
Analysis type: Steady State

Normal Hot, Contents Heat, No Solar Effects

Ambient temperature: 100°F
Contents Heat: As specified in the geometry definition
Solar effects: None
Analysis type: Steady State
NOTE: Required as the initial condition for fire accident

Fire Accident, Contents Heat, No Solar Effects

Ambient temperature during fire: 1475°F
Ambient temperature after fire: 100°F
Contents Heat: As specified in the geometry definition
Solar effects: None
Analysis type: Transient 360 minutes in duration
Duration of fire: 30 minutes
NOTE: Requires case **Normal Hot, Contents Heat, No Solar Effects** as the initial condition before the fire

Analysis Menu

Perform Thermal Analysis

All thermal cases, except the fire accident, are steady-state analyses. **CASKS** initiates steady-state analyses after the case selection is made (and after mesh generation, if necessary) and displays the steady-state thermal analysis status screen (**Figure 4-9**).

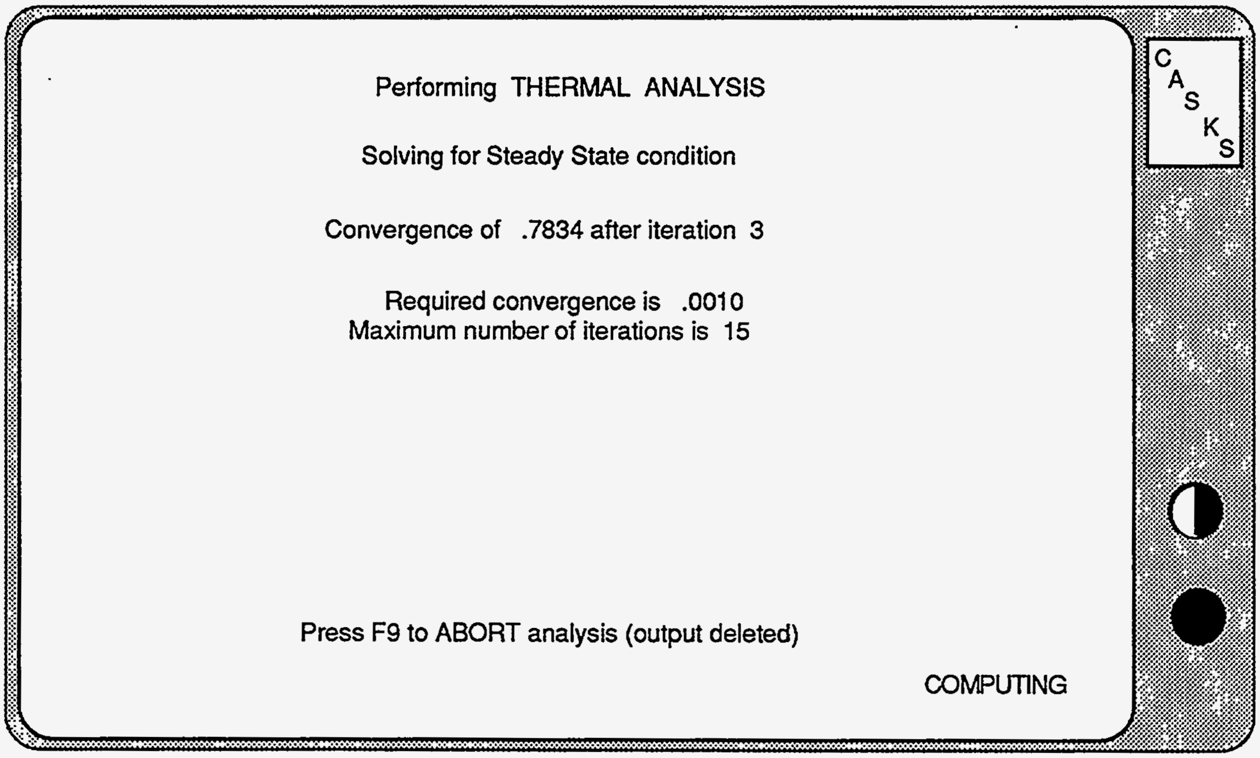


Figure 4-9. Steady State Thermal Analysis Status Screen

Since the analysis is nonlinear, **CASKS** iterates to converge on the correct solution. The iteration number and convergence achieved are updated on the display after each iteration. Also displayed is the maximum number of iterations that **CASKS** will perform. When the solution converges, **CASKS** displays the minimum and maximum temperatures and indicates where they occurred.

(3) To abort the steady state analysis (and delete the output) before convergence is achieved, press **F9**.

CASKS asks for confirmation before aborting the analysis.

(4) Press **F1** to abort the analysis.

or

Press **F9** to continue the analysis.

After the analysis is finished, **CASKS** lists the following options:

(5) Press **P** to Perform another thermal analysis (redisplays the case list screen)

or

Press **Q** to QUIT and return to the Analysis Menu

The transient fire accident analysis requires the steady-state case **Normal Hot, Contents Heat, No Solar Effects** as the initial condition. **CASKS** displays a list of transient analysis with their default values **(Figure 4-10)**.

Analysis Menu

Perform Thermal Analysis

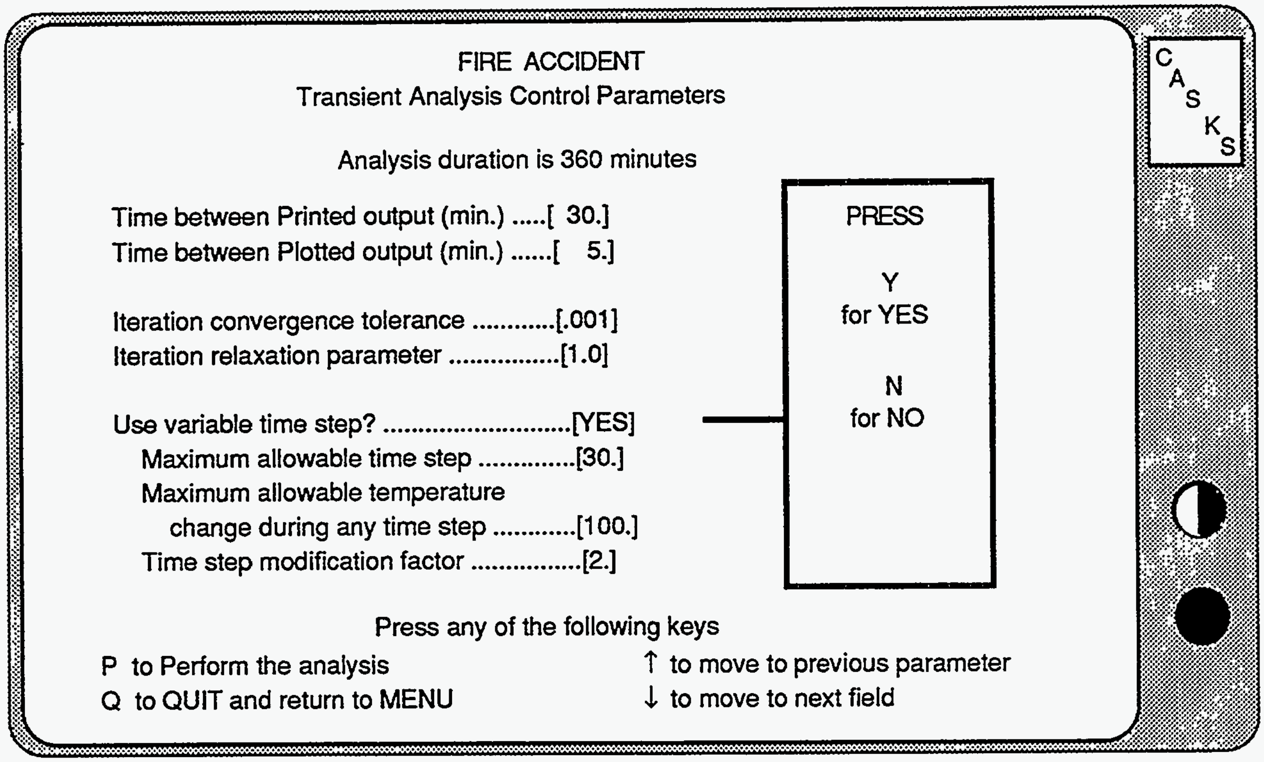


Figure 4-10. Transient Analysis Control Parameters

(6) Press **P** to proceed and perform the analysis with the parameters as displayed

To modify a parameter, use the keypad up or down arrow keys to highlight the desired field, and then use the indicated keys to select the desired value.

or

press **Q** to QUIT and return to the Analysis Menu

or

modify any of the parameters before performing the analysis.

(7) When the displayed parameter values are correct, press **P** to perform the transient analysis.

CASKS displays a transient analysis status screen that is similar to the steady-state status screen. The transient analysis status screen also includes the current solution time, solution time limit, and minimum and maximum temperature for the previous solution time.

(8)	To end the transient analysis after the current time step, press **F5**	**CASKS** asks for confirmation before ending or aborting the analysis.
or		
	To abort the transient analysis (and delete the output), press **F9**.	
(9)	Press **F1** to end or abort the analysis	After the analysis is finished, **CASKS** lists several options.
or		
	Press **F9** to continue the analysis.	
(10)	Press **P** to Perform another thermal analysis (redisplays the case list screen)	
or		
	Press **Q** to QUIT and return to the Analysis Menu	

Analysis Menu

Perform Thermal Analysis

The following descriptions will help the user work with the Transient Analysis Control Parameters Screen (Figure 4-10).

Specifying the Printed Output Interval

Highlight the *Printed Output Interval* field. Use the + and - keys to change the time interval between saving thermal states for printing. Printed output can be very long. A printout interval of 30 minutes or longer is recommended.

Specifying the Plotted Output Interval

Highlight the *Plotted Output Interval* field. Use the + and - keys to change the time interval between saving thermal states for plotting.

Specifying the Iteration Convergence Tolerance

Highlight the *Iteration Convergence Tolerance* field. Use the + and - keys to change the solution convergence tolerance. Increasing the tolerance reduces the number of iterations (and computation time) for solution convergence, but may result in a less accurate solution.

Specifying the Iteration Relaxation Parameter

Highlight the *Iteration Relaxation Parameter* field. Use the + and - keys to change the relaxation parameter. The relaxation parameter guides the temperature estimate for the current iteration by using a fraction of the temperature change during the previous iteration. Decrease the relaxation parameter to 0.75 or less to dampen highly oscillatory solutions.

Specifying the Time Step Type

Highlight the *Variable Time Step* field. Press **Y** to use a variable time step or **N** to use a fixed time step. If a fixed time step is selected, **CASKS** displays the fixed time step parameter. If a variable time step is selected, **CASKS** displays maximum allowable time step, maximum allowable temperature change during any time step, and time step modification factor.

Specifying the Fixed Time Step Parameter

Select **N** for the *Use Variable Time Step* parameter and highlight the *Fixed Time Step* field. Use the + and - keys to change the fixed time step. Small time steps will converge faster, requiring fewer iterations. However, the transient analysis duration will be divided into more time steps.

Specifying the Maximum Allowable Time Step for Variable Time Step

Select **Y** for the *Use Variable Time Step* parameter and highlight the *Maximum Allowable Time Step* field. Use the + and - keys to change the maximum allowable time step. This places a ceiling on the time step size that **CASKS** can select during the transient analysis.

Specifying the Maximum Allowable Temperature Change During Any Time Step

Select **Y** for the *Use Variable Time Step* parameter and highlight the *Maximum Allowable Temperature Change During Any Time Step* field. Use the + and - keys to change the maximum allowable temperature change during any time step. **CASKS** uses the temperature change to determine when it is necessary to change the time step size.

Specifying the Maximum Allowable Temperature Change During Any Time Step

Select **Y** for the *Use Variable Time Step* parameter and highlight the *Time Step Modification Factor* field. Use the + and - keys to change the modification factor. When the time step is increased, the new time step is the current time step multiplied by the modification factor. When the time step is reduced, the new time step is the current time step divided by the modification factor.

Analysis Menu

Perform Thermally-Induced Stress Analysis

CASKS requires at least one completed thermal analysis to perform thermally-induced stress analyses. The number of thermal analysis solutions is indicated on the Thermal Stress Analysis Title Screen. The module used for stress analyses is based on SAP80 from Computers & Structures, Inc. (used by permission).

Performing Thermally-Induced Stress Analysis:

(1) Press **Q** to QUIT and return to the Analysis Menu

or

Press any other key to display the list of available thermal stress cases (**Figure 4-11**)

The case list also indicates whether a solution exists for each case.

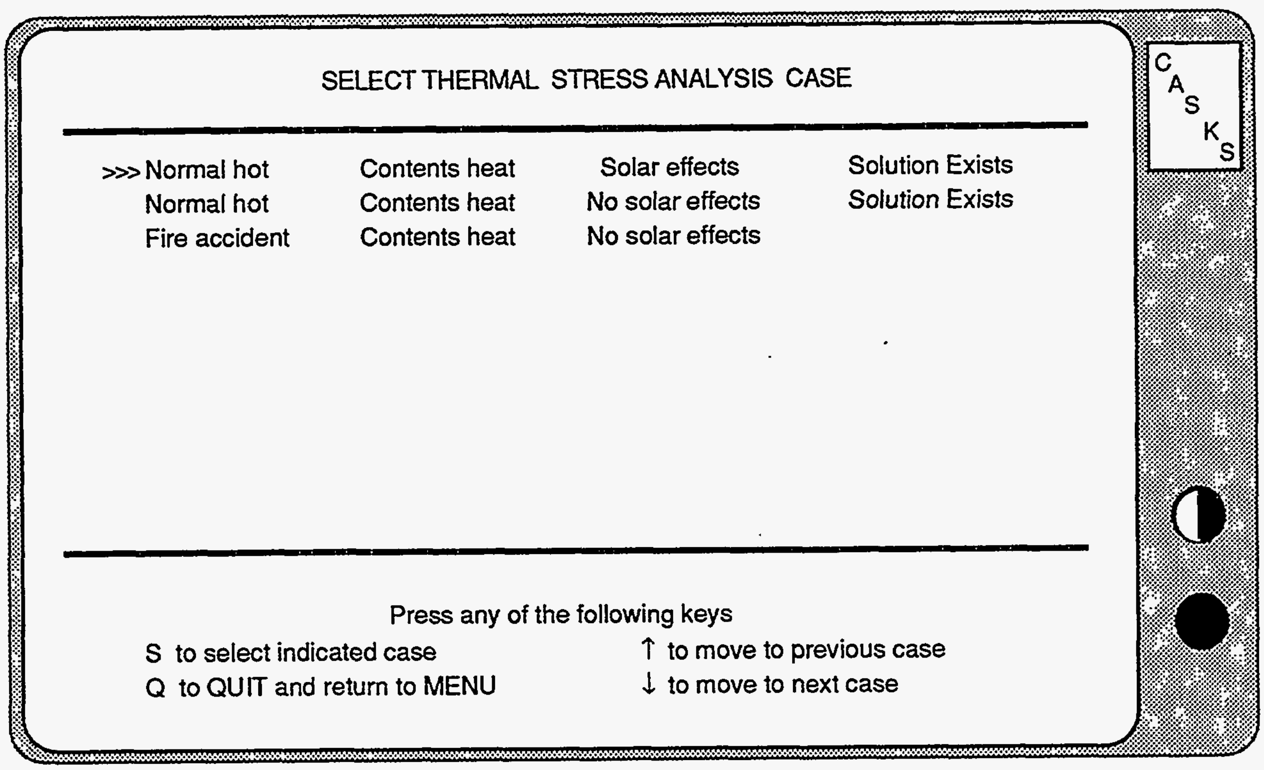


Figure 4-11. Select Thermal Stress Analysis Case

(2) Use the keypad up or down arrow keys to highlight the desired case, and then press **S** to select the indicated case.

CASKS will then display the stress-free temperature as specified in the geometry definition (**Figure 4-12**)

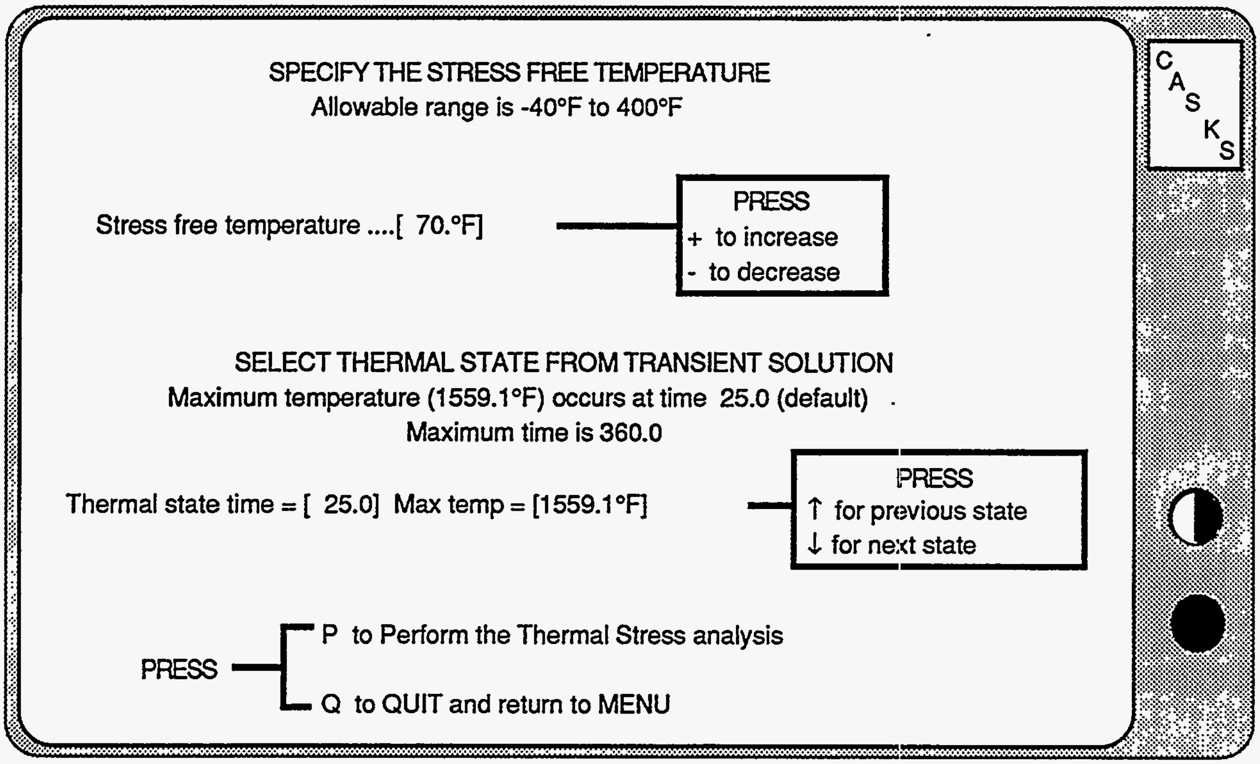


Figure 4-12. Stress Free Temperature / Thermal State

(3) Use the keypad + or - keys to change this value (allowable range is -40°F to +400°F).

For the fire accident transient analysis, the thermal stress analysis may be calculated for any thermal state (the states correspond to the temperatures saved at the plotting interval).

(4) Use the keypad up or down arrow keys to select a thermal state.

CASKS indicates which state contains the maximum temperatures on any cask component.

(5) Press **P** to perform the analysis with the displayed stress-free temperature (and indicated thermal state, if applicable)

(6) When the thermal stress analysis is complete, press **P** to perform another thermal stress analysis

or

Press **Q** to QUIT and return to the Analysis Menu.

Analysis Menu

Perform Pressure-Induced Stress Analysis

The external pressure conditions are established by the regulatory guidelines. However, the internal pressure conditions are established by the maximum normal operating pressure (input during geometry definition) or the internal pressure resulting from a thermal analysis. **CASKS** estimates the change in internal pressure using Ideal Gas Laws, based on the initial cavity charge pressure and temperature (input during geometry definition). The Pressure Stress Analysis Title Screen indicates the number of thermal solutions that exist for the cask. The module used for stress analyses is based on SAP80 from Computers & Structures, Inc. (used by permission).

Performing Pressure-Induced Stress Analysis:

(1) Press **Q** to QUIT and return to the Analysis Menu

or

Press any other key to display the list of available internal pressure conditions **(Figure 4-13)**

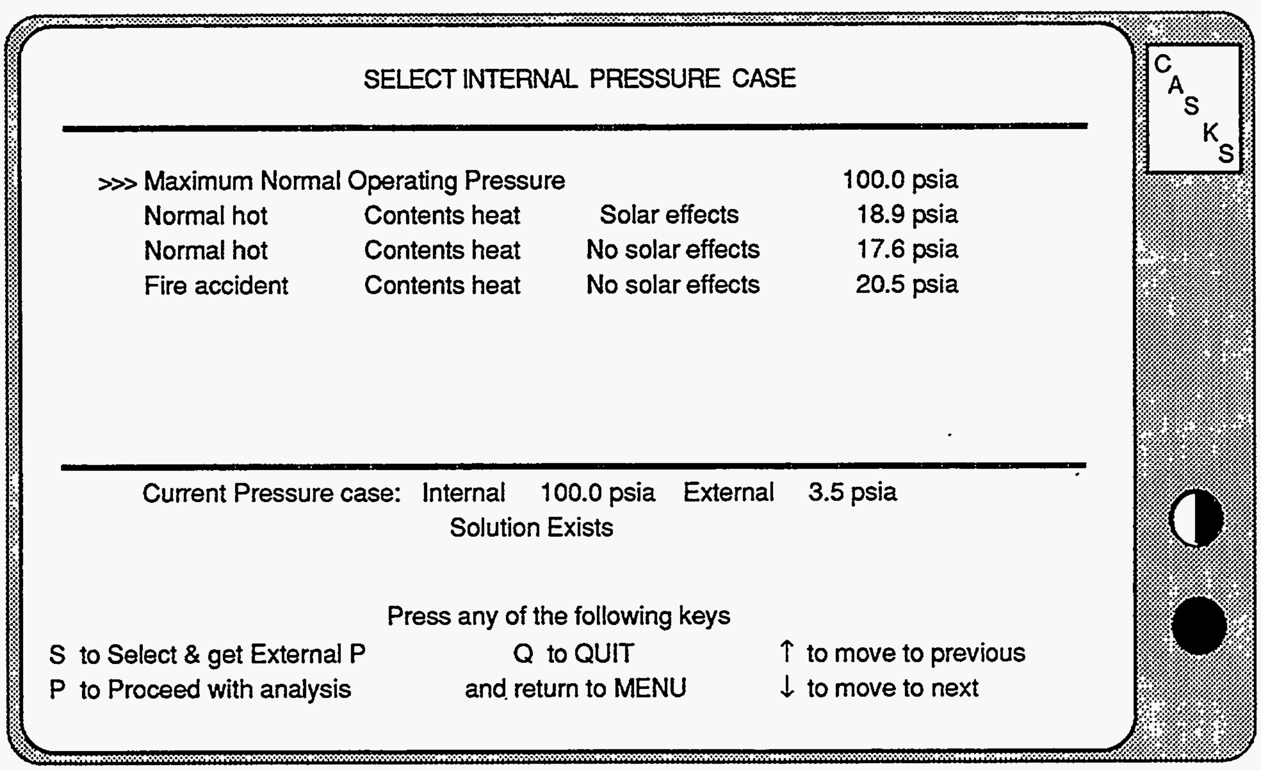


Figure 4-13. Select Internal Pressure Case

The internal pressure list consists of the Maximum Normal Operating Pressure and the internal pressures estimated by existing thermal analyses.

(2)	Use the keypad up or down arrow keys to highlight the desired internal pressure. Press **S** to select the indicated internal pressure and display the list of available external pressure conditions.	These pressure conditions are defined by the regulatory guidelines.
(3)	Use the keypad up or down arrow keys to highlight the desired external pressure.	Below the selection list, **CASKS** displays the selected internal and external pressures and whether a solution exists for this pressure condition.
(4)	Press **P** to proceed with the analysis using the indicated internal and external pressure conditions	If **P** is pressed, wait for the pressure stress analysis to complete, then press **P** to perform another pressure stress analysis
or		
	Press **S** to select the indicated external pressure and display the list of available internal pressure conditions	If **S** is pressed, the *Select External Pressure Screen* appears **(Figure 4-14).**
or		
	Press **Q** to QUIT and return to the Analysis Menu.	

Analysis Menu

Perform Pressure-Induced Stress Analysis

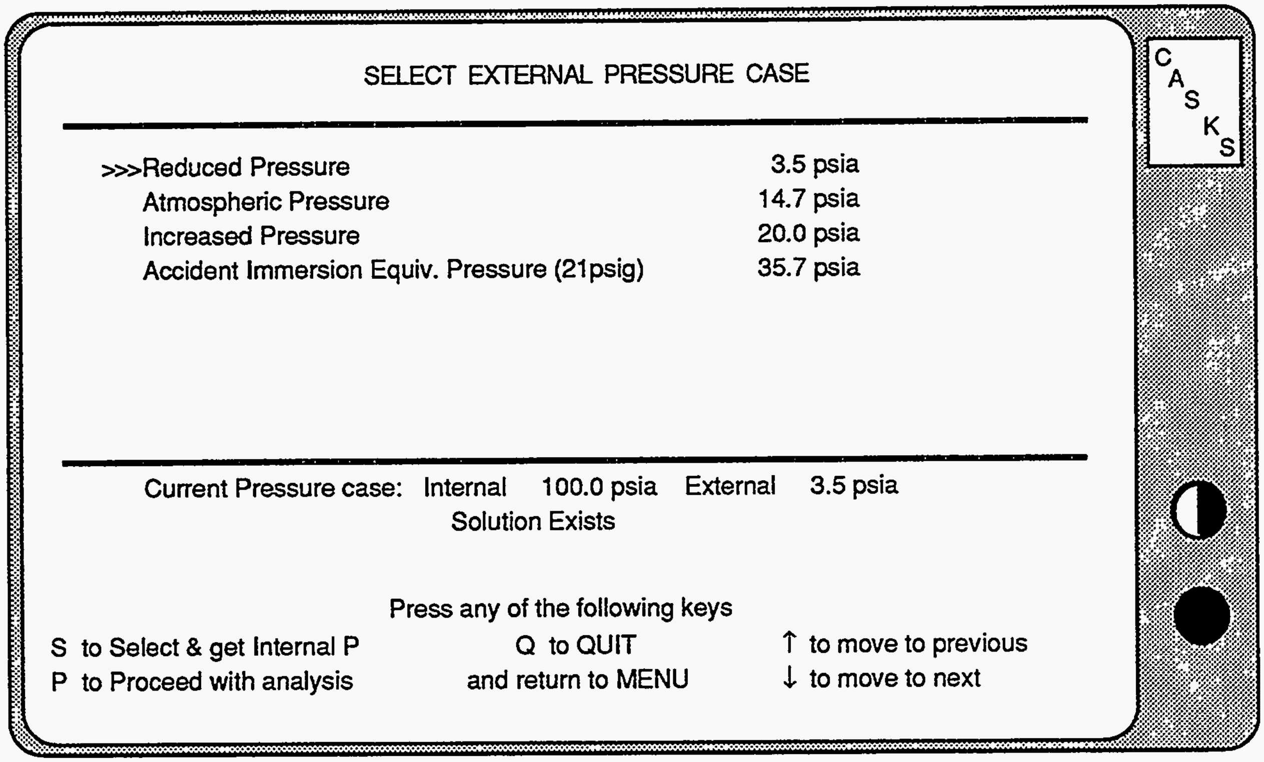


Figure 4-14. Select External Pressure Case

Display Menu

The Display Menu (**Figure 5-1**) provides options for plotting dynamic impact analysis results, displaying and printing finite element meshes, plotting thermal analysis results, and setting video and printer attributes.

PRESS 1 to Plot Dynamic Impact results

Plot the axial force, shear force, bending moment, position of cask top or bottom, cask orientation, and animation of the cask drop. For casks with an unbonded shell/shield interface, plot lead slump, and shell axial and hoop stresses.

PRESS 2 to Display/Print finite element meshes

Display the thermal and stress finite element meshes (generated during thermal or pressure stress analyses). Print the meshes as node element maps.

PRESS 3 to Plot Temperature distributions

Plot temperature distributions as iso-contours, time histories, and thermal profiles.

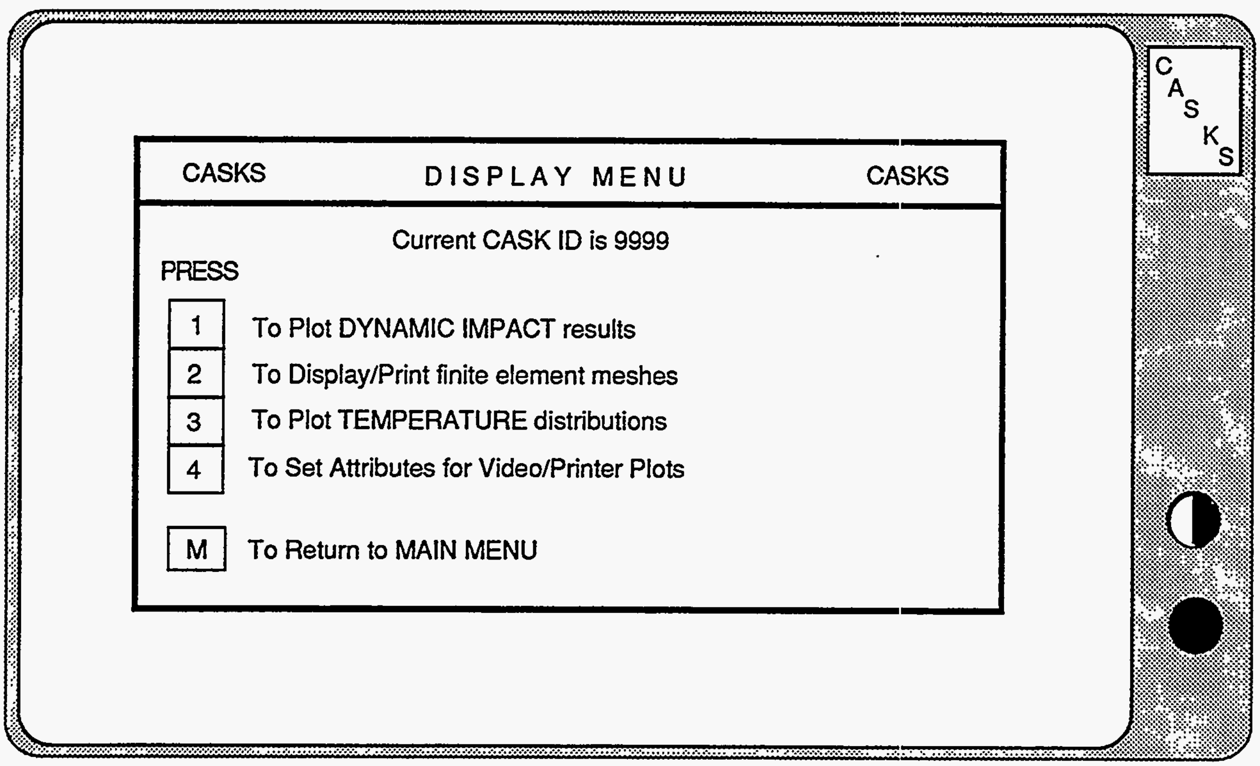


Figure 5-1. CASKS Display Menu

Display Menu

PRESS 4 to Set Attributes for Video/Printer Plots

Select video display (CGA or EGA), printer plot resolution (low or high) and type of printer (IBM/Epson graphics printer or HP LaserJet).

PRESS M to Return to MAIN MENU

CASKS returns to the Main Menu display.

Plotting the Dynamic Impact Results:

CASKS displays the Plot Dynamic Impact Results Title Screen indicating the number of dynamic impact solutions.

(1) Press **Q** to QUIT and return to the Display Menu

or

Press any other key to select the dynamic impact solution to plot.

CASKS lists the available dynamic impact solutions and indicates the shell/shield interface, impact type, impact end, drop height, impact angle, date, and time **(Figure 5-2)**.

SELECT DYNAMIC IMPACT SOLUTION TO PLOT

SHELL/SHIELD INTERFACE	IMPACT TYPE	IMPACT END	DROP HEIGHT	IMPACT ANGLE	DATE	TIME
Bonded	Primary/Secondary	Bottom	72.0	45	04-14-91	02:50p
Bonded	Primary/Secondary	Bottom	72.0	90	04-15-91	03:46p
Unbonded	Primary	Bottom	15.0	45	05-03-91	10:33a

Press any of the following keys

S to select indicated solution

Q to QUIT and return to MENU

↑ to move to previous solution

↓ to move to next solution

CASKS

Figure 5-2. Select Dynamic Impact Solution to Plot

An unbonded shell/shield interface allows the lead shield to slump.

A primary/secondary impact type includes impact of both ends.

The impact end indicates the end that impacts first. Impact angles are relative to the horizontal (i.e., 0 degrees is a side drop).

(2) Use the keypad up and down arrow keys to highlight the desired case. Press **S** to select the indicated solution for plotting.

CASKS displays the Select Plots and Display Parameters Screen (**Figure 5-3**) and lists several options.

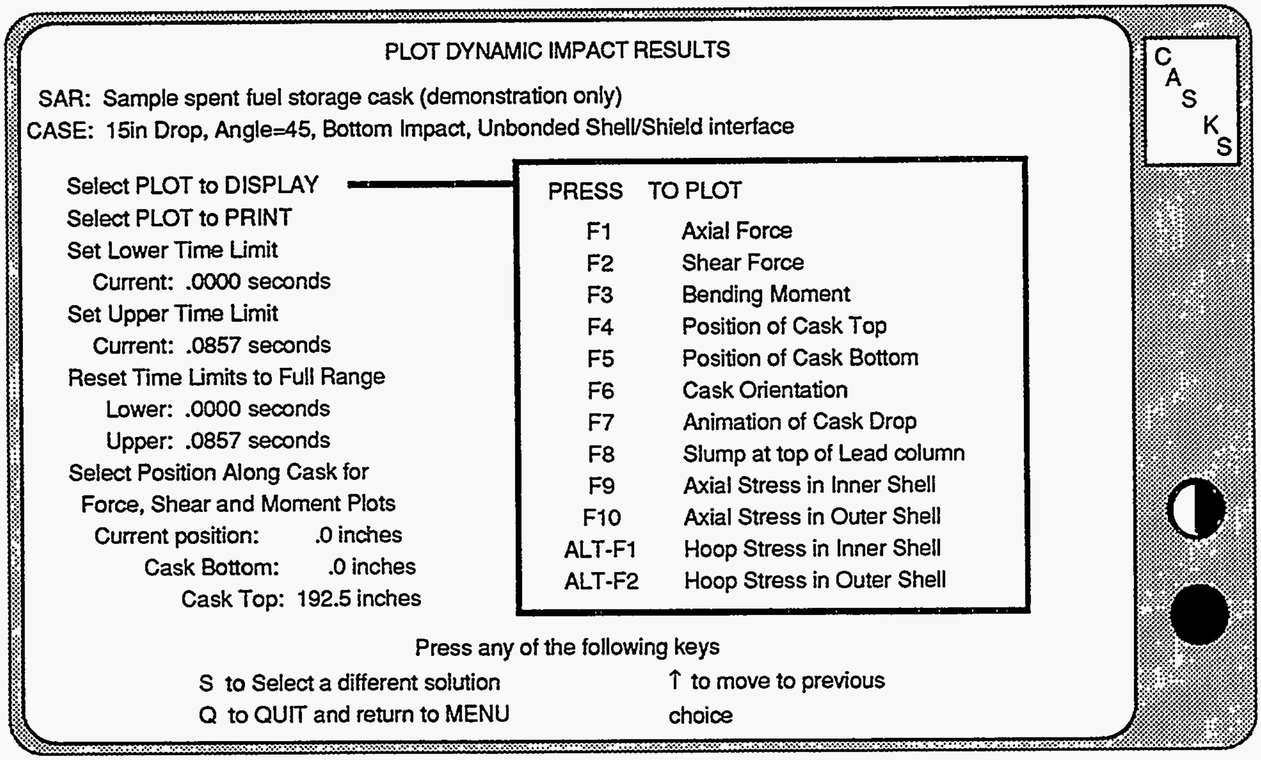


Figure 5-3. Select Plots and Display Parameters Screen

Press **S** to Select a different dynamic impact case
Press **Q** to QUIT and return to the Display Menu
Press ↑ to move to previous choice field
Press ↓ to move to next choice field

or

Press any of the keys indicated in the options box

Selecting the Plot to Display or Print

Highlight the *Select Plot to Display* field to display plots. Highlight the *Select Plot to Print* field to display and print plots. Press one of the following function keys to display the desired plot.

F1	to plot Axial Force **(Figure 5-5)**
F2	to plot Shear Force
F3	to plot Bending Moment
F4	to plot Position of Cask Top
F5	to plot Position of Cask Bottom **(Figure 5-6)**
F6	to plot Cask Orientation
F7	to plot Animation of Cask Drop
F8	to plot Lead Slump in the Lead Shield (unbonded only)
F9	to plot Axial Stress in the Inner Shell (unbonded only)
F10	to plot Axial Stress in the Outer Shell (unbonded only)
ALT-F1	to plot Hoop Stress in the Inner Shell (unbonded only)
ALT-F2	to plot Hoop Stress in the Outer Shell (unbonded only) **(Figure 5-7)**

Display Menu

Plot Dynamic Impact Results

Dynamic impact results are plotted as a function of time. The axial force, shear force, and bending moment are calculated for the total cross section of the cask. Plots of force, bending moment, and stress are at the selected position along the cask. Cask orientation plots are relative to the horizontal (0 degrees). Animation of the cask drop displays the position and orientation of the cask at discrete steps during the impact analysis.

Selecting the Lower and Upper Time Limits

Adjusting the time limits will zoom in on a portion of the time history. Highlight the *Set Lower Time Limit* field to change the lower time limit. Highlight the *Set Upper Time Limit* field to change the upper time limit. Use the + and - keys to change the selected value (times are in seconds). The lower time limit must be greater than or equal to 0. and less than the upper time limit. The upper time limit must be greater than the lower time limit and less than or equal to the maximum time limit.

Resetting the Time Limits to Full Range

Highlight the *Reset Time Limits to Full Range* field and press **F1** to reset the time limits to the full range. Used to display full time histories after time limits have been adjusted.

Selecting the Position Along Cask for Plotting

Highlight the *Select Position Along Cask* field and use the + and - keys to change the position along the cask where axial force, shear force, bending moment and stresses are plotted (**Figure 5-4**). Position **0.0** corresponds to the cask bottom.

