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MATERIAL CONTROL SYSTEM SIMULATOR USER's MANUAL

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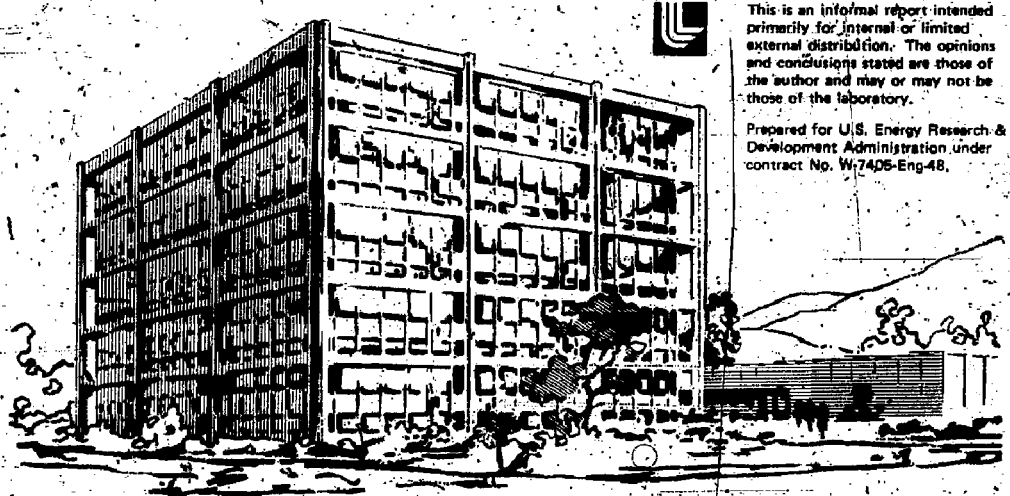

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MATERIAL CONTROL SYSTEM SIMULATOR
USER'S MANUAL

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PREFACE

The Material Control System Simulator program was developed for the United States Nuclear Regulatory Commission, Office of Nuclear Regulatory Research under research order no. 60-77-012 and the United States Department of Energy under contract no. W-7405-ENG-48.

CONTENTS

1 INTRODUCTION

PURPOSE OF MCSS

The objective of the Material Control Project at Lawrence Livermore Laboratory is the development of a methodology for use by the Nuclear Regulatory Commission in the assessment of material control and accounting systems. This report describes the use of a Material Control System Simulator (MCSS) program for determination of material accounting uncertainty and system response to particular adversary action sequences that constitute plausible material diversion attempts. The program is intended for use in situations where randomness, uncertainty, or interaction of adversary actions and material control system components make it difficult to assess safeguards effectiveness against particular material diversion attempts. Although MCSS may be used independently in the design or analysis of material handling and processing systems, it has been tailored toward the determination of material accountability and the response of material control systems to adversary action sequences.

SAFEGUARD SYSTEM SIMULATION APPROACH

The MCSS program provides a set of predefined modeling functions that are generic simulations of material processing and safeguard components. To simulate a particular system, the user selects MCSS functions that represent the relevant components, then assigns parameter values to define the performance characteristics and interconnection of all functions in the model. Initial values of system state variables are specified and the model

is operated in the computer to observe either its detailed behavior during a single simulation run or its probabilistic behavior over an ensemble of replicated runs.

Section 2 of this manual describes the preparation of input data, execution of the program, outputting of results, and provisions that aid in development of model systems. These are the mechanics of using MCSS.

Section 3 defines each of the MCSS functions in detail. The sixteen included in this first edition of the user's manual represent a variety of basic process and MC system components. They demonstrate the general capability and features of the MCSS program but are not a complete repertoire and many new functions are planned for addition in the future. It is also expected that revisions in many functions will be made as the requirements of design and assessment applications are better defined.

Section 4 contains two example applications that show in detail how functional models are constructed to determine the uncertainty of material balance area accountability due to measurement error and to obtain MC system response information that may be used in assessing the system's effectiveness against particular adversary action sequences. In the hypothetical systems simulated in these examples, eight different types of material, in various countable and continuous quantities, arrive at three receiving stations at times that deviate randomly from periodic schedules. Upon arrival, the incoming materials are measured and the observed quantities are recorded as entries in a material balance area accounting. Measurement uncertainty is characterized by systematic and random components of error. Random residence times in the material balance area are simulated by transport functions that convey material batches from incoming

measurement instruments to a single outgoing measurement instrument where all materials are again measured before placement in storage.

In the first example, the material balance uncertainty due to different measurement errors is determined for 4 week operating periods. Then data are collected over 10 and 50 replications of the 4 week operating period to determine the means, variances, and observed probability distributions of material balance errors at specified times over the ensemble of runs.

In the second example it is supposed that certain coordinated actions of two adversaries might accomplish diversion from batches in processing within the material balance area. Three actions are required of an adversary A and four actions are required of an adversary B to complete the material diversion. Adversary A disrupts the processing of materials received at one of the three receiving stations and thereby increases the mean time that those batches remain in the balance area. Adversary B performs two initial actions to gain access to the delayed material, acquires a specified amount from the processing operation within the balance area, and performs a final action in removing the material from the boundaries of the material control system. Various stimuli are presumed generated by these adversary actions and specific characteristics of the stimuli are assigned. Monitors, control actions, and decision functions of a hypothetical MC system are defined and parameter values are specified. The material processing, adversary action, and MC system models are first run for a period of 137 hours while tracing in chronological order all events that occur. The simulation run is then replicated 50 times while data are gathered for determination of means, variances, and observed probability distributions of the material balance uncertainty and the MC

response variables at specified times during the time interval of the simulated diversion attempt.

As they are now envisioned, systems that satisfy the NRC's performance based regulations will require the interaction of several different types of process and safeguards functions, many of which will involve uncertain phenomena that can be characterized only in terms of probabilistic parameters. Complexity and uncertainty involved in these systems make the credible prediction of their performance with respect to public safeguards very difficult. And the economic and strategic importance of these predictions only increase the need for credibility. By focusing attention on their functional elements, MCSS provides a systematic means of decomposing complex SNM processing facilities and their MC systems into subsystem models that can be validated individually and combined to predict safeguards effectiveness at the hierarchical levels of the NRC's performance based regulations.

PROGRAM FEATURES

Simplifies the Use of Computer Simulation

Computer simulation is often the only practical means of approaching the design or analysis of complex systems, especially those in which uncertainty is involved. But the simulation of complex systems is itself a complex problem, and the effort required to implement a computer simulation must be carefully weighed against the benefits expected from it. The details of simulation technique can easily obscure important information and insight concerning the system under investigation. MCSS simplifies the

simulation problem by providing a predefined set of functional elements whose specification in system models requires only information pertaining to the performance characteristics of material processing and safeguard components. Details concerning data structure, communications among interacting elements, scheduling of events, etc. are supplied and managed by the MCSS control program. The user needs no prior knowledge of computer programming or simulation.

Structured FORTRAN Program

MCSS is a conventional FORTRAN program that requires only an ANSI standard compiler for initial installation on most computing systems. Once the program has been installed, different model systems may be defined and operated without any additional compilation. The FORTRAN program is generated from a source program written in a specialized macro language that provides the control mechanisms of structured programming and simplified statements for recurrent segments of code. Its organization is based on the top-down philosophy of systematic programming (1,2), and its coding is made uniform by use of structured programming (3,4). Details of the program are described in the Material Control System Simulator Program Reference Manual (5).

Memory Space is Used Economically

Space for model system functions, material data, communications, etc. is allocated from a free storage pool as it is needed during the execution of the program, and it is returned to the pool when it is no longer needed. Since space is not allocated for a predetermined number of any of the

functional elements, and only space actually used at any time is taken from the free storage pool, the composition and size of model systems is limited only by the total storage space available. With 20,000 words of dynamic storage space available, which is approximately twice that required for the two example problems described in Section 4 of this manual, the file size of the complete program on the CDC 7600 computers at Lawrence Livermore Laboratory is 51,081 words. The memory requirements will vary somewhat on different computing systems and will increase as new modeling functions are added, however, many new functions and a two or three fold increase in the dynamic storage space available for model systems will require only about 128,000 words of memory which is available on some mini- and most mid-sized computing systems today.

Handles Any Number of Material Types

Material is represented by a recursive data structure in which the linkage of material data blocks defines the nature and level of material containment, and numerical contents of the blocks define the item count and or mass of particular types of material. Subprograms that manipulate material data are designed to handle an arbitrary number of material types, but in any particular system model the available storage space will eventually limit the number of material types that can be used.

Flexible Input Format

Input data that define and control the operation of model systems are easy to prepare using simple command language keywords: CREATE, DESTROY, PARAMETER, VARIABLE, RUN, REPORT and END. Numerical values are entered in a

type- and field-free format and may be interspersed with annotation to aid in the documentation of simulation results. Or, as may be the case if it is generated automatically by other programs, the MCSS input data can be compressed by omitting the annotation.

Application Oriented Output Format

Results are automatically tailored to the particular type of system being simulated because the MCSS program output is generated in the form of reports printed by the individual functions involved in a system model. Special report generation functions are also provided to gather, condense, and print output data in formats especially useful in system design and assessment applications.

Diagnostics

Error messages are printed and the simulation is halted when abnormal conditions occur that are caused by either system limitations or the user's violation of MCSS modeling rules. The simulation time at which the error occurred, the system program or functional element subroutine in control at the time of the error, and an explanatory note are followed by a dump of the complete model system which may be useful in diagnosing the cause of the error condition. Warning messages that include the time, program identification, and an explanatory note are also printed when non-fatal conditions occur that should be brought to the user's attention. Warning conditions do not produce a dump of the model system or halt execution of the program.

Model Building Aids

Tracing and interactive debugging capabilities are provided to aid in the development of complex simulation models. Tracing at various levels of detail is controlled by assignment of a numerical trace control parameter in the RUN command line. Model systems may be run without tracing, with trace messages written only at event times, with trace messages written at event times and upon each interaction of model functions, or at the times just mentioned and upon entry and return from key subprograms in the MCSS system. The user may elect to have trace messages written on an interactive terminal for immediate observation and possible intervention during the operation of a model system. Following the output of each interactive trace message, the user may interrogate any of the system common storage variables or any location in the dynamic storage allocation space. This provides a detailed, step-by-step debugging capability with which every event and every interaction among functional elements of the model system may be monitored.

2 USING MCSS

FUNCTIONAL MODELING

MCSS provides a set of predefined building blocks that represent functional elements of SNM processing facilities and MC systems. These functions include, for example, material receiving and shipping stations, material transport and processing operations, material measurement and storage, process control actions, adversary actions, monitoring, decision making, and reporting functions used to collect and display data on the performance of simulated systems. The user selects MCSS functions corresponding to those of the actual system being simulated and constructs a model system by assigning values to parameters that define performance characteristics of the individual functions and how they are interconnected. Behavior of the simulated system is investigated by observing the behavior of the interacting functional elements of the model system. Model systems may be observed in detail during individual simulation runs or data may be collected over an ensemble of replicated runs to obtain statistical information on the behavior of systems in which random variables represent either known variation in functional performance or uncertainty in the characterization of system components.

All of the MCSS functions are described in detail in Section 3 of this manual. The user must be aware of the full repertoire of modeling functions and be able to specify values of parameters and initial conditions of variables that correctly represent the functional characteristics of the actual system, but no prior knowledge of computer programming or simulation

is required to use MCSS. Model systems are defined and operated using a simple command language of seven keywords described below. Specification of model system parameters requires only information pertaining to the SNM facility/MC system. Details concerning data structure, communications among interacting elements, scheduling of events, etc. are supplied and managed by the MCSS control program.

PROGRAM INPUT

File MCSSIN

Input to the MCSS program must be placed in a file named MCSSIN. There may be any number of lines or records in MCSSIN, but there may be no more than 80 characters per line.

All of the MCSS functions used in a model system are defined in the input file. Specific values are assigned to all function parameters and to initial conditions of all function state variables not assigned automatically by the function subroutines. The number of replications and the time duration of each simulation run are specified. The input file also specifies whether the model system structure, parameters, and variables are to be displayed just prior to the start of the first run; whether trace messages indicating the occurrence of events and interactions among functions are to be written during the runs; and whether standard reports by all functions or only selected reports are to be produced at the end of each simulation run or set of runs.

The input file may also contain statements that modify a model system previously defined and run in the same input file. Old functions may be

destroyed and new ones added. Parameters and initial conditions of function state variables may be assigned new values. Using these features a particular system design may be investigated under a set of various operating conditions, or the effects of varying design parameters of a system may be determined for a particular operating condition.

Keywords

Seven keywords used in the input file provide basic instructions to the MCSS control program. These keywords are CREATE, DESTROY, PARAMETER, VARIABLE, RUN, REPORT, and END. Keywords must begin in the first column of an input line, however, they may also appear elsewhere in the annotation used to document an input file. To emphasize the keywords, it is recommended that only command lines that begin with a keyword be started in the first column and that all other lines of the input file be indented. This will eliminate accidental appearances of keywords where they are not intended.

CREATE n m x

This input line instructs the MCSS program to create function n of type m. n must be an integer between 1 and 100, the maximum allowable number of functions in a model system. Function numbers may be assigned arbitrarily by the user, but they must be unique. If an attempt is made to create a function that already exists, an error message will be written and the program will be halted. m is the 3-digit type number of the function to be created. Type numbers are given in the detailed function descriptions of Section 3. In general, any number of functions of a particular type may

appear in a model system where every function is an instance of its particular function type. 'x' is an arbitrary 4-character mnemonic function name which is also given in the detailed function descriptions of Section 3. The function names may be omitted from the CREATE input line, but they are recommended to remind the user of the function types and to simplify and standardize the preparation of model diagrams and input files.

DESTROY n

This input line destroys the previously created function n. If an attempt is made to destroy a function that does not exist, an error message will be written and the program halted. Annotation may be supplied on any number of following lines.

PARAMETER n

This input line notifies the MCSS program that the following lines contain values to be assigned to the parameters of function n. Function n must be created before parameter values are assigned. Any number of PARAMETER lines may be used to assign parameter values to function n, but it is recommended that all parameters be assigned at one time immediately following the creation of the function and thereafter only when changes are made in preparation for additional simulation runs. The parameter values that must be specified for each function are defined in Section 3.

Parameters are identified by integer indexes 1, 2, ... and may be either scalar or list valued. Scalar valued parameters are specified in the input lines following a PARAMETER line by entries of the type

... (i) ... v ...

where i is the parameter index, v is a blank delimited integer or real numeric value to be assigned to parameter i, and ... may be any character string not including a blank delimited numeric value. This means simply that scalar parameter values are specified by placing the parameter index in parentheses followed by the numeric value to be assigned to the parameter, and that the index identifier and numeric value may be interspersed with any string of characters used to annotate the parameter specification provided that the annotation does not contain parentheses or numeric values that could be confused with the intended parameter identification or assigned value.

List valued parameters are specified similarly by entries of the form

... (i j k) ... v ... v ... v ...

where i, v, and ... are as defined for scalar parameters and j and k are the lower and upper indexes respectively of consecutive list elements to be assigned the values v in the order of their appearance. For example, the input lines

```
PARAMETER 19
     (1) DEFINITION OF PARAMETER  8.304
     (2 1 3) DEFINITION OF PARAMETER LIST  5.1  3.2  9.5
```

indicate to the MCSS program that parameter values are to be assigned to function 19, that value 8.304 is to be assigned to scalar parameter 1, and that values 5.1, 3.2, and 9.5 are to be assigned to the first three elements of list valued parameter 2. Notice that the annotation could be omitted and the order of the assignment changed as in the following input lines that produce the same result:

```
PARAMETER 19
     (2 1 3)  5.1  3.2  9.5
```

(11) 8.304

All of the elements of a list valued parameter must be specified the first time values are assigned. This informs the MCSS control program of the total number of elements in the parameter list. After a list valued parameter has been initially defined, however, values may be assigned to any segment of contiguous elements. If, for example, we wished to change the last two elements of parameter 2 of function 19, we could do so as follows:

```
PARAMETER 19
      (2 2 3) NEW VALUE OF SECOND ELEMENT  2.2.
              NEW VALUE OF THIRD ELEMENT  8
```

The example above shows how parameter values may be placed on any number of lines following the parameter identifier and that the values may be interspersed with notes or explanations annotating the data. The user is free to arrange the parameter values in rows, columns, tables, or whatever arrangement is desired as long as the rules described above are strictly followed.

The last example also shows that parameter values may be entered as either integer or real numbers. The required parameter type is known to the function subroutine, so if an integer value is supplied for assignment to a real parameter, it will be converted to the corresponding real value, and if a real value is supplied for assignment to an integer parameter, it will be truncated to the next smaller integer value. Notice that real values are not rounded to the nearest integer value.

VARIABLE n

This input line notifies the MCSS program that the following lines contain values to be assigned to the initial conditions of state variables

of function n. Function n must be created before variable initial conditions may be assigned. Any number of VARIABLE lines may be used to assign variable initial conditions, but it is recommended that all assignments be made at the same time, immediately following the creation and assignment of parameter values for function n. Any of the user defined initial condition values of state variables may be changed by use of the VARIABLE input line between simulation runs specified in an input file.

Scalar and list valued initial conditions are specified in the input lines following a VARIABLE line in exactly the same way as described above for scalar and list valued parameter specifications. The format of parenthesized identifiers and value entries with interspersed annotation is the same. All elements of list valued initial conditions must be specified the first time they are assigned. Initial condition values may also be supplied in either integer or real form since they are converted to the required form by the MCSS program.

RUN n t i j k

This input line tells the MCSS program to operate the existing model system n times, starting at simulation time zero and ending at time t.

i is assigned integer value 0 to inhibit or value 1 to enable the output of the model structure, parameter values, and initial values of state variables just before the start of the first run. This is referred to as a dump of the model system. It may be used to verify in detail that the parameter and variable assignments have been incorporated into the model system and as a precise record of the system used in simulation runs. Once

a model system has been developed, it will seldom be necessary to request dumps of the complete system.

J is assigned integer values from 0 to 6 to control the trace messages written by the MCSS program during the operation of the model system. Use of the trace control parameter J is described below under MODEL DEVELOPMENT: Tracing.

k is the standard report control parameter. If it is assigned value 0, only reports generated by REPORT lines following the RUN line are generated. If k is assigned value 1, the MCSS program automatically requests a report by each function in the model system. This is called a standard report because a report is requested of every function in the model, however, the standard report is actually tailored to the model system because it is generated by the functions involved rather than by a general purpose report generator.

REPORT n

This input line instructs function n to write a report on its current status into the program output file. REPORT lines will normally be used only following a run line that specifies an operation of the model system over a specific simulation run or set of runs in which data are collected for subsequent analysis and reporting. Reporting features of MCSS functions are described in Section 3 of the manual.

END

This input line terminates the MCSSIN input file and produces a normal exit from the MCSS program. If omitted, an MCSS error message will be

written indicating that no END line was found in the input file. This will also terminate execution of the MCSS program, but it will produce a dump of the current model system which is usually not needed. The END line should be used to terminate MCSSIN input files because some computer operating systems may abnormally terminate execution of the program if an "end of file" is encountered as MCSS reads on looking for additional keyword input lines.

Format

The general format of an MCSS input file is as follows:

```
CREATE n m x
PARAMETER n
    ... (i) ... v ... (i j k) ... v ... v ... v ...
VARIABLE n
    ... (i) ... v ... (i j k) ... v ... v ... v ...
RUN n t i j k
REPORT n
CREATE n m x
DESTROY n
PARAMETER n
    ... (i) ... v ... (i j k) ... v ... v ... v ...
VARIABLE n
    ... (i) ... v ... (i j k) ... v ... v ... v ...
RUN n t i j k
REPORT n
END
```

where the input lines beginning in column 1 with keywords are as described above and ... stands for any string of characters used for annotation that does not contain blank delimited parentheses or numeric values that could be confused with identifiers or values to be assigned to parameters or the initial conditions of function state variables. Any number of input lines of the type indicated may be used where they appear above and any order of input lines may be used provided, of course, that functions are created before they are assigned parameter values or initial condition values for state variables or before they are destroyed.

PROGRAM EXECUTION

Once the program has been installed on a computing system, its use involves three steps:

- o preparation of the input file MCSSIN
- o execution of the MCSS program
- o printing of the output file MCSSOUT

Using the keywords, data format, and annotation described above, the input file MCSSIN may be prepared by any available means, for example, on cards (off line) using an ordinary keypunch, or on disk (on line) using a text editing utility program. The user may assign arbitrary names to input files and change the names to MCSSIN at the time they are to be used for input to the MCSS program. The file names should be declared in the annotation of the input files so that the names will also appear in the output file MCSSOUT and there will be no confusion as to which input file produced a particular output.

The procedure used in actual execution or running of the MCSS program

will depend upon the operating system and management of the user's computer. On the LTS system at Lawrence Livermore Laboratory, the program is available as a controllee by the name MCSS. The command

MCSS / t v

will read data from an existing input file MCSSIN, create an output file MCSSOUT, and interact via the user's terminal. So that controllee MCSS may be retained in read-only status, a dr[illegible]MCSS is created each time the program is executed.

The output file MCSSOUT generated by execution of the MCSS program may be printed by any means available. On the LTS system at Lawrence Livermore Laboratory, utility routine ALLOUT may be used to print the output file on either the RJET or high speed printers. If more than one output file is to be generated before printing, the last one generated should be assigned a name other than MCSSOUT before each execution of the program. If this is not done, the LTS system will generate a family of output files with unique names obtained by modifying the last character of the otherwise duplicate name. This procedure is acceptable if the user has identified the input files internally as recommended earlier; if not, it may be difficult to determine which output file was produced by a particular input file. Confusion of this sort can be avoided by attaching numeric suffixes to MCSSIN in naming input files and the same suffixes to MCSSOUT in naming output files.

PROGRAM OUTPUT

File MCSSOUT

Program Output

A new output file MCSSOUT is created by the MCSS main program each time it is executed. The file will be on the output mass storage device (normally disk) defined at the time the MCSS program is installed on the user's computer. The file is sequential. The first line

MATERIAL CONTROL SYSTEM SIMULATOR VERSION 1.0 1/1/78

is written by the MCSS main program for identification. The remaining lines are written by MCSS control programs and function subroutines during the execution of the program. Each line of the input file MCSSIN is copied into the output file with results produced by execution of the program inserted as they are generated. Dumps of the model system immediately follow the RUN line in which they are requested. Trace messages written into the output file during operation of the simulated system follow the model system dump output. If a standard report is requested by assigning value=1 to RUN line parameter k, the trace messages are followed by a table showing the number of times program control entered each of the function subroutines of the model system and the fraction of the total number of entries. An individual report is then generated by each function of the model system. Finally, the minimum number of free locations in the MCSS dynamic storage space during the program execution is written into the output file when execution is terminated by an END line in the input file. The output file is, therefore, a complete record of the model system and the results of simulation runs.

Reports

Reports generated by individual functions all begin with a line of the form

FUNCTION n m x

where n, m, and x are the function number, function type, and mnemonic function name as appears on the CREATE line of the input file. Contents of the individual function reports vary from the simple statement NO REPORT, indicating that no data were collected during the simulation run or runs, to elaborate reports that require computation of mean and standard deviation statistics from a collection of observations, tabulation of maximum and minimum values of observed quantities and the times at which the maximum and minimum values first occurred during the run, and plots of histograms that display the distribution of samples of random variables collected during the operation of the model system. Details of the reporting features of MCSS functions are described in Section 3 and examples are shown in Section 4

MODEL DEVELOPMENT

Dumps

If RUN line dump control parameter 1 is assigned value 1, MCSS common storage variables, the structure, parameters, variables, and variable initial conditions of each function of the model system; and the current status of free store space are printed following the RUN line. The MCSS common storage variables are defined as follows:

MTO — The last function to receive a communication. In dumps requested via the RUN line, this will be the last function in the model system to receive a communication instructing it to set initial condition values of state variables. In dumps generated by an MCSS error condition, MTO will be the last function that received a communication before the error occurred.

MFROM — The last function that transmitted a communication at the time the dump was generated. In dumps requested via the RUN line dump control parameter, this will be 0, the function number assigned to MCSS control programs for communications with

functions of the model system.

ICTYPE	A code integer indicating the type of the last communication that was transmitted at the time the dump was generated: 1 = create an instance of a particular function type, 2 = destroy a particular function, 3 = assign parameter values, 4 = assign initial condition values, 5 = print function report, 6 = set initial condition values of state variables, 7 = print data in dump format, 8 = event notice, and 9 = interaction message.
IPOINT	Location in MCSS dynamic storage space of data associated with the last communication.
IDUMP	Current value of the RUN line dump control parameter.
ISECA	Increment size of the event chain storage allocation. This is the number of additional storage locations allocated if the space needed to store scheduled event notices exceeds the space previously allocated.
ITRACE	Current value of the RUN line trace control parameter.
LB	Location in MCSS dynamic storage space of the last function to assume control of program execution.
LBCA	Location of the free storage block currently being checked for adjacency with blocks on the free store chain.
LBLIST	Location of the list of functions in the current model system.
LBPT	Location of the table of pointers to functions in the model system arranged by function number.
LBUF	Location of an 80-word buffer in dynamic storage space allocated to the MCSS main program and used by various MCSS control programs.
LCSB	Location of a dynamic storage block containing the location returned by MCSS control function LCS.
LE	Last location of the last function to assume control of program execution.
LEC	Location of the event chain containing, in chronological order, notices of currently scheduled events.
LFFB	Location of the first free block of dynamic storage space.
LFFE	Location of the first free event notice.
LI	Location of the first initial condition value of the last

function to assume control of program execution.

LLE	Location of the last event notice on the chain of scheduled events.
LLFB	Location of the last free block in MCSS dynamic storage space.
LLFE	Location of the last free event notice.
LMS	Location of the message stack used by MCSS control program SEND to verify the acknowledgement of communications among interacting functions of the model system.
LNE	Location of the next scheduled event.
LP	Location of the parameters of the last function to assume control of program execution.
LV	Location of the variables of the last function to assume control of program execution.
MINNFL	Minimum number of free locations in free storage space.
MNSE	Maximum number of scheduled events.
NFE	Number of free event notices.
NFL	Number of free locations in MCSS dynamic storage space.
NI1	Number of the device from which input file MCSSIN is read.
NI2	Number of the device from which interactive user input is read.
NO1	Number of the device on which output file MCSSOUT is written.
NO2	Number of the device on which interactive output is written.
NREP	Number of replicate runs currently specified.
NRUN	Number of the current run in a replicate set of runs.
NSE	Number of scheduled events.
TIME	Current value of simulated time.
TSTOP	Stopping time of the currently specified simulation run or set of replicate runs.

After listing the values of common storage variables defined above, a

dump includes a printout of the structure, parameters, variables, and initial conditions of each function in the model system. The function dumps are generated in numerical order and have the following format:

```
FUNCTION     n
LD+00                L        function type
   + 1               L        number of storage locations occupied
   + 2               L        function number
   + 3               L        number of parameters
   + 4               L        number of variables
LP+ 0        1       L        0
   + 1       T       L        value (location of parameter types 2 or 4)
                                 (values of parameter types 2 or 4)
   + 2       T       L        value (location of parameter types 2 or 4)
                                 (values of parameter types 2 or 4)
    .
    .
    .
LV+ 0        1       L        0
   + 1       T       L        value (location of list valued variables)
                                 (values of list valued variables)
   + 2       T       L        value (location of list valued variables)
                                 (values of list valued variables)
    .
    .
    .
LI+ 0        1       L        0
   + 1       T       L        value (location of list valued initial condition)
                                 (values of list valued initial conditions)
   + 2       T       L        value (location of list valued initial conditions)
                                 (values of list valued initial conditions)
```

In the function data dump format above, n is the function number, L is an integer location in MCSS dynamic storage space, and T is an integer code indicating a type of parameter or variable: 1 = integer scalar, 2 = integer list, 3 = real scalar, and 4 = real list. Notice that parameter 0 and variable 0 are always integer scalars assigned value zero. Parameter 0 is used as a pointer location during communications initiated by the function, and variable 0 is used to count the number of times program control enters

the function subroutine. Parameter 0 and variable 0 are never assigned values by the user.

Values of common storage variables associated with the event chain and the chain of scheduled event notices are printed next, following the dump output of the last function in the model system. From left to right, the data printed for each of the scheduled events in the chain are as follows: i) location of the event notice, ii) location of the next event notice on the chain, iii) time of the scheduled event, iv) function in which the event will occur, v) event code, and vi) the location of data associated with the scheduled event.

The dump output is completed by listing the common storage variables associated with the free store chain and, for each block in the chain, the location of the block, the location of the next block in the chain, and the number of available locations in the block. This allows the user to examine the free storage space at the beginning of a simulation run. If a large number of small blocks have accumulated at the beginning of the free store chain as a result of previous simulation runs and modifications of a model system, long runs involving many replications should be avoided. They can be run most effectively just after a system has been defined, when the free store space consists of a single block. In this case, the MSSS program saves the status of the free storage space at the time the first of a replicated sequence of runs is started and restores the free storage space to this condition at the beginning of each of the replicated runs. This avoids gradual depletion of free storage space over a set of replicated runs in which some of the space allocated during the run is not returned during

the run and is not recovered at the time initial conditions are reset before the next run.

Tracing

In the development of complex model systems, the user may need to verify the detailed operation of the system by tracing the occurrence of events and interactions among functions. This capability is provided by the trace control parameter J of the RUN line. If J is assigned value 0, no trace messages are written. Assigning a value 1 instructs the MCSS program to write event messages into the program output file each time an event occurs. Event messages indicate the time of occurrence, the number of the function in which the event occurred, a general notice that an event has occurred, and various specialized messages that are written by the individual functions. If the RUN line trace control parameter J is assigned value 2, the event information is written into the program output file and also onto the interactive output device for immediate observation and possible intervention by the user. When trace messages are sent to the interactive output device, the program prints the message and waits for either a user request for additional information or an instruction to continue operation of the model system. Requests for information are placed by typing either the symbolic name of a variable whose numeric value is to be displayed or an abbreviation of an operation to be performed such as printing out information on the next several events that have been scheduled or printing out the detailed description of material at a particular location in memory. Details of user interaction with the program will be described below in the section on model development.

If the RUN line trace control parameter J is assigned value 3, the MCSS program writes messages into the output file each time an event occurs and each time there is an interaction among functions of the model system. Interaction messages indicate the time of the interaction, the number of the function that has received an interaction message, a general notice that an interaction has taken place, and various specialized interaction messages that are written by the individual functions. If J is assigned value 4, the same information is also written on the interactive output device.

When the RUN line trace control parameter J is assigned value 5, detailed diagnostic messages are written into the program output file by key MCSS subprograms in addition to the event and interaction information just described. And when J is assigned value 6, all detailed diagnostic information is also written on the interactive output device.

Use of the RUN line trace control parameter J is summarized in Table 2.1.

TABLE 2.1 Use of RUN line trace control parameter J.

J	Trace information generated
0	None
1	Event notices and messages are written into the program output file.
2	Event notices and messages are written into the program output file and on the interactive input/output device.
3	Event notices and messages and interaction notices and messages are written into the program output file.
4	Event notices and messages and interaction notices and messages are written into the program output file and on the interactive input/output device.
5	Event notices and messages, interaction notices and messages, and MCSS subprogram diagnostic messages are written into the program output file.
6	Event notices and messages, interaction notices and messages, and MCSS subprogram diagnostic messages are written into the program output file and on the interactive input/output device.

User Interaction

When event, interaction, or program messages are written on the interactive output device, the user may continue operation of the model system by entering a carriage return, request current information by typing the symbolic name of a variable or diagnostic operation, or discontinue operation of the model system by typing ABORT. Values of any of the MCSS common storage variables may be requested by typing the symbolic name

defined above. The following diagnostic operations are performed by typing the name of the operation shown at the left:

ABORT	The error message USER ABORT is written into the program output file, a model system dump is generated, and execution of the program is halted.
EVENTS(N)	The first N event notices in the scheduled event chain are written on the interactive output device. Data contained in the event notices are, from left to right, the location of the event notice, the location of the next event notice on the event chain, the time the event is scheduled to occur, the function in which the event will occur, the event code, and the location of data associated with the scheduled event.
FREE	The current status of the free store chain is displayed by listing, for each block in the chain, the location of the block, the location of the next block in the chain, and the number of available locations in the block.
IA(n)	The contents of dynamic storage location IA(n) are written on the interactive output device.
IA(n,m)	The contents of dynamic storage locations IA(n) through IA(m) are written on the interactive output device.
IAC(L,n)	The contents of dynamic storage location IA(LCS(L,n)) are written on the interactive output device.
IAC(L,n,m)	The contents of dynamic storage locations IA(LCS(L,n)) through IA(LCS(L,m)) are written on the interactive output device.
MATL(L)	The material data structure at location L is written on the interactive output device. See Appendix B for a description of MCSS material data structure.
MSG	If the last communication was an event notice (ICTYPE 8), the event code and location of event data are written on the interactive output device. Otherwise the current values of common variables MFROM, MTO, ICTYPE, and IPOINT are written followed by the eight integer values in the message block at IPOINT.
RA(n)	The contents of dynamic storage location RA(n) are written on the interactive output device.
RA(n,m)	The contents of dynamic storage locations RA(n) through RA(m) are written on the interactive output device.
RAC(L,n)	The contents of dynamic storage location RA(LCS(L,n))

are written on the interactive output device.

RAC(L,n,m) The contents of dynamic storage locations RA(LCS(L,n)) through RA(LCS(L,m)) are written on the interactive output device.

Error and Warning Messages

When the MCSS program detects conditions that will invalidate the results of a simulation run, an error message is written into the program output file, a model system dump is generated, and the program is halted. Error messages have the format

```
*****ERROR*****
ERROR MESSAGE
```

and the model system dump format is as described above.

When the MCSS program detects conditions that should be brought to the attention of the user but which in themselves do not invalidate the results of a simulation run, a warning message is written on the interactive output device and the run is continued. The warning message is not written into the program output file, and no dump of the model system is generated. Warning messages have the format.

```
*****WARNING*****
WARNING MESSAGE
```

3. MCSS MODELING FUNCTIONS

INTRODUCTION

This section of the manual describes each of the MCSS functions and defines the information that must be supplied when they are used in model systems. Each description includes:

- o the function type number and mnemonic name,
- o a detailed description of the simulated process or MC system function,
- o reporting features,
- o events that may occur within the function and interactions with other functions caused by these events,
- o interactions caused by events that occur in other functions,
- o parameters that must be specified for each instance of the function used in a model system,
- o initial conditions of state variables that must be specified for each instance of the function used in a model system, and
- o error and warning messages printed when abnormal or suspicious conditions occur.

CLASSIFICATION OF MODELING FUNCTIONS

MCSS modeling functions are divided into nine categories indicated by the silhouette of symbols used in model diagrams and the first digit of function type numbers as shown in Table 3.1. The symbol silhouettes and mnemonic names are easily memorized and simplify the graphical representation of complex systems by eliminating the need for annotation

explaining the general purpose of functional elements. Function type numbers are unique and define a specific type of functional element whose characteristics and specifications are described in the following segments of this section. Diagram symbol silhouettes and mnemonic names are not

TABLE 3.1 Categories of MCSS functions.

Function Type Number	Diagram Symbol	Category
1xx		ENTRY functions simulate the arrival of entities entering system boundaries.
2xx		EXIT functions simulate the departure of entities leaving system boundaries.
3xx		TRANSPORT of material or information within system boundaries.
4xx		STORAGE of material or data without altering their properties.
5xx		PROCESSING operations on material or data that alter their properties form, contents, etc.
6xx		CONTROL actions of personnel or equipment in directing the operations of simulated systems.
7xx		MONITOR functions collect data related to the operations or performance of simulated systems.
8xx		DECISION functions transform the output of monitor functions into control actions or responses.
9xx		REPORT functions collect and reduce data related to the performance of simulated systems.

unique and may be shared by several modeling functions of similar type.

101 RCMB Receive Material Batches

Function

Batches of material are received at discrete times determined by random deviations from a periodic schedule. Any number of arrivals may be scheduled at arbitrary times within each period. The deviations of actual arrival times from the scheduled times have a uniform distribution with zero mean.

Any number of different material types may be received in either bulk form or in containers. The amounts of each material type received in bulk batches and in individual containers are characterized by uniform distributions over integer values of item count and/or by truncated-normal distributions of material mass. The number of containers received in individual batches also may vary randomly with a uniform discrete probability distribution.

Materials are not stored in the 101 RCMB function. At arrival times, a transport function is notified, and, if it fails to remove the incoming material, an error message is written and the simulation is halted.

Timing may be controlled by a 601 TIMR function to simulate, for example, arrivals of incoming materials at a receiving dock operated only during specified working hours.

Report

Each instance of the 101 RCMB function reports the number of material batches received during the reporting interval.

The trace level 1 message MATERIAL BATCH RECEIVED is written when a

batch has been received and accepted by the transport function connected to the 101 RCMB function.

Events

Arrivals of material batches are the only events that occur in 101 RCMB functions. When an arrival occurs in a receiving function that is controlled by a 601 TIMR function, the timer is checked to determine operational status of the receiving function. If it is in operation at the arrival time, data representing the incoming material is generated according to the material specifications of the receiving function, the transport function is notified, and the next batch arrival is scheduled. If the function is not in operation at the arrival time, the arrival is rescheduled to occur at the next time the receiving function will resume operation. If the receiving function is not controlled by a 601 TIMR function, all arrivals are accepted whenever they occur.

Interactions

Events that occur in other functions do not cause interactions with 101 RCMB functions. If an illegal interaction message is received, an error message is written and the simulation is halted.

Parameters

(1) Period of the batch arrival schedule. (2) Number of batch arrivals scheduled per period. (3 n m) Scheduled times, in chronological order, of batch arrivals within each period. (4) Maximum uniform deviation from the scheduled arrival times. (5) Number of different bulk material types.

received. (6, n m) Bulk material specifications. Repeat the following for each material type: i) mean count (number) of discrete items, ii) maximum uniform deviation from the mean count, iii) mean mass, iv) standard normal deviation of mass, v) maximum mass; vi) minimum mass. (7) Number of different material types received in containers. (8 n m) Specifications for material received in containers. Repeat the data i) through vi) above for each material type. (9) Mean number of containers received in individual batches. (10) Maximum uniform deviation from the mean number of containers received in individual batches. (11) 601 TIMR timing code. (12) 601 TIMR function. (13) Destination function. This is the function to which the received material is to be transported. (14) Transport function.

Errors,

PARAMETER 10 LARGER THAN PARAMETER 9--This could cause the receipt of a negative number of containers. The parameter values are checked at initial condition time to avoid repeated testing for a negative number of containers at batch arrival times. ATTEMPT TO SET INITIAL CONDITIONS--The user has illegally attempted to specify an initial condition value. All state variables of the 101 RCMB function are assigned automatically by the function subroutine. ILLEGAL INTERACTION--An interaction message other than an expected response from a transport function has been received. MATERIAL NOT REMOVED AT ARRIVAL TIME--The transport function did not accept the batch of material received at an arrival time.

102 IDAS Initiate Diversion Action Sequence

Function

This function initiates one or more sequences of adversary actions that constitute a simulated material diversion attempt. The objective of the attempt may be to remove a number of discrete items of bulk material, a mass of bulk material, a number of discrete items from containers, a mass of material from containers, or a number of entire containers from certain target functions in the model system. The amounts of material actually removed from particular target functions are random variables characterized by the mean and maximum deviation of uniformly distributed numbers of items or containers and by the mean and standard normal deviation of mass. These data are specified by the first eight elements of the single list valued parameter of the 102 IDAS function. The remaining elements of the parameter specify the order of actions in the sequences and the time delays between the completion of one action and the beginning of the next. The order of actions in each sequence is specified by an ordered list of the numbers of the corresponding model functions, where a negative function number designates the first action of a sequence. The action starting time delay distribution type and statistics are inserted in the lists following each action function number. The starting time of each sequence is specified by the characteristics of the time delay of the first action in the sequence.

