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7. Abstract

This document serves as the User's Manual for the TMAD code system, which includes the TMAD code and the LIBMAKR code.

CONTENTS

USER'S MANUAL FOR THE TMAD CODE

1.0 INTRODUCTION

1.1 PURPOSE

This document serves as the system user documentation for the TMAD code system, which includes the TMAD code and the LIBMAKR code.

1.2 SCOPE

The TMAD code was commissioned to make it easier to interpret moisture probe measurements in the Hanford Site waste tanks. In principle, the code is an interpolation routine that acts over a library of benchmark data based on two independent variables, typically anomaly size and moisture content. Two additional variables, anomaly type and detector type, also can be considered independent variables, but no interpolation is done over them. The dependent variable is detector response. The intent is to provide the code with measured detector responses from two or more detectors. The code then will interrogate (and interpolate upon) the benchmark data library and find the anomaly-type/anomaly-size/moisture-content combination that provides the closest match to the measured data.

1.3 OVERVIEW

The primary purpose of this document is to provide guidance to the users of the code. Guidance consists primarily of an input description.

1.4 DEFINITIONS

The following definitions will help the reader understand the neutron probe measurement process and the TMAD code:

TMAD   –   The name of the code being developed. The name was derived from the phrase "tank moisture and anomaly detection." TMAD also refers to the system of codes that includes TMAD and LIBMAKR.

LIBMAKR   –   The name of the auxiliary code being developed in conjunction with TMAD as part of the TMAD code system. LIBMAKR assembles the benchmark data into a library file.

Benchmark data   –   Predictions of detector response to different moisture contents, anomaly types, and anomaly sizes. These data are produced using the MCNP code (LANL 1986) to model the waste tank and probes.

Neutron probe   –   A device consisting of a neutron emitter and a neutron detector. The device is lowered to the bottom of a liquid observation well (LOW) and then slowly raised. While being raised, it continuously emits neutrons. At predetermined intervals it measures the number of neutrons per second reaching the detector.

Scan   –   The raw data recorded by the neutron probe (or other type of probe). It typically consists of a series of pairs of data points, with each pair consisting of a depth and a detector response.

Liquid   –   A pipe, closed at the bottom and open at the top, that observation has been inserted into the waste. By means of the LOW (LOW) probes can be lowered into the waste without coming into direct contact with the waste. Use of the LOW precludes the need to decontaminate the probe after every scan.

MCNP   –   The name of the code that will be used to model the detector response in the waste tank, thereby producing the benchmark data. The name is derived from the phrase "Monte Carlo neutron photon."

2.0 SYSTEM ENVIRONMENT

This section describes the hardware and software requirements for running the TMAD code.

2.1 HARDWARE

The TMAD code is designed to be used on a UNIX workstation. It has been implemented on the Silicon Graphics, Inc. (SGI,) workstations in the Scientific and Engineering Computing Center (SECC) network. The code can be run directly from the system monitor or from any computer or terminal with a telnet connection to the host machine.

2.2 SOFTWARE

The TMAD code system is written in the FORTRAN programming language and compiled with the f77 compiler under the UNIX operating system.

2.3 TYPICAL/MAXIMUM USE

The LIBMAKR code requires approximately 300 kb of memory and executes in less than 1 minute of real time (system time is insignificant).

The TMAD code requires approximately 500 kb of memory and has an execution speed of approximately 30 seconds for 1,000 data points. This information is based on a data library with three detector types and two

anomaly types. Larger libraries will result in proportionally longer run times.

The TMAD code system requires approximately 2 Mb of disk space to operate. This amount is based on the number of data points and library size stated above. Larger libraries or scans will result in proportionally greater space requirements.

3.0 INPUT DESCRIPTION

Users of the TMAD code need to consider five inputs: the benchmark data library file (produced by running the LIBMAKR code), the benchmark data files (required to run LIBMAKR), the probe scan files, the LIBMAKR interactive input, and the TMAD interactive input. Each of these is described in detail in the following sections.

