NUCLEAR WASTE MANAGEMENT PROCEDURE Sandia National Laboratories	**User's Manual Criteria**	**Form Number: NP 19-1-6** **Page 1 of 1**

Does the user's manual contain as appropriate:

1. **Software Name:** CUTTINGS_S
2. **Software Version:** 6.00
3. **Document Version:** 6.00
4. **ERMS #:** 537039

Prior to sign-off of the User's Manual, all items shall be appropriately addressed by the code sponsor so that "**Yes**" or "**N/A**" may be checked. Include this form as part of the User's Manual.

5. A statement(s) of functional requirements (consistent with those in the RD) and system limitations? ☑ Yes
6. An explanation of the mathematical model and numerical models, where applicable as based on code functionality? ☑ Yes ☐ N/A
7. Physical and mathematical assumptions, where applicable as based on code functionality? ☑ Yes ☐ N/A
8. The capabilities and limitations inherent in the software? ☑ Yes
9. Instructions that describe the user's interaction with the software? ☑ Yes
10. The identification of input parameters, formats, and valid ranges? ☑ Yes
11. Messages initiated as a result of improper input and how the user can respond? ☑ Yes
12. The identification and description of output specifications and formats? ☑ Yes
13. A description of any required training necessary to use the software? ☑ Yes
14. The identification of components of the code that were not tested? ☑ Yes

	Name (print)	Signature	Date
15. Code Team/Sponsor	Eric Vugrin	Eric Vugrin	~~2/4/05~~ 2/10/05
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2/10/05

Key for check boxes above:

Check **Yes** for each item reviewed and found acceptable
Check **N/A** for items not applicable, where applicable as based on code functionality

WIPP PA

USER'S MANUAL

for

CUTTINGS_S Version 6.00

Document Version 6.00

ERMS# 537039

January 2005

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1.0 INTRODUCTION

This document serves as a User's Manual for the CUTTINGS_S program as used in the Waste Isolation Pilot Plant (WIPP) Performance Assessment (PA) calculation. As such, it describes the purpose and function of the CUTTINGS_S program and the user's interaction with it.

1.1 Software Identifier

Code Name:	CUTTINGS_S
Version:	6.00
WIPP Prefix:	CUSP
Version Date:	January 27, 2005
Platform:	Compaq Fortran on OpenVMS V7.3-1 Alpha

1.2 Points of Contact

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1.3 Code Overview

The CUTTINGS_S code was written to calculate the quantity of material (in m^3) brought to the surface from a radioactive waste disposal repository as a consequence of an inadvertent human intrusion through drilling. The code determines the amount of material removed from the repository by several release mechanisms, including cuttings, cavings and spallings. Additionally, the code calculates information about the pressure, saturation, porosity, and crushed panel height, which is used as initial conditions for DBR calculations.

2.0 FUNCTIONAL REQUIREMENTS

The requirements for CUTTINGS_S are listed in the CUTTINGS_S Requirements Document (WIPP PA, 2004). The additional functionality to be tested and the functionality not tested are listed in the CUTTINGS_S Verification and Validation Plan / Validation Document (WIPP PA, 2005). The requirements and functionality are repeated here for the reader's convenience.

2.1 Functional Requirements

R.1 CUTTINGS_S calculates the amount of repository material brought to the surface due to erosion of the borehole resulting from laminar flow in the drilling fluid.

R.2 CUTTINGS_S calculates the amount of repository material brought to the surface due to erosion of the borehole resulting from turbulent flow in the drilling fluid.

R.3 CUTTINGS_S calculates the volume of spalled material using a pressure threshold and a distribution of spallings volumes (spall model 3).

R.4 CUTTINGS_S determines the volume of spalled material using a set of distributions of spalled volumes, calculated for a set of reference repository pressures, by interpolating between distributions to account for current repository pressure (spall model 4).

R.5 CUTTINGS_S calculates volume-weighted averages of porosity, pressure, saturation and permeability over specified regions of the repository.

2.2 External Interface Requirements

R.6 CUTTINGS_S requires one text input master control file identifying the scenarios, vectors, cavities, and intrusions that will be used in the analysis, and the other input files and output files.

R.7 CUTTINGS_S requires a text input control file identifying parameters that will be used in the analysis. The parameters may be values or may reference values on an input CAMDAT file.

R.8 CUTTINGS_S requires a set of input CAMDAT files containing values that will be referenced from the input control file. The CAMDAT file is normally generated by the GENMESH, MATSET, POSTLHS code sequence and contains values from the WIPP Parameter Database or sampled vector values. There should be one CAMDAT file for each vector.

R.9 CUTTINGS_S requires a set of input CAMDAT files from the BRAGFLO code containing element data for the volume-weighted averages. (This file is required for regulatory calculations, but is optional for functional testing.) There should be one BRAGFLO CAMDAT file for each scenario-vector pair.

R.10 If spall model 4 is used, CUTTINGS_S requires a text input spall data file with spall volume data.

R.11 CUTTINGS_S generates a set of output CAMDAT files. This file contains data that includes the amounts of repository material brought to the surface by drilling and the volume-weighted averages calculated by the code. There will be one CAMDAT file for each scenario-vector-cavity-intrusion combination. (In this document and subsequent CUTTINGS_S version 6.00 documents, cavity is defined as a region of the WIPP repository: for example, the intrusion panel, the south rest of repository, or the north rest of repository.) These CAMDAT files will normally be read by BRAGFLO (Version 5.00 or higher) for direct brine releases (DBR) in regulatory calculations.

R.12 CUTTINGS_S generates one text output data file suitable for use as input by the code PRECCDFGF Version 1.01 or higher. This file contains data that includes the amount of spalled material and the amount of repository material brought to the surface due to erosion of the borehole resulting from laminar or turbulent flow in the drilling fluid.

R.13 CUTTINGS_S generates one text debug file.

2.3 Additional Functionality To Be Tested

No additional CUTTINGS_S functionality is tested.

2.4 Functionality Not Tested

All CUTTINGS_S functionality is tested.

3.0 REQUIRED USER TRAINING AND/OR BACKGROUND

To exercise CUTTINGS_S, users should have basic knowledge of OpenVMS and Digital Command Language, and access to the WIPP cluster of Alpha computers with the OpenVMS operating system, or their functional equivalents.

Because CUTTINGS_S manipulates a CAMDAT database, users should have an understanding of the CAMDAT terminology, contents, and restrictions. For a detailed description of the CAMDAT database, refer to Chapter 7 of the CAMDAT_LIB User's Manual (WIPP PA, 1995).

To manipulate and/or interpret the results of CUTTINGS_S as it is exercised in WIPP PAs, users should have (1) a basic understanding of the mechanics of laminar and turbulent flow of non-Newtonian fluid suspensions in annular conduits, erosion scouring of matrixed materials, flow through permeable media, and of the large-scale deformation and failure of elastic, plastic, and viscoelastic materials; (2) a basic understanding of partial-differential equations and integral calculus, as they apply in the mathematical formulation of physical principles and especially of conservation of momentum, energy, and mass; (3) a generalist's conceptual understanding of numerical methods as they are applied to the numerical solution of the boundary-value problems of mathematical physics and chemistry; and (4) a basic overview understanding of the WIPP PA process, including conceptual models, scenarios, inventories, uncertainty sampling, input-data vectors, and a general familiarity with the files and functions of the WIPP codes that interface with CUTTINGS_S, especially GENMESH, MATSET, POSTLHS, BRAGFLO (WIPP PA, 1992) and DRSPALL.

4.0 DESCRIPTION OF THE MODELS AND METHODS

The discussion of the model and methods given below is but a brief overview of the theory and methods employed by CUTTINGS_S. It is intended for users who have only a cursory interest in the mathematical and fluid dynamical details. A thorough, detailed treatment of the theory and numerics applied in CUTTINGS_S is given in Appendix A of the CUTTINGS_S Version 5.10 User's Manual (WIPP PA, 2003b).

4.1 Description of the Model

CUTTINGS_S is a multi-faceted computational procedure to assess the effects of *direct removal* of wastes buried in a WIPP-like nuclear-waste repository. Direct removal is hypothesized to occur as the result of inadvertent penetration of the repository by a borehole drilled in connection with oil or gas exploration at some unknown time in the future (Berglund, 1993). The word "direct" refers to the fact that CUTTINGS_S removals from the repository to the surface occur *at the time* of drilling. Since drilling operations are normally completed on the time scale of weeks, removal of drilled wastes from the repository to the surface (i.e., the accessible environment) takes place entirely within a single timestep of the much-longer-term groundwater transport codes. Hence, the word "direct" should be taken to mean "from the repository to the surface within a single timestep of a typical WIPP groundwater code."

Removal is subdivided according to process, which results in three principal categories: cuttings, cavings, and spallings.

First, the borehole is assumed to penetrate into the repository, allowing those repository wastes located on a collision course with the drill bit (called cuttings) to be transported directly and immediately to the surface via the cooling fluid (muddy brine) that is circulated through the borehole during drilling. The area of repository material removed as cuttings is the portion of the repository cut by the borehole.

Wastes that originally bordered the borehole on its exterior are permitted to erode into the cooling fluid as a result of the fluid's frictional effects on the outer cylindrical surface of the borehole. If shear stresses in the cooling fluid at the wall exceed the shear strength of the matrixed materials located at the wall, erosion will occur and wall material (cavings) will be removed*. As a result, the borehole diameter may increase locally at the level of the repository. Because of that action, the volume of wastes removed from the repository can actually be larger than the volume of the borehole originally cut through the wastes. As the diameter of the borehole increases, the fluid shear stresses at the outer boundary decrease. If they decrease enough that the failure stress of the wall material equals or exceeds the fluid shear stress at the outer boundary of the flow region, then the caving process will terminate. CUTTINGS_S allows for both laminar and turbulent shear flow in the circulating fluids, which, in turn, leads to two

* In tightly matrixed or crystaline media such as the WIPP-site halite formation, exploratory boreholes are usually unlined. Rather, the drilling fluid is changed to saturated salt solution to minimize dissolution at the walls, and the borehole is permitted to support itself until the drill bit reaches granular strata below the halite horizon.

different models to assess the effects of material removal due to erosion. If the cooling-fluid flow is laminar, CUTTINGS_S employs an analytical solution of the modeling equations to evaluate wall stresses and other flow parameters. The analytical solution takes the form of non-linear integral equations, which CUTTINGS_S evaluates via an iterative numerical procedure. If the flow is turbulent, CUTTINGS_S turns to a simpler empirical model to evaluate the turbulent shear stresses. Transition to turbulence is assumed to occur at a Reynolds number greater than 2100. In nature, the transition to turbulence actually occurs over a range of Reynolds numbers and is not an abrupt process. Normally there is a transitional regime during which the flow is partly laminar and partly turbulent with active and chaotic transitions between the two states. CUTTINGS_S does not attempt to model the transition regime. Rather, it assumes the flow becomes fully and abruptly turbulent when the Reynolds exceeds 2100. CUTTINGS_S employs a corrective procedure to compensate for the effects of that assumption (see Appendix A of the CUTTINGS_S Version 5.10 User's Manual (WIPP PA, 2003b) for details).