A single parameter is used in the 102 function to simplify the passage of these objective, order, and timing data to functions simulating adversary actions. Target functions from which material is removed during diversion

sequences are specified by the individual material acquisition action functions rather than by 102 IDAS functions.

Report

No information is gathered by 102 IDAS functions. The message NO REPORT is written when reports are requested.

Events

No events occur in 102 IDAS functions. If an illegal event notice is received, an error message is written and the program is halted.

Interactions

No interaction messages are received from other functions in the model system; if an illegal interaction message is received, an error message is written and the program is halted.

Parameters

(1 n m) Diversion objective and action sequence specifications: i) objective type where 1 = countable items of bulk material, 2 = mass of bulk material, 3 = countable items from containers, 4 = mass from containers, and 5 = containers; ii) material type where 0 = blended materials and positive integer = specific material type; iii) mean number of countable items to be removed by each acquisition action; iv) maximum uniform dev'ation of the number of countable items to be removed; v) mean mass of bulk material to be removed by each acquisition action; vi) standard normal deviation of the mass to be removed by each acquisition action; vii) mean number of

containers to be removed by each acquisition action; viii) maximum uniform deviation of the number of containers to be removed by each acquisition action; (repeat items ix through xi for each action of the specified sequence) ix) action function (negative for the first of a sequence); x) action starting time delay distribution type; and xi) action starting time delay statistics (number of values depends on the distribution type).

Initial Conditions

No initial condition values of variables are specified by the user. If an attempt to set initial condition values is made, an error message is written and the program is halted.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are assigned automatically by the function subroutine. ILLEGAL EVENT MESSAGE--An illegal event notice has been received. ILLEGAL INTERACTION--An illegal interaction message has been received.

301 TRMB Transport Material Batches

Function

This function transports batches of material from point to point within a model system. Its performance is characterized only by the time required to complete transport operations, so the 301 TRMB function may be used to simulate different methods of conveyance. The random transport time is defined by the mean and maximun deviation of a uniform probability distribution.

The 301 TRMB function may be used to transport bulk and or containerized materials in any of the MCSS batch configurations, and the dashed or broken line used to represent the function is to remind the user of its applicability to batch transport. Solid lines represent functions that transport continuous material flow streams.

Any number of material batches may be transported concurrently from one source function to another destination function. Or if several transport operations have the same transport time statistics, they may be simulated by the same 301 TRMB function, even though they involve different source and destination functions. If the effect on the reporting characteristics are acceptable, this may significantly reduce the number of transport functions required to simulate a particular system. The user should think of the 301 TRMB function as a batch transport capability that may be employed at one or more locations in the model.

Material is removed from the source as soon as the transport function is notified that it is available for transport. The material is then held in the transport function for the duration of the transport operation, after

which it is transferred to the destination. The 301 TRMB function always accepts material from a source function, and it will halt the simulation if material is refused by a destination function.

When material batches are received and when the batches are delivered to the destinations, a list of functions are notified with an indication of the location of the batch then entering or leaving. This gives the notified functions an opportunity to acquire material at the beginning or end of the transport operation. Material may also be acquired at any time during the transport operation. Batches of material in transport are chained in the order they are received, so functions that make material acquisition attempts are free to remove material from any of the batches then in the transport function.

Report

Each 301 TRMB function reports the maximum number of batches concurrently in the transport function during the reporting interval and the time at which the maximum first occurred. These data apply to all of the transport operations simulated by a particular 301 TRMB function. If they are required for individual transport operations, separate transport functions must be used even though they may have the same transport time statistics.

Events

When a transport function is notified that material is ready for transport, it immediately removes the material from the source function. The actual time required to transport the batch is then determined by

generating a sample value of the random transport time variable. If the actual transport time is greater than zero, an event is scheduled to occur at the future time at which the transport operation is to be completed. (Zero transport times will not occur if the mean of the random transport time is greater than the maximum deviation, but instantaneous transport operations are sometimes desired and may be simulated by assigning zero values to these parameters.) If the transport time is zero, the transport operation is completed immediately and there is no need to schedule a future event.

At the times these scheduled events occur, the transport function notifies the destination function that material has arrived. If the destination function does not accept the material at the time the transport operation has been scheduled for completion, the transport function writes an error message and halts execution of the program. The trace level 1 message TRANSPORT COMPLETED is written when a transported material batch has been accepted by a destination function.

Interactions

Two types of interaction messages are accepted by 301 TRMB functions. The first is a notice that a material batch is ready for transport. When this type of message is received, the batch is accepted. Then, if the mean transport time is greater than zero, the batch is placed on a chain in the order received with other batches in the transport function. The event that completes the transport operation is then scheduled and the trace level 3 message TRANSPORT STARTED is written. If the mean transport time is zero,

there is no need to place the batch on the chain, and the transport operation is completed immediately.

The second type of interaction message is a notice that a material acquisition attempt is to be made on material currently in the transport function. The transport function returns the location of the last batch received, but, since all batches currently in transport are chained to this batch, the function making the diversion attempt is free to remove material from any batch it finds in the transport function. The trace level 3 message *MATERIAL ACQUISITION ATTEMPT* is written at the time this response is returned to the interacting function.

Parameters

(1) Mean transport time. (2) Maximum deviation of the uniform transport time distribution. (3) List of functions to be notified when material batches enter and leave the transport function.

Errors

PARAMETER 2 LARGER THAN PARAMETER 1--This could cause negative transport times. The parameter values are checked at initial condition time to avoid repeated testing for negative transport times each time a transport is started. ATTEMPT TO SET INITIAL CONDITIONS--The user has illegally attempted to specify an initial condition value. All state variables of the 301 TRMB function are assigned automatically by the function subroutine. ILLEGAL INTERACTION--An illegal interaction message has been received. Another function may be incorrectly connected to or incorrectly reference the transport function. MATERIAL NOT REMOVED AT TRANSPORT TIME--A

destination function failed to accept a batch of material at the time a transport operation was to have been completed. RESPONSE TO CONDITION NOTICE - A function notified at the beginning or end of a transport operation failed to acknowledge the condition message.

401 STOM Store Material

Function

Bulk materials and/or portable containers placed in this function are stored indefinitely or until they are removed by other functions. Bulk materials are homogeneously mixed in a single storage vessel where some may be "held up" by adhering to contacted surfaces. A single-deposit hold up model simulates the storage of materials that adhere to the vessel surfaces on initial contact and are not dislodged or replaced, nor does additional material adhere to that initially deposited. A re-deposit hold up model simulates the storage of miscible liquids that adhere to surfaces but also mix rapidly with materials later placed in the vessel. The bulk storage vessel is a vertical cylinder with specified end area and vertical surface area contacted per unit mass of stored material. Portable containers are stored in the order received, but they may be removed in any order.

A schematic of the material in 401 STOM storage is shown in Figure 3.1, and the corresponding data structure is shown in Figure 3.2. All material is either i) stored at location SM and available for routine removal by other functions or ii) held up bulk material at location HBM which may be removed only by simulated clean out operations. Stored bulk materials A, B, ... at location SBM are homogeneously mixed and are removed only with other materials in storage at the time of the removal. Held up bulk materials X, Y, ... at location HBM are also homogeneously mixed and are cleaned out only with other held up materials. The holdup mechanism is represented by either a single-deposit or a re-deposit model as follows.

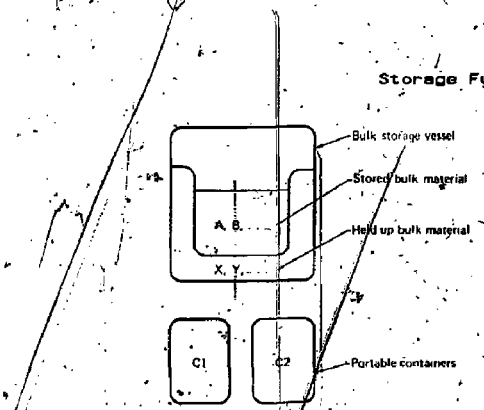


FIGURE 3.1 Schematic of material stored in 401 STOM functions.

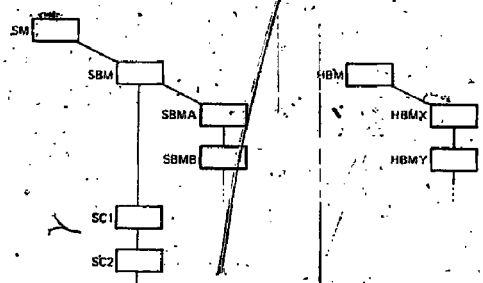


FIGURE 3.2 Data structure of material in 401 STOM functions.

The single-deposit hold up model assumes that a specified mass of bulk

material sticks to each unit of surface area upon initial contact and is not dislodged or replaced. Only that material in direct contact with the vessel surfaces is held up. This means that a clean vessel half filled with material A, then completely filled by addition of material B, will have only material A held up on the bottom and lower half of the vertical surface area, and a mixture of A and B will be held up on the upper half of the vertical surfaces. If the vessel is then emptied and filled with material C, none of it will be held up because it will not stick to the coating of A and B already deposited. The assumption that held up materials are homogeneously mixed does not affect the quantity of material held up by the single-deposit model. It does preclude cleaning sections of the vessel on which certain materials may have been deposited; but if vessels are flushed to clean them out, the held up materials will be mixed during the clean out process, and there is no need to simulate hold up on separate surface areas. This saves memory space when bulk materials are frequently placed in and removed from storage.

The re-deposit hold up model also assumes a specified mass of material sticks to each unit of surface area upon initial contact, but the held up material mixes with that later placed in the vessel, and what remains when material is removed is determined largely by what was last stored. The 401 STOM function provides two versions of re-deposit hold up.

One version assumes that filling occurs without material contacting the vertical surfaces of the storage vessel above the static material level. The sides are not washed down by the entering stream, and there is not enough agitation to cause splashing up onto the sides of the vessel. To simulate this type of bulk storage, only the material held up on the bottom

and vertical surfaces up to the static level is mixed with newly stored material to form the mixture re-deposited on the same surface area. In using this model, the assumption that held up materials are homogeneously mixed should be carefully considered. Suppose, for example, that a clean tank is filled with material A, emptied, then half filled with material B. The model will mix half of the material A initially held up with the half tank of material B, then re-deposit the correct amount of the mixture of A and B. If the tank is emptied again and a small amount of material C is stored, the held up material mixed with the newly stored C will contain more material A than if held up materials were separated rather than homogeneously mixed. In general, the assumption of homogeneous mixing of held up materials will accelerate the decay of materials held up at high storage levels and retard the decay of materials held up at low storage levels.

Another re-deposit model assumes that the sides of the bulk storage vessel are thoroughly washed down either by the inlet stream or by stirring, sparging, etc. Until enough material has been placed in storage to coat the entire inner surface area of the vessel, none is available for removal except by clean out. Thereafter, a fixed amount of material is held up until the next clean out operation; and each time additional material is placed in storage, all of the previously held up material is mixed with the stored material to obtain the new mixture re-deposited on the vessel surfaces. In this case, homogeneous mixing of the held up materials accurately simulates the mechanical operation of the bulk storage vessel.

Stored containers C1, C2, ... at locations SC1, SC2, ... respectively are linked in the order they are placed in storage, so they may be removed

in the same order (first-in-first-out), the reverse order (last-in-first-out), or in arbitrary order determined by the function that controls their removal.

A specified list of functions are notified each time material is placed in or removed from storage. If any of these functions acquire diverted material from the storage function, they must acknowledge the removal so the storage function can update its data collection regarding bulk material and container storage. Material in the storage function is also susceptible to diversion at any time, by functions that may or may not be included in the list notified at the times material is placed in or removed from storage. When an acquisition attempt is made, the storage function acknowledges the interaction message by returning the location of its stored material (material is not diverted from hold up).

Report

By assigning parameter values that enable data collection and reporting options, 401 STOM functions may be directed to print a statistical summary of bulk material and container storage during the reporting interval and/or print the data representing material in storage and hold up at the reporting time. The reported bulk material storage data include the current mass in storage, the maximum mass stored and the time at which the maximum amount was first stored, the number of observations made at times bulk material was either placed in or removed from storage, the time average of mass stored over the reporting interval, and the standard deviation of mass stored during the reporting interval. Similar data are reported for the number of containers stored. And if selected, the complete data representing the

quantity and containment of material in storage and/or in hold up at the reporting time are printed.

Events

No scheduled events occur in 401 STOM functions. If an event notice is received, an error message is written and the simulation is halted.

Interactions

When a 401 STOM function receives a notice that material is ready to be placed in storage, the total bulk mass and number of containers to be received are first determined. If the new bulk mass exceeds the maximum bulk mass previously stored, the excess is determined and saved for use by the single-deposit hold up model. If enabled by assigned values of report control parameters, data are collected on bulk and container storage, and the incoming material is transferred to storage. The selected hold up model then transfers material from bulk storage to hold up and acknowledgement that the material has been accepted is returned to the function placing the material in storage.

When attempts to divert material are made at times other than those at which material is placed in or removed from storage, the location of stored material is returned to the function attempting the acquisition.

When withdrawals from storage and clean out of materials in hold up are made, the locations of stored and held up material are returned to the interacting functions upon request.

When a 401 STOM function receives notice that material has been removed from storage, the bulk mass and number of containers currently in storage

are updated, and, if enabled, data collection on bulk and container storage is made. The quantity of bulk mass and the number and order of containers removed is controlled entirely by the functions that withdraw material. The storage function does not gather statistical data on held up materials, so it does not have to be informed when they are removed.

Parameters

(1) Hold up model where 1 = single-deposit, 2 = re-deposit on only surfaces contacted by static material, and 3 = re-deposit on all internal surfaces of the bulk storage vessel. (2) End area of the bulk storage vessel. (3) Vertical surface area contacted per unit mass of bulk material stored if hold up models 1 or 2 are used, or the total area contaced if hold up model 3 is used. (4) Surface hold up coefficient of the bulk storage vessel. This is the mass of material held up per unit of contacted surface area. (5 i 4) List of four report control parameters where 0 = disable and 1 = enable the following data collection and reporting features: i) bulk storage, ii) container storage, iii) current material in storage, and iv) current material in hold up. (6 n m) List of functions to be notified at diversion opportunity times.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are set automatically by the storage function subroutine. ILLEGAL HOLD UP MODEL SPECIFICATION--Parameter 1 has not been assigned integer value 1, 2, or 3. ILLEGAL EVENT NOTICE--Events do not occur in 401 STOM functions. ILLEGAL INTERACTION--An illegal interaction message has been

received. RESPONSE TO CONDITION NOTICE--A function notified at the time material was placed in or removed from storage did not acknowledge the condition notice.

501 INDA Independent Action

Function

This function simulates activities that take time and may generate stimuli but do not depend upon other functions in the system model. The time required to complete 501 INDA activities is a random variable with specified distribution type and statistics. Stimuli are characterized by type, delay time distribution type and statistics, duration time distribution type and statistics, and intensity distribution type and statistics. (Types of stimuli generated by adversary actions are described in Appendix C.) Dependent activities are notified at the actual completion times of 301 INDA activities. INDA activities may be placed anywhere in action sequences and they may generate any number of stimuli

Report

No data are gathered by 501 INDA functions. The message NO REPORT is written when reports are requested.

Events

When an INDA activity begins, its duration time is determined using the specified distribution type and statistics. If activities that depend upon completion of the INDA activity are specified, a completion event is scheduled so that condition messages may be sent to each of them at that time; otherwise the duration of the INDA activity is incorporated in scheduling the next activity of the sequence but an INDA completion event is not scheduled. If it is not the last activity of a sequence, a value of the

random time delay for the next activity is then determined using the distribution type and statistics specified by the function that initiated the sequence, and the next activity is scheduled. Stimuli characteristics are then transmitted to the monitor functions assigned to each of the stimuli generated by the activity. If a monitor function will not accept the stimulus transmitted to it, an error message is written and the program is halted.

Interactions

The INDA function will not accept interaction messages initiated by other functions. If an illegal interaction message is received, an error message is written and the program is halted.

Parameters

(1) Duration time distribution type. (2 n m) Duration time statistics. (3 n m) Stimulus specifications. Repeat the following for each stimulus: i) monitor function, ii) stimulus type, iii) delay time distribution type, iv) delay time statistics, v) duration time distribution type, vi) duration time statistics, vii) intensity distribution type, and viii) intensity statistics. (4 n m) Functions to be notified at the times activities are completed.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of state variables are set automatically by the function subroutine. ILLEGAL INTERACTION--An illegal interaction message has been received. STIMULI DATA NOT ACCEPTED--A

monitor function would not accept the stimuli characteristics transmitted to it. CONDITION LIST--An activity completion event was scheduled with no dependent function to notify. RESPONSE TO CONDITION NOTICE--A function notified at an activity completion time failed to acknowledge the condition message.

502 MAQA Material Acquisition Action

Function

This function simulates attempts to acquire material from specific target functions in the system model. The time required to complete 502 MAQA activities is a random variable with specified distribution type and statistics. Stimuli generated by the MAQA activities are characterized by type, delay time distribution type and statistics, duration time distribution type and statistics, and the intensity distribution type and statistics. (Types of stimuli generated by adversary actions are described in Appendix C.) Dependent activities are notified at the actual completion times of 502 MAQA functions. MAQA activities may be placed anywhere in action sequences, and they may generate any number of stimuli.

During the activities simulated by 502 MAQA functions, an attempt is made to acquire material from each of a list of specified target functions. The type and quantity of material to be acquired from each target function is specified by the diversion objective of the function that initiated the action sequence. If a target function has no material susceptible to diversion at the time of an attempted acquisition, or if no material of the type specified by the diversion objective is present, no material is acquired from that target function. If a particular attempt objective (the quantity of material to be acquired may be random) is to remove more material of a specified type than is susceptible to diversion in a target function, all of the susceptible material of that type is removed. When the objective is to remove material from a container and more than one container is susceptible to diversion, the 502 MAQA function selects one of the

containers at random and makes the acquisition attempt on that one container. If there happens to be no material of the type sought in the container selected at random, no material will be acquired, even though the material may be in other containers susceptible to diversion.

Some target functions, such as transport and measurement functions, may contain more than one batch of material that is susceptible to diversion at the time of an attempt. The 502 MAQA function selects one of the susceptible batches at random and makes the diversion attempt on that one batch. It is possible, therefore, that no material of the type sought will be acquired in a particular attempt, even though material of that type is present and is susceptible to diversion in other batches.

Report

When reports are requested, the 502 MAQA function writes the data structure of all material acquired since the last function initialization.

Events

When an activity begins in an 502 MAQA function, its duration time is determined using the specified distribution type and statistics. If dependent activities are specified, a completion event is scheduled so that condition messages may be sent to each of them at the time the MAQA activity is completed; otherwise the duration of the MAQA activity is incorporated in scheduling the next activity of the sequence. If the activity is not the last one of a sequence, a value of the random delay time of the next activity is determined using the distribution type and statistics specified by the function that initiated the sequence, and the next activity is

scheduled. An attempt is then made to acquire a specific amount of material from each of the specified list of target functions. The quantity of material to be acquired in each attempt is determined using the distribution types and statistics specified by the objective. After the acquisition attempts on all of the target functions have been completed, stimuli are transmitted to the monitor functions assigned to each of the stimuli generated by the activity. If a monitor function will not accept the stimulus transmitted to it, an error message is written and the program is halted.

Interactions

When an interaction message requesting available material is received, the 502 MAQA function returns the location of the material it has acquired since the last function initialization. No other interaction messages are accepted; if one is received, an error message is written and the program is halted.

Parameters

(1) Duration time distribution type. (2 n m) Duration time statistics. (3 n m) Stimulus specifications. Repeat the following for each stimulus: i) monitor function, ii) stimulus type, iii) delay time distribution type, iv) delay time statistics, v) duration time distribution type, vi) duration time statistics, vii) intensity distribution type, and viii) intensity statistics. (4 n m) Target functions. (5 n m) Functions to be notified at the times activities are completed.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variable are set automatically by the function subroutine. ILLEGAL INTERACTION--An illegal interaction message has been received. STIMULI NOT ACCEPTED--A monitor function would not accept the stimuli characteristics transmitted to it. MESSAGE BLOCK LINKAGE--A linkage error was encountered while traversing the chain of message blocks pointing to material susceptible to acquisition in a target function. ILLEGAL TARGET RESPONSE--An illegal response message was received from one of the specified target functions. ILLEGAL MATERIAL DIVERSION OBJECTIVE TYPE--An illegal objective type was specified for the function that initiated the activity sequence. LOCATING BULK AT LMS--A data structure error was encountered while attempting to locate the bulk material susceptible to acquisition in a target function. LOCATING CONTAINER MATERIAL DATA STRUCTURE--A data structure error was encountered while attempting to locate the first container susceptible to acquisition in a target function. CONDITION LIST--A completion event was scheduled with no functions to notify. RESPONSE TO CONDITION NOTICE--A function notified at an activity completion time failed to acknowledge the condition message.

503 DEPA Dependent Action

Function

This function inhibits progress in a sequence of activities until specific conditions occur in other functions of the system model. Two modes of conditional activity are simulated. In mode 1 the start of the activity is inhibited unless a condition has occurred within a specified reference time interval. If no such condition has occurred and the activity is delayed, it will begin at the time the next condition occurs. When the activity is actually started, stimuli are generated and the next activity is scheduled using the actual time duration of the 503 DEPA activity and the actual time delay of the next activity in the sequence. In mode 2 the activity is started and the specified stimuli are generated at the time activity progresses to the 503 DEPA function, but completion of the activity is inhibited unless a condition has occurred within a specified reference time interval. If no condition has occurred and completion of the activity is delayed, completion of the activity and the beginning of the time delay preceding the next activity occur at the time of the next condition. Figure 3.3 illustrates the operation of 503 DEPA functions in modes 1 and 2. In the example of mode 1 operation shown in the upper part of the figure, no opportunity occurred in the reference time interval preceding the time T1 at which the activity could be started. The start of the activity is delayed to time T1' when the next opportunity occurs. Notice that stimuli generation begins at the actual time the activity is started and that the time delay of the next activity begins at time T2' when the activity is actually completed. In the example of mode 2 operation shown in the lower part of

the figure, an activity is started and stimulus generation begins at time T1 determined by the previous progress of adversary activity, but completion of the activity is inhibited because no condition has occurred within the reference time interval preceding time T2 at which the activity would normally be completed. Completion of the activity is delayed to time T2' when the next opportunity occurs. The time delay of the next activity begins at the time the activity is actually completed.

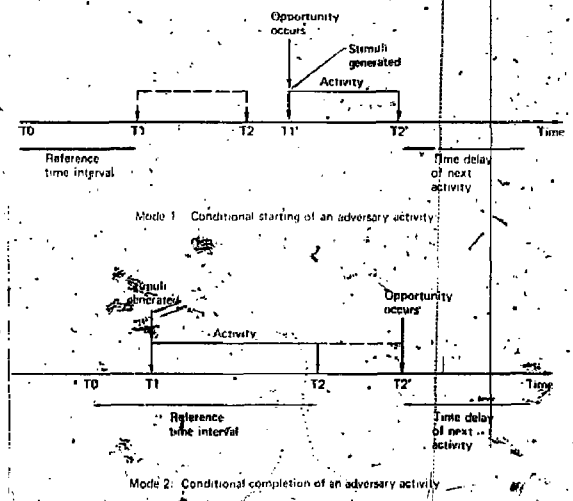


FIGURE 3.3 Operation of 503 DEPA functions in modes 1 and 2

In either mode, other activity functions that depend upon completion of 503 DEPA activities are notified at the actual completion times.

Report

The 503 DEPA function collects data on the time at which the conditions occur and, when reports are requested, prints the mean, standard deviation, number of observations, maximum, and minimum values. These data are collected over replicated runs and should be carefully interpreted if more than one condition may occur in any single run.

Events

When a sequence of actions reaches an activity simulated by a 503 DEPA function, a scheduled event occurs which may or may not coincide with the starting of the simulated DEPA activity, depending on the mode of operation. However, regardless of the operating mode, at the time of the event the duration of the DEPA activity and, if there is a next activity in the sequence, the time delay of the next activity are determined. Then if the DEPA function is in mode 1 and a condition has occurred within the specified reference time interval, the activity is started and the specified stimuli are generated. Otherwise an indication that the activity is pending and is waiting for the occurrence of a condition is stored. If the function is in mode 2, the activity is started and the specified stimuli are generated. If other activities that depend upon completion of this activity are specified, a completion event is scheduled so that condition messages may be sent to each of them at that time; otherwise the duration of the DEPA activity is

incorporated in scheduling the next activity of the sequence but a DEPA completion event is not scheduled.

Interactions

Only interaction messages indicating occurrence of a condition are accepted by 503 DEPA functions. Receipt of any other type of interaction message will produce an error message and halt the program. If the function is in mode 1 and adversary activity has not progressed to the DEPA function at the time a condition message is received, the time of the condition is recorded. If adversary activity has progressed to the DEPA function, the activity is started at the time of the condition. If the function is in mode 2 and the DEPA activity has not been started, the time of the condition is recorded. And if the DEPA activity has been started but it has not yet been completed, the next activity is scheduled with its time delay starting at the time the DEPA activity is actually completed. If the DEPA activity has been delayed, the next activity is scheduled with its time delay starting at the time of the condition that determines the delayed completion time of the DEPA activity.

Parameters

(1) Duration time distribution type. (2 n m) Duration time statistics. (3 n m) Stimulus specifications. Repeat the following for each stimulus: i) monitor function, ii) stimulus type, iii) delay time distribution type, iv) delay time statistics, v) duration time distribution type, vi) duration time statistics, vii) intensity distribution type, and viii) intensity statistics. (4) Operating mode where 1 = conditional

starting and 2 = conditional completion. (5) Reference time interval for conditional starting or conditional completion. (6 n m) Functions notified at activity completion times.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--No initial condition values are specified by the user. ILLEGAL MODE SPECIFICATION--A mode other than 1 or 2 has been specified. CONDITION LIST--A completion event was scheduled with no functions to notify. ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are set automatically by the function subroutine. RESPONSE TO CONDITION NOTICE--A function notified at an activity completion time failed to acknowledge the condition message. ILLEGAL INTERACTION--An interaction message other than a material acquisition attempt message was received. CONDITIONAL START--A logical error was encountered in mode 1 at the time a condition message was received. CONDITIONAL END--A logical error was encountered in mode 2 at the time a condition message was received. STIMULI NOT ACCEPTED--Stimulus data were not accepted by one of the assigned stimulus monitor functions.

504 MODA Modification Action

Function

This function simulates activities that modify parameters and/or current values of state variables in any function of the model system. The time required to complete these modification activities is a random variable with specified distribution type and statistics. Stimuli generated by the activities are characterized by type, delay time distribution type and statistics, duration time distribution type and statistics, and intensity distribution type and statistics. (Types of stimuli generated by adversary actions are described in Appendix C.) Activities that depend upon completion of MODA activities are notified at the actual completion times. MODA activities may be placed anywhere in action sequences, and they may generate any number of stimuli.

Any number of parameters and/or variables of any number of functions may be modified by an instance of the 504 MODA function. The modifications are made at the starting time of the activity, at the same time stimuli generated by the activity are transmitted to monitor functions. Each modification is specified by i) the function to be modified, ii) a parameter/variable index, iii) a first element index, and iv) a last element index. Positive values of the parameter/variable index indicate parameter modification and negative values indicate variable modification. If the parameter/variable to be modified is a scalar, the first element index is assigned value zero and the second element index is assigned value zero or one to indicate respectively integer or real type. If the parameter/variable to be modified is list-valued, positive (negative) values

are used for the first element index to specify the first of contiguous elements to be modified in an integer (real) list. The second element index, which must be assigned a positive value, specifies the last of the contiguous list elements to be modified. The user must specify the correct type and scalar or list-valued designation; the 504 MODA function will not correct the type if it is incorrectly specified. The new values of modified parameters (variables) and initial values to be reset at initial condition time are specified by list valued parameters.

Report

No data are gathered by 504 MODA functions. The message NO REPORT is written when reports are requested.

Events

When an activity begins in a MODA function, its duration time is determined using the specified distribution type and statistics. If activities that depend upon completion of this activity are specified, a completion event is scheduled so that condition messages may be sent to each of them at that time; otherwise the duration of the MODA activity is incorporated in scheduling the next activity of the sequence but a MODA completion event is not scheduled. If the activity is not the last one of a sequence, the delay time of the next activity is determined using the distribution type and statistics specified by the function that initiated the sequence, and the next activity is scheduled. Stimuli are then transmitted to the monitor functions assigned to each of the stimuli

generated by the activity. If a monitor function will not accept the stimulus transmitted to it, an error message is written and the program is halted.

Interactions

The MODA function will not accept interaction messages initiated by other functions. If an interaction message is received, an error message is written and the program is halted.

Parameters

(1) Duration time distribution type. (2 n m) Duration time statistics. (3 n m) Stimulus specifications. Repeat the following for each stimulus: i) monitor function, ii) stimulus type, iii) delay time distribution type, iv) delay time statistics, v) duration time distribution type, vi) duration time statistics, vii) intensity distribution type, and viii) intensity statistics. (4 n m) Modification specifications. Repeat the following for each parameter or variable to be modified: i) function number, ii) parameter (variable) index where positive (negative) values indicate a parameter (variable) is to be modified, iii) first element index where zero indicates scalar values and positive (negative) values indicate the first index of a contiguous list of integer (real) values, iv) last element index of contiguous list of values, (5 n m) New values to be assigned to the specified parameters or variables. These values are specified by a real parameter list of the MODA function but are assigned as the type specified by parameter 4. (6 n m) Initial values of modified

parameters (variables) to be reset at initial condition time. (7 n m) Functions to be notified at activity completion time.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are set automatically by the function subroutine. CONDITION LIST--A completion event was scheduled with no function to notify. RESPONSE TO CONDITION NOTICE--A function notified at an activity completion time failed to acknowledge the condition message. ILLEGAL INTERACTION--An illegal interaction message has been received. STIMULI DATA NOT ACCEPTED--A monitor function would not accept the stimuli characteristics transmitted to it. ATTEMPT TO MODIFY AN UNDEFINED FUNCTION--A function designated in the modification specifications did not exist at the time the modification was to be performed. ILLEGAL PARAMETER/VARIABLE NUMBER ZERO--An illegal zero value was specified for the parameter or variable index. LAST INDEX FOR SCALAR--A value other than 0 or 1 was specified or a modification in which a value 0 was specified for the first element index. LAST INDEX FOR INTEGER LIST--The last element index of an integer list modification specification is either negative or less than the first element index. LAST INDEX FOR REAL LIST--The last element index of a real list modification specification is either negative or less than the first element index.

505 HDAS Halt Diversion Action Sequence

Function

This function may be used to halt and subsequently resume diversion action sequences at any number of points. They are inserted as dummy actions that are initialized to a non halt status in which they serve as null actions that are performed in zero time and generate no stimuli. When placed in a halt status by modifying the value of 505 HDAS variable 1 from 0 to 1, they will interrupt (halt) progress of the action sequence at that point until returned to the non halt status by receipt of an interaction message from any other function in the model system.

Report

No information is gathered by 505 HDAS functions which write the message NO REPORT when reports are requested.

Events

At the event time of the dummy action, the information needed to continue the sequence is saved. If the HDAS function is in the non halt status, the sequence is continued immediately without interruption. If the function is in the halt status, the next event in the action sequence is not scheduled, and the action sequence is thereby halted.

Interactions

When a 505 HDAS function receives an interaction communication instructing it to perform a control function, the interrupted action

sequence is continued by scheduling the next event in the sequence. No action is taken if an interaction message is received while the function is in the non halt status.

Parameters

No parameters are specified by the user.

Initial Conditions

(1) Halt status. The 505 HOAS function may be initialized to the halt status by setting the initial value of variable 1 to 1.

Errors

ATTEMPT TO SET PARAMETERS--No parameters are assigned by the user.
ILLEGAL INTERACTION--An illegal interaction message has been received from some other function in the model system.

601 TIMR Timer

Function

A periodic schedule of shifts and intervals is maintained for reference by other functions in controlling the timing of their operations. For example, if one or more functions are to operate only during normal 8 hour shift working hours (8 a.m. to 5 p.m. on weekdays with an hour break from 12 noon to 1 p.m.) a timer with a 168 hour (7 days X 24 hours per day) period could be included in the MCSS model system to control those functions. Shifts represent the 8 a.m. to 5 p.m. segments and intervals the 8 p.m. to 12 noon and 1 p.m. to 5 p.m. segments of the weekly period, so in this case there would be 5 shifts and 10 intervals specified in each period. The period, number of shifts and intervals, and the starting and ending times of each are parameters to be specified for each instance of the timer function.

In the example above, intervals are contained within shifts. However, shifts and intervals are independent and may overlap provided that no shift overlaps another shift and no interval overlaps another interval. The end of one shift or interval may coincide with the beginning of the next.

Any number of functions may refer to a particular timer function. And any number of timer functions may be used in an MCSS model to establish different operating schedules for subsets of functions. But no function may refer to more than one timer.

Report

No information is gathered by the 601 TIMR functions which write the

message NO REPORT when reports are requested.

Events

Events occur in 601 TIMR functions at the beginning of each period, shift, and interval, and at the end of shifts and intervals. Trace level 1 messages BEGIN PERIOD, BEGIN SHIFT, END SHIFT, BEGIN INTERVAL, and END INTERVAL are written at the corresponding event times.

Interactions

When the timer function receives a request for timing information, it returns a pointer to a data vector containing the time the current period will end (and the next period begin), the number of the current shift, the time the current shift will end, the time the next shift will begin, the number of the current interval, the time the current interval will end, and the time the next interval will begin. The timer writes the trace level 3 message RETURNING TIMING DATA at the times this information is requested.

Parameters

(1) Period of the timing schedule. (2) Number of shifts per period. (3 n m) List of shift starting times, in chronological order, relative to the beginning of each period. (4 n m) List of shift ending times, in chronological order, relative to the beginning of each period. No shift ending time may be less than the corresponding shift starting time. (5) Number of intervals per period. (6 n m) List of interval starting times, in chronological order, relative to the beginning of each period. (7 n m) List of interval ending times, in chronological order, relative to the beginning

of each period. No interval ending time may be less than the corresponding interval starting time.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are set automatically by the function subroutine.

602 SCAS Start Control Action Sequence

Function

This function starts control action sequences upon command of other functions. An 80' DTBI decision function, for example, may start one or more control action sequences if the conditions of a particular decision rule are satisfied. Any number of control action sequences may be started concurrently. The time delay of individual actions in the sequences are specified by time delay distribution type and statistics.

Report

No data are gathered by 602 SCAS functions. The message NO REPORT is written when reports are requested.

Interactions

When an interaction message is received indicating that the control action sequences defined by the 602 SCAS function are to be started, events are scheduled at the current time plus the time delay of the first event in each sequence. By appropriate choice of time delay characteristics for the first action of each sequence, any number of action sequences may be started with a particular desired timing relationship.

Parameters

(1 n m) Action sequence specification. Repeat the following for each action: i) action function (negative for the first action of a sequence),

(ii) starting time delay distribution type, (iii) starting time delay statistics.

- Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are set automatically by the function subroutine. ILLEGAL EVENT MESSAGE--An illegal event notice has been received. No events occur in 602 SCAS functions. ILLEGAL INTERACTION--An illegal interaction message has been received.

701 MZMB Measure Material Batches

Function

This function simulates the measurement of item count and/or mass of specified material types in discrete material batches. The simulated measurements are made with uncertainty characterized by the mean and maximum deviation of uniformly distributed count error, a bias or systematic mass error component, and the standard deviation of a normally distributed random mass error component. The observed (measured) number of discrete items of each measured material type are determined by adding an integer sample from the count error to the actual number of items in the batch. The observed mass of each measured material type is determined by summing the actual mass, the systematic error component, and a sample from the specified random mass error.

The time required to complete all of the specified material measurements for a batch is a uniformly distributed random variable with specified mean and maximum deviation. MZMB functions may represent measurement processes in which samples drawn from material batches are analyzed simultaneously and the overall measurement time is determined by the procedure that takes the greatest length of time. Or they may represent measurements whose completion time is controlled by something other than the actual measurement process, for example, the recording and verification that may be required by safeguards procedures in an analytical laboratory.

Opportunities to divert material from the measurement function occur each time a measurement is started and each time a measurement is completed. At these times, a list of functions are notified with an indication of the

location of the material batch then entering or leaving the measurement function. Material is also subject to diversion at any time during the measurement operation. Batches of material in the measurement function are chained in the order they are received, so functions that make material acquisition attempts are free to remove material from any of the batches then in the measurement function. If material is removed at the time a batch measurement is started, the observed values are based on the actual amount of material left after the diversion has taken place. However, if material is removed at the time a batch measurement is completed, the observed values are based on the actual amount of material present before the diversion. If material is removed during the measurement process, the effect on the observed values of the measurement will be the same as if the diversion had occurred at the time the measurement was started.

At the time each batch measurement is completed, the actual and observed values of item count and mass of all measured material types are sent to a specified list of monitor functions. If any of the monitor functions fail to acknowledge receipt of the measurement data, an error message is written and the program is halted. Any number of batches may be measured concurrently, and the order in which they are completed may or may not be the same as the order in which they were received and the measurements started.

Operation of MZMB functions may be controlled by 601 TIMR functions. Material batches are accepted from the input transport function whenever they are available, but if an MZMB function is not in operation at the time a batch is received, the start of the measurement time interval is delayed until the next time the measurement function resumes operation. If an MZMB

function is out of operation at the end of a batch measurement time interval, completion of the measurement is also delayed until the measurement function resumes operation. In other words, measurements are started and completed only when MZMB functions are in operation, regardless of the random time interval required to perform the measurement.

Material batches are stored while waiting for measurements to be started, during the measurement process, and while waiting for completion of measurements. But they are not stored beyond the time at which the measurement is completed. At that time, an output transport function is notified that the material batch is ready, and it must remove the material from the measurement function or an error message will be written and the simulation halted.

Report

Each instance of the 701 MZMB function reports the maximum number of batches concurrently measured and the time the maximum number of batches first entered the measurement function.

Events

Completion of material batch measurements is the only event that occurs in 701 MZMB functions. If the measurement function is in operation at the time a batch measurement has been scheduled for completion, the observed values of item count and/or mass are determined for each of the specified material types to be measured, the actual and observed values are sent to the specified monitor functions, and the output transport function is notified that the batch is ready. If the measurement function is not in

operation at the time the measurement has been scheduled for completion, the completion event is rescheduled to occur the next time the measurement function resumes operation. The trace level 1 message MEASUREMENT COMPLETED is written at the times batch measurements are actually completed and the batches leave the measurement function.

Interactions

Two types of interaction messages are accepted by 701 MZMB functions. The first is a notice that a material batch is ready for measurement. When an interaction message of this type is received, the batch is placed on a chain in the order received with other batches in the measurement function. The measurement completion event is then scheduled and the trace level 3 message BATCH RECEIVED FOR MEASUREMENT is written. Data are then collected on the number of batches concurrently in the measurement function, and acknowledgement that the batch has been accepted is returned to the interacting function.

The second type of interaction message accepted by the 701 MZMB function is the notice of an attempt to acquire material from the measurement function. When this type of interaction message is received, a response is returned indicating the location of the material batch last accepted, and, since batches of material are chained in the order of their acceptance, the function making the acquisition attempt is free to remove material from any of the batches it finds in the measurement function. The trace level 3 message MATERIAL ACQUISITION ATTEMPT is written when the response is returned to the interacting function.