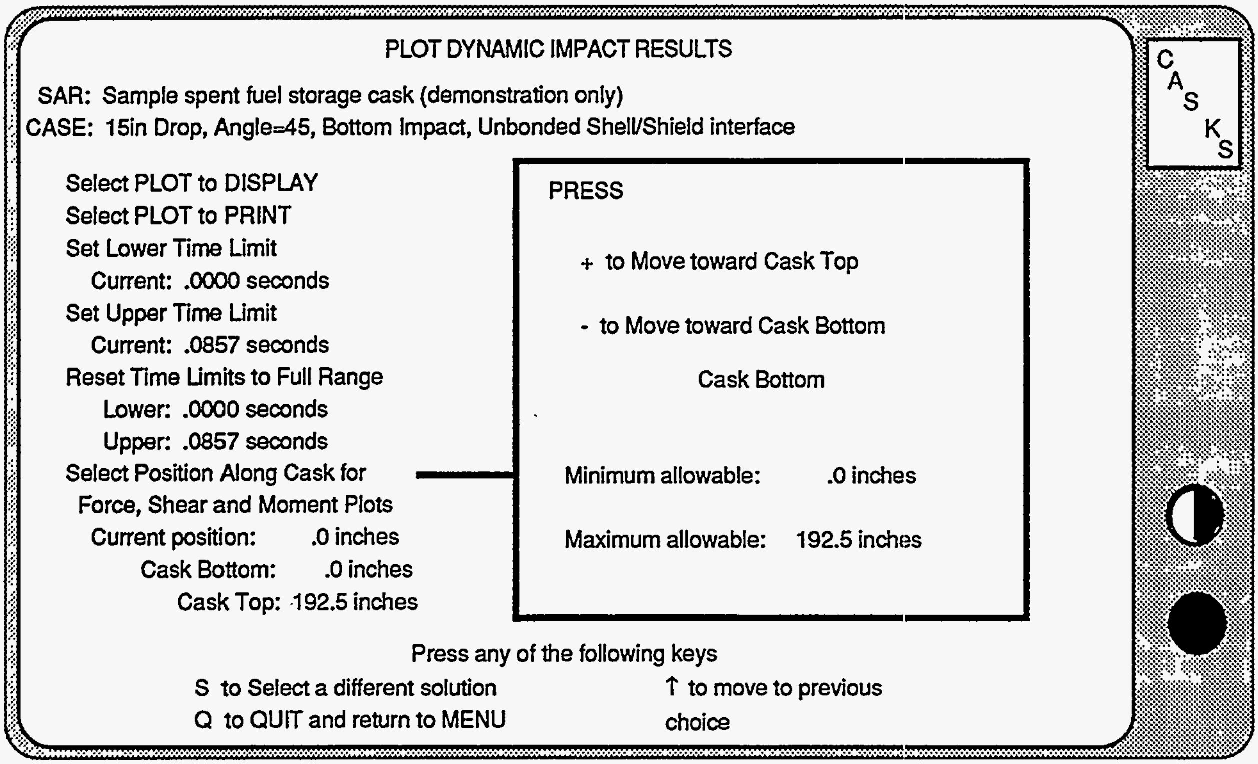


Figure 5-4. Selecting Position Along Cask for Plotting

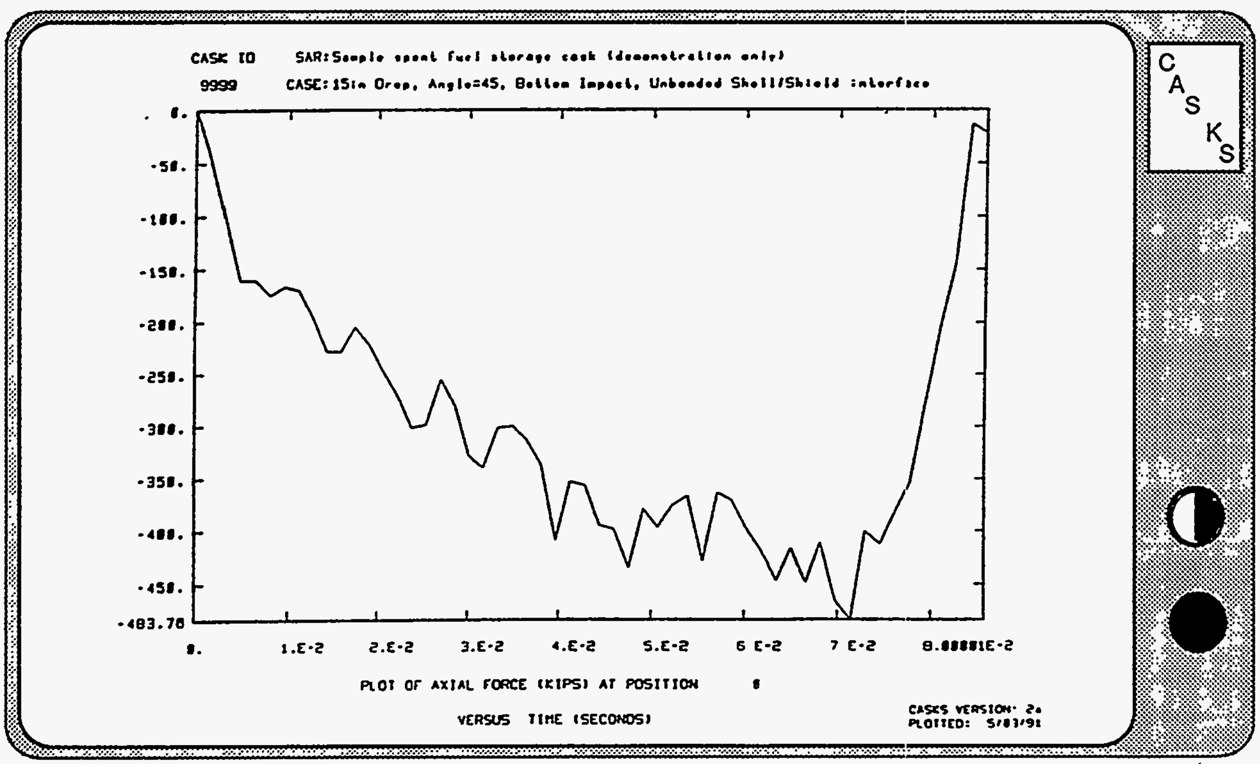


Figure 5-5. Axial Force Time History Plot

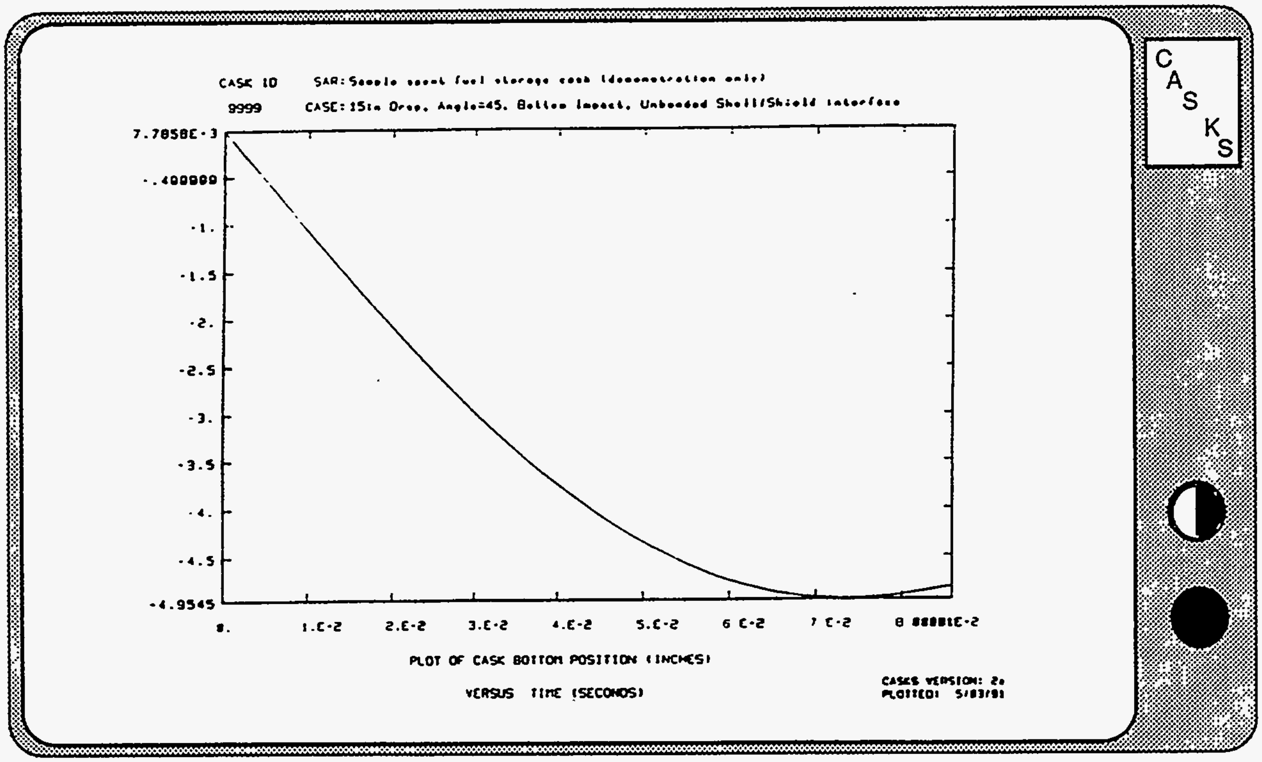


Figure 5-6. Plot of Position of Cask Bottom

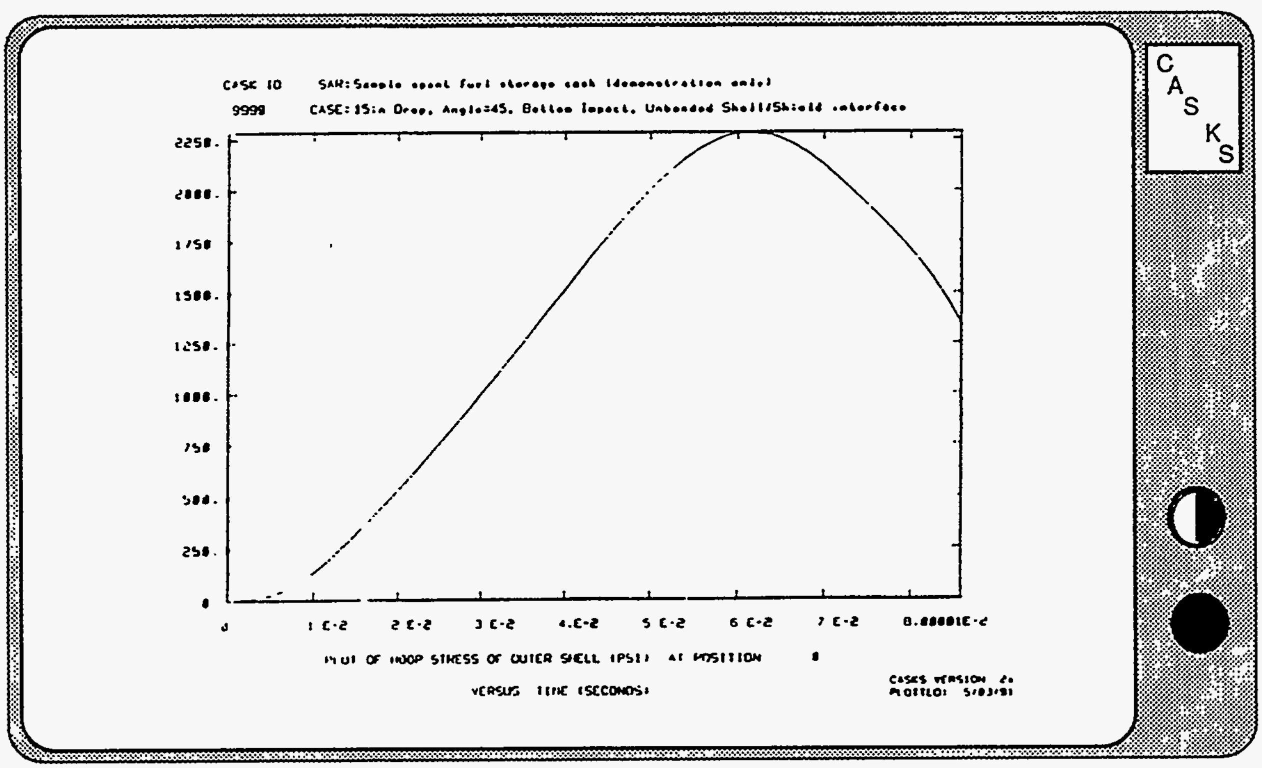


Figure 5-7. Hoop Stress Time History Plot

Display/Print Finite Element Meshes:

CASKS displays the Display/Print Finite Element Mesh title screen and gives the status of the F.E. meshes. Mesh displays are always based on the basic geometry description for the TOP end of the cask and use axisymmetry. Thermal meshes use 4-node elements and include all cask components. Stress meshes use 9-node elements and include only the cask shell and end caps.

(1) Press **Q** to QUIT and return to the Display Menu

or

Press any other key to display the finite element meshes (**Figure 5-8**).

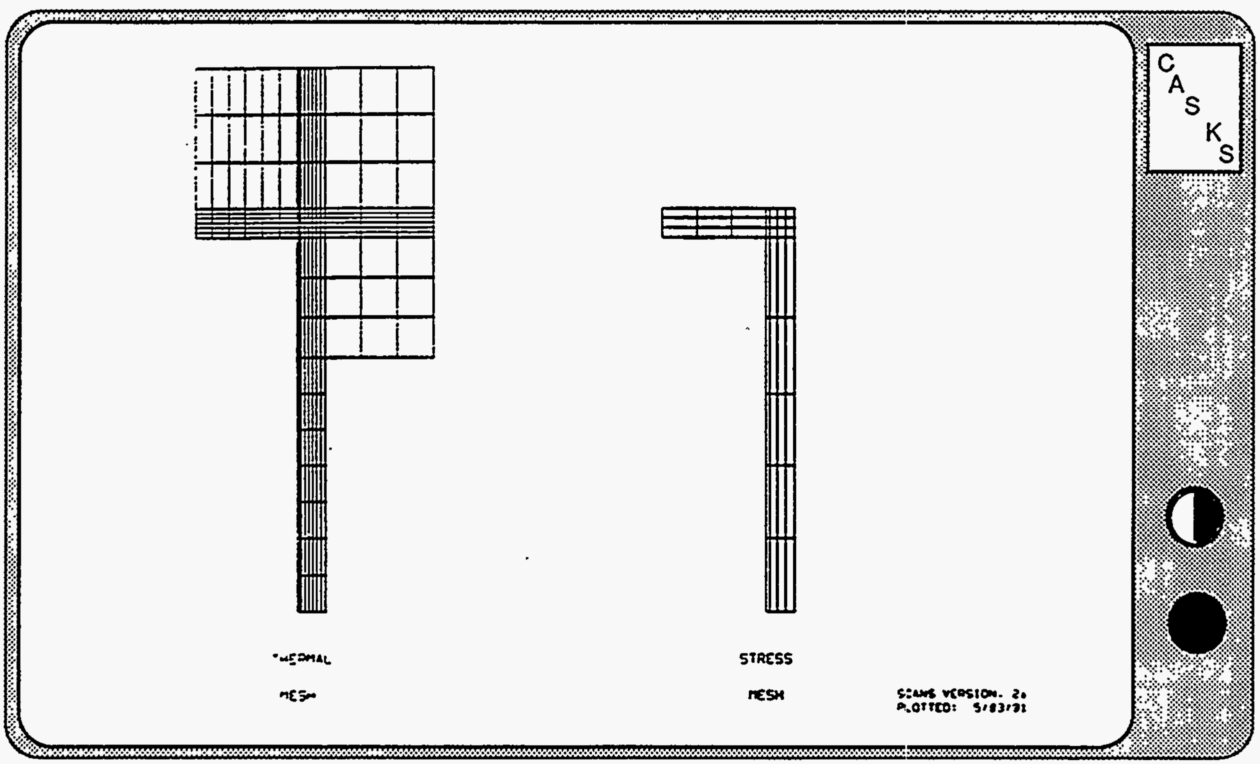


Figure 5-8. Display of Thermal and Stress meshes

Display Menu
Display/Print Finite Element Meshes

(2) Press **ENTER** after reviewing the meshes and select one of the following options:

Press **T** to print the Thermal mesh as a node/element map **(Figure 5-9)**.

Press **S** to print the Stress mesh as a node/element map

Press **D** to Display the meshes again

Press **Q** to QUIT and return to the Display Menu

```
CASK ID: 9999  NODE/ELEMENT map of THERMAL MESH     SCANS Version 2a
Generated on  5/09/91 at  6:57:55
SAR: Sample spent fuel shipping cask (demonstration only)

N O T    T O    S C A L E

NOTE -- Mesh is axisymmetric model for TOP half of cask

Material numbers  ... (printed in corner of each element)

1= Inner Shell    4= End cap inner layer     7= Neutron Shield
2= Shell shield   5= End cap shield layer    8= Water Jacket
3= Outer Shell    6= End cap outer layer     9= Impact Limiter
```

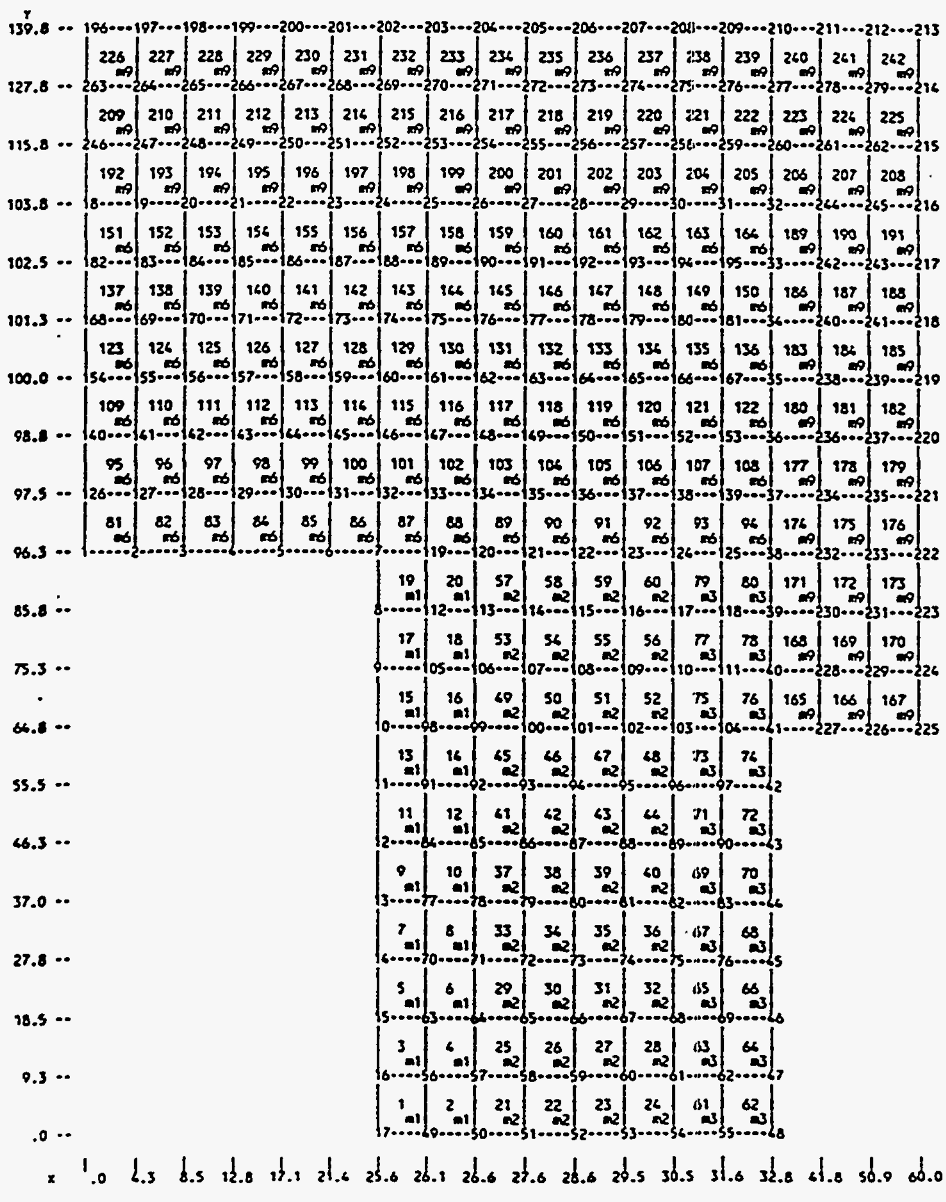


Figure 5-9. Thermal Node/Element Map

Plotting Temperature Distributions:

CASKS displays the Plot Thermal Analysis Results Title Screen and indicates the number of thermal solutions.

(1) Press **Q** to QUIT and return to the Display Menu, or press any other key to select the thermal solution to plot.

CASKS lists the available thermal solutions and displays the thermal case description, contents heat, date, and time for each solution (**Figure 5-10**).

THERMAL SOLUTIONS

THERMAL CASE DESCRIPTION			CONTENTS HEAT	DATE	TIME
Normal hot	Contents heat	Solar effects	500.00	10-02-88	3:19p
Normal hot	Contents heat	No solar effects	500.00	10-13-88	1:51p
Fire accident	Contents heat	No solar effects	500.00	10-13-88	1:58p

Press any of the following keys

S to Select indicated case — ↑ to move to previous case

Q to QUIT and return to MENU — ↓ to move to next case

CASKS

Figure 5-10. Select Thermal Solution to Plot

The case description indicates the external temperature condition and the status of contents heat and solar effects. The applied contents heat is in Btu/min.

(2) Use the keypad up or down arrow keys to highlight the desired case and press **S** to select the indicated solution for plotting.

After the case is selected, **CASKS** displays the Select Plots and Display Parameters Screen (**Figure 5-11**) and lists several options.

Press **S** to select a different thermal case

Press **Q** to QUIT and return to the Display Menu

Press ↑ to move to previous choice field

Press ↓ to move to next choice field

or

Press any of the keys indicated in the options box

Display Menu

Plot Temperature Distributions

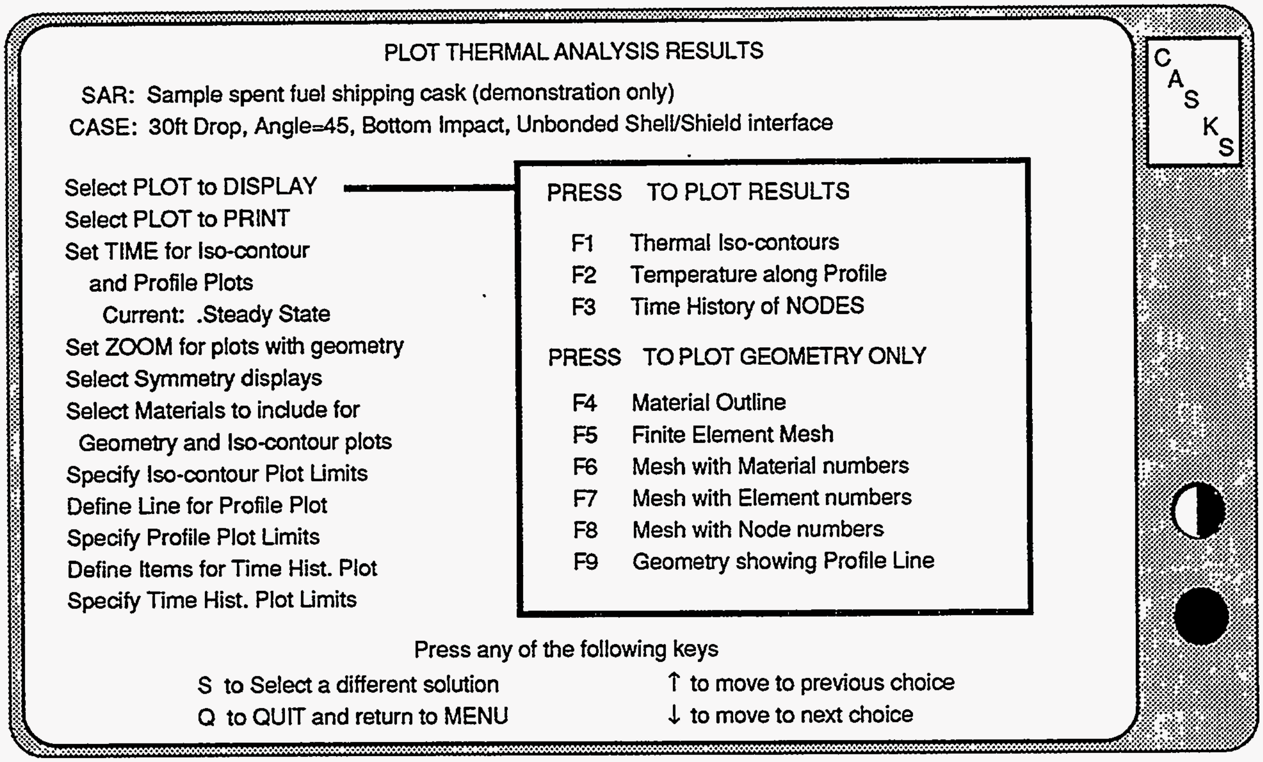


Figure 5-11. Select Plots and Display Parameters Screen

NOTE: Enter values in the same manner as entering values when editing the geometry or impact limiter curves (see Appendix A).

Selecting the Plot to Display or Print

Highlight the *Select Plot to Display* field to display plots. Highlight the *Select Plot to Print* field to display and print plots. Press one of the following function keys to display the desired plot.

- **F1** to plot Thermal Iso-contours **(Figure 5-16)**
- **F2** to plot Temperature along a Profile **(Figure 5-17)** (only if Line for Profile Plot is defined)
- **F3** to plot Time History of Nodes (or Elements) **(Figure 5-18)** (only if Items for Time History Plots are defined)
- **F4** to plot Material Outline **(Figure 5-19)**
- **F5** to plot Finite Element (F.E.) Mesh
- **F6** to plot F.E. Mesh with Material Numbers
- **F7** to plot F.E. Mesh with Element Numbers
- **F8** to plot F.E. Mesh with Node Numbers
- **F9** to plot Geometry showing Profile Line **(Figure 5-20)** (only if Line for Profile Plot is defined)

Thermal iso-contours are lines of constant temperature plotted on the geometry material outline. Plots of temperature along a profile are: (1) the temperature profile along a line cutting the geometry (the line may be defined by XY coordinates or nodes numbers); or (2) temperature plotted for specified nodes as a function of distance between the nodes. Time history plots of nodal temperatures or averaged element temperatures are only available for the transient fire case. Up to six time histories per plot are allowed. Cask components are represented as different materials. Material outline plots are composed of outlines for each component selected for display. The finite element mesh can be plotted showing the mesh only, the mesh with material numbers, the mesh with element numbers, and the mesh with node numbers. Use the ZOOM option to isolate portions of the mesh when element or node numbers overlay one another. When a temperature profile line has been defined, the line can be plotted on the cask material outline to verify its location.

Selecting the Time for Iso-contour and Profile Plots

Highlight the *Time for Iso-contour and Profile Plots* field and use the + and - keys to change the time state for plotting. If the case is a steady state solution (all cases except transient fire) the time cannot be changed.

Setting the Zoom for plots with geometry

Highlight the *Set Zoom* field and press one of the indicated function keys to change the zoom for geometry displays. Zoom on small portions of the geometry for more detailed views (**Figure 5-21**). This is helpful when displaying the finite element mesh with node or element numbers.

F1 to Automatically center and display the full geometry
F2 to ZOOM on specified coordinates
F3 to ZOOM on a specified node

For zoom on specified coordinates (**Figure 5-12**), enter the X and Y coordinates which define the center of the plot and the width of the geometry to plot around the plot center. For zoom on a specified node, enter the number of the node which defines the center of the plot instead of X Y coordinates. After specifying the zoom conditions, press one of the following keys:

Press **D** when DONE entering values
Press **A** to revert to Automatic centering and display full geometry
Press **Q** to QUIT and return to the Display Menu

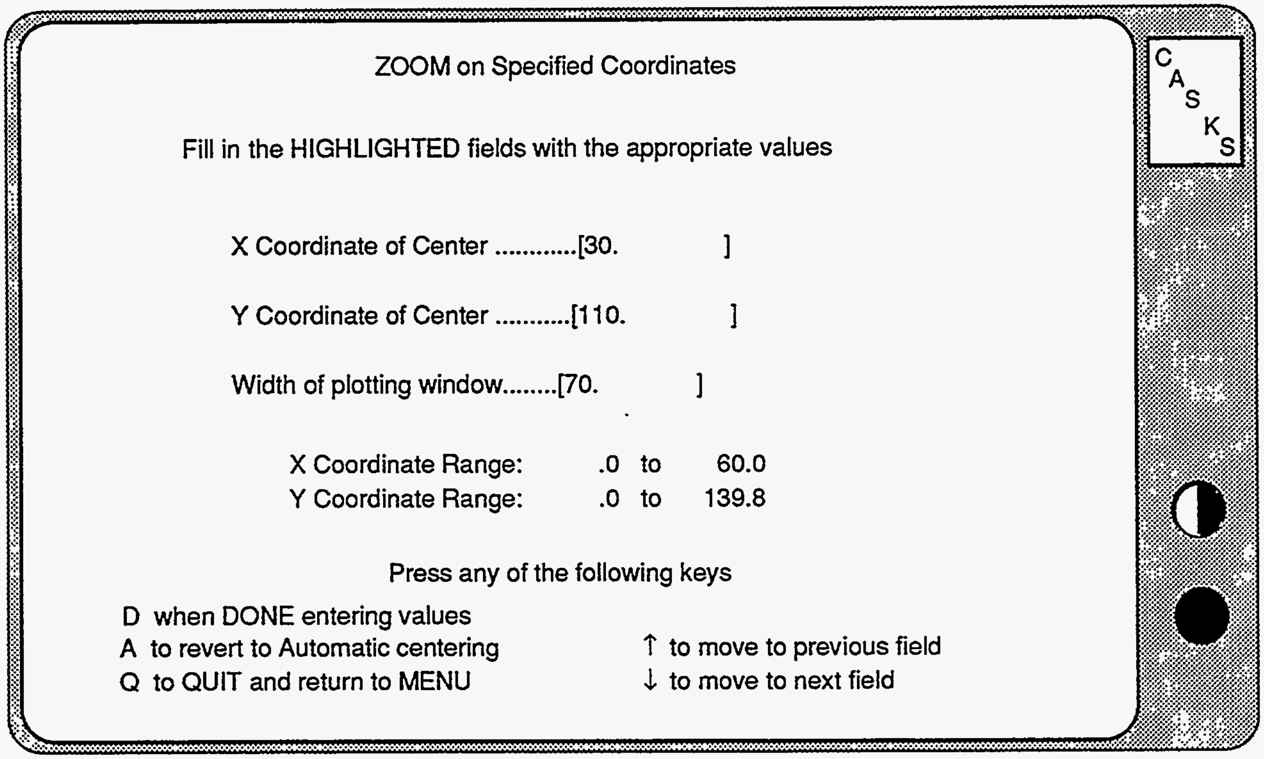


Figure 5-12. ZOOM on Specified Coordinates

Selecting the Symmetry Displays

Highlight the *Select Symmetry Displays* field and press one of the indicated function keys. **CASKS** uses an axisymmetric model of the TOP end of the cask to represent the thermal geometry. Reflect about the Y axis to simulate the geometry full width. Reflect about the X axis to simulate the geometry full length. Reflect about both the X and Y axes to simulate the full cask geometry.

F1 for NO symmetry reflections
F2 to reflect about the Y axis (**Figure 5-22**)
F3 to reflect about the X axis
F4 to reflect about the X and Y axes

Selecting the Materials to Include for Geometry and Iso-contour Plots

Highlight the *Select the Materials to Include* field and press one of the indicated function keys. **CASKS** represents each cask component as a different material. Use this option to isolate cask components for iso-contour and outline plots.

F1 to Include ALL Materials in the Plots
F2 to Select Materials for Plots

Select Materials for Plots

PRESS To Include	PRESS To Omit	Number	Material Name	Status
F1	Alt-F1	1	Inner Shell	Omitted
F2	Alt-F2	2	Shell Shield	Included
F3	Alt-F3	3	Outer Shell	Omitted
F6	Alt-F6	6	Endcap Outer Layer	Included
F9	Alt-F9	9	Impact Limiter	Omitted

Press any of the following keys

D when DONE selecting materials
A to include ALL materials
Q to QUIT and return to MENU

CASKS

Figure 5-13. Select Materials for Plotting

When selecting materials, **CASKS** displays a list of all cask components indicating the material number, component name, and whether the component is included or omitted for iso-contour and outline plots (**Figure 5-13**). Press the indicated function keys to include specific components or press **ALT** and the function key to omit components. To complete material selections, press one of the following:

Press **D** when DONE selecting materials
Press **A** to include ALL materials
Press **Q** to QUIT and return to the Display Menu

Specifying the Iso-contour Plot Limits

Highlight the *Specify the Iso-contour Plot Limits* field and press one of the indicated function keys to specify the contour range. Use the + and - keys to change the number of evenly spaced contour lines.

F1 to set to Automatic ranging
F2 to specify the contour range
+ to increase the number of contour lines (maximum is 8)
- to decrease the number of contour lines (minimum is 2)

Plot Temperature Distributions

Automatic ranging sets the contour range based on the minimum and maximum temperatures of the components included for display. For a specified contour range, enter values for the FIRST and LAST contour lines. The remaining contour lines are evenly spaced in between. Enter values in the same manner as entering values when editing the geometry or impact limiter curves. NOTE: The value of the FIRST contour line must be less than the value for the LAST contour line. After specifying the contour range, press one of the following:

Press **D** when DONE entering values
Press **A** to revert to Automatic ranging
Press **Q** to QUIT and return to the Display Menu

Defining a Line for a Profile Plot

Highlight the *Define Line for Profile Plot* field and press one of the indicated function keys to define one of the three types of temperature profile lines. Profile lines defined between XY coordinates or between two nodes produce plots of the temperature profile along the defined line where it crosses the geometry. Profile lines defined as a series of nodes produce plots of temperature for the specified nodes as a function of the distance between the nodes. The temperature profiles between successive nodes in the series are drawn as a straight lines and do not reflect the actual temperature profiles between nodes.

F1 to Define a Line Between XY Coordinates
F2 to Define a Line Between Two Nodes **(Figure 5-14)**
F3 to Define a Line as a Series of Nodes

When defining a profile line between XY coordinates, enter X and Y coordinates for both ends of the line. NOTE: The line must have a finite length (the coordinates of the first point must not equal the coordinates of the second point). When defining a profile line between two nodes, enter a node number for each end. NOTE: the first node must not equal the second node. When defining a profile line as a series of nodes, enter node numbers for each node in the series. If the series has less than 12 nodes, terminate the list with a node number of zero. After defining the profile line, press one of the following keys:

Press **D** when DONE entering values
Press **A** to ABANDON line definition
Press **Q** to QUIT and return to the Display Menu

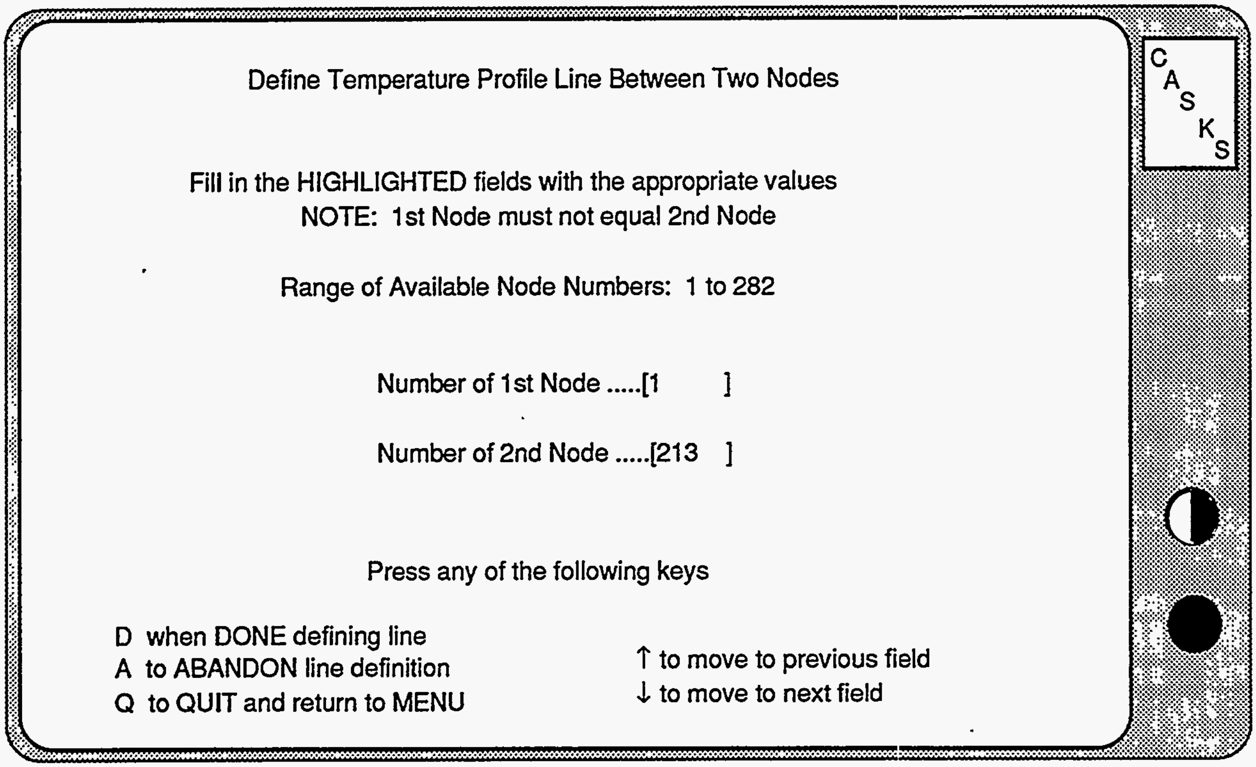


Figure 5-14. Define Profile Line Between Two Nodes

Specifying Profile Plot Limits

Highlight the *Specify Profile Plot Limits* field and press one of the indicated function keys to specify the temperature range for the temperature profile plots.

F1 to set to Automatic ranging
F2 to specify the Temperature range

Automatic ranging sets the temperature range based on the minimum and maximum temperatures along the profile line. For a specified temperature range, enter values for the LOWER and UPPER temperature limits. NOTE: The value of the LOWER temperature limit must be less than the value for the UPPER temperature limit. After specifying the profile temperature range, press one of the following:

Press **D** when DONE entering values
Press **A** to revert to Automatic ranging
Press **Q** to QUIT and return to the Display Menu

Display Menu

Plot Temperature Distributions

Defining Items for Time History Plots

Highlight the *Define Items for Time History Plots* field and press one of the indicated function keys to select the nodes or elements for time history plots. Up to six nodes or elements may be plotted on a single time history plot. Element temperatures are calculated as the average of the temperatures of the nodes defining the element. Time history plots are only available for transient fire case solutions.

F1 to Specify NODES for Time History Plots **(Figure 5-15)**
F2 to Specify ELEMENTS for Time History Plots

Enter up to six node or element numbers. If the list has less than six node or element numbers, terminate the list with a node or element number of zero. After specifying items for time history plots, press one of the following keys:

Press **D** when DONE selecting items
Press **A** to ABANDON selections
Press **Q** to QUIT and return to the Display Menu

Specifying Time History Plot Limits

Highlight the *Specify Time History Plot Limits* field and press one of the indicated function keys to specify the temperature range for time history plots.