If the repository is pressurized at the time of penetration, and if the pressure within the repository is high enough (i.e., above the hydrostatic pressure in the cooling-fluid column), repository materials originally surrounding the borehole, but interior to the repository-fluid interface, can be forced to deform inward toward the borehole so as to replace the materials already removed by action of the cutting bit and the erosive brine. The solid fraction of these materials are called spallings*. If repository materials are more permeable, the pressurized gas may simply seep through the matrix carrying loose particles with it. Alternatively, if repository pressures are too low, CUTTINGS_S may return a spall volume of zero.

4.2 Description of the Modeling Methods

CUTTINGS_S does not endeavor to integrate conservation equations characterizing the flow on a point-for-point, time-for-time basis in search of a detailed space-time history of the removal process. Rather, removal is treated as instantaneous, that is, within a single timestep of the longer-term groundwater codes. Thus, numerical methods are used primarily to determine the limiting values of the physical parameters that represent the final configurations of the various (sampled) drilled systems, which is all that is required to assess radioactive waste removal due to the cuttings, cavings, and spallings that arise during drilling operations. These methods are fairly straightforward, iterative, recursive approximation techniques that involve systems of algebraic equations. They are discussed thoroughly in Appendix A of the CUTTINGS_S Version 5.10 User's Manual (WIPP PA, 2003b) (Sections 2.2.1.1, 2.2.2.1, and 2.4.1.2.1), which is highly recommended to readers who aim to understand this code.

* If the repository is wet with brine at time of penetration, which possibility is allowed in WIPP PAs, three phases of material could, in principle, flow toward the borehole, namely: pressurized gases, pressurized brine, and solid wastes. CUTTINGS_S estimates only the amount of solids that are moved into the borehole. Pressurized brine that may be released into the borehole is treated by the independent BRAGFLO DBR calculations. The gas flow, although crucial to the overall deformational process, transports no radioisotopes and is therefore not assessed.

5.0 CAPABILITIES AND LIMITATIONS OF THE SOFTWARE

CUTTINGS_S is not presently put forward as a general borehole-mechanics code. Rather, it was developed with WIPP-like conditions and applications firmly in mind. To function properly, it requires inputs from other WIPP PA codes, specifically GENMESH, MATSET, POSTLHS, BRAGFLO, and DRSPALL. Thus, although CUTTINGS_S is quite likely to be fully applicable to other kinds of boreholes, other geologies, and other parameter ranges, it is not presently recommended for applications outside the presently-conceived boundaries that define the WIPP, primarily because such applications have not yet been tested. Consequently, no claims are made that CUTTINGS_S should give reasonable results for parameter ranges that are atypical of the WIPP and its immediate environs.

All aspects of CUTTINGS_S are based on the present-day drilling methods and technologies that would apply at a WIPP-like site. CUTTINGS_S has been tested under those conditions and those conditions only. Hence, applications beyond the limits of those assumptions are not recommended at this time.

6.0 USER INTERACTIONS WITH THE SOFTWARE

6.1 Defining the CUTTINGS_S Executable Symbol

To execute CUTTINGS_S, it is necessary to define a symbol that invokes its executable. For example, the following command (issued at the VMS $ prompt or from within a command file) defines the symbol CUTTINGS_S to invoke the executable for Version 6.00:

```
$ CUTTINGS_S :== "$WP$PRODROOT:[CUSP.EXE]CUTTINGS_S_QA0600.EXE"
```

This command only needs to be issued once per VMS session. On the WIPP Alpha Cluster, the symbol CUTTINGS_S may already be appropriately defined. The VMS command "SHOW SYMBOL CUTTINGS_S" will display the symbol definition, if any.

6.2 Executing CUTTINGS_S

Once the symbol is defined, typing "CUTTINGS_S" followed by carriage-return at the VMS system "$" prompt will run the program. The names of the two required files will be requested sequentially by CUTTINGS_S. Alternately, the user may append the names of the files (in order) to the CUTTINGS_S command line before pressing the carriage-return key. The required information is as follows:

1. The master control file describing the scenarios, vectors, cavities, and intrusion times to run and identifying the other input files that CUTTINGS_S needs and the output files that will be generated. The master control file is described in Section 7.1.

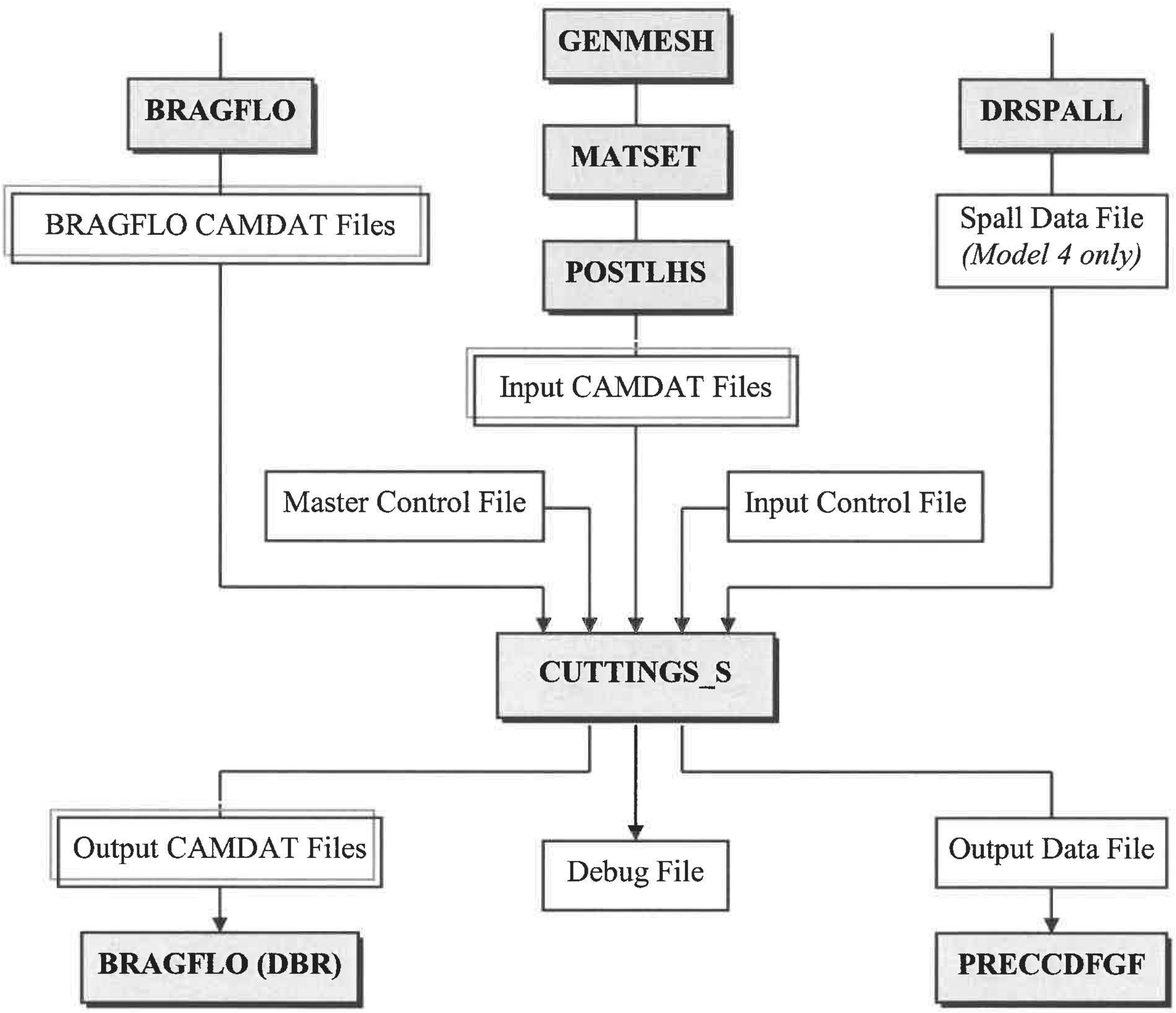
2. The output debug file containing diagnostic information. This text file is described in Section 9.3.

If the code executes without errors, CUTTINGS_S will run and issue a "normal completion" message. If errors are encountered, CUTTINGS_S will issue an error message and abort. See Section 8.0 for information on handling error messages.

6.3 Code Sequence for CUTTINGS_S within a Regulatory Calculation

Within regulatory calculations, CUTTINGS_S is normally exercised as one of a sequence of codes that includes GENMESH, MATSET, and POSTLHS, and requires input data files that originate with the code BRAGFLO and DRSPALL. CUTTINGS_S output is normally transferred to codes PRECCDFGF and BRAGFLO (DBR). To assist the reader, the code sequence is depicted in Figure 6.3-1. Note that codes LHS, CCDFGF, and BRAGFLO have pre- and post-processors, and that data on the CAMDAT file may be manipulated with the ALGEBRACDB or RELATE codes. These code sequences are compressed for brevity.

Figure 6.3-1 Code Sequence for CUTTINGS_S in Regulatory Calculation



6.4 Accessing Files in CMS

The following sections make references to files stored in the Configuration Management System (CMS). Each file is stored in CMS on the WIPP Alpha cluster under a particular CMS library (usually CUSP for CUTTINGS_S) and identified by a file name. Commands for accessing the CMS are defined in the Software Configuration Management System (SCMS) Plan (WIPP PA, 2003a), but the following examples may be helpful.