Parameters

(1) Number of material types measured. (2 n m) Measurement specifications. Repeat the following for each type of material measured: i) integer material type code, ii) mean count error, iii) maximum uniform deviation of count error, iv) systematic mass error, v) mean of random mass error, and vi) standard normal deviation of the random mass error. (3) Mean time to complete all measurements. (4) Maximum uniform deviation of the measurement time. (5) 601 TIMR timing code. (6) 601 TIMR function. (7 n m) List of monitor functions to receive observed and true values of measured material count and mass at the times measurements are completed. (8) Destination function to which the material batches are to be transported when the measurements are completed. (9) Transport function that takes the material batches when the measurements are completed. (10 n m) List of functions to be notified when material batches are received and when the measurements are completed.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--All state variables are initialized automatically by the function subroutine. ILLEGAL INTERACTION--An illegal interaction message has been received. MATERIAL NOT REMOVED AT TRANSPORT TIME--The transport function failed to remove a material batch at the time its measurement was completed. RESPONSE TO CONDITION NOTICE--A function notified at the time a batch was received or a batch measurement was completed failed to acknowledge the condition message.

702 CMBA Compute Material Balance

Function

The 702 CMBA function is used to compute material balances of areas defined in the model system by input and output measurements as shown in Figure 3.4. Balances on any number of different material types may be computed if all batch pathways and streams entering and leaving the balance area are measured for the specified material types. Each time a quantity of a measured material enters or leaves a balance area, one of the input/output functions reports the observed (measured) and true amounts to a list of monitor functions. When these measurement data are received, CMBA functions scan their lists of input/output functions to determine whether the material is entering or leaving the balance area, and then, if the material type is one of those specified for the CMBA function, they update the quantity of material of that type currently in the balance area.

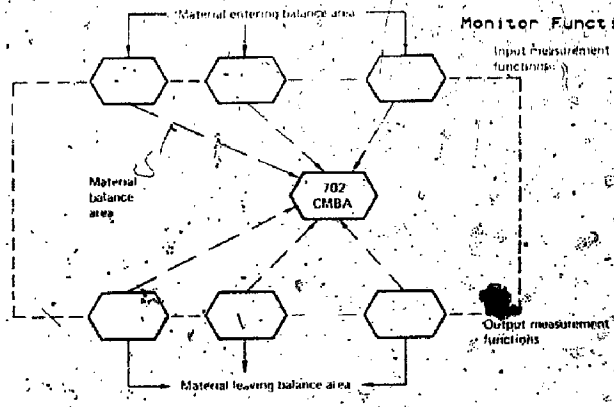


FIGURE 3.4. Use of the 702 CMBA function to compute the material balance of an area defined by input and output measurement functions.

Report

Material balances may be computed for observed, true, and/or error (observed - true) quantities and for either discrete item count or mass of any material type.

Data are gathered for the CMBA report using either of two types of sampling. When sampling type 1 is specified, the new quantity of monitored material in the balance area is sampled each time material enters or leaves the area. These sample values are tabulated over individual simulation runs and are discarded when the CMBA functions are initialized at the beginning of each run. When sampling type 2 is specified, one sample of the material quantity in the balance area is taken at a specified replicate sampling time

within machine. These data are gathered over an ensemble of replicated runs and are reported at the end of the run sequence.

Any number of material balance computations may be specified for each instance of the 702 CMBA function. Computations for different balance areas defined by different sets of input/output measurement functions will, of course, require the use of different instances of the CMBA function. Each material balance computation generates a report that includes the quantity tabulated, sampling type, replicate sampling time, the computed mean and standard deviation of the tabulated values, the maximum and minimum values, and the times at which the maximum and minimum values first occurred. Histograms of the tabulated data may also be generated by specifying the number and width of the cells and the lower limit of the first cell.

Events

At initialization time, sampling type 2 events are scheduled at the specified replicate sampling times. These are the only events that occur in 702 CMBA functions. The trace level 1 message REPLICATE SAMPLE TAKEN is written at the times replicate samples are taken.

Interactions

702 CMBA functions accept only interaction messages conveying material measurement data. If any other interaction message is received, an error message is written and the program is halted. When measurement data are received, the CMBA function scans its report specifications to see if a material balance is to be computed on the measured material type. If so, the lists of input/output functions are checked to verify that the

Measurement data are coming from a valid measurement function and to [illegible] material is entering or leaving the balance area. Current [illegible] are then updated, and if sampling type 1 is specified, samples are taken. A trace level 3 message MEASUREMENT DATA RECEIVED is written each time a material measurement is reported to a 702 monitor function.

Parameters

(1) Number of material balance reports to be generated. (2 n m) Report specifications. Repeat the following for each report. i) number, material type code, ii) data type where 1 = observed, 2 = true, and 3 = error (observed - true), iii) variable type where 1 = discrete item count and 2 = mass, iv) sampling type where 1 = at each input or output and 2 = at report date sampling times, v) number of histogram cells, vi) width of histogram cells, and vii) the lower limit of the first histogram cell. (3 n m) Input measurement functions. (4 n m) Output measurement functions.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--All state variables are initialized automatically by the function subroutine. ILLEGAL INTERACTION--An illegal interaction message was received. DATA RECEIVED FROM ILLEGAL I/O FUNCTION--Measurement data was received from a function not in the specified list of input or output functions. ILLEGAL SAMPLING PARAMETER--A sampling type other than 1 or 2 was specified. NO REPORT DATA TO RESET--No report data existed at initialization time when it was to be reset. ILLEGAL REPORT DATA PARAMETER--A report data parameter other than 1, 2, or 3 was specified.

ILLEGAL REPORT VARIABLE PARAMETER--A report variable parameter other than 1 or 2 was specified.

703 MNTR Monitor Stimulus Type 1

Function

This function simulates devices that monitor stimuli of type 1 which are rectangular pulse signals characterized by delay time, duration, and intensity. (The types of stimuli generated by activity functions are described in Appendix C.) When a type 1 stimulus is transmitted to a 703 MNTR function, the monitor may or may not produce an output signal indicating detection of the stimulus. The probability of detection depends upon the stimulus intensity as specified by pairs of intensity and detection probability values that define a piecewise constant (staircase) representation of an arbitrary sensitivity curve as shown in Figure 3.5. Any number of pairs may be used in specifying the monitor sensitivity. For stimulus intensities greater than or equal to Ai but less than Ai+1, the probability that the monitor will produce an output pulse is Pi.

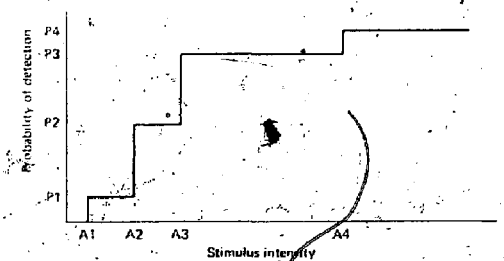


FIGURE 3.5 Representation of 703 MNTR monitor sensitivity by pairs (A1,P1), (A2,P2), ...

When stimuli are detected, the monitor produces an output pulse signal of specified amplitude during a monitor detection signal interval as shown in Figure 3.6. The monitor output is delayed by a random monitor delay time after the beginning of the stimulus pulse, and the duration of the monitor pulse signal depends on which of three operating modes are specified. In mode 1, the monitor detection signal interval is a random variable of specified distribution type and statistics. In mode 2, it is equal to the duration of the stimulus pulse plus a random variable of specified distribution type and statistics. In mode 3, the output of the monitor remains latched until it is cleared by receipt of a control signal from another function of the model system.

Spurious output signals are generated by the monitor at random times. The number of spurious output signals generated per unit time is Poisson distributed. Since in most cases the mean rate of spurious signal generation will be very small, this characteristic of the monitor performance is specified in terms of the mean of the exponentially distributed time interval between spurious output signals.

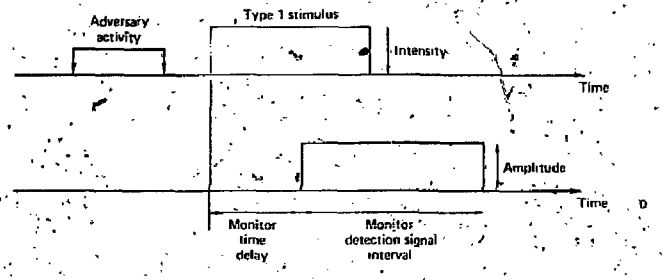


FIGURE 3.6 Timing of 703 MNTR monitor detection signals.

Report

No data are gathered by 703 MNTR functions. The message NO REPORT is written when reports are requested.

Events

Scheduled events occur at the beginning and end of the monitor detection signal interval. At the time of the beginning event, the specified detection signal amplitude is sent to each of a specified list of decision functions, and at the time of the ending event a zero value is sent to the same list of functions.

Events also occur at the times spurious output signals are generated. The first spurious output event is scheduled before the run begins, at the time initial conditions of state variables are assigned. Thereafter, the next spurious output event is scheduled each time a spurious output event

occurs. The amplitude of spurious output signals is the same as those produced by the receipt of stimulus signals of sufficient intensity.

Interactions

Two types of interaction messages are accepted by 703 MNTR functions. One is the stimulus message sent by activity functions. The MNTR function first determines the delay, duration, and intensity of the stimulus using the distribution types and statistics supplied by the activity function. It then determines the probability of detection using the specified sensitivity characteristics and intensity of the generated stimulus; and, with a corresponding frequency, determines whether or not the monitor will produce a detection signal. When detection signals are produced and the monitor is operating in mode 1 or 2, the monitor time delay and detection signal interval are determined using the specified distribution types and statistics and (for mode 2) the actual duration of the stimulus pulse. The beginning and ending events of the monitor detection signal are then scheduled to occur at the appropriate times.

The second type of interaction message accepted by 703 MNTR functions is a control message indicating that the monitor output is to be reset to the nondetection state. If the monitor is not operating in mode 3 or the output is not in the detection state, an error message is written and the program is halted.

Parameters

Y: n(m) Sensitivity characteristics. Any number of pairs of stimulus intensity and detection probability may be specified, but the pairs must be

in increasing order of stimulus intensity. (2 n m) Monitor time delay distribution type and statistics. (3) Operating mode where 1 = random detection signal interval, 2 = detection signal interval based on the duration of the stimulus, and 3 = detection signal latching until cleared by receipt of a control message. (4 n m) Distribution type and statistics of the random component of the detection signal interval when operating in modes 1 or 2. (5) Signal index. (6) Signal amplitude. (7 n m) Decision functions that receive new values of the monitor output signal each time it changes. (8) Mean of the exponentially distributed time interval between spurious output signals. If this parameter is assigned a nonpositive value, no spurious signals are generated.

Initial Conditions

The monitor is automatically initialized to the nondetection state.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--No initial condition values are specified by the user. ILLEGAL STIMULUS TYPE--The stimulus received from another function is not type 1. ILLEGAL MODE-A mode other than 1, 2, or 3 has been specified. RESET--Either the monitor is not in mode 3 or the output was not indicating a detection when a control signal was received instructing the monitor to reset to the nondetection state. ILLEGAL INTERACTION--An illegal interaction message was received. MONITOR SIGNAL NOT ACCEPTED--A decision function failed to acknowledge receipt of the monitor output signal.

801 DTBL Decision Table

Function

This function implements decision tables having the structure shown in Figure 3.7. Decision tables provide a simple and systematic means of representing decision making situations in which specified actions are to be performed when certain specified conditions are satisfied (6). The four parts of a decision table are separated in Figure 3.7 by the horizontal and vertical double lines. In the upper left corner are a set of n conditions involved in the decision rules represented by the table. The entries in the table that represent these conditions are called "condition stubs". To meet the requirements of a particular decision rule, some of the conditions represented by condition stubs may have to be satisfied, some may have to be violated, and it may not matter if some of the conditions listed in the condition stubs of the table are satisfied or not. The conditions that must be satisfied are said to be required to be true, those that must be violated are said to be required to be false, and the others are referred to as "don't care" conditions. In the lower left corner of the table are a set of m actions involved in the decision rules represented by the table. Each action is represented by an action stub. A particular decision rule may require that some of the actions be performed and that the others not be performed. There are no "don't care" actions; it must be explicitly defined whether each of the actions are to be performed or not if the conditions of a particular decision rule are satisfied. The condition and action entries in the upper and lower right corners respectively define the k decision rules represented by the k columns of the table.

Any number of condition rows, action rows, and decision rules may be used in an 801 DTBL decision table. Condition stubs are of the form

$i (operator) Sk

or

$i (operator) Vk

where Si and Sk are input signals, Vk is a specified numeric value, and "operator" is one of the relational operators below:

.EQ.	EQUAL TO
.LT.	LESS THAN
.GT.	GREATER THAN
.NE.	NOT EQUAL TO
.LE.	LESS THAN OR EQUAL TO
.GE.	GREATER THAN OR EQUAL TO

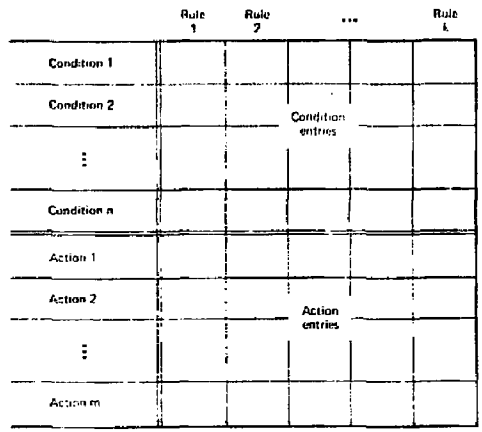


FIGURE 3.7 Decision table structure of 801 DTBL functions.

The condition stubs are specified in a list parameter by triplets i,j,k where i is the index of the first operand Si, j indicates the type of condition and the relational operator as defined in Table 3.1, and k is either the index of the second operand Sk or the numeric value Vk.

TABLE 3.1 Definition of condition stub specification parameter j for 801 DTBL functions.

j	Relational Operator	Condition Operands
1	.EQ.	Si,Sk
2	.LT.	"
3	.GT.	"
4	.NE.	"
5	.LE.	"
6	.GE.	"
7	.EQ.	Si,Vk
8	.LT.	"
9	.GT.	"
10	.NE.	"
11	.LE.	"
12	.GE.	"

Two types of action may be specified. One is the assignment of a specified value to an output signal of the decision table, and the other is the initiation of specified control action sequence. Output signal values are assigned by the 801 DTBL function, and the control activities are performed by other functions in the system model. Action stubs are specified in a list parameter by pairs i,j where, if i is positive, it is the index of the output signal Si to be assigned value j, and if i is

negative, -1 is the function notified that a control action sequence is to be initiated.

Condition entries -1, 0, and +1 stand for "no", "don't care", and "yes" respectively. Else rules are specified by don't care entries in every condition row.

Action entries 0 and +1 stand for "don't perform action" and "perform action" respectively.

Report

Samples of output signals taken at specified times in replicated simulation runs are used to determine their mean, standard deviation, maximum, and minimum values and to construct relative frequency histograms that represent the probability distributions of the signals at the specified sampling times. The responses of simulated material control system are defined by these output signals, so 801 DTBL function reports are essential in safeguards assessment applications of MCSS.

A report is generated by specifying the output signal index, sampling time, number of histogram cells, width of the cells, and the lower limit of the first histogram cell. Reports may be generated for only those signals that are outputs of the DTBL function.

Events

Decision events are scheduled to occur at the same time the DTBL function receives new values of any of its input signals. This allows the function to receive new signal values from any number of interacting functions before it makes its own decision, that is, determines which of its

decision rules is satisfied and takes the corresponding action. At most one decision event is scheduled to occur at an instant of simulated time, so the decision logic implemented by several DTBL functions may contain loops in which control signals are assigned values that depend upon their previous values.

At decision event times, using the current values of input signals, the decision rules are tested from left to right until one is found for which all of the conditions are satisfied. The actions of that decision rule are then carried out in the order that they appear from top to bottom in the decision table. The specified decision rules must be exhaustive so that at least one will be found for which the conditions are satisfied for all possible values of the input signals. If no decision rule is found for which all of the conditions are satisfied, an error message is written and the program is halted. The 801 DTBL function does not check for redundancy or contradiction among the decision rules. If two or more rules are redundant or contradictory, the leftmost rule for which the conditions are satisfied will be invoked. If actions of a decision rule assign new values to output signals of the DTBL function, a specified list of functions are notified of the new values. Notice that every material control signal must be an output signal of one and only one decision function, but the control signals may be inputs of any number of decision functions.

Scheduled events occur in each run at the sampling times specified for each report. At these event times, the current value of the specified material control signal and its square are added to running totals, the value is compared with the maximum and minimum values previously

encountered, and the count in the appropriate histogram cell is incremented. The trace level 1 message SAMPLE TAKEN is written at the sampling times.

Interactions

The 801 DTBL function will accept only interaction messages that convey new values of material control signals. If any other type of interaction message is received, an error message is written and the program is halted.

Parameters

(1 n m) Input signal indexes. (2) Number of condition rows. (3 n m) Triplets i,J,k that define the conditions of each condition row. i is always the index of the first operand signal. See Table 3.1 for the definition of j. k may be either the index of a second signal operand or a specified numeric value, depending on the value of j. (4 n m) Output signal indexes. (5) Number of action rows. (6 n m) Pairs i,j that define actions. Positive values of i mean that value j is to be assigned to output signal Si. Negative valu s of i mean that function -i is to initiate control action type j. (7) Number of decision rules. (8 n m) Decision rules. A list of integers representing condition entries (-1 = no, 0 = don't care, +1 = yes) followed by a list of integers representing action entries (negative integer values indicate action sequence order, 0 = don't perform action, 1 = perform action) must be specified for each decision rule. (9 n m) Functions to be notified when any of the output variables are assigned a new value. (10) Number of reports. (11 n m) Report specifications. Repeat the following for each report: i) material control signal index, ii) sampling

time, iii) number of histogram cells iv) width of histogram cells, v) lower limit of the first histogram cell.

Initial Conditions

(1 n m) Input signal values. (2 n m) Output signal values. The default initial condition value of input and output variables is zero.

Errors

ILLEGAL INTERACTION--An illegal interction message has been received. NO REPORT DATA TO RESET--No report data existed at the initialization time of the first run of a replicated set of runs. At least one report must be specified. NO INPUT SIGNALS IN THOSE RECEIVED--A control signal message was received that conveyed no DTBL function input signals. NUMBER CONTROL SIGNALS TRANSMITTED--The number of control signals received did not match the number indicated in the control signal message. ZERO CONTROL SIGNALS TRANSMITTED--A control signal was received with no transmitted signal values. NO CONDITION SATISFIED--No decision rule was found for which all of the specified conditions were satisfied. RESPONSE TO OUTPUT SIGNALS--One of the functions notified at the time an output signal changed value failed to acknowledge the control signal message. ILLEGAL CONDITION ENTRY--A value other than -1, 0, or +1 was specified for a condition entry. ILLEGAL SIGNAL INDEX IN ASSIGNMENT ACTION--An index value of an assignment action specification is not in the list of output signal indexes. RESPONSE TO CONTROL MESSAGE--A function notified in order to initiate a control action failed to acknowledge the control message. ILLEGAL ZERO VALUE IN ACTION PAIR--A zero value was specified for the first element of an action pair.

ILLEGAL RELATIONAL OPERATOR IN CONDITION--A value other than 1 to 12 was specified as the second element of a condition triplet. SIGNAL OF CONDITION ENTRY NOT AN INPUT--The signal index in a condition specification is not in the list of input signals.

901 TRCN Trace Control

Function

This function allows the user to set the trace control parameter during the operation of a model system. At simulated time zero, and at subsequent times specified by the user, the 901 TRCN function queries the user via the interactive device and reads input values of the trace control parameter and the next time at which the parameter is to be assigned a new value.

This capability is very useful in debugging model systems. Assume, for example, that an error halted operation of a model system late in the time interval of operation and inspection of the input file does not reveal the cause of the error. The user may add a 901 TRCN function to the system, set the initial trace control value to zero (no trace) or an odd value (trace messages are written into the output file but not on the interactive device) and specify a time for assignment of a new trace control value just prior to the time at which the error occurred in the previous run. The trace control parameter may then be set at 2 (event messages), 4 (event and interaction messages), or 6 (event, interaction, and control program messages) to observe the operation of the model system at various levels of detail as the error occurs.

Events

At event times, the message NEW TRACE? is written on the interactive output device. The user must then enter an integer value specifying the value to be assigned to the trace control parameter. If the value is less than 0 or greater than 6, the message ILLEGAL TRACE VALUE is written and the

user must enter a value within this range to proceed. After the new trace control value has been read and accepted, the message NEXT TRACE CONTROL TIME? is written on the interactive output device. The user must then enter a real (non-integer) value specifying the next time at which the trace control parameter is to be assigned a new value. If the specified time is less than or equal to the current time, the message TIME IS NOW (current time) is written and the user must enter a new value greater than the current time in order to proceed.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state variables are set automatically by the function subroutine. ILLEGAL INTERACTION--An illegal interaction message has been received during operation of the model system. 901 TRCN functions do not interact with any of the other MCSS functions.

902 RMDS Report Material Diversion Statistics

Function

This function collects and reports data on the time required to reach specific points in action sequences, and the amount of material acquired by acquisition functions up to that point. 902 RMDS functions may be placed anywhere in action sequences with no effect on progress through the sequence. When a 902 RMDS function is reached, the current time and quantity of material that has been acquired by a specified list of material acquisition functions are recorded. The recorded material type is that defined by the diversion objective of the function that initiated the action sequence. These data are collected over replicated simulation runs.

Report

902 RMDS functions report the mean, standard deviation, maximum, and minimum times at which progress through an action sequence reached the function during a set of replicated runs. A histogram showing the distribution of these times may also be requested by specifying the number of histogram cells, width of the cells, and the lower limit of the first cell.

The function also reports the mean, standard deviation, maximum, minimum, and the times at which the maximum and minimum values occurred for the quantity of material in the specified set of material acquisition functions at the time activity reached the function during individual runs.

Events

Events occur in 902 RMDS functions at the time progress through an action sequence reaches the function. If a zero time delay is assigned to the RMDS function in the specification of the action sequence, the function will sample the recorded values at the time the preceding action in the sequence is completed. If the time delay associated with the following action in the sequence is assigned to the RMDS function and the time delay of the following action is set to zero, the function will sample the recorded values at the time the following action is started. Or by dividing the time delay of the following action into two delays, the function may be used to sample the recorded values at any time between the preceding and following actions. In any case, the 902 RMDS function placed in a sequence of actions may be viewed as a sampling action that requires zero time duration and, therefore, has no effect on the progress of activity through the action sequence. A 902 RMDS function placed at the end of an action sequence will sample the recorded values at the time the sequence is completed.

Parameters

(1 n m) Material acquisition functions tabulated at sampling times. (2 n m) Time report specifications: i) number of histogram cells, ii) width of the histogram cells, iii) lower limit of the first cell. (3 n m) Diverted material report specification: i) number of histogram cells, ii) width of the histogram cells, iii) lower limit of the first cell.

Errors

ATTEMPT TO SET INITIAL CONDITIONS--Initial values of all state

variables are set automatically by the function subroutine. RESPONSE OF TABULATED FUNCTION--A material acquisition function did not acknowledge a request for the location of material it had acquired ILLEGAL MATERIAL DIVERSION OBJECTIVE TYPE- A material diversion objective type code other than 1 - 5 was found in determining the material acquired by a tabulated material acquisition function.

4 EXAMPLES

MATERIAL BALANCE AREA ACCOUNTABILITY

Introduction

The system simulated in this example is a hypothetical one contrived to illustrate various features of the MCSS program. All characteristics of the system functions have been assigned arbitrarily, but with realistic parameter values that serve the purposes of the example as well as those that might be obtained from an actual system.

The example system, as shown in Figure 4.1, has three receiving stations at which incoming materials arrive. Eight different types of material enter the system at times that deviate randomly from a periodic delivery schedule for each receiving station. The materials are identified as types 1, 2, ... , 8. Daily deliveries of bulk quantities of materials 1 and 2 are scheduled at 8 a.m. and 1 p.m., but the actual deliveries may miss the scheduled times by as much as two hours. On the average, 100 discrete or countable units of material 1 are received in each delivery, and the item count varies randomly with a maximum deviation of 50 units. An average of 20.0 mass units of material 2 are received in each delivery, and the quantity varies randomly with a standard normal deviation of 5.0 mass units.

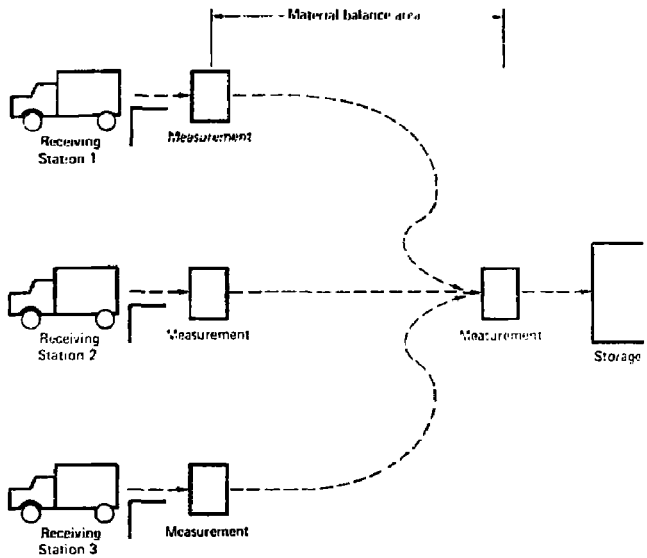


FIGURE 4.1 System simulated in the Material Balance Area Accountability example.

Upon the arrival of each batch of material 1 and 2 at receiving station 1, the batches are moved immediately into a measurement facility where the number of units of material 1 are counted and the mass of material 2 is measured. These measurements are accurate in the sense that the average errors are zero, but they are not precise. The measured or observed count of units of material 1 may be off by plus or minus one unit, and the standard normal deviation of the random error in the measurement of material 2 is 5.0 percent of the mean amount scheduled for delivery or 1.0 mass units. The average time required to complete the measurement of each incoming batch of materials 1 and 2 is 4.0 hours, and this time varies randomly by as much as 0.5 hours.

When the measurements of each incoming batch of material are completed the results are used to update a record of the quantity of each material type present in the material balance area defined by the incoming and outgoing measurement facilities shown in Figure 4.1. After they have been received and measured, batches of materials 1 and 2 remain in the material balance area for a random time interval that varies between 12.0 and 36.0 hours. The details of the handling and processing of materials within the material balance area are not of concern in this case because it is assumed that no material is removed from or added to the individual batches while they are in the material balance area. In many systems the incoming batches will lose their identity within the material balance area as the materials are processed, blended, repackaged, etc. before they leave the balance area.

As they leave the material balance area, batches of material are measured a second time and the results are used to update the record of the quantity of each material type in the balance area. The error or

uncertainty in the measurement of material types 1 and 2 as the batches leave the material balance area is the same as described above for the incoming measurement facility. The time required to complete the measurement of each batch in the outgoing measurement facility varies randomly between 3.0 and 5.0 hours.

Finally, as the measurements are completed on batches of material leaving the balance area, they are immediately placed in a storage area.

Material types 3 and 4 arrive in containers at receiving station 2 once a day at times that vary randomly from 8 a.m. to 5 p.m. Two containers are received in each delivery with an average of 300 countable units of material 3 and an average of 40.0 mass units of material 4 in each container. The count of material 3 items varies randomly by up to 100 units, and the standard normal deviation of material 4 in each container is 20.0 mass units. The containers of materials 3 and 4 are immediately placed in the measurement facility upon arrival at receiving station 2. There the items of material 3 are counted with zero average error and a maximum count error of 3 units. The mass of material 4 is measured with zero average error and a standard normal deviation of 2.0 mass units. The batches of materials 3 and 4 remain in the balance area for a random time interval ranging from 24.0 to 72.0 hours after which they are measured as they leave the balance area with the same uncertainty as in the incoming measurement. The time required to complete the outgoing measurement of material 3 and 4 batches is the same 3.0 to 5.0 hours as for materials 1 and 2.

Four material types: 5, 6, 7, and 8 arrive at receiving station 3 with one delivery between 8 a.m. and noon and a second delivery between 1 p.m. and 5 p.m. of each day. Materials 5 and 6 are in bulk form. Materials 7

and 8 arrive in two containers at each delivery time. An average of 500 countable items of material 5 with a random variation of up to 10 items and an average of 60.0 mass units with a standard normal deviation of 6.0 mass units of material 6 arrive in each delivery. In each of the containers arriving at receiving station 3 there are an average of 700 items of material type 7 with a random variation of up to 50 items and an average of 80.0 mass units of material 8 with a standard normal deviation of only 0.8 mass units. Materials 5, 6, 7, and 8 are measured with the same uncertainty as they enter and leave the material balance area. All of these measurements have zero average error. The maximum deviations of count error for materials 5 and 7 are 5 and 7 respectively, and the standard normal deviations of the random mass measurement errors for materials 6 and 8 are respectively 3.0 and 4.0 mass units. The batches of materials 5, 6, 7, and 8 remain in the balance area for a random time interval between 36.0 and 60.0 hours.

Functional Model

The MCSS model system is shown in Figure 4.2. Three instances of the 101 RCMB function are used to represent the receiving stations of the simulated system. Function 4 is used to transport the arriving material batches from their receiving stations to the incoming measurement facilities. Notice that a single instance of the 301 TRMB function is used to represent the three tranport operations since they are all to be performed instantaneously upon arrival of materials at the receiving stations. Functions 5, 6, 7, and 11 represent the four measurement facilities of the simulated system. Separate instances of the 701 MZMB

function are used since different material types are measured and it may be desirable to be able to assign different measurement time characteristics to the individual facilities. Three instances of the 301 TRMB function are used to represent the random time intervals that the three different types of material batches remain in the material balance area. Separate instances of the transport function are required here because of the differences in the characteristics of the three transport times that are required. Function 12 represents the instantaneous transport of material from the outgoing measurement facility to the storage area. Although a separate instance of the 301 TRMB function is used here, function 4 could also have been used since it has already been selected to represent instantaneous transport operations. Function 13 is used to represent the storage area in order to illustrate the use of the 401 STOM function and the data structure representing material in storage and holdup. Function 14 represents the computation or recording of materials currently in the balance area and is associated with input measurement functions 5, 6, and 7 and output measurement function 11. Finally, function 15, an instance of the 601 TIMR function, is used to provide operational timing control of any of the other functions in the model system that refer to it for operation schedule or timing information.

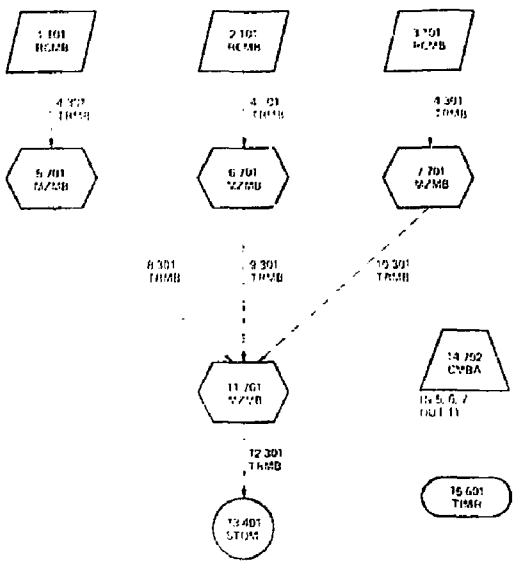


FIGURE 4.2 Functional model for the Material Balance Area Accountability example.

If the reader has not already done so, the detailed descriptions of the functions used in the model system should now be read carefully to see how they represent the corresponding functions of the simulated system.

Input File MCSSIN

The input file reproduced below creates and specifies all of the functions of the model system, makes a three day simulation run of the system as originally defined, then performs additional runs after various modifications of the model system have been made. The last two runs are replicated 10 and 50 times respectively to illustrate how data are gathered over an ensemble of runs to obtain statistical information on random processes at particular times throughout the simulated operation of the system. The input file is shown here exactly as it is prepared for execution of the MCSS program. Further explanation of the input data and the results produced by the program are included in the following description of the output file produced by MCSS.

```
      MCSS USERS MANUAL
      EXAMPLE 1
      MATERIAL BALANCE AREA ACCOUNTABILITY
      10/18/77   MCSSIN24

CREATE 1 101 RCMB
      RECEIVE BULK MATERIALS 1 AND 2

PARAMETER 1
      (1) PERIOD OF ARRIVAL SCHEDULE 24.
      (2) NUMBER OF ARRIVALS PER PERIOD 2
      (3 1 2) SCHEDULED ARRIVAL TIMES 8. 13.
      (4) MAX DEVIATION FROM SCHEDULED TIMES 2.
      (5) NUMBER OF BULK MATERIAL TYPES 2
      (6 1 14) BULK MATERIAL SPECIFICATIONS
            TYPE 1
            MEAN COUNT 100
            MAX DEVIATION OF COUNT 50
            MEAN MASS 0.
            STD DEVIATION OF MASS 0.
            MAX MASS 0.
            MIN MASS 0.
            2 0 0 20. 5. 1000. 0.
      (11) TIMING CODE 1
      (12) TIMER FUNCTION 15
```

```
      (13) DESTINATION FUNCTION 5
      (14) TRANSPORT FUNCTION 4

CREATE 2 101 RCMB
      RECEIVE CONTAINERIZED MATERIALS 3 AND 4

PARAMETER 2
      (1) 24.
      (2) 1
      (3 1 1) 12.5
      (4) 4.5
      (7) NUMBER OF MATERIAL TYPES RECEIVED IN CONTAINERS 2
      (8 1 14) CONTAINERIZED MATERIAL SPECIFICATIONS
           3 300 100 0. 0. 0. 0.
           4 0 0 40. 20. 1000. 0.
      (9) MEAN NUMBER OF CONTAINERS RECEIVED PER ARRIVAL 2
      (10) MAX DEVIATION OF NUMBER CONTAINERS RECEIVED PER ARRIVAL 1
      (11) 1
      (12) 15
      (13) 6
      (14) 4

CREATE 3 101 RCMB
      RECEIVE BULK MATERIALS 5 AND 6 AND CONTAINERIZED MATERIALS 7 AND 8

PARAMETER 3
      (1) 24.
      (2) 2
      (3 1 2) 10. 15.
      (4) 2.
      (5) 2
      (6 1 14)
           5 500 10 0. 0. 0. 0.
           6 0 0 60. .6. 1000. 0.
      (7) 2
      (8 1 14)
           7 700 50 0. 0. 0. 0.
           8 0 0 30. .8 1000. 0.
      (9) 2
      (10) 0
      (11) 1
      (12) 15
      (13) 7
      (14) 4

CREATE 4 301 TRMB
      TRANSPORT MATERIALS FROM RECEIVING STATIONS TO MEASUREMENT STATIONS

PARAMETER 4
      (1) MEAN TRANSPORT TIME 0.
      (2) MAX DEVIATION OF TRANSPORT TIME 0.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES
```

```
CREATE 5 701 MZMB
     MEASURE INCOMING MATERIALS 1 AND 2 AND REPORT TO MATERIAL
     BALANCE FUNCTION

PARAMETER 5
     (1) NUMBER OF MATERIAL TYPES MEASURED 2
     (2 1 12) MEASUREMENT SPECIFICATIONS
          TYPE 1
          MEAN COUNT ERROR 0
          MAX DEVIATION OF COUNT ERROR 1
          SYSTEMATIC MASS ERROR 0.
          MEAN OF RANDOM MASS ERROR 0.
          STD DEVIATION OF RANDOM MASS ERROR 0.
          2 0 0 0. 0. 1.
     (3) MEAN TIME TO COMPLETE ALL MEASUREMENTS 4.
     (4) MAX DEVIATION OF MEASUREMENT TIME .5
     (5) TIMING CODE 1
     (6) TIMER FUNCTION 15
     (7 1 1) MONITOR FUNCTION 14
     (8) DESTINATION FUNCTION 11
     (9) TRANSPORT FUNCTION 8
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 6 701 MZMB
     MEASURE INCOMING MATERIALS 3 AND 4 AND REPORT TO MATERIAL
     BALANCE COMPUTER

PARAMETER 6
     (1) 2
     (2 1 12)
          3 0 3 0. 0. 0.
          4 0 0 0. 0. 2.
     (3) 4.
     (4) .5
     (5) 1
     (6) 15
     (7 1 1) 14
     (8) 11
     (9) 9

CREATE 7 701 MZMB
     MEASURE INCOMING MATERIALS 5, 6, 7, AND 8 AND REPORT TO MATERIAL
     BALANCE COMPUTER

PARAMETER 7
     (1) 4
     (2 1 24)
          5 0 5 0. 0. 0.
          6 0 0 0. 0. 3.
          7 0 7 0. 0. 0.
          8 0 0 0. 0. 4.
     (3) 4.
```

```
      (4) 1.
      (5) 1
      (6) 15
      (7 1 1) 14
      (8) 11
      (9) 10

CREATE 8 301 TRMB
      TRANSPORT MATERIALS 1 AND 2 FROM INPUT MEASUREMENT STATION TO THE
      STORAGE MEASUREMENT STATION

PARAMETER 8
      (1) 24.
      (2) 12.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 9 301 TRMB
      TRANSPORT MATERIALS 3 AND 4 FROM INPUT MEASUREMENT STATION TO THE
      STORAGE MEASUREMENT STATION

PARAMETER 9
      (1) 48.
      (2) 24.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 10 301 TRMB
      TRANSPORT MATERIALS 5, 6, 7, AND 8 FROM INPUT MEASUREMENT STATIONS
      TO THE STORAGE MEASUREMENT STATION

PARAMETER 10
      (1) 48.
      (2) 12.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 11 701 MZMB
      MEASURE OUTGOING MATERIALS 1 THROUGH 8 AND REPORT TO MATERIAL
      BALANCE COMPUTER

PARAMETER 11
      (1) 8
      (2 ) 48)
           1 0 1 0. 0  0.
           2 0 0 0. 0. 1.
           3 0 3 0. 0. 0.
           4 0 0 0. 0. 2.
           5 0 5 0. 0. 0.
           6 0 0 0. 0. 3.
           7 0 7 0. 0. 0.
           8 0 0 0. 0. 4.
      (3) 4.
      (4) 1.
      (5) 1
```

```
      (6) 15
      (7 1 1) 14
      (8) 13
      (9) 12

CREATE 12 301 TRMB
      TRANSPORT MATERIALS 1 THROUGH 6 FROM OUTPUT MEASUREMENT TO STORAGE

PARAMETER 12
      (1) 0.
      (2) 0.

CREATE 13 401 STOR
      STORE BULK AND CONTAINERIZED MATERIALS

PARAMETER 13
      (1) SINGLE DEPOSIT HOLDUP 1
      (2) END AREA OF BULK STORAGE 10.
      (3) VERTICAL SURFACE AREA CONTACTED PER UNIT MASS BULK STORAGE 1
      (4) BULK STORAGE SURFACE HOLDUP COEFFICIENT .05
      (5 1 4) REPORT
            BULK STORAGE DATA 1
            CONTAINER STORAGE DATA 1
            MATERIAL IN STORAGE 1
            MATERIAL IN HOLDUP 1
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 14 702 CMBA
      MATERIAL BALANCE COMPUTATION

PARAMETER 14
      (1) NUMBER OF REPORTS 16
      (2 1 128) REPORT SPECIFICATIONS
            TYPE 1
            TRUE 2
            COUNT 1
            SAMPLING AT INPUT/OUTPUT TIMES 1
            DUMMY SAMPLING TIME 0.
            NUMBER OF HISTOGRAM CELLS 40
            WIDTH OF HISTOGRAM CELLS 20.
            LOWER LIMIT OF FIRST HISTOGRAM CELL 0.
            1 3 1 1 0. 40 1. -20.
            2 2 2 1 0. 40 5. 0.
            2 3 2 1 0. 40 1. -20.
            3 2 1 1 0. 40 50  0.
            3 3 1 1 0. 40 2. -40.
            4 2 2 1 0. 40 10  0.
            4 3 2 1 0. 40 1. -20.
            5 2 1 1 0. 40 100. 0.
            5 3 1 1 0. 40 5. -100.
            6 2 2 1 0. 40 20  0.
            6 3 2 1 0. 40 2. -40.
```

```
          7 2 1 1 0. 40 500. 0.
          7 3 1 1 0. 40 5. -100.
          8 2 2 1 0. 40 50. 0.
          8 3 2 1 0. 40 5. -100.
     (3 1 3) INPUT FUNCTIONS 5 6 7
     (4 1 1) OUTPUT FUNCTIONS 11

CREATE 15 601 TIMR
     TIMER FOR A STANDARD WORK WEEK WITH ONE 8 A.M. TO 5 P.M.
     SHIFT WEEKDAYS AND INTERVALS 8 A.M. TO 12 NOON AND 1 P.M.
     TO 5 P.M. EACH SHIFT

PARAMETER 15
     (1) PERIOD 168.
     (2) SHIFTS PER PERIOD 5
     (3 1 5) SHIFT STARTING TIMES 8. 32. 56. 80. 104.
     (4 1 5) SHIFT ENDING TIMES 17. 41. 65. 89. 113.
     (5) INTERVALS PER PERIOD 10
     (6 1 10) INTERVAL STARTING TIMES 8. 13. 32. 37. 56. 61. 80. 85.
          104. 109.
     (7 1 10) INTERVAL ENDING TIMES 12. 17. 36. 41. 60. 65. 84. 89
          108. 113.

     SIMULATE 2 DAYS OF OPERATION WITH A DUMP, LEVEL 3 TRACE, AND
     NO REPORT
RUN 1 48. 1 3 0

     SIMULATE 28 DAYS OF OPERATION WITH NO DUMP OR TRACE AND
     WITH A STANDARD REPORT
RUN 1 672. 0 0 1

     REDUCE THE UNCERTAINTY OF ALL MASS MEASUREMENTS BY A FACTOR OF TWO
     AND REPEAT THE 28 DAY RUN COLLECTING ONLY MASS ERROR DATA AND
     REPORTING ONLY FUNCTION 11 AND 14
PARAMETER 5
     (2 12 12) .5
PARAMETER 6
     (2 12 12) 1.
PARAMETER 7
     (2 12 12) 1.5
     (2 24 24) 2.
PARAMETER 11
     (2 12 12) .5
     (2 24 24) 1.
     (2 36 36) 1.5
     (2 48 48) 2.
PARAMETER 14
     (1) 4
     (2 1 32)
          2 3 2 1 0. 40 1. -20.
          4 3 2 1 0. 40 1. -20.
          6 3 2 1 0. 40 2. -40.
```

```
          8 3 2 1 0. 40 2. -40.
RUN 1 672. 0 0 0
REPORT 11
REPORT 14

     PLACE ALL MEASUREMENT FUNCTIONS ON THE 8 A.M. TO NOON 1 P.M. TO 5 P.M.
     OPERATING SCHEDULE OF TIMER FUNCTION 15.  REPEAT THE 28 DAY RUN AND
     REPORT FUNCTIONS 5 THROUGH 12.
PARAMETER 5
     (5) 3
PARAMETER 6
     (5) 3
PARAMETER 7
     (5) 3
PARAMETER 11
     (5) 3
RUN 1 672. 0 0 0
REPORT 5
REPORT 6
REPORT 7
REPORT 8
REPORT 9
REPORT 10
REPORT 11
REPORT 12

     RETURN MEASUREMENT FUNCTIONS 6 AND 11 TO CONTINUOUS OPERATION AND
     MEASURE ONLY MATERIAL 4 WITH 2.0 STANDARD DEVIATION OF RANDOM ERROR
PARAMETER 6
     (1) 1   (2 1 6) 4 0 0 0. 0. 2.   (5) 1
PARAMETER 11
     (1) 1   (2 1 6) 4 0 0 0. 0. 2.   (5) 1

     CHANGE CMBA FUNCTION 14 TO REPLICATE SAMPLING OF THE
     MATERIAL BALANCE MASS ERROR FOR MATERIAL 4 AT THE END OF EACH
     OF THE FIRST FOUR WEEKS OF OPERATION AND REMOVE INPUT FUNCTIONS 5 AND 7
PARAMETER 14
     (1) 4
     (2 1 32)
          4 3 2 2 168. 40 5. -100.
          4 3 2 2 336. 40 5. -100.
          4 3 2 2 504. 40 5. -100.
          4 3 2 2 672. 40 5. -100.
     (3 1 1) 6

     ELIMINATE FUNCTIONS 1, 3, 5, AND 7
DESTROY 1
DESTROY 3
DESTROY 5
DESTROY 7
```

```
      TEN REPLICATIONS OF 20 DAYS OF OPERATION WITH A DUMP, NO TRACE,
      AND REPORT 'M' ONLY CMBA FUNCTION 14
RUN 10 620, 1 0 0
REPORT 14

      REPEAT WITH FIFTY REPLICATE RUNS AND NO DUMP
RUN 50 620, 0 0 0
REPORT 14

END
```