F1 to set to Automatic ranging
F2 to specify the Temperature range

Automatic ranging sets the temperature range based on the minimum and maximum temperatures of the nodes or element for the full time history. For a specified temperature range, enter values for the LOWER and UPPER temperature limits. NOTE: The value of the LOWER temperature limit must be less than the value for the UPPER temperature limit. After specifying the time history temperature range, press one of the following:

Press **D** when DONE entering values
Press **A** to revert to Automatic ranging
Press **Q** to QUIT and return to the Display Menu

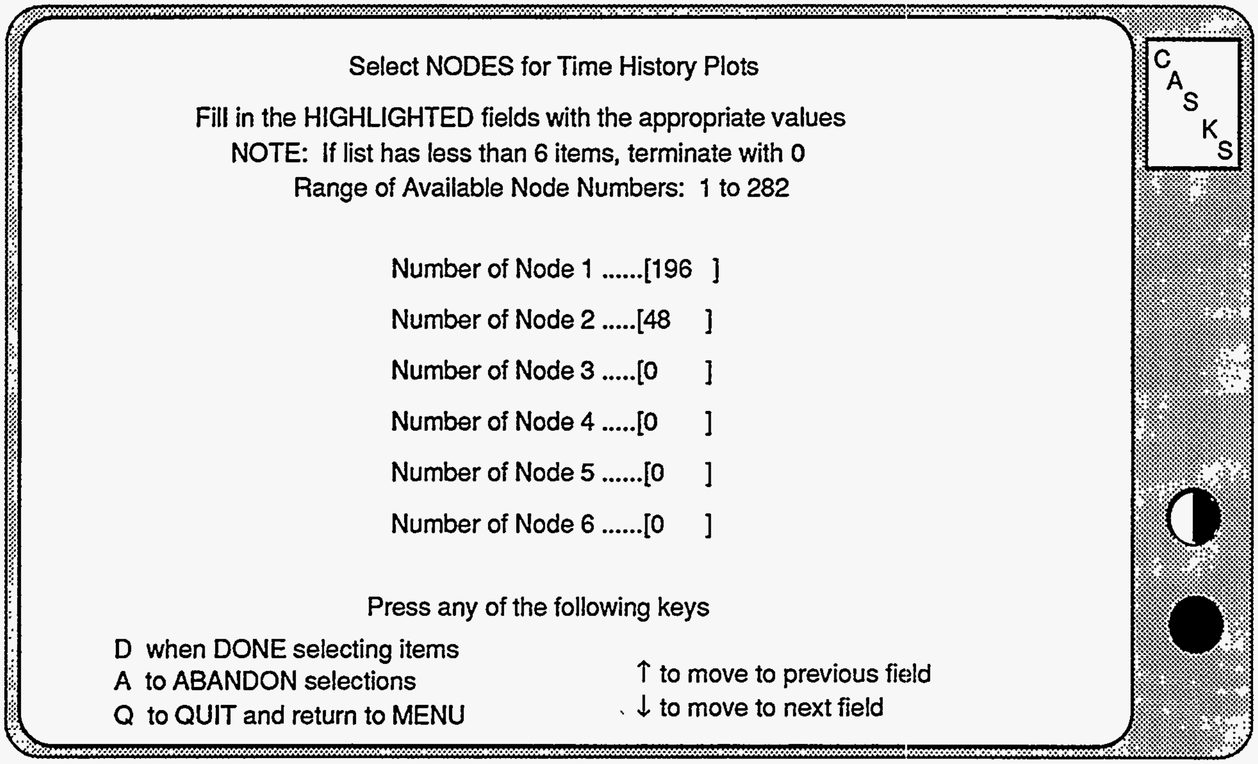


Figure 5-15. Select NODES for Time History Plots

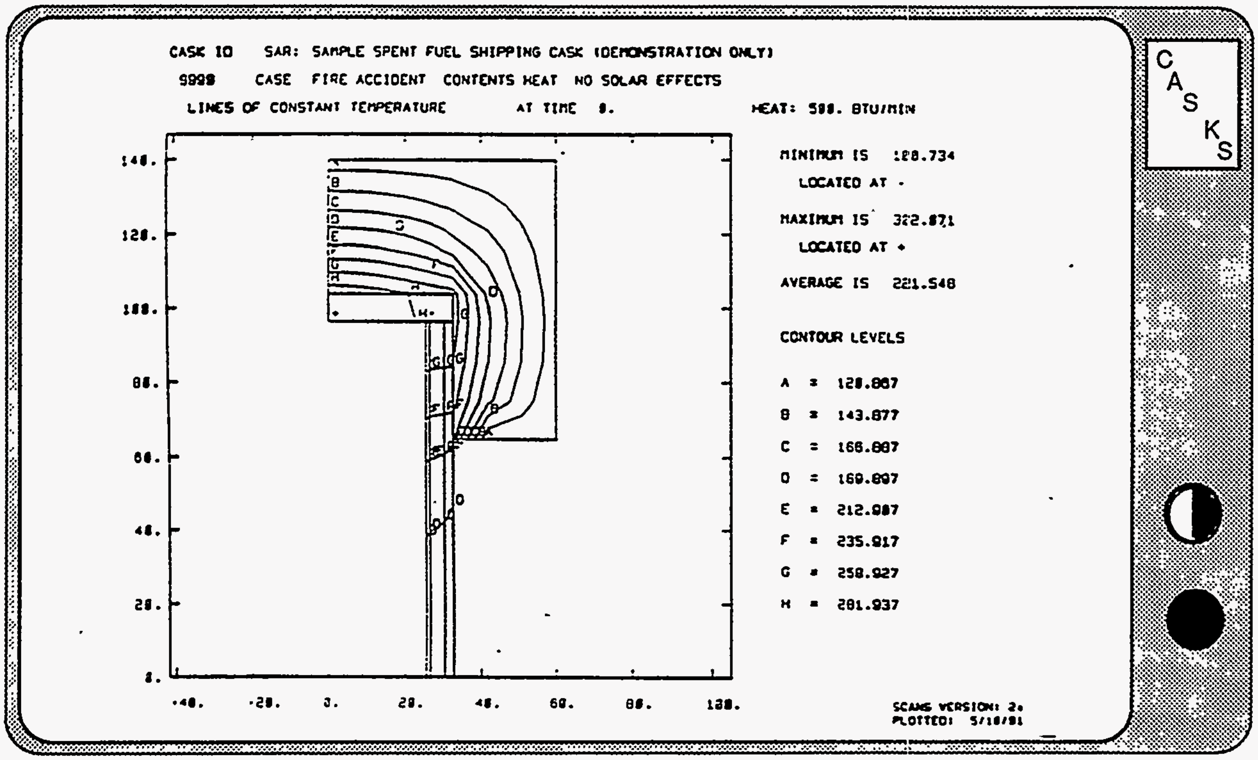


Figure 5-16. Plot of Thermal Iso-contours

Display Menu

Plot Temperature Distributions

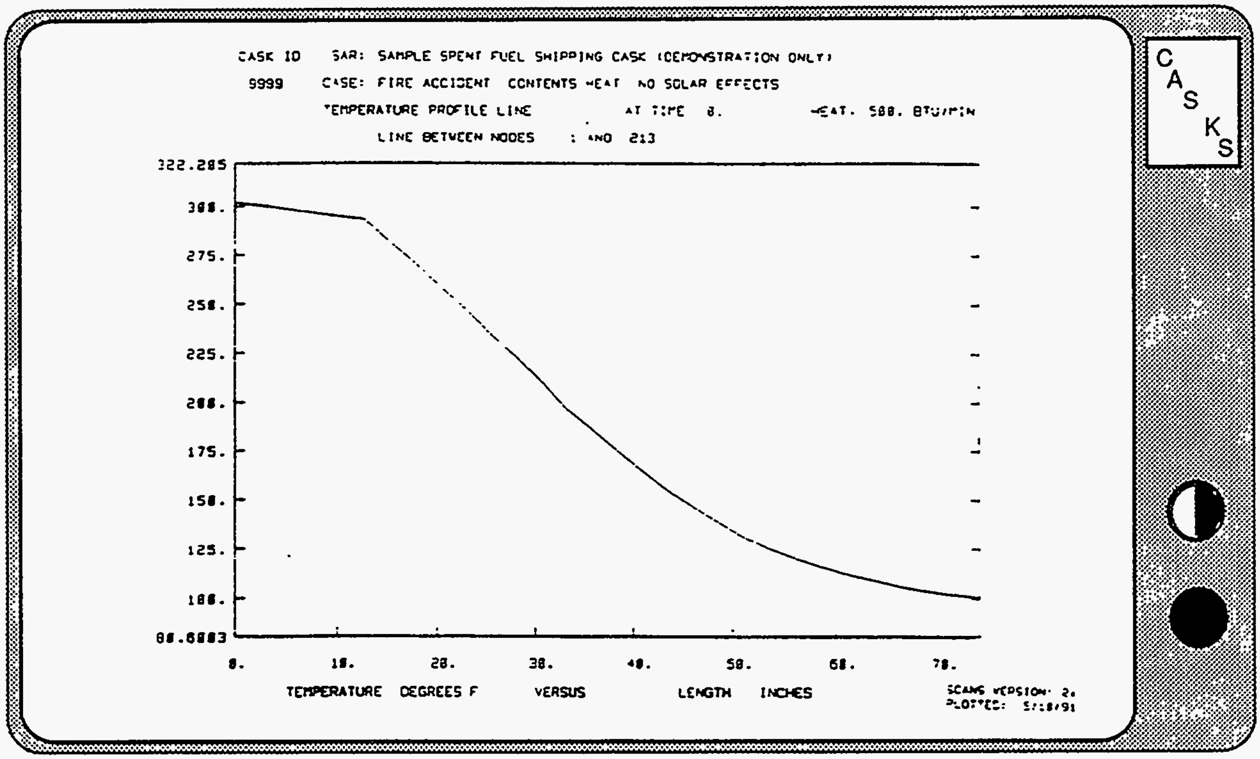


Figure 5-17. Plot of Temperature Along Profile Between Nodes 1 and 213
Profile line is shown in Figure 5-20

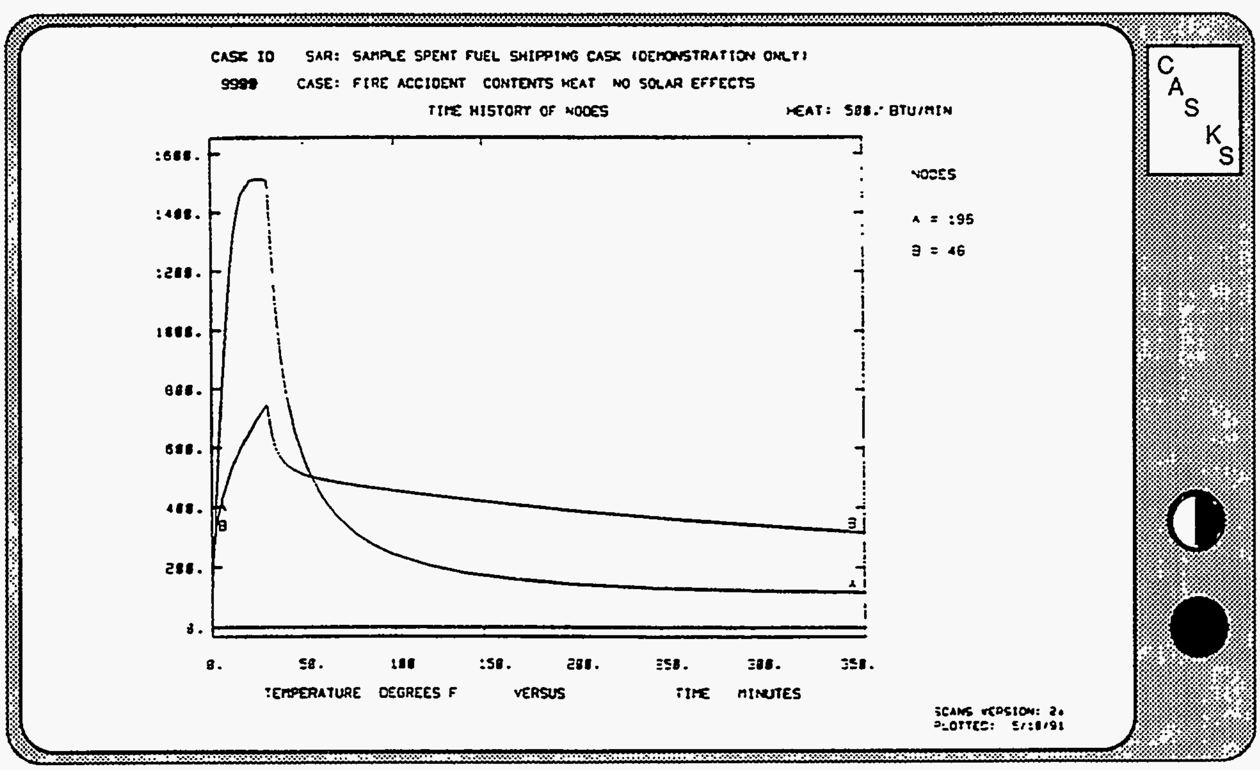


Figure 5-18. Plot of Time History of Nodes 196 and 48

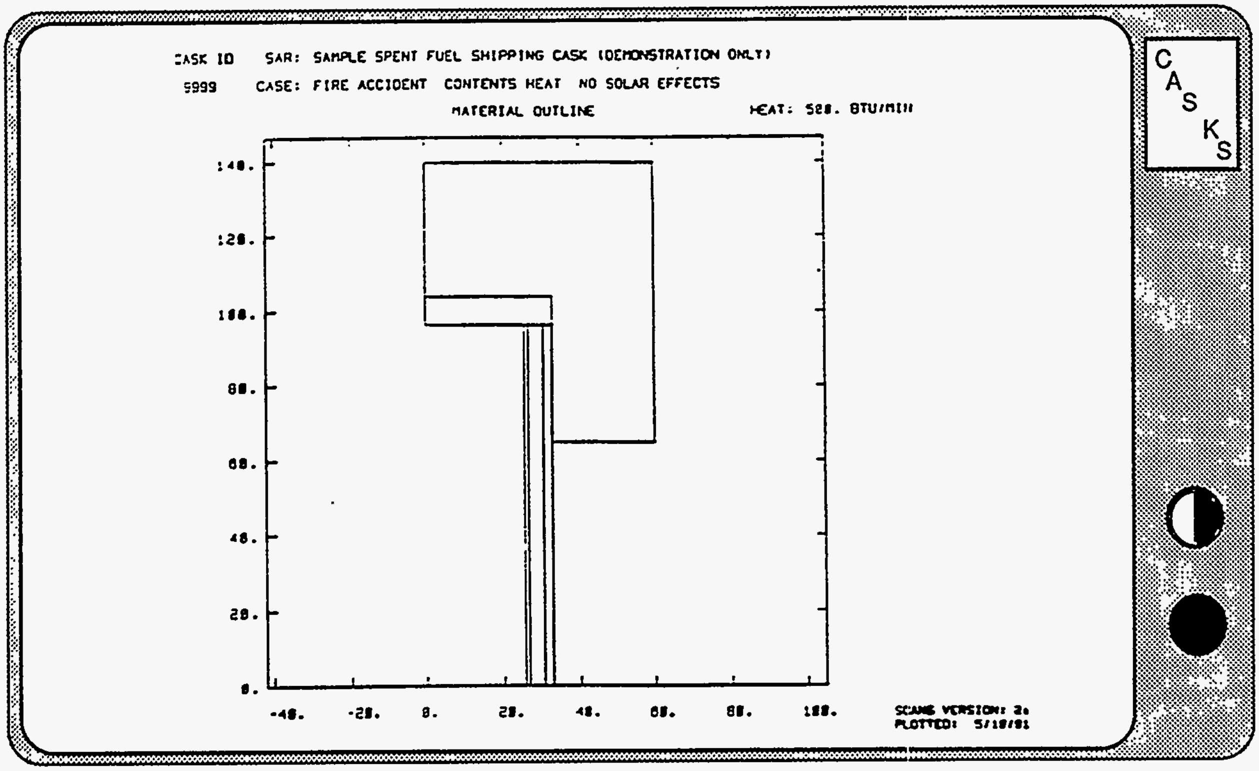


Figure 5-19. Plot of Material Outline

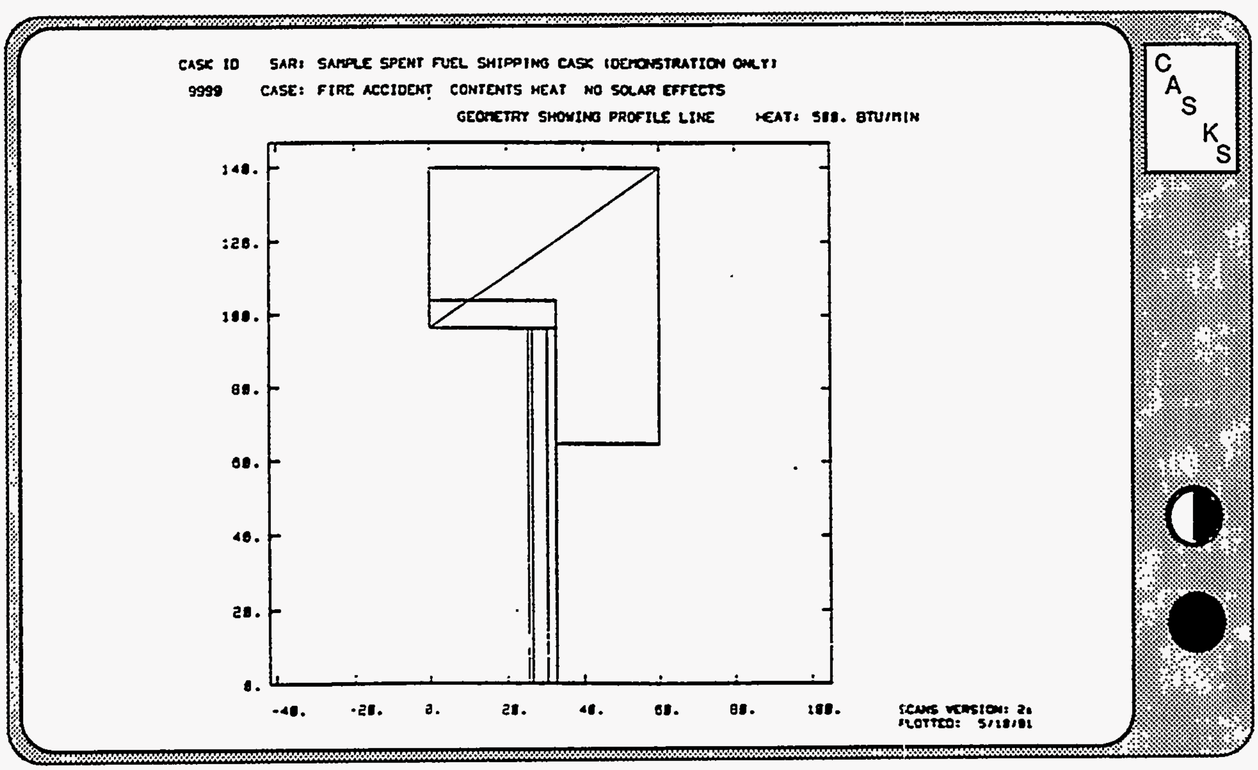


Figure 5-20. Plot of Geometry Showing Profile Line

Display Menu

Plot Temperature Distributions

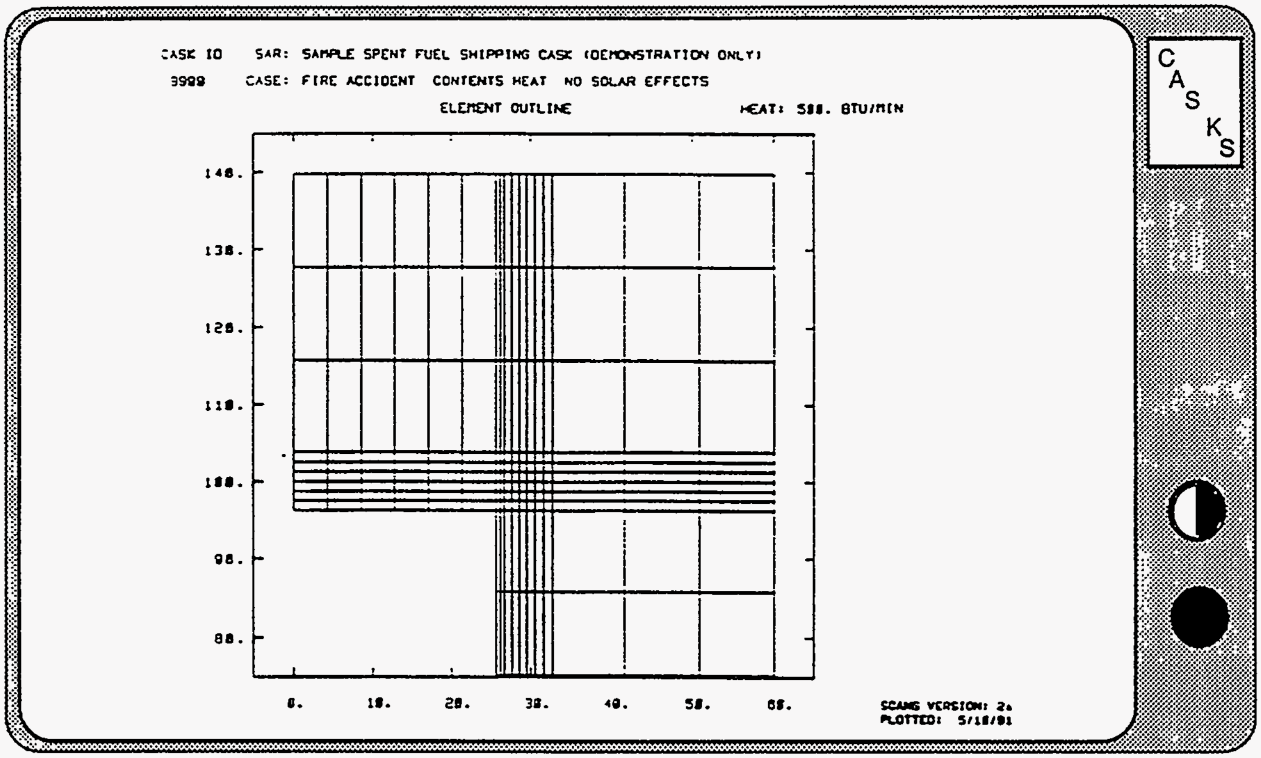


Figure 5-21. Plot of Elements Using ZOOM

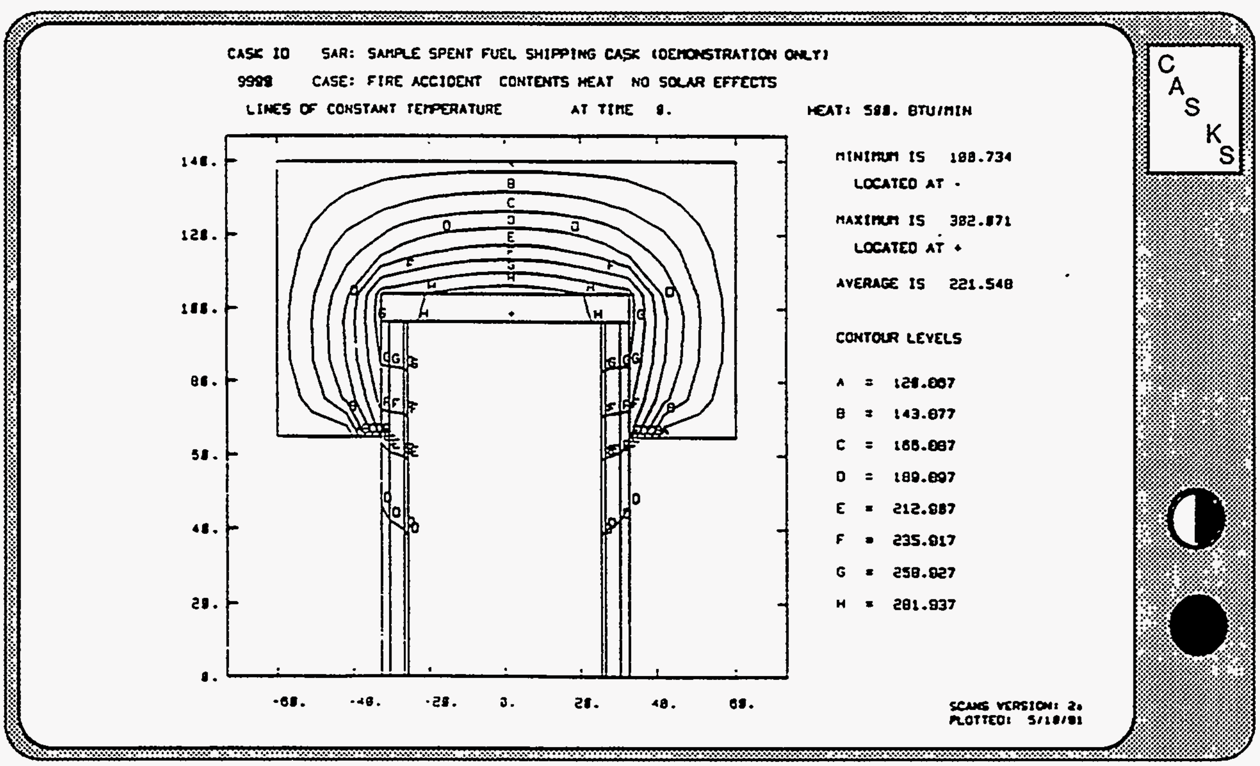


Figure 5-22. Iso-contour Plot with Y Axis Reflection

CASKS displays the Set Attributes for Video/Printer Plots Screen shown in **Figure 5-23**. Select the desired attributes for display type, printer plot resolution, and printer type. Then press **Q** to QUIT and return to the Display Menu.

Selecting the Display Type

Press **C** for Color Graphics Adapter (one color, 640 x 200 pixels)
Press **E** for Enhanced Graphics Adapter (three colors, 640 x 350 pixels)

Selecting the Printer Plot Resolution

Press **H** for HIGH resolution printer plots
Press **L** for LOW resolution printer plots

Printer plots are for graphics displays and require a printer that supports graphics. High resolution plots take up to 10 times longer to print than low resolution plots.

Hint:

Use low resolution plots until report-quality plots are required. Switch to high resolution for report-quality plots, then return to low resolution.

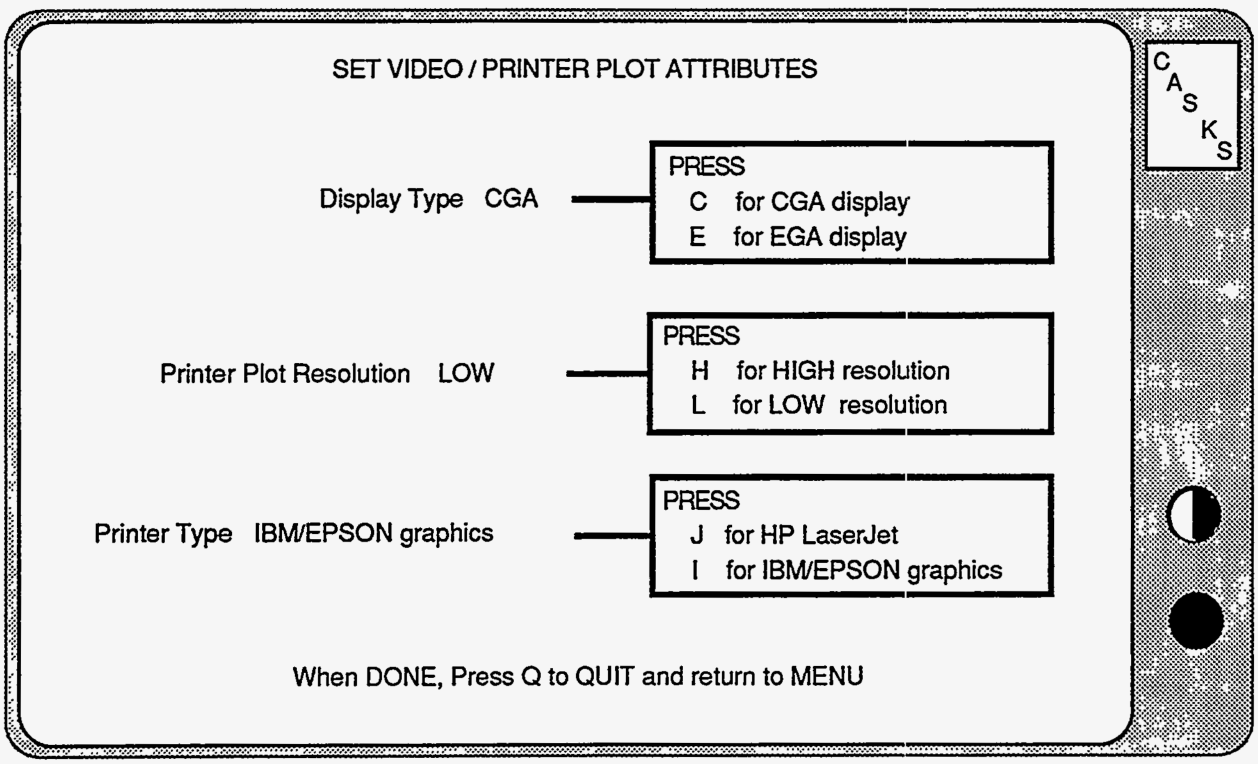


Figure 5-23. Set Video/Printer Plot Attributes

Display Menu

Selecting the Printer Type

Press **J** for Hewlett Packard LaserJet printer
Press **I** for IBM/Epson graphics type dot matrix printer

CASKS can utilize any dot matrix printer that uses the same graphics commands as the IBM Proprinter and Epson FX-85.

CASKS uses the three Hewlett Packard LaserJet printer models in a limited fashion. Node/element mesh maps are printed using the standard Courier font (10 characters per inch) and the Line Printer font (16.66 characters per inch). LOW resolution plots are drawn using 150 dpi (dots per inch) graphics mode; HIGH resolution plots are drawn using 300 dpi graphics mode. Each LaserJet model is described below with its particular limitations and possible remedies.

LaserJet

(1) The Line printer font is not an internal font. Provide a font cartridge which contains the Line Printer font for mesh maps.
(2) The maximum graphics mode resolution is 75 dpi. Both LOW and HIGH resolution printer plots are printed piecemeal on several pages. If the LaserJet upgrade is installed, printer plots are printed on one page.

LaserJet+

(1) The maximum graphics mode resolution is 150 dpi. LOW resolution printer plots are printed on one page and HIGH resolution plots are printed piecemeal on several pages. If the LaserJet+ upgrade is installed, HIGH resolution plots are printed on one page.

LaserJet Series II

(1) The maximum graphics mode resolution is 150 dpi. LOW resolution printer plots are printed on one page and HIGH resolution plots are printed piecemeal on several pages. If a 1 Mbyte memory board is installed, HIGH resolution plots are printed on one page.

Print/Review Menu

The Print/Review Menu (**Figure 6-1**) provides options for printing and reviewing the Cask Summary/Data Check and outputs from Impact, Thermal, Thermal Stress, and Pressure Stress analyses. Output for Thermal, Thermal Stress, and Pressure Stress can also be printed as an abbreviated output summary. The review function displays the output on the screen. The outputs are discussed in Appendix C.

PRESS 1 to Print/Review Impact Output

Print or Review Dynamic or Quasi-Static Impact analysis output.

PRESS 2 to Print/Review Thermal Output

Print or Review Thermal output. Abbreviated prints skip the summary of input, printing the temperature output with flux balances.

PRESS 3 to Print/Review Thermal Stress Output

Print or Review Thermal stress output. Abbreviated prints skip nodal displacements and element stresses, printing the summary of maximum stresses and stresses corresponding to Impact nodal locations.

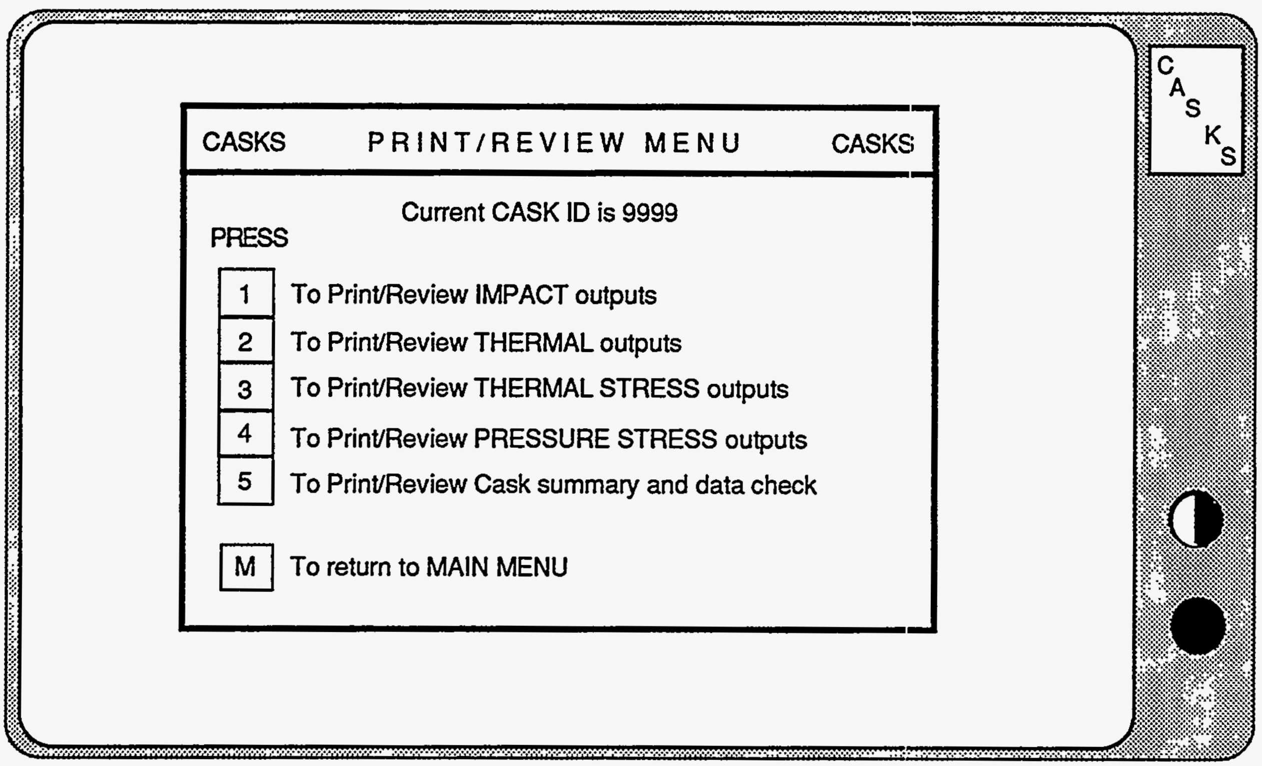


Figure 6-1. CASKS Print/Review Menu

Print/Review Menu

PRESS 4 to Print/Review Pressure Stress output

Print or Review Pressure stress output. The abbreviated print skips the nodal displacements and element stresses and includes a table of maximum stresses and the stresses corresponding to Impact nodal locations.

PRESS 5 to Print/Review Cask Summary and Data Check

Print or Review the geometry summary / data check for basic geometry and impact limiter force/deflection curve data.

PRESS M to Return to Menu

CASKS returns to the Main Menu display.

Selecting the Output to Print/Review:

(1) Press the appropriate Menu key to select the output type.

CASKS displays the Print/Review Title Screen indicating the number of outputs available for printing or review.

(2) Press **Q** to QUIT and return to the Print/Review Menu, or press any other key to select a particular output case to print or review.

CASKS lists the available outputs and displays a description, date, and time for each output (**Figure 6-2**).

IMPACT SOLUTIONS

ANALYSIS TYPE	SHELL/SHIELD INTERFACE	IMPACT TYPE	IMPACT END	DROP HEIGHT	IMPACT ANGLE	DATE	TIME
Dynamic	Bonded	Primary/Secondary	Bottom	72.0	45	04-15-91	02:50p
Dynamic	Bonded	Primary/Secondary	Bottom	72.0	90	04-15-91	02:46p
Dynamic	Unbonded	Primary	Bottom	15.0	45	05-03-91	10:33a
Quasi-static	Bonded	Primary/Secondary	Bottom	72.0	45	04-15-91	02:51p
Quasi-static	Bonded	Primary/Secondary	Bottom	72.0	90	04-15-91	02:51p

Press any of the following keys

S to Select indicated solution
Q to QUIT and return to MENU
↑ to move to previous solution
↓ to move to next solution

CASKS

Figure 6-2. Select Solution to Print/Review

Output Type	Description
Impact	The case descriptions indicate the analysis type, shell/shield interface, impact type, impact end, drop height, and impact angle. An unbonded shell/shield interface allows the lead shield to slump. A primary/secondary impact type includes impact of both ends. The impact end indicates the end that impacts first. Impact angles are relative to the horizontal (i.e., 0 degrees is a side drop).
Thermal and Thermal stress	The case descriptions indicate the external temperature condition, the status of the applied contents heat, and the status of solar effects. The applied contents heat is in Btu/min.
Pressure stress	The case descriptions indicate the internal and external pressures. The internal pressure is the maximum normal operating temperature (input during geometry definition) or the internal pressure resulting from a thermal analysis. The external pressure is established by regulatory guidelines.
Summary / Data Checks	The description indicates the basic geometry specifications or impact limiter force/deflection curves.

(3) Use the keypad up or down arrow keys to highlight the desired case. Press **S** to select the indicated solution to print or review.

After the output is selected, **CASKS** displays an Output Summary Screen indicating the number of pages in the output, if abbreviated output is available, and the output header (**Figure 6-3**).

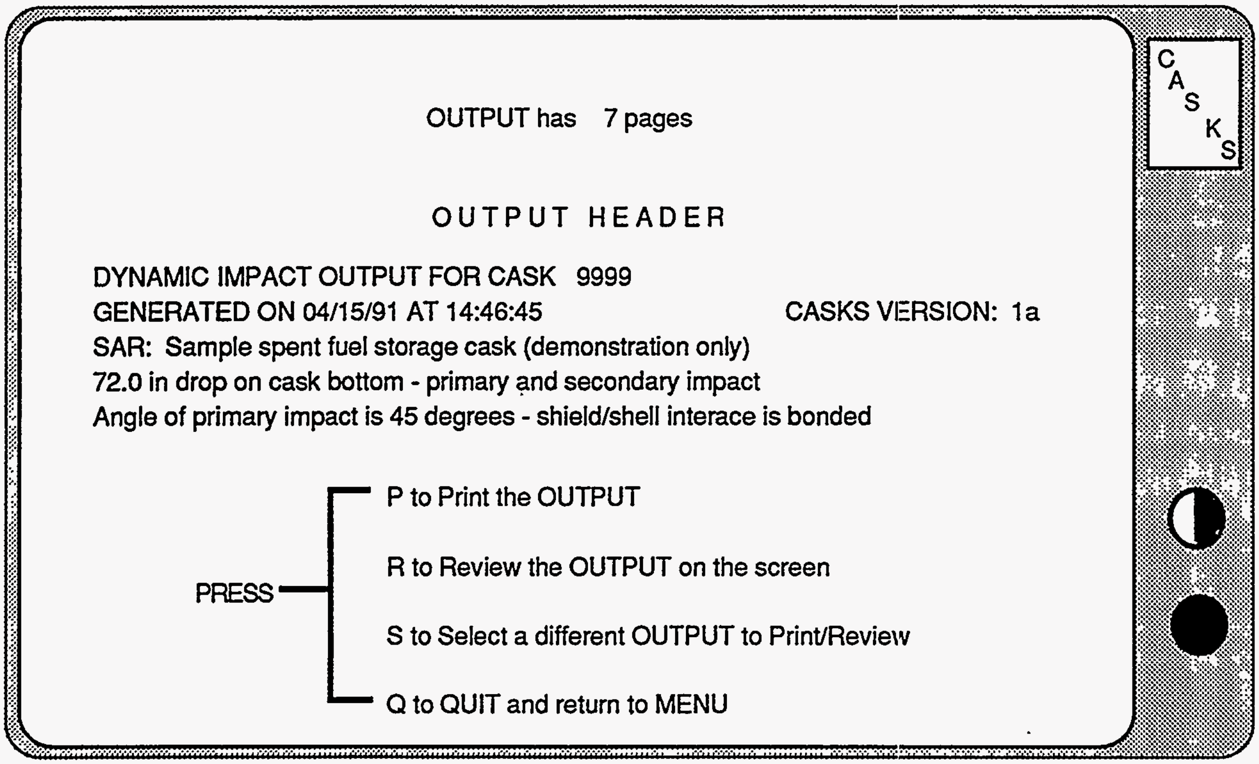


Figure 6-3. Output Summary Screen

The output header indicates the type of analysis, date and time the output was generated, and a brief description of the parameters defining the output. **CASKS** then lists several options.

Press **P** to Print the OUTPUT

Press **R** to Review the OUTPUT on the screen

Press **S** to Select a different OUTPUT to Print/Review

Press **Q** to QUIT and return to the Print/Review Menu

Print/Review Menu

Printing the Output

If you press **P** at the Output Summary Screen, **CASKS** displays a reminder to make sure the printer is ON-LINE and set to the TOP-OF-PAGE. Press one of the following keys:

Press **P** to Print the complete output
Press **A** to print the Abbreviated output (if available)
Press **Q** to QUIT and return to the Print/Review Menu

As the output is printed, **CASKS** indicates the current page being printed. Press any key to suspend printing. When printing is halted, **CASKS** lists the following options:

Press **C** to Continue
Press **Q** to QUIT and return to the Print/Review Menu

After printing is finished, **CASKS** lists the following options:

Press **P** to Print/Review another case
(redisplays the case list screen for current output type)
Press **Q** to QUIT and return to the Print/Review Menu

Print/Review Menu

Reviewing the Output

After pressing **R** on the Output Summary Screen, **CASKS** displays the first 20 lines of the full output on the screen (**Figure 6-4**). **CASKS** can review up to 4000 lines of output (the entire output can be printed). The review control options are:

Press	**S**	to print the 20 lines displayed on the screen
Press	**ESC**	to exit (end review)
Press	**P**	to print the output (see **Printing the Output**)
Press	↑	to scroll screen down, displaying previous line at top
Press	↓	to scroll screen up, displaying next line at bottom
Press	**Home**	to display first 20 lines of output
Press	**End**	to display last 20 lines of output
Press	**PgUp**	to display previous 20 lines of output
Press	**PgDn**	to display next 20 lines of output

The symbol <FF> represents form feeds used to paginate the output. Press **ESC** to terminate reviewing the output. **CASKS** lists the following options:

Press	**P**	to Print/Review another case (redisplays the case list screen for current output type)
Press	**Q**	to QUIT and return to the Print/Review Menu

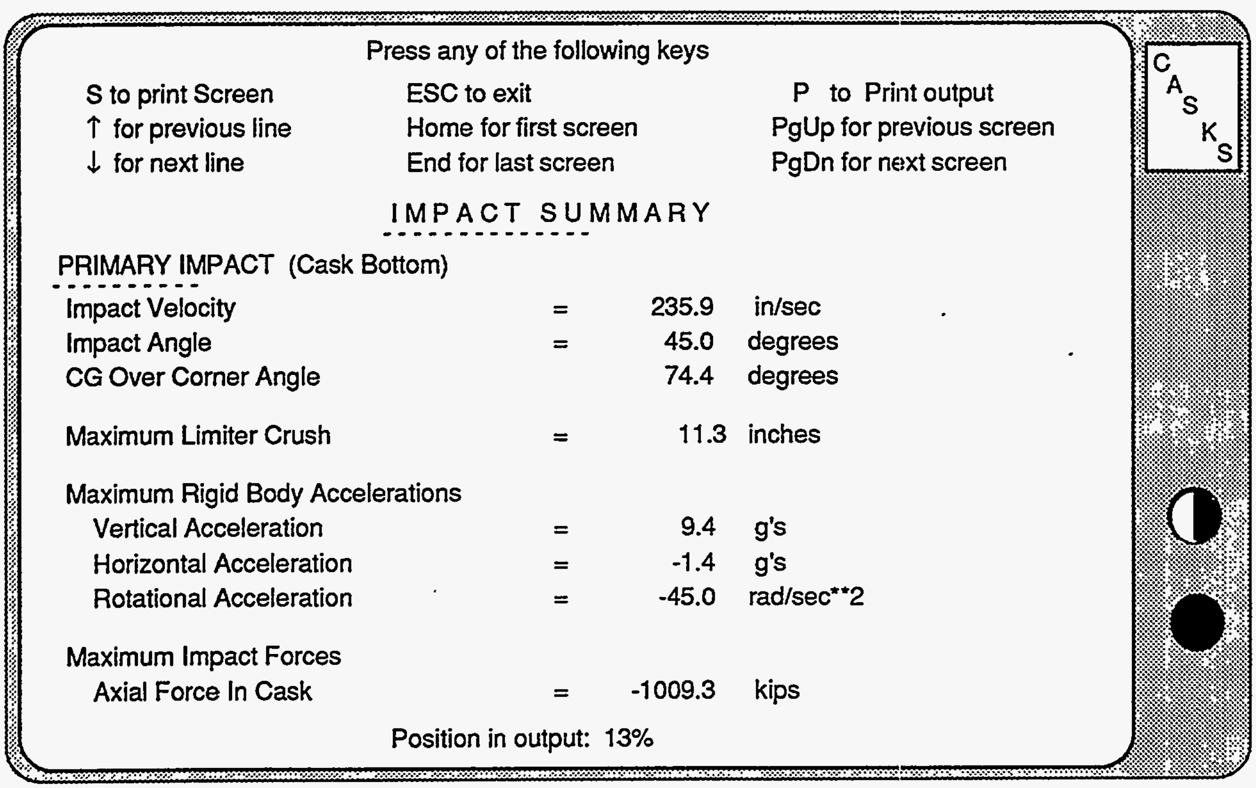


Figure 6-4. Reviewing the Output

NOTES:

Archive Menu

The Archive Menu (**Figure 7-1**) provides options for archiving cask data sets to diskettes, retrieving archived cask data sets, and deleting cask data sets from the hard disk.