The following commands retrieve file CUSP_TEST_1.CDB from the CUSP library. The file is stored in the current directory.

```
$ LIBCUSP
$ CFE CUSP_TEST_1.CDB
```

The following commands list files in the CUSP library whose names match the CUSP_TEST_*.* template. The file names are listed, but the files are not retrieved.

```
$ LIBCUSP          (command only needs to be issued once per session)
$ CSE CUSP_TEST_*.*
```

7.0 DESCRIPTION OF INPUT FILES

The input files for CUTTINGS_S are described in this section.

7.1 Master Control File

The master control file is a text file that describes the scenarios, vectors, cavities, and intrusion times to run. It also identifies the input files that CUTTINGS_S needs and the output files that the code generates.

Most of these files are identified using a file name "template." The provided template is the base name that will be applied to a set of files. The template has "wildcard" characters that will be replaced with the appropriate characters to form a file name. The following wildcards are defined: % for scenario, (for cavity, ^ for vector (zero padded to three characters), ! for intrusion time. Thus, the file name template CUSP_R1_S%_V^_(_T!.CDB for scenario 2, vector 40, cavity U, intrusion time 100 would result in file name CUSP_R1_S2_V040_U_T100.CDB. All wildcards are not appropriate for all templates. If a wildcard is missing, the same file name will be generated for all items of the missing category. For example, LHS3_CUSP_R1_V^.CDB would generate a new file name for each vector, but have the same file name for vector *n* of all scenarios, cavities, and intrusion times.

The master control file is fixed format, with certain parameters expected on certain lines. Below is the list of items expected on each line, in order. Note that one bullet may encompass more than one line. Any number of blanks may precede, follow, or separate items on a line. Numeric values should be in any valid Fortran format.

- The number of scenarios, vectors, and cavities.
- The scenario identifier, the number of intrusions, and the intrusion times for each scenario, with one line for each scenario. The order the scenarios are listed in this section determines the order they will appear on the output data file.
- The abbreviation for each cavity (e.g., U,M,L), with one line for each cavity. (In this document, cavity is defined to be a region of the WIPP repository. For example, in recent calculations, the following cavities were defined: the intrusion panel, the south rest of repository, and the north rest of repository.)
- The file name template for the input control file. A wildcard is allowed for scenario only, but usually there will be just one input control file. These input control files specify drilling and intrusion parameters along with parameters specific to the spall model. These text files are described in Section 7.1.
- The file name template for the input CAMDAT file. A wildcard is allowed for scenario and vector only, but usually there will be one input CAMDAT file for each vector. The input CAMDAT files are created by the GENMESH, MATSET, POSTLHS sequence described in Section 6.3. These binary file are described in Section 7.3.

- The file name template for the input BRAGFLO CAMDAT file. A wildcard is allowed for scenario and vector only, and usually there will be one input BRAGFLO CAMDAT file for each scenario – vector pair. The binary input BRAGFLO CAMDAT file is described in Section 7.4. **This file is optional for test runs; it is required for regulatory runs.** If there is no BRAGFLO CAMDAT file for the test run, enter "CANCEL" for the file name template.

- The input spall data file for Spall Model 4 specifying pressures and their volumes by vector. A wildcard is allowed for scenario only, but usually there will be just one input spall data file. This text file is described in Section 7.5. **This file is required for Spall Model 4 only**; for all other models, enter "CANCEL" to specify that there is no file.

- The file name of the output text file containing the CUTTINGS_S output needed for the PRECCDFGF run described in Section 6.3. This text file is described in Section 9.1.

- The file name template for the output CAMDAT files. All wildcards are allowed; the template must specify one CAMDAT file for each cavity – scenario – vector – intrusion combination. The output CAMDAT files contain the CUTTINGS_S output needed for the BRAGFLO runs described in Section 6.3. These binary files are described in Section 9.1.

Example master control files for regulatory runs and for test or debug runs are shown in Appendix A.

7.2 Input Control File

The input control file is a text file that contains various drilling parameters and repository data required by CUTTINGS_S. This file also identifies which spall model will be used and specifies parameters appropriate for that spall model. In regulatory calculations, many of the parameters are read from the input CAMDAT file properties, where they were set with values from the QA-controlled WIPP Parameter Database by the MATSET code or with sampled values provided by the POSTLHS code. (Parameters DOMEGA, TAUFAIL, VOLSPALL, and RNDSPALL in Table 7.2-1 are normally sampled.)

Each statement in the input control file begins with a keyword, followed by parameters that apply. There is no required order for keywords. The generic format of a statement is explained in detail in Section 2.9.4 of the User's Reference Manual for CAMCON (Rechard, 1992). The following syntax rules apply:

- Either lowercase or uppercase letters are acceptable, but lowercase letters are converted to uppercase. The only exception is a quoted string in a command.

- Valid delimiters are a comma (,), an equal sign (=), and one or more blanks.

- An exclamation point (!) in any line starts a comment. The exclamation point (!) and any characters following it on the line are ignored.

- A statement can be continued over several lines with an ampersand (&). The ampersand (&) and any characters following it on the current line are ignored, and the next line is appended to the current line.

Table 7.2-1 lists the input control file keywords that are recognized by CUTTINGS_S with their expected parameters. In most cases, the parameter may either be a real number or a reference to a property on the input CAMDAT file. To reference a CAMDAT property, the parameter must have a colon (:) separating the CAMDAT material name on the left from the CAMDAT property name on the right, with no intervening blanks.

Example input control files for regulatory runs and for test or debug runs are shown in Appendix B. Test samples are available in CMS under the CUSP library as file CUSP_TEST_*n*.INP, where *n* is the QA test problem number.

Table 7.2-1 Input Control File Keywords and Parameters

Keyword	Parameter Type; Number	Parameter Description
The following keywords set parameters for drilling and general use. They are required, unless the listed default applies.		
PI	Real or Property	Mathematical constant π; default provided
YRSEC	Real or Property	Years-to-seconds conversion factor (i.e., the number of seconds in a year); default is 3.1556930E+7. The conversion factor may be specified with either YRSEC or SECYR; only one keyword should be present in the input control file.
SECYR	Real or Property	Seconds-to-years conversion factor; default is 1.0/3.1556930E+7. This conversion factor, if provided, will be converted into a years-to-seconds factor. Thus, the conversion factor may be specified with either YRSEC or SECYR; only one keyword should be present in the input control file.
DIAMMOD	Real or Property or BRAGFLO Property	Drill diameter for each intrusion time. Drill diameter is supplied by the BRAGFLO CAMDAT file if "BRAGFLO" precedes the property designator.
DNSFLUID	Real or Property	Density for drilling mud (kg/m^3)
DOMEGA	Real or Property	Angular velocity of drillstring (rad/s)
ABSROUGH	Real or Property	Absolute borehole roughness (m)
TAUFAIL	Real or Property	Effective shear strength of drilling fluid (Pa)
VISCO	Real or Property	Plastic viscosity of drilling fluid (Pa-s)
YLDSTRSS	Real or Property	Drilling fluid yield stress (Pa)
HREPO	Real or Property	Height of repository at burial time (m)
COLDIA	Real or Property	Collar diameter (m)
SHEARRT	Real or Property	Shear rate (/s); default is 1020
MUDFLWRT	Real or Property	Drilling mud flow rate ($m^3/(s*m)$); default is 0.09935
The following keywords select the spall model and set the parameters dependent on the spall model.		
NOMODEL	No parameter	No Spall Model is selected
Spall Model 3 requires the following keywords.		
MODEL3	No parameter	Select Spall Model 3
VOLSPALL	Real or Property	Sampled volume for spall model 3
PTHRESH	Real or Property	Pressure threshold for spall model 3
Spall Model 4 requires the following keywords.		
MODEL4	No parameter	Select Spall Model 4
RNDSPALL	Real or Property	Random number for spall model 4 to map DRSPALL vectors to BRAGFLO vectors

The following keywords apply to the input BRAGFLO CAMDAT file variables and the output CAMDAT files. The keywords are required (if there is a BRAGFLO CAMDAT file) unless the listed default applies.		
OUT_MAT	Character*8	Output CAMDAT material where properties are to be written; default is the last material
INTR_*n* where *n* is 0 to the number of averages requested, in order	Integers or CAMDAT material name; any number	The "zone" or elements to average over for BRAGFLO element variables, expressed as a series of integer element numbers or the material name. If NO_GRDVOL is included as a parameter, the average will be a simple average; otherwise the average will be weighted by grid volume.
NAME_GRIDVOL	Character*8	Name of the BRAGFLO CAMDAT attribute containing the grid volume; default is GRIDVOL
NAME_POROS	Character*8	Name of the BRAGFLO CAMDAT element variable (and output CAMDAT global variable) containing porosity; default is POROS
NAME_PRESGAS	Character*8	Name of the BRAGFLO CAMDAT element variable (and output CAMDAT global variable) containing pressure in gas; default is PRESGAS
NAME_PRESBRIN	Character*8	Name of the BRAGFLO CAMDAT element variable (and output CAMDAT global variable) containing pressure in brine; default is PRESBRIN
NAME_SATGAS	Character*8	Name of the BRAGFLO CAMDAT element variable (and output CAMDAT global variable) containing saturation in gas; default is SATGAS
NAME_SATBRIN	Character*8	Name of the output CAMDAT global variable containing saturation in brine; default is SATBRIN
NAME_PERMBRIN	Character*8	Name of the BRAGFLO CAMDAT element variable (and output CAMDAT global variable) containing permeability of brine; default is PERMBRX
NAME_BRAG	Character*8; any number	Names of additional BRAGFLO CAMDAT element variables to be averaged and written to the output CAMDAT file. Variables POROS, PRESGAS, PRESBRIN, SATGAS, SATBRIN (calculated from SATGAS), and PERMBRIN are always output. Multiple NAME_BRAG statements are allowed in the file.
NAME_REPPRES or REPPR_NM	Character*8	Name of the BRAGFLO CAMDAT element variable containing repository average pressure. If no NAME_REPPRES keyword is present, the name will default to the name of the variable containing pressure in gas (NAME_PRESGAS).