Program Execution

With the input file above named MCSSIN, the MCSS program was executed on the time sharing system at Lawrence Livermore Laboratory as shown in the following copy of what appeared on the user's terminal. The first two lines were produced by a CONTROL-E U inquiry to determine the user's time charged prior to execution of the example problem. The third line is the user command that executes the MCSS program with a time limit of one minute and a priority of 1.0. These are followed by the keyword command lines of the input file which are written on the interactive output device as they are encountered during execution of the program. This informs the user of progress in execution when several tasks are defined in a single input file. The ALL DONE message indicates normal completion of controllce execution on the LTS system. And the last two lines are the response to a second CONTROL-E U inquiry. The difference in user's charged time before and after execution of the example indicates that 0.4796 minutes of CDC 7600 time were required.

```
*U
0000.1232
MCSS  1 1
 CREATE 1 101 ACMB
 PARAMETER 1
 CREATE 2 101 ACMB
 PARAMETER 2
 CREATE 3 101 ACMB
 PARAMETER 3
 CREATE 4 301 TRMB
 PARAMETER 4
 CREATE 5 701 MZMB
 PARAMETER 5
 CREATE 6 701 MZMB
 PARAMETER 6
 CREATE 7 701 MZMB
 PARAMETER 7
 CREATE 8 301 TRMB
 PARAMETER 8
 CREATE 9 301 TRMB
 PARAMETER 9
 CREATE 10 301 TRMB
 PARAMETER 10
 CREATE 11 701 MZMB
 PARAMETER 11
 CREATE 12 301 TRMB
 PARAMETER 12
 CREATE 13 401 STOR
 PARAMETER 13
 CREATE 14 702 CMBA
 PARAMETER 14

 *****WARNING*****
 SET PARAMETER LIST EXCEEDS 100 ELEMENTS
 CREATE 15 601 TIMR
 PARAMETER 15
 RUN 1 48. 1 3 0
 RUN 1 672. 0 0 1
```

```
PARAMETER 5
PARAMETER 6
PARAMETER 7
PARAMETER 11
PARAMETER 14
RUN 1 672. 0 0 0
REPORT 11
REPORT 14
PARAMETER 5
PARAMETER 6
PARAMETER 7
PARAMETER 11
RUN 1 672. 0 0 0
REPORT 5
REPORT 6
REPORT 7
REPORT 8
REPORT 9
REPORT 10
REPORT 11
REPORT 12
PARAMETER 6
PARAMETER 11
PARAMETER 14
DESTROY 1
DESTROY 3
DESTROY 5
DESTROY 7
RUN 10 673. 1 0 0
REPORT 14
RUN 50 673. 0 0 0
REPORT 14

ALL DONE
%0
0000.6028
```

Output File MCSSOUT

The complete output file produced by execution of the program is reproduced below. All output produced by the MCSS program is in upper case lettering. Explanatory notes inserted at various places in the program output are indented and are in lower case text format.

```
MATERIAL CONTROL SYSTEM SIMULATOR   VERSION 1.0   1/1/78

      MCSS USERS MANUAL
      EXAMPLE 1
      MATERIAL BALANCE AREA ACCOUNTABILITY
      10/18/77   MCSSIN24


 CREATE 1 101 RCMB
      RECEIVE BULK MATERIALS 1 AND 2

 PARAMETER 1
      (1) PERIOD OF ARRIVAL SCHEDULE 24.
      (2) NUMBER OF ARRIVALS PER PERIOD 2
      (3 1 2) SCHEDULED ARRIVAL TIMES 8. 13.
      (4) MAX DEVIATION FROM SCHEDULED TIMES 2.
      (5) NUMBER OF BULK MATERIAL TYPES 2
      (6 1 14) BULK MATERIAL SPECIFICATIONS
           TYPE 1
           MEAN COUNT 100.
           MAX DEVIATION OF COUNT 50
           MEAN MASS 0.
           STD DEVIATION OF MASS 0.
           MAX MASS 0.
           MIN MASS 0.
           2 0 0 20. 5. 1000. 0.
      (11) TIMING CODE 1
      (12) TIMER FUNCTION 15
      (13) DESTINATION FUNCTION 5
      (14) TRANSPORT FUNCTION 4
          To avoid repetition, annotation defining values specified in the
          input file is included at only the first appearance of a
          particular type of entry.  In specifying the 14 elements of list
          valued parameter 6 above, annotation is included to define the
          first seven elements, but, since those definitions also apply to
          subsequent groups of elements within the list, only numerical
          values of the last seven are supplied.  In specifying the
          parameters of function 2 below, only numerical values of
          parameters already defined in the specification of function 1 are
```

included. Note that parameters 7 through 10 are not specified in function 1 so they are defined in the specifications of function 2. Notice also that since all of the parameters of 101 RCMB functions have been defined previously, only numerical values are supplied for the parameters of function 3. To simplify modification of model systems, the specifications of parameters and variable initial conditions are placed in separate lines of the input file. These conventions in defining and specifying values supplied to the MCSS program are not required by the program. The user may employ other methods of documentation and may choose to compress the input file substantially by combining several entries on single lines.

```
CREATE 2 101 RCMB
     RECEIVE CONTAINERIZED MATERIALS 3 AND 4

PARAMETER 2
     (1) 24.
     (2) 1
     (3 1 1) 12.5
     (4) 4.5
     (7) NUMBER OF MATERIAL TYPES RECEIVED IN CONTAINERS 2
     (8 1 14) CONTAINERIZED MATERIAL SPECIFICATIONS
          3 300 100 0. 0. 0. 0.
          4 0 0 40. 20. 1000. 0.
     (9) MEAN NUMBER OF CONTAINERS RECEIVED PER ARRIVAL 2
     (10) MAX DEVIATION OF NUMBER CONTAINERS RECEIVED PER ARRIVAL 1
     (11) 1
     (12) 15
     (13) 6
     (14) 4

CREATE 3 101 RCMB
     RECEIVE BULK MATERIALS 5 AND 6 AND CONTAINERIZED MATERIALS 7 AND 8

PARAMETER 3
     (1) 24.
     (2) 2
     (3 1 2) 10. 15.
     (4) 2.
     (5) 2
     (6 1 14)
          5 500 10 0. 0. 0. 0.
          6 0 0 60. 6. 1000 0.
     (7) 2
     (8 1 14)
          7 700 50 0. 0. 0. 0.
          8 0 0 80. .8 1000. 0.
     (9) 2
     (10) 0
     (11) 1
     (12) 15
```

```
     (13) 7
     (14) 4

CREATE 4 301 TRMD
     TRANSPORT MATERIALS FROM RECEIVING STATIONS TO MEASUREMENT STATIONS

PARAMETER 4
     (1) MEAN TRANSPORT TIME 0.
     (2) MAX DEVIATION OF TRANSPORT TIME 0.
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES
          By specifying zero mean transport time and zero deviation,
          transport function 4 simulates the movement of incoming material
          batches into the measurement facilities of the three receiving
          stations immediately upon their arrival.

CREATE 5 701 MZMB
     MEASURE INCOMING MATERIALS 1 AND 2 AND REPORT TO MATERIAL
     BALANCE FUNCTION

PARAMETER 5
     (1) NUMBER OF MATERIAL TYPES MEASURED 2
     (2 1 12) MEASUREMENT SPECIFICATIONS
          TYPE 1
          MEAN COUNT ERROR 0
          MAX DEVIATION OF COUNT ERROR 1
          SYSTEMATIC MASS ERROR 0.
          MEAN OF RANDOM MASS ERROR 0.
          STD DEVIATION OF RANDOM MASS ERROR 0.
          2 0 0 0. 0. 1.
     (3) MEAN TIME TO COMPLETE ALL MEASUREMENTS 4.
     (4) MAX DEVIATION OF MEASUREMENT TIME .5
     (5) TIMER CODE 1
     (6) TIMER FUNCTION 15
     (7 1 1) MONITOR FUNCTION 14
     (8) DESTINATION FUNCTION 11
     (9) TIMER SET FUNCTION 8
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 6 701 MZMB
     MEASURE INCOMING MATERIALS 3 AND 4 AND REPORT TO MATERIAL
     BALANCE COMPUTER

PARAMETER 6
     (1) 2
     (2 1 12)
          3 0 3 0. 0. 0.
          4 0 0 0. 0. 2.
     (3) 4.
     (4) .5
     (5) 1
     (6) 15
     (7 1 1) 14
```

```
      (8) 11
      (9) 9

CREATE 7 701 M2MB
      MEASURE INCOMING MATERIALS 5, 6, 7, AND 8 AND REPORT TO MATERIAL
      BALANCE COMPUTER

PARAMETER 7
      (1) 4
      (2 1 24)
           5 0 5 0. 0. 0.
           6 0 0 0. 0. 3.
           7 0 7 0. 0. 0.
           8 0 0 0. 0. 4.
      (3) 4.
      (4) 1.
      (5) 1
      (6) 15
      (7 1 1) 14
      (8) 11
      (9) 10
          Measurement functions 5, 6, and 7 have in this example been
          specified to measure all of the materials that are received.  The
          701 M2MB function may, in general, be used to measure any
          specified set of material types.  If no material of a specified
          type is present in a measured batch, the measured quantity
          reported to the specified monitor function is zero.

CREATE 8 301 TRMB
      TRANSPORT MATERIALS 1 AND 2 FROM INPUT MEASUREMENT STATION TO THE
      STORAGE MEASUREMENT STATION

PARAMETER 8
      (1) 24
      (2) 12.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 9 301 TRMB
      TRANSPORT MATERIALS 3 AND 4 FROM INPUT MEASUREMENT STATION TO THE
      STORAGE MEASUREMENT STATION

PARAMETER 9
      (1) 48.
      (2) 24.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 10 301 TRMB
      TRANSPORT MATERIALS 5, 6, 7, AND 8 FROM INPUT MEASUREMENT STATIONS
      TO THE STORAGE MEASUREMENT STATION

PARAMETER 10
      (1) 48.
```

```
     (2) 12.
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES
```

Three instances of the 301 TRMB function were required to simulate the different times that material batches from the three receiving stations reside in the material balance area. If the statistics of these three residence times had been the same (and no necessarily zero as in the case of function 4) a single transport function could have been used to simulate all three transport operations.

```
CREATE 11 701 MZMB
     MEASURE OUTGOING MATERIALS 1 THROUGH 8 AND REPORT TO MATERIAL
     BALANCE COMPUTER

PARAMETER 11
     (1) 8
     (2 1 48)
          1 0 1 0. 0. 0.
          2 0 0 0. 0. 1.
          3 0 3 0. 0. 0.
          4 0 0 0. 0. 2.
          5 0 5 0. 0. 0.
          6 0 0 0. 0. 3.
          7 0 7 0. 0. 0.
          8 0 0 0. 0. 4.
     (3) 4.
     (4) 1.
     (5) 1
     (6) 15
     (7 1 1) 14
     (8) 13
     (9) 12
```

No annotation is used in the specification of function 11 because all of the parameters of the 701 MZMB function have previously been defined in specifying functions 5, 6, and 7. Notice how the 48 values of parameter 2 are arranged in tabular form to make the input file readable and easy to modify; each row of the table contains the measurement specifications for a particular material type.

```
CREATE 12 301 TRMB
     TRANSPORT MATERIALS 1 THROUGH 8 FROM OUTPUT MEASUREMENT TO STORAGE

PARAMETER 12
     (1) 0.
     (2) 0.

CREATE 13 401 STOR
     STORE BULK AND CONTAINERIZED MATERIALS

PARAMETER 13
     (1) SINGLE DEPOSIT HOLDUP 1
```

```
(2) END AREA OF BULK STORAGE 10.
(3) VERTICAL SURFACE AREA CONTACTED PER UNIT MASS BULK STORAGE 1.
(4) BULK STORAGE SURFACE HOLDUP COEFFICIENT .05
(5 1 4) REPORT
     BULK STORAGE DATA 1
     CONTAINER STORAGE DATA 1
     MATERIAL IN STORAGE 1
     MATERIAL IN HOLDUP 1
NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES
```

[The CUSTOM] function is used in this example only to illustrate the details of its specification and reporting. If the [destination] function specified by parameter 8 of function 11 had been assigned the value zero, the material batches would have been destroyed at the time they completed the transport operation [simulated by function] 12. The storage space occupied by the data structure representing material batches would then have been [returned] to free store at the time the batches were destroyed. In this case, all of the material is placed in the storage function and remains there until the end of each simulation run. Arbitrary values of bulk storage vessel end (bottom) area, surface area contacted per unit of mass in bulk storage, and the surface holdup coefficient of the single deposit holdup model were specified for this example.

```
  1 7 [illegible]
  [illegible] [illegible] COMPUTATION

  [illegible] 12
(1) NUMBER OF REPORTS 16
(2 [illegible] 20) REPORT SPECIFICATIONS
     TYPE 1
     TRUE 2
     COUNT 1
     SAMPLING AT INPUT/OUTPUT TIMES 1
     [illegible] SAMPLING TIME 0.
     NUMBER OF HISTOGRAM CELLS 40
     WIDTH OF HISTOGRAM CELLS 20.
     [illegible] OF FIRST HISTOGRAM CELL 0.
     1 3 [illegible] 1 0. 40 1. -20.
     2 2 3 1 0. 40 5. 0
     2 3 2 1 0. 40 1. -20.
     3 2 1 1 0. 40 50. 0.
     3 3 1 1 0. 40 2. -40.
     4 2 2 1 0. 40 10. 0.
     4 3 2 1 0 40 1 -20.
     5 2 1 1 0. 40 100. 0.
     5 3 1 1 0. 40 5. -100.
     6 2 2 1 0. 40 20. 0.
     6 3 2 1 0. 40 2. -40.
     7 2 1 1 0. 40 500. 0.
     7 3 1 1 0. 40 5. -100.
     8 2 2 1 0. 40 50. 0.
```

```
      8 3 2 1 0. 40 5  -100.
(3 1 3) INPUT FUNCTIONS 5 6 7
(4 1 1) OUTPUT FUNCTIONS 11
```

Function 14 is specified to maintain two material balance computations for each of the eight types of material entering and leaving the material balance area. True and error (observed or book value minus the true value) material balance computations are specified by the second element in each group of eight elements of list valued parameter 2. Notice how the values of parameter 2 are arranged in a tabular form with each row or line of the input file specifying the material balance computation for a particular material type.

```
CREATE 15 601 TIMR
     TIMER FOR A STANDARD WORK WEEK WITH ONE 8 A.M. TO 5 P.M.
     SHIFT WEEKDAYS AND INTERVALS 8 A.M. TO 12 NOON AND 1 P.M.
     TO 5 P.M. EACH SHIFT

PARAMETER 15
     (1) PERIOD 168.
     (2) SHIFTS PER PERIOD 5
     (3 1 5) SHIFT STARTING TIMES 8. 32. 56. 80. 104.
     (4 1 5) SHIFT ENDING TIMES 17. 41. 65. 89. 113.
     (5) INTERVALS PER PERIOD 10
     (6 1 10) INTERVAL STARTING TIMES 8. 13. 32. 37. 56. 61. 80. 85.
          104. 109.
     (7 1 10) INTERVAL ENDING TIMES 12. 17. 36. 41. 60. 65. 84. 89.
          108. 113.
```

This completes the creation and specification of the model system. To verify that the model system has been constructed properly and that it performs as specified, we next perform a short simulation run, requesting a dump of the model system and printout of event and interaction messages.

```
     SIMULATE 2 DAYS OF OPERATION WITH A DUMP, LEVEL 3 TRACE, AND
     NO REPORT
RUN 1 48. 1 3 0
COMMON
          MTO          15
        MFROM           0
       ICTYPE          -6
       IPOINT           0
        IDUMP           1
        ISECA         100
       ITRACE           3
           LB        1483
         LBCA        2417
       LBLIST        1560
         LBPT           1
         LBUF         650
         LCSB         104
           LE        1511
```

```
          LEC          148
         LFFB         2417
         LFFE          180
           LI         1504
          LLE          155
         LLFB         2417
         LLFE          645
          LMS          104
          LNE          165
           LP         1488
           LV         1496
       MINNFL        17582
         MNSE            6
          NFE           94
          NFL        17582
          NI1            5
          NI2           59
          NO1            6
          NO2           59
         NREP            1
         NRUN            1
          NSE            6
         TIME   0.
        TSTOP   4.8000E+01
FUNCTION    1
LB+00     732          101
   + 1    733           22
   + 2    734            1
   + 3    735           15
   + 4    736            2
LP+ 0  1  737            0
   + 1  3  738  2.4000E+01
   + 2  1  739            2
   + 3  4  740          756
                                8.0000E+00  1.3000E+01
   + 4  3  741  2.0000E+00
   + 5  1  742            2
   + 6  4  743          766
                                1.0000E+00  1.0000E+02  5.0000E+01  0.          0.
                                0.          0.          2.0000E+00  0.          0.
                                2.0000E+01  5.0000E+00  1.0000E+03  0.
   + 7  1  744            0
   + 8  4  745            0
   + 9  3  746  0.
   +10  3  747  0.
   +11  1  748            1
   +12  1  749           15
   +13  1  750            5
   +14  1  751            4
LV+ 0  1  752            1
   + 1  1  753            0
LI+ 0  1  754            0
```

```
   + 1     1   755            0
FUNCTION       2
LB+00          784          101
   + 1         785           22
   + 2         786            2
   + 3         787           15
   + 4         788            2
LP+ 0     1    789            0
   + 1     3   790   2.4000E+01
   + 2     1   791            1
   + 3     4   792          808
                      1.2500E+01
   + 4     3   793   4.5000E+00
   + 5     1   794            0
   + 6     4   795            0
   + 7     1   796            2
   + 8     4   797          818
                      3.0000E+00  3.0000E+02  1.0000E+02  0.          0.
                      0.          0.          4.0000E+00  0.          0.
                      4.0000E+01  2.0000E+01  1.0000E+03  0.
   + 9     3   798   2.0000E+00
   +10     3   799   1.0000E+00
   +11     1   800            1
   +12     1   801           15
   +13     1   802            6
   +14     1   803            4
LV+ 0     1    804            1
   + 1     1   805            0
LI+ 0     1    806            0
   + 1     1   807            0
FUNCTION       3
LB+00          836          101
   + 1         837           22
   + 2         838            3
   + 3         839           15
   + 4         840            2
LP+ 0     1    841            0
   + 1     3   842   2.4000E+01
   + 2     1   843            2
   + 3     4   844          860
                      1.0000E+01  1.5000E+01
   + 4     3   845   2.0000E+00
   + 5     1   846            2
   + 6     4   847          870
                      5.0000E+00  5.0000E+02  1.0000E+01  0.          0.
                      0.          0.          6.0000E+00  0.          0.
                      6.0000E+01  6.0000E+00  1.0000E+03  0.
   + 7     1   848            2
   + 8     4   849          888
                      7.0000E+00  7.0000E+02  5.0000E+01  0.          0.
                      0.          0.          8.0000E+00  0.          0.
                      8.0000E+01  8.0000E-01  1.0000E+03  0.
```

+ 9	3	850	2.0000E+00					
+10	3	851	0.					
+11	1	852	1					
+12	1	853	5					
+13	1	854	7					
+14	1	855	4					
LV+ 0	1	856	1					
+ 1	1	857	0					
LI+ 0	1	858	0					
+ 1	1	859	0					
FUNCTION		4						
LB+00		906	301					
+ 1		907	18					
+ 2		908	4					
+ 3		909	5					
+ 4		910	5					
LP+ 0	1	911	0					
+ 1	3	912	0.					
+ 2	3	913	0					
+ 3	2	914	0					
+ 4	1	915	0					
LV+ 0	1	916	1					
+ 1	1	917	0					
+ 2	1	918	0					
+ 3	3	919	0.					
+ 4	1	920	0					
LI+ 0	1	921	0					
+ 1	1	922	0					
+ 2	1	923	0					
+ 3	3	924	0.					
+ 4	1	925	0					
FUNCTION		5						
LB+00		926	701					
+ 1		927	24					
+ 2		928	5					
+ 3		929	11					
+ 4		930	5					
LP+ 0	1	931	0					
+ 1	1	932	2					
+ 2	4	933	952	1.0000E+00	0.	1.0000E+00	0.	0.
				0.	2.0000E+00	0.	0.	0.
				0.	1.0000E+00			
+ 3	3	934	4.0000E+00					
+ 4	3	935	5.0000E-01					
+ 5	1	936	1					
+ 6	1	937	15					
+ 7	2	938	968					
				14				
+ 8	1	939	11					
+ 9	1	940	8					
+10	2	941	0					

LV+	0	1	942		1					
	+ 1	1	943		0					
	+ 2	1	944		0					
	+ 3	3	945	0.						
	+ 4	1	946		0					
LI+	0	1	947		0					
	+ 1	1	948		0					
	+ 2	1	949		0					
	+ 3	3	950	0.						
	+ 4	1	951		0					
FUNCTION			6							
LB+00			976		701					
	+ 1		979		24					
	+ 2		980		6					
	+ 3		981		11					
	+ 4		982		5					
LP+	0	1	983		0					
	+ 1	1	984		2					
	+ 2	4	985		1004					
						3.0000E+00	0.	3.0000E+00	0	0.
						0.	4.0000E+00	0	0	0.
						0.	2.0000E+00			
	+ 3	3	986	4.0000E+00						
	+ 4	3	987	5.0000E-01						
	+ 5	1	988		1					
	+ 6	1	989		15					
	+ 7	2	990		1020					
					14					
	+ 8	1	991		11					
	+ 9	1	992		9					
	+10	2	993		0					
LV+	0	1	994		1					
	+ 1	1	995		0					
	+ 2	1	996		0					
	+ 3	3	997	0.						
	+ 4	1	998		0					
LI+	0	1	999		0					
	+ 1	1	1000		0					
	+ 2	1	1001		0					
	+ 3	3	1002	0.						
	+ 4	1	1003		0					
FUNCTION			7							
LB+00			1030		701					
	+ 1		1031		24					
	+ 2		1032		7					
	+ 3		1033		11					
	+ 4		1034		5					
LP+	0	1	1035		0					
	+ 1	1	1036		4					
	+ 2	4	1037		1056					
						5.0000E+00	0.	5.0000E+00	0	0.
						0.	6.0000E+00	0.	0.	0.

				0.	3.0000E+00	7.0000E+00	0.	7.0000E+00
				0.	0.	0.	8.0000E+00	0.
				0.	0.	0.	4.0000E+00	
+ 3	3	1038	4.0000E+00					
+ 4	3	1039	1.0000E+00					
+ 5	1	1040	1					
+ 6	1	1041	15					
+ 7	2	1042	1084					
				14				
+ 8	1	1043	11					
+ 9	1	1044	10					
+10	2	1045	0					
LV+ 0	1	1046	1					
+ 1	1	1047	0					
+ 2	1	1048	0					
+ 3	3	1049	0.					
+ 4	1	1050	0					
LI+ 0	1	1051	0					
+ 1	1	1052	0					
+ 2	1	1053	0					
+ 3	3	1054	0.					
+ 4	1	1055	0					
FUNCTION		8						
LB+00		1094	301					
+ 1		1095	18					
+ 2		1096	8					
+ 3		1097	5					
+ 4		1098	5					
LP+ 0	1	1099	0					
+ 1	3	1100	2.4000E+01					
+ 2	3	1101	1.2000E+01					
+ 3	2	1102	0					
+ 4	1	1103	0					
LV+ 0	1	1104	1					
+ 1	1	1105	0					
+ 2	1	1106	0					
+ 3	3	1107	0.					
+ 4	1	1108	0					
LI+ 0	1	1109	0					
+ 1	1	1110	0					
+ 2	1	1111	0					
+ 3	3	1112	0.					
+ 4	1	1113	0					
FUNCTION		9						
LB+00		1114	301					
+ 1		1115	18					
+ 2		1116	9					
+ 3		1117	5					
+ 4		1118	5					
LP+ 0	1	1119	0					
+ 1	3	1120	4.8000E+01					
+ 2	3	1121	2.4000E+01					

```
   + 3     2 1122                0
   + 4     1 1123                0
LV+ 0     1 1124                1
   + 1     1 1125                0
   + 2     1 1126                0
   + 3     3 1127  0.
   + 4     1 1128                0
LI+ 0     1 1129                0
   + 1     1 1130                0
   + 2     1 1131                0
   + 3     3 1132  0.
   + 4     1 1133                0
FUNCTION    10
LB+00       1134              301
   + 1      1135               18
   + 2      1136               10
   + 3      1137                5
   + 4      1138                5
LP+ 0     1 1139                0
   + 1     3 1140  4.9000E+01
   + 2     3 1141  1.2000E+01
   + 3     2 1142                0
   + 4     1 1143                0
LV+ 0     1 1144                1
   + 1     1 1145                0
   + 2     1 1146                0
   + 3     3 1147  0.
   + 4     1 1148                0
LI+ 0     1 1149                0
   + 1     1 1150                0
   + 2     1 1151                0
   + 3     3 1152  0.
   + 4     1 1153                0
FUNCTION    11
LB+00       1154              701
   + 1      1155               24
   + 2      1156               11
   + 3      1157               11
   + 4      1158                5
LP+ 0     1 1159                0
   + 1     1 1160                8
   + 2     4 1161             1180
```

1.0000E+00	0.	1.0000E+00	0.	0.
0.	2.0000E+00	0.	0.	0.
0.	1.0000E+00	3.0000E+00	0.	3.0000E+00
0.	0.	0.	4.0000E+00	0.
0.	0.	0.	2.0000E+00	5.0000E+00
0.	5.0000E+00	0.	0.	0.
6.0000E+00	0.	0.	0.	0.
3.0000E+00	7.0000E+00	0.	7.0000E+00	0.
0.	0.	8.0000E+00	0.	0.
0.	0.	4.0000E+00		

	+ 3	3	1162	4.0000E+00
	+ 4	3	1163	1.0000E+00
	+ 5	1	1164	1
	+ 6	1	1165	15
	+ 7	2	1166	1232
	+ 8	1	1167	13
	+ 9	1	1168	12
	+10	2	1169	0
LV+	0	1	1170	1
	+ 1	1	1171	0
	+ 2	1	1172	0
	+ 3	3	1173	0.
	+ 4	1	1174	0
LI+	0	1	1175	0
	+ 1	1	1176	0
	+ 2	1	1177	0
	+ 3	3	1178	0.
	+ 4	1	1179	0
FUNCTION			12	
LC+00			1242	301
	+ 1		1243	18
	+ 2		1244	12
	+ 3		1245	5
	+ 4		1246	5
LP+	0	1	1247	0
	+ 1	3	1248	0.
	+ 2	3	1249	0.
	+ 3	2	1250	0
	+ 4	1	1251	0
LV+	0	1	1252	1
	+ 1	1	1253	0
	+ 2	1	1254	0
	+ 3	3	1255	0.
	+ 4	1	1256	0
LI+	0	1	1257	0
	+ 1	1	1258	0
	+ 2	1	1259	0
	+ 3	3	1260	0.
	+ 4	1	1261	0
FUNCTION			13	
LC+00			1262	401
	+ 1		1263	44
	+ 2		1264	13
	+ 3		1265	9
	+ 4		1266	16
LP+	0	1	1267	0
	+ 1	1	1268	1
	+ 2	3	1269	1.0000E+01
	+ 3	3	1270	1.0000E+00
	+ 4	3	1271	3.0000E-02
	+ 5	2	1272	1308

					1	1	1	1	
+ 6	2	1273		0					
+ 7	1	1274		1579					
+ 8	1	1275		1580					
LV+ 0	1	1276		1					
+ 1	1	1277		0					
+ 2	1	1278		0					
+ 3	3	1279	0.						
+ 4	1	1280		0					
+ 5	3	1281	0.						
+ 6	3	1282	0.						
+ 7	3	1283	0.						
+ 8	3	1284	0.						
+ 9	3	1285	0.						
+10	3	1286	0.						
+11	1	1287		0					
+12	3	1288	0.						
+13	3	1289	0.						
+14	3	1290	0.						
+15	3	1291	0.						
LI+ 0	1	1292		0					
+ 1	1	1293		0					
+ 2	1	1294		0					
+ 3	3	1295	0.						
+ 4	1	1296		0					
+ 5	3	1297	0.						
+ 6	3	1298	0.						
+ 7	3	1299	0.						
+ 8	3	1300	0.						
+ 9	3	1301	0.						
+10	3	1302	0.						
+11	1	1303		0					
+12	3	1304	0.						
+13	3	1305	0.						
+14	3	1306	0.						
+15	3	1307	0.						
FUNCTION		14							
LB+00		1318		702					
+ 1		1319		11					
+ 2		1320		14					
+ 3		1321		6					
+ 4		1322		1					
LP+ 0	1	1323		0					
+ 1	1	1324		16					
+ 2	4	1325		1331					
					1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	0.
					4.0000E+01	2.0000E+01	0.	1.0000E+00	3.0000E+00
					1.0000E+00	1.0000E+00	0.	4.0000E+01	1.0000E+00
					-2.0000E+01	2.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00
					0.	4.0000E+01	5.0000E+00	0.	2.0000E+00
					3.0000E+00	2.0000E+00	1.0000E+00	0.	4.0000E+01
					1.0000E+00	-2.0000E+01	3.0000E+00	2.0000E+00	1.0000E+00

1.0000E+00	0.		4.0000E+01	5.0000E+01	0.				
3.0000E+00	3.0000E+00		1.0000E+00	1.0000E+00	0.				
4.0000E+01	2.0000E+00		-4.0000E+01	4.0000E+00	2.0000E+00				
2.0000E+00	1.0000E+00		0.	4.0000E+01	1.0000E+01				
0.	4.0000E+00		3.0000E+00	2.0000E+00	1.0000E+00				
0.	4.0000E+01		1.0000E+00	-2.0000E+01	5.0000E+00				
2.0000E+00	1.0000E+00		1.0000E+00	0.	4.0000E+01				
1.0000E+02	0.		5.0000E+00	3.0000E+00	1.0000E+00				
1.0000E+00	0.		4.0000E+01	5.0000E+00	-1.0000E+02				
6.0000E+00	2.0000E+00		2.0000E+00	1.0000E+00	0.				
4.0000E+01	2.0000E+01		0.	6.0000E+00	3.0000E+00				
2.0000E+00	1.0000E+00		0.	4.0000E+01	2.0000E+00				
-4.0000E+01	7.0000E+00		2.0000E+00	1.0000E+00	1.0000E+00				
0.	4.0000E+01		5.0000E+02	0.	7.0000E+00				
3.0000E+00	1.0000E+00		1.0000E+00	0.	4.0000E+01				
5.0000E+00	-1.0000E+02		8.0000E+00	2.0000E+00	2.0000E+00				
1.0000E+00	0.		4.0000E+01	5.0000E+01	0.				
8.0000E+00	3.0000E+00		2.0000E+00	1.0000E+00	0.				
4.0000E+01	5.0000E+00		-1.0000E+02						
	5		6	7					
	11								

+ 3	2	1326		1463
+ 4	2	1327		1473
+ 5	1	1328		1599
LV+ 0	1	1329		1
LI+ 0	1	1330		0
FUNCTION		15		
LO+00		1483		601
+ 1		1484		27
+ 2		1485		15
+ 3		1486		8
+ 4		1487		8
LP+ 0	1	1488		0
+ 1	3	1489	1.6800E+02	
+ 2	1	1490		5
+ 3	4	1491		1512
			8.0000E+00	3.2000E+01
+ 4	4	1492		1522
			1.7000E+01	4.1000E+01
+ 5	1	1493		10
+ 6	4	1494		1532
			8.0000E+00	1.3000E+01
			6.1000E+01	8.0000E+01
+ 7	4	1495		1546
			1.2000E+01	1.7000E+01
			6.5000E+01	8.4000E+01
LV+ 0	1	1496		1
+ 1	3	1497	1.6800E+02	
+ 2	1	1498		0
+ 3	3	1499	0.	
+ 4	3	1500	8.0000E+00	
+ 5	1	1501		0

5.6000E+01	8.0000E+01	1.0400E+02		
6.5000E+01	8.9000E+01	1.1300E+02		
3.2000E+01	3.7000E+01	5.6000E+01		
8.5000E+01	1.0400E+02	1.0900E+02		
3.6000E+01	4.1000E+01	6.0000E+01		
8.9000E+01	1.0800E+02	1.1300E+02		

```
  + 6      3 1502   0.
  + 7      3 1503   8.0000E+00
L1+ 0      1 1504            0
  + 1      3 1505   1.6800E+02
  + 2      1 1506            0
  + 3      3 1507   0.
  + 4      3 1508   8.0000E+00
  + 5      1 1509            0
  + 6      3 1510   0.
  + 7      3 1511   8.0000E+00
EVENT CHAIN
          LEC            148
          LNE            165
          LLE            155
         LFFE            180
         LLFE            645
          NSE              6
         MNSE              6
          NFE             94
        ISECA            100
        165          170      0.              15         1         0
        170          175      8.0000E+00      15         2         0
        175          150      8.0000E+00      15         3         0
        150          160      9.4375E+00       1         1         0
        160          155      1.1125E+01       3         1         0
        155            0      1.5594E+01       2         1         0
FREE STORE
         LFFB           2417
         LLFB           2417
          NFL          17582
         LBCA           2417
       MINNFL          17582
       2417            0      17582
```

This completes the dump of the model system. Since this is the first run of the model system, the free store chain consists of a single block of 17582 available memory locations. The output file next contains the chronological list of event and interactions written during the 48 hour simulation run.