PRESS 1 to Archive CASK data set on diskettes

Creates a compressed data set archive containing the basic geometry, impact limiter force-deflection curve data, finite-element meshes and all analysis output for the selected cask. Then writes the data set archive to diskettes.

PRESS 2 to Retrieve CASK data set from diskettes

Retrieves a compressed data set archive from diskettes and uncompress, restoring the data set to the hard disk.

PRESS 3 to Delete CASK data set from hard disk

Deletes either a complete data set or analysis output for the selected cask.

PRESS M to Return to MAIN MENU

CASKS returns to the Main Menu display.

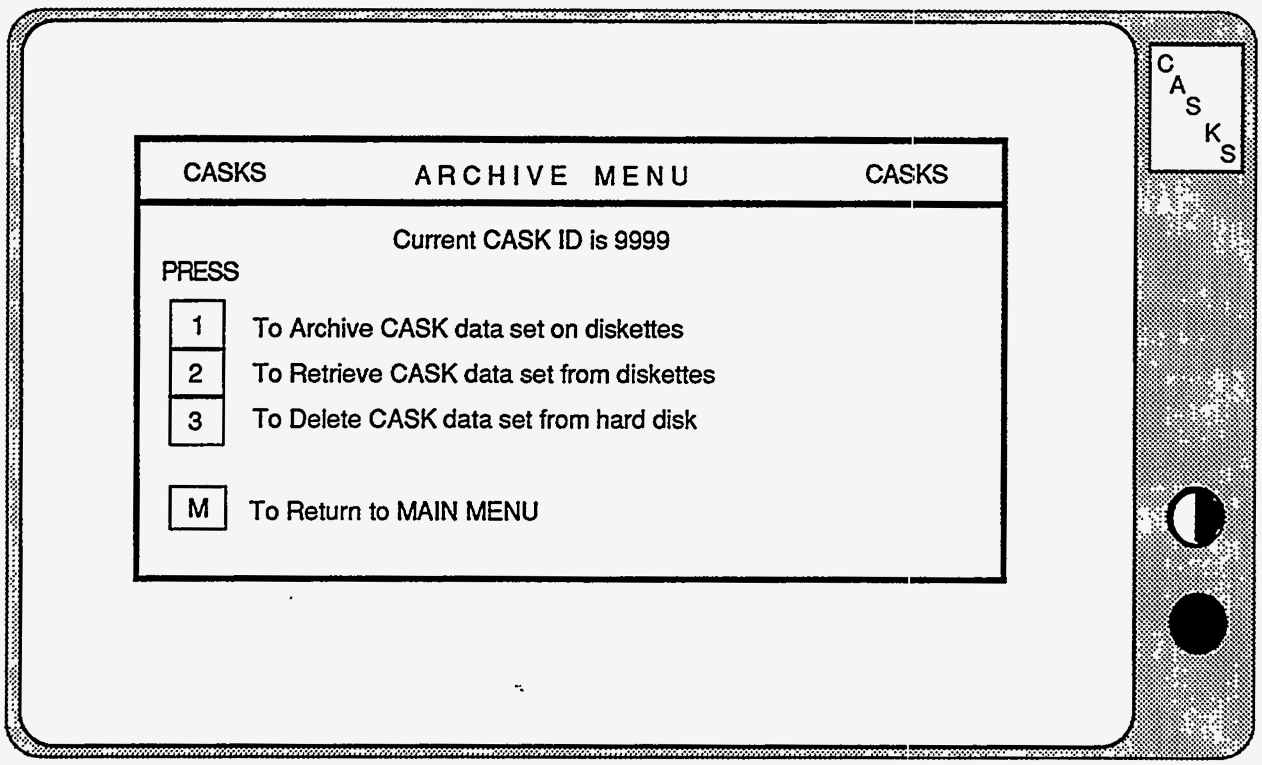


Figure 7-1. CASKS Archive Menu.

Archiving Data Sets:

CASKS archives data sets by creating a compressed data set archive and then writing the archive to a diskette. If the archive is larger than a single diskette, **CASKS** automatically uses the DOS utility *BACKUP* to save the archive on more than one diskette. The module used to create the compressed archive is adapted from ARC version 5.1 from System Enhancement Associates (used by permission). All existing data sets can be archived from the Archive Menu. The number of existing data sets is indicated on the Archive Data Sets Title Screen.

(1) Press **Q** to QUIT and return to the Archive Menu

or

Press any other key to select the data set to archive.

If more than one data set exists, **CASKS** displays a list of CASKIDs and several options.

- Press **S** to Select the highlighted CASKID and display summary
- Press **Q** to QUIT and return to the Archive Menu
- Press ↑ to highlight the previous CASKID
- Press ↓ to highlight the next CASKID

If only one data set exists, **CASKS** selects that data set. The data set summary screen is shown in **Figure 7-2**.

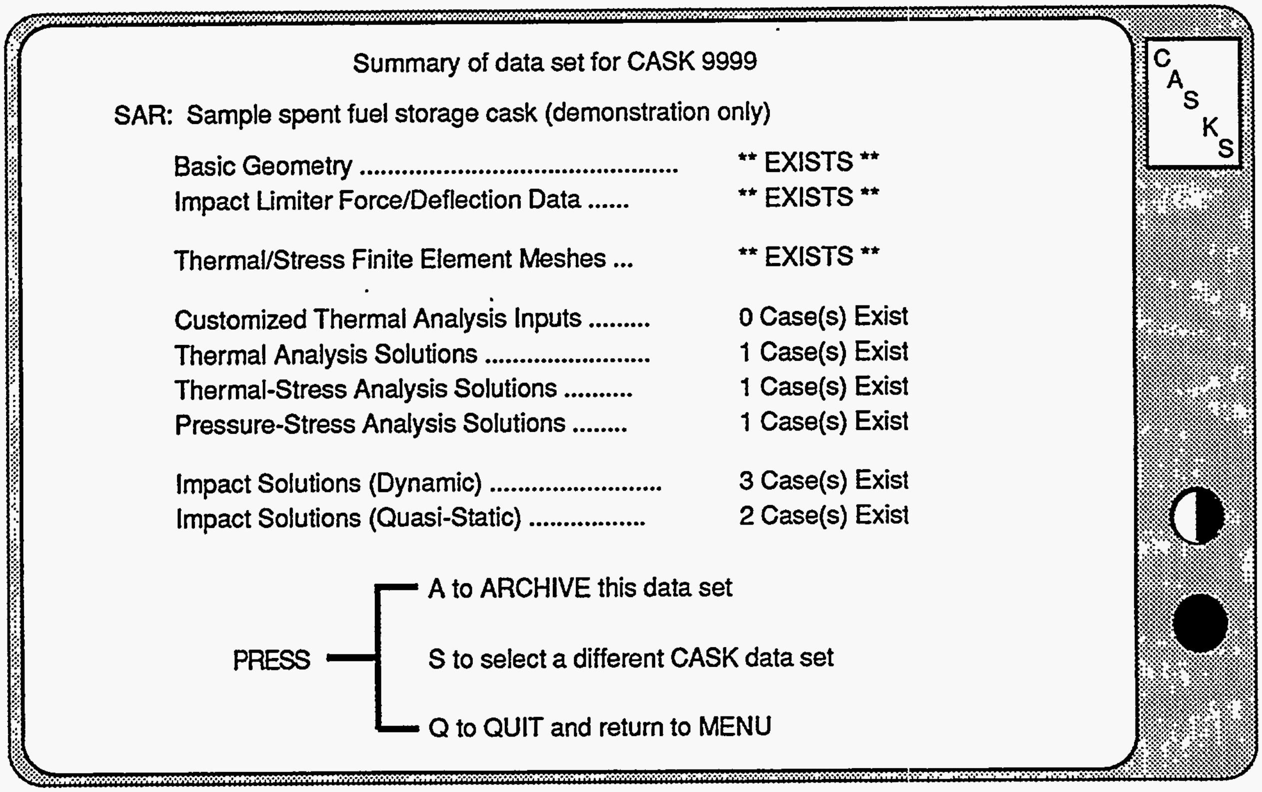


Figure 7-2. Summary of data set for Archive

If **S** is selected, the Summary Screen options are:

Press **A** to Archive the summarized data set

Press **S** to select a different CASKID (return to the CASKID list screen—only if more than one data set exists)

Press **Q** to QUIT and return to the Archive Menu

CASKS starts the archive process by creating a compressed data set archive. This process can take up to 30 minutes if the data set is large and the PC is slow (ATs are much faster). The resulting compressed archive requires only 15 to 30 percent of the space the complete data requires. After the compressed archive is created, **CASKS** asks for a **formatted** diskette in drive **A:** or **B:**. Because of potential drive/diskette incompatibility, do not use a 360Kb diskette in a 1.2Mb drive.

Press **A** to Select DRIVE **A:**

Press **B** to Select DRIVE **B:**

Press **Q** to QUIT and return to the Archive Menu

CASKS checks the selected drive and compares the space requirements for the archive with the available space on the diskette.

The error conditions that can occur are listed in **Table 7-1**. Archiving will not proceed until all error conditions are satisfied.

If the compressed archive will fit on a single diskette, **CASKS** will use *COPY* to write the archive to the diskette. If the archive will not fit on a single diskette, **CASKS** will use *BACKUP* to write the archive to multiple diskettes (**CASKS** indicates how many formatted diskettes of similar density are required). If the archive exists on the diskette, **CASKS** displays the date and time of the hard disk version and diskette version of the archive.

Press the appropriate key to continue with archiving:

Press **ENTER** to write the Archive to diskette

(using *COPY* if the archive will fit on one diskette)

(using *BACKUP* if the archive will not fit on one diskette)

NOTE: If archive exists on diskette, it is pre-deleted

BACKUP will request necessary number of diskettes to complete the *BACKUP* process. Be sure to label the diskettes with the order in which they were processed. *RESTORE* will request *BACKUP* diskettes in the order they were written.

or

Press **S** to Select different Diskette or Drive

When **CASKS** finishes writing the archive to diskettes, the following options are presented.

or

Press **Q** to QUIT and return to the Archive Menu

Press **C** to Continue (to select other data sets to archive)

Press **D** to DELETE cask data set (from the hard disk)

CASKS asks for confirmation before deleting any data set.

Press **F1** to delete the data set

or

Press **F9** to continue without deleting.

After archiving the data set is complete, **CASKS** displays the number of data sets remaining on the hard disk that may potentially be archived.

If no data sets remain on disk, press **ENTER** to return to the Archive Menu.

or

If one or more data sets remain on disk, press **A** to archive additional data sets.

or

Press **Q** to QUIT and return to the Archive Menu.

Archive Menu

Archiving Data Sets

Table 7-1. Possible Error Messages during Archiving

There is NO diskette in drive *X:*
Possible causes: wrong drive selected, or drive door is not closed. Make sure a diskette is in drive **A:** or **B:** and that the drive door is closed.

Diskette is UNFORMATTED or a 1.2Mb diskette is in a 360K drive
Possible causes: diskette is unformatted, diskette is damaged and unreadable, or 1.2Mb diskette is in a 360K drive. Make sure the diskette is formatted and of the correct density.

General ERROR on drive *X:*
Possible causes: diskette is reversed, diskette is damaged and unreadable, or drive is malfunctioning. Try a different drive and/or diskette.

Not enough space on the diskette
The compressed archive will fit on the diskette if other data is not on the diskette. Either remove data from the diskette or provide a diskette that has more space.

Diskette is a BACKUP diskette, ARCHIVE will fit on one diskette
CASKS will use *COPY* to write the archive on a single diskette. Existing data on the diskette was written by *BACKUP*. Use a non-*BACKUP* diskette.

Diskette is a BACKUP diskette NOT for this ARCHIVE
CASKS will use *BACKUP* to write the archive on multiple diskettes. Existing data on the diskette was written by *BACKUP* for data other than this archive. Use a different diskette.

Retrieving Data Sets:

CASKS retrieves compressed data sets from diskettes and then unpacks the archive, restoring the data set to the hard disk. The module used to unpack the compressed archive is adapted from ARC version 5.1 from System Enhancement Associates (used by permission). **CASKS** lists two options on the Retrieve Data Sets title screen:

Press **Q** to QUIT and return to the Archive Menu

or

Press any other key to start retrieval of data set

Place the diskette containing the compressed data set archive (or the first *BACKUP* diskette for the archive) in either drive **A:** or **B:**

Press one of the following keys:

Press **A** to find data sets on diskette in Drive **A:**

Press **B** to find data sets on diskette in Drive **B:**

Press **Q** to QUIT and return to the Archive Menu

CASKS checks the selected drive and searches for archived data sets. The error conditions that can occur are listed in **Table 7-2.** Retrieval will not proceed until all error conditions are satisfied.

If the diskette contains only one archived data set, **CASKS** selects that data set for retrieval. If the diskette contains more than one archived data set, **CASKS** displays a list of CASKIDs for the archived data sets and lists several options:

Press **S** to Select the highlighted CASKID for retrieval

Press **Q** to QUIT and return to the Archive Menu

Press ↑ to highlight the previous CASKID

Press ↓ to highlight the next CASKID

CASKS displays the date and time of the selected archive on the diskette and warns if this data set will replace an existing data set on the hard disk. **CASKS** lists the following options

Archive Menu
Retrieving Data Sets

Press **ENTER** to retrieve the Archive

(using *COPY* if the archive was saved with *COPY*)

(using *RESTORE* if the archive was saved with *BACKUP*)

or

Press **S** to Select different Diskette or Drive

or

Press **Q** to QUIT and return to the Archive Menu

Press **F1** to delete the data set from the hard disk, or press **F9** to QUIT and return to the Archive Menu.

CASKS asks for confirmation before deleting the existing data set.

After deleting the data set (if necessary), **CASKS** starts retrieving the archived data set.

If the archive was saved using *BACKUP*, **CASKS** uses *RESTORE* for retrieval. *RESTORE* will request the archive *BACKUP* diskettes in the order they were written.

After the archive is retrieved from the diskette, **CASKS** unpacks the data from the archive. Be patient, this process may take a little while.

When unpacking is complete, press **R** to retrieve additional data sets or press **Q** to QUIT and return to the Archive Menu.

Table 7-2. Possible Error Messages during Retrieving

There is NO diskette in drive *X:*
Possible causes: selected the wrong drive; drive door is not closed. Make sure a diskette is in drive **A:** or **B:** and that the drive door is closed.

Diskette is UNFORMATTED or a 1.2Mb diskette is in a 360K drive
Possible causes: diskette is unformatted; diskette is damaged and unreadable; 1.2Mb diskette is in a 360K drive. Make sure the diskette is formatted and of the correct density.

General ERROR on drive *X:*
Possible causes: diskette is reversed; diskette is damaged and unreadable; drive is malfunctioning. Try a different drive and/or diskette.

NO Archives on diskette
Diskette does not contain any compressed data set archives. Archive names have the form **xxxxDATA.ARC**, where **xxxx** is the four digit CASKID. Try a different diskette.

Deleting Data Sets:

Data sets consist of basic geometry descriptions, impact limiter force-deflection curves, and analysis outputs. **CASKS** has two options for deleting data sets: (1) delete the complete data set, or (2) delete just the analysis outputs. All existing data sets can be deleted from this menu. **CASKS** indicates the number of existing data sets and lists two choices:

Press **Q** to QUIT and return to the Archive Menu

or

Press any other key to select the data set to delete

If only one data set exists, **CASKS** selects that data set and displays a summary of the data set. If more than one data set exists, **CASKS** displays a list of CASKIDs and indicates several options.

Press **S** to Select the highlighted CASKID and display data set summary

Press **Q** to QUIT and return to the Archive Menu

Press ↑ to highlight the previous CASKID

Press ↓ to highlight the next CASKID

After the data set is selected, **CASKS** displays a summary of the data set. The data set summary screen displays several options:

Press **C** to delete COMPLETE data set

Press **O** to delete OUTPUT for the data set

Press **S** to select a different data set

(available only if more than one data set is on disk)

Press **Q** to QUIT and return to the Archive Menu

Press **F1** to delete the data set or output

CASKS asks for confirmation before deleting the data set or output as shown in **Figure 7-3**.

or

Press **F9** to QUIT and return to the Archive Menu without deleting

or

If no data sets remain on disk, press **ENTER** to return to the Archive Menu.

When **CASKS** has completed deleting the data set or output, if one or more data sets remain on disk, **CASKS** lists several options.

Press **D** to Delete additional data sets

(redisplays the data set list screen)

Press **Q** to QUIT and return to the Archive Menu

CAUTION!!

Once a data set or its output is deleted, it is not recoverable unless it was archived on diskettes. **Be careful when deleting data sets or data set outputs.**

HINT:

Consider deleting data set outputs before archiving. **CASKS** can reproduce analysis outputs based on the basic geometry descriptions and impact limiter force/deflection curves. Archiving just the basic geometry and limiter curves is much faster than archiving a data set with numerous outputs.

Archive Menu

Retrieving Data Sets

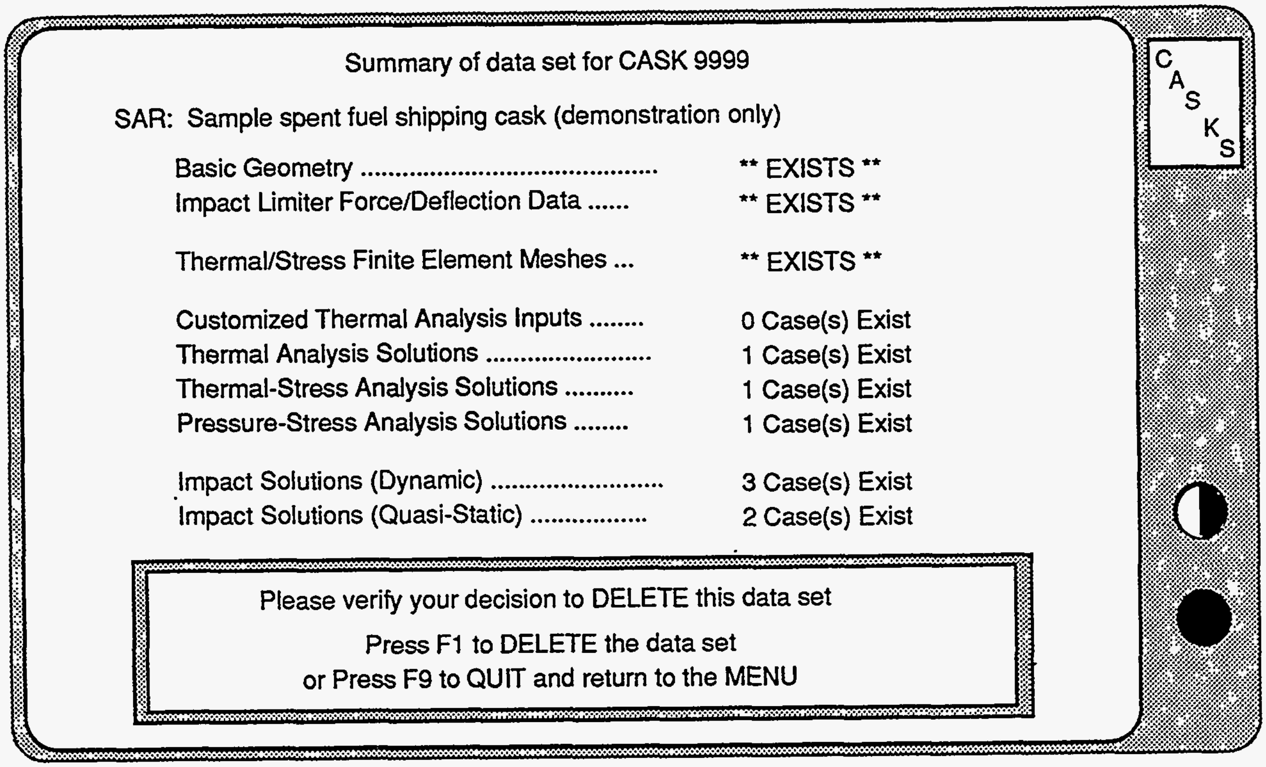


Figure 7-3. Confirm decision to DELETE screen

Appendix A
The Editor

CASKS uses a general purpose fill-in-the-blank type editor to enter data for the basic geometry definition, impact limiter force-deflection curve definitions, and yielding surface force-deflection curve definitions. The editor title screen indicates the status of the data set. If the data set does not exist, **CASKS** lists the following options:

Press **Q** to QUIT and return to the Menu
Press any other key to proceed with editing (creates a new data set)

If the data set already exists **CASKS** lists the following options:

Press **Q** to QUIT and return to the Menu
Press **D** to delete current data set and create a new data set
Press any other key to proceed with editing (edit the current data set)

Delete the data set to start with a fresh data set with all data set to default values. **CASKS** asks for confirmation before deleting the existing data set:

Press **F1** to delete the data set and create a new data set
(edit the new data set)
Press **Q** to QUIT and return to the Menu
Press **F2** to proceed with editing (edit the current data set)

CASKS reads a template which describes the editor pages and how data values are saved in the data set. If creating a new data set, **CASKS** displays a status screen which indicates each editor page as it is created. As pages are created, all values are set to appropriate defaults. **CASKS** then displays the first editor page.

Description of Editor Pages

Each data set is divided into pages of related items. For example, all the items necessary to define the cask shell are on the same editor page. All pages have the same format (**Figure A-1**). The top line indicates the name of the data set [A], the CASK ID [B], and the current date [C]. The second line indicates the name of the editor page [D], the current page number of how many [E], and the date any item on the page was last changed [F]. The third line is a double green bar the full width of the screen. This line also indicates how many pages remain which must be accessed [G] and Insert Mode (if applicable) [H]. Below the second double green bar is a list of available function keys and their application [I].

Between the double green bars are the item requests [J]. Each item request has a descriptive label indicating what to enter (units are included if appropriate) [K], and an item field delimited by square brackets [L]. Item descriptions displayed in *light blue* require an entry, while item descriptions displayed in *green* have default values which can be accepted as is. The count of pages remaining which must be accessed indicates pages which have items requiring an entry. Once entries are made on a page for *ALL* items requiring an entry, the page need not be accessed.

Appendix A
The Editor

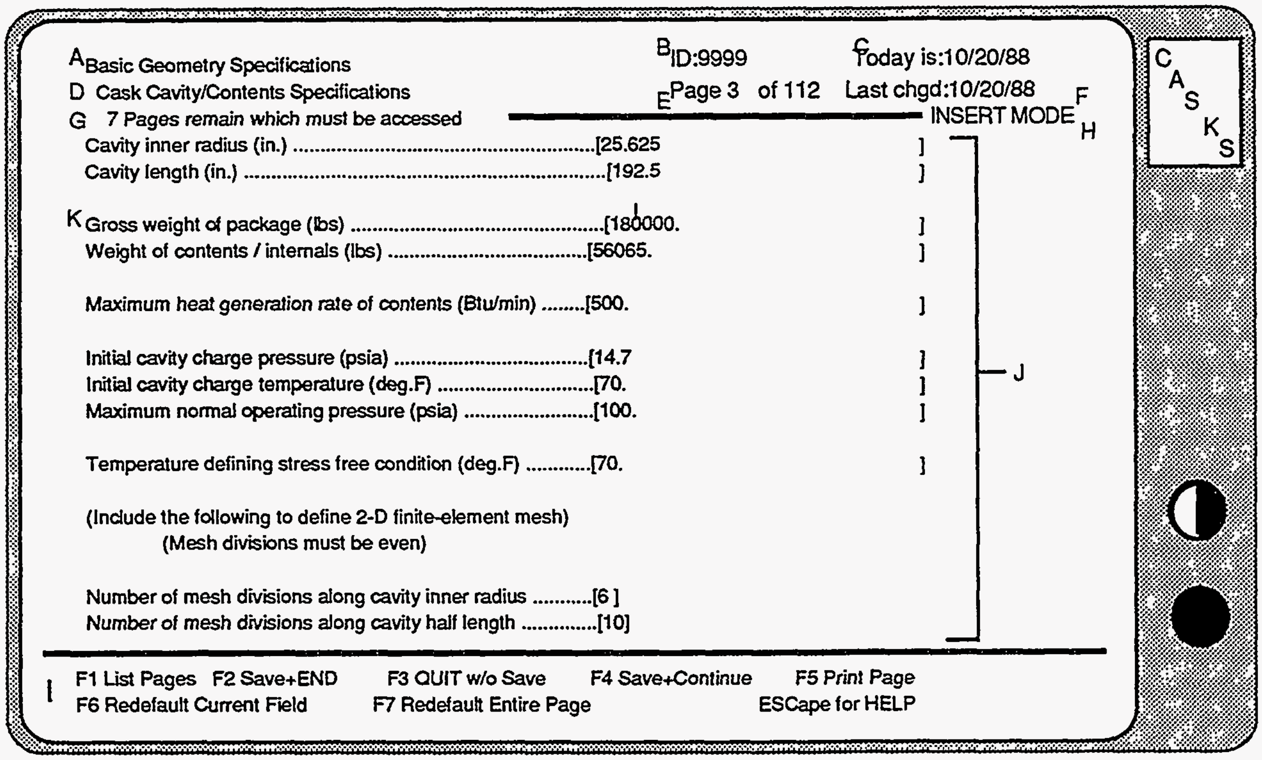


Figure A-1. CASKS Editor Page Layout

Getting Help

Press the **ESC** key to display the *HELP* screens. The first screen indicates the current item type and restrictions placed on the item and describes the use of the function keys. The second *HELP* screen indicates the data entry and editing keys. The third *HELP* screen indicates the keys used to move between item fields and editor pages.

Saving the Edits

Save the changes made during the editing session using the following keys. The value in the current item field must be a valid item before **CASKS** will save the edits.

F2 (function key)
Save the data set as is, end the editing session and return to the current menu.

F4 (function key)
Save the data set as is and redisplay the current page to continue editing. Use this feature to save the edits periodically during a protracted editing session. **CASKS** *will lose all edits not saved if a power failure interrupts the operation of the PC.*

Ending the Edit Session

End the editing session by pressing one of the following function keys:

F2 (function key)
Save the data set as is, end the editing session, and return to the current menu.

F3 (function key)
Abandon all edits during this session (or since the previous save), end the editing session and return to the current menu. **CASKS** asks for confirmation before proceeding: press **F1** to QUIT, abandoning the edits; or press **F9** to return to editing.

Moving Around

The blinking solid cursor identifies the current item field expecting an entry. The entry in the item field is checked for validity when the cursor is moved from this field to another. The entry must be valid before **CASKS** will allow the cursor to leave the current item field. Use the following keys to accept the current entry and move to another item field:

UP Arrow (on the keypad)
Move to the previous item field on the current page. If the current item field is the FIRST on the page, move to the LAST item field.

DOWN Arrow (on the keypad) or **ENTER**
Move to the next item field on the current page. If the current item field is the LAST on the page, move to the FIRST item field.

PgUp (on the keypad)
Move to the FIRST item field on the previous page. If the current page is the FIRST editor page, move to the FIRST item field on the current page.

PgDn (on the keypad)
Move to the FIRST item field on the next page. If the current page is the LAST editor page, move to the FIRST item field on the current page.

F1 (function key)
Display list of all pages in the data set. Use the keypad **UP Arrow** and **DOWN Arrow** keys to highlight the desired page, and then press **F1** to move to the FIRST item field on the indicated page. The page list indicates which pages have items requiring an entry.

Appendix A
The Editor

Entering a Value

Enter values by typing in the item field (typing in the first character position clears the field). Enter character string type items using letters, numeric digits and special character ($,%,#, etc.). Enter integer number type items using the form **nnn**. The sign is optional; **n** is any numeric digit (0-9). Enter real number type items using either the form **nn.mmm** or **nn.mmmEjj** (scientific notation). The sign, decimal point and exponent are optional; **n**, **m**, and **j** are any numeric digit (0-9). Use the following keys to assist editing values in the item field.

LEFT Arrow (on the keypad)
: Accept the character under the cursor and move the cursor to the left one character (can move as far left as the first character position).

RIGHT Arrow (on the keypad)
: Accept the character under the cursor and move the cursor to the right one character (can move as far right as the last character position).

DEL (on the keypad)
: Delete the character under the cursor and shift the remaining characters to the left.

BACKSPACE (above **ENTER**)
: Delete the character to the left of the cursor and shift the remaining characters to the left.

INS (on the keypad)
: Toggle insert mode on and off. When insert mode is on, **INSERT** appears in the upper right corner of the screen on the double green bar. All new characters are inserted at the cursor, shifting the remaining characters to the right. When insert modes is off, new characters are inserted at the cursor, and they write over previous characters.

F6 (function key)
: Set the current item to the **CASKS** default (NOT the previous saved value).

F7 (function key)
: Set all items on the current page to the **CASKS** defaults (NOT the previous saved values).

Making Selections From a List

Certain items are restricted to values presented in a list (**Figure A-2**). Use the following keys to change the selection indicated in the item field:

N or **n** Move blinking highlight cursor to the *NEXT* list item.
P or **p** Move blinking highlight cursor to the *PREVIOUS* list item.
S or **s** Select the item indicated by the blinking highlight cursor.

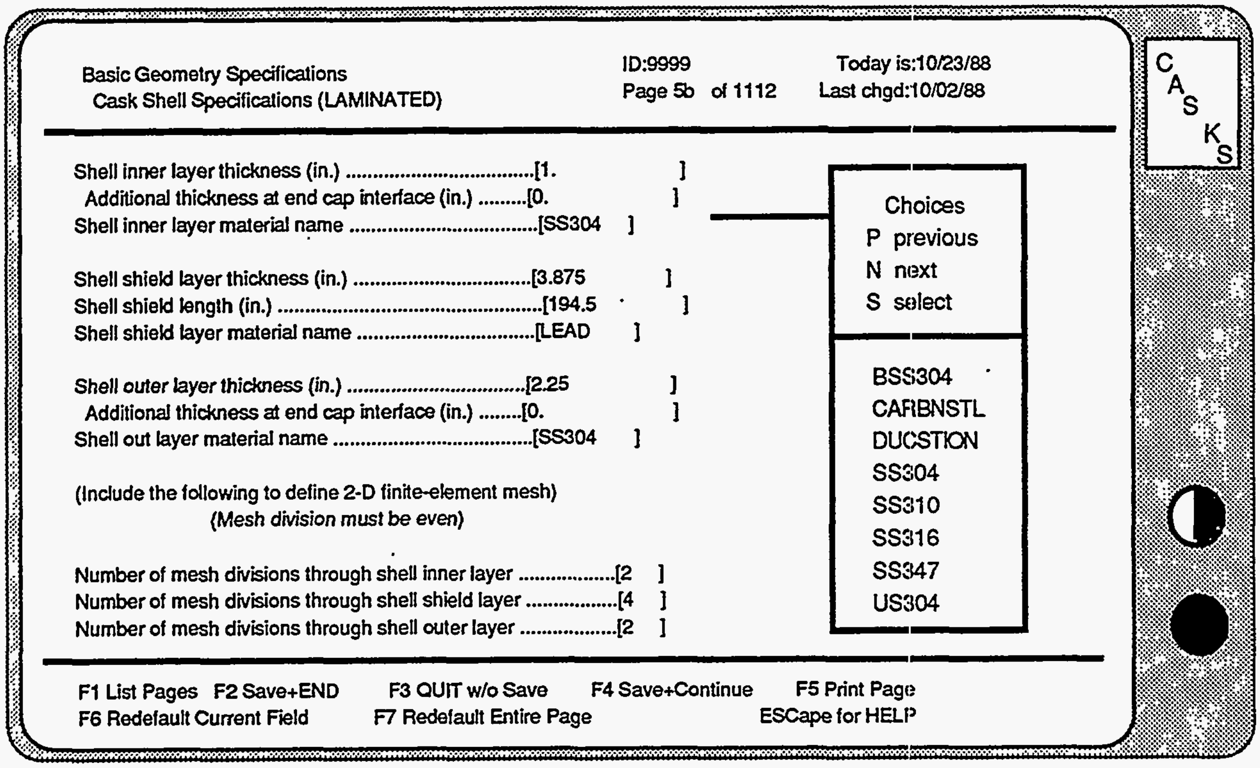


Figure A-2. Select Item From a List

Copying Data From Another Editor Page

If the item requests displayed on the current editor page are the same as those on another editor page, press **F10** to copy data from another page. **CASKS** displays a list of all pages that are appropriate for copying and indicates the current page. Use the **UpArrow** and **DnArrow** keys to indicate the page to copy from, and then press **C** to perform the copy. Press **R** to return without performing a copy.

Printing an Editor Page

Press the **F5** function key to print a copy of the current page. Make sure the printer is on-line and ready before printing the page.

Handling Errors

If an entry is invalid for the specified item, **CASKS** displays an error message at the bottom of the screen and indicates any restrictions on the item. Press **ENTER** to clear the error message and return to editing.

NOTES:

Appendix B
Material Properties

The material sets used in **CASKS** contain all the information required to perform Impact, Thermal, Thermal-Stress, and Pressure-Stress analyses. These materials marked "LOCKED" are material properties built into **CASKS** and cannot be modified. **CASKS** also provides the ability to let the user input and/or modify the material sets.

Impact analyses use dynamic Young's Modulus, Poisson's Ratio, and material density (used for component weight calculations). Thermal analyses use temperature dependent properties for thermal conductivity and specific heat capacity. Thermal stress analyses use temperature dependent properties for Young's Modulus, Poisson's Ratio and coefficient of thermal expansion. Pressure stress analyses use the thermal stress properties at 70 degrees F.

Material	References
Structural and Water Jacket Materials	
Borated SS 304	5, 6, 7, 8
Carbon Steel	1, 2
Ductile cast iron	5, 6, 7, 8
Stainless Steel 304	1, 2, 8
Stainless Steel 310	5, 6, 7, 8
Stainless Steel 316	5, 6, 7, 8
Stainless Steel 347	5, 6, 7, 8
Copper (Water Jacket Only)	5, 6, 7, 8
Shielding Materials	
Lead	1, 2, 10
Impact Limiter Materials	
Polyfoam	9
Polyurethane	2
Balsa Cross-Grained	2
Redwood Cross-Grained	4
Neutron Shield Materials	
Air Convection	3
Water Convection	3

Appendix B
Material Properties

Structural and Water Jacket Materials

Borated/Stainless Steel 304 (1.1% Boron) Set name: *BSS304*

Impact Young's Modulus: 3.194E+07 psi
Impact Poisson's ratio: 0.2990
Density: 0.2900 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-58.	.011250	.1200	3.273E+07	.2990	9.070E-06
68.	.011400	.1230	3.194E+07	.2990	9.070E-06
212.	.012083	.1238	3.110E+07	.3060	9.070E-06
392.	.012083	.1275	2.997E+07	.3060	9.360E-06
572.	.013056	.1312	2.884E+07	.3060	9.580E-06
752.	.013889	.1350	2.693E+07	.3060	9.810E-06
1112.	.015278	.1425	2.535E+07	.3060	9.930E-06
1472.	.018056	.1500	2.535E+07	.3060	9.930E-06

Carbon Steel Set name: *CARBNSTL*

Impact Young's Modulus: 2.800E+07 psi
Impact Poisson's ratio: 0.2900
Density: 0.2820 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-100.	.035000	.1130	2.900E+07	.2900	6.600E-06
68.	.034700	.1130	2.790E+07	.2900	6.639E-06
200.	.034700	.1130	2.770E+07	.2900	6.670E-06
300.	.034000	.1130	2.740E+07	.2900	6.870E-06
400.	.033300	.1130	2.700E+07	.2900	7.070E-06
500.	.032600	.1130	2.640E+07	.2900	7.250E-06
600.	.031500	.1130	2.570E+07	.2900	7.420E-06
700.	.029600	.1130	2.480E+07	.2900	7.590E-06

Structural and Water Jacket Materials *(continued)*

Ductile Cast Iron   Set name: *DUCSTION*

Impact Young's Modulus: 2.450E+07 psi
Impact Poisson's ratio: 0.2900
Density: 0.2840 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
70.	.031944	.1100	2.450E+07	.2900	6.230E-06
390.	.029860	.1100	2.450E+07	.2900	6.780E-06
570.	.027080	.1180	2.450E+07	.2900	7.120E-06
750.	.025280	.1210	2.450E+07	.2900	7.340E-06
930.	.023610	.1230	2.450E+07	.2900	7.510E-06
1110.	.022920	.1280	2.450E+07	.2900	7.620E-06
1290.	.022640	.1440	2.450E+07	.2900	7.670E-06
1400.	.021940	.1440	2.450E+07	.2900	8.230E-06

Stainless Steel 304   Set name: *SS304*

Impact Young's Modulus: 3.194E+07 psi
Impact Poisson's ratio: 0.2990
Density: 0.2900 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-58.	.011250	.1200	3.273E+07	.2990	9.070E-06
68.	.011400	.1230	3.194E+07	.2990	9.070E-06
212.	.012083	.1238	3.110E+07	.3060	9.070E-06
392.	.012083	.1275	2.997E+07	.3060	9.360E-06
572.	.013056	.1312	2.884E+07	.3060	9.580E-06
752.	.013889	.1350	2.693E+07	.3060	9.810E-06
1112.	.015278	.1425	2.535E+07	.3060	9.930E-06
1472.	.018056	.1500	2.535E+07	.3060	9.930E-06

Appendix B
Material Properties

Structural and Water Jacket Materials *(continued)*

Stainless Steel 310 Set name: *SS310*

Impact Young's Modulus: 2.820E+07 psi
Impact Poisson's ratio: 0.2900
Density: 0.2870 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-50.	.010400	.0880	2.820E+07	.2900	7.576E-06
68.	.010600	.0880	2.820E+07	.2900	8.056E-06
300.	.012200	.0880	2.820E+07	.2900	9.001E-06
600.	.014800	.1055	2.820E+07	.2900	9.159E-06
900.	.017700	.1200	2.820E+07	.2900	9.175E-06
1200.	.021100	.1300	2.820E+07	.2900	9.230E-06
1600.	.025400	.1310	2.820E+07	.2900	9.531E-06
2000.	.025400	.1310	2.820E+07	.2900	9.889E-06

Stainless Steel 316 Set name: *SS316*

Impact Young's Modulus: 2.810E+07 psi
Impact Poisson's ratio: 0.2900
Density: 0.2870 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-50.	.010100	.0980	2.810E+07	.2900	7.997E-06
68.	.010900	.1080	2.810E+07	.2900	8.321E-06
300.	.012600	.1170	2.810E+07	.2900	8.958E-06
600.	.015200	.1310	2.810E+07	.2900	9.605E-06
900.	.016700	.1360	2.810E+07	.2900	9.921E-06
1200.	.019200	.1400	2.810E+07	.2900	1.028E-05
1600.	.021600	.1550	2.810E+07	.2900	1.051E-05
2000.	.021600	.1620	2.810E+07	.2900	1.173E-05

Structural and Water Jacket Materials *(continued)*

Stainless Steel 347 Set name: *SS347*

Impact Young's Modulus: 2.820E+07 psi
Impact Poisson's ratio: 0.2900
Density: 0.2860 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-50.	.011400	.0980	2.820E+07	.2900	8.502E-06
68.	.011900	.1080	2.820E+07	.2900	8.786E-06
300.	.012700	.1200	2.820E+07	.2900	9.345E-06
600.	.015100	.1310	2.820E+07	.2900	9.831E-06
900.	.016700	.1370	2.820E+07	.2900	1.019E-05
1200.	.018800	.1440	2.820E+07	.2900	1.044E-05
1600.	.020500	.1590	2.820E+07	.2900	1.086E-05
2000.	.020500	.1640	2.820E+07	.2900	1.229E-05

Copper Set name: *COPPER* (Water Jacket Only)

Density: 0.3240 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-100.	.331900	.0851
68.	.320800	.0917
260.	.313900	.0951
440.	.311100	.0974
620.	.306900	.0998
800.	.302800	.1020
1160.	.291700	.1067
1340.	.286100	.1091

Appendix B
Material Properties

Shielding Materials

Cast Lead   Set name: *LEAD*

Impact Young's Modulus:	2.775E+04 psi
Impact Poisson's ratio:	0.4200
Impact Yield Stress:	4.300E+03 psi
Impact Plastic Modulus:	2.400E+03 psi
Density:	0.4110 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)	Young's Modulus (psi)	Poisson's Ratio	Coefficient of Thermal Expansion (in./in.°F)
-58.	.028888	.0300	2.000E+06	.4200	1.600E-05
68.	.028000	.0307	2.000E+06	.4200	1.600E-05
212.	.026800	.0315	2.000E+06	.4200	1.600E-05
392.	.025278	.0326	2.000E+06	.4200	1.600E-05
572.	.023889	.0337	2.000E+06	.4200	1.600E-05
630.	.016806	.0340	2.000E+06	.4200	1.600E-05
717.	.013472	.0339	2.000E+06	.4200	1.600E-05
1276.	.012028	.0337	2.000E+06	.4200	1.600E-05

Impact Limiter Materials

Polyfoam   Set name: *POLYFOAM*

Density: 0.0116 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-58.	.000278	.3000
68.	.000278	.3000
1300.	.000278	.3000

Impact Limiter Materials *(continued)*

Polyurethane Set name: *PURETHAN*

Density: 0.0021 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-58.	.000034	.4200
68.	.000034	.4200
1300.	.000034	.4200

Balsa Cross-Grained Set name: *BALSAXGR*

Density: 0.0162 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-58.	.000067	.5500
68.	.000067	.5500
1300.	.000067	.5500

Redwood Cross-Grained Set name: *REDWDXGR*

Density: 0.0150 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-58.	.000088	.6900
68.	.000088	.6900
1300.	.000088	.6900

Appendix B
Material Properties

Neutron Shield Materials

Air Convection Set name: *AIRCONV*

Density: 0.0000 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-38.	.000139	.2400
68.	.000139	.2401
263.	.000139	.2421
533.	.000139	.2482
803.	.000139	.2568
983.	.000139	.2621
1253.	.000139	.2704
1523.	.000139	.2770

Water Convection Set name: *H2OCONV*

Density: 0.0347 lb/cu.inch

Temp (°F)	Thermal Conductivity (BTU/in.min°F)	Specific Heat Capacity (BTU/lbm°F)
-58.	.000182	.4100
68.	.001200	.9990
150.	.020500	1.0000
200.	.024100	1.0050
300.	.028900	1.0300
400.	.032400	1.0760
500.	.035500	1.1820
600.	.038500	1.3700

Material References

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Appendix C

Sample Cask and Description of Output

Description of Sample Cask

This sample spent fuel storage cask is included in the **CASKS** release. The CASKID is 9999. The cask geometry includes a long cylindrical cask body, top and bottom end caps, and top and bottom impact limiters. The cask body has an inner shell layer of Stainless Steel 304, a Lead shielding layer, and an outer shell layer of Stainless Steel 304. Both end caps are solid Stainless Steel 304. The impact limiters overhang the cask body and are constructed of Polyfoam. This sample cask does not include a neutron shield and water jacket. Cask dimensions are shown in **Figure C-1**. Component weights, closure bolt information, and impact limiter force-deflection data are listed below:

Weights (in pounds)

Gross package:	180000
Contents/internals:	56065
Top impact limiter:	10000
Bottom impact limiter:	10000

Closure Bolts (for Top End Cap)

Number of bolts:	32
Bolt diameter:	1.5 inches
Bolt circle radius:	29.5 inches

Impact Limiter Force-Deflection Data

NOTE: The following data is for Top and Bottom limiters for all impact angles.