REPPRES	Integers or CAMDAT material name; any number	Elements to average over for repository pressure, expressed as a series of integer element numbers or the material name. If NO_GRDVOL is included as a parameter, the average will be a simple average, otherwise it will be grid-volume averaged. If no REPPRES keyword is present, the repository pressure will default to the average pressure in gas for INTR_0 (PRESGAS0).
The following keywords set parameters that are normally read from the input BRAGFLO CAMDAT file. They are only valid if there is no BRAGFLO CAMDAT file. Thus, they are valid for TESTING ONLY.		
POROSITY	Real; 1+NHITS	The initial repository porosity (at time of decommissioning), followed by the porosity for each intrusion time
PRESSURE	Real; 1 or NHITS	Pressure in gas for each intrusion time

7.3 Input CAMDAT Files

A CAMDAT file is a binary, sequential file. A CAMDAT file may be referred to as a *CDB* or a *CAMDAT database*, but it is not a database in the traditional use of the word. A detailed description of the CAMDAT file format is given in Chapter 7 of the CAMDAT_LIB User's Manual (WIPP PA, 1995). The CAMDAT file may be examined with the GROPECDB program described in the GROPECDB User's Manual (WIPP PA, 1996).

There is usually one input CAMDAT file for each vector. The input CAMDAT file serves two purposes: 1) input parameters are provided to CUTTINGS_S through references in the input control file to property values in the file (see Section 7.1) and 2) the contents of this file are the basis of the output CAMDAT file, to which CUTTINGS_S's results will be transferred. In regulatory runs, this file is normally provided by GENMESH, MATSET, POSTLHS code sequence illustrated in Figure 6.3-1. MATSET adds unsampled material and property values from the WIPP Parameter Database, and POSTLHS adds the sampled data. Note that POSTLHS creates *N* CAMDAT files, one for each of the *N* samples. These correspond to the *N* vectors.

As a convenience to users, an all-purpose input CAMDAT file for use with test or debug runs is stored in CMS under the CUSP library as file CUSP_TEST_1.CDB.

7.4 Input BRAGFLO CAMDAT Files

An input BRAGFLO CAMDAT file is the CAMDAT file output from BRAGFLO as it is exercised in the various scenarios. There is usually one input CAMDAT file for each scenario – vector pair. The CAMDAT values listed in Table 7.4-1 are extracted from this file.

Table 7.4-1 Items Extracted from BRAGFLO CAMDAT File

CAMDAT Name	CAMDAT Type	Description
DIAMMOD	Property	The drill diameter, if specified with DIAMMOD BRAGFLO in the input control file
GRIDVOL	Attribute	The grid volume of each element; for grid-volume averaging
POROS	Element variable	The porosity for each element at each intrusion time. The porosity at time=0.0 is the initial porosity (at time of decommissioning).
PRESGAS	Element variable	The pressure in gas for each element at each intrusion time
PRESBRIN	Element variable	The pressure in brine for each element at each intrusion time
SATGAS	Element variable	The saturation of gas for each element at each intrusion time
PERMBRX	Element variable	The permeability of brine for each element at each intrusion time

The names of each CAMDAT item in Table 7.4-1 may be changed with the NAME_xxx commands in the input control file (see Table 7.2-1). Note that the variable name on the input

BRAGFLO CAMDAT file is the variable name used on the output CAMDAT file (see Table 9.2-1). The time step time must be in seconds, and element values will be interpolated from the time steps straddling each intrusion time. All intrusion times must be in a single BRAGFLO CAMDAT file.

As a convenience to users, a BRAGFLO CAMDAT file for use with test or debug runs is stored in CMS under the CUSP library as file CUSP_TEST_BF.CDB.

7.5 Input Spall Model 4 Data File

The input spall model 4 data file is a text file that contains information pertinent to spall model 4. The file supplies the code with pressures and their corresponding data to determine the spall volume. The spall data is normally provided by the DRSPALL code.

The input spall model 4 data file is fixed format, with certain parameters expected on certain lines. Below is the list of items expected on each line. Any number of blanks may precede, follow, or separate items on a line. Numeric values should be in any valid Fortran format.

- Line 1 of the file is the number of vectors in pressure data set. Note that the spall data file vectors are not necessarily the same as the vectors discussed elsewhere in this document.
- Line 2 is the number of pressure data sets.
- Line 3 lists the different pressures in increasing order for the number of data sets given in Line 2.
- The following lines list the data sets relating to each pressure. The first data set is for the first pressure given in Line 3, the second data set is for the second pressure in Line 3, etc. The data sets have three columns of data: column 1 is the vector number, column 2 is the time (not used), and column 3 is the volume. Each of the data sets must contain the number of vectors listed in Line 1 (one line per vector), in order. *Each data set is followed by a blank line.*

An example spall model 4 data file for test or debug runs is shown in Appendix C. This file is available in CMS under the CUSP library as file CUSP_TEST_10_SPL4.DAT.

8.0 ERROR MESSAGES

CUTTINGS_S can generate three types of error messages: a warning, error, or fatal error. In general, a warning signals a condition about which the user should be aware; an error signals a serious problem; a fatal error causes the program to immediately abort. All error messages are written to the output debug file, if open. Fatal error messages are also written to the screen.

Numerous procedural errors can cause CUTTINGS_S to abort. In general, these errors relate to the improper input of data. By noting where the code was when the abort occurred, and what the code was trying to read at the time, these problems can generally be resolved.

When CUTTINGS_S reads the master control file, it writes the information read to the output debug file. If any errors are detected, CUTTINGS_S will write an error message and abort. The user should check the output debug file; any mismatch of information indicates missing or extra fields in the master control file. If the output debug file does not provide sufficient information to correct the file, the user should consult Section 7.1 for information about the file format, and check all file names.

When CUTTINGS_S processes the input control file, it echoes the file to the output debug file. If the code detects an error, it writes an error message directly below the statement that caused the error. If any errors are detected in the input control file, CUTTINGS_S will abort after the entire input control file is read.

For example, the following segment from the output debug file identifies several errors in the input control file.

```
Reading input control file
   U1:[TESTDIR]CUSP_ERROR.INP;6

! Spallings Model selection

MODEL4
NAME_REPPRES PRESGAS
REPPRES    CAVITY_1
*** ERROR - Expected cavity abbreviation or "*"
RNDSPALL   DUM5:RNDSPALL

! Properties

TAUFAIL    BOREHOLE:TAUFAIL
DNSFLUID   DRILLMUD:DENSITY
DOMEGA     BOREHOLE:DOMEGA
VISCO      DRILLMUD:VISCO
YLDSTRSS   DRILLMUD:YLDSTRSS
ABSROUGH   WAS_AREA:BAD_PROP
*** ERROR - Invalid ABSROUGH material:property WAS_AREA:BAD_PROP - property BAD_PROP is
not on input CAMDAT file

BAD_KEY
*** ERROR - Unknown keyword BAD_KEY

! BRAGFLO zones

INTR_0  CAVITY_1
*** ERROR - Expected cavity abbreviation or "*"
```

```
INTR_1  *  CAVITY_1   NO_GRDVOL
>>> Simple average will be used; average will not be weighted by grid volume

INTR_2  *  457  458  459
```

%%% FATAL ERROR - Reading input control file

The following fatal error message would be written to the screen.

```
%%% FATAL ERROR - Reading input control file
%%%                (see output file for more information)
%%% Program is aborting %%%
%SYSTEM-?-ABORT, abort
```

If the error message does not provide sufficient information to correct the statement, the user should consult Section 7.2 for information about syntax or the appropriate keyword and parameters. If the error is an invalid CAMDAT property reference, the user should examine the input CAMDAT file described in Section 7.3 to determine the correct material and property name.

Once the input control file is read, CUTTINGS_S reads data from the BRAGFLO CAMDAT file. Errors may occur if the expected CAMDAT items (e.g., element variables) are not on the file. The user may need to examine the input BRAGFLO CAMDAT file described in Section 7.4.

To familiarize readers with CUTTINGS_S's error-message patterns, CUTTINGS_S's various fatal error messages are listed below.

```
%%% FATAL ERROR - Calling DBSETUP
%%% FATAL ERROR - Opening input control file
%%% FATAL ERROR - Opening input control file
%%% FATAL ERROR - Opening input CAMDAT file
%%% FATAL ERROR - Opening input BRAGFLO CAMDAT file
%%% FATAL ERROR - Opening Spall Model 4 data file
%%% FATAL ERROR - Invalid BRAGFLO CAMDAT file items requested
%%% FATAL ERROR - Reading BRAGFLO CAMDAT file

%%% FATAL ERROR - Reading input control file
%%% FATAL ERROR - Retrieving vector parameters from input CAMDAT file

%%% FATAL ERROR - Opening output data file
%%% FATAL ERROR - Cannot assign files
%%% FATAL ERROR - Reading Master Control File
%%% FATAL ERROR - Reading CAMDAT sizing info
%%% FATAL ERROR - Reading CAMDAT material IDs and names
%%% FATAL ERROR - Reading CAMDAT property names
%%% FATAL ERROR - Reading CAMDAT property values

%%% FATAL ERROR - Reading BRAGFLO CAMDAT sizing parameters
%%% FATAL ERROR - Reading number of BRAGFLO CAMDAT variables
%%% FATAL ERROR - Reading BRAGFLO CAMDAT material names
%%% FATAL ERROR - Reading BRAGFLO CAMDAT number of elements per block
%%% FATAL ERROR - Reading BRAGFLO CAMDAT property names
%%% FATAL ERROR - Reading BRAGFLO CAMDAT attribute names
%%% FATAL ERROR - Reading BRAGFLO CAMDAT element variable names
%%% FATAL ERROR - Reading BRAGFLO CAMDAT sizing parameters
```

```
%%% FATAL ERROR - Reading BRAGFLO CAMDAT material names
%%% FATAL ERROR - Opening output CAMDAT file
%%% FATAL ERROR - Closing output CAMDAT file
%%% FATAL ERROR - Adding QA record to CAMDAT file
%%% FATAL ERROR - Writing CAMDAT property name
%%% FATAL ERROR - Writing "header" to the CAMDAT file
%%% FATAL ERROR - Adding CAMDAT global variable name name
%%% FATAL ERROR - Writing CAMDAT time step time
%%% FATAL ERROR - Writing CAMDAT global variable name
%%% FATAL ERROR - Writing time step (DBOSTEP)

%%% FATAL ERROR - Negative ROUTER in DRILL
```

9.0 DESCRIPTION OF OUTPUT FILES

The output files for CUTTINGS_S mentioned in Section 6.2 are described in this section.

9.1 Output Data File

The output data file is the principal CUTTINGS_S output file. It is a text file that contains the drill diameter and the amount of material removed by cuttings and cavings (as area) and spallings (as volume) for each scenario – vector – cavity – intrusion time combination.