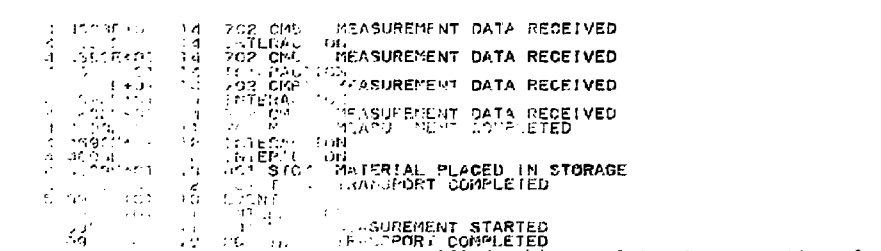
```
0.             15   EVENT
0.             15   601 TIMR   BEGIN PERIOD
8.0000E+00     15   EVENT
8.0000E+00     15   601 TIMR   BEGIN SHIFT
8.0000E+00     15   EVENT
8.0000E+00     15   601 TIMR   BEGIN INTERVAL
9.4375E+00      1   EVENT
9.4375E+00      4   INTERACTION
9.4375E+00      5   INTERACTION
9.4375E+00      5   701 MZMB   MEASUREMENT STARTED
9.4375E+00      4   301 TRMB   TRANSPORT COMPLETED
9.4375E+00      1   101 RCMB   MATERIAL BATCH RECEIVED
1.1125E+01      3   EVENT
1.1125E+01      4   INTERACTION
```

1.1125E+01	7	INTERACTION
1.1125E+01	7	701 MZMB MEASUREMENT STARTED
1.1125E+01	4	301 TRMB TRANSPORT COMPLETED
1.1125E+01	3	101 RCMB MATERIAL BATCH RECEIVED
1.1250E+01	1	EVENT
1.1250E+01	4	INTERACTION
1.1250E+01	5	INTERACTION
1.1250E+01	5	701 MZMB MEASUREMENT STARTED
1.1250E+01	4	301 TRMB TRANSPORT COMPLETED
1.1250E+01	1	101 RCMB MATERIAL BATCH RECEIVED
1.2000E+01	15	EVENT
1.2000E+01	15	601 TIMR END INTERVAL
1.3000E+01	15	EVENT
1.3000E+01	15	601 TIMR BEGIN INTERVAL
1.3750E+01	5	EVENT
1.3750E+01	14	INTERACTION
1.3750E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.3750E+01	14	INTERACTION
1.3750E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.3750E+01	5	701 MZMB MEASUREMENT COMPLETED
1.3750E+01	8	INTERACTION
1.3750E+01	8	301 TRMB TRANSPORT STARTED
1.4125E+01	7	EVENT
1.4436E+01	14	INTERACTION
1.4436E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.4436E+01	14	INTERACTION
1.4436E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.4436E+01	14	INTERACTION
1.4436E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.4436E+01	14	INTERACTION
1.4436E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.4436E+01	7	701 MZMB MEASUREMENT COMPLETED
1.4436E+01	10	INTERACTION
1.4436E+01	10	301 TRMB TRANSPORT STARTED
1.5577E+01	3	EVENT
1.5577E+01	4	INTERACTION
1.5577E+01	7	INTERACTION
1.5577E+01	7	701 MZMB MEASUREMENT STARTED
1.5577E+01	4	301 TRMB TRANSPORT COMPLETED
1.5577E+01	3	101 RCMB MATERIAL BATCH RECEIVED
1.5594E+01	2	EVENT
1.5594E+01	4	INTERACTION
1.5594E+01	6	INTERACTION
1.5594E+01	6	701 MZMB MEASUREMENT STARTED
1.5594E+01	4	301 TRMB TRANSPORT COMPLETED
1.5594E+01	2	101 RCMB MATERIAL BATCH RECEIVED
1.5772E+01	5	EVENT
1.5772E+01	14	INTERACTION
1.5772E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.5772E+01	14	INTERACTION
1.5772E+01	14	702 CMBA MEASUREMENT DATA RECEIVED
1.5772E+01	5	701 MZMB MEASUREMENT COMPLETED

```
1.5772E+01    8  INTERACTION
1.5772E+01    8  301 TRNS  TRANSPORT STARTED
1.7000E+01   15  EVENT
1.7000E+01   15  601 TIMR  END SHIFT
1.7000E+01   15  EVENT
1.7000E+01   15  601 TIMR  END INTERVAL
1.8400E+01    7  EVENT
1.8400E+01   14  INTERACTION
1.8402E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
1.8402E+01   14  INTERACTION
1.8402E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
1.8402E+01   14  INTERACTION
1.8402E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
1.8402E+01   14  INTERACTION
1.8402E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
1.8402E+01    7  701 MZMB  MEASUREMENT COMPLETED
1.8402E+01   10  INTERACTION
1.8431E+01   13  301 TRNS  TRANSPORT STARTED
1.8431E+01    6  EVENT
1.8431E+01   14  INTERACTION
1.8431E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
1.8431E+01   14  INTERACTION
1.8431E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
1.8431E+01    6  701 MZMB  MEASUREMENT COMPLETED
1.8431E+01    9  INTERACTION
1.8431E+01    9  301 TRNS  TRANSPORT STARTED
3.0200E+01    1  EVENT
3.0200E+01    4  INTERACTION
3.0200E+01    5  INTERACTION
3.0200E+01    5  701 MZMB  MEASUREMENT STARTED
3.0200E+01    4  301 TRNS  TRANSPORT COMPLETED
3.0200E+01    1  101 PCMB  MATERIAL BATCH RECEIVED
3.1767E+01    8  EVENT
3.1767E+01   11  INTERACTION
3.1767E+01   11  701 MZMB  MEASUREMENT STARTED
3.1767E+01    8  301 TRNS  TRANSPORT COMPLETED
3.2000E+01   15  EVENT
3.2000E+01   15  601 TIMR  BEGIN SHIFT
3.2000E+01   15  EVENT
3.2000E+01   15  601 TIMR  BEGIN INTERVAL
3.2043E+01    3  EVENT
3.2043E+01    4  INTERACTION
3.2043E+01    7  INTERACTION
3.2043E+01    7  701 MZMB  MEASUREMENT STARTED
3.2043E+01    4  301 TRNS  TRANSPORT COMPLETED
3.2043E+01    3  101 PCMB  MATERIAL BATCH RECEIVED
3.5000E+01    5  EVENT
3.5000E+01   14  INTERACTION
3.5000E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
3.5000E+01   14  INTERACTION
3.5000E+01   14  702 CMBA  MEASUREMENT DATA RECEIVED
3.5000E+01    5  701 MZMB  MEASUREMENT COMPLETED
```

3.5000E+01	8	INTERACTION	
3.5000E+01	8	301 TRMB	TRANSPORT STARTED
3.5222E+01	11	EVENT	
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	14	INTERACTION	
3.5222E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5222E+01	11	701 MZMB	MEASUREMENT COMPLETED
3.5222E+01	12	INTERACTION	
3.5222E+01	13	INTERACTION	
3.5222E+01	13	401 STOM	MATERIAL PLACED IN STORAGE
3.5222E+01	12	301 TRMB	TRANSPORT COMPLETED
3.5403E+01	7	EVENT	
3.5403E+01	14	INTERACTION	
3.5403E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5403E+01	14	INTERACTION	
3.5403E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5403E+01	14	INTERACTION	
3.5403E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5403E+01	14	INTERACTION	
3.5403E+01	14	702 CMBA	MEASUREMENT DATA RECEIVED
3.5403E+01	7	701 MZMB	MEASUREMENT COMPLETED
3.5403E+01	10	INTERACTION	
3.5403E+01	10	301 TRMB	TRANSPORT STARTED
3.5514E+01	1	EVENT	
3.5514E+01	4	INTERACTION	
3.5514E+01	5	INTERACTION	
3.5514E+01	5	701 MZMB	MEASUREMENT STARTED
3.5514E+01	4	301 TRMB	TRANSPORT COMPLETED
3.5514E+01	1	101 RCMB	MATERIAL BATCH RECEIVED
3.6000E+01	15	EVENT	
3.6000E+01	15	601 TIMR	END INTERVAL
3.7000E+01	15	EVENT	
3.7000E+01	15	601 TIMR	BEGIN INTERVAL
3.7347E+01	2	EVENT	
3.7347E+01	4	INTERACTION	
3.7347E+01	6	INTERACTION	
3.7347E+01	6	701 MZMB	MEASUREMENT STARTED
3.7347E+01	4	301 TRMB	TRANSPORT COMPLETED
3.7347E+01	2	101 RCMB	MATERIAL BATCH RECEIVED

```
3.8337E+01   3  EVENT
3.8337E+01   4  INTERACTION
3.8337E+01   7  INTERACTION
3.8337E+01   7  701 MZMB  MEASUREMENT STARTED
3.8337E+01   4  301 TRMB  TRANSPORT COMPLETED
3.8337E+01   3  101 RCMB  MATERIAL BATCH RECEIVED
3.9316E+01   5  EVENT
3.9316E+01  14  INTERACTION
3.9316E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
3.9316E+01  14  INTERACTION
3.9316E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
3.9316E+01   5  701 MZMB  MEASUREMENT COMPLETED
3.9316E+01   8  INTERACTION
3.9316E+01   8  301 TRMB  TRANSPORT STARTED
4.0961E+01   8  EVENT
4.0961E+01  11  INTERACTION
4.0961E+01  11  701 MZMB  MEASUREMENT STARTED
4.0961E+01   8  301 TRMB  TRANSPORT COMPLETED
4.1000E+01  15  EVENT
4.1000E+01  15  601 TIMR  END SHIFT
4.1000E+01  15  EVENT
4.1000E+01  15  601 TIMR  END INTERVAL
4.1315E+01   6  EVENT
4.1315E+01  14  INTERACTION
4.1315E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.1315E+01  14  INTERACTION
4.1315E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.1315E+01   6  701 MZMB  MEASUREMENT COMPLETED
4.1315E+01   9  INTERACTION
4.1315E+01   9  301 TRMB  TRANSPORT STARTED
4.2260E+01   7  EVENT
4.2260E+01  14  INTERACTION
4.2260E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.2260E+01  14  INTERACTION
4.2260E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.2260E+01  14  INTERACTION
4.2260E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.2260E+01  14  INTERACTION
4.2260E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.2260E+01   7  701 MZMB  MEASUREMENT COMPLETED
4.2260E+01  10  INTERACTION
4.2260E+01  10  301 TRMB  TRANSPORT STARTED
4.4693E+01  11  EVENT
4.4693E+01  14  INTERACTION
4.4693E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.4693E+01  14  INTERACTION
4.4693E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.4693E+01  14  INTERACTION
4.4693E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.4693E+01  14  INTERACTION
4.4693E+01  14  702 CMBA  MEASUREMENT DATA RECEIVED
4.4693E+01  14  INTERACTION
```



specified by the first RUN line. We next conduct operation of the model system without a dump the details of operation during the run. Data operation of the model system are output in a at the end of the run.

OPERATION WITH NO DUMP OR TRACE AND

or into the program output file during the model system specified above. The following begins with a table showing the number of times was transferred to the individual functions of the This does not necessarily indicate the relative time spent in simulating the different functions. The table is followed by an individual report generated by each function of the model system.

FUNCTION	TYPE	ENTRIE	FRACTION
1	101	11	0.0217
2	101	5	0.0109
3	101	11	0.0217
4	301	28	0.0543
5	201	28	0.0543
6	201	14	0.0272
7	701	39	0.0761
8	201	16	0.0314
9	201	8	0.0155
10	301	16	0.0311
11	701	143	0.2778
12	301	26	0.0505
13	401	13	0.0252
14	709	1439	0.2780
15	501	13	0.0243

```
FUNCTION   1 101 RCMB
           NUMBER OF BATCHES RECEIVED                    56

FUNCTION   2 101 RCMB
           NUMBER OF BATCHES RECEIVED                    28

FUNCTION   3 101 RCMB
           NUMBER OF BATCHES RECEIVED                    56

FUNCTION   4 301/TRMB
           MAXIMUM NUMBER OF BATCHES IN TRANSPORT         1
           TIME MAXIMUM FIRST OCCURRED          7.1863E+00

FUNCTION   5 701/MZMB
           MAXIMUM NUMBER OF BATCHES IN MEASUREMENT       2
           TIME MAXIMUM FIRST OCCURRED          5.9105E+01

FUNCTION   6 701/MZMB
           MAXIMUM NUMBER OF BATCHES IN MEASUREMENT       1
           TIME MAXIMUM FIRST OCCURRED          1.1145E+01

FUNCTION   7 701/MZMB
           MAXIMUM NUMBER OF BATCHES IN MEASUREMENT       2
           TIME MAXIMUM FIRST OCCURRED          3.7352E+01

FUNCTION   8 301/TRMB
           MAXIMUM NUMBER OF BATCHES IN TRANSPORT         4
           TIME MAXIMUM FIRST OCCURRED          2.3165E+02

FUNCTION   9 301/TRMB
           MAXIMUM NUMBER OF BATCHES IN TRANSPORT         4
           TIME MAXIMUM FIRST OCCURRED          2.7638E+02

FUNCTION  10 301/TRMB
           MAXIMUM NUMBER OF BATCHES IN TRANSPORT         5
           TIME MAXIMUM FIRST OCCURRED          6.6070E+01

FUNCTION  11 701/MZMB
           MAXIMUM NUMBER OF BATCHES IN MEASUREMENT       4
           TIME MAXIMUM FIRST OCCURRED          1.3531E+02
```

FUNCTION 12.301/TRMB
MAXIMUM NUMBER OF BATCHES IN TRANSPORT 1
TIME MAXIMUM FIRST OCCURRED 4.2536E+01

FUNCTION 13.401 STOM

BULK STORAGE
CURRENTLY IN STORAGE 4.10 0E+03
MAXIMUM MASS STORED 4.10 0E+03 AT TIME 6.6545E+02
NUMBER OBSERVATIONS 104
MEAN 1.9486E+03
STANDARD DEVIATION 1.2779E+03

CONTAINER STORAGE
CURRENTLY IN STORAGE 141
MAXIMUM NUMBER STORED 141 AT TIME 6.5486E+02
NUMBER OBSERVATIONS 77
MEAN 6.26-5E+01
STANDARD DEVIATION 4.3095E+01

MATERIAL IN STORAGE

3047	0	2707	0	0	0	6	0	5.4312E+02
2707	0	3327	3047	0	0	5	4713	0.
3327	0	3187	2707	0	0	2	0	1.7547E+02
3187	2477	0	3327	0	0	1	851	0.
2717	0	2677	0	0	0	4	0	6.0828E+01
2677	2757	0	2717	0	0	3	396	0.
2757	2487	0	0	2677	1	0	396	6.0828E+01
2557	0	2547	0	0	0	8	0	7.8917E+01
2547	2537	0	2557	0	0	7	658	0.
2537	2497	0	0	2547	1	0	658	7.8917E+01
2527	0	2517	0	0	0	8	0	7.8373E+01
2517	2507	0	2527	0	0	7	665	0.
2507	2567	0	0	2517	1	0	665	7.8373E+01
3317	0	2467	0	0	0	4	0	3.3662E+01
2467	2437	0	3317	0	0	3	392	0.
2437	3117	0	0	2467	1	0	392	3.3662E+01
2957	0	2917	0	0	0	8	0	8.0202E+01
2917	2997	0	2957	0	0	7	723	0.
2997	2907	0	0	2917	1	0	723	8.0202E+01
2927	0	2987	0	0	0	8	0	7.9269E+01
2987	2977	0	2927	0	0	7	692	0.
2977	2967	0	0	2987	1	0	692	7.9269E+01
3227	0	3217	0	0	0	8	0	7.9813E+01
3217	3277	0	3227	0	0	7	652	0.
3277	3267	0	0	3217	1	0	652	7.9813E+01
2787	0	3307	0	0	0	8	0	8.0286E+01
3307	3297	0	2787	0	0	7	657	0.
3297	3237	0	0	3307	1	0	657	8.0286E+01
3097	0	3087	0	0	0	8	0	7.9840E+01
3087	3147	0	3097	0	0	7	655	0.

3147	3137	0	0	3087	1	0	655	7.3840E+01
2837	0	2847	0	0	0	8	0	7.8225E+01
2847	2877	0	2837	0	0	7	748	0.
2877	3107	0	0	2847	1	0	748	7.8225E+01
3147	0	3337	0	0	0	8	0	8.0835E+01
3337	2897	0	3347	0	0	7	705	0.
2897	2887	0	0	3337	1	0	705	8.0835E+01
3307	0	3377	0	0	0	8	0	7.9374E+01
3377	3367	0	3387	0	0	7	677	0.
3367	3357	0	0	3377	1	0	677	7.9374E+01
3447	0	3437	0	0	0	8	0	7.8102E+01
3437	2737	0	3447	0	0	7	744	0.
2737	3177	0	0	3437	1	0	744	7.8102E+01
3487	0	3477	0	0	0	8	0	8.1068E+01
3477	3467	0	3487	0	0	7	718	0.
3467	3457	0	0	3477	1	0	718	8.1068E+01
3557	0	3547	0	0	0	4	0	7.0168E+01
3547	3537	0	3557	0	0	3	323	0.
3537	2767	0	0	3547	1	0	323	7.0168E+01
3597	0	3587	0	0	0	4	0	3.3600E+01
3587	3577	0	3597	0	0	3	385	0.
3577	3567	0	0	3587	1	0	385	3.3600E+01
2947	0	2937	0	0	0	4	0	6.1501E+01
2937	2867	0	2947	0	0	3	371	0.
2867	2647	0	0	2937	1	0	371	6.1501E+01
3807	0	3797	0	0	0	4	0	3.5695E+01
3797	3657	0	3807	0	0	3	394	0.
3657	3007	0	0	3797	1	0	394	3.5695E+01
3707	0	3697	0	0	0	8	0	7.8419E+01
3697	3687	0	3707	0	0	7	675	0.
3687	3677	0	0	3697	1	0	675	7.8419E+01
3747	0	3737	0	0	0	8	0	7.9600E+01
3737	3727	0	3747	0	0	7	729	0.
3727	3717	0	0	3737	1	0	729	7.9600E+01
3897	0	3887	0	0	0	8	0	7.9103E+01
3887	3867	0	3897	0	0	7	746	0.
3867	2597	0	0	3887	1	0	746	7.9103E+01
3937	0	3927	0	0	0	8	0	8.0946E+01
3927	3917	0	3937	0	0	7	659	0.
3917	3907	0	0	3927	1	0	659	8.0946E+01
4177	0	4167	0	0	0	4	0	1.8959E+01
4167	4157	0	4177	0	0	3	377	0.
4157	4017	0	0	4167	1	0	377	1.8959E+01
3127	0	3067	0	0	0	8	0	8.0039E+01
3067	3207	0	3127	0	0	7	663	0.
3207	3287	0	0	3067	1	0	663	8.0039E+01
3787	0	3027	0	0	0	8	0	7.8567E+01
3027	3167	0	3787	0	0	7	738	0.
3167	2857	0	0	3027	1	0	738	7.8567E+01
4067	0	4057	0	0	0	8	0	7.9665E+01
4057	4047	0	4067	0	0	7	711	0.
4047	4037	0	0	4057	1	0	711	7.9665E+01

4107	0	4097	0	0	0	8	0	8.0400E+01
4097	4087	0	4107	0	0	7	716	0.
4037	4077	0	0	4097	1	0	716	8.0400E+01
3497	0	2777	0	0	0	8	0	7.8630E+01
2777	2797	0	3497	0	0	7	714	0.
2797	2727	0	0	2777	1	0	714	7.8630E+01
4217	0	4197	0	0	0	8	0	8.0863E+01
4197	3517	0	4217	0	0	7	741	0.
3517	3507	0	0	4197	1	0	741	8.0863E+01
4397	0	4387	0	0	0	8	0	7.9532E+01
4367	4367	0	4397	0	0	7	691	0.
4367	2617	0	0	4387	1	0	691	7.9532E+01
4387	0	4427	0	0	0	8	0	7.9799E+01
4427	4417	0	4437	0	0	7	721	0.
4417	4407	0	0	4427	1	0	721	7.9799E+01
4267	0	2747	0	0	0	4	0	2.1504E+01
2747	3427	0	4267	0	0	3	268	0.
3427	4207	0	0	2747	1	0	268	2.1504E+01
4307	0	4297	0	0	0	4	0	4.8963E+01
4297	4287	0	4307	0	0	3	354	0.
4227	4277	0	0	4297	1	0	354	4.8963E+01
4577	0	4567	0	0	0	8	0	7.9549E+01
4567	4557	0	4577	0	0	7	701	0.
4557	4547	0	0	4567	1	0	701	7.9649E+01
4617	0	4607	0	0	0	8	0	8.0702E+01
4607	4597	0	4617	0	0	7	712	0.
4597	4587	0	0	4607	1	0	712	8.0702E+01
3967	0	3957	0	0	0	8	0	8.0158E+01
3957	3947	0	3967	0	0	7	660	0.
3947	2457	0	0	3957	1	0	660	8.0158E+01
3767	0	3757	0	0	0	8	0	8.0843E+01
3757	3667	0	3767	0	0	7	677	0.
3667	4357	0	0	3757	1	0	677	8.0843E+01
4687	0	4677	0	0	0	4	0	4.9121E+01
4677	4657	0	4687	0	0	3	226	0.
4667	4527	0	0	4677	1	0	226	4.9121E+01
2657	0	2637	0	0	0	4	0	4.0974E+01
2637	3257	0	2657	0	0	3	362	0.
3257	4697	0	0	2637	1	0	362	4.0974E+01
4747	0	4737	0	0	0	4	0	5.6638E+01
4737	4727	0	4747	0	0	3	317	0.
4727	4707	0	0	4737	1	0	317	5.6638E+01
4327	0	3857	0	0	0	8	0	8.0555E+01
3857	3417	0	4327	0	0	7	654	0.
3417	3997	0	0	3857	1	0	654	8.0555E+01
4117	0	4027	0	0	0	8	0	8.0767E+01
4027	4497	0	4117	0	0	7	720	0.
4497	4347	0	0	4027	1	0	720	8.0767E+01
4877	0	4867	0	0	0	8	0	8.1082E+01
4867	4357	0	4877	0	0	7	657	0.
4857	4647	0	0	4867	1	0	657	8.1082E+01
4917	0	4907	0	0	0	8	0	7.8319E+01

4907	4897	0	4917	0	0	7	655	0.
4897	4387	0	0	4907	1	0	655	7.8915E+01
4457	0	4187	0	0	0	8	0	7.9157E+01
4187	4447	0	4457	0	0	7	660	0.
4447	4487	0	0	4167	1	0	660	7.9157E+01
4237	0	4227	0	0	0	8	0	7.9432E+01
4227	2807	0	4237	0	0	7	745	0.
2807	4807	0	0	4227	1	0	745	7.9432E+01
5047	0	5027	0	0	0	8	0	8.0582E+01
5027	4647	0	5047	0	0	7	695	0.
4647	4637	0	0	5027	1	0	695	8.0582E+01
5087	0	5077	0	0	0	8	0	8.0173E+01
5077	5067	0	5087	0	0	7	728	0.
5067	5057	0	0	5077	1	0	728	8.0173E+01
5277	0	5267	0	0	0	8	0	7.9641E+01
5267	5257	0	5277	0	0	7	664	0.
5257	5247	0	0	5267	1	0	664	7.9641E+01
5317	0	5307	0	0	0	8	0	8.1937E+01
5307	5297	0	5317	0	0	7	724	0.
5297	5287	0	0	5307	1	0	724	8.1937E+01
3877	0	3837	0	0	0	8	0	8.0605E+01
3837	4377	0	3877	0	0	7	662	0.
4377	3827	0	0	3837	1	0	662	8.0605E+01
5157	0	5147	0	0	0	8	0	8.0416E+01
5147	5137	0	5157	0	0	7	713	0.
5137	4537	0	0	5147	1	0	713	8.0416E+01
5007	0	4997	0	0	0	4	0	2.8940E+01
4997	4987	0	5007	0	0	3	370	0.
4987	3017	0	0	4997	1	0	370	2.8940E+01
4137	0	4127	0	0	0	4	0	3.4923E+01
4127	4147	0	4137	0	0	3	255	0.
4147	5217	0	0	4127	1	0	255	3.4923E+01
5377	0	5367	0	0	0	4	0	5.3893E+01
5367	5227	0	5377	0	0	3	391	0.
5227	4517	0	0	5367	1	0	391	5.3893E+01
5537	0	5527	0	0	0	4	0	4.7611E+01
5527	5517	0	5537	0	0	3	390	0.
5517	2687	0	0	5527	1	0	390	4.7611E+01
4257	0	5407	0	0	0	8	0	7.9072E+01
5407	4947	0	4257	0	0	7	650	0.
4947	4937	0	0	5407	1	0	650	7.9072E+01
5417	0	5397	0	0	0	8	0	7.8885E+01
5397	2817	0	5417	0	0	7	670	0.
2817	4657	0	0	5397	1	0	670	7.8885E+01
5587	0	5577	0	0	0	4	0	2.8437E+01
5577	5557	0	5587	0	0	3	398	0.
5557	5107	0	0	5577	1	0	398	2.8437E+01
5627	0	5617	0	0	0	4	0	6.7077E+01
5617	5607	0	5627	0	0	3	347	0.
5607	5597	0	0	5617	1	0	347	6.7077E+01
3057	0	5387	0	0	0	8	0	8.1506E+01
5387	4967	0	3057	0	0	7	730	0.

4967	4827	0	0	5387	1	0	730	8.1506E+01
5467	0	4507	0	0	0	8	0	8.0217E+01
4507	3817	0	5467	0	0	7	745	0.
3817	4777	0	0	4507	1	0	745	8.0217E+01
5717	0	5707	0	0	0	8	0	7.9798E+01
5707	5897	0	5717	0	0	7	654	0.
5697	5687	0	0	5707	1	0	654	7.9798E+01
5757	0	5747	0	0	0	8	0	7.9617E+01
5747	5737	0	5757	0	0	7	680	0.
5737	5727	0	0	5747	1	0	680	7.9617E+01
5847	0	5837	0	0	0	8	0	7.9905E+01
5837	5827	0	5847	0	0	7	727	0.
5827	5817	0	0	5837	1	0	727	7.9905E+01
5887	0	5877	0	0	0	8	0	7.9563E+01
5877	5867	0	5887	0	0	7	676	0.
5867	5857	0	0	5877	1	0	676	7.9563E+01
5437	0	5427	0	0	0	4	0	4.3970E+01
5427	4927	0	5437	0	0	3	253	0.
4927	5947	0	0	5427	1	0	253	4.3970E+01
6017	0	6007	0	0	0	8	0	7.8945E+01
6007	5997	0	6017	0	0	7	692	0.
5997	5987	0	0	6007	1	0	692	7.8945E+01
6057	0	6047	0	0	0	8	0	8.0012E+01
6047	6037	0	6057	0	0	7	689	0.
6037	6027	0	0	6047	1	0	689	8.0012E+01
3777	0	5207	0	0	0	8	0	7.8520E+01
5207	4817	0	3777	0	0	7	702	0.
4817	5357	0	0	5207	1	0	702	7.8520E+01
5127	0	4957	0	0	0	8	0	7.9495E+01
4957	5557	0	5127	0	0	7	681	0.
5557	3607	0	0	4957	1	0	681	7.9495E+01
6167	0	6157	0	0	0	4	0	2.4019E+01
6157	6147	0	6167	0	0	3	219	0.
6147	6107	0	0	6157	1	0	219	2.4019E+01
5797	0	5187	0	0	0	8	0	7.9927E+01
5187	4627	0	5797	0	0	7	650	0.
4627	5567	0	0	5187	1	0	650	7.9927E+01
4787	0	6097	0	0	0	8	0	8.0784E+01
6097	5237	0	4787	0	0	7	744	0.
5237	5647	0	0	6097	1	0	744	8.0784E+01
6297	0	6287	0	0	0	8	0	7.8967E+01
6287	6277	0	6297	0	0	7	725	0.
6277	6267	0	0	6287	1	0	725	7.8967E+01
6337	0	6327	0	0	0	8	0	7.9235E+01
6327	6317	0	6337	0	0	7	668	0.
6317	6307	0	0	6327	1	0	668	7.9235E+01
5677	0	5497	0	0	0	8	0	8.0460E+01
5497	5667	0	5677	0	0	7	673	0.
5667	3077	0	0	5497	1	0	673	8.0460E+01
6227	0	5787	0	0	0	8	0	7.9798E+01
5787	5777	0	6227	0	0	7	742	0.
5777	5767	0	0	5787	1	0	742	7.9798E+01

6527	0	6517	0	0	0	4	0	3.2960E+01
6517	6507	0	6527	0	0	3	338	0.
6507	6207	0	0	6517	1	0	338	3.2960E+01
6567	0	6557	0	0	0	4	0	1.8461E+01
6557	6547	0	6567	0	0	3	308	0.
6547	6537	0	0	6557	1	0	308	1.8461E+01
6417	0	6407	0	0	0	8	0	8.0718E+01
6407	6397	0	6417	0	0	7	678	0.
6397	6387	0	0	6407	1	0	678	8.0718E+01
6457	0	6447	0	0	0	8	0	7.8839E+01
6447	6437	0	6457	0	0	7	700	0.
6437	6427	0	0	6447	1	0	700	7.8839E+01
6187	0	6087	0	0	0	8	0	7.8760E+01
6087	6077	0	6187	0	0	7	676	0.
6077	6067	0	0	6087	1	0	676	7.8760E+01
6587	0	4247	0	0	0	8	0	7.8470E+01
4247	4837	0	6587	0	0	7	700	0.
4837	5957	0	0	4247	1	0	700	7.8470E+01
5337	0	6377	0	0	0	4	0	2.7523E+01
6377	6257	0	5337	0	0	3	229	0.
6257	5347	0	0	6377	1	0	229	2.7523E+01
5307	0	5927	0	0	0	8	0	8.0505E+01
5927	6367	0	5507	0	0	7	680	0.
6367	6357	0	0	5927	1	0	680	8.0505E+01
6857	0	6127	0	0	0	8	0	8.1247E+01
6127	6117	0	6857	0	0	7	694	0.
6117	5967	0	0	6127	1	0	694	8.1247E+01
6717	0	6707	0	0	0	8	0	7.9670E+01
6707	6697	0	6717	0	0	7	721	0.
6697	6687	0	0	6707	1	0	721	7.9670E+01
6757	0	6747	0	0	0	8	0	7.9973E+01
6747	6737	0	6757	0	0	7	744	0.
6737	6727	0	0	6747	1	0	744	7.9973E+01
6927	0	6917	0	0	0	8	0	8.1054E+01
6917	6907	0	6927	0	0	7	688	0.
6907	6897	0	0	6917	1	0	688	8.1054E+01
6967	0	6957	0	0	0	8	0	7.9638E+01
6957	6947	0	6967	0	0	7	707	0.
6947	6937	0	0	6957	1	0	707	7.9638E+01
6827	0	6817	0	0	0	4	0	1.8928E+01
6817	6807	0	6827	0	0	3	255	0.
6807	6667	0	0	6817	1	0	255	1.8928E+01
6467	0	6237	0	0	0	8	0	7.8236E+01
6237	6177	0	6467	0	0	7	659	0.
6177	5487	0	0	6237	1	0	659	7.8236E+01
6247	0	5907	0	0	0	8	0	7.9214E+01
5907	6487	0	6247	0	0	7	665	0.
6487	6477	0	0	5907	1	0	665	7.9214E+01
7067	0	7057	0	0	0	4	0	3.0918E+01
7057	7047	0	7067	0	0	3	353	0.
7047	6637	0	0	7057	1	0	353	3.0918E+01
7197	0	7187	0	0	0	8	0	7.5896E+01

7187	7177	0	7197	0	0	7	747	0.
7177	7167	0	0	7187	1	0	747	7.9896E+01
7237	0	7227	0	0	0	8	0	8.0484E+01
7227	7217	0	7237	0	0	7	715	0.
7217	7207	0	0	7227	1	0	715	8.0484E+01
4757	0	7277	0	0	0	8	0	7.9445E+01
7277	5017	0	4757	0	0	7	741	0.
5017	5177	0	0	7277	1	0	741	7.9445E+01
6837	0	6217	0	0	0	8	0	8.0293E+01
6217	6577	0	6837	0	0	7	743	0.
6577	3527	0	0	6217	1	0	743	8.0293E+01
6677	0	6367	0	0	0	8	0	8.0351E+01
6867	6997	0	6677	0	0	7	657	0.
6937	6927	0	0	6867	1	0	657	8.0351E+01
7007	0	6787	0	0	0	8	0	7.8822E+01
6787	6777	0	7007	0	0	7	744	0.
6777	6767	0	0	6787	1	0	744	7.8822E+01
7437	0	7427	0	0	0	8	0	7.9628E+01
7427	7417	0	7437	0	0	7	653	0.
7417	7407	0	0	7427	1	0	653	7.9628E+01
7477	0	7467	0	0	0	8	0	7.9619E+01
7467	7457	0	7477	0	0	7	703	0.
7457	7447	0	0	7467	1	0	703	7.9619E+01
7017	0	6877	0	0	0	4	0	2.3643E+01
6877	5167	0	7017	0	0	3	380	0.
5167	7377	0	0	6877	1	0	380	2.3643E+01
7537	0	7527	0	0	0	4	0	2.2561E+01
7527	7387	0	7537	0	0	3	388	0.
7387	7027	0	0	7527	1	0	388	2.2561E+01
7107	0	3407	0	0	0	4	0	2.9879E+01
3407	5447	0	7107	0	0	3	288	0.
5447	7317	0	0	3407	1	0	288	2.9879E+01
7797	0	7787	0	0	0	8	0	7.9560E+01
7787	7777	0	7797	0	0	7	668	0.
7777	7767	0	0	7787	1	0	668	7.9560E+01
7837	0	7827	0	0	0	8	0	8.1379E+01
7827	7817	0	7837	0	0	7	691	0.
7817	7807	0	0	7827	1	0	691	8.1379E+01
7627	0	7617	0	0	0	8	0	8.0847E+01
7617	7607	0	7627	0	0	7	744	0.
7607	7597	0	0	7617	1	0	744	8.0847E+01
7667	0	7657	0	0	0	8	0	7.9446E+01
7657	7647	0	7667	0	0	7	702	0.
7647	7637	0	0	7657	1	0	702	7.9446E+01
7727	0	6497	0	0	0	4	0	8.4076E+01
6497	7137	0	7727	0	0	3	381	0.
7137	7257	0	0	6497	1	0	381	8.4076E+01
7707	0	6347	0	0	0	4	0	2.8764E+01
6347	6657	0	7707	0	0	3	301	0.
6657	5457	0	0	6347	1	0	301	2.8764E+01
7977	0	7967	0	0	0	8	0	8.0027E+01
7967	7957	0	7977	0	0	7	651	0.

7957	7947	0	0	7967	1	0	651	8.0027E+01
8017	0	8007	0	0	0	8	0	7.9095E+01
8007	7997	0	8017	0	0	7	695	0.
7957	7987	0	0	8007	1	0	695	7.9095E+01
7337	0	7327	0	0	0	4	0	5.6609E+01
7357	5897	0	7357	0	0	3	322	0.
5317	7347	0	0	7327	1	0	322	5.6609E+01
8077	0	8067	0	0	0	4	0	5.7050E+01
8037	7927	0	8077	0	0	3	308	0.
7927	6547	0	0	8067	1	0	308	5.7050E+01
8287	0	7287	0	0	0	8	0	7.3734E+01
7287	7147	0	8057	0	0	7	722	0.
7147	6627	0	0	7287	1	0	722	7.3734E+01
5937	0	7717	0	0	0	8	0	8.0046E+01
7717	7577	0	5537	0	0	7	665	0.
7577	7557	0	0	7717	1	0	665	8.0046E+01
8207	0	8197	0	0	0	8	0	8.0311E+01
8197	8187	0	8207	0	0	7	708	0.
8187	8177	0	0	8197	1	0	708	8.0311E+01
8247	0	8237	0	0	0	8	0	7.9210E+01
8237	8227	0	8247	0	0	7	708	0.
8227	8217	0	0	8237	1	0	708	7.9210E+01
8457	0	8447	0	0	0	4	0	6.2340E+01
8447	8437	0	8457	0	0	3	262	0.
8437	8297	0	0	8447	1	0	262	6.2340E+01
8487	8477	0	0	0	0	3	282	0.
8477	8467	0	0	8487	1	0	282	0.
8347	0	8337	0	0	0	8	0	8.0909E+01
8337	8327	0	8347	0	0	7	722	0.
8327	8317	0	0	8337	1	0	722	8.0909E+01
8387	0	8377	0	0	0	8	0	7.9117E+01
8377	8367	0	8387	0	0	7	747	0.
8367	8357	0	0	8377	1	0	747	7.9117E+01
7297	0	7857	0	0	0	8	0	7.9729E+01
7857	7697	0	7297	0	0	7	736	0.
7697	7537	0	0	7857	1	0	736	7.9729E+01
7077	0	7037	0	0	0	8	0	8.0196E+01
7037	7737	0	7877	0	0	7	712	0.
7737	7257	0	0	7887	1	0	712	8.0196E+01
7907	0	6797	0	0	0	4	0	4.4873E+01
6737	7507	0	7907	0	0	3	391	0.
7507	6267	0	0	6797	1	0	391	4.4873E+01
8547	0	8527	0	0	0	4	0	1.0786E+01
8527	8507	0	8537	0	0	3	271	0.
8507	7397	0	0	8527	1	0	271	1.0786E+01
8627	0	8617	0	0	0	8	0	8.0427E+01
8617	8607	0	8627	0	0	7	737	0.
8607	8597	0	0	8617	1	0	737	8.0427E+01
8667	0	8657	0	0	0	8	0	8.0508E+01
8657	8547	0	8667	0	0	7	730	0.
8547	8637	0	0	8657	1	0	730	8.0508E+01
8607	0	8517	0	0	0	8	0	8.0169E+01

8517	8117	0	6607	0	0	7	687	0.
8117	8097	0	0	8517	1	0	687	8.0169E+01
8037	0	8027	0	0	0	8	0	8.0482E+01
8027	7937	0	8037	0	0	7	677	0.
7937	8157	0	0	8027	1	0	677	8.0482E+01
8777	0	8767	0	0	0	4	0	3.8170E+01
8767	8757	0	8777	0	0	3	364	0.
8757	7867	0	0	8767	1	0	364	3.8170E+01
7497	0	7917	0	0	0	8	0	8.1120E+01
7917	8707	0	7497	0	0	7	699	0.
8707	7097	0	0	7917	1	0	699	8.1120E+01
8577	0	7757	0	0	0	8	0	7.9878E+01
7757	6887	0	8577	0	0	7	686	0.
6887	7747	0	0	7757	1	0	686	7.9878E+01
8857	0	8837	0	0	0	8	0	8.0530E+01
8837	8417	0	8857	0	0	7	700	0.
8417	8407	0	0	8837	1	0	700	8.0530E+01
8897	0	8887	0	0	0	8	0	8.0334E+01
8887	8877	0	8897	0	0	7	730	0.
8877	8867	0	0	8887	1	0	730	8.0334E+01
9177	0	9167	0	0	0	4	0	6.2523E+01
9167	9157	0	9177	0	0	3	387	0.
9157	7847	0	0	9167	1	0	387	6.2523E+01
9217	0	9207	0	0	0	4	0	3.2384E+01
9207	9197	0	9217	0	0	3	353	0.
9197	9187	0	0	9207	1	0	353	3.2384E+01
8947	0	8307	0	0	0	8	0	7.9445E+01
8307	8167	0	8947	0	0	7	705	0.
8167	7127	0	0	8307	1	0	705	7.9445E+01
8987	0	8977	0	0	0	8	0	7.9239E+01
8977	8967	0	8987	0	0	7	667	0.
8067	8957	0	0	8977	1	0	667	7.9239E+01
8957	0	7127	0	8967	2	0	667	7.9239E+01
7127	0	9187	8957	8167	2	0	705	7.9445E+01
9187	0	7847	7127	9197	2	0	353	3.2384E+01
7847	0	8867	9187	9157	2	0	387	6.2523E+01
8867	0	8407	7847	8877	2	0	730	8.0334E+01
8407	0	7747	8867	8417	2	0	700	8.0530E+01
7747	0	7097	8407	8887	2	0	686	7.9878E+01
7097	0	7867	7747	8707	2	0	699	8.1120E+01
7867	0	8157	7097	8757	2	0	364	3.8170E+01
8157	0	8097	7867	7937	2	0	677	8.0482E+01
8097	0	8637	8157	8117	2	0	687	8.0169E+01
8637	0	8597	8097	8647	2	0	730	8.0508E+01
8597	0	7397	8637	8607	2	0	737	8.0427E+01
7397	0	8267	8597	8507	2	0	271	1.0786E+01
8267	0	7267	7397	7507	2	0	391	4.4873E+01
7267	0	7687	8267	7737	2	0	712	8.0196E+01
7687	0	8357	7267	7697	2	0	736	7.9729E+01
8357	0	8317	7687	8367	2	0	747	7.9117E+01
8317	0	8467	8357	8327	2	0	722	8.0909E+01
8467	0	8297	8317	8477	2	0	282	0.