3.1 BENCHMARK DATA LIBRARY FILE

This file consists of benchmark data representing all of the detector and anomaly data to be used in the TMAD analysis. Before running TMAD, create the library file and have it accessible. Create the library file by running the LIBMAKR code (see Section 3.4). See the system design description (SDD) for the TMAD code for more details of this input.

3.2 BENCHMARK DATA FILES

To run the LIBMAKR code requires two or more benchmark data files. These files contain the benchmark data (as produced by a modelling code such as MCNP) representing the detectors and anomalies to be represented in the benchmark data library. Each file represents a single detector-/anomaly-type combination. The files are ASCII formatted and contain data as indicated below. See the SDD for the TMAD code for more details of this input; a sample file appears in Appendix A.

    Line 1: Title.
    Line 2: Number of anomaly sizes.
    Line 3: Anomaly size; number of moisture values.
    Line 4: Moisture value; predicted detector value; standard deviation.
        Line 4 is repeated once for each moisture value.
        Lines 3 through 4 are repeated for each anomaly size.

3.3 SCAN DATA FILES

The TMAD code requires that two or more scan data files be analyzed. These files contain the measured detector responses for a scan with each file corresponding to a different detector. The files are ASCII formatted and

contain data as indicated below. See the SDD for the TMAD code for more details of this input; a sample file appears in Appendix B.

Line 1: Title.
Line 2: Date of scan (i.e., 12 29 1994).
Line 3: Number of data points in the scan.
Line 4: Depth in meters; detector response.
        Line 4 is repeated once for each data point in the scan.

3.4 LIBMAKR INPUT DESCRIPTION

LIBMAKR is a menu-driven code. Each of the possible options and their implications are described below.

Initiating the TMAD code prompts the user for the name of the benchmark data library file. Once this filename has been entered, the code checks to see whether the file exists. If the file does not exist, the code offers the user the options of aborting, creating a new library, or entering a new filename. This process is repeated until the user enters a valid filename or chooses to abort or create a new library.

If the user elects to create a new library, the code prompts for the effective date of the source code in the library.

Once the library file has been identified, the main menu appears, which includes the following options:

- Done
- Add data to library
- Delete data from library
- Modify weights
- List data in library
- Modify anomaly limits.

The first option, "done," exits the program. If the user selects any of the other options, once that option is executed, the user is returned to the main menu. This process is repeated until the user selects the "done" option.

The second option, "add," allows the user to identify a file containing benchmark data to be added to the library (see Section 3.2). The user is first prompted for a filename. The code checks to see whether the file exists, and if it does not, returns the user to the LIBMAKR main menu. Once a benchmark data file has been read, the user is prompted for a detector type and anomaly type to associate with the new data set. In either case, the user may select from those types already existing in the library or may identify a new type.

If a new detector type is specified, the user is prompted for a decay constant to associate with that detector type. The decay constant (λ) represents the radioactive decay rate of the source of a neutron probe. The decay constant must be entered in units of inverse days and can be calculated by dividing the natural log of 2 (= 0.693147) by the half life (in days) of

the source isotope. If the detector does not make use of a radioactive source (e.g., an electromagnetic induction probe), then the decay constant should be set to 0.0.

If a new anomaly type is specified, the user is prompted for minimum and maximum allowable sizes for the anomaly. After this data has been entered, the code writes out the benchmark data library file and returns to the main menu.

The third option, "delete," allows the user to delete a data set from the library. If this option is selected, the user is presented with a list of all the detector and anomaly types represented in the library. The user may select either a specific detector/anomaly pair or all data associated with one detector or one anomaly type. Selected data then are removed from the library and the library file is re-written.

The fourth option, "modify weights," allows the user to change the weighting factor associated with a particular detector or anomaly type. The user is first prompted for a new weight value and selects the data sets to apply it to. The weights can be used to "devalue" one or more of the detector/anomaly combinations. The default value for all of the weights is 1.0, and normally this value is not changed. The selection process here is the same as for the "delete" option. After the modification is complete, the code re-writes the library file and returns to the main menu.

The fifth option, "list," allows the user to list the data associated with a particular detector or anomaly type. The selection process here is the same as for the "delete" option. After the data have been listed, the code returns to the main menu.