The output data file is in a specific format expected by the PRECCDFGF code (Version 1.01 or higher). The format is described below.

- The first line of the output data file is a header record with the following columns:
  1. the number of scenarios
  2. the number of vectors
  3. the number of cavities
- The second line lists the number of intrusion times for each scenario, in the order that the scenarios were defined on the master control file and are written on the output data file.
- The third line is a comment that describes the data columns for the data lines.
- The data lines follow. The data lines are ordered by scenario, then cavity, then intrusion time, and finally vector. Thus, all the data for a particular scenario appears together, and the vector index increments each line. The scenario order is determined by the order they were defined on the master control file. Each data line has the following columns:
  1. the scenario number,
  2. the cavity abbreviation,
  3. the intrusion time,
  4. the vector number,
  5. the drill diameter,
  6. the footprint area of the material brought to the surface by cuttings and cavings, and
  7. the volume of the material brought to the surface by spallings.

An example output data file is shown in Appendix D.

9.2 Output CAMDAT Files

A CAMDAT file is a binary file, as described under Section 7.3. It is not directly human readable, but may be read with programs that use the CAMDAT_LIB library routines.

One output CAMDAT file will be generated for each scenario – vector – cavity – intrusion time combination. Each output CAMDAT file contains the amount of material removed by cuttings, cavings, and spallings, along with volume-weighted averaged variables from the corresponding input BRAGFLO CAMDAT file.

All of the model information on the input CAMDAT file is copied to the output CAMDAT file. CUTTINGS_S parameters are added as CAMDAT properties of the material specified in the input control file with OUT_MAT. These parameters are DNSFLUID (as property DENSITY), DOMEGA, ABSROUGH (as property ABSRO), TAUFAIL, VISCO, and YLDSTRSS.

Each CAMDAT file has a single time step corresponding to the appropriate intrusion time (in seconds). CUTTINGS_S output is written to the CAMDAT file as global variables. Table 9.2-1 lists the global variables that are written to the CAMDAT file for a regulatory run.

Table 9.2-1 CAMDAT Global Variables Output by CUTTINGS_S

Global Variable Name	Description
AREA_C	Footprint area of the material brought to the surface by cuttings and cavings
AREA_S	Footprint area of the material brought to the surface by spallings (volume / initial repository height)
AREA_T	Area of all material brought to the surface (AREA_C + AREA_S)
VOL_C	Volume of the material brought to the surface by cuttings and cavings (area * initial repository height)
VOL_S	Volume of the material brought to the surface by spallings
VOL_T	Volume of all material brought to the surface (VOL_C + VOL_S)
DRILDIAM	Drill diameter
NUM_INTR	Number of zones defined with INTR_*n* commands, with *n* starting at 0 (e.g., if NUM_INTR is 3, *n* ranges from 0 to 2)
POROS*n*	Final porosity for zone *n*, calculated from volume-weighted average POROS from BRAGFLO CAMDAT file
HFINAL_*n*	Final height for zone *n*, calculated from volume-weighted average POROS from BRAGFLO CAMDAT file
PRESGAS*n*	Volume-weighted average PRESGAS from BRAGFLO CAMDAT file for zone *n*
PRESBRI*n*	Volume-weighted average PRESBRIN from BRAGFLO CAMDAT file for zone *n*
SATGAS*n*	Volume-weighted average SATGAS from BRAGFLO CAMDAT file for zone *n*
SATBRIN*n*	1.0 - SATGAS*n*
PERMBRX*n*	Volume-weighted average PERMBRX from BRAGFLO CAMDAT file for zone *n*

The set of variables ending in *n* is output for each zone. Zone *n* is defined by the INTR_*n* keyword in the input control file. Most of these variables are from element variables from the input BRAGFLO CAMDAT file. The element variable values are interpolated from the BRAGFLO times straddling the intrusion time. The element variable values are weighted by grid volume and averaged, unless simple averaging is requested in the INTR_*n* command. The names of the variables from the BRAGFLO CAMDAT file may be changed with the NAME_xxx keywords in the input control file.

If there is no BRAGFLO CAMDAT file, the only *n*-type variables that will be output are POROSITY, HFINAL, and PRESGAS (without the *n*).

CUTTINGS_S attempts to define properties and time step variables on the output CAMDAT file in a reasonable order, but the user should not make assumptions about this ordering.

9.3 Output Debug File

The text output debug file echoes the input control file (along with the values of any input CAMDAT properties referenced), and includes a summary of the calculated results. Error messages, if any, appear in this file.

An annotated example of the debug file is given in Appendix E.

10.0 REFERENCES

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WIPP PA (Performance Assessment). 2004. Requirements Document for CUTTINGS_S Version 6.00. Sandia National Laboratories. Sandia WIPP Central Files ERMS # 537037.

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APPENDIX A: EXAMPLE MASTER CONTROL FILE

The master control file is discussed in Section 7.1. It describes the scenarios, vectors, cavities, and intrusion times to run, and identifies the input files that CUTTINGS_S needs and the output files that the code generates. Two examples are shown below. The first is designed for a regulatory calculation; the second is designed for a test run. The examples are annotated with explanatory comments (in italics) that are not part of the file.

Example Master Control File for Regulatory Run

`5 100 3`	*5 scenarios, 100 vectors, 3 cavities*
`1 6 100 350 1000 3000 5000 10000`	*6 intrusion times for Scenario 1*
`2 5 550 750 2000 4000 10000`	*... 5 for Scenario 2*
`4 5 550 750 2000 4000 10000`	*... 5 for Scenario 4*
`3 5 1200 1400 3000 5000 10000`	*... 5 for Scenario 3, and Scenario 5 (below)*
`5 5 1200 1400 3000 5000 10000`	*Scenario ordering is 1,2,4,3,5*
`L`	*Abbreviation for first cavity*
`M`	*... second cavity*
`U`	*... third cavity*
`CUSP_CRA1.INP`	*Input control file*
`LHS3_CRA1_CUSP_A1_R^.CDB`	*Input CAMDAT files (one for each vector)*
`BF3_CRA1_R1_S%_V^.CDB`	*BRAGFLO CAMDAT files (one for each scen-vec pair)*
`SUM_DRS_SPLVOL2.TBL`	*Spall model 4 data file*
`CUSP_CRA1_OUT.TBL`	*Output data file*
`CUSP_CRA1_S%_V^_(_T!_OUT.CDB`	*Output CAMDAT files (one for each scen-vec-cav-intr)*

Example Master Control File for Test Run

`1 1 1`	*Single run*
`1 1 1000`	*One intrusion time of 1000 for Scenario 1*
`-`	*"-" for no cavity abbreviation*
`CUSP_TEST_4.INP`	*Input control file*
`CUSP_TEST_4.CDB`	*Input CAMDAT file*
`CANCEL`	*No BRAGFLO CAMDAT file*
`CANCEL`	*No spall model 4 data file*
`CUSP_QA0600_TEST_4_OUT.TBL`	*Output data file*
`CUSP_QA0600_TEST_4_OUT.CDB`	*Output CAMDAT file*

APPENDIX B: EXAMPLE INPUT CONTROL FILE

The input control file is discussed in Section 7.2. It contains the drilling parameters and repository data. Two examples are shown below. The first is designed for a regulatory calculation; the second is designed for a test run. Note that the control file for the test run defines specific numerical values for the various parameters; the file for the regulatory run references properties from the input CAMDAT file.

Example Input Control File for Regulatory Run

```
! Input Control File for CUTTINGS_S
!
SECYR      REFCON:SECYR        ! Seconds-to-year conversion factor

HREPO      BLOWOUT:HREPO       ! Height of repository at burial time (m)

COLDIA     BOREHOLE:COLDIA     ! Collar diameter (m)
DIAMMOD    BOREHOLE:DIAMMOD    ! Borehole diameter

TAUFAIL    BOREHOLE:TAUFAIL    ! Effective shear strength of erosion
DOMEGA     BOREHOLE:DOMEGA     ! Angular velocity of drillstring
DNSFLUID   DRILLMUD:DNSFLUID   ! Density of the drilling fluid (mud)
VISCO      DRILLMUD:VISCO      ! Plastic viscosity
YLDSTRSS   DRILLMUD:YLDSTRSS   ! Yield stress of drilling fluid (mud)
ABSROUGH   WAS_AREA:ABSROUGH   ! Absolute borehole roughness
!
! Parameters for Spall Model 4
!
MODEL4
RNDSPALL   SPALLMOD:RNDSPALL
!
! Define "zones" for Bragflo averaged variables
! Intr_0 zone is defined for each cavity; all others defined for all cavities
!
INTR_0    L   CAVITY_1
INTR_0    M   CAVITY_1
INTR_0    U   CAVITY_2

INTR_1    *   1434 1435 1436 1437 1438 1439
INTR_2    *   1428 1429 1430 1431 1432 1433
INTR_3    *   2225
INTR_4    *   2244
INTR_5    *   1168
INTR_6    *   1417
INTR_7    *   DRZ_0
!
! Define zone for Bragflo averaged repository pressure (for spallings)
! Zone defined for each cavity
!
REPPRES  L  CAVITY_1
REPPRES  M  1428 1429 1430 1431 1432 1433
REPPRES  U  1434 1435 1436 1437 1438 1439
!
! Define material on output CAMDAT file for CUTTINGS_S parameters
!
OUT_MAT  BOREHOLE
```

Substitute for Spall Model 3:

```
! Parameters for Spall Model 3

MODEL3
PTHRESH    WAS_AREA:PTHRESH
VOLSPALL   WAS_AREA:VOLSPALL
```

Example Input Control File for Test Run

```
! CUTTINGS_S TEST PROBLEM 4 checks laminar flow
!
!!! There is no BRAGFLO CAMDAT file for this test
!!! Note that no spall model is selected

! Parameters that normally come from BRAGFLO CAMDAT file
PRESSURE        15.0E6
POROSITY  0.88   0.606

! Parameters that normally come from input CAMDAT file
HREPO             3.96
COLDIA     0.2032004
DIAMMOD        0.26663
DNSFLUID        1200.0
DOMEGA             4.2
TAUFAIL          0.048
VISCO             0.06
YLDSTRSS           4.4
ABSROUGH     0.25E-01

OUT_MAT      BOREHOLE
```

APPENDIX C: EXAMPLE SPALL MODEL 4 DATA FILE

The data file required for spall model 4 is discussed in Section 7.5. It contains pressures and their corresponding data to determine the spall volume. An example spall model 4 data file suitable for a test run is shown below. The example contains two data sets of five vectors each. The example is annotated with explanatory comments (in italics) that are not part of the file.