8297	0	8217	8467	8437	2	0	262	6.2340E+01
8217	0	8177	8297	8227	2	0	706	7.9210E+01
8177	0	7557	8217	8187	2	0	708	8.0311E+01
7557	0	6627	8177	7577	2	0	665	8.0046E+01
6627	0	6647	7557	7147	2	0	722	7.8734E+01
6647	0	7347	6627	7927	2	0	308	5.7050E+01
7347	0	7987	6647	5897	2	0	322	5.6609E+01
7987	0	7947	7347	7997	2	0	695	7.9095E+01
7947	0	5457	7987	7957	2	0	651	8.0027E+01
5457	0	7257	7947	6657	2	0	301	2.8764E+01
7257	0	7637	5457	7137	2	0	381	8.4076E+01
7637	0	7597	7257	7647	2	0	702	7.9446E+01
7597	0	7807	7637	7607	2	0	744	8.0847E+01
7807	0	7767	7597	7817	2	0	691	8.1379E+01
7767	0	7317	7807	7777	2	0	668	7.9560E+01
7317	0	7027	7767	5447	2	0	288	2.9879E+01
7027	0	7377	7317	7387	2	0	388	2.2561E+01
7377	0	7447	7027	5167	2	0	380	2.3643E+01
7447	0	7407	7377	7457	2	0	703	7.9619E+01
7407	0	6767	7447	7417	2	0	653	7.9628E+01
6767	0	6987	7407	6777	2	0	744	7.8822E+01
6987	0	3527	6767	6997	2	0	657	8.0351E+01
3527	0	5177	6987	6577	2	0	743	8.0293E+01
5177	0	7207	3527	5017	2	0	741	7.9445E+01
7207	0	7167	5177	7217	2	0	715	8.0484E+01
7167	0	6637	7207	7177	2	0	747	7.9696E+01
6637	0	6477	7167	7047	2	0	353	3.0918E+01
6477	0	5487	6637	6487	2	0	665	7.9214E+01
5487	0	6667	6477	6177	2	0	659	7.8236E+01
6667	0	6937	5487	6807	2	0	255	1.8929E+01
6937	0	6897	6667	6947	2	0	707	7.9638E+01
6897	0	6727	6937	6907	2	0	688	8.1054E+01
6727	0	6687	6897	6737	2	0	744	7.9973E+01
6687	0	5967	6727	6697	2	0	721	7.9670E+01
5967	0	6357	6687	6117	2	0	684	8.1247E+01
6357	0	5347	5967	6367	2	0	680	8.0505E+01
5347	0	5957	6357	6257	2	0	229	2.7523E+01
5957	0	6067	5347	4837	2	0	700	7.8470E+01
6067	0	6427	5957	6077	2	0	676	7.8760E+01
6427	0	6387	6067	6437	2	0	700	7.8829E+01
6387	0	6537	6427	6397	2	0	678	8.0718E+01
6537	0	6207	6387	6547	2	0	308	1.8461E+01
6207	0	5767	6537	6507	2	0	333	3.2960E+01
5767	0	3077	6207	5777	2	0	742	7.9798E+01
3077	0	6307	5767	5667	2	0	673	8.0460E+01
6307	0	6267	3077	6317	2	0	668	7.9235E+01
6267	0	5647	6307	6277	2	0	725	7.8957E+01
5647	0	5567	6267	5237	2	0	744	8.0784E+01
5567	0	6107	5647	4827	2	0	650	7.9927E+01
6107	0	3607	5567	6147	2	0	219	2.4019E+01
3607	0	5357	6107	5657	2	0	681	7.9495E+01
5357	0	6027	3607	4817	2	0	702	7.8520E+01

6027	0	5987	5357	6037	2	0	689	8.0012E+01
5967	0	6047	6027	5997	2	0	692	7.8945E+01
5947	0	5987	5987	4927	2	0	253	4.3970E+01
5857	0	5917	5947	5867	2	0	676	7.9563E+01
5817	0	5777	5857	5627	2	0	727	7.9905E+01
5727	0	5687	5817	5737	2	0	680	7.9617E+01
5687	0	4777	5727	5697	2	0	654	7.9798E+01
4777	0	4827	5687	3817	2	0	745	8.0217E+01
4827	0	5597	4777	4967	2	0	730	8.1506E+01
5597	0	5107	4827	5607	2	0	347	6.7077E+01
5107	0	4857	5597	5557	2	0	398	2.8437E+01
4857	0	4937	5107	2817	2	0	670	7.8885E+01
4937	0	2927	4657	4947	2	0	650	7.9072E+01
2687	0	4517	4937	5517	2	0	390	4.7611E+01
4517	0	5417	2637	5227	2	0	391	5.3893E+01
5217	0	3017	4517	4147	2	0	255	3.4923E+01
3017	0	4527	5217	4987	2	0	370	2.8940E+01
4537	0	3627	3017	5137	2	0	713	8.0416E+01
3627	0	5287	4537	4377	2	0	662	8.0605E+01
5287	0	5247	3527	5297	2	0	724	8.1937E+01
5247	0	5057	5287	5257	2	0	664	7.9641E+01
5057	0	4647	5247	5067	2	0	728	8.0173E+01
4647	0	4807	5057	4647	2	0	695	8.0502E+01
4807	0	4487	4637	2807	2	0	743	7.9432E+01
4487	0	4887	4807	4447	2	0	660	7.9157E+01
4887	0	4847	4487	4897	2	0	655	7.8319E+01
4847	0	4417	4687	4857	2	0	657	8.1082E+01
4417	0	4037	4847	4497	2	0	720	8.0767E+01
4037	0	4707	4347	3417	2	0	654	8.0555E+01
4707	0	4007	3997	4727	2	0	317	5.6636E+01
4697	0	4527	4707	3257	2	0	362	4.0974E+01
4527	0	4357	4697	4687	2	0	226	4.9121E+01
4357	0	2457	4527	3667	2	0	677	8.0843E+01
2457	0	4597	4357	3947	2	0	660	8.0158E+01
4587	0	4547	2457	4597	2	0	712	8.0702E+01
4547	0	4277	4587	4557	2	0	701	7.9649E+01
4277	0	4207	4547	4287	2	0	354	4.8963E+01
4207	0	4407	4277	3427	2	0	268	2.1504E+01
4407	0	2617	4207	4417	2	0	721	7.9799E+01
2617	0	3507	4407	4367	2	0	691	7.9532E+01
3507	0	2727	2617	3517	2	0	741	8.0863E+01
2727	0	4077	3507	2797	2	0	714	7.8630E+01
4077	0	4037	2727	4067	2	0	716	8.0400E+01
4037	0	2857	4077	4047	2	0	711	7.9665E+01
2857	0	3287	4037	3167	2	0	738	7.8567E+01
3287	0	4017	2857	3207	2	0	663	8.0039E+01
4017	0	3907	3287	4157	2	0	377	1.8959E+01
3907	0	2597	4017	3917	2	0	659	8.0946E+01
2597	0	3717	3907	3867	2	0	746	7.9103E+01
3717	0	3677	2597	3727	2	0	729	7.9600E+01
3677	0	3007	3717	3687	2	0	675	7.8419E+01
3007	0	2647	3677	3657	2	0	394	3.5695E+01

2647	0	3567	3007	2867	2	0	371	6.1501E+01
3567	0	2767	2647	3577	2	0	385	3.3690E+01
2767	0	3457	3567	3537	2	0	323	7.0168E+01
3457	0	3177	2767	3467	2	0	718	8.1068E+01
3177	0	3357	3457	2737	2	0	744	7.8102E+01
3357	0	2837	3177	3367	2	0	677	7.9374E+01
2857	0	3107	3357	2897	2	0	705	8.0835E+01
3107	0	3137	2887	2877	2	0	748	7.8225E+01
3137	0	3237	3107	3147	2	0	655	7.9840E+01
3237	0	3267	3137	3297	2	0	657	8.0286E+01
3267	0	2967	3237	3277	2	0	652	7.9813E+01
2967	0	2907	3257	2977	2	0	692	7.9285E+01
2907	0	3117	2967	2997	2	0	723	8.0202E+01
3117	0	2567	2907	2437	2	0	392	3.3662E+01
2567	0	2487	3117	2507	2	0	665	7.8373E+01
2497	0	2467	2567	2537	2	0	658	7.8917E+01
2467	0	2477	2497	2757	2	0	396	6.0828E+01
2477	1579	0	2487	3187	1	0	5564	7.1853E+02
1579	0	0	0	2477	2	0	89738	1.0406E+04

MATERIAL IN HOLDUP

2567	0	2577	0	0	0	6	0	2.4742E+03
2577	0	2427	2567	0	0	5	20791	0.
2427	0	2417	2577	0	0	2	0	9.1311E+02
2417	1589	0	2427	0	0	1	4164	0.
1589	0	0	0	2417	1	0	24975	3.3874E+03

REPORT TIME INTERVAL 0. TO 6.7200E+02

This report of storage function 13 illustrates the enormous amount of data structure that may be required to maintain the containment identity of materials in complex model systems that handle and process many different types of materials. It also illustrates the storage space savings that may be realized by designing model systems that have as little long term material storage capacity as possible. The user should transport or ship material out of the model system whenever it is possible to do so and accurately represent the simulated system.

The following reports generated by the 702 CMSA function are automatically started on a new page to avoid splitting of histograms.

14.702 MBA
MATERIAL TYPE
DATA
SAMPLE
SAMPLING
REPLICATE SAMPLING TIME
MEAN VALUE
MAXIMUM VALUE
MINIMUM VALUE

REPORT NO. 1
1
TRUE
COUNT
EACH INPUT/OUTPUT TIME
0.
2.3268E+02
4.4100E+02
0.

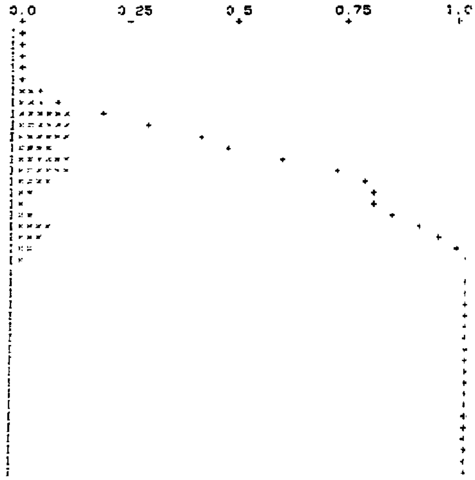
NUMBER OF OBSERVATIONS 186
STANDARD DEVIATION 8.0714E+01
TIME OF MAXIMUM VALUE 4.7431E+02
TIME OF MINIMUM VALUE 5.9652E+01

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
0.	1	0.0054	0.0054
4.0000E+01	0	0.	0.0054
8.0000E+01	0	0.	0.0054
1.2000E+02	3	0.0161	0.0215
1.6000E+02	1	0.0054	0.0269
2.0000E+02	9	0.0484	0.0753
2.4000E+02	9	0.0484	0.1237
2.8000E+02	9	0.0430	0.1667
3.2000E+02	13	0.0699	0.2366
3.6000E+02	22	0.1183	0.3548
4.0000E+02	21	0.1129	0.4677
4.4000E+02	15	0.0806	0.5484
4.8000E+02	22	0.1183	0.6667
5.2000E+02	15	0.0806	0.7473
5.6000E+02	7	0.0376	0.7849
6.0000E+02	14	0.0753	0.8602
6.4000E+02	7	0.0376	0.8978
6.8000E+02	3	0.0161	0.9140
7.2000E+02	4	0.0215	0.9355
7.6000E+02	5	0.0269	0.9624
8.0000E+02	6	0.0323	0.9946
8.4000E+02	0	0.	0.9946
8.8000E+02	1	0.0054	1.0000
9.2000E+02	0	0.	1.0000
9.6000E+02	0	0.	1.0000
1.0000E+03	0	0.	1.0000
1.0400E+03	0	0.	1.0000
1.0800E+03	0	0.	1.0000
1.1200E+03	0	0.	1.0000
1.1600E+03	0	0.	1.0000
1.2000E+03	0	0.	1.0000
1.2400E+03	0	0.	1.0000
1.2800E+03	0	0.	1.0000
1.3200E+03	0	0.	1.0000
1.3600E+03	0	0.	1.0000
1.4000E+03	0	0.	1.0000
1.4400E+03	0	0.	1.0000
1.4800E+03	0	0.	1.0000
1.5200E+03	0	0.	1.0000
1.5600E+03	0	0.	1.0000
1.6000E+03	0	0.	1.0000

Material Balance Area Accountability

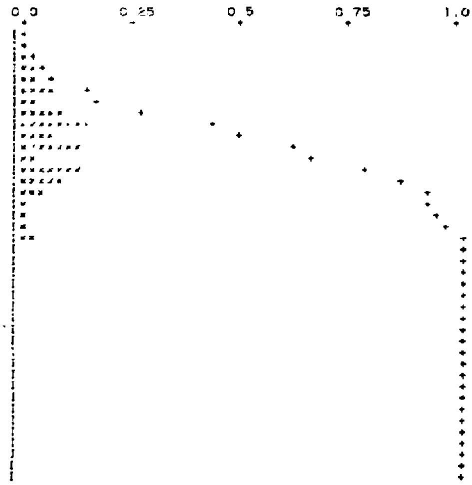
[illegible]	14 702 CMBA	REPORT NO. 2	
	MATERIAL TYPE	1	
	DATA	ERROR (OBSERVED - TRUE)	
	VARIABLE	COUNT	
	SAMPLING	EACH INPUT/OUTPUT TIME	
	DUPLICATE SAMPLING TIME	0	NUMBER OF OBSERVATIONS 186
	MEAN VALUE	-6.9194E+00	STANDARD DEVIATION 3.9019E+00
	MAXIMUM VALUE	0.	TIME OF MAXIMUM VALUE 0.
	MINIMUM VALUE	-1.6000E+01	TIME OF MINIMUM VALUE 6.1237E+02

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRI-BUTION
-2.0000E+01	0	0.	0.
-1.9000E+01	0	0.	0.
-1.8000E+01	0	0.	0.
-1.7000E+01	0	0.	0.
-1.6000E+01	2	0.0108	0.0108
-1.5000E+01	6	0.0323	0.0430
-1.4000E+01	8	0.0430	0.0860
-1.3000E+01	19	0.1022	0.1882
-1.2000E+01	21	0.1129	0.3011
-1.1000E+01	20	0.1075	0.4086
-1.0000E+01	14	0.0753	0.4839
-9.0000E+00	22	0.1183	0.6022
-8.0000E+00	21	0.1129	0.7151
-7.0000E+00	12	0.0645	0.7796
-6.0000E+00	4	0.0215	0.8011
-5.0000E+00	1	0.0054	0.8065
-4.0000E+00	7	0.0376	0.8441
-3.0000E+00	12	0.0645	0.9086
-2.0000E+00	9	0.0484	0.9570
-1.0000E+00	5	0.0269	0.9839
0	3	0.0161	1.0000
1.0000E+00	0	0.	1.0000
2.0000E+00	0	0.	1.0000
3.0000E+00	0	0.	1.0000
4.0000E+00	0	0.	1.0000
5.0000E+00	0	0.	1.0000
6.0000E+00	0	0.	1.0000
7.0000E+00	0	0.	1.0000
8.0000E+00	0	0.	1.0000
9.0000E+00	0	0.	1.0000
1.0000E+01	0	0.	1.0000
1.1000E+01	0	0.	1.0000
1.2000E+01	0	0.	1.0000
1.3000E+01	0	0.	1.0000
1.4000E+01	0	0.	1.0000
1.5000E+01	0	0.	1.0000
1.6000E+01	0	0.	1.0000
1.7000E+01	0	0.	1.0000
1.8000E+01	0	0.	1.0000
1.9000E+01	0	0.	1.0000



[illegible] 13 202 [illegible]	REPORT NO 3		
MATERIAL TYPE	2		
DATA	TRUE		
VARIABLE	MASS		
SAMPLING	EACH INPUT/OUTPUT	TIME	
[illegible] SAMPLING TIME	0	NUMBER OF OBSERVATIONS	186
MEAN VALUE	5.0641E+01	STANDARD DEVIATION	1.8424E+01
MAXIMUM VALUE	9.2509E+01	TIME OF MAXIMUM VALUE	1.6095E+02
MINIMUM VALUE	-1.[illegible]300E-13	TIME OF MINIMUM VALUE	5.9652E+01

UPPER LIMIT OF CELL	COUNT	DENSITY	DISTRI-BUTION
0.	1	0.0054	0.0054
5.0000E 00	0	0	0.0054
1.0000E+01	5	0.0269	0.0323
1.5000E+01	4	0.0215	0.0538
2.0000E+01	5	0.0269	0.0806
2.5000E+01	14	0.0753	0.1559
3.0000E+01	4	0.0215	0.1774
3.5000E+01	18	0.0968	0.2742
4.0000E+01	29	0.1559	0.4301
4.5000E+01	14	0.0753	0.5054
5.0000E+01	23	0.1237	0.6290
5.5000E+01	5	0.0269	0.6559
6.0000E+01	23	0.1237	0.7796
6.5000E+01	17	0.0914	0.8710
7.0000E+01	11	0.0591	0.9301
7.5000E+01	1	0.0054	0.9355
8.0000E+01	2	0.0108	0.9462
8.5000E+01	3	0.0161	0.9624
9.0000E+01	7	0.0376	1.0000
9.5000E+01	0	0.	1.0000
1.0000E+02	0	0.	1.0000
1.0500E+02	0	0.	1.0000
1.1000E+02	0	0.	1.0000
1.1500E+02	0	0.	1.0000
1.2000E+02	0	0.	1.0000
1.2500E+02	0	0.	1.0000
1.3000E+02	0	0.	1.0000
1.3500E+02	0	0.	1.0000
1.4000E+02	0	0.	1.0000
1.4500E+02	0	0.	1.0000
1.5000E+02	0	0.	1.0000
1.5500E+02	0	0.	1.0000
1.6000E+02	0	0.	1.0000
1.6500E+02	0	0.	1.0000
1.7000E+02	0	0.	1.0000
1.7500E+02	0	0.	1.0000
1.8000E+02	0	0.	1.0000
1.8500E+02	0	0.	1.0000
1.9000E+02	0	0.	1.0000
1.9500E+02	0	0.	1.0000



IFUNCTION	14 TOP CMBA	REPORT NO. 4		
	MATERIAL TYPE	2		
	DATA	ERROR (OBSERVED - TRUE)		
	VARIABLE	MASS		
	SAMPLING	EACH INPUT/OUTPUT TIME		
	REPLICATE SAMPLING TIME	0.	NUMBER OF OBSERVATIONS	186
	MEAN VALUE	-1.1726E+01	STANDARD DEVIATION	4.5605E+00
	MAXIMUM VALUE	0.	TIME OF MAXIMUM VALUE	0
	MINIMUM VALUE	-2.0001E+01	TIME OF MINIMUM VALUE	4.6791E+02

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRI-BUTION	0.0 0.25 0.5 0.75 1.0
-2.0000E+01	9	0.0484	0.0484	I***
-1.9000E+01	11	0.0591	0.1075	I***
-1.8000E+01	10	0.0538	0.1613	I***
-1.7000E+01	7	0.0376	0.1989	I**
-1.6000E+01	10	0.0538	0.2527	I***
-1.5000E+01	15	0.0806	0.3333	I****
-1.4000E+01	17	0.0914	0.4247	I*****
-1.3000E+01	19	0.1022	0.5269	I******
-1.2000E+01	27	0.1452	0.6720	I********
-1.1000E+01	9	0.0484	0.7204	I***
-1.0000E+01	5	0.0269	0.7473	I**
-9.0000E+00	8	0.0430	0.7903	I***
-8.0000E+00	5	0.0269	0.8172	I**
-7.0000E+00	1	0.0054	0.8226	I*
-6.0000E+00	1	0.0054	0.8280	I*
-5.0000E+00	6	0.0323	0.8602	I**
-4.0000E+00	11	0.0591	0.9194	I***
-3.0000E+00	10	0.0538	0.9731	I***
-2.0000E+00	3	0.0161	0.9892	I*
-1.0000E+00	2	0.0108	1.0000	I*
0.	0	0.	1.0000	I
1.0000E+00	0	0.	1.0000	I
2.0000E+00	0	0.	1.0000	I
3.0000E+00	0	0.	1.0000	I
4.0000E+00	0	0.	1.0000	I
5.0000E+00	0	0.	1.0000	I
6.0000E+00	0	0.	1.0000	I
7.0000E+00	0	0.	1.0000	I
8.0000E+00	0	0.	1.0000	I
9.0000E+00	0	0.	1.0000	I
1.0000E+01	0	0.	1.0000	I
1.1000E+01	0	0.	1.0000	I
1.2000E+01	0	0.	1.0000	I
1.3000E+01	0	0.	1.0000	I
1.4000E+01	0	0.	1.0000	I
1.5000E+01	0	0.	1.0000	I
1.6000E+01	0	0.	1.0000	I
1.7000E+01	0	0.	1.0000	I
1.8000E+01	0	0.	1.0000	I
1.9000E+01	0	0.	1.0000	I

REPORT NO 5

TRUE
COUNT
EACH INPUT/OUTPUT TIME

0		NUMBER OF OBSERVATIONS	156
9.5232E+02		STANDARD DEVIATION	4.3762E+02
2.4688E+03		TIME OF MAXIMUM VALUE	5.2136E+02
0		TIME OF MINIMUM VALUE	3.0612E+02

	OF ALT	DISTRIBUTION	0.0	0.25	0.5	0.75
	2	0.0127	*			
	0	0.0127	*			
	0	0.0127	*			
	0	0.0127	*			
	2	0.0253	*			
0.0190	3	0.0443	*			
	0	0.0443	*			
0.0696	11	0.1139	*			
	0	0.1139	*			
0.0633	10	0.1772	*			
0.0823	13	0.2595	*			
0.0127	2	0.2722	*			
0.0316	5	0.3038	*			
0.0253	4	0.3291	*			
0.0633	10	0.3924	*			
0.0127	2	0.4051	*			
0.0127	2	0.4177	*			
0.0316	5	0.4494	*			
0.0253	4	0.4747	*			
0.0633	10	0.5380	*			
0.0253	4	0.5633	*			
0.0696	11	0.6329	*			
0.0127	2	0.6456	*			
0.0696	11	0.7152	*			
0.0063	1	0.7215	*			
0.0127	2	0.7342	*			
0.0190	3	0.7532	*			
0.0570	9	0.8101	*			
0	0	0.8101	*			
0.0380	6	0.8481	*			
0.0316	5	0.8797	*			
0.0190	3	0.8987	*			
0	0	0.8987	*			
0.0063	1	0.9051	*			
0	0	0.9051	*			
0.0380	6	0.9430	*			
0.0190	3	0.9620	*			
0	0	0.9620	*			
0.0190	3	0.9810	*			
0	0	0.9810	*			
0.0190	3	1.0000	*			

REPORT NO. 6
3
ERROR (OBSERVED - TRUE)
COUNT
EACH INPUT/OUTPUT TIME
0
-5.3797E-01
1.6000E+01
-1.6000E+01

NUMBER OF OBSERVATIONS 158
STANDARD DEVIATION 6.2116E+00
TIME OF MAXIMUM VALUE 1.9000E+02
TIME OF MINIMUM VALUE 4.4415E+02

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
-1.6000E+01	0	0	0.	+
-1.4000E+01	0	0	0.	+
-1.2000E+01	0	0	0.	+
-1.0000E+01	0	0	0.	+
-8.0000E+00	0	0	0.	+
-6.0000E+00	0	0	0.	+
-4.0000E+00	0	0	0.	+
-2.0000E+00	0	0	0.	+
0.	0	0	0.	+
2.0000E+00	0	0	0.	+
4.0000E+00	0	0	0.	+
6.0000E+00	0	0	0.	+
8.0000E+00	0	0	0.	+
1.0000E+01	5	0.0127	0.0127	+**
1.2000E+01	5	0.0443	0.0570	+**
1.4000E+01	6	0.0380	0.0949	+**
1.6000E+01	12	0.0759	0.1709	+****
1.8000E+01	7	0.0380	0.2089	+**
2.0000E+01	7	0.0443	0.2532	+**
2.2000E+01	6	0.0380	0.2911	+**
2.4000E+01	19	0.1203	0.4114	+******
2.6000E+01	19	0.1203	0.5316	+******
2.8000E+01	24	0.1519	0.6835	+********
3.0000E+01	25	0.1582	0.8416	+********
3.2000E+01	19	0.1203	0.9620	+******
3.4000E+01	5	0.0316	0.9937	+**
3.6000E+01	1	0.0063	1.0000	+*
3.8000E+01	0	0	1.0000	+
4.0000E+01	0	0	1.0000	+
4.2000E+01	0	0	1.0000	+
4.4000E+01	0	0	1.0000	+
4.6000E+01	0	0	1.0000	+
4.8000E+01	0	0	1.0000	+
5.0000E+01	0	0	1.0000	+
5.2000E+01	0	0	1.0000	+
5.4000E+01	0	0	1.0000	+
5.6000E+01	0	0	1.0000	+
5.8000E+01	0	0	1.0000	+
6.0000E+01	0	0	1.0000	+

1FUNCTION 14.702 CMBA

REPORT NO. 7

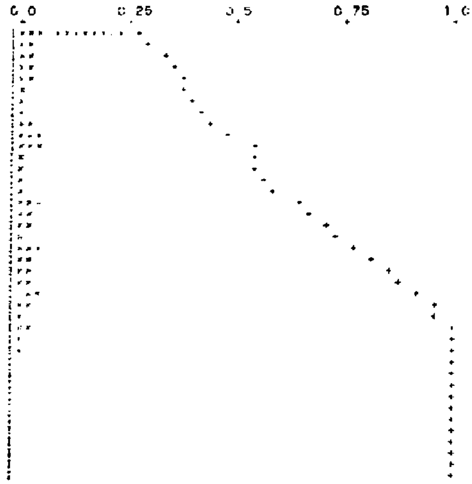
MATERIAL TYPE	4		
DATA	TRUE		
VARIABLE	MASS		
SAMPLING	EACH INPUT/OUTPUT TIME		
REPLICATE SAMPLING TIME	0.	NUMBER OF OBSERVATIONS	158
MEAN VALUE	1.1264E+02	STANDARD DEVIATION	6.4110E+01
MAXIMUM VALUE	2.0258E+02	TIME OF MAXIMUM VALUE	6.2159E+02
MINIMUM VALUE	-1.0642E-12	TIME OF MINIMUM VALUE	3.0612E+02

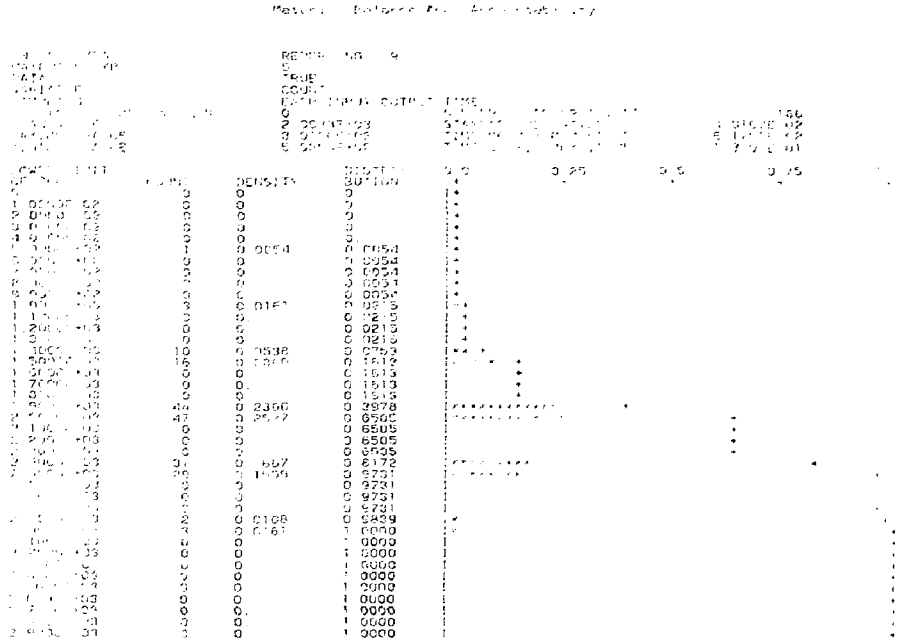
LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
0.	2	0.0127	0.0127	I+
1.0000E+01	0	0.	0.0127	I+
2.0000E+01	4	0.0253	0.0380	I++
3.0000E+01	7	0.0443	0.0823	I+++ +
4.0000E+01	14	0.0886	0.1709	I+++++ +
5.0000E+01	6	0.0380	0.2089	I++ +
6.0000E+01	16	0.1013	0.3101	I++++++ +
7.0000E+01	16	0.1139	0.4241	I++++++ +
8.0000E+01	4	0.0253	0.4494	I++ +
9.0000E+01	11	0.0696	0.5190	I++++ +
1.0000E+02	7	0.0443	0.5633	I+++ +
1.1000E+02	16	0.1013	0.6646	I++++++ +
1.2000E+02	1	0.0063	0.6709	I+ +
1.3000E+02	4	0.0253	0.6962	I++ +
1.4000E+02	6	0.0380	0.7342	I++ +
1.5000E+02	3	0.0190	0.7532	I+ +
1.6000E+02	3	0.0190	0.7722	I+ +
1.7000E+02	6	0.0380	0.8101	I++ +
1.8000E+02	7	0.0443	0.8544	I+++ +
1.9000E+02	0	0.	0.8544	I +
2.0000E+02	5	0.0316	0.8861	I++ +
2.1000E+02	6	0.0380	0.9241	I++ +
2.2000E+02	6	0.0380	0.9620	I++ +
2.3000E+02	2	0.0127	0.9747	I+ +
2.4000E+02	0	0.	0.9747	I +
2.5000E+02	1	0.0063	0.9810	I+ +
2.6000E+02	2	0.0127	0.9937	I+ +
2.7000E+02	0	0.	0.9937	I +
2.8000E+02	0	0.	0.9937	I +
2.9000E+02	0	0.	0.9937	I +
3.0000E+02	1	0.0063	1.0000	I+ +
3.1000E+02	0	0.	1.0000	I +
3.2000E+02	0	0.	1.0000	I +
3.3000E+02	0	0.	1.0000	I +
3.4000E+02	0	0.	1.0000	I +
3.5000E+02	0	0.	1.0000	I +
3.6000E+02	0	0.	1.0000	I +
3.7000E+02	0	0.	1.0000	I +
3.8000E+02	0	0.	1.0000	I +
3.9000E+02	0	0.	1.0000	I +

Material Balance Area Accountability

```
FUNCTION   14.702 CMBA                          REPORT NO   9
           MATERIAL TYPE                        4
           DATA                                 ERROR (OBSERVED - TRUE)
           VARIABLE                             MASS
           SAMPLING                             EACH INPUT-OUTPUT TIME
           [illegible] ING TIME                 0          NUMBER OF OBSERVATIONS            158
           [illegible]                          -9.3083E+00 STANDARD DEVIATION         1.0469E+01
           MAXIMUM VALUE                        6.1506E+00 TIME OF MAXIMUM VALUE       [illegible].7670E+02
           MINIMUM VALUE                        -3.1193E+01 TIME OF MINIMUM VALUE      [illegible].3517E+02
```

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
-2.0000E+01	44	0.2785	0.2785
-1.9000E+01	4	0.0253	0.3038
-1.8000E+01	4	0.0253	0.3291
-1.7000E+01	4	0.0253	0.3544
-1.6000E+01	4	0.0253	0.3797
-1.5000E+01	1	0.0063	0.3861
-1.4000E+01	2	0.0127	0.3987
-1.3000E+01	2	0.0127	0.4114
-1.2000E+01	4	0.0253	0.4367
-1.1000E+01	8	0.0506	0.4873
-1.0000E+01	7	0.0443	0.5316
-9.0000E+00	2	0.0127	0.5443
-8.0000E+00	1	0.0063	0.5506
-7.0000E+00	3	0.0190	0.5696
-6.0000E+00	1	0.0063	0.5759
-5.0000E+00	9	0.0570	0.6329
-4.0000E+00	6	0.0380	0.6709
-3.0000E+00	6	0.0380	0.7089
-2.0000E+00	2	0.0127	0.7215
-1.0000E+00	7	0.0443	0.7558
0	5	0.0380	0.8039
1.0000E+00	5	0.0380	0.8418
2.0000E+00	5	0.0316	0.8734
3.0000E+00	7	0.0443	0.9177
4.0000E+00	4	0.0253	0.9430
5.0000E+00	2	0.0127	0.9557
6.0000E+00	4	0.0253	0.9810
7.0000E+00	2	0.0127	0.9937
8.0000E+00	1	0.0063	1.0000
9.0000E+00	0	0.	1.0000
1.0000E+01	0	0.	1.0000
1.1000E+01	0	0.	1.0000
1.2000E+01	0	0.	1.0000
1.3000E+01	0	0.	1.0000
1.4000E+01	0	0.	1.0000
1.5000E+01	0	0.	1.0000
1.6000E+01	0	0.	1.0000
1.7000E+01	0	0.	1.0000
1.8000E+01	0	0.	1.0000
1.9000E+01	0	0.	1.0000



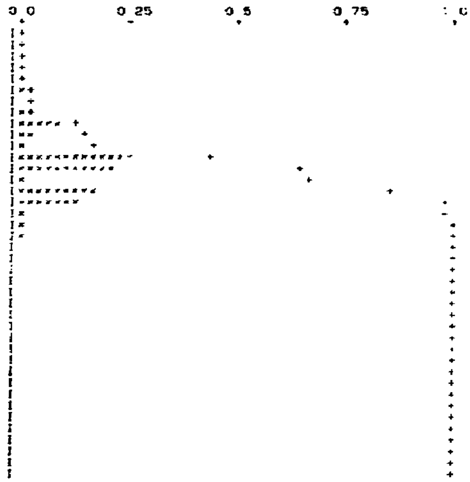


[illegible]	14 702 CMBA	REPORT NO 10	
MATERIAL TYPE		5	
DATA		ERROR (OBSERVED - TRUE)	
VARIABLE		COUNT	
SAMPLING		EACH INPUT/OUTPUT TIME	
REPLICATE SAMPLING TIME		0.	NUMBER OF OBSERVATIONS 186
MEAN VALUE		1.6820E+01	STANDARD DEVIATION 1.5027E+01
MAXIMUM VALUE		4.9000E+01	TIME OF MAXIMUM VALUE 3.8650E+02
MINIMUM VALUE		-1.2000E+01	TIME OF MINIMUM VALUE 3.7667E+01

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRI-BUTION	0.0 . . . 0.25 . . . 0.5 . . . 0.75 . . . 1.0
-1.0000E+02	0	0.	0	I+
-9.5000E+01	0	0.	0	I+
-9.0000E+01	0	0.	0	I+
-8.5000E+01	0	0.	0	I+
-8.0000E+01	0	0.	0	I+
-7.5000E+01	0	0.	0	I+
-7.0000E+01	0	0.	0	I+
-6.5000E+01	0	0.	0	I+
-6.0000E+01	0	0.	0	I+
-5.5000E+01	0	0.	0	I+
-5.0000E+01	0	0.	0.	I+
-4.5000E+01	0	0.	0.	I+
-4.0000E+01	0	0.	0	I+
-3.5000E+01	0	0.	0	I+
-3.0000E+01	0	0.	0	I+
-2.5000E+01	0	0.	0.	I+
-2.0000E+01	0	0.	0.	I+
-1.5000E+01	1	0.0054	0.0054	I+
-1.0000E+01	4	0.0215	0.0269	I*+
-5.0000E+00	17	0.0914	0.1183	I******+
0	24	0.1290	0.2473	I******** +
5.0000E+00	24	0.1290	0.3763	I******** +
1.0000E+01	27	0.1452	0.5215	I********* +
1.5000E+01	14	0.0753	0.5968	I**** +
2.0000E+01	17	0.0914	0.6882	I***** +
2.5000E+01	18	0.0968	0.7849	I****** +
3.0000E+01	11	0.0591	0.8441	I*** +
3.5000E+01	10	0.0538	0.8978	I*** +
4.0000E+01	9	0.0484	0.9462	I*** +
4.5000E+01	10	0.0538	1.0000	I*** +
5.0000E+01	0	0	1.0000	I +
5.5000E+01	0	0.	1.0000	I +
6.0000E+01	0	0.	1.0000	I +
6.5000E+01	0	0.	1.0000	I +
7.0000E+01	0	0.	1.0000	I +
7.5000E+01	0	0.	1.0000	I +
8.0000E+01	0	0.	1.0000	I +
8.5000E+01	0	0.	1.0000	I +
9.0000E+01	0	0.	1.0000	I +
9.5000E+01	0	0.	1.0000	I +

1FUNCTION	14 702 OMBA	REPORT NO 11	
	MATERIAL TYPE	6	
	DATA	TRUE	
	VARIABLE	MASS	
	SAMPLING	EACH INPUT/OUTPUT TIME	
	REPLICATE SAMPLING TIME	0.	NUMBER OF OBSERVATIONS 186
	MEAN VALUE	2.4786E+02	STANDARD DEVIATION 4.9284E+01
	MAXIMUM VALUE	3.6236E+02	TIME OF MAXIMUM VALUE 3.5482E+02
	MINIMUM VALUE	6.0223E+01	TIME OF MINIMUM VALUE 1.3101E+01

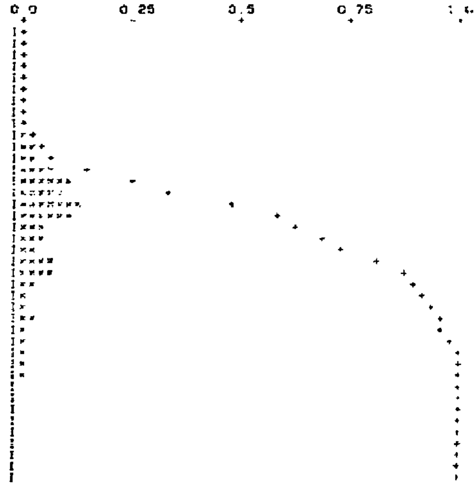
LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
0.	0	0	0.
2.0000E+01	0	0.	0.
4.0000E+01	0	0.	0.
6.0000E+01	1	0.0054	0.0054
8.0000E+01	0	0.	0.0054
1.0000E+02	3	0.0161	0.0215
1.2000E+02	0	0.	0.0215
1.4000E+02	1	0.0054	0.0269
1.6000E+02	18	0.0968	0.1237
1.8000E+02	7	0.0376	0.1613
2.0000E+02	3	0.0161	0.1774
2.2000E+02	49	0.2634	0.4409
2.4000E+02	39	0.2097	0.6505
2.6000E+02	3	0.0161	0.6667
2.8000E+02	32	0.1720	0.8387
3.0000E+02	25	0.1344	0.9731
3.2000E+02	1	0.0054	0.9785
3.4000E+02	3	0.0161	0.9946
3.6000E+02	1	0.0054	1.0000
3.8000E+02	0	0.	1.0000
4.0000E+02	0	0	1.0000
4.2000E+02	0	0.	1.0000
4.4000E+02	0	0.	1.0000
4.6000E+02	0	0.	1.0000
4.8000E+02	0	0.	1.0000
5.0000E+02	0	0.	1.0000
5.2000E+02	0	0.	1.0000
5.4000E+02	0	0.	1.0000
5.6000E+02	0	0.	1.0000
5.8000E+02	0	0.	1.0000
6.0000E+02	0	0.	1.0000
6.2000E+02	0	0.	1.0000
6.4000E+02	0	0.	1.0000
6.6000E+02	0	0.	1.0000
6.8000E+02	0	0.	1.0000
7.0000E+02	0	0.	1.0000
7.2000E+02	0	0.	1.0000
7.4000E+02	0	0.	1.0000
7.6000E+02	0	0.	1.0000
7.8000E+02	0	0.	1.0000