Deflection (inches)	Force (kips)
0.5	250.
13.0	1700.
26.5	4000.
30.0	6000.
33.5	10000.

Appendix C
Sample Cask and Description of Output

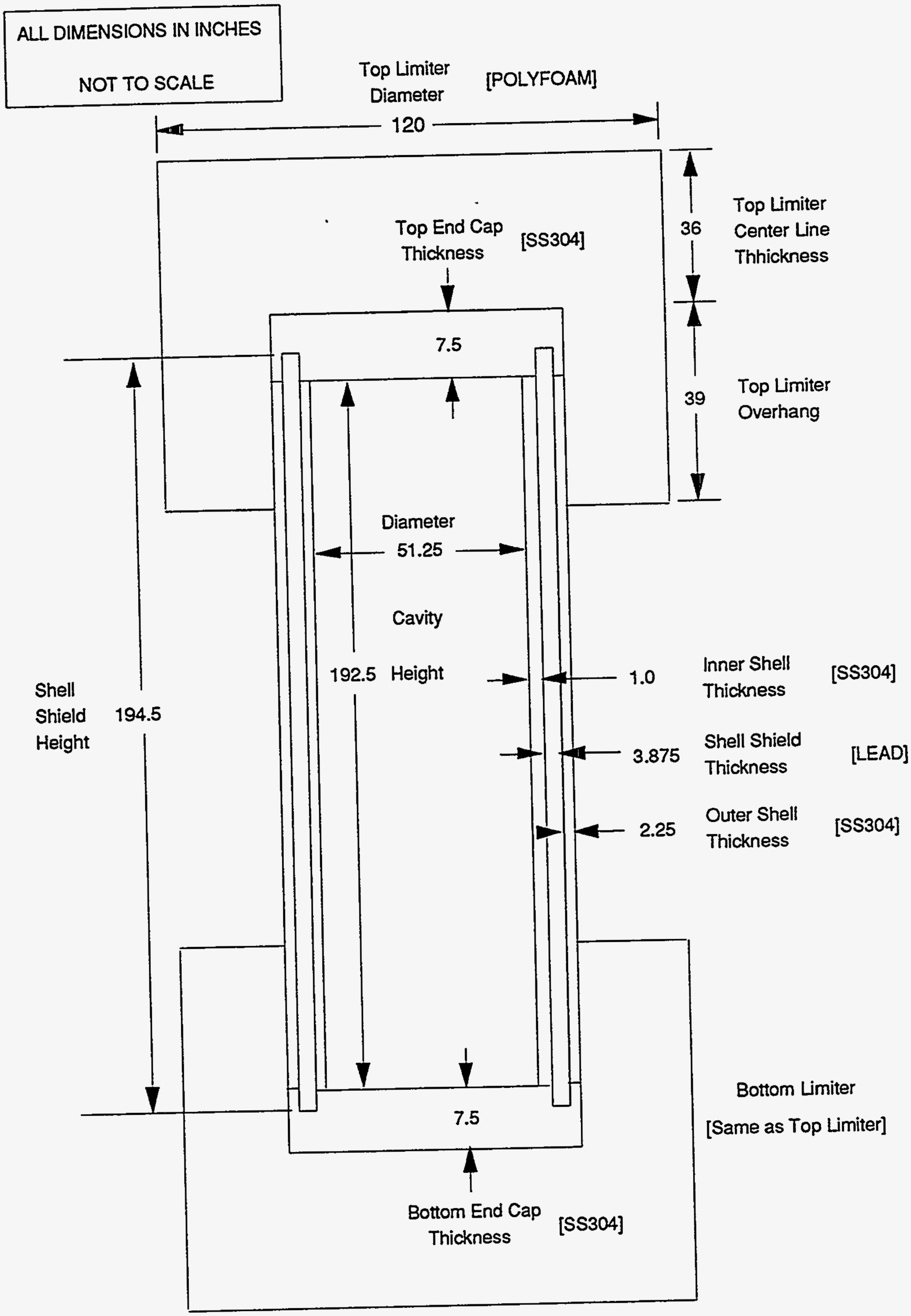

Figure C-1. Sample Cask Geometry and Dimensions

Appendix C

Sample Cask and Description of Output

Geometry Data Summary Output

This output is produced during the data check performed when the basic geometry is saved (Geometry Menu). It is a complete summary of all specifications for the cask. Warning and error messages appear when specified weights differ from calculated weights and when geometry dimensions are inconsistent. This output does not have any warning messages. The output format follows.

(1) **Header**
Indicates Geometry Data Summary, page number of how many, date and time the output was generated, and **CASKS** version number. The header shown in **Figure C-2** is printed at the top of every page of output.

(2) **Data Set Status**
Indicates whether the Basic Geometry data set is *COMPLETE* (**Figure C-2**). The data set has items requiring an entry if the status indicates *INCOMPLETE*.

(3) **General Information**
Lists general SAR information, general cask and contents specifications, and cask component weights (**Figure C-2**). The general SAR information includes the SAR title, report information, additional information, licensee's address, and names of review team members.

(4) **Component Specifications**
Summary of geometry specifications for each cask component (**Figure C-3**).

(5) **Closure Bolts**
Lists the number of bolts, bolt diameter, and bolt circle radius (**Figure C-4**).

(6) **Finite Element Mesh Grading**
Lists the number of mesh divisions through each cask component (**Figure C-4**). The output also indicates the status and size of the meshes. The Finite Element meshes are used for 2-D Thermal and Stress analyses.

(7) **Material Properties**
Tables listing properties for each material (**Figure C-4**). The output also indicates the components using the material.

(8) **Impact Model Description**
Lists the geometry of the simplified Impact model (**Figure C-5**).

Appendix C
Sample Cask and Description of Output

```
GEOMETRY DATA SUMMARY FOR CASK 9999                          Page  1 of  8
GENERATED ON 11/16/88 AT  8:20:00                        CASKS VERSION: 1a


Basic geometry data set is COMPLETE


GENERAL SAR INFORMATION
--------------------

      SAR: Sample spent fuel storage cask (demonstration only)

      Report number:       123 Volume 1
      Report date:         4/15/91
      Docket number:       9999
      Docket start date:   4/15/91
          ...
           ...
            ...


CASK GENERAL DIMENSIONS AND SPECIFICATIONS
-----------------------------------

      Cavity inner radius:          25.625  inches
      Cavity length:               192.500  inches

      Cask body outer radius:       32.750  inches
      Cask body length:            207.500  inches

      Top    impact limiter     is      included  in  model
      Bottom impact limiter     is      included  in  model
      Neutron shield            is not  included  in  model
      Water jacket              is not  included  in  model

      Contents maximum heat generation rate:     500.00  Btu/minute


      Temperature defining stress free condition:      70. degrees F

      Initial cavity charge pressure:          14.70    psia
      Initial cavity charge temperature:       70.00    degrees F
      Maximum normal operating pressure:      100.00    psia


CASK WEIGHTS (By component)
----------------------

      Gross package:            180000.  lbs
      Contents/internals:        56065.  lbs
      Top    impact limiter:      8294.  lbs    (Calculated)
      Bottom impact limiter:      8294.  lbs    (Calculated)
      Cask shell / end caps:    103935.  lbs    Gross wt - (Contents+Limiters)
          Top end cap:      7497.  lbs
        Bottom end cap:     7497.  lbs
                Shell:     92353.  lbs
```

Figure C-2. Cask Geometry Summary Output -- General Information

CASK SHELL DESCRIPTION

Layer	Material Name	Thickness Inches	Inner Radius Inches	Outer Radius Inches	X-section Area Sq Inches
Inner Shell	SS304	1.000	25.625	26.625	164.148
Shield	LEAD	3.875	26.625	30.500	695.421
Outer Shell	SS304	2.250	30.500	32.750	47.088
	Total Thickness	7.125		Total Area	1306.657

Inner Shell additional thickness at end cap interface: .000 inches
Outer Shell additional thickness at end cap interface: .000 inches

Shield height: 194.500 inches

TOP END CAP DESCRIPTION

Layer	Material Name	Thickness Inches
End cap	SS304	7.500

BOTTOM END CAP DESCRIPTION

Layer	Material Name	Thickness Inches
Endcap	SS304	7.500

IMPACT LIMITERS

TOP Impact Limiter
- Material: POLYFOAM
- Radius: 60.000 inches
- Thickness above end cap: 36.000 inches
- Overhang along cask body: 39.000 inches

BOTTOM Impact Limiter
- Material: POLYFOAM
- Radius: 60.000 inches
- Thickness above end cap: 36.000 inches
- Overhang along cask body: 39.000 inches

NEUTRON SHIELD

Neutron Shield is NOT included in model

WATER JACKET

Water Jacket is NOT included in model

Figure C-3. Cask Geometry Summary Output -- Component Specifications

```
CLOSURE BOLTS
------------

        Number of bolts:          32
        Bolt diameter:         1.500
        Bolt circle radius:   29.500

FINITE ELEMENT MESH GRADING  (Applies to 2-D Thermal and Stress calculations)
-----------------------

        Cavity
             Number of mesh divisions along inner radius:              6
             Number of mesh divisions along cavity half length:       10
        Shell
             Number of mesh divisions through inner  layer:            2
             Number of mesh divisions through shield layer:            4
             Number of mesh divisions through outer  layer:            2
        Top End Cap
             Number of mesh divisions through end cap:                 6
        Bottom End Cap
             Number of mesh divisions through end cap:                 6
        Top Impact Limiter
             Number of mesh divisions through center-line thickness:   3
             Number of mesh divisions through overhang width:          3
        Bottom Impact Limiter
             Number of mesh divisions through center-line thickness:   3
             Number of mesh divisions through overhang width:          3

        Finite element meshes were generated on 10-02-88 at  3:17p

             Thermal mesh has      282     nodes and  245                         4-
node elements     lo
             Stress  mesh has      195     nodes and  41     9-node elements

MATERIAL PROPERTIES
----------------

        This model uses  3 different materials

        SS304          (SS 304    )

           -  Used in:    Shell inner layer
                          Shell outer layer
                          Top end cap
                          Bottom end cap

             Impact Young's Modulus:    2.830E+07  psi
             Impact Poisson's ratio:         .2900

             Density:    .2841  lb/cu.inch
                                                                       Coefficient
                       Thermal          Specific       Young's     Poisson's   of Thermal
             Temp                     Conductivity     Heat Capacity           Modulus
Ratio        Expansion                lo
              F    BTU/in min F        BTU/lbm F        psi                      in/in F
             ----   ----------        -----------      -------    --------    ----------
             -58.     .011250            .1200        2.910E+07     .2900     8.700E-06
              68.     .011400            .1230        2.840E+07     .2900       .000
             212.     .012083            .1238        2.760E+07     .2900     8.700E-06
                                    . . .
                                     . . .
```

Figure C-4. Cask Geometry Summary Output -- Bolts, F.E. Mesh, and Materials

IMPACT MODEL DESCRIPTION

Nodal masses and shell stiffness values

Node Number	Position inches	Translational Mass lb-sec**2/in	Rotational Mass lb-sec**2-in	AE lbs	EI lb-in**2
1 BOT	0.	74.	39578.		
2	48.	58.	24756.	1.730E+10	7.922E+12
3	96.	58.	24756.	1.730E+10	7.922E+12
4	144.	58.	24756.	1.730E+10	7.922E+12
5 TOP	193.	74.	39578.		

Shell areas and inertias for nodes 2 through 4

Layer	Area in**2	Moment of Inertia in**4
Inner Shell	164.15	56037.
Shield	695.42	284973.
Outer Shell	447.09	223858.

Figure C-5. Cask Geometry Summary Output -- Impact Model Description

Appendix C

Sample Cask and Description of Output

Limiter Curve Summary Output

This output is produced during the data check performed when the impact limiter force/deflection data set is saved (Geometry Menu). It is a complete summary of all specifications for the cask. Error messages appear when impact limiter force-deflection curve definitions are incorrectly specified. The output format follows.

(1) **Header**
Indicates Limiter Curve Summary, page number of how many, date and time the output was generated, and **CASKS** version number. The header shown in **Figure C-6** is printed at the top of every page of output.

(2) **Data Set Status**
Indicates whether the Limiter F/D data set is *COMPLETE* (**Figure C-6**). The data set has items requiring an entry if the status indicates *INCOMPLETE.*

(3) **Impact Limiter Force/Deflection Curves**
Lists the impact limiter force-deflection curve specifications (**Figure C-6**). The limiter curves are specified individually for each end of the cask and for various impact orientations.

```
LIMITER CURVE SUMMARY FOR CASK 9999                                  Page  1  of  2
GENERATED ON 11/16/88 AT   8:22:00                              CASKS VERSION: 1a



Limiter F/D   data set is COMPLETE



IMPACT LIMITER FORCE/DEFLECTION CURVES



        Bottom Limiter

          Side Impact  ( 0 degrees)

                    Deflection        Force          Slope
                      inches          Kips         Kips/inch
                    ----------       -------       ---------
                        0               0
                       .500          250.00         500.00
                     13.000         1700.00         116.00
                     26.500         4000.00         170.37
                     30.000         6000.00         571.43
                     33.500        10000.00        1142.86

                     ...
                      ...
                       ...
```

Figure C-6. Limiter Curve Summary Output

Impact Analysis Output

This sample Impact analysis is based on a 30-foot hypothetical accident drop on the cask bottom on an unyielding surface at an initial impact angle of 45 degrees. Primary and secondary impacts are included in the analysis, and the shield/shell interface is bonded (the lead shield is not allowed to slump). The discussion of the output format includes a detailed description of output for a Dynamic Analysis. Quasi-static output is in the same format. Differences in output for an unbonded lead shield analysis are also noted.

(1) **Header**
Indicates the type of analysis, page number of how many, date and time the output was generated, **CASKS** version number, and a brief description of the parameters defining the analysis case. The header shown in **Figure C-7** is printed at the top of every page of output.

(2) **Impact Summary**
Lists the impact velocity, impact angle, CG (center-of-gravity) over corner angle, limiter crush, rigid body accelerations, maximum cask axial and shear forces, and maximum impact moment about the cask center line for both primary and secondary impacts (**Figure C-7**). For an unbonded lead shield analysis, **CASKS** lists the permanent lead slump. For secondary impacts, **CASKS** lists the secondary impact angle and the impact limiter data used (the force-deflection curve for the angle closest to the actual secondary impact angle).

(3) **Maximum Force and Moment Results**
Tables for maximum axial force, maximum shear force, and maximum bending moment are printed for each node location along the cask body and at the cask ends (**Figure C-8**). These forces and moments are beam-type values for the composite cross-section of the cask.

(4) **Impact Stress Intensity Results**
Tables for maximum stress intensity are printed for each shell layer at each node location along the cask body. Stress intensity is the absolute value of the maximum difference between the principal stresses. Principal stresses are calculated from axial, bending, shear, hoop, and radial stresses. For bonded shell/shield interface analyses the hoop stress is assumed to be zero. Axial and shear forces and bending moments are applied to the composite cross-section of the cask in order to calculate axial, bending, and shear stresses for each shell layer based on its individual stiffness. **CASKS** prints the stress intensity for the three maximum stress conditions listed below (**Figure C-9**).

A. Maximum Tension. Based on the maximum sum of the axial stress and bending stress at the extreme fiber. Shear stress is zero for this condition. This stress is the first principal stress. The second principal stress is the hoop stress.

B. Maximum Compression. Based on the maximum difference of the axial stress and bending stress. Shear stress is zero for this condition. This stress is the first principal stress. The second principal stress is the hoop stress.

C. Maximum Shear. Based on the axial stress, maximum shear stress, hoop stress and radial stress, occurring at the neutral axis. The principal stresses are calculated using Mohr's circle.

(5) **Interface Force and Moment Results** *(unbonded lead shield analysis only)*
Tables for edge moments and shear forces are printed for the inner and outer shell at the bottom end cap and top closure interfaces (**Figure C-11**). A positive moment results in compression in the outermost fiber of the shell, and a positive shear force is directed radially inward.

(6) **End Cap Stresses**
Lists the bending and shear stresses in the end caps (**Figure C-10**). The end caps are treated as circular plates with fixed boundary conditions for the bottom end cap and pinned boundary conditions for the top end cap. The inertial forces are evenly distributed across the end caps, and the impact limiters contribute no bending resistance. The shear stress is calculated as a maximum at the indicated radius.

(7) **Top Closure Bolt Stresses**
Indicates bolt axial and shear stresses (**Figure C-12**). Bolt axial stresses are calculated only when the bolts are in tension.

```
DYNAMIC IMPACT OUTPUT FOR CASK 9999                                  Page 1 of 7
GENERATED ON 4/15/91 AT 14:46:47                                     CASKS VERSION: 1a
SAR: Sample spent fuel storage cask (demonstration only)
  72.0    in    drop on cask bottom - primary & secondary impact
Angle of primary impact is 45 degrees - shield/shell interface is bonded
ANALYSIS INCLUDES USER DEFINED MATERIALS

                         I M P A C T   S U M M A R Y
                         --------------------


PRIMARY IMPACT (Cask Bottom)
-------------

      Impact Velocity                 =      235.9    in/sec
      Impact Angle                    =       45.0    degrees
      CG Over Corner Angle            =       74.4    degrees

      Maximum Limiter Crush           =       11.3    inches


      Maximum Rigid Body Accelerations
        Vertical Acceleration         =        9.4    g's
        Horizontal Acceleration       =       -1.4    g's
        Rotational Acceleration       =      -45.0    rad/sec**2

      Maximum Impact Forces
        Axial Force In Cask           =    -1009.3    kips
        Shear Force In Cask           =     1115.0    kips

      Maximum Impact Moment (C.L.)    =   -21025.2    in-kips


SECONDARY IMPACT (Cask Top)
---------------

      Impact Velocity                 =      406.8    in/sec
      Impact Angle                    =        1.1    degrees
      Limiter Angle Used              =         .0    degrees

      Maximum Limiter Crush           =       14.2    inches

      Maximum Rigid Body Accelerations
        Vertical Acceleration         =        9.9    g's
        Horizontal Acceleration       =        2.2    g's
        Rotational Acceleration       =       81.5    rad/sec**2


      Maximum Impact Forces
        Axial Force In Cask           =      -54.0    kips
        Shear Force In Cask           =    -1905.1    kips


      Maximum Impact Moment (C.L.)    =    12722.8    in-kips



Run Time For Dynamic Analysis         =      358.6    seconds
```

Figure C-7. Dynamic Impact Output -- Header and Impact Summary

MAXIMUM FORCES AND MOMENTS

NOTE: Node 1 is at Cavity BOTTOM, Node 5 is at Cavity TOP

PRIMARY IMPACT (on cask bottom)

Node Number (Location)	Axial Position (Inches)	Max Axial Force (Kips)	Max Shear Force (Kips)	Max Moment (In-Kips)
Cask Bottom		-1009.3	1115.0	-21025.2
1	.0	-842.5	558.8	--23844.8
2	48.1	-744.1	362.2	3844.0
3	96.3	-554.5	71.9	11273.1
4	144.4	-344.5	-91.7	7639.5
5	192.5	-262.3	-126.5	2689.8
Cask Top		.0	.0	.0

SECONDARY IMPACT (on cask top)

Node Number (Location)	Axial Position (Inches)	Max Axial Force (Kips)	Max Shear Force (Kips)	Max Moment (In-Kips)
Cask Bottom		.0	.0	.0
1	.0	83.0	449.6	4427.8
2	48.1	96.7	409.4	26849.6
3	96.3	116.6	199.5	45819.1
4	144.4	100.0	-396.6	44832.3
5	192.5	-96.3	-740.0	10186.2
Cask Top		-54.0	-1905.1	12722.8

Figure C-8. Dynamic Impact Output -- Maximum Forces and Moments

STRESS INTENSITY

NOTE: SI is based on maximum combined axial & bending stress
or maximum shear stress

NOTE: Node 1 is at Cavity BOTTOM, Node 5 is at Cavity TOP

PRIMARY IMPACT (on cask bottom)

Node Number (Location)	Axial Position (Inches)	STRESS INTENSITY BASED ON ... Max (P/A+Mc/I) (psi)	Max (P/A-Mc/I) (psi)	Max Shear (psi)
Inner Shell				
1	.0	1673.	4405.	4275.
2	48.1	1237.	1757.	2885.
3	96.3	733.	2294.	903.
4	144.4	601.	1537.	829.
5	192.5	438.	708.	1000.
Outer Shell				
1	.0	1859.	4588.	4275.
2	48.1	1232.	1785.	2885.
3	96.3	818.	2381.	903.
4	144.4	657.	1596.	829.
5	192.5	438.	728.	1000.

SECONDARY IMPACT (on cask top)

Node Number (Location)	Axial Position (Inches)	STRESS INTENSITY BASED ON ... Max (P/A+Mc/I) (psi)	Max (P/A-Mc/I) (psi)	Max Shear (psi)
Inner Shell				
1	.0	611.	525.	3232.
2	48.1	3428.	3341.	2943.
3	96.3	5803.	5818.	1441.
4	144.4	5646.	5771.	2851.
5	192.5	1286.	1404.	5320.
Outer Shell				
1	.0	646.	559.	3232.
2	48.1	3638.	3551.	2943.
3	96.3	6162.	6174.	1441.
4	144.4	5994.	6122.	2851.
5	192.5	1362.	1484.	5320.

Figure C-9. Dynamic Impact Output -- Stress Intensity

```
                         END CAP STRESSES
                         ----------------------

NOTE:  Limiters contribute no bending stiffness to the end caps
       Inertial forces are evenly distributed across the end caps

       All stresses are in PSI

PRIMARY IMPACT  (on cask bottom)
--------------

    BOTTOM END CAP  (based on inertia of end cap and contents)
    -------------
                                          Solid End Cap
                                          ----------
        Maximum Bending Stresses
            At center of end cap              2228.4
            At edge near inner shell         -3454.8

        Average Shear Stresses                 674.1
            At radius =  25.6 inches

    TOP END CAP  (based on inertia of end cap)
    ----------
                                          Solid End Cap
                                          -----------
        Maximum Bending Stresses
            At center of end cap               312.8

        Average Shear Stresses                  37.1
            At radius =  25.6 inches


SECONDARY IMPACT  (on cask top)
---------------

    BOTTOM END CAP  (based on inertia of end cap)
    -------------
                                          Solid End Cap
                                          -----------
        Maximum Bending Stresses
            At center of end cap                43.2
            At edge near inner shell           -67.0

        Average Shear Stresses                  13.1
            At radius =  25.6 inches

    TOP END CAP  (based on inertia of end cap and contents)
    ----------
                                          Solid End Cap
                                          -----------
        Maximum Bending Stresses
            At center of end cap             -6756.8

        Average Shear Stresses                 696.2
            At radius =  29.5 inches
```

Figure C-10. Dynamic Impact Output -- End Cap Stresses

```
MAXIMUM CASK SHELL / END CAP

INTERFACE FORCES AND MOMENTS
------------------------------------

A positive moment results in compression in the outermost fiber of shell.
A positive shear force is directed radially inward.

    Edge moment of inner shell at bottom end cap   =  -4.957  in-kips/in.
    Edge moment of outer shell at bottom end cap   =  14.500  in-kips/in.

    Edge shear of inner shell at bottom end cap    =  -2.521  kips/in.
    Edge shear of outer shell at bottom end cap    =   4.500  kips/in.

    Edge moment of inner shell at top closure      =   -.993  in-kips/in.
    Edge moment of outer shell at top closure      =   3.326  in-kips/in.

    Edge shear of inner shell at top closure       =   -.466  kips/in.
    Edge shear of outer shell at top closure       =    .917  kips/in.
```

Figure C-11. Dynamic Impact Output -- Interface Forces and Moments
Note: Results based on unbonded shell/shield interface for primary impact only

```
TOP CLOSURE BOLT STRESSES
--------------------------------

Bolt Shear Stress   (psi)                 PRIMARY IMPACT    SECONDARY IMPACT
--------------                            ------------     --------------

   Applied to ALL bolts equally              2238.             13086.

Bolt Axial Tensile Stress  (psi)          PRIMARY IMPACT    SECONDARY IMPACT
--------------------                      ------------     --------------

   Case 1:  Applied to ALL bolts equally       0.              17079.

   Case 2:  Maximum stress based on bolt       0.               226.87
            position relative to impacting
            edge of the cask

NOTE:  1. Axial load is due to mass of the contents and top end cap
       2. Compressive stresses are printed as zero
       3. Case 2 is best case when impact angle is less than C.G. angle
```

Figure C-12. Dynamic Impact Output -- Closure Bolt Stresses

Appendix C

Sample Cask and Description of Output

Thermal Analysis Output

This Thermal analysis is based on the thermal case *Normal Hot, Contents Heat, Solar Effects*. The ambient temperature is 100°F, contents heat load is 500 Btu/min, and solar effects are included. The Thermal Analysis output format is typical for a Finite Element analysis program and is described below.

(1) **Header**
Indicates the type of analysis, page number of how many, date and time the output was generated, **CASKS** version number, and a brief description of the parameters defining the analysis case. The header shown in **Figure C-13** is printed at the top of every page of output.

(2) **Control Data**
Lists the parameters controlling the analysis. Typical control parameters are: number of materials, nodes, and elements; type of geometry; number and type of boundary and initial conditions; and non-linear solution convergence controls. A partial summary of control parameters is shown in **Figure C-13.**

(3) **Summary of Nodal Data**
Table of nodes for the Finite Element mesh, indicating the coordinates. The mesh is an axisymmetric representation of the TOP end of the cask. A partial summary of node data is shown in **Figure C-14.**

(4) **Summary of Element Data**
Table of elements for the Finite Element mesh, indicating the nodes which define the element, material number, and element volume. A partial summary of element data is shown in **Figure C-14.**

(5) **Summary of Material Data**
Table for each material used in the analysis, indicating the material name, cask component, material number for reference by element data, and material properties. A summary of Material 1 is shown in **Figure C-14.**

(6) **Summary of Temperature Initial Conditions**
Table of initial temperatures applied to nodes. A partial summary of initial temperatures is shown in **Figure C-15.**

(7) **Summary of Flux Boundary Conditions**
Table of flux boundary conditions applied to boundary segments. Each segment is defined by two nodes. Flux boundary conditions are applied to (1) the cavity surface to represent the contents heat and (2) the outer surface to represent solar effects. A partial summary of flux boundary conditions is shown in **Figure C-15**.

(8) **Summary of Convection Boundary Conditions**
Table of convection boundary conditions applied to boundary segments. Each segment is defined by two nodes. Convection boundary conditions are applied to the outer surface to transfer heat between the cask and the ambient environment. A partial summary of convection boundary conditions is shown in **Figure C-15.**

(9) **Summary of Radiation Boundary Conditions**
Table of radiation boundary conditions applied to boundary segments. Each segment is defined by two nodes. Radiation boundary conditions are applied to the outer surface to transfer heat between the cask and the ambient environment. Radiation boundary conditions are also used to represent fire conditions. A partial summary of radiation boundary conditions is shown in **Figure C-15.**

(10) **Bandwidth Minimization Information**
Summary of results of bandwidth minimization, used internally for improved calculational speed.

(11) **Summary of Output**
Table of nodal temperatures, indicating the location and magnitude of the minimum and maximum temperatures and the cavity pressure and temperature. The cavity temperature is the average cavity surface temperature. The cavity pressure is calculated using the ideal gas law. **CASKS** also prints the energy transferred across each boundary condition segment, permitting an energy balance check. For the transient Fire Accident case, temperature and energy results are printed for each time specified by the printing interval. A partial summary of temperature and energy results are shown in **Figure C-16.**

(12) **Termination Message**
Indicates the total clock time in seconds for the analysis and indicates the status of the analysis (**Figure C-16**). *Normal Termination* indicates the analysis was completed. *Error Termination* indicates the analysis was either terminated early by the user or because of an internal error condition (e.g., unable to extract values from function curves). When the analysis ends with an error termination, the resulting output can be printed but cannot be plotted.

```
THERMAL OUTPUT        FOR CASK  9999                              Page   1 of  34
GENERATED ON 11/16/88 AT  8:50:00                           CASKS VERSION:  1a
SAR:             Sample spent fuel shipping cask (demonstration only)
THERMAL CASE:    Normal hot          Contents heat          Solar effects
Maximum contents heat generation:         500.00 BTU/MIN


using the TOPAZ version compiled -        8/23/88

reference - Gary L. Johnson    ph: 415-422-9323


******************************************************************************
       *******        ****           *****          ***        *******
          *          *    *          *    *        *   *             *
          *          *    *          *    *        *   *            *
          *          *    *          * ****        ******          *
          *          *    *          *             *   *          *
          *          *    *          *             *   *         *
          *           ****           *             *   *        *******

******************************************************************************


SUMMARY OF INPUT

                              ***c o n t r o l   d a t a***


     number of materials                         =    9

     number of nodes                             =  282

     number of elements                          =  245

     temperature units                           =    3
          eq.1: dimensionless
          eq.2: centigrade
          eq.3: Fahrenheit
          eq.4: kelvin
          eq.5: rankine

     type of geometry                            =    1
          eq.1: axisymmetric
          eq.2: plane

     bandwidth minimization                      =    1
          eq.0: no minimization
          eq.1: minimization
          eq.2: minimization - nodal destination
                vector read from input file
```

Figure C-13. Thermal Output -- Header and Control Data

*** nodal data ***

node number	x1-coordinate	x2-coordinate	temperature (deg. f)
1	.00000	96.250	.00000
2	4.2708	96.250	.00000
3	8.5417	96.250	.00000
4	12.813	96.250	.00000
5	17.083	96.250	.00000
6	21.354	96.250	.00000

...
...
...

*** element data ***

elem. no.	i	j	k	l	matl. no.	matl. angle	volume
1	17	49	56	56	1	.00000	877.24
2	49	50	57	56	1	.00000	894.19
3	16	56	63	15	1	.00000	877.24
4	56	57	64	63	1	.00000	894.19
5	15	63	70	14	1	.00000	877.24
6	63	64	71	70	1	.00000	94.19

...
...
...

*** material data ***

SS 304 Used in the INNER SHELL

material number = 1

material type = 3

density = .28414

thermal generation rate curve number = 0

thermal generation rate multiplier = .00000

material angle = .00000

temperature	cv	k1
-58.00	.1200	1.1250E-02
68.00	.1230	1.1400E-02
212.0	.1238	1.2083E-02
392.0	.1275	1.2083E-02
572.0	.1312	1.3056E-02
752.0	.1350	1.3889E-02
1112.	.1425	1.5278E-02
1472.	.1500	1.8056E-02

Figure C-14. Thermal Output -- Node/Element/Material Summary

temperature initial conditions

temperature units = (deg. f)

node	temp	node	temp	node	temp	node	temp
1	100.0	72	100.0	143	100.0	214	100.0
2	100.0	73	100.0	144	100.0	215	100.0
3	100.0	74	100.0	145	100.0	216	100.0
4	100.0	75	100.0	146	100.0	217	100.0
5	100.0	76	100.0	147	100.0	218	100.0

...
...
...

flux boundary condition

node i	node j	curve no.	i-multiplier	j-multiplier
1	2	0	-1.42371E-02	-1.42371E-02
2	3	0	-1.42371E-02	-1.42371E-02
3	4	0	-1.42371E-02	-1.42371E-02
4	5	0	-1.42371E-02	-1.42371E-02
5	6	0	-1.42371E-02	-1.42371E-02

...
...
...

convection boundary condition

node i	node j	h curve	h multiplier	free conv exponent	t curve	temp i multiplier	temp j multiplier
196	197	0	2.1990E-05	.3333	0	100.0	100.0
197	198	0	2.1990E-05	.3333	0	100.0	100.0
198	199	0	2.1990E-05	.3333	0	100.0	100.0
199	200	0	2.1990E-05	.3333	0	100.0	100.0
200	201	0	2.1990E-05	.3333	0	100.0	100.0

...
...
...

radiation boundary condition

node i	node j	f curve #	f multiplier	temp curve #	temp i multiplier	temp j multiplier
196	197	0	1.001E-13	0	100.	100.
197	198	0	1.001E-13	0	100.	100.
198	199	0	1.001E-13	0	100.	100.
199	200	0	1.001E-13	0	100.	100.
200	201	0	1.001E-13	0	100.	100.

...
...
...

Figure C-15. Thermal Output -- Initial/Boundary Conditions Summary

```
SUMMARY OF OUTPUT

Steady State Solution

     Minimum temperature    =    157.7 F    at node  228
     Maximum temperature    =    348.6 F    at node    1

     Cavity pressure        =   20.1 psia
     Cavity temperature     = 265.1 deg F

node     temperature          node     temperature          node     temperature

  1         348.6              95        264.1              189        322.2
  2         347.8              96        263.3              190        321.6
  3         345.9              97        261.1              191        320.6
                          ...
                          ...

internal energy is 0. at the initial state
positive heat flow is in direction of the surface outward normal vector

                                    transfer rate       heat transfer     total heat
                                    this step           this step         transferred
     type      seg #     area       [energy/time]       [energy/step]     [energy]

     flux        1      57.303        -.81582
                          ...
                          ...
                                    ===========
     flux TOTAL                       -898.03


     conv        1      57.303         .34631
                          ..
                          ...
                                    ===========
     conv TOTAL                        460.13


     rad         1      57.303         .32472
                          ...
                          ...
                                    ===========
     rad TOTAL                                               440.96


                        heat gen.    total heat          change in        internal
                        this step    generation          int. energy      energy
             mat #      [energy]     [energy]            [energy]         [energy]

               1                      .00000
                          ...
                          ...
                                    ===========
             TOTAL                    .00000

execution ended on 10/02/88  at 15:19:20
execution time =          104 sec

*** normal termination ***
```

Figure C-16. Thermal Output -- Temperature Output and Energy Balance

Appendix C

Sample Cask and Description of Output

Thermal and Pressure Stress Analysis Output

Thermal Stress and Pressure Stress analyses have the same output format. The sample output shown in **Figures C-17, C-18,** and **C-19** is for a Thermal Stress analysis. The analysis is based on the thermal case *Normal Hot, Contents Heat, Solar Effects*. The ambient temperature is 100°F, contents heat load is 500 Btu/min, solar effects are included, and the stress free temperature is 70°F. The output format is as follows:

(1) **Header**
Indicates the type of analysis, page number of how many, date and time the output was generated, **CASKS** version number, and a brief description of the parameters defining the analysis case. The header shown in **Figure C-17** is printed at the top of every page of output.

(2) **Nodal Results**
Table of coordinates and displacements for each node in the Finite Element mesh. The mesh is an axisymmetric representation of the TOP end of the cask. The results for the first ten nodes are shown in **Figure C-17**.

(3) **Element Stress results**
Table of stresses for each element in the mesh. Stresses are calculated at element integration points. These stress are extrapolated to the nodes which define the element and printed in the output. Stresses are not calculated for nodes which lie on the axis of symmetry. The stresses for the first two elements are shown in **Figure C-18**. The stress components are defined as follows:

Srr	Radial stress
Szz	Axial Stress
Stt	Hoop Stress
Srz	Shear stress in the axial cutting plane
S(MAX)	Maximum Principal Stress
S(MIN)	Minimum Principal Stress
ANGLE	Orientation of the principal stresses

(4) **Summary of Output**
Table of maximum and minimum stresses (radial, axial, hoop, shear), indicating the elements where they occur; table of stresses at locations corresponding to Impact model node locations. Stresses are printed for the outer radius of each shell layer along the cask body. Stresses are interpolated to the Impact node locations when necessary. The stresses at the outer radius of the Shell Inner Layer corresponding to Impact node locations are shown in **Figure C-19**.

STRESS OUTPUT FOR CASK 9999 Page 1 of 19
GENERATED ON 11/16/88 AT 8:55:00 CASKS VERSION: 1a
TITLE: Sample spent fuel shipping cask (demonstration only)
THERMAL CASE: Normal hot Contents heat Solar effects
Maximum contents heat generation: 500.00 BTU/MIN
Stress Free Temp= 70. Thermal State 2 at Time S.S.