`5`	*5 vectors in the pressure data set*
`2`	*2 pressure data sets*
`10000000    20000000`	*Pressure for Set 1; pressure for Set 2*
`1    0    1`	*Set 1: Vector 1, unused, volume*
`2    0    1.25`	*... Vector 2 volume*
`3    0    1.5`	*... Vector 3 volume*
`4    0    1.75`	*... Vector 4 volume*
`5    0    2.00`	*... Vector 5 volume*
	This line is ignored
`1    0    10`	*Set 2: Vector 1, unused, volume*
`2    0    12.5`	*... Vector 2 volume*
`3    0    15`	*... Vector 3 volume*
`4    0    17.5`	*... Vector 4 volume*
`5    0    20`	*... Vector 5 volume*
	This line is ignored

APPENDIX D: SAMPLE OUTPUT DATA FILE

The output data file is discussed in Section 9.1. A sample file is shown below.

Line 1 of the file specifies that there are five scenarios, four vectors, and three cavities. Line 2 specifies that there are six intrusion times for Scenario 1, five times for Scenarios 2 and 4, and four times for Scenario 3 and 5. Note that the scenarios do not have the same intrusion times and the scenarios are not in numerical order. The intrusion times and the ordering of the scenarios are specified in the master control file. Line 3 of the file is a comment describing the contents of the data lines that follow. The file contains 288 data lines (4 vectors * 3 cavities * (6+5+5+4+4) intrusion times per scenario). Many of the data lines have been removed for brevity and replaced with "…" and a comment (in italics) explaining what data lines have been removed.

```
         5        4        3
         6        5        5       4        4
SCN CAV       TIME        VEC     DRILDIAM        AREA_C         VOL_S
  1 L      1.00000E+02     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 L      1.00000E+02     2   3.111500E-01  1.131132E-01  0.000000E+00
  1 L      1.00000E+02     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 L      1.00000E+02     4   3.111500E-01  1.309525E-01  0.000000E+00
  1 L      3.50000E+02     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 L      3.50000E+02     2   3.111500E-01  1.131132E-01  0.000000E+00
  1 L      3.50000E+02     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 L      3.50000E+02     4   3.111500E-01  1.309525E-01  2.410427E-02
  1 L      1.00000E+03     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 L      1.00000E+03     2   3.111500E-01  1.131132E-01  4.980908E-01
  1 L      1.00000E+03     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 L      1.00000E+03     4   3.111500E-01  1.309525E-01  3.760077E-01
  1 L      3.00000E+03     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 L      3.00000E+03     2   3.111500E-01  1.131132E-01  5.401633E-01
  1 L      3.00000E+03     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 L      3.00000E+03     4   3.111500E-01  1.309525E-01  2.590723E-01
  1 L      5.00000E+03     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 L      5.00000E+03     2   3.111500E-01  1.131132E-01  5.332199E-01
  1 L      5.00000E+03     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 L      5.00000E+03     4   3.111500E-01  1.309525E-01  2.110886E-01
  1 L      1.00000E+04     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 L      1.00000E+04     2   3.111500E-01  1.131132E-01  4.988766E-01
  1 L      1.00000E+04     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 L      1.00000E+04     4   3.111500E-01  1.309525E-01  1.872676E-01
  1 M      1.00000E+02     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 M      1.00000E+02     2   3.111500E-01  1.131132E-01  0.000000E+00
```

… *The 24 (6*4) data lines for Scenario 1, Cavity M, 6 intrusion times (100, 350, 1000, 3000, 5000, 10000), Vectors 1-4 follow the same pattern as for Cavity L above.*

```
  1 M      1.00000E+04     3   3.111500E-01  7.603780E-02  0.000000E+00
  1 M      1.00000E+04     4   3.111500E-01  1.309525E-01  1.864856E-01
  1 U      1.00000E+02     1   3.111500E-01  2.128595E-01  0.000000E+00
  1 U      1.00000E+02     2   3.111500E-01  1.131132E-01  0.000000E+00
```

… *The 24 data lines for Scenario 1, Cavity M, 6 intrusion times, Vectors 1-4.*

```
  1 U      1.00000E+04     4   3.111500E-01  1.309525E-01  1.846775E-01
  2 L      5.50000E+02     1   3.111500E-01  2.128595E-01  3.135009E-02
  2 L      5.50000E+02     2   3.111500E-01  1.131132E-01  2.227808E-01
```

… *The 60 (3*5*4) data lines for Scenario 2, 3 cavities (L,U,M), 5 intrusion times, Vectors 1-4 follows the same pattern as for Scenario 1 above.*

```
  2 U    1.00000E+04    4  3.111500E-01  1.309525E-01  0.000000E+00
  4 L    5.50000E+02    1  3.111500E-01  2.128595E-01  0.000000E+00
  4 L    5.50000E+02    2  3.111500E-01  1.131132E-01  2.248455E-01
```

... *The 60 data lines for Scenario 4, 3 cavities (L,U,M), 5 intrusion times, Vectors 1-4.*

```
  4 U    1.00000E+04    4  3.111500E-01  1.309525E-01  0.000000E+00
  3 L    1.20000E+03    1  3.111500E-01  2.128595E-01  3.691427E-02
  3 L    1.20000E+03    2  3.111500E-01  1.131132E-01  3.954772E-01
```

... *The 48 (3*4*4) data lines for Scenario 3, 3 cavities (L,U,M), 4 intrusion times, Vectors 1-4.*

```
  3 U    1.00000E+04    4  3.111500E-01  1.309525E-01  0.000000E+00
  5 L    1.20000E+03    1  3.111500E-01  2.128595E-01  0.000000E+00
  5 L    1.20000E+03    2  3.111500E-01  1.131132E-01  5.141423E-01
```

... *The 48 data lines for Scenario 5, 3 cavities (L,U,M), 4 intrusion times, Vectors 1-4.*

```
  5 U    1.00000E+04    4  3.111500E-01  1.309525E-01  0.000000E+00
```

APPENDIX E: SAMPLE OUTPUT DEBUG FILE

The output debug file is discussed in Section 9.3. A portion of a sample file is shown below, annotated with explanatory comments (in italics) that describe the various sections.

> *Below is standard header information found on many WIPP output debug files. It includes the code version and the run date, and the names of the files input on the command line.*

```
CUTTINGS_S_QA0600 6.00 PROD QA0600 01/27/2005              01/27/2005 12:48:45

                               CUTTINGS_S_QA0600

 CCCCC  UU    UU TTTTTT  TTTTTT    IIII  N     NN  GGGGG   SSSSSS          SSSSSS
CC   CC UU    UU   TT      TT       II   NN    NN GG    GG SS             SS
CC      UU    UU   TT      TT       II   NNN   NN GG       SS             SS
CC      UU    UU   TT      TT       II   NN N  NN GG        SSSSS          SSSSS
CC      UU    UU   TT      TT       II   NN   NNN GG   GGG      SS              SS
CC   CC UU    UU   TT      TT       II   NN    NN GG    GG      SS              SS
 CCCCC    UUUUU    TT      TT      IIII  NN     N  GGGGG   SSSSSS  _______ SSSSSS

           Program for computing the quantity of radioactive material
            brought to the surface as cuttings/spall generated by a
           drilling operation that penetrates a rad-waste repository.

                         CUTTINGS_S_QA0600 Version 6.00
                          PROD QA0600 Built 01/27/2005
                      Written by Jerry W. Berglund (1995)
                            Sponsored by Eric Vugrin

                         Run on 01/27/2005 at 12:48:45
                      Run on ALPHA AXP CCR OpenVMS V7.3-1

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

          Prepared for
          Sandia National Laboratories
          Albuquerque, New Mexico 87185-5800
          for the United States Department of Energy
          under Contract DE-AC04-76DP00789

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

                                   Disclaimer
                                   ----------

          This computer program was prepared as  an  account  of  work
          sponsored  by  an  agency  of  the United States Government.
          Neither the United States Government nor any agency thereof,
          nor  any  of  their employees, nor any of their contractors,
          subcontractors, or  their  employees,  makes  any  warranty,
          express  or  implied,  or  assumes  any  legal  liability or
          responsibility for the accuracy, completeness, or usefulness
          of any information, apparatus, product, or process disclosed
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          manufacturer,  or otherwise, does not necessarily constitute
          or imply its endorsement, recommendation, or favoring by the
```

```
          United States Government, any agency thereof or any of their
          contractors or subcontractors.  The views and opinions
          expressed herein do not necessarily state or reflect those
          of the United States Government, any agency thereof or any
          of their contractors or subcontractors.

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


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

FILE ASSIGNMENTS:
-----------------
Master control file:
   U1:[CUSP_TEST]CUSP_TEST_11_MASTER.INP;15
      Written on 01/26/2005 14:02:31
Output debug file:
   U1:[CUSP_TEST]CUSP_QA0600_TEST_11_600.DBG
```

The master control file is read once. Information from this file is written to the debug file as the file is read. If errors were detected when reading this file, error messages would appear in this section and the code would abort.

```
********************************************************************************
Reading master control file
   U1:[CUSP_TEST]CUSP_TEST_11_MASTER.INP;15

Process for each Scenario:     4 Vectors   3 Cavities
Process Scenarios in the following order:
Scenario 1 Intrusions:    100.    350.    1000.    3000.    5000.  10000.
Scenario 2 Intrusions:    550.    750.    2000.    4000.  10000.
Scenario 4 Intrusions:    550.    750.    2000.    4000.  10000.
Scenario 3 Intrusions:   1200.   3000.    5000.  10000.
Scenario 5 Intrusions:   1200.   3000.    5000.  10000.
Cavity Abbreviations:  L   M   U

Input Control File:
   CUSP_TEST_11.INP
Input CAMDAT File:
   inpdir:LHS3_CRA1_CUSP_A1_R^.CDB
Input BRAGFLO CAMDAT File:
   inpdir:BF3_CRA1_R1_S%_V^.CDB
Input Spall Model 4 Data File:
   inpdir:SUM_DRS_SPLVOL2.TBL
Output Data File:
   CUSP_QA0600_TEST_11_OUT.TBL
Output CAMDAT File:
   cdb600dir:CUSP_QA0600_TEST_11_S%_V^_(_T!.CDB
```