IFUNCTION 14 702 OMBA — REPORT NO. 12

MATERIAL TYPE	6		
DATA	ERROR (OBSERVED - TRUE)		
VARIABLE	MASS		
SAMPLING	EACH INPUT/OUTPUT TIME		
REPLICATE SAMPLING TIME	0.	NUMBER OF OBSERVATIONS	186
MEAN VALUE	-5.5209E+00	STANDARD DEVIATION	9 0017E+00
MAXIMUM VALUE	2 1656E+01	TIME OF MAXIMUM VALUE	1 2657E+02
MINIMUM VALUE	-2 0582E+01	TIME OF MINIMUM VALUE	6 4170E+02

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRI-BUTION
-4.0000E+01	0	0	0
-3.8000E+01	0	0.	0.
-3.6000E+01	0	0.	0.
-3.4000E+01	0	0	0
-3 2000E+01	0	0.	0.
-3.0000E+01	0	0	0
-2.8000E+01	0	0.	0
-2.6000E+01	0	0	0
-2.4000E+01	0	0	0
-2.2000E+01	4	0 0215	0.0215
-2.0000E+01	7	0 0376	0 0591
-1.8000E+01	4	0 0215	0.0806
-1.6000E+01	12	0 0645	0.1452
-1.4000E+01	19	0.1022	0 2473
-1.2000E+01	18	0 0968	0 3441
-1.0000E+01	24	0 1290	0.4731
-8.0000E+00	20	0.1075	0.5806
-6.0000E+00	9	0 0484	0.6290
-4.0000E+00	11	0.0591	0.6882
-2.0000E+00	7	0.0376	0.7258
0.	14	0.0753	0.8011
2.0000E+00	13	0.0699	0.8710
4.0000E+00	5	0 0269	0.8978
6.0000E+00	3	0 0161	0.9140
8.0000E+00	3	0.0161	0.9301
1.0000E+01	4	0.0215	0.9516
1.2000E+01	1	0 0054	0.9570
1.4000E+01	3	0.0161	0.9731
1.6000E+01	3	0.0161	0.9892
1.8000E+01	1	0.0054	0.9945
2.0000E+01	1	0.0054	1.0000
2.2000E+01	0	0.	1.0000
2.4000E+01	0	0.	1.0000
2.6000E+01	0	0.	1.0000
2.8000E+01	0	0	1 0000
3.0000E+01	0	0.	1.0000
3.2000E+01	0	0.	1.0000
3.4000E+01	0	0.	1.0000
3.6000E+01	0	0.	1.0000
3.8000E+01	0	0.	1.0000



[illegible]	[illegible]	REPORT NO 13	
	[illegible] TYPE	7	
	DATA	TRUE	
	VARIABLE	COUNT	
	[illegible]	EACH INPUT/OUTPUT TIME	
	REPLICATE SAMPLING TIME	0	NUMBER OF OBSERVATIONS [illegible]
	[illegible] VALUE	5 0027E+03	STANDARD DEVIATION [illegible]
	MAXIMUM VALUE	5 4930E+03	TIME OF MAXIMUM VALUE 6 41?0E+0?
	[illegible] VALUE	1 0230E+03	TIME OF MINIMUM VALUE [illegible]

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
0	0	0	0
5 [illegible] 02	0	0.	0
[illegible] 03	1	0 0054	0 0054
[illegible] 500[illegible]+03	0	0	0 0054
[illegible]	0	0.	0 0054
2 [illegible] 03	3	0 0161	0 0215
3 [illegible]	0	0	0 0215
[illegible]	0	0	0 0215
4 [illegible]	26	0 1398	0 1613
4 [illegible]	0	0.	0 1613
5 [illegible]	8	0.0430	0 2043
[illegible]	83	0 4462	0 6505
[illegible]	0	0.	0 6505
[illegible]	34	0 1826	0.8333
[illegible]	25	0 1338	0 9731
[illegible]	0	0	0 9731
[illegible]	5	0.0269	1.0000
[illegible]	0	0.	1 0000
[illegible]	0	0.	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0.	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0.	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0.	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0	1.0000
[illegible]	0	0	1 0000
[illegible]	0	0.	1.0000
[illegible]	0	0.	1 0000
[illegible]	0	0.	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0.	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0.	1.0000
[illegible]	0	0	1 0000
[illegible]	0	0	1 0000

0.0 0.25 0.5 0.75 [illegible]

REPORT NO. 14
7
ERROR (OBSERVED - TRUE)
COUNT
EACH INPUT/OUTPUT TIME
0
2.4844E+01
5.4000E+01
-1.0000E-00

NUMBER OF OBSERVATIONS 186
STANDARD DEVIATION 1.2201E+01
TIME OF MAXIMUM VALUE 5.7478E+02
TIME OF MINIMUM VALUE 3.9747E+02

LOWER LIMIT OF CELL	COUNT	DENSITY	CUMULATIVE DISTRIBUTION	0.0 0.25 0.5 0.75 1
-1.0000E+02	0	0.	0.	I+
-9.0000E+01	0	0.	0.	I+
-8.0000E+01	0	0.	0.	I+
-7.0000E+01	0	0.	0.	I+
-6.0000E+01	0	0.	0.	I+
-5.0000E+01	0	0.	0.	I+
-4.0000E+01	0	0.	0.	I+
-3.0000E+01	0	0.	0.	I+
-2.0000E+01	0	0.	0.	I+
-1.0000E+01	0	0.	0.	I+
0.	0	0.	0.	I+
1.0000E+01	18	0.0108	0.0108	I+
2.0000E+01	41	0.0430	0.0538	I***
3.0000E+01	19	0.0215	0.1183	I** +
4.0000E+01	24	0.1290	0.2473	I******
5.0000E+01	15	0.0806	0.3280	I****
6.0000E+01	22	0.1559	0.4839	I********
7.0000E+01	22	0.1237	0.6075	I*******
8.0000E+01	29	0.1452	0.7527	I********
9.0000E+01	20	0.1237	0.8763	I*******
1.0000E+02	10	0.0430	0.9193	I***
1.1000E+02	2	0.0215	0.9892	I**
1.2000E+02	2	0.0108	1.0000	I*
1.3000E+02	0	0.	1.0000	I
1.4000E+02	0	0.	1.0000	I
1.5000E+02	0	0.	1.0000	I
1.6000E+02	0	0.	1.0000	I
1.7000E+02	0	0.	1.0000	I
1.8000E+02	0	0.	1.0000	I
1.9000E+02	0	0.	1.0000	I
2.0000E+02	0	0.	1.0000	I

IDENTIFICATION	14 102 CMBA	REPORT NO. 15	
	MATERIAL TYPE	B	
	DATA	TRUE	
	VARIABLE	MASS	
	SAMPLING	EACH INPUT/OUTPUT TIME	
	REPLICATE SAMPLING TIME	0.	NUMBER OF OBSERVATIONS 186
	MEAN VALUE	6.6871E+02	STANDARD DEVIATION 1.2665E+02
	MAXIMUM VALUE	9.6118E+02	TIME OF MAXIMUM VALUE 6.1703E+02
	MINIMUM VALUE	1.5725E+02	TIME OF MINIMUM VALUE 1.3101E+01

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
0.	0	0.	0.	I+
5.0000E+01	0	0.	0.	I+
1.0000E+02	0	0.	0.	I+
1.5000E+02	1	0.0054	0.0054	I+
2.0000E+02	0	0.	0.0054	I+
2.5000E+02	0	0.	0.0054	I+
3.0000E+02	3	0.0161	0.0215	I+
3.5000E+02	0	0.	0.0215	I +
4.0000E+02	0	0.	0.0215	I +
4.5000E+02	26	0.1398	0.1613	I******+
5.0000E+02	0	0.	0.1613	I +
5.5000E+02	0	0.	0.1613	I +
6.0000E+02	91	0.4892	0.6505	I**********+ +
6.5000E+02	0	0.	0.6505	I +
7.0000E+02	0	0.	0.6505	I +
7.5000E+02	47	0.2527	0.9032	I**********+ +
8.0000E+02	18	0.0699	0.9731	I**** +
8.5000E+02	0	0.	0.9731	I +
9.0000E+02	0	0.	0.9731	I +
9.5000E+02	5	0.0269	1.0000	I** +
1.0000E+03	0	0.	1.0000	I +
1.0500E+03	0	0.	1.0000	I +
1.1000E+03	0	0.	1.0000	I +
1.1500E+03	0	0.	1.0000	I +
1.2000E+03	0	0.	1.0000	I +
1.2500E+03	0	0.	1.0000	I +
1.3000E+03	0	0.	1.0000	I +
1.3500E+03	0	0.	1.0000	I +
1.4000E+03	0	0.	1.0000	I +
1.4500E+03	0	0.	1.0000	I +
1.5000E+03	0	0.	1.0000	I +
1.5500E+03	0	0.	1.0000	I +
1.6000E+03	0	0.	1.0000	I +
1.6500E+03	0	0.	1.0000	I +
1.7000E+03	0	0.	1.0000	I +
1.7500E+03	0	0.	1.0000	I +
1.8000E+03	0	0.	1.0000	I +
1.8500E+03	0	0.	1.0000	I +
1.9000E+03	0	0.	1.0000	I +
1.9500E+03	0	0	1.0000	I

1FUNCTION 14.702 CMBA
MATERIAL TYPE
DATA
VARIABLE
SAMPLING
REPLICATE SAMPLING TIME
MEAN VALUE
MAXIMUM VALUE
MINIMUM VALUE

REPORT NO. 16
8
ERROR (OBSERVED - TRUE)
MASS
EACH INPUT/OUTPUT TIME
0.
2.0056E+01
4.0396E+01
-1.5956E+00

NUMBER OF OBSERVATIONS 186
STANDARD DEVIATION 9.1478E+00
TIME OF MAXIMUM VALUE 4.452-IE+02
TIME OF MINIMUM VALUE 8.7248E+01

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
-1.0000E+02	0	0.	0.	I+
-9.5000E+01	0	0.	0.	I+
-9.0000E+01	0	0.	0.	I+
-8.5000E+01	0	0.	0.	I+
-8.0000E+01	0	0.	0.	I+
-7.5000E+01	0	0.	0.	I+
-7.0000E+01	0	0.	0.	I+
-6.5000E+01	0	0.	0.	I+
-6.0000E+01	0	0.	0.	I+
-5.5000E+01	0	0.	0.	I+
-5.0000E+01	0	0.	0.	I+
-4.5000E+01	0	0.	0.	I+
-4.0000E+01	0	0.	0.	I+
-3.5000E+01	0	0.	0.	I+
-3.0000E+01	0	0.	0.	I+
-2.5000E+01	0	0.	0.	I+
-2.0000E+01	0	0.	0.	I+
-1.5000E+01	0	0.	0.	I+
-1.0000E+01	0	0.	0.	I+
-5.0000E+00	2	0.0108	0.0108	I+
0.	8	0.0430	0.0538	I***
5.0000E+00	12	0.0645	0.1183	I***** +
1.0000E+01	40	0.2151	0.3333	I********** +
1.5000E+01	35	0.1882	0.5215	I********** +
2.0000E+01	33	0.1774	0.6989	I********* +
2.5000E+01	25	0.1344	0.8333	I****** +
3.0000E+01	21	0.1129	0.9462	I***** +
3.5000E+01	9	0.0430	0.9892	I*** +
4.0000E+01	2	0.0108	1.0000	I* +
4.5000E+01	0	0.	1.0000	I +
5.0000E+01	0	0.	1.0000	I +
5.5000E+01	0	0.	1.0000	I +
6.0000E+01	0	0.	1.0000	I +
6.5000E+01	0	0.	1.0000	I +
7.0000E+01	0	0.	1.0000	I +
7.5000E+01	0	0.	1.0000	I +
8.0000E+01	0	0.	1.0000	I +
8.5000E+01	0	0.	1.0000	I +
9.0000E+01	0	0.	1.0000	I +
9.5000E+01	0	0.	1.0000	I +

```
FUNCTION  15 601 TIMR
  NO REPORT
```

This completes the standard report generated by the second RUN line of the input file. The reports generated by individual functions are self explanatory, but the reader is reminded that this is a report of a single simulation run and that the sample values reported by the 702 CMBA function were taken each time a quantity of an accountable material crossed the boundary of the material balance area. The determination of material balance uncertainty at specific times will be illustrated later in the example by collecting data over ensembles of replicated runs. But before doing that we will next show how model systems may be modified and individual runs repeated to determine the effects of modifications.

```
      REDUCE THE UNCERTAINTY OF ALL MASS MEASUREMENTS BY A FACTOR OF TWO
      AND REPEAT THE 28 DAY RUN COLLECTING ONLY MASS ERROR DATA AND
      REPORTING ONLY FUNCTION 11 AND 14
PARAMETER 5
     (2 12 12)  5
PARAMETER 6
     (2 12 12) 1.
PARAMETER 7
     (2 12 12) .5
     (2 24 24) 2.
PARAMETER 11
     (2 12 12)  5
     (2 24 24)  1
     (2 36 36) .5
     (2 48 48) 2.
PARAMETER 14
     (1) 4
     (2 1 32)
          2 3 2 1 0. 40 1. -20.
          4 3 2 1 0. 40 1. -20.
          6 3 2 1 0. 40 2. -40.
          8 3 2 1 0. 40 2. -40.
```

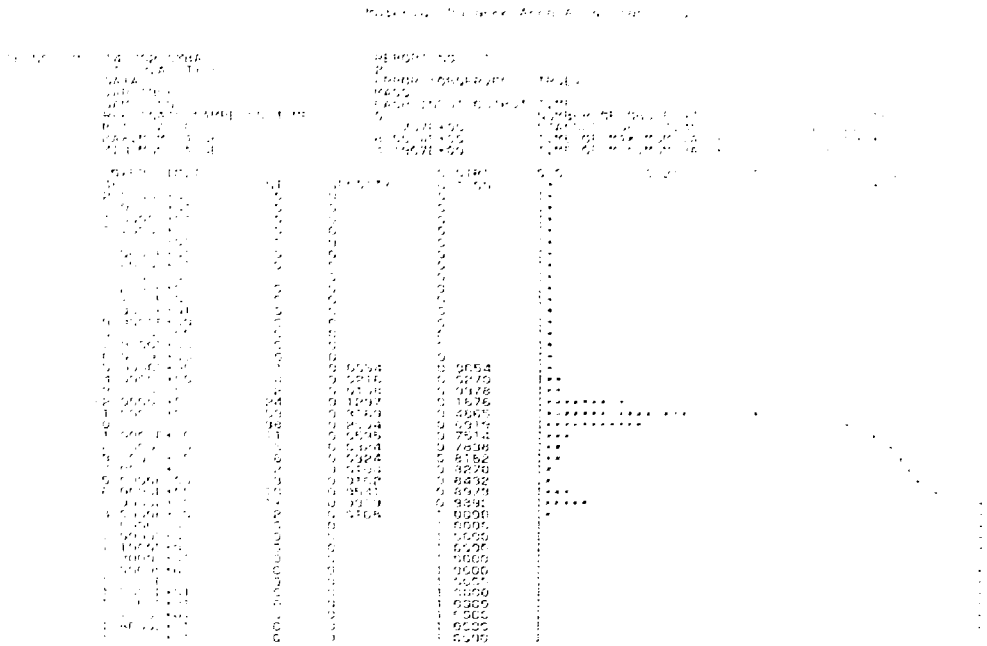
Individual elements of list valued parameters are modified in functions 5, 6, 7, and 11 above. The number of reports to be generated by function 14 is reduced from 16 to 4, and the first 32 elements of parameter 2 are modified to define the new material balance report specifications. Any number of modifications or redefinitions of the material balance report specifications could have been made if there were no need to increase the number of elements in list valued parameter 2. To increase the number of elements in a list valued parameter, the function must be destroyed and recreated.

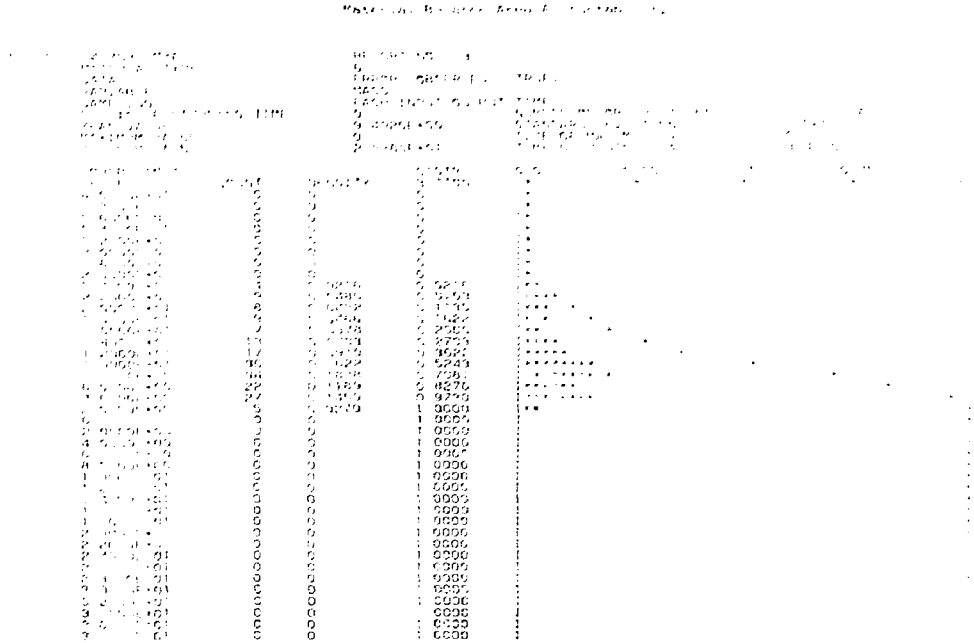
```
RUN 1 672. 0 0 0
```

This line produces a 28 day (672 hour) run of the modified model system but generates no output. Individual reports of data gathered during the run by functions 11 and 14 are requested separately as appears below. Notice that now only four reports

are generated by function 14 and that a change in the width of the cells of the error histogram for material B has been effected.

```
REPORT 11

FUNCTION  11 701/MZMB
          MAXIMUM NUMBER OF BATCHES IN MEASUREMENT          5
          TIME MAXIMUM FIRST OCCURRED              1.3345E+02
REPORT 14
```





```
      PLACE ALL MEASUREMENT FUNCTIONS ON THE 8 A.M. TO NOON, 1 P.M. TO 5 P.M.
      OPERATING SCHEDULE OF TIMER FUNCTION 15.  REPEAT THE 28 DAY RUN AND
      REPORT FUNCTIONS 5 THROUGH 12
PARAMETER 5
      (5) 3
PARAMETER 6
      (5) 3
PARAMETER 7
      (5) 3
PARAMETER 11
      (5) 3
RUN 1 672  0 0 0
REPORT 5

FUNCTION    5 701/MZMB
        MAXIMUM NUMBER OF BATCHES IN MEASUREMENT                  2
        TIME MAXIMUM FIRST OCCURRED                      [illegible]
REPORT 6

FUNCTION    6 701/MZMB
        MAXIMUM NUMBER OF BATCHES IN MEASUREMENT                  [illegible]
        TIME MAXIMUM FIRST OCCURRED                      [illegible]E+01
REPORT 7

FUNCTION    7 701/MZMB
        MAXIMUM NUMBER OF BATCHES IN MEAS REMAIN                  2
        TIME MAXIMUM FIRST OCCURRED                      [illegible]
REPORT 8

FUNCTION    8 301/TRMB
        MAXIMUM NUMBER OF BATCHES IN TRANSPORT                 4
        TIME MAXIMUM FIRST OCCURRED                  4 [illegible]
REPORT 9

FUNCTION    9 301/TRMB
        MAXIMUM NUMBER OF BATCHES IN TRANSPORT                 [illegible]
        TIME MAXIMUM FIRST OCCURRED                  2 [illegible]
REPORT 10

FUNCTION   10 301/TRMB
        MAXIMUM NUMBER OF BATCHES IN TRANSPORT                 5
        TIME MAXIMUM FIRST OCCURRED                  4 [illegible]E+02
REPORT 11

FUNCTION   11 701/MZMB
```

```
MAXIMUM NUMBER OF BATCHES IN MEASUREMENT          5
TIME MAXIMUM FIRST OCCURRED              5 C081E+02
:

12 301/TRM5
MAXIMUM NUMBER OF BATCHES IN TRANSPORT            :
TIME MAXIMUM FIRST OCCURRED              2 8106E+0

RETURN MEASUREMENT FUNCTIONS 6 AND 11 TO CONTINUOUS OPERATION AND
MEASURE ONLY MATERIAL 4 WITH 2 0 STANDARD DEVIATION OF RANDOM ERROR
      (2 1 6) 4 0 0 0   0  2      (5) 1
      (2 1 6) 4 0 0 0   0  2.     (5) 1

USE CMBA FUNCTION 14 TO REPLICATE SAMPLING OF THE
BALANCE MASS ERROR FOR MATERIAL 4 AT THE END OF EACH
OF THE FIRST FOUR WEEKS OF OPERATION AND REMOVE INPUT FUNCTIONS 5 AND 7
    14

  22,
   3 2 2 168   40 5   -100
   3 2 2 336   40 5   -100.
   3 2 2 504   40 5.  -100.
   3 2 2 672   40 5.  -100
  1, 6

  ELIMINATE FUNCTIONS 1, 3, 5, AND 7
```

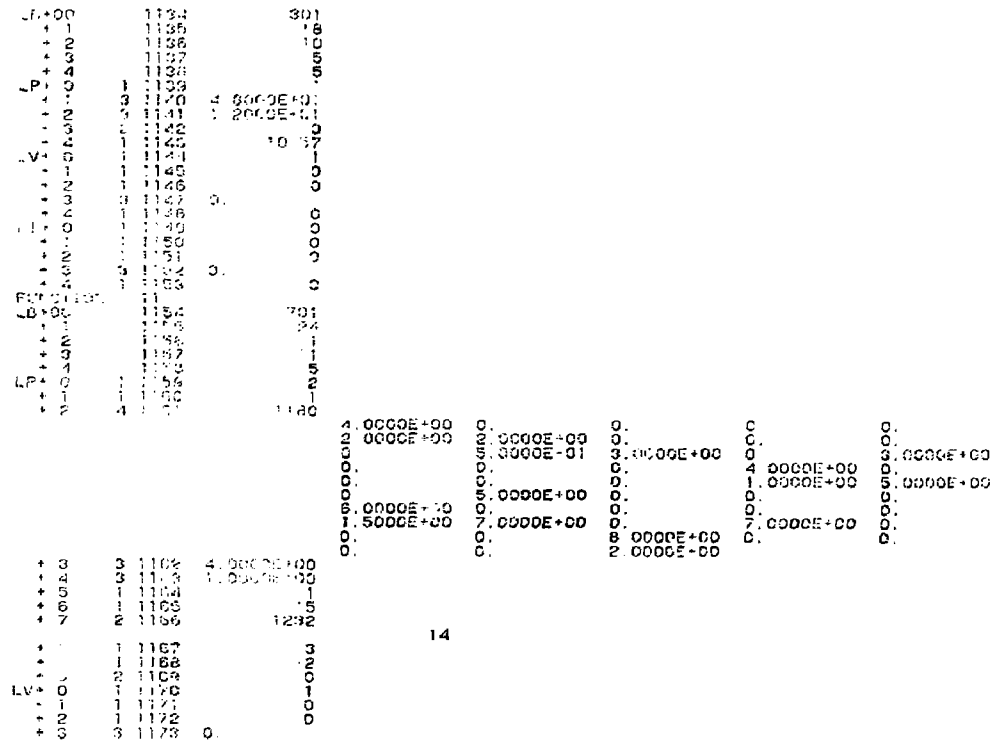
Several functions of the original model system have now been modified, some have been destroyed, and the material balance function has been changed to gather data over replicated simulation runs. We next make a set of ten replicated runs with a dump of the current model system to verify that all of the modifications have been implemented and to display the status of the free store chain.

```
TEN REPLICATIONS OF 28 DAYS OF OPERATION WITH A DUMP, NO TRACE,
AND REPORT OF ONLY CMBA FUNCTION 14
      1 0 0

  MTO        15
  RANDOM      0
  TYPE       -6
  POINT       0
  DUMP        1
  SFCA      100
```

```
          ITRACE            0
             LB          1483
            LBCA          7667
          LBLIST          1030
            LBPI             1
            LBUF           650
            LCSB           104
              LE          1511
             LEC           148
            LFFB          2487
            LFFE           190
              LI          1504
             LLE           170
            LLFB         10867
            LLFE           645
             LMS           104
             LNE           175
              LP          1488
              LV          1496
          MINNFL          9132
            MNSE             8
             NFE            92
             NFL         14730
             NI1             5
             NI2            59
             NO1             6
             NO2            59
            NREP            10
            NRUN             1
             NSE             8
            TIME  0.
           TSTOP  6.7300E+02
FUNCTION      2
LB+00       784           101
  + 1       785            22
  + 2       786             2
  + 3       787            15
  + 4       788             2
LP+ 0   1   789             2
  + 1   3   790  2.4000E+01
  + 2   1   791             1
  + 3   4   792           808
                                1.2500E+01
  + 4   3   793  4.5000E+00
  + 5   1   794             0
  + 6   4   795             0
  + 7   1   796             2
  + 8   4   797           818
                                3.0000E+00  3.0000E+02  1.0000E+02  0.          0.
                                0.          0.          4.0000E+00  0.          0.
                                4.0000E+0.  2.0000E+01  1.0000E+03  0.
  + 9   3   798  2.0000E+00
```

```
   +10      3   799   1.0000E+0C
   +11      1   800            i
   +12      1   801           15
   +13      1   802            6
   +14      1   803            4
LV+ 0       1   804            1
  + 1       1   605            0
LI+ 0       1   606            0
  + 1       1   607            0
FUNCTION        4
LB+00           906          301
  + 1           907           18
  + 2           908            4
  + 3           909            5
  + 4           910            5
LP+ 0       1   911            1
  + 1       3   912   0.
  + 2       3   913   0
  + 3       2   914            0
  + 4       1   915        10707
LV+ 0       1   916            1
  + 1       1   917            0
  + 2       1   918            0
  + 3       3   919   0.
  + 4       1   920            0
LI+ 0       1   921            0
  + 1       1   922            0
  + 2       1   923            0
  + 3       3   924   0.
  + 4       1   925            0
FUNCTION        6
LB+00           978          701
  + 1           979           24
  + 2           980            6
  + 3           981           11
  + 4           982            5
LP+ 0       1   983            4
  + 1       1   984            1
  + 2       4   985         1004
                                  4.0000E+00  0.           0                  0
                                  2.0000E+00  4 0000E+00   0         -        0
                                  0           1.0000E+00
  + 3       3   986   4.0000E+00
  + 4       3   987   5.0000E-01
  + 5       1   988            1
  + 6       1   989           15
  + 7       2   990         1020
                                              14
  + 8       1   991           11
  + 9       1   992            9
  +10       2   993            0
LV+ 0       1   994            1
```

```
  + 1     1   99.               0
  + 2     1   .96               0
  + 3     3   997    0
  + 4     1   998               0
LI+ 0     1   999               0
  + 1     1  1000               0
  + 2     1  1001               0
  + 3     3  1002    0
  + 4     1  1003               0
FUNCTION       8
LA+00        1094             301
  + 1        1095              18
  + 2        1096               8
  + 3        1097               5
  + 4        1098               5
LP+ 0     1  1099               1
  + 1     3  1100    2  4000E+01
  + 2     3  1101    1  2000E+01
  + 3     2  1102               0
  + 4     1  1103           10517
LV+ 0     1  1104               1
  + 1     1  1105               0
  + 2     1  1106               0
  + 3     1  1107
  + 4     1  1108               0
LI+ 0     1  1109               0
  + 1     1  1110               0
  + 2     1  1111               0
  + 3     3  1112    0
  + 4     1  1113               0
FUNCTION       9
LA+00        1114             301
  + 1        1115              18
  + 2        1116               9
  + 3        1117               5
  + 4        1118               5
LP+ 0     1  1119               1
  + 1     3  1120    1  2000E+01
  + 2     3  1121    2  1000E+01
  + 3     2  1122               0
  + 4     1  1123           10717
LV+ 0     1  1124               1
  + 1     1  1125               0
  + 2     1  1126               0
  + 3     3  1127    0
  + 4     1  1128               0
LI+ 0     1  1129               0
  + 1     1  1130               0
  + 2     1  1131               0
  + 3     3  1132    0
  + 4     1  1133               0
FUNCTION      10
```



```
   + 4     1 1174                    0
LI + 0     1 1175                    0
   + 1     1 1176                    0
   + 2     1 1177                    0
   + 3     3 1178  0.
   + 4     1 1179                    0
FUNCTION    12
LB+00       1242                  301
   + 1      1243                   18
   + 2      1244                   12
   + 3      1245                    5
   + 4      1246                    5
LP+ 0     1 1247                    1
   + 1     3 1248  0.
   + 2     3 1249  0.
   + 3     2 1250                    0
   + 4     1 1251                 5217
LV+ 0     1 1252                    1
   + 1     1 1253                    0
   + 2     1 1254                    0
   + 3     3 1255  0.
   + 4     1 1256                    0
LI + 0     1 1257                    0
   + 1     1 1258                    0
   + 2     1 1259                    0
   + 3     3 1260  0.
   + 4     1 1261                    0
FUNCTION    13
LB+00       1262                  401
   + 1      1263                   44
   + 2      1264                   13
   + 3      1265                    9
   + 4      1266                   16
LP+ 0     1 1267                    0
   + 1     1 1268                    1
   + 2     3 1269  1.0000E+01
   + 3     3 1270  1.0000E+00
   + 4     3 1271  5.0000E-02
   + 5     2 1272                 1309
                                      1          1          1          1
   + 6     2 1273                    0
   + 7     1 1274                 1579
   + 8     1 1275                 1589
LV+ 0     1 1276                    1
   + 1     1 1277                    0
   + 2     1 1278                    0
   + 3     3 1279  0.
   + 4     1 1280                    0
   + 5     3 1281  0.
   + 6     3 1282  0.
   + 7     3 1283  0.
   + 8     3 1284  0.
```

+ 9	3	1285	0.	
+10	3	1286	0.	
+11	1	1287		0
+12	3	1288	0.	
+13	3	1289	0.	
+14	3	1290	0.	
+15	3	1291	0.	
LI+ 0	1	1292		0
+ 1	1	1293		0
+ 2	1	1294		0
+ 3	3	1295	0.	
+ 4	1	1296		0
+ 5	3	1297	0.	
+ 6	3	1298	0.	
+ 7	3	1299	0.	
+ 8	3	1300	0.	
+ 9	3	1301	0.	
+10	3	1302	0.	
+11	1	1303		0
+12	3	1304	0.	
+13	3	1305	0.	
+14	3	1306	0.	
+15	3	1307	0.	
FUNCTION		14		
LB+00		1318		702
+ 1		1319		11
+ 2		1320		14
+ 3		1321		6
+ 4		1322		1
LP+ 0	1	1323		0
+ 1	1	1324		4
+ 2	4	1325		1331

4.0000E+00	3.0000E+00	2.0000E+00	2.0000E+00	1.6800E+02
4.0000E+01	5.0000E+00	-1.0000E+02	4.0000E+00	3.0000E+00
2.0000E+00	2.0000E+00	3.3600E+02	4.0000E+01	5.0000E+00
-1.0000E+02	4.0000E+00	3.0000E+00	2.0000E+00	2.0000E+00
5.0400E+02	4.0000E+01	5.0000E+00	-1.0000E+02	4.0000E+00
3.0000E+00	2.0000E+00	2.0000E+00	6.7200E+02	4.0000E+01
5.0000E+00	-1.0000E+02	3.0000E+00	2.0000E+00	1.0000E+00
1.0000E+00	0.	4.0000E+01	5.0000E+01	0.
3.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	0.
4.0000E+01	2.0000E+00	-4.0000E+01	4.0000E+00	2.0000E+00
2.0000E+00	1.0000E+00	0.	4.0000E+01	1.0000E+01
0.	4.0000E+00	3.0000E+00	2.0000E+00	1.0000E+00
0.	4.0000E+01	1.0000E+00	-2.0000E+01	5.0000E+00
2.0000E+00	1.0000E+00	1.0000E+00	0.	4.0000E+01
1.0000E+02	0.	5.0000E+00	3.0000E+00	1.0000E+00
1.0000E+05	0.	4.0000E+01	5.0000E+00	-1.0000E+02
5.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00	0.
4.0000E+01	2.0000E+01	0.	5.0000E+00	3.0000E+00
2.0000E+00	1.0000E+00	0.	4.0000E+01	2.0000E+00
-4.0000E+01	7.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00

```
                                          0.           4.0000E+01   5.0000E+02   0.           7.0000E+00
                                          3.0000E+00   1.0000E+00   1.0000E+00   0.           4.0000E+01
                                          5.0000E+00  -1.0000E+02   8.0000E+00   2 0000E+00   2.0000E+00
                                          1.0000E+00   0.           4.0000E+01   5.0000E+01   0.
                                          6.0000E+00   3.0000E+00   2.0000E+00   1.0000E+00   0
                                          4 0000E+01   5.0000E+00  -1.0000E+02
    + 3     2 1326              1463
                                                   6            6            7
    + 4     2 1327              1473
                                                  11
    + 5     1 1328              1599
 LV+  0     1 1329                 1
 LI+  0     1 1330                 0
 FUNCTION     15
 LR+90        1483               601
    + 1       1484                27
    + 2       1485                15
    + 3       1486                 8
    + 4       1487                 8
 LP+  0     1 1488                 0
    + 1     3 1489        1.6800E+02
    + 2     1 1490                 5
    + 3     4 1491              15 2
                                          8.0000E+00   3.2000E+01   5.6000E+01   8 0000E+01   1.0400E+02
    + 4     4 1492              1522
                                          1.7000E+01   4.1000E+01   6.5000E+01   5.9000E+01   1.1300E 02
    + 5     1 1493                10
    + 6     4 1494              1532
                                          8.0000E+00   1.3000E+01   3.2000E+01   3.7000E+01   5 6000E+01
                                          6.1000E+01   8.0000E+01   8.5000E+01   1 0100E+02   1 0900E 02
    + 7     4 1495              1546
                                          1.2000E+01   1.7000E+01   3.6000E+01   4.1000E+01   6.0000E+01
                                          6.5000E+01   8.4000E+01   8.9000E+01   1 0600E+02   1.1300E+02

 LV+  0     1 1496                 1
    + 1     3 1497        1.6800E+02
    + 2     1 1498                 0
    + 3     3 1499        0.
    + 4     3 1500        8.0000E+00
    + 5     1 1501                 0
    + 6     3 1502        0.
    + 7     3 1503        8.0000E+00
 LI+  0     1 1504                 0
    + 1     3 1505        1.6800E+02
    + 2     1 1506                 0
    + 3     3 1507        0.
    + 4     3 1508        8.0000E+00
    + 5     1 1509                 0
    + 6     3 1510        0.
    + 7     3 1511        8.0000E+00
 EVENT  CHAIN
            LEC              148
            LNE              175
```

```
     LLE          170
    LFFE          190
    LLFE          645
     NSE            6
    MNSE            8
     NFE           92
   ISLCA          100
   175       180        0.                    15          1          0
   180       185        3.0000E+00            15          2          0
   15'       150        3.0000E+00            15          3          0
   150       155         .5200E+01             2          1          0
   155       160         .6800E+02            14          1          0
   160       165        3.3600E+02            14          2          0
   165       170        5.0400E+02            14          3          0
   170         0        6.7200E+02            14          4          0
FREE STORE
    LFFB         2487
    LLFB        10587
     NFL        14730
    LBCA         7687
  MINNFL         9132
  2467      2497         8
  2497      8517         8
  8517      7977         8
  7977      8317         8
  8317      7687         8
  7687      7757         8
```

To conserve space, 600 lines of the output file containing linked blocks of 8 available locations in the free store chain have been removed here. Many of these blocks are placed in the free store chain when space representing material in the storage function is released. The large number of small, noncontiguous blocks at the beginning of the free store chain does not markedly affect the execution time of the program because once a model system has been defined most of the space allocated from free store is in small blocks used in material data structures and for communications among interacting functions.

```
 10597      8817         8
  8817      9137         8
  9137      7747         8
  7747     10267         8
 10267      9027         8
  9027      9317         8
  9317      9047         8
  9047      2757         8
  2757      9957         8
  9957     10547         8
 10547     10557         8
 10557     10567         8
 10567     10717         8
 10717     10737         8
 10737     10827         8
```

10827	10747	8
10747	10787	8
10787	10797	8
10797	10807	8
10807	10817	8
10817	10757	8
10757	10767	8
10767	10777	8
10777	10837	8
10837	10847	8
10847	2707	8
2707	9997	8
9997	6217	8
10217	10367	8
10367	10377	8
10377	10387	8
10387	10397	8
10397	10207	8
10207	10347	8
10347	10357	8
10357	5217	8
5217	10577	8
10577	10607	8
10607	10657	8
10657	10667	8
10667	10677	8
10677	10687	8
10687	10627	8
10627	10637	8
10637	10647	8
10647	10407	8
10407	9277	8
9277	4647	8
4647	6667	8
6667	8017	8
8017	9787	8
9787	5987	8
5987	9227	8
9227	10707	8
10707	7337	8
7337	6267	8
6267	10587	8
10587	1045	8
1045	1084	8
1084	1056	8
1056	926	26
926	969	24
968	952	8
952	836	14
836	888	22
888	870	16
870	860	16

860	732	8
732	766	22
766	756	16
756	1560	8
1560	6307	17
6307	10617	8
10617	9637	8
9637	9837	8
9837	9847	8
9847	7247	8
7247	10727	8
10727	10867	8
10867	0	9132

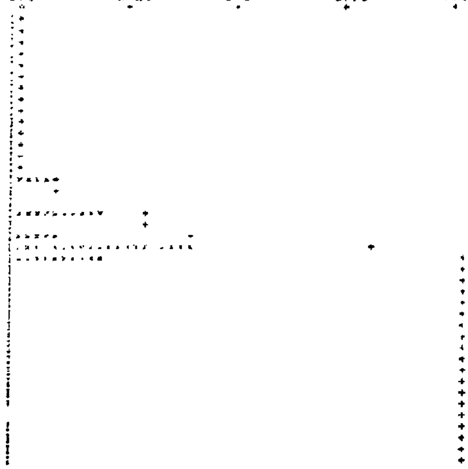
REPORT 14

[illegible]
DATA
VARIABLE
SAMPLING
[illegible] TEST
MEAN VALUE
MAXIMUM VALUE
MINIMUM VALUE

LOWER LIMIT OF CELL	[illegible]
-1.0000E+00	
-9.5000E+00	
-9.0000E+00	
-8.5000E+00	
-8.0000E+00	
-7.5000E+00	
-7.0000E+00	
-6.5000E+00	
-6.0000E+00	
-5.5000E+00	
-5.0000E+00	
-4.5000E+00	
-4.0000E+00	
-3.5000E+00	
-3.0000E+00	
-2.5000E+00	
-2.0000E+00	
-1.5000E+00	
-1.0000E+00	
-5.0000E-00	
0	
5.0000E-00	
1.0000E+00	
[illegible]	
2.5000E+00	
3.0000E+00	
3.5000E+00	
4.0000E+00	
4.5000E+00	
5.0000E+00	
5.5000E+00	
6.0000E+00	
6.5000E+00	
7.0000E+00	
7.5000E+00	
8.0000E+00	
[illegible]	
[illegible]	

Mate[illegible]al Balance Area Accountability

[illegible]	REPORT NO. 2		
[illegible]	4		
[illegible]	ERROR (OBSERVED - TRUE)		
[illegible]	MASS		
[illegible]	REPLICATE		
[illegible] TIME	3.3000E+02	NUMBER OF OBSERVATIONS	10
[illegible] VALUE	-2.3615E-00	STANDARD DEVIATION	1.0907E+01
[illegible]	7.3[illegible]3[illegible]E+00	TIME OF MAXIMUM VALUE	3.3600E+02
MI[illegible] VALUE	-2.9465E+01	TIME OF MINIMUM VALUE	3.3600E+02