The last option, "modify limits," allows the user to change the minimum and/or maximum sizes specified for a particular anomaly. After selecting an anomaly type to modify, the user is presented with the current minimum and maximum size limits and is prompted for new values. After the modification is complete, the code re-writes the library file and returns to the main menu.

3.5 TMAD INPUT DESCRIPTION

TMAD is a menu-driven code. Each of the possible options and their implications are described below.

Initiating the TMAD code prompts the user for the name of the benchmark data library file (see Section 3.1). Once this filename has been entered, the code checks to see whether the file exists. If the file does not exist, the user is given the options of aborting or entering a new filename. This process is repeated until the user either enters a valid filename or chooses to abort.

Once the library file has been identified, the main menu appears, giving the following options:

- Done
- Select scan data to analyze
- Analyze scan data.

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The first option, "done," exits the program. The second option, "select," takes the user to the Input Scan Menu (described below), and the third option, "analyze," initiates the processing of scan data. If either of the other options is selected, once that option has been executed, the user will be returned to the main menu. This process will continue until the user selects the "done" option.

The Input Scan Menu provides the user with the following options:

- Return to previous menu
- Select a scan
- Unselect a scan
- Change scan detector type
- List selected scan data.

The first option, "return," returns the user to the TMAD main menu. If the user selects any of the other four options, once the option has been executed, the user will return to the Input Scan Menu. This process will continue until the user selects the "return" option.

The second option, "select," allows the user to select a scan data file for inclusion in the evaluation. When the user selects this option, the code presents a list of previously selected scans (if any) and then prompts the user for a scan data filename (see Section 3.3). The code checks to see whether this file exists, and if it does not, returns the user to the TMAD main menu. If the file does exist, the code prompts user for the detector type associated with this file, after which the code will return to the input scan menu. Typically, the "select" option will be exercised several times.

The third option, "unselect," allows the user to replace one scan data set with another in the course of an evaluation. Selecting this option presents the user with a list of previously selected scans and prompts him/her to select one. The code then removes the designated scan from the list of scans to be evaluated and returns the user to the input scan menu.

The fourth option, "change scan detector type," allows the user to change the detector type assigned to a particular scan. Selecting this option presents the user with a list of possible detector types and the current setting, then prompts him/her to select a new detector type. The code then returns to the input scan menu.

The fifth option, "list," allows the user to list the data in one or more of the selected scans. After the data have been listed, the code returns to the input scan menu.

4.0 ERRORS, ERROR MESSAGES, AND RECOVERY

Error messages that may be generated by the TMAD code system and what to do in the event that an error is encountered is discussed in this section.

4.1 ERROR MESSAGES

The TMAD and LIBMAKR codes check for certain off-normal conditions and produce error messages when those conditions are detected. This section describes those error messages, what they indicate, and the appropriate user response.

"error found in input file, aborting"

This message is generated by the Addlib module of the LIBMAKR code when it is unable to read all of the data from a benchmark data file. This error results in the termination of the code execution. It is typically the result of an inappropriate file being specified to be read, or a formatting error in the file. When this error is encountered, the user should check to be sure that a valid file has been specified and that the file is formatted as described in Section 3.2. If the user is unable to resolve this error, the user should consult the code custodian.

"error encountered in reading library file, aborting"

This message is generated by the Getlib module, of both the TMAD and LIBMAKR codes, when it is unable to read all of the data from a benchmark data library file. This error results in the termination of the code execution. It is typically the result of an inappropriate file being specified to be read, or a corruption of the file. When this error is encountered, the user should check to be sure that a valid file has been specified. If that is not the problem, the user should attempt to locate a backup of the library file. Failing that, the library file should be recreated. If the user is unable to resolve this error, the user should consult the code custodian.

"error! isolcnt > MAXSOL"

This message is generated by the Analyze module of the TMAD code. It is produced when more solutions are produced, for a particular point in the scan, that the code can accommodate. Along with this message will be printed the total number of solutions and the maximum acceptable. The implication of this error is that a number of possible solutions have been discarded without evaluation and, as a result, the solution predicted for this point in the scan is suspect. Consult the code custodian if this situation in not acceptable.