Processing starts with Scenario 1, Vector 1. The input control file is read (and echoed) once for each scenario. If errors were detected when reading this file, error messages would appear in this section and the code would abort.

```
********************************************************************************

                    *** SCENARIO 1 *** VECTOR   1 ***

********************************************************************************
Reading input control file
   U1:[CUSP_TEST]CUSP_TEST_11.INP;8
```

```
! Input Control File for CUTTINGS_S
!
SECYR       3.168876E-8          ! Seconds-to-year conversion factor
                                 ! (as listed in CUTTINGS_S 5.10 code)
SHEARRT     1020
MUDFLWRT    0.09935

HREPO       3.960000E+00         ! Height of repository at burial time (m)

COLDIA      2.032004E-01         ! Collar diameter (m)
DIAMMOD     BOREHOLE:DIAMMOD     ! Borehole diameter

TAUFAIL     BOREHOLE:TAUFAIL     ! Effective shear strength of erosion
DOMEGA      BOREHOLE:DOMEGA      ! Angular velocity of drillstring
DNSFLUID    DRILLMUD:DNSFLUID    ! Density of the drilling fluid (mud)
VISCO       DRILLMUD:VISCO       ! Plastic viscosity
YLDSTRSS    DRILLMUD:YLDSTRSS    ! Yield stress of drilling fluid (mud)
ABSROUGH    WAS_AREA:ABSROUGH    ! Absolute borehole roughness
!
! Properties for Spall Model 4
!
MODEL4
PTHRESH     WAS_AREA:PTHRESH      ! Not needed
*** WARNING - PTHRESH ignored if not MODEL3
RNDSPALL    SPALLMOD:RNDSPALL
!
! Define "zones" for Bragflo averaged variables
! Intr_0 zone is defined for each cavity; all others defined for all cavities
!
INTR_0    L   CAVITY_1
INTR_0    M   CAVITY_1
INTR_0    U   CAVITY_2

INTR_1    *   1434 1435 1436 1437 1438 1439
INTR_2    *   1428 1429 1430 1431 1432 1433
INTR_3    *   2225
INTR_4    *   2244
INTR_5    *   1168
INTR_6    *   1417
INTR_7    *   DRZ_0
!
! Define zone for Bragflo averaged repository pressure (for spallings)
! Zone defined for each cavity
!
REPPRES   L  CAVITY_1
REPPRES   M  1428 1429 1430 1431 1432 1433
REPPRES   U  1434 1435 1436 1437 1438 1439
!
! Define material on output CAMDAT file for CUTTINGS_S parameters
!
OUT_MAT   BOREHOLE
```

The spall model 4 data file, if any, is read once for each scenario. The spall data file information is written to the debug file after the entire file is read. Note that there are 50 vectors for the spall data, as opposed to the four scenario vectors.

```
*************************************************************************************
Reading data from spall model 4 data file
   U1:[CUSP_TEST.INPUT]SUM_DRS_SPLVOL2.TBL;1

        Pressure     Pressure     Pressure     Pressure
Vec    1.000E+07    1.200E+07    1.400E+07    1.480E+07
  1      0.00000      0.00000      0.39698      0.55740
  2      0.00000      1.21931      7.21800      7.29747
  3      0.00000      0.00000      0.00000      0.00000
  4      0.00000      0.56480      1.28846      1.61065
  5      0.00000      0.00000      0.07992      0.20739
  6      0.00000      0.00000      0.07098      0.18250
  7      0.00000      0.00000      0.00000      0.00000
  8      0.00000      0.00000      0.00000      0.00000
  9      0.00000      0.00000      0.18940      0.34033
 10      0.00000      0.00000      0.00000      0.00000
 11      0.00000      0.00000      0.27726      0.38106
 12      0.00000      0.00000      0.04028      0.09224
 13      0.00000      0.00000      0.10279      0.21631
 14      0.00000      0.00000      0.03571      0.13727
 15      0.00000      0.00000      0.11268      0.26969
 16      0.00000      1.70843      3.13084      3.95235
 17      0.00000      0.00000      0.09304      0.37601
 18      0.00000      0.00000      0.60119      1.17003
 19      0.00000      0.60725      4.40509      5.31755
 20      0.00000      0.00793      0.22480      0.31829
 21      0.00000      0.00000      0.00000      0.00000
 22      0.00000      0.00000      0.02613      0.10822
 23      0.00000      0.16660      1.78811      2.24854
 24      0.00000      0.00000      0.46102      0.63377
 25      0.00000      0.00000      0.06482      0.16545
 26      0.00000      0.13925      1.03301      1.79472
 27      0.00000      0.00000      0.00000      0.00000
 28      0.00000      0.03465      0.73828      1.45235
 29      0.00000      0.00000      0.38457      0.48691
 30      0.00000      7.00046      9.45296     12.06204
 31      0.00000      0.09779      0.69424      1.42762
 32      0.00000      0.00000      0.02365      0.09781
 33      0.00000      0.00000      0.12073      0.25728
 34      0.00000      0.00000      0.40617      0.60189
 35      0.00000      0.00000      0.26889      0.44177
 36      0.00000      0.18289      0.94880      1.67078
 37      0.00000      0.00000      0.00000      0.00000
 38      0.00000      0.00000      0.05157      0.16094
 39      0.00000      0.00000      0.21003      0.34530
 40      0.00000      0.00000      0.00000      0.00000
 41      0.00000      0.00000      0.00951      0.08979
 42      0.00000      0.00000      0.31108      0.52060
 43      0.00000      0.00000      0.15705      0.32514
 44      0.00000      0.00000      0.06953      0.17972
 45      0.00000      0.00000      0.48437      0.65265
 46      0.00000      0.00000      0.22432      0.43197
 47      0.00000      0.24431      1.80972      3.10536
 48      0.00000      0.22413      1.33613      2.32965
 49      0.00000      0.00000      0.00000      0.00000
 50      0.00000      0.00000      0.32360      0.54603
```

Below starts the information that is included for each vector. The parameter values for this vector are listed. The parameters are defined in the input control file as values or as references to properties on the input CAMDAT file.

```
*********************************************************************************
Retrieving vector parameters from input CAMDAT file
   U1:[CUSP_TEST.INPUT]LHS3_CRA1_CUSP_A1_R001.CDB;1

PI              3.141593E+00   Default
SECYR           3.168876E-08   Value
HREPO           3.960000E+00   Value
COLDIA          2.032004E-01   Value
DNSFLUID        1.210000E+03   CAMDAT material:property DRILLMUD:DNSFLUID
DOMEGA          7.009000E+00   CAMDAT material:property BOREHOLE:DOMEGA
ABSROUGH        2.500000E-02   CAMDAT material:property WAS_AREA:ABSROUGH
TAUFAIL         1.025000E+00   CAMDAT material:property BOREHOLE:TAUFAIL
VISCO           9.170000E-03   CAMDAT material:property DRILLMUD:VISCO
YLDSTRSS        4.400000E+00   CAMDAT material:property DRILLMUD:YLDSTRSS
SHEARRT         1.020000E+03   Value
MUDFLWRT        9.935000E-02   Value
DIAMMOD         3.111500E-01   CAMDAT material:property BOREHOLE:DIAMMOD
RNDSPALL        1.664000E-01   CAMDAT material:property SPALLMOD:RNDSPALL
```

Information from the BRAGFLO CAMDAT file for all cavities and intrusion times for this scenario-vector is listed below. This section lists the BRAGFLO CAMDAT times straddling the intrusion times (for interpolation). It also lists the volume-weighted averages for the variables that will be written to the output CAMDAT file.

```
*********************************************************************************
Reading BRAGFLO CAMDAT file
   U1:[CUSP_TEST.INPUT]BF3_CRA1_R1_S1_V001.CDB;1

GRIDVOL read from BRAGFLO CAMDAT attribute GRIDVOL

Intrusion Time =     0.   BRAGFLO Time                0.00 years
Intrusion Time =   100.   BRAGFLO Times     67.61   100.00 years
Intrusion Time =   350.   BRAGFLO Times    287.51   350.00 years
Intrusion Time =  1000.   BRAGFLO Times    709.26  1000.00 years
Intrusion Time =  3000.   BRAGFLO Times   2835.11  3000.01 years
Intrusion Time =  5000.   BRAGFLO Times   4999.85  6040.26 years
Intrusion Time = 10000.   BRAGFLO Times   9273.72 10000.02 years

Cav  Time  Zone   POROS         PRESGAS       PRESBRIN      SATGAS        PERMBRX

L     100.   0  2.34896E-01  9.39054E+05  9.39054E+05  7.90090E-01  2.39990E-13
L     100.   1  2.35074E-01  9.45601E+05  9.45601E+05  7.99190E-01  2.39990E-13
L     100.   2  2.34999E-01  9.42836E+05  9.42836E+05  7.99304E-01  2.39990E-13
L     100.   3  6.07459E-01  1.60658E+07  1.60600E+07  0.00000E+00  7.76248E-13
L     100.   4  6.07459E-01  1.60658E+07  1.60600E+07  0.00000E+00  7.76248E-13
L     100.   5  1.87235E-02  9.39028E+05  9.39028E+05  6.83386E-01  4.89778E-16
L     100.   6  2.34896E-01  9.39054E+05  9.39054E+05  8.62339E-01  2.39990E-13
L     100.   7  1.87134E-02  7.64854E+05  7.64854E+05  5.86296E-01  4.87412E-16


L     350.   0  1.55342E-01  3.51274E+06  3.51274E+06  6.78721E-01  2.39990E-13
L     350.   1  1.54875E-01  3.48705E+06  3.48705E+06  7.12897E-01  2.39990E-13
L     350.   2  1.54767E-01  3.48109E+06  3.48109E+06  7.12050E-01  2.39990E-13
L     350.   3  6.07459E-01  1.60658E+07  1.60600E+07  0.00000E+00  7.76248E-13
```

```
L      350.    4  6.07459E-01  1.60658E+07  1.60600E+07  0.00000E+00  7.76248E-13
L      350.    5  2.01347E-02  3.51022E+06  3.51022E+06  7.64502E-01  4.89778E-16
L      350.    6  1.55298E-01  3.51031E+06  3.51031E+06  8.86932E-01  2.39990E-13
L      350.    7  1.98108E-02  2.75826E+06  2.75826E+06  6.48809E-01  4.87412E-16
```