NODAL RESULTS

NODE NUMBER	COORDINATES X	Y	DISPLACEMENTS DX	DY
1	.000	96.250	.000000	.173338
2	4.271	96.250	.009740	.173180
3	8.542	96.250	.019431	.172724
4	12.813	96.250	.029021	.171950
5	17.083	96.250	.038461	.170854
6	21.354	96.250	.047802	.169543
7	25.625	96.250	.056273	.168131
8	25.625	88.375	.046712	.148118
9	25.625	80.500	.046414	.130258
10	25.625	72.625	.044109	.114609

Figure C-17. Thermal Stress Output -- Header and Nodal Results

ELEMENT STRESS RESULTS

Integration point stresses are extrapolated to the element nodes

Elem Numb	Node Numb	Srr psi	Szz psi	Stt psi	Srz psi	S(MAX) psi	S(MIN) si	ANGLE eg.
1								
	17	-3.	1447.	-3151.	15.	1448.	-3.	89.40
	49	-59.	1612.	-2906.	11.	1612.	-59.	89.62
	50	-113.	1771.	-2670.	7.	1771.	-113.	89.78
	16	3.	1547.	-3153.	-10.	547.	3.	-89.64
	56	-51.	1709.	-2908.	-14.	1709.	-51.	-89.54
	57	-103.	1864.	-2672.	-18.	1864.	-104.	-89.46
	15	10.	1647.	-3155.	-35.	1647.	9.	-88.78
	63	-43.	1805.	-2910.	-40.	1806.	-44.	-88.78
	64	-93.	1957.	-2674.	-44.	1958.	-94.	-88.77
2								
	15	-21.	1591.	-3174.	13.	1591.	-21.	89.54
	63	-85.	1725.	-2940.	-1.	725.	-85.	-89.95
	64	-147.	1854.	-2714.	-15.	1854.	-147.	-89.56
	14	-24.	1891.	-3164.	-54.	1892.	-25.	-88.40
	70	-69.	2008.	-2929.	-69.	2010.	-71.	-88.11
	71	-113.	2121.	-2702.	-83.	2124.	-116.	-87.87
	13	-26.	2191.	-3154.	-120.	2197.	-32.	-86.91
	77	-53.	2291.	-2918.	-136.	2299.	-61.	-86.69
	78	-79.	2387.	-2690.	-151.	2396.	-88.	-86.51

Figure C-18. Thermal Stress Output -- Typical Element Stresses

```
SUMMARY OF OUTPUT

Elements with minimum and maximum stress values

Srr  minimum of   -12843.   psi   occurs in element   14 at node   122
     maximum of    45558.   psi   occurs in element   26 at node   124

Szz  minimum of   -14372.   psi   occurs in element   14 at node   120
     maximum of    24511.   psi   occurs in element   26 at node   124

Stt  minimum of   -15114.   psi   occurs in element   14 at node   120
maximum of         24232.   psi   occurs in element   26 at node   124

Srz  minimum of   -24557.   psi   occurs in element   26 at node   124
     maximum of    21143.   psi   occurs in element   25 at node   120


Stresses along Cask body at radius of each SHELL layer
   Stresses are interpolated to IMPACT node positions
      Cask bottom end:   Impact node is  1,   position is      .0 inches
      Cask top end:      Impact node is  5,   position is   192.5 inches

SHELL INNER LAYER   outer radius= 26.625 inches

Impact
Model   Pos.    Srr      Szz      Stt      Srz     S(MAX)   S(MIN)   ANGLE
Node    inch    psi      psi      psi      psi     psi      psi      deg.
-----   -----   -----    -----    -----    -----   ------   ------   -----
  1        .0   -3536.   12020.    1683.   6011.   14072.   -5588.   71.15
          7.9   -2024.    4505.   -2710.   1329.    4765.   -2284.   78.93
         15.8     461.     452.   -5228.    458.     914.      -1.   44.71
         23.6     665.    2989.   -3111.   2531.    4612.    -957.   57.33
         31.5     -20.    2057.   -2896.    388.    2127.     -90.   79.77
         42.3     -65.    2159.   -2816.     12.    2159.     -65.   89.69
  2      48.1    -103.    2251.   -2754.    -24.    2251.    -104.  -89.42
         53.1    -136.    2328.   -2701.    -55.    2329.    -137.  -88.73
         63.9    -113.    2121.   -2702.    -83.    2124.    -116.  -87.87
         74.7    -120.    1906.   -2694.    -30.    1906.    -120.  -89.16
         85.5    -103.    1864.   -2672.    -18.    1864.    -104.  -89.46
  3      96.3    -113.    1771.   -2670.      7.    1771.    -113.   89.78
        107.0    -103.    1864.   -2672.    -18.    1864.    -104.  -89.46
        117.8    -120.    1906.   -2694.    -30.    1906.    -120.  -89.16
        128.6    -113.    2121.   -2702.    -83.    2124.    -116.  -87.87
        139.4    -136.    2328.   -2701.    -55.    2329.    -137.  -88.73
  4     144.4    -103.    2251.   -2754.    -24.    2251.    -104.  -89.42
        150.2     -65.    2159.   -2816.     12.    2159.     -65.   89.69
        161.0     -20.    2057.   -2896.    388.    2127.     -90.   79.77
        168.9     665.    2989.   -3111.   2531.    4612.    -957.   57.33
        176.8     461.     452.   -5228.    458.     914.      -1.   44.71
        184.6   -2024.    4505.   -2710.   1329.    4765.   -2284.   78.93
  5     192.5   -3536.   12020.    1683.   6011.   14072.   -5588.   71.15
```

Figure C-19. Thermal Stress Output -- Summary of Stresses

Appendix D

Thermal Analysis Boundary Conditions

CASKS uses heat flux, convection, and radiation boundary conditions to define the thermal analysis conditions. Following is a list of the boundary condition values used for each **CASKS** thermal analysis.

NOTE: Refer to Volume 4, *SCANS Thermal Analysis Theory Manual* for a more complete description of the following terms and equations.

Convection Equation: $\dot{q}'' = h\,(T - T_\infty)^a\,(T - T_\infty)$

Where:

$\dot{q}''$ = Surface heat flux due to convection
h = Convection coefficient
a = Free convection exponent
T = Surface temperature
T_∞ = Convection flow temperature

Radiation Equation: $\dot{q}'' = f(T + T_\infty)(T^2 + T_\infty^2)(T - T_\infty)$

and $f = \sigma F$

Where:

$\dot{q}''$ = Surface heat flux due to radiation
σ = Stefan-Boltzmann constant
F = characteristic exchange factor (includes effects of geometry, emissivity and reflectivity)
T = Surface temperature
T_∞ = Radiation source temperature

Cold Soak, Contents Heat, No Solar Effects

All boundary conditions are constant

Heat Flux

Cavity: Contents heat as specified in the geometry definition
Outer Surfaces (solar): None

Convection

Flat surfaces
h = .00002199 Btu / in.^{2} min °F
a = .3333
T_∞ = -40 °F

Cylindrical surfaces
h = .00002083 Btu / in.^{2} min °F
a = .3333
T_∞ = -40 °F

Radiation

f = 1.001E-13 Btu / in.^{2} min °F^4
T_∞ = -40 °F

Appendix D

Thermal Analysis Boundary Conditions

Cold Soak, No Contents, No Solar Effects

All boundary conditions are constant

Heat Flux

Cavity: None

Outer Surfaces (solar): None

Convection

Flat surfaces

$h = .00002199$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = -40$ °F

Cylindrical surfaces

$h = .00002083$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = -40$ °F

Radiation

$f = 1.001E-13$ Btu / in.^{2} min °F^4

$T_\infty = -40$ °F

Normal Cold, Contents Heat, No Solar Effects

All boundary conditions are constant

Heat Flux

Cavity: Contents heat as specified in the geometry definition

Outer Surfaces (solar): None

Convection

Flat surfaces

$h = .00002199$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = -20$ °F

Cylindrical surfaces

$h = .00002083$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = -20$ °F

Radiation

$f = 1.001E-13$ Btu / in.^{2} min °F^4

$T_\infty = -20$ °F

Normal Cold, No Contents, No Solar Effects

All boundary conditions are constant

Heat Flux
Cavity: None
Outer Surfaces (solar): None

Convection
Flat surfaces
$h = .00002199$ Btu / in.^{2} min °F
$a = .3333$
$T_\infty = -20$ °F

Cylindrical surfaces
$h = .00002083$ Btu / in.^{2} min °F
$a = .3333$
$T_\infty = -20$ °F

Radiation
$f = 1.001E-13$ Btu / in.^{2} min °F^4
$T_\infty = -20$ °F

Normal Hot, Contents Heat, Solar Effects

All boundary conditions are constant

Heat Flux
Cavity: Contents heat as specified in the geometry definition
Outer Surfaces (solar): .01065 Btu / in.^{2} min

Convection
Flat surfaces
$h = .00002199$ Btu / in.^{2} min °F
$a = .3333$
$T_\infty = 100$ °F

Cylindrical surfaces
$h = .00002083$ Btu / in.^{2} min °F
$a = .3333$
$T_\infty = 100$ °F

Radiation
$f = 1.001E-13$ Btu / in.^{2} min °F^4
$T_\infty = 100$ °F

Appendix D

Thermal Analysis Boundary Conditions

Normal Hot, Contents Heat, No Solar Effects

All boundary conditions are constant

Heat Flux

Cavity: Contents heat as specified in the geometry definition

Outer Surfaces (solar): None

Convection

Flat surfaces

$h = .00002199$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = 100$ °F

Cylindrical surfaces

$h = .00002083$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = 100$ °F

Radiation

$f = 1.001E\text{-}13$ Btu / in.^{2} min °F^4

$T_\infty = 100$ °F

Fire Accident, Contents Heat, No Solar Effects

All boundary conditions are time dependent

Heat Flux **Applied for complete analysis**

Cavity: Contents heat as specified in the geometry definition

Outer Surfaces (solar): None

Convection **Applied after fire (30-360 minutes)**

Flat surfaces

$h = .00002199$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = 100$ °F

Cylindrical surfaces

$h = .00002083$ Btu / in.^{2} min °F

$a = .3333$

$T_\infty = 100$ °F

Radiation **Applied during fire (0-30 minutes)**

$f = 1.47087E\text{-}13$ Btu / in.^{2} min °F^4

$T_\infty = 1475$ °F

Radiation **Applied after fire (30-360 minutes)**

$f = 1.6016E\text{-}13$ Btu / in.^{2} min °F^4

$T_\infty = 100$ °F

Contents of Distribution Diskettes

The **CASKS** release package contains four 5¨-inch double-density (360Kb) distribution diskettes, listed below. Each file is identified and its function explained.

DISK 1 (5 files)

File Name	Function
CASKSV1B.D1	CASKS Disk 1 Identification File
CASKS.VER	CASKS Version File
INSTALL.EXE	Program to Install CASKS on the PC
SAMPLE.EXE	Packed Sample Cask Data Set
D1.EXE	Packed File. Install process will unpack the file and produce following files:
PLTDYN.EXE	Program to Plot Dynamic Impact Analysis Results
LIMITER.EDT	Editor Template File for Limiter Force-Deflection Curves
EDITOR.EXE	Program to Edit Geometry and Limiter Data Files
TOPAZ.EDT	Editor Template for Creating Thermal Analysis Input

DISK 2 (2 files)

File Name	Function
CASKSV1B.D2	CASKS Disk 2 Identification File
D2.EXE	Packed File. Install process will unpack the file and produce following files:
TOPAZ.EXE	Program to Perform Thermal Analysis
MSHDSP.EXE	Program to Display Finite Element Meshes
POSTPZ.EXE	Program to Plot Thermal Analysis Results
IMPACT.EXE	Program to Perform Impact Analysis
CASKS.BAT	CASKS Main Control Batch File
GEOMETRY.EDT	Editor Template File for Basic Geometry
SURFACE.EDT	Editor Template File for Yielding Surface Force-Deflection Curves
T7RGTPZI	Thermal Analysis B.C. File
MATERIAL.EDT	Editor Template for Creating/Modifying materials

DISK 3 (2 files)

File Name	Function
CASKSV1B.D3	CASKS Disk 3 Identification File
D3.EXE	Packed File. Install process will unpack the file and produce following files:
DATACK.EXE	Program to Create Cask Summary and Data Check
SAPPHIRE.EXE	Program for Thermal/Pressure Analysis module
SAPRESS.EXE	Program to Create Pressure Analysis Input
SAVER.EXE	Program to Archive/Retrieve/Delete Data Sets
ASOLIDF.EXE	Program for Thermal/Pressure Analysis module
PRETOPAZ.EXE	Program to Select Thermal Case and Control Thermal Analysis
ASOLID.EXE	Program for Thermal/Pressure Analysis module
CASKSDM.COM	CASKS Display Menu
VIDEO.VGA	Flag File for Video Display Type
CASKSFM.COM	CASKS Archive Menu
CASKSGM.COM	CASKS Geometry Menu
CASKSMM.COM	CASKS Main Menu
CASKSPM.COM	CASKS Print Menu
CASKSAM.COM	CASKS Analysis Menu
BSS304.STM	Shell/End Cap Material File, Borated Steel 304
DUCSTION.STM	Shell/End Cap Material File, Ductile Cast/Iron

Appendix E
Program Reference

DISK 4 (2 files)

File Name	Function
CASKSV1B.D4	CASKS Disk 4 Identification File
D4.EXE	Packed File. Install process will unpack the file and produce following files:
GETID.EXE	Program to Select CASK ID
DISCLAIM.EXE	Program to Display Disclaimer
ALLDONE.EXE	Program for Termination Message
SOLVE2.EXE	Program for Thermal/Pressure Analysis module
EDGLP.EXE	Program to Initialize Editor
PRINTIT.EXE	Program to Print and Review Outputs
SAPINPT.EXE	Program to Create Thermal Stress Analysis Input
COPYFL.EXE	Program to Copy Geometry/Limiter Data Files
MATCK.EXE	Program to Check Material Data Files
SOLVE1.EXE	Program for Thermal/Pressure Analysis module
ARCSCANS.EXE	Program to Compress/Expand Data Sets for Archive
EDMAT.EXE	Program to Edit Material Data Files
T1RGTPZI	Thermal Analysis B.C. File
T2RGTPZI	Thermal Analysis B.C. File
T3RGTPZI	Thermal Analysis B.C. File
T4RGTPZI	Thermal Analysis B.C. File
T5RGTPZI	Thermal Analysis B.C. File
T6RGTPZI	Thermal Analysis B.C. File
SS304.STM	Shell/End Cap Material File, Stainless Steel 304
SS304.WJM	Water Jacket Material File, Stainless Steel 304
SS310.STM	Shell/End Cap Material File, Stainless Steel 310
SS310.WJM	Water Jacket Material File, Stainless Steel 310
SS316.STM	Shell/End Cap Material File, Stainless Steel 316
SS316.WJM	Water Jacket Material File, Stainless Steel 316
SS347.STM	Shell/End Cap Material File, Stainless Steel 347
SS347.WJM	Water Jacket Material File, Stainless Steel 347
AIRCONV.NSM	Neutron Shield Material File, Air Convection
BALSAXGR.ILM	Impact Limiter Material File, Balsa wood cross-grained
CARBNSTL.STM	Shell/End Cap Material File, Carbon Steel
CARBNSTL.WJM	Water Jacket Material File, Carbon Steel
COPPER.WJM	Water Jacket Material File, Copper
H2OCONV.NSM	Neutron Shield Material File, Water Convection
LEAD.SHM	Shield Material File, Lead
POLYFOAM.ILM	Impact Limiter Material File, Polyfoam
PLOTRES.LOW	Flag File for Printer Plot Resolution
PRINTER.EPS	Flag File for Printer Type
PURETHAN.ILM	Impact Limiter Material File, Polyurethane
REDWDXGR.ILM	Impact Limiter Material File, Redwood cross-grained
DOT2.COM	Program for Thermal/Pressure Stress Analysis Module
PRINTER.LJT	Program to Control Laser Jet Printer
SURFACE.EDT	Editor Template for Yielding Surface Force-Deflection Curves
DOT1.COM	Program for Thermal/Pressure Stress Analysis Module

System Details

CASKS uses a DOS *BATCH* command file to coordinate the menus, input programs, cask analysis programs, output programs, data archive programs and databases. A *BATCH* file is a file containing commands that DOS executes one at a time. The **CASKS** *BATCH* file is controlled using menu programs. Each menu program displays a list of options and waits until one of the indicated keys is pressed. After accepting the key, the menu program sets the DOS ERRORLEVEL to indicate which key was pressed. The *BATCH* file branches based on ERRORLEVEL, to perform the selected task.

CASKS has six menu programs. Each menu program is written in Assembly Language, making it small, fast, and flexible. All other programs in **CASKS** are written in FORTRAN. The FORTRAN programs use a set of FORTRAN callable Assembly Language routines to provide access to DOS and BIOS functions. These functions include manipulating the video screen, sending data to the printer, managing disk files, and obtaining disk space and directory information.

The **CASKS** *BATCH* file is listed below with comments identifying the flow of control.

```
C:                                    | Switch to hard disk continuing CASKS
PROMPT $e[1;37;40m                    | Clear prompt, set white text over black background
ECHO OFF                              | Turn off echo feature of batch file
MODE CO80                             | Set video mode to CGA with 80 columns of text
REM ****** TEST FOR COMMAND.COM ON CASKS DRIVE *****

IF EXIST\COMMAND.COM  GOTO CHNGDIR

ECHO
ECHO
ECHO
ECHO ERROR -- CANNOT INITIALIZE CASKS
ECHO
ECHO     COMMAND.COM DOES NOT EXIST IN THE ROOT DIRECTORY OF THE
ECHO      DRIVE WHICH CONTAINS CASKS
ECHO
ECHO

PROMPT $P$G
GOTO END2

REM ********************************************

:CHNGDIR
CD\CASKS                              | Change to CASKS subdirectory
DISCLAIM                              | Display CASKS disclaimer
GETID                                 | Select CASK ID
IF NOT EXIST CASK.ID  GOTO END        | If no CASK ID selected, go to end CASKS

:MAIN
CASKSMM                               | Display MAIN MENU
IF ERRORLEVEL 7 GOTO END              | Check ERRORLEVEL and branch
IF ERRORLEVEL 6 GOTO SAVE
```

```
IF ERRORLEVEL 5 GOTO PRINTER
IF ERRORLEVEL 4 GOTO DISPLAY
IF ERRORLEVEL 3 GOTO ANALYZE
IF ERRORLEVEL 2 GOTO GEOMETRY

:INIT
GETID                                          | Select CASK ID
GOTO MAIN                                      |  and return to MAIN MENU

:GEOMETRY
IF EXIST EDITOR.EDM DEL EDITOR.EDM             | Delete EDITOR control file
CASKSGM                                        | Display GEOMETRY MENU
IF ERRORLEVEL 7 GOTO MAIN                      | Check ERRORLEVEL and branch
IF ERRORLEVEL 6 GOTO EDITM                     | Check ERRORLEVEL and branch
IF ERRORLEVEL 5 GOTO COPYLM
IF ERRORLEVEL 4 GOTO COPYBG
IF ERRORLEVEL 3 GOTO EDITS
IF ERRORLEVEL 2 GOTO EDITL
:EDITG   EDIT THE BASIC GEOMETRY DATA FILE AND PERFORM DATA CHECK
EDGLP G                                        | Setup to edit GEOMETRY
IF NOT EXIST EDITOR.EDM GOTO GEOMETRY          | If control file missing, return to GEOMETRY MENU
EDITOR                                         | Edit GEOMETRY
IF NOT EXIST DATACHCK GOTO GEOMETRY            | If not doing data check, return to GEOMETRY MENU
DATACK G                                       | Perform data check on basic geometry
GOTO GEOMETRY                                  |  and return to GEOMETRY MENU

:EDITL   EDIT THE IMPACT LIMITER DATA FILE AND PERFORM DATA CHECK
EDGLP L                                        | Setup to edit LIMITER
IF NOT EXIST EDITOR.EDM GOTO GEOMETRY          | If control file missing, return to GEOMETRY MENU
EDITOR                                         | Edit LIMITER
IF NOT EXIST DATACHCK GOTO GEOMETRY            | If not doing data check, return to GEOMETRY MENU
DATACK L                                       | Perform data check on limiter F/D curves
GOTO GEOMETRY                                  |  and return to GEOMETRY MENU

:EDITS                                         | Setup to edit SURFACE
EDGLP S
IF NOT EXIST EDITOR.EDM GOTO GEOMETRY
EDITOR
DATACK S
GOTO GEOMETRY

:COPYBG  COPY BASIC GEOMETRY FROM DIFFERENT CASK
COPYFL B                                       | Copy GEOMETRY from different data set
GOTO GEOMETRY                                  |  and return to GEOMETRY MENU

:COPYLM  COPY LIMITER DATA FROM DIFFERENT CASK
COPYFL L                                       | Copy LIMITER from different data set
GOTO GEOMETRY                                  |  and return to GEOMETRY MENU
```

```
:EDITM
EDMAT S
IF NOT EXIST EDITOR.EDM GOTO GEOMETRY
EDITOR
IF NOT DATACHCK TOTO GEOMETRY
MATCK
GOTO GEOMETRY

:ANALYZE   PERFORM ANALYSIS
CASKSAM                                      | Display ANALYSIS MENU
IF ERRORLEVEL 5 GOTO MAIN                    | Check ERRORLEVEL and branch

IF ERRORLEVEL 4 GOTO PSTRESS
IF ERRORLEVEL 3 GOTO TSTRESS
IF ERRORLEVEL 2 GOTO THERMAL

:IMPACTIT  PERFORM IMPACT ANALYSIS
IMPACT                                       | Perform IMPACT analysis
GOTO ANALYZE                                 |  and return to ANALYSIS MENU

:THERMAL   PERFORM THERMAL ANALYSIS
PRETOPAZ                                     | Perform THERMAL analysis
IF NOT EXIST TOPAZ.CMD GOTO ANALYZE
TOPAZ
IF EXIST CONTINUE.TPZ GOTO THERMAL
GOTO ANALYZE                                 |  and return to ANALYSIS MENU

:PSTRESS
SAPRESS                                      | Select case for PRESSURE STRESS analysis
IF NOT EXIST TEMPCASK GOTO ANALYZE           | If no case selected, return to ANALYSIS MENU
SAPPHIRE                                     | Perform PRESSURE STRESS analysis
ASOLID
DOT1
SOLVE1 >TEMPCASK.JNK
DOT2
SOLVE2 >>TEMPCASK.JNK
ASOLIDF
DEL TEMPCASK.*                               | Delete temporary files
DEL SYSTEM
IF EXIST CONTINUE.TSO GOTO PSTRESS           | If performing another, go to select case
GOTO ANALYZE                                 |  else return to ANALYSIS MENU
```

Appendix E

Program Reference

```
:TSTRESS
SAPINPT                                        | Select case for THERMAL STRESS analysis
IF NOT EXIST TEMPCASK GOTO ANALYZE             | If no case selected, return to ANALYSIS MENU
SAPPHIRE                                       | Perform THERMAL STRESS analysis
ASOLID
DOT1
SOLVE1 >TEMPCASK.JNK
DOT2
SOLVE2 >>TEMPCASK.JNK
ASOLIDF
DEL TEMPCASK.*                                 | Delete temporary files
DEL SYSTEM
IF EXIST CONTINUE.TSO GOTO TSTRESS             | If performing another, go to select case
GOTO ANALYZE                                   | else return to ANALYSIS MENU

:DISPLAY
CASKSDM                                        | Display DISPLAY MENU
IF ERRORLEVEL 5 GOTO MAIN                      | Check ERRORLEVEL and branch
IF ERRORLEVEL 4 GOTO ATTRIB
IF ERRORLEVEL 3 GOTO PLOTT
IF ERRORLEVEL 2 GOTO PMESH

:PLOTI   PLOT IMPACT RESULTS
PLTDYN                                         | Plot DYNAMIC IMPACT ANALYSIS results
GOTO DISPLAY                                   | and return to DISPLAY MENU

:PMESH   PLOT FINITE ELEMENT MESHES
MSHDSP D                                       | Display FINITE ELEMENT meshes
GOTO DISPLAY                                   | and return to DISPLAY MENU

:PLOTT   PLOT THERMAL DISTRIBUTIONS
POSTPZ                                         | Plot THERMAL ANALYSIS results
GOTO DISPLAY                                   | and return to DISPLAY MENU

:ATTRIB  SET VIDEO ATTRIBUTES
SETVIDEO                                       | Select Video/Printer type and plot resolution
GOTO DISPLAY                                   | and return to DISPLAY MENU

:PRINTER
CASKSPM                                        | Display PRINT/REVIEW MENU
IF ERRORLEVEL 6 GOTO MAIN                      | Check ERRORLEVEL and branch
IF ERRORLEVEL 5 GOTO PRINTD
IF ERRORLEVEL 4 GOTO PRINTP
IF ERRORLEVEL 3 GOTO PRINTS
IF ERRORLEVEL 2 GOTO PRINTT
```

```
:PRINTI  PRINT IMPACT RESULTS
PRINTIT I                                  | Print IMPACT ANALYSIS results
GOTO PRINTER                               |  and return to PRINT/REVIEW MENU
:PRINTT  PRINT THERMAL RESULTS
PRINTIT T                                  | Print THERMAL ANALYSIS results
GOTO PRINTER                               |  and return to PRINT/REVIEW MENU

:PRINTS  PRINT THERMAL STRESS RESULTS
PRINTIT S                                  | Print THERMAL STRESS ANALYSIS results
GOTO PRINTER                               |  and return to PRINT/REVIEW MENU

:PRINTP  PRINT PRESSURE STRESS RESULTS
PRINTIT P                                  | Print PRESSURE STRESS ANALYSIS results
GOTO PRINTER                               |  and return to PRINT/REVIEW MENU

:PRINTD  PRINT CASK SUMMARY AND DATA CHECK
PRINTIT D                                  | Print CASK SUMMARY/DATA CHECK
GOTO PRINTER                               |  and return to PRINT/REVIEW MENU

:SAVE
CASKSFM                                    | Display ARCHIVE MENU
IF ERRORLEVEL 4 GOTO MAIN                  | Check ERRORLEVEL and branch
IF ERRORLEVEL 3 GOTO DELETE
IF ERRORLEVEL 2 GOTO GET

:PUT     ARCHIVE CASK DATA SET
SAVER A                                    | ARCHIVE data sets
GOTO SAVE                                  |  and return to ARCHIVE MENU

:GET     RETRIEVE CASK DATA SET
SAVER R                                    | RETRIEVE data sets
GOTO SAVE                                  |  and return to ARCHIVE MENU

:DELETE  DELETE CASK DATA SET
SAVER D                                    | DELETE data sets
GOTO SAVE                                  |  and return to ARCHIVE MENU

:END  ***** END OF THE CASKS PROCESS       | Terminate CASKS
IF EXIST CASK.ID DEL CASK.ID               | Delete CASK ID identification file
PROMPT $p $g                               | Set prompt to display drive and path
ALLDONE                                    | Display termination message
:END2
CD\                                        | Change to root directory
ECHO ON                                    | Restore ECHO
```

Appendix E

Program Reference

Description of Databases

CASKS uses integrated databases to pass information between various programs. These databases describe the cask geometry, impact limiter force-deflection curves, material properties, boundary conditions for Thermal analyses, analysis results for plotting, and analysis results for printing. All databases, with the exception of printable output, are *random access* files with fixed record lengths. Thus, each program that utilizes the database has access to individual elements in the data base, identified by record number. Following is a description of each *random access* database.

Basic Geometry Database

Purpose:	Contains all geometry specifications for the cask.
Used by:	IMPACT, DATACK, PRETOPAZ, SAPINPT, SAPRESS, MSHDSP
Created by:	EDITOR
Modified by:	EDITOR, PRETOPAZ
Record Length:	12

NOTE: Record types are as follows:

Real	= Real Number
Int	= Integer Number
Char	= Character string
List	= Single Character which must match specific choices
Name	= Value is selected from a file name list

Header

Record	Description	Type	Length	Comments
1	Casks Id			Must be 'Scans gei'
2 \				
3 |				
4 |--	Database name	Char	60	
5 |				
6 /				
8	File creation date	Char	8	Form 'mm/dd/yy'
9	File creation time	Char	8	Form 'hh:mm:ss'
10	Editor code name	Char	8	Editor
11	Editor version no.	Char	3	2.1
12	Editor compile date	Char	8	Form 'mm/dd/yy'
13	Geometry template file name	Char	12	Geometry.edt
14	Unused at this time			
15	Data file status	Char	12	'Complete' or 'Incomplete'
16	Page 1 mod date, PGACC, PGREQ	Char	8 1 1	Form 'mm/dd/yy AR'
17	Page 2 mod date, PGACC, PGREQ	Char	8 1 1	Form 'mm/dd/yy AR'
.	. NOTE: See TEMPLATE for definition of PGACC & PGREQ			
45	Page 45 mod date, PGACC, PGREQ	Char	8 1 1	Form 'mm/dd/yy AR'

General SAR Information and Reviewer Information

Record	Description	Type	Length	Restrictions	Default
46 \					
47 |					
48 |--	SAR title	Char	54		(blank)
49 |					
50 /					
51	SAR report number	Char	12		(blank)
52	SAR report date	Char	8		(blank)
53	SAR docket number	Char	7		(blank)
54	SAR docket start date	Char	8		(blank)
55 \					
56 |					
57 |--	Additional SAR info Line 1	Char	54		(blank)
58 |					
59 /					
60 \					
61 |					
62 |--	Additional SAR info Line 2	Char	54		(blank)
63 |					
64 /					
65 \					
66 |					
67 |--	Additional SAR info Line 3	Char	54		(blank)
68 |					
69 /					
70 \					
71 |					
72 |--	Submitters address Line 1	Char	54		(blank)
73 |					
74 /					
75 \					
76 |					
77 |--	Submitters address Line 2	Char	54		(blank)
78 |					
79 /					
80 \					
81 |					
82 |--	Submitters address Line 3	Char	54		(blank)
83 |					
84 /					
85	Cask review leader name	Char	24		(blank)
86	(cont'd)				
87	Thermal analyst's name	Char	24		(blank)
88	(cont'd)				
89	Structural analyst's name	Char	24		(blank)
90	(cont'd)				
91	Nucleonics analyst's name	Char	24		(blank)
92	(cont'd)				
93-99	Unused at this time				

Appendix E
Program Reference

Cask Cavity/Contents Specifications

Record	Description	Type	Length	Restrictions	Default
100	Gross weight of package (lbs)	Real	12	Positive	0.
101	Cavity radius (inches)	Real	12	$.001 \le X \le 2000$	0.
102	Cavity radius mesh divisions	Int	2	Even $2 \le I \le 20$	6
103	Cavity length (inches)	Real	12	$.001 \le X \le 2000$	0.
104	Half length mesh divisions	Int	2	Even $2 \le I \le 40$	8
105	Weight of contents (lbs)	Real	12	Positive	0
106	Max contents heat (btu/min)	Real	12	$0 \le X$	0
107	Initial cavity pressure (psia)	Real	12	$0 \le X \le 500$	14.7
108	Initial cavity temperature (°F)	Real	12	$-100 \le X \le 300$	70
109	Maximum Normal Operating Pressure (psia)	Real	12	$0 \le X \le 2000$	14.7
110	Stress free temperature (°F)	Real	12	$-100 \le X \le 300$	70

Cask Component Configurations

Record	Description	Type	Length	Restrictions	Default
111	Shell configuration	List	1	S or L	S
112	Top end cap configuration	List	1	S or L	S
113	Bottom end cap configuration	List	1	S or L	S
114	Top limiter present?	List	1	Y or N	Y
115	Bottom limiter present?	List	1	Y or N	Y
116	Neutron shield/water jacket?	List	1	Y or N	Y

117-120 Unused at this time

Cask Shell Specifications

Record	Description	Type	Length	Restrictions	Default
The following 3 records are for Solid Shells (1 layer)					
121	Shell thickness (in.)	Real	12	$.001 \le X \le 2000$	0.
122	Shell material	Name	8	List from *.STM	SS304
123	Shell mesh divisions	Int	2	Even $2 \le I \le 10$	4
The following 12 records are for Laminated Shells (1-3 layers)					
124	Shell inner layer thickness (in.)	Real	12	$0. \le X \le 2000$	0.
125	Shell inner layer material	Name	8	List from *.STM	SS304
126	Shell inner layer mesh divisions	Int	2	Even $2 \le I \le 10$	2
127	Shell shield thickness (in.)	Real	12	$0. \le X \le 2000$	0.
128	Shell shield length (in.)	Real	12	$0. \le X \le 2000$	0.
129	Shell shield material	Name	8	List from *.SHM	LEAD
130	Shell shield mesh divisions	Int	2	Even $2 \le I \le 10$	4
131	Shell outer layer thickness (in.)	Real	12	$.001 \le X \le 2000$	0.
132	Shell outer layer material	Name	8	List from *.STM	SS304
133	Shell outer layer mesh divisions	Int	2	Even $2 \le I \le 10$	2
134	Inner Shell additional thickness (in.)	Real	12	$0. \le X \le 2000$	0.
135	Outer Shell additional thickness (in.)	Real	12	$0. \le X \le 2000$	0.

Cask Top End Cap Specifications

Record	Description	Type	Length	Restrictions	Default
The following 3 records are for Solid Top End Caps (1 layer)					
136	Top End Cap thickness (in.)	Real	12	.001 ≤ X ≤ 2000	0.
137	Top End Cap material	Name	8	List from *.STM	SS304
138	Top End Cap mesh divisions	Int	2	Even 2 ≤ I ≤ 10	4
The following 10 records are for Laminated Top End Caps (1-3 layers)					
139	Top End Cap inner layer thickness (in.)	Real	12	0. ≤ X ≤ 2000	0.
140	Top End Cap inner layer material	Name	8	List from *.STM	SS304
141	Top End Cap inner layer mesh divisions	Int	2	Even 2 ≤ I ≤ 10	2
142	Top End Cap shield thickness (in.)	Real	12	0. ≤ X ≤ 2000	0.
143	Top End Cap shield length (in.)	Real	12	0. ≤ X ≤ 2000	0.
144	Top End Cap shield material	Name	8	List from *.SHM	LEAD
145	Top End Cap shield mesh divisions	Int	2	Even 2 ≤ I ≤ 10	4
146	Top End Cap outer layer thickness (in.)	Real	12	.001 ≤ X ≤ 2000	0.
147	Top End Cap outer layer material	Name	8	List from *.STM	SS304
148	Top End Cap outer layer mesh divisions	Int	2	Even 2 ≤ I ≤ 10	2
149-150	Unused at this time				

Cask Bottom End Cap Specifications

Record	Description	Type	Length	Restrictions	Default
The following 3 records are for Solid Bottom End Caps (1 layer)					
151	Bottom End Cap thickness (in.)	Real	12	.001 ≤ X ≤ 2000	0.
152	Bottom End Cap material	Name	8	List from *.STM	SS304
153	Bottom End Cap mesh divisions	Int	2	Even 2 ≤ I ≤ 10	4
The following 10 records are for Laminated Bottom End Caps (1-3 layers)					
154	Bottom End Cap inner layer thickness (in.)	Real	12	0. ≤ X ≤ 2000	0.
155	Bottom End Cap inner layer material	Name	8	List from *.STM	SS304
156	Bottom End Cap inner layer mesh divisions	Int	2	Even 2 ≤ I ≤ 10	2
157	Bottom End Cap shield thickness (in.)	Real	12	0. ≤ X ≤ 2000	0.
158	Bottom End Cap shield length (in.)	Real	12	0. ≤ X ≤ 2000	0.
159	Bottom End Cap shield material	Name	8	List from *.SHM	LEAD
160	Bottom End Cap shield mesh divisions	Int	2	Even 2 ≤ I ≤ 10	4
161	Bottom End Cap outer layer thickness (in.)	Real	12	.001 ≤ X ≤ 2000	0.
162	Bottom End Cap outer layer material	Name	8	List from *.STM	SS304
163	Bottom End Cap outer layer mesh divisions	Int	2	Even 2 ≤ I ≤ 10	2
164-167	Unused at this time				

Appendix E
Program Reference

Cask Closure Bolts Information

Record	Description	Type	Length	Restrictions	Default
168	Closure bolt circle radius (in.)	Real	12	$.001 \le X \le 2000$	0.
169	Number of closure bolts	Int	2	$1 \le I \le 99$	0
170	Diameter of closure bolts (in.)	Real	12	$.001 \le X \le 10$	0.

171-175 Unused at this time

Cask Neutron Shield / Water Jacket Specifications

Record	Description	Type	Length	Restrictions	Default
176	Neutron shield / Water Jacket length (in.)	Real	12	$0. \le X \le 2000$	0.
177	Neutron shield thickness (in.)	Real	12	$0. \le X \le 2000$	0.
178	Neutron shield material	Name	8	List from *.NSM	H2OCONV
179	Neutron shield mesh divisions	Int	2	$2 \le I \le 9$	1
180	Water jacket thickness (in.)	Real	12	$0. \le X \le 2000$	0.
181	Water jacket material	Name	8	List from *.WJM	SS304
182	Water jacket mesh divisions	Int	2	$2 \le I \le 9$	1

183-185 Unused at this time

Cask Top Impact Limiter Specifications

Record	Description	Type	Length	Restrictions	Default
186	Top limiter outer radius	Real	12	$.001 \le X \le 2000$	0.
187	Top limiter centerline thickness (in.)	Real	12	$.001 \le X \le 2000$	0.
188	Top limiter centerline mesh divisions	Int	2	$2 \le I \le 10$	4
189	Top limiter overhang thickness (in.)	Real	12	$0. \le X \le 2000$	0.
190	Top limiter overhang mesh divisions	Int	2	$2 \le I \le 10$	3
191	Top limiter material	Name	8	List from *.ILM	POLYFOAM

192-195 Unused at this time

Cask Bottom Impact Limiter Specifications

Record	Description	Type	Length	Restrictions	Default
196	Bottom limiter outer radius	Real	12	$.001 \le X \le 2000$	0.
197	Bottom limiter centerline thickness (in.)	Real	12	$.001 \le X \le 2000$	0.
198	Bottom limiter centerline mesh divisions	Int	2	$2 \le I \le 10$	4
199	Bottom limiter overhang thickness (in.)	Real	12	$0. \le X \le 2000$	0.
200	Bottom limiter overhang mesh divisions	Int	2	$2 \le I \le 10$	3
201	Bottom limiter material	Name	8	List from *.ILM	POLYFOAM

202-205 Unused at this time

Cask Impact Model Specifications

Record	Description	Type	Length	Restrictions	Default
206	Number of elements for 1d model	Int	2	3 ≤ I ≤ 20	4
207	Top limiter weight (lbs)	Real	12	0 ≤ X	0.
208	Bottom limiter weight (lbs)	Real	12	0 ≤ X	0.
209	Define model with user properties ?	List	1	Y or N	N
210	Shell translational mass (lb-sec**2/in.)	Real	12	POSITIVE	0.
211	Shell rotational mass (lb-sec**2-in.)	Real	12	POSITIVE	0.
212	Shell inside length (in.)	Real	12	POSITIVE	0.
213	Shell composite E*I (lb-in.**2)	Real	12	POSITIVE	0.
214	Shell composite A*E (lb)	Real	12	POSITIVE	0.
215	Top End translational mass (lb-sec**2/in.)	Real	12	POSITIVE	0.
216	Top End rotational mass (lb-sec**2-in.)	Real	12	POSITIVE	0.
217	Bottom End translational mass (lb-sec**2/in.)	Real	12	POSITIVE	0.
218	Bottom End rotational mass (lb-sec**2/in.)	Real	12	POSITIVE	0.
219	Characteristic cross-section (in.)	Real	12	POSITIVE	0.

220 Unused at this time

Thermal Transient Analysis Control Parameters

NOTE: These parameters cannot be modified using the EDITOR

Record	Description	Type	Length	Restrictions	Default
221	Allow phase change ?	List	1	Y or N	N
222	Print output interval (min)	Real	12	10 ≤ X ≤ 3603	0.
223	Plot output interval (min)	Real	12	2 ≤ X ≤ 30	5.
224	Use variable time step ?	List	1	Y or N	N
225	Iteration convergence tolerance	Real	12	.001 ≤ X ≤ .1	.001
226	Iteration relaxation parameter	Real	12	.3 ≤ X ≤ 1.	1.
227	Maximum allowable time step (min)	Real	12	5 ≤ X ≤ 30	30.
228	Maximum allowable temperature change (°F)	Real	12	25 ≤ X ≤ 50	100.
229	Time step modification factor	Real	12	2 ≤ X ≤ 6	2.
230	Fixed time step size (min)	Real	12	.25 ≤ X ≤ 5	.5

Appendix E
Program Reference

Impact Limiter Force-Deflection Curves Database

Purpose: Contains all limiter force-deflection curve specifications
Used by: IMPACT, DATACK
Created by: EDITOR
Modified by: EDITOR
Record Length: 12

NOTE: Record types are as follows:
- Real = Real Number
- Int = Integer Number
- Char = Character string
- List = Single Character which must match specific choices
- Name = Value is selected from a file name list

Header

Record	Description	Type	Length	Comments
1	Casks Id			Must be 'Scans lmi'
2 \				
3 |				
4 |--	Database name	Char	60	
5 |				
6 /				
8	File creation date	Char	8	Form 'mm/dd/yy'
9	File creation time	Char	8	Form 'hh:mm:ss'
10	Editor code name	Char	8	Editor
11	Editor version no.	Char	3	2.1
12	Editor compile date	Char	8	Form 'mm/dd/yy'
13	Limiter template file name	Char	12	Limiter.edt
14	Unused at this time			
15	Data file status	Char	12	'Complete' or 'Incomplete'
16	Page 1 mod date, PGACC, PGREQ	Char	8 1 1	Form 'mm/dd/yy AR'
17	Page 2 mod date, PGACC, PGREQ	Char	8 1 1	Form 'mm/dd/yy AR'
.				
.	NOTE: See TEMPLATE for definition of PGACC & PGREQ			
.				
45	Page 45 mod date, PGACC, PGREQ	Char	8 1 1	Form 'mm/dd/yy AR'

Impact Limiter Unloading Specification

Record	Description	Type	Length	Restrictions	Default
48	Type of limiter unloading	List	1	N or U or C	N
49	User unloading slope (kips/in.)	Real	12	POSITIVE	0.