"error! weights sum to 0, aborting"

This message is generated by the Gsolve module of the TMAD code. It is produced when the weights of the various points comprising a solution (for one point in the scan) sum to 0. This error results in termination of the execution of the code. This problem can be resolved by ensuring that all weights are greater than 1.0×10^{-6}. If this is not acceptable or does not resolve the problem, consult the code custodian.

"warning, no solution"

This warning message, written to the file tmad.debug, is generated by the Findsols module of the TMAD code. This message indicates that there is no intersection between the horizontal line formed by the measured detector response (for a given point in the scan) and the curve representing the

predicted relationship between the detector response and the moisture content (for a given anomaly type and size). This message is followed by additional information regarding the nature of the curve. The implication of this message is that the given anomaly type/size could not have resulted in the measured detector response, or that there is no unique moisture content that can be associated with it. The implication of this message is that the resulting solution for this point in the scan may be suspect. If this point is of particular importance, the user should consult with the code custodian.

"warning! split curve n, j, i"

This warning message, written to the file tmad.debug, is generated by the Getfit module of the TMAD code. This message indicates that the moisture/ anomaly size curve, for a given detector type/anomaly type, is split into two regions and the second region is being arbitrarily discarded. The implication of this warning is that the resulting solution, for this point in the scan, may be suspect. If this point is of particular importance, the user should consult with the code custodian.

4.2 UNDOCUMENTED ERRORS

In the event that an undocumented error (one not discussed in Section 4.1) is discovered by the user, the user should report that error to the code custodian. The report should include enough information so that the code custodian can reproduce the error but may otherwise be informal in nature.

4.3 SYSTEM FAILURE AND RECOVERY

In the event that the TMAD code system fails to function as documented, the user should report the problem to the code custodian. The report should include enough information so that the code custodian can reproduce the problem but may otherwise be informal in nature. The code custodian will inform the users when the code is again available for use.

APPENDIX A

SAMPLE BENCHMARK DATA FILE

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```
tmad test benchmark data, detector type 1, anomaly type 1
9
0. 9
   0. 1947. 20.
  10. 3363. 25.
  20. 4571. 33.
  30. 5596. 50.
  40. 6474. 49.
  50. 7241. 64.
  70. 8143. 77.
  80. 8473. 80.
 100. 8907. 61.
1. 9
   0. 1701. 18.
  10. 2981. 28.
  20. 4050. 30.
  30. 4944. 36.
  40. 5683. 51.
  50. 6526. 54.
  70. 7362. 74.
  80. 7632. 77.
 100. 8076. 69.
2. 9
   0. 1478. 16.
  10. 2602. 20.
  20. 3532. 33.
  30. 4359. 41.
  40. 5066. 38.
  50. 5701. 44.
  70. 6492. 53.
  80. 6711. 54.
 100. 7230. 54.
4. 5
   0. 1095. 14.
  10. 1973. 19.
  20. 2729. 23.
  30. 3320. 26.
  50. 4355. 30.
8. 5
   0.  695. 12.
  10. 1286. 16.
  20. 1695. 19.
  30. 2077. 20.
  50. 2677. 25.
11. 5
   0.  521.  7.
  10.  921. 17.
  20. 1260. 23.
  30. 1477. 26.
  50. 1929. 22.
15. 5
   0. 261. 5.
  10. 655. 9.
  20. 843. 11.
  30. 1031. 13.
  50. 1304. 25.
20. 5
   0. 200.  5.
  10. 443.  9.
  20. 574. 10.
  30. 695. 15.
  50. 904. 19.
25. 5
   0. 141.  5.
  10. 309.  7.
  20. 419. 11.
  30. 478. 12.
  50. 570. 12.
```

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APPENDIX B

SAMPLE SCAN DATA FILE

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```
tmad test tank scan, detector type 1
9 25 94
6
14.09666   6879
13.01462   5797
12.00878   1162
11.00294   1589
10.01234   230
 9.00650   15
```