... This section lists the volume-weighted average BRAGFLO variables over the eight zones (0-7) for all six intrusion times for Cavity L, M, and U. Most of this data has been removed for brevity.

```
U    10000.    0  1.70617E-01  1.00510E+07  1.00510E+07  9.11193E-01  2.39990E-13
U    10000.    1  1.70502E-01  1.00387E+07  1.00387E+07  9.11402E-01  2.39990E-13
U    10000.    2  1.70762E-01  1.00662E+07  1.00662E+07  9.10932E-01  2.39990E-13
U    10000.    3  6.07459E-01  1.60658E+07  1.60600E+07  0.00000E+00  7.76248E-13
U    10000.    4  6.07459E-01  1.60658E+07  1.60600E+07  0.00000E+00  7.76248E-13
U    10000.    5  2.42781E-02  1.01318E+07  1.01318E+07  8.71956E-01  4.89778E-16
U    10000.    6  1.71384E-01  1.01320E+07  1.01320E+07  1.00000E+00  2.39990E-13
U    10000.    7  2.43268E-02  1.00485E+07  1.00485E+07  7.71751E-01  4.87412E-16

From these two relationships:
   (1.0-Pi)*Hi = (1.0-Pf)*Hf
         Pf*Hf = Pb*Hi
Where:
   Pi = Initial porosity
   Hi = Initial height
   Pb = BRAGFLO porosity
   Pf =  Final  porosity
   Hf =  Final  height
Code will calculate:
   Pf = Pb/(1.0-Pi+Pb)
   Hf = (1.0-Pi)/(1.0-Pf)*Hi

HREPO (initial repository height) =  3.96000E+00

Cav  Time  Zone   InitPoro     BRAGPoro     POROF        HFINAL

L      100.    0  8.48350E-01  2.34896E-01  6.07679E-01  1.53072E+00
L      100.    1  8.48350E-01  2.35074E-01  6.07859E-01  1.53143E+00
L      100.    2  8.48350E-01  2.34999E-01  6.07783E-01  1.53113E+00
L      100.    3  6.07459E-01  6.07459E-01  6.07459E-01  3.96000E+00
L      100.    4  6.07459E-01  6.07459E-01  6.07459E-01  3.96000E+00
L      100.    5  1.82870E-02  1.87235E-02  1.87154E-02  3.96173E+00
L      100.    6  8.48350E-01  2.34896E-01  6.07679E-01  1.53072E+00
L      100.    7  1.83515E-02  1.87134E-02  1.87067E-02  3.96143E+00

L      350.    0  8.48350E-01  1.55342E-01  5.06012E-01  1.21569E+00
L      350.    1  8.48350E-01  1.54875E-01  5.05260E-01  1.21384E+00
L      350.    2  8.48350E-01  1.54767E-01  5.05085E-01  1.21341E+00
L      350.    3  6.07459E-01  6.07459E-01  6.07459E-01  3.96000E+00
L      350.    4  6.07459E-01  6.07459E-01  6.07459E-01  3.96000E+00
L      350.    5  1.82870E-02  2.01347E-02  2.00976E-02  3.96732E+00
L      350.    6  8.48350E-01  1.55298E-01  5.05941E-01  1.21552E+00
L      350.    7  1.83515E-02  1.98108E-02  1.97819E-02  3.96578E+00
```

... This section lists the calculated values of final porosity and height over the eight zones for all six intrusion times for Cavity L, M, and U. Most of this data has have been removed for brevity.

```
U    10000.    0  8.48350E-01  1.70617E-01  5.29428E-01  1.27618E+00
U    10000.    1  8.48350E-01  1.70502E-01  5.29259E-01  1.27572E+00
U    10000.    2  8.48350E-01  1.70762E-01  5.29638E-01  1.27675E+00
```

```
U    10000.    3  6.07459E-01  6.07459E-01  6.07459E-01  3.96000E+00
U    10000.    4  6.07459E-01  6.07459E-01  6.07459E-01  3.96000E+00
U    10000.    5  1.82870E-02  2.42781E-02  2.41336E-02  3.98372E+00
U    10000.    6  8.48350E-01  1.71384E-01  5.30543E-01  1.27921E+00
U    10000.    7  1.83515E-02  2.43268E-02  2.41823E-02  3.98366E+00
```

The section below lists information from the cuttings and caving calculation for this scenario-vector. Cavity and intrusion time do not affect this calculation.

```
*******************************************************************************
Calculating Cuttings and Cavings

DOMEGA    =  7.0090E+00    DENSITY   =  1.2100E+03    TAUFAIL   =  1.0250E+00
ABSRO     =  2.5000E-02    VISCO     =  9.1700E-03    YLDSTRSS  =  4.4000E+00
DRILDIA   =  3.1115E-01    COLDIA    =  2.0320E-01    FLOWRATE  =  3.0913E-02
ETA0      =  1.8340E-02    SIGMA1    =  1.0821E-06    SIGMA2    =  5.4103E-07

Initial Reynolds Number =       8244., Flow is TURBULENT
   If >=2100 assumes TURBULENT AXIAL Flow; <2100 assumes LAMINAR HELICAL Flow

VBAR Multiplier (CC) =  1.4295E+00

Collar     Drill      Final      Critical   Final      Reynolds   Solution
Radius     Radius     Radius     Radius     Area       Number     Algorithm
---------- ---------- ---------- ---------- ---------- ---------- ----------
1.0160E-01 1.5558E-01 2.6030E-01 9.0803E-01 2.1286E-01 5.8587E+03 TURBULENT
```

The section below lists information from the spalling calculation for all cavities and intrusion times for this scenario-vector. It then lists the cavings and cuttings area and spall volume, which appear on the output data file.

```
*******************************************************************************
Cuttings+Cavings and Spallings for Scenario 1  Vector   1

Spall Model: MODEL4

MODEL4: RNDSPALL = 1.664000E-01   Spall Vector   9

Cav  Time  Drill Diam (m)   Cut+Cav AREA  Rep Pres (pa)   Spall VOLUME

L     100.    3.111500E-01   2.128595E-01   9.390538E+05   0.000000E+00
L     350.    3.111500E-01   2.128595E-01   3.512741E+06   0.000000E+00
L    1000.    3.111500E-01   2.128595E-01   8.068527E+06   0.000000E+00
L    3000.    3.111500E-01   2.128595E-01   1.103574E+07   0.000000E+00
L    5000.    3.111500E-01   2.128595E-01   1.066139E+07   0.000000E+00
L   10000.    3.111500E-01   2.128595E-01   1.013201E+07   0.000000E+00

M     100.    3.111500E-01   2.128595E-01   9.428356E+05   0.000000E+00
M     350.    3.111500E-01   2.128595E-01   3.481091E+06   0.000000E+00
M    1000.    3.111500E-01   2.128595E-01   7.948160E+06   0.000000E+00
M    3000.    3.111500E-01   2.128595E-01   1.029245E+07   0.000000E+00
M    5000.    3.111500E-01   2.128595E-01   1.011404E+07   0.000000E+00
M   10000.    3.111500E-01   2.128595E-01   1.006624E+07   0.000000E+00

U     100.    3.111500E-01   2.128595E-01   9.456009E+05   0.000000E+00
U     350.    3.111500E-01   2.128595E-01   3.487050E+06   0.000000E+00
U    1000.    3.111500E-01   2.128595E-01   7.822204E+06   0.000000E+00
U    3000.    3.111500E-01   2.128595E-01   8.975890E+06   0.000000E+00
U    5000.    3.111500E-01   2.128595E-01   9.691426E+06   0.000000E+00
U   10000.    3.111500E-01   2.128595E-01   1.003875E+07   0.000000E+00
```

The output CAMDAT files for all cavities and intrusion times for this scenario-vector are written at this point.

```
*********************************************************************************
Writing CAMDAT files

   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_L_T100.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_L_T350.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_L_T1000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_L_T3000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_L_T5000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_L_T10000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_M_T100.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_M_T350.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_M_T1000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_M_T3000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_M_T5000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_M_T10000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_U_T100.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_U_T350.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_U_T1000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_U_T3000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_U_T5000.CDB
   U1:[CUSP_TEST.CDB600]CUSP_QA0600_TEST_11_S1_V001_U_T10000.CDB
```

The section below signals the start of processing for the next vector.

```
*********************************************************************************

                   *** SCENARIO 1 *** VECTOR    2 ***

*********************************************************************************
Retrieving vector parameters from input CAMDAT file
   U1:[CUSP_TEST.INPUT]LHS3_CRA1_CUSP_A1_R002.CDB;1

PI              3.141593E+00   Default
SECYR           3.168876E-08   Value
HREPO           3.960000E+00   Value
COLDIA          2.032004E-01   Value
DNSFLUID        1.210000E+03   CAMDAT material:property DRILLMUD:DNSFLUID
DOMEGA          1.154000E+01   CAMDAT material:property BOREHOLE:DOMEGA
ABSROUGH        2.500000E-02   CAMDAT material:property WAS_AREA:ABSROUGH
TAUFAIL         1.092000E+01   CAMDAT material:property BOREHOLE:TAUFAIL
VISCO           9.170000E-03   CAMDAT material:property DRILLMUD:VISCO
YLDSTRSS        4.400000E+00   CAMDAT material:property DRILLMUD:YLDSTRSS
SHEARRT         1.020000E+03   Value
MUDFLWRT        9.935000E-02   Value
DIAMMOD         3.111500E-01   CAMDAT material:property BOREHOLE:DIAMMOD
RNDSPALL        3.579000E-01   CAMDAT material:property SPALLMOD:RNDSPALL
```

... The rest of the file has been removed for brevity. Similar information is listed for each scenario-vector. For the first vector of the scenario, the input control file and spall model 4 data file information will be repeated. The scenarios will be ordered as defined in the master control file.

The output data file is written at the end of the CUTTINGS_S run. The section below will be written if CUTTINGS_S runs to completion.

```
*******************************************************************************
Writing Output Data File
   CUSP_QA0600_TEST_11_OUT.TBL


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


CUTTINGS_S_QA0600 CPU time is 0:05 (minute:second)




*** END OF CUTTINGS_S_QA0600 ***
CUTTINGS_S_QA0600 6.00 PROD QA0600 01/27/2005               01/27/2005 12:48:45
```