Bottom Impact Limiter Curve for a 0-Degree Impact

Record	Description	Type	Length	Restrictions	Default
50	Is this limiter defined ?	List	1	Y or N	N
51	Deflection #1 (in.)	Real	12	POSITIVE	0.
52	Force #1 (kips)	Real	12	POSITIVE	0.
53	Deflection #2 (in.)	Real	12	POSITIVE	0.
54	Force #2 (kips)	Real	12	POSITIVE	0.
55	Deflection #3 (in.)	Real	12	0. ≤ X	0.
56	Force #3 (kips)	Real	12	0. ≤ X	0.
57	Deflection #4 (in.)	Real	12	0. ≤ X	0.
58	Force #4 (kips)	Real	12	0. ≤ X	0.
59	Deflection #5 (in.)	Real	12	0. ≤ X	0.
60	Force #5 (kips)	Real	12	0. ≤ X	0.
61	Deflection #6 (in.)	Real	12	0. ≤ X	0.
62	Force #6 (kips)	Real	12	0. ≤ X	0.
63	Deflection #7 (in.)	Real	12	0. ≤ X	0.
64	Force #7 (kips)	Real	12	0. ≤ X	0.
65	Deflection #8 (in.)	Real	12	0. ≤ X	0.
66	Force #8 (kips)	Real	12	0. ≤ X	0.
67	Deflection #9 (in.)	Real	12	0. ≤ X	0.
68	Force #9 (kips)	Real	12	0. ≤ X	0.
69	Deflection #10 (in.)	Real	12	0. ≤ X	0.
70	Force #10 (kips)	Real	12	0. ≤ X	0.
71-74	Unused at this time				

Bottom Impact Limiter Curve for a 15-Degree Impact

Record	Description	Type	Length	Restrictions	Default
75	Is this limiter defined ?	List	1	Y or N	N
76	Deflection #1 (in.)	Real	12	POSITIVE	0.
77	Force #1 (kips)	Real	12	POSITIVE	0.
78	Deflection #2 (in.)	Real	12	POSITIVE	0.
79	Force #2 (kips)	Real	12	POSITIVE	0.
80	Deflection #3 (in.)	Real	12	0. ≤ X	0.
81	Force #3 (kips)	Real	12	0. ≤ X	0.
82	Deflection #4 (in.)	Real	12	0. ≤ X	0.
83	Force #4 (kips)	Real	12	0. ≤ X	0.
84	Deflection #5 (in.)	Real	12	0. ≤ X	0.
85	Force #5 (kips)	Real	12	0. ≤ X	0.
86	Deflection #6 (in.)	Real	12	0. ≤ X	0.
87	Force #6 (kips)	Real	12	0. ≤ X	0.
88	Deflection #7 (in.)	Real	12	0. ≤ X	0.
89	Force #7 (kips)	Real	12	0. ≤ X	0.
90	Deflection #8 (in.)	Real	12	0. ≤ X	0.
91	Force #8 (kips)	Real	12	0. ≤ X	0.
92	Deflection #9 (in.)	Real	12	0. ≤ X	0.
93	Force #9 (kips)	Real	12	0. ≤ X	0.
94	Deflection #10 (in.)	Real	12	0. ≤ X	0.
95	Force #10 (kips)	Real	12	0. ≤ X	0.
96-99	Unused at this time				

Bottom Impact Limiter Curve for a 30-Degree Impact

Record	Description			Type	Length	Restrictions	Default
100	Is this limiter defined ?			List	1	Y or N	N
101	Deflection	#1	(in.)	Real	12	POSITIVE	0.
102	Force	#1	(kips)	Real	12	POSITIVE	0.
103	Deflection	#2	(in.)	Real	12	POSITIVE	0.
104	Force	#2	(kips)	Real	12	POSITIVE0.	
105	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
106	Force	#3	(kips)	Real	12	0. ≤ X	0.
107	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
108	Force	#4	(kips)	Real	12	0. ≤ X	0.
109	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
110	Force	#5	(kips)	Real	12	0. ≤ X	0.
111	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
112	Force	#6	(kips)	Real	12	0. ≤ X	0.
113	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
114	Force	#7	(kips)	Real	12	0. ≤ X	0.
115	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
116	Force	#8	(kips)	Real	12	0. ≤ X	0.
117	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
118	Force	#9	(kips)	Real	12	0. ≤ X	0.
119	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
120	Force	#10	(kips)	Real	12	0. ≤ X	0.
121-124	Unused at this time						

Bottom Impact Limiter Curve for a 45-Degree Impact

Record	Description			Type	Length	Restrictions	Default
125	Is this limiter defined ?			List	1	Y or N	N
126	Deflection	#1	(in.)	Real	12	POSITIVE	0.
127	Force	#1	(kips)	Real	12	POSITIVE	0.
128	Deflection	#2	(in.)	Real	12	POSITIVE	0.
129	Force	#2	(kips)	Real	12	POSITIVE	0.
130	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
131	Force	#3	(kips)	Real	12	0. ≤ X	0.
132	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
133	Force	#4	(kips)	Real	12	0. ≤ X	0.
134	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
135	Force	#5	(kips)	Real	12	0. ≤ X	0.
136	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
137	Force	#6	(kips)	Real	12	0. ≤ X	0.
138	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
139	Force	#7	(kips)	Real	12	0. ≤ X	0.
130	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
141	Force	#8	(kips)	Real	12	0. ≤ X	0.
142	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
143	Force	#9	(kips)	Real	12	0. ≤ X	0.
144	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
145	Force	#10	(kips)	Real	12	0. ≤ X	0.
146-149	Unused at this time						

Bottom Impact Limiter Curve for a 60-Degree Impact

Record	Description	Type	Length	Restrictions	Default
150	Is this limiter defined ?	List	1	Y or N	N
151	Deflection #1 (in.)	Real	12	POSITIVE	0.
152	Force #1 (kips)	Real	12	POSITIVE	0.
153	Deflection #2 (in.)	Real	12	POSITIVE	0.
154	Force #2 (kips)	Real	12	POSITIVE	0.
155	Deflection #3 (in.)	Real	12	0. ≤ X	0.
156	Force #3 (kips)	Real	12	0. ≤ X	0.
157	Deflection #4 (in.)	Real	12	0. ≤ X	0.
158	Force #4 (kips)	Real	12	0. ≤ X	0.
159	Deflection #5 (in.)	Real	12	0. ≤ X	0.
160	Force #5 (kips)	Real	12	0. ≤ X	0.
161	Deflection #6 (in.)	Real	12	0. ≤ X	0.
162	Force #6 (kips)	Real	12	0. ≤ X	0.
163	Deflection #7 (in.)	Real	12	0. ≤ X	0.
164	Force #7 (kips)	Real	12	0. ≤ X	0.
165	Deflection #8 (in.)	Real	12	0. ≤ X	0.
166	Force #8 (kips)	Real	12	0. ≤ X	0.
167	Deflection #9 (in.)	Real	12	0. ≤ X	0.
168	Force #9 (kips)	Real	12	0. ≤ X	0.
169	Deflection #10 (in.)	Real	12	0. ≤ X	0.
170	Force #10 (kips)	Real	12	0. ≤ X	0.
171-174	Unused at this time				

Bottom Impact Limiter Curve for a 75-Degree Impact

Record	Description	Type	Length	Restrictions	Default
175	Is this limiter defined ?	List	1	Y or N	N
176	Deflection #1 (in.)	Real	12	POSITIVE	0.
177	Force #1 (kips)	Real	12	POSITIVE	0.
178	Deflection #2 (in.)	Real	12	POSITIVE	0.
179	Force #2 (kips)	Real	12	POSITIVE	0.
180	Deflection #3 (in.)	Real	12	0. ≤ X	0.
181	Force #3 (kips)	Real	12	0. ≤ X	0.
182	Deflection #4 (in.)	Real	12	0. ≤ X	0.
183	Force #4 (kips)	Real	12	0. ≤ X	0.
184	Deflection #5 (in.)	Real	12	0. ≤ X	0.
185	Force #5 (kips)	Real	12	0. ≤ X	0.
186	Deflection #6 (in.)	Real	12	0. ≤ X	0.
187	Force #6 (kips)	Real	12	0. ≤ X	0.
188	Deflection #7 (in.)	Real	12	0. ≤ X	0.
189	Force #7 (kips)	Real	12	0. ≤ X	0.
190	Deflection #8 (in.)	Real	12	0. ≤ X	0.
191	Force #8 (kips)	Real	12	0. ≤ X	0.
192	Deflection #9 (in.)	Real	12	0. ≤ X	0.
193	Force #9 (kips)	Real	12	0. ≤ X	0.
194	Deflection #10 (in.)	Real	12	0. ≤ X	0.
195	Force #10 (kips)	Real	12	0. ≤ X	0.
196-199	Unused at this time				

Bottom Impact Limiter Curve for a 90-Degree Impact

Record	Description			Type	Length	Restrictions	Default
200	Is this limiter defined ?			List	1	Y or N	N
201	Deflection	#1	(in.)	Real	12	POSITIVE	0.
202	Force	#1	(kips)	Real	12	POSITIVE	0.
203	Deflection#2		(in.)	Real	12	POSITIVE	0.
204	Force	#2	(kips)	Real	12	POSITIVE	0.
205	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
206	Force	#3	(kips)	Real	12	0. ≤ X	0.
207	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
208	Force	#4	(kips)	Real	12	0. ≤ X	0.
209	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
210	Force	#5	(kips)	Real	12	0. ≤ X	0.
211	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
212	Force	#6	(kips)	Real	12	0. ≤ X	0.
213	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
214	Force	#7	(kips)	Real	12	0. ≤ X	0.
215	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
216	Force	#8	(kips)	Real	12	0. ≤ X	0.
217	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
218	Force	#9	(kips)	Real	12	0. ≤ X	0.
219	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
220	Force	#10	(kips)	Real	12	0. ≤ X	0.
221-224	Unused at this time						

Bottom Impact Limiter Curve for a C.G. Degree Impact

Record	Description			Type	Length	Restrictions	Default
225	Is this limiter defined ?			List	1	Y or N	N
226	Deflection	#1	(in.)	Real	12	POSITIVE	0.
227	Force	#1	(kips)	Real	12	POSITIVE	0.
228	Deflection	#2	(in.)	Real	12	POSITIVE	0.
229	Force	#2	(kips)	Real	12	POSITIVE	0.
230	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
231	Force	#3	(kips)	Real	12	0. ≤ X	0.
232	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
233	Force	#4	(kips)	Real	12	0. ≤ X	0.
234	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
235	Force	#5	(kips)	Real	12	0. ≤ X	0.
236	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
237	Force	#6	(kips)	Real	12	0. ≤ X	0.
238	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
239	Force	#7	(kips)	Real	12	0. ≤ X	0.
230	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
241	Force	#8	(kips)	Real	12	0. ≤ X	0.
242	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
243	Force	#9	(kips)	Real	12	0. ≤ X	0.
244	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
245	Force	#10	(kips)	Real	12	0. ≤ X	0.
246-249	Unused at this time						

Top Impact Limiter Curve for a 0-Degree Impact

Record	Description			Type	Length	Restrictions	Default
250	Is this limiter defined ?			List	1	Y or N	N
251	Deflection	#1	(in.)	Real	12	POSITIVE	0.
252	Force	#1	(kips)	Real	12	POSITIVE	0.
253	Deflection	#2	(in.)	Real	12	POSITIVE	0.
254	Force	#2	(kips)	Real	12	POSITIVE	0.
255	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
256	Force	#3	(kips)	Real	12	0. ≤ X	0.
257	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
258	Force	#4	(kips)	Real	12	0. ≤ X	0.
259	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
260	Force	#5	(kips)	Real	12	0. ≤ X	0.
261	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
262	Force	#6	(kips)	Real	12	0. ≤ X	0.
263	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
264	Force	#7	(kips)	Real	12	0. ≤ X	0.
265	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
266	Force	#8	(kips)	Real	12	0. ≤ X	0.
267	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
268	Force	#9	(kips)	Real	12	0. ≤ X	0.
269	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
270	Force	#10	(kips)	Real	12	0. ≤ X	0.
271-274	Unused at this time						

Top Impact Limiter Curve for a 15-Degree Impact

Record	Description			Type	Length	Restrictions	Default
275	Is this limiter defined ?			List	1	Y or N	N
276	Deflection	#1	(in.)	Real	12	POSITIVE	0.
277	Force	#1	(kips)	Real	12	POSITIVE	0.
278	Deflection	#2	(in.)	Real	12	POSITIVE	0.
279	Force	#2	(kips)	Real	12	POSITIVE	0.
280	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
281	Force	#3	(kips)	Real	12	0. ≤ X	0.
282	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
283	Force	#4	(kips)	Real	12	0. ≤ X	0.
284	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
285	Force	#5	(kips)	Real	12	0. ≤ X	0.
286	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
287	Force	#6	(kips)	Real	12	0. ≤ X	0.
288	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
289	Force	#7	(kips)	Real	12	0. ≤ X	0.
290	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
291	Force	#8	(kips)	Real	12	0. ≤ X	0.
292	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
293	Force	#9	(kips)	Real	12	0. ≤ X	0.
294	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
295	Force	#10	(kips)	Real	12	0. ≤ X	0.
296-299	Unused at this time						

Top Impact Limiter Curve for a 30-Degree Impact

Record	Description			Type	Length	Restrictions	Default
300	Is this limiter defined ?			List	1	Y or N	N
301	Deflection	#1	(in.)	Real	12	POSITIVE	0.
302	Force	#1	(kips)	Real	12	POSITIVE	0.
303	Deflection	#2	(in.)	Real	12	POSITIVE	0.
304	Force	#2	(kips)	Real	12	POSITIVE0.	
305	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
306	Force	#3	(kips)	Real	12	0. ≤ X	0.
307	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
308	Force	#4	(kips)	Real	12	0. ≤ X	0.
309	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
310	Force	#5	(kips)	Real	12	0. ≤ X	0.
311	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
312	Force	#6	(kips)	Real	12	0. ≤ X	0.
313	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
314	Force	#7	(kips)	Real	12	0. ≤ X	0.
315	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
316	Force	#8	(kips)	Real	12	0. ≤ X	0.
317	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
318	Force	#9	(kips)	Real	12	0. ≤ X	0.
319	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
320	Force	#10	(kips)	Real	12	0. ≤ X	0.
321-324	Unused at this time						

Top Impact Limiter Curve for a 45-Degree Impact

Record	Description			Type	Length	Restrictions	Default
325	Is this limiter defined ?			List	1	Y or N	N
326	Deflection	#1	(in.)	Real	12	POSITIVE	0.
327	Force	#1	(kips)	Real	12	POSITIVE	0.
328	Deflection	#2	(in.)	Real	12	POSITIVE	0.
329	Force	#2	(kips)	Real	12	POSITIVE	0.
330	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
331	Force	#3	(kips)	Real	12	0. ≤ X	0.
332	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
333	Force	#4	(kips)	Real	12	0. ≤ X	0.
334	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
335	Force	#5	(kips)	Real	12	0. ≤ X	0.
336	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
337	Force	#6	(kips)	Real	12	0. ≤ X	0.
338	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
339	Force	#7	(kips)	Real	12	0. ≤ X	0.
330	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
341	Force	#8	(kips)	Real	12	0. ≤ X	0.
342	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
343	Force	#9	(kips)	Real	12	0. ≤ X	0.
344	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
345	Force	#10	(kips)	Real	12	0. ≤ X	0.
346-349	Unused at this time						

Top Impact Limiter Curve for a 60-Degree Impact

Record	Description	Type	Length	Restrictions	Default
350	Is this limiter defined ?	List	1	Y or N	N
351	Deflection #1 (in.)	Real	12	POSITIVE	0.
352	Force #1 (kips)	Real	12	POSITIVE	0.
353	Deflection #2 (in.)	Real	12	POSITIVE	0.
354	Force #2 (kips)	Real	12	POSITIVE	0.
355	Deflection #3 (in.)	Real	12	0. ≤ X	0.
356	Force #3 (kips)	Real	12	0. ≤ X	0.
357	Deflection #4 (in.)	Real	12	0. ≤ X	0.
358	Force #4 (kips)	Real	12	0. ≤ X	0.
359	Deflection #5 (in.)	Real	12	0. ≤ X	0.
360	Force #5 (kips)	Real	12	0. ≤ X	0.
361	Deflection #6 (in.)	Real	12	0. ≤ X	0.
362	Force #6 (kips)	Real	12	0. ≤ X	0.
363	Deflection #7 (in.)	Real	12	0. ≤ X	0.
364	Force #7 (kips)	Real	12	0. ≤ X	0.
365	Deflection #8 (in.)	Real	12	0. ≤ X	0.
366	Force #8 (kips)	Real	12	0. ≤ X	0.
367	Deflection #9 (in.)	Real	12	0. ≤ X	0.
368	Force #9 (kips)	Real	12	0. ≤ X	0.
369	Deflection #10 (in.)	Real	12	0. ≤ X	0.
370	Force #10 (kips)	Real	12	0. ≤ X	0.
371-374	Unused at this time				

Top Impact Limiter Curve for a 75-Degree Impact

Record	Description	Type	Length	Restrictions	Default
375	Is this limiter defined ?	List	1	Y or N	N
376	Deflection #1 (in.)	Real	12	POSITIVE	0.
377	Force #1 (kips)	Real	12	POSITIVE	0.
378	Deflection #2 (in.)	Real	12	POSITIVE	0.
379	Force #2 (kips)	Real	12	POSITIVE	0.
380	Deflection #3 (in.)	Real	12	0. ≤ X	0.
381	Force #3 (kips)	Real	12	0. ≤ X	0.
382	Deflection #4 (in.)	Real	12	0. ≤ X	0.
383	Force #4 (kips)	Real	12	0. ≤ X	0.
384	Deflection #5 (in.)	Real	12	0. ≤ X	0.
385	Force #5 (kips)	Real	12	0. ≤ X	0.
386	Deflection #6 (in.)	Real	12	0. ≤ X	0.
387	Force #6 (kips)	Real	12	0. ≤ X	0.
388	Deflection #7 (in.)	Real	12	0. ≤ X	0.
389	Force #7 (kips)	Real	12	0. ≤ X	0.
390	Deflection #8 (in.)	Real	12	0. ≤ X	0.
391	Force #8 (kips)	Real	12	0. ≤ X	0.
392	Deflection #9 (in.)	Real	12	0. ≤ X	0.
393	Force #9 (kips)	Real	12	0. ≤ X	0.
394	Deflection #10 (in.)	Real	12	0. ≤ X	0.
395	Force #10 (kips)	Real	12	0. ≤ X	0.
396-399	Unused at this time				

Top Impact Limiter Curve for a 90-Degree Impact

Record	Description			Type	Length	Restrictions	Default
400	Is this limiter defined ?			List	1	Y or N	N
401	Deflection	#1	(in.)	Real	12	POSITIVE	0.
402	Force	#1	(kips)	Real	12	POSITIVE	0.
403	Deflection	#2	(in.)	Real	12	POSITIVE	0.
404	Force	#2	(kips)	Real	12	POSITIVE	0.
405	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
406	Force	#3	(kips)	Real	12	0. ≤ X	0.
407	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
408	Force	#4	(kips)	Real	12	0. ≤ X	0.
409	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
410	Force	#5	(kips)	Real	12	0. ≤ X	0.
411	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
412	Force	#6	(kips)	Real	12	0. ≤ X	0.
413	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
414	Force	#7	(kips)	Real	12	0. ≤ X	0.
415	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
416	Force	#8	(kips)	Real	12	0. ≤ X	0.
417	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
418	Force	#9	(kips)	Real	12	0. ≤ X	0.
419	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
420	Force	#10	(kips)	Real	12	0. ≤ X	0.
421-424	Unused at this time						

Top Impact Limiter Curve for a C.G. Degree Impact

Record	Description			Type	Length	Restrictions	Default
425	Is this limiter defined ?			List	1	Y or N	N
426	Deflection	#1	(in.)	Real	12	POSITIVE	0.
427	Force	#1	(kips)	Real	12	POSITIVE	0.
428	Deflection	#2	(in.)	Real	12	POSITIVE	0.
429	Force	#2	(kips)	Real	12	POSITIVE	0.
430	Deflection	#3	(in.)	Real	12	0. ≤ X	0.
431	Force	#3	(kips)	Real	12	0. ≤ X	0.
432	Deflection	#4	(in.)	Real	12	0. ≤ X	0.
433	Force	#4	(kips)	Real	12	0. ≤ X	0.
434	Deflection	#5	(in.)	Real	12	0. ≤ X	0.
435	Force	#5	(kips)	Real	12	0. ≤ X	0.
436	Deflection	#6	(in.)	Real	12	0. ≤ X	0.
437	Force	#6	(kips)	Real	12	0. ≤ X	0.
438	Deflection	#7	(in.)	Real	12	0. ≤ X	0.
439	Force	#7	(kips)	Real	12	0. ≤ X	0.
430	Deflection	#8	(in.)	Real	12	0. ≤ X	0.
441	Force	#8	(kips)	Real	12	0. ≤ X	0.
442	Deflection	#9	(in.)	Real	12	0. ≤ X	0.
443	Force	#9	(kips)	Real	12	0. ≤ X	0.
444	Deflection	#10	(in.)	Real	12	0. ≤ X	0.
445	Force	#10	(kips)	Real	12	0. ≤ X	0.
446-450	Unused at this time						

Finite Element Mesh Node Database

Purpose: Contains all Finite Element mesh nodes, all boundary specifications
Used by: TOPAZ, SAPRESS
Created by: MSHDSP
Record Length: 65

NOTES:

1. Node/element lists are defined by number of first node/element, number of additional nodes/elements, and increment between nodes/elements.
2. Surface segment lists are defined by first node pair, number of additional segments and increment between node pairs.
3. Slideline surfaces defined by first node, last node, and increment between node identified by positive length of list. Slideline surfaces defined by list of nodes, separated by commas identified by negative length of list.
4. FORTRAN read/write format for each data item follows the description.

Header

Record	Description *[format]*	
1	Casks Id. 'Scans geo'	*[9a1]*
2	Title	*[65a1]*
3	Date of Mesh Generation	*[9a1]*
4	Time of Mesh Generation	*[9a1]*
5	Geometry DB Basic Dimensions Filename	*[12a1]*

6-10 Unused at this time

Node Control Data

Record	Description *[format]*	
11	Number of Nodes (thermal)	*[i6]*
12	Number of Nodes (stress)	*[i6]*

13-21 Unused at this time

Appendix E
Program Reference

Slide Line Control Data Data

Record	Description [*format*]	
22	Number of Slidelines	[*i6*]
23	Total Number of Slave Nodes	[*i6*]
24	Total Number of Master Nodes	[*i6*]
25	Number of Slave Nodes in Slideline 1	[*i6*]
26	Number of Master Nodes in Slideline 1	[*i6*]
26	Number of Slave Nodes in Slideline 2	[*i6*]
28	Number of Master Nodes in Slidèline 2	[*i6*]

29 Unused at this time

Boundary and Initial Conditions Control Data Data

Record	Description [*format*]	
30	Number of Elements with Heat Generation	[*i6*]
31	Number of Nodes with Non-Zero Temperature Initial Conditions	[*i6*]
32	Number of Nodes with Temperature Boundary Conditions	[*i6*]
33	Number of Cavity Boundary Segments	[*i6*]
34	Number of Outer Boundary Segments (Sections 2,3,4-Limiter)	[*i6*]
35	Number of Outer Boundary Segments (Section 2-Limiter Top)	[*i6*]
36	Number of Outer Boundary Segments (Section 3-Limiter Side)	[*i6*]
37	Number of Outer Boundary Segments (Section 4-Limiter Bot.)	[*i6*]
38	Number of Outer Boundary Segments (Section 5-H2OJkt. Side)	[*i6*]
39	Number of Outer Boundary Segments (Section 6-Limiter Bot. to shell)	[*i6*]
40	Number of Outer Boundary Segments (Sections 1->10-All Surf)	[*i6*]
41	Number of Outer Boundary Segments (Sections 2->10-Conv Surf)	[*i6*]
42	Number of Outer Boundary Segments (Sections 2->10-Rad Surf)	[*i6*]
43	Number of Outer Boundary Segments (Section 7-Limiter side to cask)	[*i6*]
44	Number of Outer Boundary Segments (Section 8-NS/WJ top to shell)	[*i6*]
45	Number of Outer Boundary Segments (Sections 9-NS/WJ top)	[*i6*]
46	Number of Outer Boundary Segments (Sections 10-Cask side)	[*i6*]

47-50 Unused at this time

Slideline No. 1 Node Description

Record	Description [*format*]	
51	First Slave Node	[*i6*]
52	Last Slave Node	[*i6*]
53	Increment between Slave Nodes	[*i6*]
54	List of Slave Nodes separated by commas	[*65a1*]
55	First Master Node	[*i6*]
56	Last Slave Node	[*i6*]
57	Increment between Master Nodes	[*i6*]
58	List of Master Nodes separated by commas	[*65a1*]

Slideline No. 2 Node Description

Record	Description *[format]*	
59	First Slave Node	*[i6]*
60	Last Slave Node	*[i6]*
61	Increment between Slave Nodes	*[i6]*
62	List of Slave Nodes separated by commas	*[65a1]*
63	First Master Node	*[i6]*
64	Last Slave Node	*[i6]*
65	Increment between Master Nodes	*[i6]*
66	List of Master Nodes separated by commas	*[65a1]*

List of Elements With Heat Generation

Record	Description *[format]*	
67	First element	*[i6]*
68	Number of additional element	*[i6]*
69	Increment between elements	*[i6]*

List of Nodes With Non-Zero Temperature Initial Conditions

Record	Description *[format]*	
70	First node	*[i6]*
71	Number of additional nodes	*[i6]*
72	Increment between nodes	*[i6]*

List of Nodes Temperature Boundary Conditions

Record	Description *[format]*	
73	First node	*[i6]*
74	Number of additional nodes	*[i6]*
75	Increment between nodes	*[i6]*

Cavity Boundary Surface Segments

Record	Description *[format]*	
76	Node A of First Surface Segment	*[i6]*
77	Node B of First Surface Segment	*[i6]*
78	Number additional segments defined	*[i6]*
79	Nodal increment between Node Pairs	*[i6]*

Outer Boundary Surface Segments (Sections 2,3,4-Limiter)

Record	Description *[format]*	
80	Node A of First Surface Segment	[*i6*]
81	Node B of First Surface Segment	[*i6*]
82	Number additional segments defined	[*i6*]
83	Nodal increment between Node Pairs	[*i6*]

Outer Boundary Surface Segments (Section 2-Limiter Top)

Record	Description *[format]*	
84	Node A of First Surface Segment	[*i6*]
85	Node B of First Surface Segment	[*i6*]
86	Number additional segments defined	[*i6*]
87	Nodal increment between Node Pairs	[*i6*]

Outer Boundary Surface Segments (Section 3-Limiter Side)

Record	Description *[format]*	
88	Node A of First Surface Segment	[*i6*]
89	Node B of First Surface Segment	[*i6*]
90	Number additional segments defined	[*i6*]
91	Nodal increment between Node Pairs	[*i6*]

Outer Boundary Surface Segments (Section 4-Limiter Bottom)

Record	Description *[format]*	
92	Node A of First Surface Segment	[*i6*]
93	Node B of First Surface Segment	[*i6*]
94	Number additional segments defined	[*i6*]
95	Nodal increment between Node Pairs	[*i6*]

Outer Boundary Surface Segments (Section 5-Water Jacket Side)

Record	Description *[format]*	
96	Node A of First Surface Segment	[*i6*]
97	Node B of First Surface Segment	[*i6*]
98	Number additional segments defined	[*i6*]
99	Nodal increment between Node Pairs	[*i6*]

Outer Boundary Surface Segments (Section 6-Limiter Bot. to shell)

Record	Description *[format]*	
100	Two nodes separated by a comma	[*i3, 1x, i3*]

List of Inner Boundary Nodes With Pressure Conditions

Record	Description *[format]*	
101	First node	*[i6]*
102	Number of additional nodes	*[i6]*
103	Increment between nodes	*[i6]*

List of Outer Boundary Nodes With Pressure Conditions

Record	Description *[format]*	
104	First node	*[i6]*
105	Number of additional nodes	*[i6]*
106	Increment between nodes	*[i6]*

Outer Boundary Surface Segments (Section 7-Limiter Side to Cask Top)

Record	Description *[format]*	
107	Two nodes separated by a comma	*[i3, 1x, i3]*

Outer Boundary Surface Segments (Section 8-NS/WJ Top to Shell)

Record	Description *[format]*	
108	Two nodes separated by a comma	*[i3, 1x, i3]*

Outer Boundary Surface Segments (Section 9-NS/WJ Top)

Record	Description *[format]*	
109	Node A of First Surface Segment	*[i6]*
110	Node B of First Surface Segment	*[i6]*
111	Number additional segments defined	*[i6]*
112	Nodal increment between Node Pairs	*[i6]*

Outer Boundary Surface Segments (Section 10-Exposed Cask Side)

Record	Description *[format]*	
113	Node A of First Surface Segment	*[i6]*
114	Node B of First Surface Segment	*[i6]*
115	Number additional segments defined	*[i6]*
116	Nodal increment between Node Pairs	*[i6]*
117-120	Unused	

Nodal Description

Record	Description *[format]*
121	Node Coordinates (2 nodes per record for remainder of file)

i x(i) y(i) i+1 x(i+1) y(i+1) (each record)
format [*(i4, 1p2e14.7, 1x, i4, 2e14.7)*]

Appendix E
Program Reference

Finite Element Mesh Element Database

Purpose:	Contains all Finite Element mesh elements for Thermal and Stress analyses, and contains names of materials for each cask component
Used by:	TOPAZ, SAPRESS
Created by:	MSHDSP
Record Length:	65

NOTES:

1. FORTRAN read/write format for each data item follows the description.

Header

Record	Description [*format*]	
1	Casks Id. 'Scans geo'	[*9al*]
2	Title	[*65al*]
3	Date of Mesh Generation	[*9al*]
4	Time of Mesh Generation	[*9al*]
5	Geometry DB Basic Dimensions Filename	[*12al*]

6-10 Unused at this time

Node Control Data

Record	Description [*format*]	
11	Number of Elements (stress) NELS	[*i6*]
12	Number of Elements (thermal) NELT	[*i6*]
13	Number of Materials	[*i6*]
14	Material No. 1 ID Shell inner layer	[*8al*]
15	Material No. 2 ID Shell shield layer	[*8al*]
16	Material No. 3 ID Shell outer layer	[*8al*]
17	Material No. 4 ID End cap inner layer	[*8al*]
18	Material No. 5 ID End cap shield layer	[*8al*]
19	Material No. 6 ID End cap outer layer	[*8al*]
20	Material No. 7 ID Neutron shield	[*8al*]
21	Material No. 8 ID Water jacket	[*8al*]
22	Material No. 9 ID Impact limiter	[*8al*]

23-30 Unused at this time

4-Node Elements For Thermal Analyses

Record	Description [*format*]	
31	4-Node elements (2 per record)	[*6i5,5x,6i5*]

en(n) m(n) i(n) j(n) k(n) l(n) en(n+1) m(n+1) i(n+1) j(n+1) k(n+1) l(n+1)

9-Node Elements For Stress Analyses

Record	Description [*format*]	
ii	9-Node elements (1 per record)	[*11i5*]

en(n) m(n) n1(n) n2(n) n3(n) n4(n) n5(n) n6(n) n7(n) n8(n) n9(n)

The start of 9-node elements (ii) is calculated as follows

ii = 31 + (NELT+1)/2

Impact Analysis Plot Database

Purpose: Contains time history results for Impact Analysis
Used by: PLTDYN
Created by: IMPACT
Record Length: 36

NOTES:

1. FORTRAN read/write format for each data item follows the description.

2. Maximum number of nodal variables (NVAR) is 8.
   If NVAR=3, variables are:
   (1) FORCE, (2) SHEAR, (3) MOMENT
   If NVAR=8, variables are:
   (1) FORCE, (2) SHEAR, (3) MOMENT, (4) PERM. LEAD SLUMP
   (5) AXIAL STRESS (inner shell), (6) AXIAL STRESS (outer shell)
   (7) HOOP STRESS (inner shell), (8) HOOP STRESS (outer shell)

Header

Record	Description [*format*]	
1	Casks Id. 'Scans Imp'	[*9a1*]
2	Title	[*36a1*]
3	Title (continued)	[*29a1*]

Control Data

Record	Description [*format*]	
4	Number of time states (NTS) Number of nodes (NNODE) Length of Cask (CLEN) Number of nodal variables per node (NVAR)	[*2i5,f10.0,i5*]

Plot Variable Data *(repeat for each time state)*

Record	Description [*format*]	
ii	Time, X(bottom),Y(bottom)	[*3f12.0*]
ii+1	Angle, X(top), Y(top)	[*3f12.0*]
ii+2	Node 1 Variables	[*(3f12.0)*]
	...	
jj	Node i Variables	[*(3f12.0)*]
	...	
kk	Node NNODE Variables	[*(3f12.0)*]

Start of time history for any node N: jj = 7 + (N-1)*((NVAR+2)/3)
Increment between time states for node: inc = 2 + NNODES*((NVAR+2)/3)

Thermal Analysis Plot Database

Purpose:	Contains Finite Element mesh elements for Thermal and Stress analyses. Also contains Thermal Analysis results (nodal temperatures)
Used by:	POSTPZ, SAPINPT
Created by:	TOPAZ
Record Length:	65

NOTES:

1. FORTRAN read/write format for each data item follows the description.
2. Number of states is 2 for steady state and is greater than 2 for transient.
3. Maximum number of model global variables is 5.
4. Maximum number of material global variables is 5 for each material.
5. Maximum number of nodal distribution variables is 5.
6. Global variables can be maximums, minimums, averages, etc.

Header

Record	**Description** *[format]*	
1	Casks Id. 'Scans tpp'	*[9a1]*
2	Title	*[65a1]*
3	Date of Analysis	*[9a1]*
4	Time of Analysis	*[9a1]*
5	Geometry DB Basic dimensions filename	*[12a1]*
6-10	Unused at this time	

Control Data

Record	**Description** *[format]*		
11	Number of Nodes (thermal)	*[i6]*	NODT
12	Number of Nodes (stress)	*[i6]*	NODS
13	Number of Elements (thermal)	*[i6]*	NELT
14	Number of Elements (stress)	*[i6]*	NELS
15	Number of Materials	*[i6]*	NMAT
16	Material No. 1 ID Shell inner layer	*[a8]*	
17	Material No. 2 ID Shell shield layer	*[a8]*	
18	Material No. 3 ID Shell outer layer	*[a8]*	
19	Material No. 4 ID End cap inner layer	*[a8]*	
20	Material No. 5 ID End cap shield layer	*[a8]*	
21	Material No. 6 ID End cap outer layer	*[a8]*	
22	Material No. 7 ID Neutron shield	*[a8]*	
23	Material No. 8 ID Water jacket	*[a8]*	
24	Material No. 9 ID Impact limiter	*[a8]*	

Control Data *(continued)*

Record	Description *[format]*	
25	Unused at this time	
26	Number of Time States	*[i6]* NTS
27	Maximum time of analysis	*[f12.0]*
28	Maximum temperature, state number, time	*[f12.0,i6,f12.0]*
29	Minimum pressure, state number, time Maximum pressure, state number, time	*[2(f12.0,i6,f12.0)]*
30	Number of Model Global Variables	*[i6]* NUMGV
31	Number of Material Global Variables	*[i6]* NUMMV
32	Number of Nodal Distribution Variables	*[i6]* NUMNV
33	Unused at this time	

Variable Descriptors

Record	Description *[format]*	
34	Time Descriptor and units	*[2a12]*
35	Length Descriptor and units	*[2a12]*
36	Model Global Var 1 Descriptor/units	*[2a12]*
37	Model Global Var 2 Descriptor/units	*[2a12]*
38	Model Global Var 3 Descriptor/units	*[2a12]*
39	Model Global Var 4 Descriptor/units	*[2a12]*
40	Model Global Var 5 Descriptor/units	*[2a12]*
41	Material Global Var 1 Descriptor/units	*[2a12]*
42	Material Global Var 2 Descriptor/units	*[2a12]*
43	Material Global Var 3 Descriptor/units	*[2a12]*
44	Material Global Var 4 Descriptor/units	*[2a12]*
45	Material Global Var 5 Descriptor/units	*[2a12]*
46	Nodal Variable 1 Descriptor/units	*[2a12]*
47	Nodal Variable 2 Descriptor/units	*[2a12]*
48	Nodal Variable 3 Descriptor/units	*[2a12]*
49	Nodal Variable 4 Descriptor/units	*[2a12]*
50	Nodal Variable 5 Descriptor/units	*[2a12]*

Nodal Description

Record	Description *[format]*	
51	Node Coordinates (2 nodes per record) i x(i) y(i) i+1 x(i+1) y(i+1) (each record)	*[i4,2f14.0,1x,i4,2f14.0]*

4-Node Elements for Thermal Analyses

Record	Description *[format]*	
ii	4-Node elements (2 per record)	*[6i5,5x,6i5]*

en(n) m(n) i(n) j(n) k(n) l(n)
en(n+1) m(n+1) i(n+1) j(n+1) k(n+1) l(n+1)

The start of 4-node elements (ii) is calculated as follows:

ii = 51 + (NODT+1)/2

9-Node Elements for Thermal Stress Analyses

Record	Description *[format]*
jj	9-Node elements 1 element per record *[11i5]* en(n) m(n) n1(n) n2(n) n3(n) n4(n) n5(n) n6(n) n7(n) n8(n) n9(n)

The start of 9-node elements (jj) is calculated as follows:

jj = ii + (NELT+1)/2

Plot Variable Data *(repeat for each time state)*

Record	Description *[format]*
kk	Time for state *[f12.0]*

The start of state data is calculated as follows:

kk = jj + NELS

ll	NUMGV model global variables 1 per record *[f12.0]* Model Variable 1 = Maximum temperature Model Variable 2 = Maximum pressure

The start of model global variables is calculated as follows:

ll = kk + 1

mm	NUMMV material global variables *[5f12.0]* Each material variable is entered for all materials Number of records for each variable is (NMAT+4)/5

The start of material global variables is calculated as follows:

mm = kk + 1 + NUMGV

nn	NUMNV nodal variables 5 nodes per record *[5f12.0]* Nodal Variable 1 = Nodal temperature Nodal Variable 2 = Nodal flux in global X direction Nodal Variable 3 = Nodal flux in global Y direction

The start of a nodal variable is calculated as follows:

nn = kk + 1 + NUMGV + NUMMV*(NMAT+4)/5 + (NV-1)*(NODT+4)/5
where NV is the nodal variable number

Length of state is calculated as follows:

LEN = 1 + NUMGV + NUMMV*(NMAT+4)/5 + NUMNV*(NODT+4)/5

Appendix E
Program Reference

Description of Editor Templates

The **CASKS** editor uses a *template* to describe the editor pages and how data values are saved in the data sets. The *template* is a *random access* ASCII file. It is divided into three sections: control information, page headers, and descriptions of each editor page. The record length for the *template* is 150. The format of the *template* and the function of *template* parameters are described below.

Control Information

Record	Description [*format*]	
1	Casks Id 'Scans edt'	[*9a1*]
2	Name of the Template	[*65a1*]
3	Date of last modification	[*20a1*]
4	RECTOT, PAGTOT, TRECL, MAXREC, RECLN	[*5i6*]
	where RECTOT = Number of records in the template file	
	PAGTOT = Number of editor pages	
	TRECL = Template file record length (unused)	
	MAXREC = Number of records to create in data file	
	RECLN = Data file record length	
5	FORTRAN read format for body of template	[*a127*]

Page Headers

Record	Variable	Columns	Format	Comments
6	HDPGNO	1-3	I3	Sequential page number (unused)
	PAGNUM	5-7	A3	Page number displayed with editor page
	PGNAME	9-53	A45	Page identification line (end with \)
	NPRECS	55-57	I3	Number of records used to describe this page (If NPRECS<0, then this editor page is a copy of page IABS(NPRECS))
	PGACC	70	A1	Page access flag (reported in data file header) (Y=page always on, otherwise toggle A=on, N=off)
	PGREQ	72	A1	Required access flag (reported in data file) (R=page must be accessed, O=optional access)
	CBYPGN	74-75	I2	Page which has data which controls this page (0=this page not controlled by another)
	CBYRCN	77-78	I2	Record on page CBYPGN which controls this page
	CPON	80	A1	Character which defines page accessibility if record CBYRCN is character type and data is CPON
	IPON	82-83	I2	Number which defines page accessibility if record CBYRCN is integer type and data ≥ IPON
	GRCOFF	85-87	I3	Global record offset in data file added to the data global record if page is copy (NPRECS<0)
	FL1OFF	89-91	I3	1st default file data offset for copy pages
	FL1EXT	93-95	A3	1st default file extension to use FL1OFF
	FL2OFF	89-91	I3	2nd default file data offset for copy pages
	FL2EXT	93-95	A3	2nd default file extension to use FL2OFF

Repeat record 6 for each editor page (PAGTOT)

Description of Editor Pages

Record	Variable	Columns	Format	Comments
ii	NPG	1-2	I2	Page number (reference only)
	NLINE	4-5	I2	Description line number (reference only)
	GRBASE	6-9	I3	Global record in data file for data item (0=description line on screen is comment, GRCOFF is added to GRBASE if page is copy)
	REQDAT	11	A1	Is this required data ? (must be filled in) (Y=yes, display cyan; N=no, display green)
	CNTRL	13	A1	Control flag for displaying rest of page If CNTRL=blank and DTYPE=C or L, then if data item matches CNTRL rest of page is avail.
	LROW	15-16	I2	Row to display description (3 to 21)
	LCOL	18-19	I2	Column to display description (0 to 65)
	LABEL	21-94	A74	Data item description (must end with \)
	DTYPE	96	A1	Data item type ' ' (blank) = comment, not a data item 'c' = Character string 'n' = Data item selected from name list 'l' = Single character which must match list 'i' = Integer number 'r' = Real number
	DLEN	98-99	I2	Length of data item field
	DROW	101-102	I2	Row for data item field (0=use LROW) (3-21)
	DCOL	104-105	I2	Column for data item field (0-70)
	NUMCHK	107-108	A2	Numeric data item validation requirement ' ' (blank) = No checking 'NC' = No checking 'GT' = must be greater than NUM1 'LT' = must be less than NUM1 'GE' = must be greater than or equal to NUM1 'LE' = must be less than or equal to NUM1 'RG' = must be in range NUM1 to NUM2 inclusive 'PS' = must be positive 'ER' = must be even and in range NUM1 to NUM2 NOTE: NUM1 and NUM2 are contained in CHK
	CHK	110-130	var	For DTYPE='l' list of appropriate characters (end list with a blank character) For DTYPE='i' or 'r' NUM1 and NUM2 are in CHK READ (CHK, 'f10.0,1x,f10.0') NUM1,NUM2 For DTYPE='n' mask for file names (i.e. '*.mat')
	DFLT	131-145	var	For DTYPE='c', 'l' or 'n' default characters For DTYPE='i' or 'r' numeric default is in CHK READ (CHK, 'f10.0') RDVAL
	DFLTRC	147-150	I4	Record in default data file to find default value 0 = default is specified as DFLT in template >0 = default data file name is in DFLT and DFLTRC is record number in default data file

Repeat record ii for each line describing the editor page (NPRECS)
Repeat the set of records for each editor page (PAGTOT)

```
Scans get
Template for SCANS basic geometry
06/23/88 at  1:12pm by Michael A. Gerhard
   143    16   163   230    12
(bn,5x,i4,2(1x,a1),2(1x,i2),1x,a74,1x,a1,3(1x,i2),1x,a2,1x,a21,1x,a14,1x,i4)
  1 1    General SAR Information                  \  11          Y R  0  0
  2 2    Reviewer Information                     \   4          Y O  0  0
  3 3    Cask Cavity/Contents Specifications      \  13          Y R  0  0
  4 4    Cask Component Configurations            \   9          Y O  0  0
  5 5a   Cask Shell Specifications (SOLID)        \   5          N R  4  1 S
  6 5b   Cask Shell Specifications (LAMINATED)    \  14          N R  4  1 L
  7 6a   Cask Top End Cap Specifications (SOLID)  \   6        Y N R  4  3 S
  8 6b   Cask Top End Cap Specifications (LAMINATED)\ 13       Y N R  4  3 L
  9 7a   Cask Bottom End Cap Specifications (SOLID) \ -7       Y N R  4  5 S     15
 10 7b   Cask Bottom End Cap Specs (LAMINATED)    \  -8        Y N R  4  5 L     15
 11 8    Cask Closure Bolts Information           \   3          Y R  0  0
 12 9    CASK Neutron Shield / Water Jacket Specs \   8          N R  4  9 Y
 13 10   CASK Top Impact Limiter Specifications   \   8        Y N R  4  7 Y
 14 11   CASK Bottom Impact Limiter Specifications \ -13       Y N R  4  8 Y     10
 15 12   Cask Impact Model Specifications         \  18          Y O  0  0
 16 12   Thermal transient analysis control params \  10         N O  0  0
1  1  46 R    3  0 SAR title\                                              c 54    14                                    0
1  2  53      5  0 SAR docket number\                                      c  7  5 29                                    0
1  3  51      5 40 SAR report number\                                      c 12  5 65                                    0
1  4  54      7  0 SAR docket start date\                                  c  8  7 29                                    0
1  5  52      7 40 SAR report date\                                        c  8  7 65                                    0
1  6  55      9  0 Add. info\                                              c 54    14                                    0
1  7  60     11  0 Add. info\                                              c 54    14                                    0
1  8  65     13  0 Add. info\                                              c 54    14                                    0
1  9  70     15  0 Comp addr\                                              c 54    14                                    0
1 10  75     17  0 Comp addr\                                              c 54    14                                    0
1 11  80     19  0 Comp addr\                                              c 54    14                                    0
2  1  85      3  0 Cask review leader name\                                c 24    35                                    0
2  2  87      5  0 Thermal analyst name\                                   c 24    35                                    0
2  3  89      7  0 Structural analyst name\                                c 24    35                                    0
2  4  91      9  0 Nucleonics analyst name\                                c 24    35                                    0
3  1 101 R    3  0 Cavity inner radius (in.)\                              r 12    58 RG .001      2000.      0.0        0
3  2 103 R    4  0 Cavity length (in.)\                                    r 12    58 RG .001      2000.      0.0        0
3  3 100 R    6  0 Gross weight of package (lbs)\                          r 12    58 PS                      0.0        0
3  4 105 R    7  0 Weight of contents / internals (lbs)\                   r 12    58 PS                      0.0        0
3  5 106      9  0 Maximum heat generation rate of contents (Btu/min)\     r 12    58 GE 0.                   0.0        0
3  6 107     11  0 Initial cavity charge pressure (psia)\                  r 12    58 RG 0.        500.       14.7       0
3  7 108     12  0 Initial cavity charge temperature (deg.F)\              r 12    58 RG -100.     300.       70.        0
```

Basic Geometry Template *continued*

3	8	109		13	0	Maximum normal operating pressure (psia)\	r	12	58	RG	0.	2000.	14.7	0
3	9	110		15	0	Temperature defining stress free condition (deg.F)\	r	12	58	RG	-100.	300.	70.	0
3	10	0		17	0	(Include the following to define 2-D finite-element mesh)\								0
3	11	0		18	0	(Mesh divisions must be even)\								0
3	12	102		20	0	Number of mesh divisions along cavity inner radius\	i	2	58	ER	2.	20.	6.	0
3	13	104		21	0	Number of mesh divisions along cavity half length\	i	2	58	ER	2.	40.	8.	0
4	1	111		3	0	Shell configuration\	l	1	36	SL			S	0
4	2	0		4	0	[S=solid, L=laminated]\								0
4	3	112		6	0	Top end cap configuration\	l	1	36	SL			S	0
4	4	0		7	0	[S=solid, L=laminated]\								0
4	5	113		9	0	Bottom end cap configuration\	l	1	36	SL			S	0
4	6	0		10	0	[S=solid, L=laminated]\								0
4	7	114		13	0	Is Top impact limiter present? [Y/N]\	l	1	55	YN			Y	0
4	8	115		15	0	Is Bottom impact limiter present? [Y/N]\	l	1	55	YN			Y	0
4	9	116		17	0	Is Neutron shield / water jacket present? [Y/N]\	l	1	55	YN			Y	0
5	1	121	R	3	0	Shell thickness (in.)\	r	12	32	RG	.001	2000.	0.	0
5	2	122		5	0	Shell material name\	n	8	32		*.stm		SS304	0
5	3	0		10	0	(Include the following to define 2-D finite-element mesh)\								0
5	4	0		11	0	(Mesh divisions must be even)\								0
5	5	123		13	0	Number of mesh divisions through shell\	i	2	46	ER	2.	10.	4.	0
6	1	124	R	3	0	Shell inner layer thickness (in.)\	r	12	52	RG	0.	2000.	0.	0
6	2	134		4	0	Additional thickness at end cap interface (in.)\	r	12	52	RG	0.	2000.	0.	0
6	3	125		5	0	Shell inner layer material name\	n	8	52		*.stm		SS304	0
6	4	127	R	7	0	Shell shield layer thickness (in.)\	r	12	52	RG	0.	2000.	0.	0
6	5	128	R	8	0	Shell shield length (in.)\	r	12	52	RG	0.	2000.	0.	0
6	6	129		9	0	Shell shield layer material name\	n	8	52		*.shm		LEAD	0
6	7	131	R	11	0	Shell outer layer thickness (in.)\	r	12	52	RG	.001	2000.	0.	0
6	8	135		12	0	Additional thickness at end cap interface (in.)\	r	12	52	RG	0.	2000.	0.	0
6	9	132		13	0	Shell outer layer material name\	n	8	52		*.stm		SS304	0
6	10	0		16	0	(Include the following to define 2-D finite-element mesh)\								0
6	11	0		17	0	(Mesh divisions must be even)\								0
6	12	126		19	0	Number of mesh divisions through shell inner layer\	i	2	62	ER	2.	10.	2.	0
6	13	130		20	0	Number of mesh divisions through shell shield layer\	i	2	62	ER	2.	10.	4.	0
6	14	133		21	0	Number of mesh divisions through shell outer layer\	i	2	62	ER	2.	10.	2.	0
7	1	136	R	3	0	End cap thickness (in.)\	r	12	31	RG	.001	2000.	0.	0
7	2	137		5	0	End cap material name\	n	8	31		*.stm		SS304	0
7	3	0		10	0	(Include the following to define 2-D finite-element mesh)\								0
7	4	0		11	0	(Mesh divisions must be even)\								0
7	5	138		13	0	Number of mesh divisions through end cap\	i	2	45	ER	2.	10.	4.	0
7	6	0		19	0	Press F10 to copy data from other end cap (if it is SOLID)\								0
8	1	139	R	3	0	End cap inner layer thickness (in)\	r	12	44	RG	0.	2000.	0.	0
8	2	140		4	0	End cap inner layer material name\	n	8	44		*.stm		SS304	0
8	3	142	R	6	0	End cap shield layer thickness (in.)\	r	12	44	RG	0.	2000.	0.	0
8	4	143	R	7	0	End cap shield layer radius (in.)\	r	12	44	RG	0.	2000.	0.	0
8	5	144		8	0	End cap shield layer material name\	n	8	44		*.shm		LEAD	0

8	6	146	R	10	0	End cap outer layer thickness (in.)\	r	12	44	RG	.001	2000.	0.	0
8	7	147		11	0	End cap outer layer material name\	n	8	44	*.atm			SS304	0
8	8	0		13	0	(Include the following to define 2-D finite-element mesh)\								0
8	9	0		14	0	(Mesh divisions must be even)\								0
8	10	141		16	0	Number of mesh divisions through end cap inner layer\	i	2	61	ER	2.	10.	2.	0
8	11	145		17	0	Number of mesh divisions through end cap shield layer\	i	2	61	ER	2.	10.	4.	0
8	12	148		18	0	Number of mesh divisions through end cap outer layer\	i	2	61	ER	2.	10.	2.	0
8	13	0		21	0	Press F10 to copy data from other end cap (if it is LAMINATED)\								0
11	1	169	R	3	0	Number of closure bolts\	i	2	50	RG	1.	99.	0.	0
11	2	170	R	5	0	Diameter of closure bolts (in.)\	r	12	50	RG	.001	10.	0.	0
11	3	168	R	7	0	Closure bolt circle radius (in.)\	r	12	50	RG	.001	2000.	0.	0
12	1	176	R	3	0	Neutron shield/waterjacket length (in.)\	r	12	52	RG	0.	2000.	0.	0
12	2	177	R	5	0	Neutron shield thickness (in.)\	r	12	52	RG	0.	2000.	0.	0
12	3	178		6	0	Neutron shield material name\	n	8	52	*.nsm			H2OCONV	0
12	4	180	R	8	0	Water jacket thickness (in.)\	r	12	52	RG	0.	2000.	0.	0
12	5	181		9	0	Water jacket material name\	n	8	52	*.wjm			SS304	0
12	6	0		14	0	(Include the following to define 2-D finite-element mesh)\								0
12	7	179		16	0	Number of mesh divisions through neutron shield\	i	2	55	RG	1.	9.	1.	0
12	8	182		17	0	Number of mesh divisions through water jacket\	i	2	55	RG	1.	9.	1.	0
13	1	186	R	3	0	Impact limiter radius (in.)\	r	12	50	RG	.001	2000.	0.	0
13	2	187	R	5	0	Impact limiter center line thickness (in.)\	r	12	50	RG	.001	2000.	0.	0
13	3	189	R	7	0	Impact limiter overhang thickness (in.)\	r	12	50	RG	0.	2000.	0.	0
13	4	191		9	0	Impact limiter material name\	n	8	50	*.ilm			POLYFOAM	0
13	5	0		12	0	(Include the following to define 2-D finite-element mesh)\								0
13	6	188		14	0	Number of mesh divisions through limiter CL thickness\	i	2	63	RG	1.	10.	4.	0
13	7	190		16	0	Number of mesh divisions through limiter overhang width\	i	2	63	RG	1.	10.	3.	0
13	8	0		20	0	Press F10 to copy data from other impact limiter\								0
15	1	206		3	0	Number of elements for 1-D impact model\	i	2	47	RG	3.	20.	4.	0
15	2	207		4	0	TOP impact limiter weight (lbs)\	r	12	47	GE	0.		0.	0
15	3	208		5	0	BOTTOM impact limiter weight (lbs)\	r	12	47	GE	0.		0.	0
15	4	0		6	0	(If omitted, weights are calculated based on volume and density)\								0
15	5	209	Y	8	0	Define impact model with user specified properties? [Y/N]\	l	1	65	YN			N	0
15	6	0		9	0	NOTE - Weight of contents must be defined (Page 3)\								0
15	7	0		10	0	No stress recovery is available for user defined casks\								0
15	8	210	R	11	5	Shell translational mass (lb-sec**2/in)\	r	12	57	PS			0.	0
15	9	211	R	12	5	Shell rotational mass (lb-sec**2-in)\	r	12	57	PS			0.	0
15	10	212	R	13	5	Shell inside length (in.)\	r	12	57	PS			0.	0
15	11	213	R	14	5	Shell E*I (lb-in**2)\	r	12	57	PS			0.	0
15	12	214	R	15	5	Shell A*E (lb)\	r	12	57	PS			0.	0
15	13	220	R	16	5	Shell composite Poisson's Ratio\	r	12	57	PS			0.	0
15	14	215	R	17	5	Top end translational mass (lb-sec**2/in)\	r	12	57	PS			0.	0
15	15	216	R	18	5	Top end rotational mass (lb-sec**2-in)\	r	12	57	PS			0.	0
15	16	217	R	19	5	Bottom end translational mass (lb-sec**2/in)\	r	12	57	PS			0.	0
15	17	218	R	20	5	Bottom end rotational mass (lb-sec**2-in)\	r	12	57	PS			0.	0
15	18	219	R	21	5	Characteristic cross-section width (in)\	r	12	57	PS			0.	0

Basic Geometry Template *continued*

16	1	221	3	0	Allow phase change? [Y/N]\	l	1	57	YN			N	0
16	2	222	5	0	Time between printed output (min.)\	r	12	57	RG	10.	360.	30.	0
16	3	223	6	0	Time between plotted output (min.)\	r	12	57	RG	2.	30.	5.	0
16	4	224	8	0	Use variable time step? [Y/N]\	l	1	57	YN			Y	0
16	5	225	10	0	Iteration convergence tolerance\	r	12	57	RG	.001	.1	.001	0
16	6	226	11	0	Iteration relaxation parameter\	r	12	57	RG	.3	1.	1.	0
16	7	227	13	0	Maximum allowable time step for variable TS (min.)\	r	12	57	RG	5.	30.	30.	0
16	8	228	14	0	Maximum temperature change per time step (F)\	r	12	57	RG	25.	100.	100.	0
16	9	229	15	0	Time step modification factor for variable TS\	r	12	57	RG	2.	6.	2.	0
16	10	230	17	0	Fixed time step size for fixed TS (min.)\	r	12	57	RG	.25	5.	.5	0

Impact Limiter Force-Deflection Curves Template

```
Scans lmt
Template file for LIMITER  editor
05/05/88 at  4:47pm  by Michael Gerhard
    56    17   150   450    12
(bn,5x,i4,2(1x,a1),2(1x,i2),1x,a74,1x,a1,3(1x,i2),1x,a2,1x,a21,1x,a14,1x,i4)
  1 0    Impact Limiter Unloading Specification     \   8           Y C
  2 1a   Bottom Impact Limiter for 0 degree impact  \  26         Y Y C           0
  3 1b   Bottom Impact Limiter for 15 degree impact \  -2         Y Y C          25
  4 1c   Bottom Impact Limiter for 30 degree impact \  -2         Y Y C          50
  5 1d   Bottom Impact Limiter for 45 degree impact \  -2         Y Y C          75
  6 1e   Bottom Impact Limiter for 60 degree impact \  -2         Y Y C         100
  7 1f   Bottom Impact Limiter for 75 degree impact \  -2         Y Y C         125
  8 1g   Bottom Impact Limiter for 90 degree impact \  -2         Y Y C         150
  9 1h   Bottom Impact Limiter for C.G. impact      \  -2         Y Y C         175
 10 2a   Top Impact Limiter for 0 degree impact     \  -2         Y Y C         200
 11 2b   Top Impact Limiter for 15 degree impact    \  -2         Y Y C         225
 12 2c   Top Impact Limiter for 30 degree impact    \  -2         Y Y C         250
 13 2d   Top Impact Limiter for 45 degree impact    \  -2         Y Y C         275
 14 2e   Top Impact Limiter for 60 degree impact    \  -2         Y Y C         300
 15 2f   Top Impact Limiter for 75 degree impact    \  -2         Y Y C         325
 16 2g   Top Impact Limiter for 90 degree impact    \  -2         Y Y C         350
 17 2h   Top Impact Limiter for C.G. impact         \  -2         Y Y C         375
 0  1          4  2  Select the slope of the unloading path for impact limiters\                                   0
 0  2          6  4  C -- Unloading slope is maximum slope of limiter curve\                                       0
 0  3          7  4  N -- No elastic recovery of impact limiter\                                                   0
 0  4          8  4        (Approximated by unloading slope of 5 times max slope of curve)\                        0
 0  5          9  4  U -- User specified unloading slope\                                                          0
 0  6  48   U 11  3 Type of Impact Limiter Unloading\                        l  1    50   UNC          N           0
 0  7  49 R   13  3 User specified unloading slope (kips/inch)\             r 12    50 PS             0.           0
 0  8         15  4  Unloading slope is KIPS of unloading per inches elastic recovery\                             0
 1  1          3  0 Press  F10  to copy Force/Deflection data from another impact angle\                           0
 1  2          5  0 Impact angle is defined as follows:  SIDE impact angle is 0.\                                  0
 1  3          6  0                              END ON impact angle is 90.\                                       0
 1  4  50   Y  8  0 Do you wish to define a Deflection/Force curve for this angle ? [Y/N]\  l  1    77   YN    N     0
 1  5         10 13   You must define at least 2 deflection/force pairs\                                          0
 1  6         11  4 Deflection #0  (in)    .0             Force #0  (kips)    .0\                                  0
 1  7  51 R   12  4 Deflection #1  (in)\                                     r 12    27 PS             0.           0
 1  8  52 R   12 45 Force #1  (kips)\                                        r 12    65 PS             0.           0
 1  9  53 R   13  4 Deflection #2  (in)\                                     r 12    27 PS             0.           0
 1 10  54 R   13 45 Force #2  (kips)\                                        r 12    65 PS             0.           0
 1 11  55     14  4 Deflection #3  (in)\                                     r 12    27 GE 0.          0.           0
 1 12  56     14 45 Force #3  (kips)\                                        r 12    65 GE 0.          0.           0
 1 13  57     15  4 Deflection #4  (in)\                                     r 12    27 GE 0.          0.           0
```

Impact Limiter Force-Deflection Curves Template *continued*

```
1 14 58   15 45 Force #4  (kips)\      r 12   65 GE 0.     0.     0
1 15 59   16  4 Deflection #5  (in)\   r 12   27 GE 0.     0.     0
1 16 60   16 45 Force #5  (kips)\      r 12   65 GE 0.     0.     0
1 17 61   17  4 Deflection #6  (in)\   r 12   27 GE 0.     0.     0
1 18 62   17 45 Force #6  (kips)\      r 12   65 GE 0.     0.     0
1 19 63   18  4 Deflection #7  (in)\   r 12   27 GE 0.     0.     0
1 20 64   18 45 Force #7  (kips)\      r 12   65 GE 0.     0.     0
1 21 65   19  4 Deflection #8  (in)\   r 12   27 GE 0.     0.     0
1 22 66   19 45 Force #8  (kips)\      r 12   65 GE 0.     0.     0
1 23 67   20  4 Deflection #9  (in)\   r 12   27 GE 0.     0.     0
1 24 68   20 45 Force #9  (kips)\      r 12   65 GE 0.     0.     0
1 25 69   21  4 Deflection #10 (in)\   r 12   27 GE 0.     0.     0
1 26 70   21 45 Force #10 (kips)\      r 12   65 GE 0.     0.     0
```

Yielding Surface Force-Deflection Curves Template

```
Scans fce
Template file for SURFACE  editor
10/20/92 at  4:40pm  by T.  F.    Chen
    56    17   150   450    12
(bn,5x,i4,2(1x,a1),2(1x,i2),1x,a74,1x,a1,3(1x,i2),1x,a2,1x,a21,1x,a14,1x,i4)
  1 0    Impact Surface Unloading Specification     \   8           Y C
  2 1a   User Input Impact Surface F/D Curve CASE 1 \  26         Y Y C            0
  3 1b   User Input Impact Surface F/D Curve CASE 2 \  -2         Y Y C           25
  4 1c   User Input Impact Surface F/D Curve CASE 3 \  -2         Y Y C           50
  5 1d   User Input Impact Surface F/D Curve CASE 4 \  -2         Y Y C           75
  6 1e   User Input Impact Surface F/D Curve CASE 5 \  -2         Y Y C          100
  7 1f   User Input Impact Surface F/D Curve CASE 6 \  -2         Y Y C          125
  8 1g   User Input Imapct Surface F/D Curve CASE 7 \  -2         Y Y C          150
  9 1h   User Input Impact Surface F/D Curve CASE 8 \  -2         Y Y C          175
 10 2a   User Input Impact Surface F/D Curve CASE 9 \  -2         Y Y C          200
 11 2b        This  CASE  reserved for future use   \  -2         Y Y C          225
 12 2c        This  CASE  reserved for future use   \  -2         Y Y C          250
 13 2d        This  CASE  reserved for future use   \  -2         Y Y C          275
 14 2e        This  CASE  reserved for future use   \  -2         Y Y C          300
 15 2f        This  CASE  reserved for future use   \  -2         Y Y C          325
 16 2g        This  CASE  reserved for future use   \  -2         Y Y C          350
 17 2h        This  CASE  reserved for future use   \  -2         Y Y C          375
 0  1          4  2  Select the slope of the unloading path for impact surface \                                    0
 0  2          6  4  C -- Unloading slope is maximum slope of   F/D   curve\                                        0
 0  3          7  4  N -- No elastic recovery of  F/D  curves  \                                                    0
 0  4          8  4        (Approximated by unloading slope of 5 times max slope of curve)\                         0
 0  5          9  4  U -- User specified unloading slope\                                                           0
 0  6  48   U 11  3 Type of Impact surface Unloading\                          1  1    50    UNC              N     0
 0  7  49 R   13  3 User specified unloading slope (kips/inch)\                r 12    50 PS                  0.    0
 0  8         15  4  Unloading slope is KIPS of unloading per inches elastic recovery\                              0
 1  1          3  0 Press  F10  to copy Force/Deflection data from another impact CASE \                            0
 1  2          5  0                                                      \                                      0
 1  3          6  0                                                       \                                     0
 1  4  50   Y  8  0 Do you wish to define a Deflection/Force curve for this  CASE ? [Y/N]\  1  1    77    YN    N     0
 1  5         10 13   You must define at least 2 deflection/force pairs\                                            0
 1  6         11  4 Deflection #0  (in)     .0              Force #0  (kips)     .0\                                0
 1  7  51 R   12  4 Deflection #1  (in)\                                        r 12    27 PS                  0.   0
 1  8  52 R   12 45 Force #1  (kips)\                                           r 12    65 PS                  0.   0
 1  9  53 R   13  4 Deflection #2  (in)\                                        r 12    27 PS                  0.   0
 1 10  54 R   13 45 Force #2  (kips)\                                           r 12    65 PS                  0.   0
 1 11  55     14  4 Deflection #3  (in)\                                        r 12    27 GE 0.               0.   0
 1 12  56     14 45 Force #3  (kips)\                                           r 12    65 GE 0.               0.   0
 1 13  57     15  4 Deflection #4  (in)\                                        r 12    27 GE 0.               0.   0
```

Yielding Surface Force-Deflection Curves Template *continued*

```
1 14  58     15 45 Force #4  (kips)\        r 12    65 GE 0.      0.      0
1 15  59     16  4 Deflection #5  (in)\     r 12    27 GE 0.      0.      0
1 16  60     16 45 Force #5  (kips)\        r 12    65 GE 0.      0.      0
1 17  61     17  4 Deflection #6  (in)\     r 12    27 GE 0.      0.      0
1 18  62     17 45 Force #6  (kips)\        r 12    65 GE 0.      0.      0
1 19  63     18  4 Deflection #7  (in)\     r 12    27 GE 0.      0.      0
1 20  64     18 45 Force #7  (kips)\        r 12    65 GE 0.      0.      0
1 21  65     19  4 Deflection #8  (in)\     r 12    27 GE 0.      0.      0
1 22  66     19 45 Force #8  (kips)\        r 12    65 GE 0.      0.      0
1 23  67     20  4 Deflection #9  (in)\     r 12    27 GE 0.      0.      0
1 24  68     20 45 Force #9  (kips)\        r 12    65 GE 0.      0.      0
1 25  69     21  4 Deflection #10 (in)\     r 12    27 GE 0.      0.      0
1 26  70     21 45 Force #10 (kips)\        r 12    65 GE 0.      0.      0
```

Material Properties Template

```
ACASK mat
Template for AUTOCASK  Cask Geometry
Modified on 21 Mar 91  at  2:40pm by Gerald Mok
    50    12   163   150    12
(bn,5x,i4,2(1x,a1),2(1x,i2),1x,a74,1x,a1,3(1x,i2),1x,a2,1x,a21,1x,a14,1x,i4)
  1 1    Material Name and material density        \   2           Y R  0  0
  2 2    Impact, Puncture, Buckling Analysis Props  \  12           Y R  0  0
  3 3    Temperature-Dependent Properties          \   2           Y R  0  0
  4 4a   Temperature 1 Properties                  \   6           N R  3  1    1
  5 4b   Temperature 2 Properties                  \  -4           N R  3  1    2  10
  6 4c   Temperature 3 Properties                  \  -4           N R  3  1    3  20
  7 4d   Temperature 4 Properties                  \  -4           N R  3  1    4  30
  8 4e   Temperature 5 Properties                  \  -4           N R  3  1    5  40
  9 4f   Temperature 6 Properties                  \  -4           N R  3  1    6  50
 10 4g   Temperature 7 Properties                  \  -4           N R  3  1    7  60
 11 4h   Temperature 8 Properties                  \  -4           N R  3  1    8  70
 12 4h   Dummy page for hidden properties          \  11           N 0  0  0
 1  1  46 R    4  0 Material name\                                                    c 24    45                                   0
 1  2  51 R    6  0 Density (lbm/in.**3)\                                             r 12    45 PS                      .1        0
 2  1  52 R    4  0 Impact Young's Modulus (psi)\                                     r 12    45 PS                      1.        0
 2  2  53 R    5  0 Impact Poisson's Ratio\                                           r 12    45 RG .001       .499      .3        0
 2  3          7  0 The following properties are used for puncture and buckling\                                                   0
 2  4  54      9  0 Yield Stress (psi )\                                              r 12    45 GE 0.                   0.0       0
 2  5  55     10  0 Plastic Modulus (psi)\                                            r 12    45 GE 0.                   0.0       0
 2  6  56     11  0 Ultimate stress (psi)\                                            r 12    45 GE 0.                   0.0       0
 2  7         13  0 \                                                                                                              0
 2  8         14  0 Io and m define the stress-strain relation at stress levels\                                                   0
 2  9         15  0 above the proportional stress limit according to  I = Io * Y**m\                                              0
 2 10  57     17  0 Proportional stress limit (psi)\                                  r 12    45 GE 0.                   0.0       0
 2 11  58     18  0 Io (psi)\                                                         r 12    45 GE 0.                   0.0       0
 2 12  59     19  0 m\                                                                r 12    45 GE 0.                   0.0       0
 3  1  66 R    4  0 Number of temperature sets (max is 8)\                            i  1    45 RG 1.         8.        1.        0
 3  2  65      6  0 Material type (Only type 3 is available)\                         i  1    45 RG 3.         3.        3.        0
 4  1  71 R    4  0 Temperature (F)\                                                  r 12    45 GE -459.                0.0       0
 4  2  72 R    6  0 Young's Modulus (psi)\                                            r 12    45 PS                      1.        0
 4  3  73 R    7  0 Poisson's Ratio\                                                  r 12    45 RG .001       .499      .3        0
 4  4  74      8  0 Coefficient of thermal expansion (in./in.F)\                      r 12    45                         0.        0
 4  5  75     10  0 Thermal conductivity (Btu/in.min F)\                              r 12    45 PS                      1.        0
 4  6  76     11  0 Specific heat capacity (Btu/lbm F)\                               r 12    45 PS                      1.        0
12  1  61      4  0 Melt Temperature (F)\                                             r 12    45 GE -459.                10000.    0
12  2  62      5  0 Heat of Fusion (Btu/lbm)\                                         r 12    45 PS                      1.        0
12  3  63      6  0 Internal heat generation (Btu/in.**3 min)\                        r 12    45 GE 0.                   0.        0
12  4  77      7  0 Thermal emissivity for radiation\  temp 1                         r 12    45 RG 0.         1.        1.        0
```

Material Properties Template *continued*

12	5	87	8	0	Thermal emissivity for radiation\	temp 2	r	12	45	RG	0.	1.	1.	0
12	6	97	9	0	Thermal emissivity for radiation\	temp 3	r	12	45	RG	0.	1.	1.	0
12	7	107	10	0	Thermal emissivity for radiation\	temp 4	r	12	45	RG	0.	1.	1.	0
12	8	117	11	0	Thermal emissivity for radiation\	temp 5	r	12	45	RG	0.	1.	1.	0
12	9	127	12	0	Thermal emissivity for radiation\	temp 6	r	12	45	RG	0.	1.	1.	0
12	10	137	13	0	Thermal emissivity for radiation\	temp 7	r	12	45	RG	0.	1.	1.	0
12	11	147	14	0	Thermal emissivity for radiation\	temp 8	r	12	45	RG	0.	1.	1.	0

Appendix E
Program Reference

Data Set File Naming Conventions

CASKS data set files have 12 character names which specify the CASK ID, the analysis case, and the file type. File names are of the form:

```
IIIICCCC·TTT
____ ____ ___
 |    |    |
 |    |    * File Type
 |    * Analysis Case (or data name)
 * CASKID
```

Data Files

CCCC.TTT identifies the data type database:

BASE.GEI = Basic Geometry Database
BASE.CHK = Basic Geometry Data Check Output
LMTR.LMI = Limiter Force-Deflection Curves Database
LMTR.CHK = Limiter Force-Deflection Curves Data Check Output
YLDS. FCE = Yielding Surface Force-Deflection Curve Database
YLDS.CHK = Yielding Surface Force-Deflection Curve Data Check Output
DATA.FLG = Data Check Flags for Basic Geometry and Limiter Databases
NODE.GEO = Finite Element Mesh Node Database
ELEM.GEO = Finite Element Mesh Element Database

Impact Analysis Files

CCCC.TTT identifies the analysis parameters and type and is of the form

```
HETD·AAO
_ _ _ _ __ _
| | | |  |  |
| | | |  |  * Output Type
| | | |  * Analysis Type
| | | * Impact Angle (user input digit or character)
| | * Impact Type
| * Primary Impact End
* Drop Height (user input digit or character)
```

where the individual parameters are

Drop Height	**Impact End**	**Impact Type**	**Impact Angle**	**Analysis Type**	**Output Type**
user input digit or character	T=Top B=Bottom	P=Primary only S=Primary with Secondary	user input digit or character	QB=Quasi-Static (bonded) QU=Quasi-Static (unbonded) IB=Dynamic (bonded) IU=Dynamic (unbonded)	O=Printable P=Plot file

Thermal Analysis Files

CCCC identifies the analysis case:

- **T1RG** = Cold Soak, Contents Heat, No Solar Effects
- **T2RG** = Cold Soak, No Contents Heat, No Solar Effects
- **T3RG** = Normal Cold, Contents Heat, No Solar Effects
- **T4RG** = Normal Cold, No Contents Heat, No Solar Effects
- **T5RG** = Normal Hot, Contents Heat, Solar Effects
- **T6RG** = Normal Hot, Contents Heat, No Solar Effects
- **T7RG** = Fire Accident, Contents Heat, No Solar Effects

TTT identifies the output type:

- **TPO** = Printable output
- **TPP** = Plot file for POSTPZ

Thermal Stress Analysis Files

CCCC identifies the analysis case:

- **T1RG** = Cold Soak, Contents Heat, No Solar Effects
- **T2RG** = Cold Soak, No Contents Heat, No Solar Effects
- **T3RG** = Normal Cold, Contents Heat, No Solar Effects
- **T4RG** = Normal Cold, No Contents Heat, No Solar Effects
- **T5RG** = Normal Hot, Contents Heat, Solar Effects
- **T6RG** = Normal Hot, Contents Heat, No Solar Effects
- **T7RG** = Fire Accident, Contents Heat, No Solar Effects

TTT identifies the output type:

- **TSO** = Printable output

Pressure Stress Analysis Files

CCCC identifies the internal and external pressure conditions and is of the form:

I I E E

* External Pressure

* Internal Pressure

Where the internal and external pressures are identified as follows:

Internal Pressure

MX=Maximum Normal Operating Pressure
Tn=Pressure from Thermal case n

External Pressure

RP=Reduced pressure	(3.5 psia)
AP=Atmospheric pressure	(14.7 psia)
IP=Increased Pressure	(20.0 psia)
IM=Accident Immersion	(35.7 psia)

TTT identifies the output type:

- **PSO** = Printable output

Appendix F

Yielding Surface F/D Curve Generation

CASKS provides the user with a companion software. This software can be used to estimate and generate a yielding surface force-deformation curve for a given concrete slab/soil subgrade combination. The theoretical background is contained in the Deformable Foundation Theory Report (Appendix G).

The software is divided into five programs. *model.bat* is a batch file that controls the other four programs. *dsep.exe* is a data input routine that splits the main input data file, *model.in,* into a file called *mcurve.in* containing reinforced concrete parameters, and a file called *mater.dat* containing finite-element mesh parameters. *mcurve.exe* inputs the reinforced concrete parameters from *mcurve. in* and generates five coordinates to represent the approximate moment-curvature relationship. These coordinates are output to the file *mcurve.out*. *meshgen.exe* inputs data from *mcurve.out* and *matr.dat*, and generates the final input file, *plate.in,* for the nonlinear finite-element code. *nlrmplate.exe* is the nonlinear finite element code that generates force-deformation data for a centrally loaded reinforced concrete slab on engineered fill. General data is output to a file called *plate.out*. Force-deformation data is output to a file called *plate.plt.*

All operations are carried out automatically. The user need only generate the main input file, *model.in*. NOTE: All output files are overwritten with each program execution. Therefore, data files should be renamed and stored before each program execution if they are to be kept.

The codes may either be run directly from the appropriate directory, or may be copied to a directory on a hard drive. To run the code, the main input file, *model.in*, must first be generated. This may be done using any text editor. Depending on the version of MS-DOS that the machine is running, *edlin.com* or *edit.com* may be used to generate the input file. Once *model.in* has been generated, the program may be executed by typing *MODEL* and then *ENTER*. The program must be run from the same directory that contains all data files and all executable files. Again, old versions of the output files will be overwritten each time the program is run.

The codes require approximately 570 KB of usable memory to execute. Make sure the required memory is available before you execute the code. To free the extra memory, temporarily shift and/or delete some memory–resident programs.

Format for *model.in*

The main input file is called *model.in*. This file is the only user-generated input file. It has the following format:

First Line:

d_x d_y A_{sx} A_{sy} A'_{sx} A'_{sy} d'_x d'_y

Second Line:

$\varepsilon_{max,x}$ $\varepsilon_{max,y}$

Third Line:

h E_s f'_c f_y K_s G_p

Fourth Line

x_a y_a x_b y_b r shape atype

where: d_x is the distance from the top of the slab to the centroid of the tension steel in the X-direction

d_y is the distance from the top of the slab to the centroid of the tension steel in the Y-direction

A_{sx} and A_{sy} are the areas of the tension steel per unit width in the X and Y directions.

A'_{sx} and A'_{sy} are the areas of the compression steel per unit width in the X and Y directions.

d'_x and d'_y are distances from the top of the slab to the centroid of the compression steel in the X and Y directions.

$\varepsilon_{max,x}$ and $\varepsilon_{max,y}$ are the maximum compressive strains in the X and Y directions.

h is the thickness of the slab.

E_s is Young's Modulus for steel.

f'_c is the maximum compressive strength of the concrete.

f_y is the yield strength of the steel.

K_s is the soil subgrade modulus.

G_p is the soil shear modulus.

X_a and Y_a are the width and depth of a rectangular loading pattern in the X and Y directions.

X_b and Y_b are the width and depth of a rectangular slab in the X and Y directions.

r is the radius of a circular loading area.

shape is a flag indicating the shape of the loading area (1 = Rectangular, 2 = Circular).

atype is a flag representing the type of analysis to be performed (1 = Nonlinear, 2 = Linear).

All units are in kips and inches.

Examples

Two examples follow. Example 1 creates a nonlinear model of slab A-1b from Elstner and Hognestad (1956) on a 6" subgrade of clay subjected to a 10" square shaped loading pattern. Example 2 creates a nonlinear model of the same slab subjected to a circular loading pattern of 5" radius. All examples utilize a two-parameter model of the soil.

Example 1

Slab A-1b from Elstner and Hognestad (1956) is modeled on a 6" subgrade of clay. The following table lists slab parameters as reported by Elstner and Hognestad.

Table F.1
Slab Parameters from Elstner and Hognestad (1956)

			Longitudinal Reinforcement					
			Tension Mat			Compression Mat		
				Spacings			Spacings	
Slab	f'_c (ksi)	f_y (ksi)	Bar #	Bot. (in)	Top (in)	Bar #	Bot. (in)	Top (in)
A-1b	3.66	48.2	6	9	7.5	4	7	8

Taking the X-direction to correspond to the top steel in the tension and compression mats, and the Y-direction to correspond to the bottom steel in the tension and compression mats, the following additional data may be derived from Elstner and Hognestad (1956):

dx = 5.0
d′x = 1.5
dy = 4.25
d′y = 1.0

The values of A_{sx}, A'_{sx}, A_{sy}, and A'_{sy} may be derived by dividing the cross sectional area of the appropriate steel bar by its spacing. For example, the bottom layer of the tension mat has #6 bars at nine-inch spacing. Each #6 bar has a cross sectional area of 0.44 in^2. Therefore,

$$A_{sx} = \frac{0.44 inch^2}{9 inch} = 4.889E-2$$

Similarly, A'_{sx} = 2.857E-2, A_{sy} = 5.867E-2, and A'_{sy} = 0.025.

We will take $\varepsilon_{max,x}$ and $\varepsilon_{max,y}$ to be 0.0035. The slab is six inches thick, so $h = 6.0$. We take E_s to be 29.0E3. f'_c is given as 3.66. f_y is given as 48.2. K_s and G_p are estimated to be $K_s = 2.374$, and $G_p = 9.402$.

The loading pattern is 10" X 10" square. Therefore, $x_a = 10.0$, $y_a = 10.0$, and *shape* = 1. The slab is 72" X 72", so $x_b = 72.0$, and $y_b = 72.0$. Any value may be assigned to r for this example. We will perform a nonlinear analysis, so *atype* = 1.

The following input file, *model.in*, is appropriate for this example:

```
5.0 4.25 4.889E-2 5.867E-2 2.857E-2 0.025 1.5 1.0
0.0035 0.0035
6.0 29.0E3 3.66 48.2 2.374 9.402
10.0 10.0 72.0 72.0 0.0 1 1
```

Appendix F
Yielding Surface F/D Curve Generation

Example 2

All parameters here are the same as for Example 1, with the following exceptions. The loading pattern is now circular with a radius of 5". Therefore, $r = 5.0$, and *shape* $= 2$. x_a and y_a may hold any value for this example:

The following input file is appropriate for this example:

```
5.0  4.25  4.889E-2  5.867E-2  2.857E-2  0.025  1.5  1.0
0.0035  0.0035
6.0  29.0E3  3.66  48.2  2.374  9.402
0.0  0.0  72.0  72.0  5.0  2  1
```

Appendix G
Contents of Reference Volumes

Volume 2
Impact Analysis Theory Manual

Appendix G
Contents of Reference Volumes

Volume 3
Lead Slump in Impact Analysis Theory Manual and Verification of Impact Analysis

Volume 4
Thermal Analysis Theory Manual

Volume 4
Thermal Analysis Theory Manual *Continued*

Volume 5
Thermal / Pressure Stress Analysis Theory Manual

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CASKS (Computer Analysis of Storage CasKS) is a microcomputer-based system of computer programs and databases developed at the Lawrence Livermore National Laboratory (LLNL) for evaluating safety analysis reports on spent-fuel storage casks. The bulk of the complete program and this user's manual are based upon the SCANS (Shipping Cask ANalysis System) program previously developed at LLNL. A number of enhancements and improvements were added to the original SCANS program to meet requirements unique to storage casks. CASKS is an easy-to-use system that calculates global response of storage casks to impact loads, pressure loads and thermal conditions. This provides reviewers with a tool for an independent check on analyses submitted by licensees. CASKS is based on microcomputers compatible with the IBM-PC family of computers. The system is composed of a series of menus, input programs, cask analysis programs, and output display programs. All data is entered through fill-in-the-blank input screens that contain descriptive data requests.

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