[illegible]	COUNT	DENSITY	DISTRIBUTION	0.0 · 0.25 · 0.5 · 0.75 · 1.0
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	1	.1000	0.1000	
[illegible]	[illegible]	[illegible]	0.1000	
[illegible]	[illegible]	[illegible]	0.1000	
[illegible]	[illegible]	.2000	0.3000	
[illegible]	[illegible]	[illegible]	0.3000	
[illegible]E+00	[illegible]	.[illegible]000	0.[illegible]000	
[illegible]	[illegible]	[illegible]000	[illegible]000	
[illegible]E+00	[illegible]	[illegible]000	1.0000	
[illegible]E+01	0	[illegible]	1.0000	

1FUNCTION 14 702 CNEA
MATERIAL TYPE
DATA
VARIABLE
SAMPLING
REPLICATE SAMPLING TIME
MEAN VALUE
MAXIMUM VALUE
MINIMUM VALUE

REPORT NO 3
4
ERROR (OBSERVED - TRUE)
MASS
REPLICATE
5.0400E+02
-4.9438E-00
2.084[illegible]-01
-2.5081E+01

NUMBER OF OBSERVATIONS 10
STANDARD DEVIATION 1.3675E+01
TIME OF MAXIMUM VALUE 5.0400E+02
TIME OF MINIMUM VALUE 5.0400E+02

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
-1.0000E+02	0	0.	0.	+
-9.5000E+01	0	0.	0.	+
-9.0000E+01	0	0.	0.	+
-8.5000E+01	0	0.	0.	+
-8.0000E+01	0	0.	0.	+
-7.5000E+01	0	0.	0.	+
-7.0000E+01	0	0.	0.	+
-6.5000E+01	0	0.	0.	+
-6.0000E+01	0	0.	0.	+
-5.5000E+01	0	0.	0.	+
-5.0000E+01	0	0.	0.	+
-4.5000E+01	0	0.	0.	+
-4.0000E+01	0	0.	0.	+
-3.5000E+01	0	0.	0.	+
-3.0000E+01	1	0.1000	0.1000	+*****
-2.5000E+01	1	0.1000	0.2000	+***** +
-2.0000E+01	1	0.1000	0.3000	+***** +
-1.5000E+01	0	0.	0.3000	+ +
-1.0000E+01	3	0.3000	0.6000	+********** +
-5.0000E+00	1	0.1000	0.7000	+***** + +
0.	0	0.	0.7000	+ +
5.0000E+00	2	0.2000	0.9000	+********** +
1.0000E+01	0	0.	0.9000	+ +
1.5000E+01	0	0.	0.9000	+ +
2.0000E+01	1	0.1000	1.0000	+***** +
2.5000E+01	0	0.	1.0000	+ +
3.0000E+01	0	0.	1.0000	+ +
3.5000E+01	0	0.	1.0000	+ +
4.0000E+01	0	0.	1.0000	+ +
4.5000E+01	0	0.	1.0000	+ +
5.0000E+01	0	0.	1.0000	+ +
5.5000E+01	0	0.	1.0000	+ +
6.0000E+01	0	0.	1.0000	+ +
6.5000E+01	0	0.	1.0000	+ +
7.0000E+01	0	0.	1.0000	+ +
7.5000E+01	0	0.	1.0000	+ +
8.0000E+01	0	0.	1.0000	+ +
8.5000E+01	0	0.	1.0000	+ +
9.0000E+01	0	0.	1.0000	+ +
9.5000E+01	0	0.	1.0000	+ +

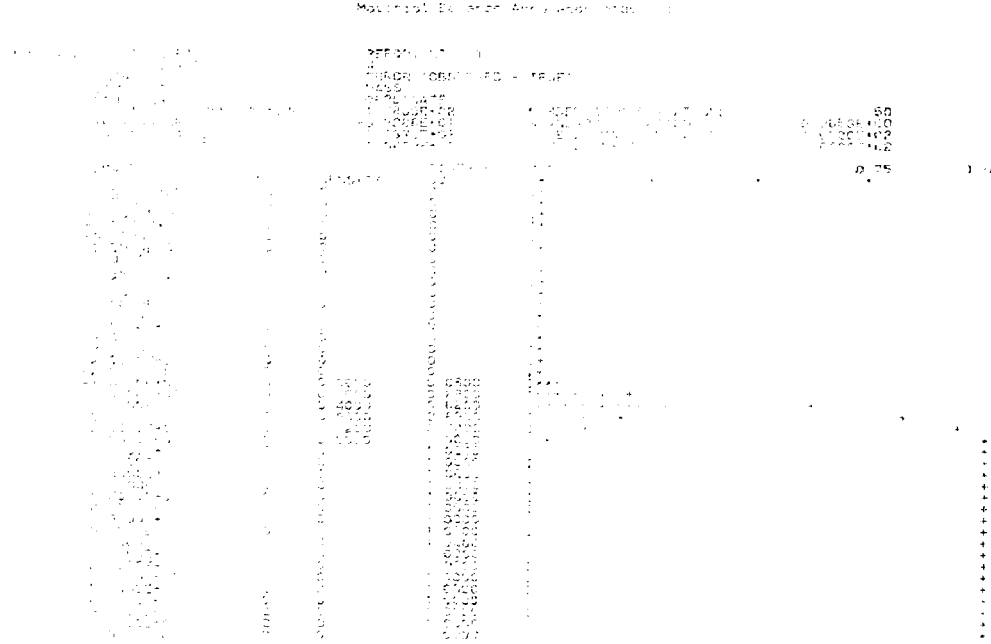
1FUNCTION [illegible]

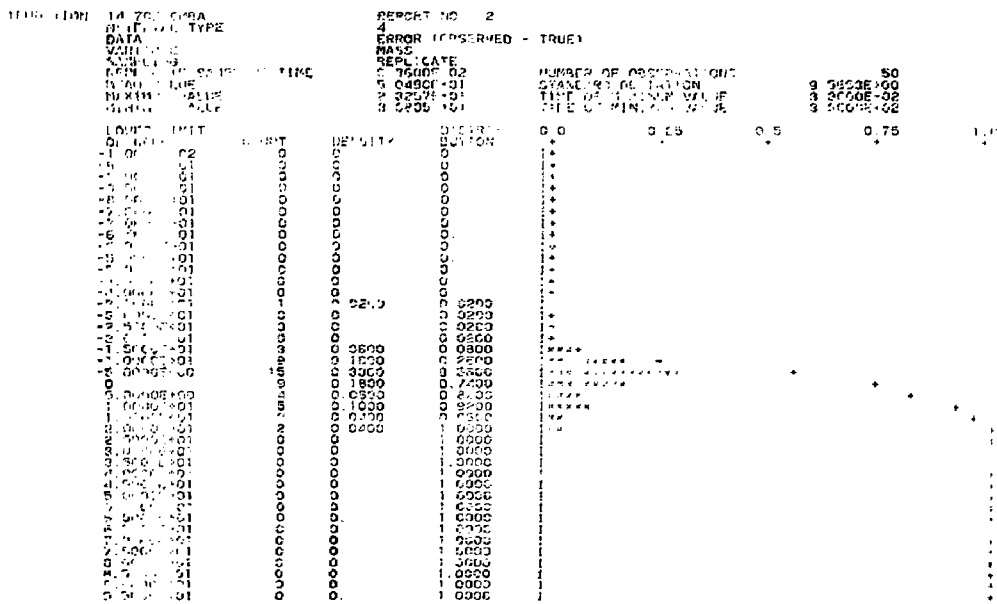
REPORT NO. 4
4
ERROR (OBSERVED - TRUE)
MASS
REPLICATE

[illegible] TIME	6 7200E+02	NUMBER OF OBSERVATIONS	10
[illegible]	-7.3311E-01	STANDARD DEVIATION	1 7270E+01
[illegible]	2.3736E+01	TIME OF MAXIMUM VALUE	6 7200E+02
[illegible]	-3 0649E+01	TIME OF MINIMUM VALUE	6 7200E-02

LOWER LIMIT	COUNT	DENSITY	DISTRIBUTION
[illegible]E+02	0	0	0
[illegible]	0	0.	0
[illegible]	0	0.	0
[illegible]	0	0	0
[illegible]	0	0	0
[illegible]	0	0	0
[illegible]	0	0	0.
[illegible]	0	0	0
[illegible]	0	0	0
[illegible]	0	0	0
[illegible]	0	0	0
-4 [illegible] 01	0	0	0
[illegible]	[illegible]	0.	0
[illegible]	1	0.1000	0 1000
-3 [illegible]	0	0	0 1000
-2 [illegible]+01	0	0.	0 1000
-2 [illegible]+01	1	0.1000	0 2000
-1 [illegible]	2	0.2000	0 4000
-1 0000E+01	1	0.1000	0.5000
[illegible]+00	1	0.1000	0 6000
0	0	0	0.6000
5 00 00E+00	0	0.	0 6000
[illegible]+01	1	0 1000	0 7000
[illegible]+01	1	0.1000	0 8000
[illegible]	2	0 2000	1.0000
[illegible]	0	0	1.0000
[illegible]	0	0	1 0000
[illegible]	0	0	1 0000
4 [illegible]	0	0	1 0000
[illegible]	0	0	1 0000
[illegible]	0	0	1.0000
[illegible]	0	0	1 0000
[illegible]	0	0	0000
6 [illegible]	0	0	0000
[illegible]	0	0	0000
[illegible] 0000E+01	0	0	1 0000
8.0000E+01	0	0	1.0000
[illegible] 0000E+01	0	0.	1.0000
[illegible] 0000E+01	0	0.	1 0000
[illegible] 0000E+01	0	0.	1 0000

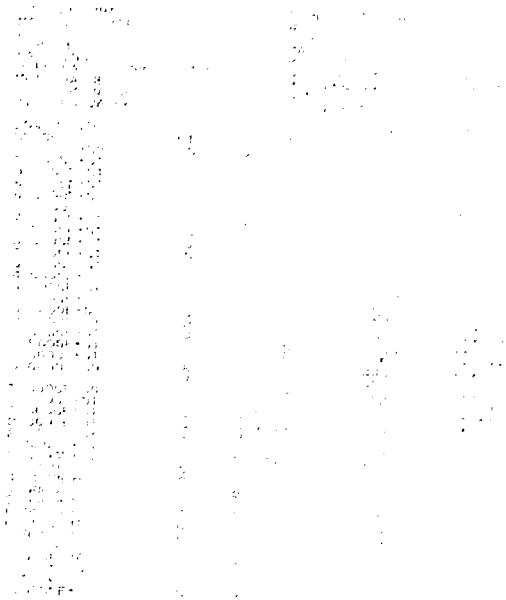
REPEAT WITH FIFTY REPLICATE RUNS AND NO DUMP
RUN 50 371. 0 0 0
REPORT 14




REPORT NO 2
ERROR (OBSERVED - TRUE)
MASS
REPLICATE
NUMBER OF OBSERVATIONS 50
STANDARD DEVIATION 9.3933E+00
TIME
LOWER LIMIT
UPPER LIMIT
DENSITY
DISTRIBUTION
0.0
0.25
0.5
0.75
1.0

1FUNCTION 14 ZRO (FBA REPORT NO 3
MATERIAL TYPE 4
DATA ERROR (OBSERVED - TRUE)
VARIABLE MASS
SAMPLING REPLICATE
FREQUENCY SAMPLING TYPE 5.0400E-02 NUMBER OF OBSERVATIONS 50
MEAN VALUE 2.2555E+00 STANDARD DEVIATION 1.2989E+01
MAXIMUM VALUE 3.1573E+01 TIME OF MAXIMUM VALUE 5.0400E-02
MINIMUM VALUE -2.6097E+01 TIME OF MINIMUM VALUE 6.0483E-02

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
-1.5000E+02	0	0.	0	|+
-5.5000E+01	0	0	0	|+
-9.5000E+01	0	0	0	|+
-6.5000E+01	0	0	0	|+
-9.5000E+01	0	0	0	|+
-7.5000E+01	0	0	0	|+
-7.5000E+01	0	0.	0	|+
-6.5000E+01	0	0.	0	|+
-9.5000E+01	0	0.	0	|+
-5.5000E+01	0	0.	0	|+
-5.5000E+01	0	0	0	|+
-4.5000E+01	0	0	0	|+
-4.5000E+01	0	0	0	|+
-3.5000E+01	0	0.	0.	|+
-3.5000E+01	3	0.0600	0.0600	|*+
-2.5000E+01	1	0.0200	0.0800	|* +
-2.5000E+01	0	0.	0.0800	| +
-1.5000E+01	5	0.0600	0.1400	|*** +
-1.5000E+01	8	0.1600	0.3000	|*** **** +
-5.0000E+00	7	0.1400	0.4400	|******* +
0	5	0.1000	0.5400	|*****
5.0000E+00	9	0.1800	0.7200	|*********
1.0000E+01	7	0.1400	0.8600	|*******
1.5000E+01	2	0.0400	0.9000	|**
2.0000E+01	2	0.0400	0.9400	|**
2.5000E+01	2	0.0400	0.9800	|**
3.0000E+01	1	0.0200	1.0000	|* +
3.5000E+01	0	0.	1.0000	| +
4.0000E+01	0	0.	1.0000	| +
4.5000E+01	0	0.	1.0000	| +
5.0000E+01	0	0.	1.0000	| +
5.5000E+01	0	0.	1.0000	| +
6.0000E+01	0	0.	1.0000	| +
6.5000E+01	0	0.	1.0000	| +
7.0000E+01	0	0.	1.0000	| +
7.5000E+01	0	0.	1.0000	| +
8.0000E+01	0	0.	1.0000	| +
8.5000E+01	0	0.	1.0000	| +
9.0000E+01	0	0.	1.0000	| +
9.5000E+01	0	0.	1.0000	| +



MATERIAL CONTROL SYSTEM RESPONSE TO ADVERSARY ACTION SEQUENCES

Introduction

This example illustrates the use of MASS in the analysis of adversary action sequences and in the determination of material control system responses to the diversion attempts represented by these sequences.

With one exception, which will be explained shortly, the receipt of material, measurement, transport, recording of material balance data, and storage are the same as in the previous example. We now suppose that preliminary analysis has revealed that it may be possible for two adversaries, by performing certain coordinated actions, to accomplish a diversion of material 4 from the processing operations performed between the measurement of batches arriving at receiving station 2 and the second measurement performed just before the materials are placed in storage. The order of the actions required of the two adversaries is specified, but the times at which each adversary action sequence may begin and the length of time required to perform each of the actions are uncertain and may only be approximated by random variables. Some of these actions also may be performed only when material is entering the incoming measurement facility and during the period of time that the material is being processed. The adversary action sequences are, therefore, dependent upon the timing of material flow through the facility, which we have seen occurs with considerable random variation about a periodic operating schedule. Stimuli that may be sensed by monitors employed in the material control system are generated by the performance of many actions of the sequences. The time delay following the start of an adversary action, the intensity, and the

duration of these stimuli are, in general, random variables that represent known variation of the generated stimuli and/or uncertainty in their characterization. The ability of monitors to detect stimuli generated by adversary actions depends upon the sensitivity characteristics of individual monitors which are expressed in terms of probability of detection vs. stimulus intensity. Signals generated by the monitors are used in making decisions that constitute the response of the material control system to the attempted adversary action sequences. Intermediate decisions of the material control system may initiate control action sequences that activate monitors that were previously turned off.

The problem in this example is to determine the probability distributions of material control system responses at specified times under the condition that the adversary action sequence occurs, that is, that the material diversion attempt is made. We are also to determine the probability distribution of the quantity of material successfully diverted, the probability distribution of the time required to complete the diversion, and the uncertainty associated with the material balance during the time interval of the diversion attempt. This is the type of information needed to assess the effectiveness of material control systems in detecting and preventing the successful completion of material diversion attempts.

The actions of the two adversaries which we will call A and B are illustrated in Figure 4.3 A begins the sequence of actions A1, A2, and A3 at some time between 8 a.m 0 and noon of the first day of the simulated diversion attempt. Time t = 0. at the beginning of the simulated time interval so we specify that in the model system action A1 begins at a random time that is uniformly distributed on the interval 8.<t<12. as indicated in

[illegible] figure [illegible] [illegible] the duration of the action [illegible] upon completion of [illegible] A [illegible] in some way, [illegible] [illegible] material [illegible] [illegible] [illegible] [illegible] The duration of action A2 [illegible] specified [illegible] [illegible] material [illegible] facility [illegible] knowledge of [illegible] [illegible] 12 and [illegible] uniformly distributed [illegible] of [illegible] 25 [illegible] [illegible] the measurement facility [illegible] completion of A2 [illegible] on the first opportunity [illegible] after adversary A [illegible] action A1. A is then able to perform [illegible] A3, which requires [illegible] length of time ranging from 25 to [illegible] The performance of action A3 actually delays the [illegible] of the material batch then entering the measurement facility. As specified in the Material Balance Area Accountability example, processing of material batches that arrive at counting station 2 normally requires between 24.0 and 72.0 hours. In this example, if adversary A is able to complete action A3 before an incoming batch of material enters the processing [illegible], the average processing time will be increased to 96.0 hours. The maximum deviation of the processing time will be left unchanged so the disrupted processing [illegible] will require a uniformly distributed time interval of between 72.0 and 1[illegible].0 hours. We will see that this delay is required to give adversary

[illegible] Sequences

[illegible]

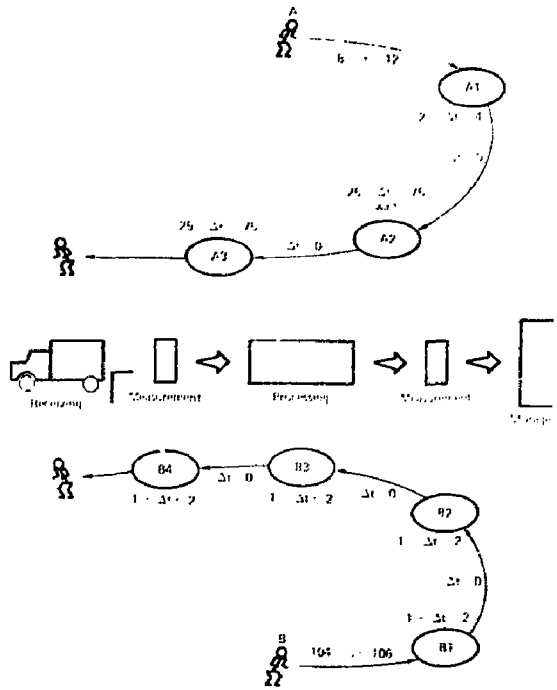


FIGURE 4.3. Action sequences simulated in the MC System Response to Adversary Action example.

In this example, the period of material batch arrivals at receiving station 2 has been increased to a weekly interval of 168 hours. This was done to illustrate a case where coordinated timing of actions performed by two adversaries is required to complete a successful diversion. This is the single change, mentioned earlier, in the process model of the previous example. Now, with only one batch of material arriving at some time between 8 a.m. and 5 p.m. of the first day, adversary A must accomplish the delay of that batch in order to give adversary B an opportunity to acquire and remove the material while it is being processed in the material balance area.

Adversary B is able to begin the first action of the sequence B1, B2, B3, B4 at some time between 8 and 10 a.m.0 on the fifth day of the simulated diversion attempt. Action B1 in the model system is therefore specified to occur at a random time uniformly distributed on the interval $104.<t<106$. To simplify the example, each of the actions performed by adversary B are assumed to require a uniformly distributed random time interval of between 1.0 and 2.0 hours with no time delay between the ending of one action of the sequence and the beginning of the next. Actions B1 and B2 might represent steps required for B to enter and gain access to materials in the processing operation. During action B3, adversary B may acquire material from the processing operation. Action B4 represents a step required in removing the acquired material from the boundaries of the material control system. Completion of the diversion attempt is defined as the time at which B completes action B4.

The time delays (in this case only actions A1 and B1 have nonzero time delays) and durations of actions in this example are all assumed to be

uniformly distributed random variables. In general, each of these may have any of the probability distributions defined in Appendix A.

Figure 4.3 does not depict the stimuli generated by the performance of actions involved in the simulated diversion attempt. We suppose that the analyst has determined, based on the configuration of the material control system under investigation, that two stimuli are generated by action A1, three by action A3, and one each by actions B1, B2, B3 and B4. Although actions A2 and B2 do not generate stimuli monitored by the material control system, they must be included in the model system to accurately simulate the timing of the adversary action sequences in relation to material flow in the processing facility. Characteristics of stimuli generated by adversary actions are defined below in the description of the functional model of the example system.

Functional Model

Figure 4.4 is the MCSS functional model that represents the system simulated in this example. Functions 1 through 15 on the left side of the figure, are the same as in the Material Balance Area Accountability example except, as described above for the period of material batch arrivals at receiving station 2.

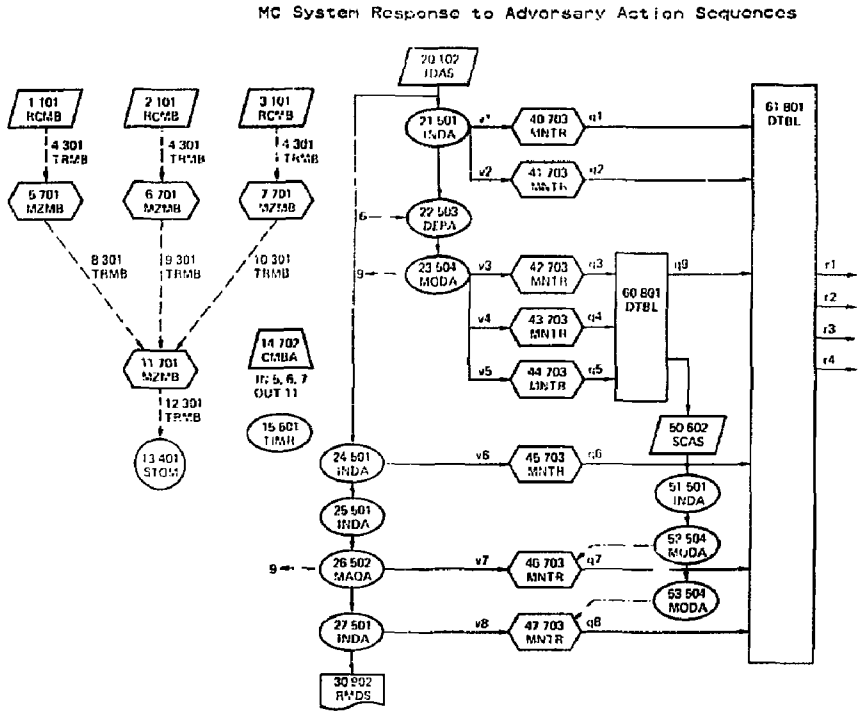


FIGURE 4.4 Functional model of the MC System Response to Adversary Action example.

Function 20 initiates the diversion action sequences performed by adversaries A and B. A single list valued parameter of function 20 specifies the objective of the diversion attempt, which functions simulate adversary actions, the order of these functions in the adversary action sequences of A and B, and the time delay characteristics of each action in the sequences. In this case, the objective is to divert, on the average, 10.0 mass units of material type 4 from batches in transport function 9 which simulates the time spent in the material balance area for processing operations. The standard deviation of the amount of material removed in individual acquisition actions is set to 2.0, so, unless there is insufficient material of type 4 present at the times of an acquisition action, a random, normally distributed quantity will be acquired in the successful diversion attempts.

Functions 21, 22, and 23 simulate respectively actions A1, A2, and A3 of adversary A. Two stimuli, indicated by v1 and v2 in Figure 4.4, are generated by the occurrence of action A1. The stimuli generated by SOI INDA functions (and all other action functions in this example) are characterized by a time delay after which generation of the stimuli follows the beginning of the action, a time duration over which the stimuli are present, and an intensity of the generated stimuli. Also specified for each stimulus generated by an adversary action, is the number of the function that simulates the material control system monitor intended to sense the stimulus. The parameters of function 21 define functions 40 and 41 respectively as the monitor functions of stimuli v1 and v2. Both stimuli have uniformly distributed time delays ranging from 0.0 to 1.0; uniformly distributed durations ranging from 0.0 to 1.0; and intensities of truncated

normal distribution with mean value 1.0, standard deviation .2, maximum value 100.0, and minimum value 0.

Function 22 is a 503 DEPA function used in the conditional completion mode to simulate the waiting of adversary A for an opportunity created by the beginning of a measurement in function 6. If a measurement has been started within 4.0 hours preceding the time action A2 would be completed if it were not dependent upon function 6, A2 is completed without delay. But if this condition has not occurred within the reference time interval of 4.0 hours, completion of action A2 will be delayed until the necessary condition is satisfied. The undelayed duration of action A2 is uniformly distributed and ranges from .25 to .75 hours. No stimuli are generated by action A2

Function 23 simulates action A3 by which the mean transport time of function 9 is modified from 48.0 to 96.0 hours. The duration of A3 is uniformly distributed and ranges from .25 to .75 hours. Stimuli v3, v4, and v5 are generated by action A3 and are sensed by monitor functions 42, 43, and 44 of the materiel control system model. The three stimuli have the same characteristics: their time delays are uniformly distributed and range from .05 to .15 hours; the durations of the stimuli are uniformly distributed and range from 0.0 to 1.0 hours; and the stimulus intensities have truncated normal distributions with mean value 1.0, standard deviation 0.2, maximum value 100.0, and minimum value 0.

Functions 24 and 25 are 501 INDA functions that simulate actions B1 and B2 of adversary B. Both are specified to have uniformly distributed duration times ranging from 1.0 to 2.0 hours. Action B1 generates stimulus v6 with uniformly distributed delay and duration times ranging from 0.0 to 1.0 hours and a truncated normal intensity distribution with mean value 1.0,

standard deviation 0.2, maximum value 100.0, and minimum value 0. Action B2 does not generate stimuli sensed by the simulated material control system.

Function 26 simulates action B3 during which adversary B acquires material from function 9 according to the material diversion objectives specified by function 20. Action B3 generates stimulus v7 that may be sensed by monitor function 46 and which has stimulus characteristics identical to those of stimulus v6. The duration characteristics of action B3 are the same as for B1 and B2.

Finally, function 27 simulates the last action, B4, of adversary B. This action generates stimulus v8 that may be sensed by monitor function 47 and which has stimulus characteristics identical to those of stimuli v6 and v7.

The 902 RMDS function 30 is used to gather data on the completion time of the action sequence representing adversary B and the quantity of material in the possession of B at that time. This may be interpreted as the completion time of the diversion attempt and the quantity of material actually diverted by the attempt. The time report histogram of function 30 is specified to have 40 cells of width 0.5 starting at a lower limit of the first cell at 100. The material report histogram is specified to have 40 cells of width 0.5 starting at a lower limit of the first cell at 0.

The 703 MNTR functions 40 through 47 simulate the monitors of the material control system used to sense stimuli v1 through v8 as indicated in Figure 4.4. To simplify the example, the characteristics of all of the monitors have been made identical. The sensitivity characteristics are represented by three pairs of stimulus intensity and detection probability values as shown in Figure 4.5. The time delays of the monitors are set to

zero by specifying a uniform probability distribution with zero mean and zero deviation. All of the monitors are operated in the latching mode which means their output signals remain fixed until reset by receipt of control signals that are not issued in the system of this example. Output signal indexes 1, 2, ... , 8 are assigned correspondingly to monitor output signals q1, q2, ... , q8 as shown in Figure 4.4. The output signals of monitor functions 42, 43, and 44 are specified to be transmitted to decision function 60 and those of monitor functions 40, 41, 45, 46, and 47 are specified to be transmitted to decision function 61.

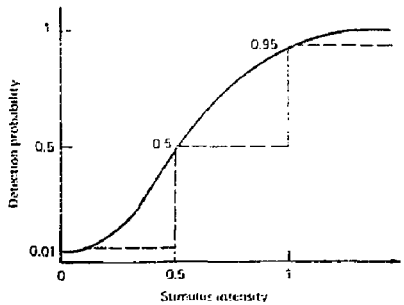


FIGURE 4.5 Sensitivity characteristics of 703 MNTR functions used in the MC System Response to Adversary Action example.

Function 50 starts a control action sequence simulated by functions 51, 52, and 53 upon receipt of a signal generated by decision function 60. A

list valued parameter of the 602 SCAS function 50 specifies the functions that simulate actions in the sequence, their order, and the characteristics of time delays between the actions of the sequence in the same way that these characteristics are defined for diversion action sequences initiated by type 102 IDAS functions. In this example, the delay time of the action simulated by function 51 is uniformly distributed and ranges from 4.0 to 12.0 hours. This could represent the variation in delays of control personnel instructed by decision function 60 to turn on monitor functions 46 and 47 which had previously been inactive. The time delays of functions 52 and 53 are set to zero by specifying uniform probability distributions with zero mean and zero deviation.

The duration of action function 51 is uniformly distributed and ranges from 0.5 to 1.5 hours. No stimuli are generated by this instance of the 501 INDA function, however, if appropriate to do so, stimuli may be generated by control actions as well as adversary actions. These stimuli could be used to simulate signals verifying the occurrence of control actions in more complex material control system models.

Functions 52 and 53 are instances of the 504 MODA function used to modify the value of parameter 6 of functions 46 and 47 respectively from 0.0 to 1.0. Parameter 6 of the 703 MNTR function is the output signal amplitude, so the modifications performed by functions 52 and 53 simulate the activation of initially inactive monitor functions 46 and 47. The duration of control actions simulated by functions 52 and 53 are uniformly distributed and range from 0.5 to 1.5 hours.

Function 60 simulates a set of decision rules that may be expressed as follows:

```
If [one of q3, q4, q5 is equal to 1]
     set q9 to value 1 and do not start the control action sequence

Or if [any two of q3, q4, q5 are equal to 1]
     set q9 to value 1 and start the control action sequence

Or if [all three of q3, q4, q5 are equal to 1]
     set q9 to value 2 and do not start the control action sequence

Otherwise
     set q9 to value 0 and do not start the control action sequence
```

This set of decision rules is implemented by 801 DTBL function 60 as shown in Figure 4.6. See the description of the 801 DTBL function in Section 3 for details on the representation of condition stubs, action stubs, condition entries, and action entries of decison tables.

	Rule							
	1	2	3	4	5	6	7	8
q_3. EQ. 0	-1	1	1	-1	-1	1	-1	0
q_4. EQ. 0	1	-1	1	-1	1	-1	-1	0
q_5. EQ. 0	1	1	-1	1	-1	-1	-1	0
$q_9 = 0$	0	0	0	0	0	0	0	1
$q_9 = 1$	1	1	1	1	1	1	0	0
$q_9 = 2$	0	0	0	0	0	0	1	0
Start action	0	0	0	1	1	1	0	0

FIGURE 4.6 Decision rules of 001 DTBL function 60 of the MC System Response to Adversary Action example.

The logic of the decision rules simulated by function 60 in this example system might be explained as follows: Acton A3 must be performed in the vicinity of the safeguarded material where three critical monitors are located. If any one of these monitors detect an abnormality, a low level alert signal represented by setting q9 to value 1 is to be sent to a higher level of material control system decision making represented by function 61. If any two of these monitors detect an abnormality, the same alert signal is generated and the control action sequence represented by functions 51, 52, and 53 is started to provide additional monitoring of the processing area.

If all three of the monitors indicate an abnormality, the level of the alert signal is raised by setting q9 to value 2. And if none of the monitors indicate a detection of the sensed stimuli, q9 is set to value 0.

Function 61 simulates the higher level decision making function of the material control system that defines the four components of the system response r1, r2, r3, and r4. The decision rules of function 61 are as follows:

```
If [q1 or q2 equal 1 and q9, q6, q7, q8 equal 0]
     set r1 to 1 and r2, r3, r4 to 0

Or if [q9 equals 1 and q6, q7, q8 equal 0]
     set r2 to 1 and r1, r3, r4 to 0

Or if [q9 equals 1 and any of q6, q7, q8 equal 1]
     set r3 to 1 and r1, r2, r4 to 0

Or if [q9 equals 2 and any of q6, q7, q8 equal 1]
     set r4 to 1 and r1, r2, r3 to 0

Otherwise
     set r1, r2, r3, r4 to 0
```

These decision rules are implemented by 801 DTBL function 61 as shown in Figure 4.7. The decision rules of function 61 were defined primarily to illustrate the use of 801 DTBL functions, however, they do generate mutually exclusive response signals r1, r2, r3, r4 that represent increasing levels of stimulus indication related to possible diversion activity. The probabilities of r1, r2, r3, and r4 at specified times during the simulated diversion attempt define the response of the material control system.

	Rule									
	1	2	3	4	5	6	7	8	9	10
q_1 · Eq. 0	-1	0	0	0	0	0	0	0	0	0
q_2 · Eq. 0	0	-1	0	0	0	0	0	0	0	0
q_9 · Eq. 0	1	1	-1	-1	-1	-1	-1	-1	-1	0
q_9 · Eq. 1	-1	-1	1	1	1	1	-1	-1	-1	0
q_9 · Eq. 2	-1	-1	-1	-1	-1	-1	1	1	1	0
q_6 · Eq. 0	1	1	1	-1	0	0	-1	0	0	0
q_7 · Eq. 0	1	1	1	0	-1	0	0	-1	0	0
q_8 · Eq. 0	1	1	1	0	0	-1	0	0	-1	0
$r_1 = 0$	0	0	1	1	1	1	1	1	1	1
$r_2 = 0$	1	1	0	1	1	1	1	1	1	1
$r_3 = 0$	1	1	1	0	0	0	1	1	1	1
$r_4 = 0$	1	1	1	1	1	1	0	0	0	1
$r_1 = 1$	1	1	0	0	0	0	0	0	0	0
$r_2 = 1$	0	0	1	0	0	0	0	0	0	0
$r_3 = 1$	0	0	0	1	1	1	0	0	0	0
$r_4 = 1$	0	0	0	0	0	0	1	1	1	0

FIGURE 4.7 Decision rules of 801 DTBL function 61 of the MC System Response to Adversary Action example.

Input File MCSSIN

The input file MCSSIN was reproduced in the previous example to show exactly how it is prepared and how it reappears in the output file produced by execution of the MCSS program. Since the output file is a complete record of the definition and operation of a simulated system, the input file is omitted in this example.

Output File MCSSOUT

The output file reproduced below contains the specification of each function of the model system followed by two simulation runs. In the first run, the model system is operated for 137.0 hours with a dump of the numerical data structure of the complete model, a level 1 trace of events, and a report of function 26 to illustrate the representation of material acquired by adversary B during a successful diversion attempt. In the second run, 50 replications of the previous run are made with no dump or trace but with a standard report of all functions of the model system.

Lines of the output file produced by the MCSS program are in upper case lettering. For the purposes of this user's manual, additional explanatory remarks have been inserted at various places in the reproduction of the output file. These insertions are indented and are in lower case format so they may be distinguished readily from the lines produced by the MCSS program.

MATERIAL CONTROL SYSTEM SIMULATOR VERSION 1.0 1/1/78

MCSS USERS MANUAL
EXAMPLE 2
MATERIAL CONTROL SYSTEM RESPONSE TO ADVERSARY ACTION SEQUENCES

```
      11/16/77   MCSSIN26

CREATE 1 101 RCMB
      RECEIVE BULK MATERIALS 1 AND 2

PARAMETER 1
      (1) PERIOD OF ARRIVAL SCHEDULE 24.
      (2) NUMBER OF ARRIVALS PER PERIOD 2
      (3 1 2) SCHEDULED ARRIVAL TIMES 8. 13.
      (4) MAX DEVIATION FROM SCHEDULED TIMES 2.
      (5) NUMBER OF BULK MATERIAL TYPES 2
      (6 1 14) BULK MATERIAL SPECIFICATIONS
            TYPE 1
            MEAN COUNT 100
            MAX DEVIATION OF COUNT 50
            MEAN MASS 0.
            STD DEVIATION OF MASS 0.
            MAX MASS 0.
            MIN MASS 0.
            2 0 0 20. 5. 1000. 0.
      (11) TIMING CODE 1
      (12) TIMER FUNCTION 15
      (13) DESTINATION FUNCTION 5
      (14) TRANSPORT FUNCTION 4

CREATE 2 101 RCMB
      RECEIVE CONTAINERIZED MATERIALS 3 AND 4

PARAMETER 2
      (1) 168.
          The period of scheduled material arrivals at receiving station 2
          has been increased.  This is the only change in functions 1
          through 15 of the previous Material Balance Area Accountability
          example.  The values of parameters 2, 3, and 4 below specify one
          batch arrival between 8 a.m. and 5 p.m. on the first day of
          operation.  Adversary A must successfully delay the processing
          time (transport time of function 9) to give adversary B an
          opportunity to acquire material some time after 8 a.m. of the
          fifth day.
      (2) 1
      (3 1 1) 12.5
      (4) 4.5
      (7) NUMBER OF MATERIAL TYPES RECEIVED IN CONTAINERS 2
      (8 1 14) CONTAINERIZED MATERIAL SPECIFICATIONS
            3 300 100 0. 0. 0. 0.
            4 0 0 40. 20. 1000. 0.
      (9) MEAN NUMBER OF CONTAINERS RECEIVED PER ARRIVAL 2
      (10) MAX DEVIATION OF NUMBER CONTAINERS RECEIVED PER ARRIVAL 1
      (11) 1
      (12) 15
      (13) 6
```

```
     (14) 4

CREATE 3 101 RCMB
     RECEIVE BULK MATERIALS 5 AND 6 AND CONTAINERIZED MATERIALS 7 AND 8

PARAMETER 3
     (1) 24.
     (2) 2
     (3 1 2) 10. 15.
     (4) 2.
     (5) 2
     (6 1 14)
          5 500 10 0. 0. 0. 0.
          6 0 0 60. 6. 1000. 0.
     (7) 2
     (8 1 14)
          7 700 50 0. 0. 0. 0.
          8 0 0 80. .8 1000. 0.
     (9) 2
     (10) 0
     (11) 1
     (12) 15
     (13) 7
     (14) 4

CREATE 4 301 TRMB
     TRANSPORT MATERIALS FROM RECEIVING STATIONS TO MEASUREMENT STATIONS

PARAMETER 4
     (1) MEAN TRANSPORT TIME 0.
     (2) MAX DEVIATION OF TRANSPORT TIME 0.
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 5 701 MZMB
     MEASURE INCOMING MATERIALS 1 AND 2 AND REPORT TO MATERIAL
     BALANCE FUNCTION

PARAMETER 5
     (1) NUMBER OF MATERIAL TYPES MEASURED 2
     (2 1 12) MEASUREMENT SPECIFICATIONS
          TYPE 1
          MEAN COUNT ERROR 0
          MAX DEVIATION OF COUNT ERROR 1
          SYSTEMATIC MASS ERROR 0.
          MEAN OF RANDOM MASS ERROR 0.
          STD DEVIATION OF RANDOM MASS ERROR 0.
          2 0 0 0. 0. 1.
     (3) MEAN TIME TO COMPLETE ALL MEASUREMENTS 4.
     (4) MAX DEVIATION OF MEASUREMENT TIME .5
     (5) TIMING CODE 1
     (6) TIMER FUNCTION 15
     (7 1 1) MONITOR FUNCTION 14
```

```
      (8) DESTINATION FUNCTION 11
      (9) TRANSPORT FUNCTION 8
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 6 701 MZMB
      MEASURE INCOMING MATERIALS 3 AND 4 AND REPORT TO MATERIAL
      BALANCE COMPUTER

PARAMETER 6
      (1) 2
      (2 1 12)
           3 0 3 0. 0. 0.
           4 0 0 0. 0. 2.
      (3) 4.
      (4) .5
      (5) 1
      (6) 15
      (7 1 1) 14
      (8) 11
      (9) 9
      (10 1 1) FUNCTIONS NOTIFIED AT CONDITION TIMES 22

CREATE 7 701 MZM3
      MEASURE INCOMING MATERIALS 5, 6, 7, AND 8 AND REPORT TO MATERIAL
      BALANCE COMPUTER

PARAMETER 7
      (1) 4
      (2 1 24)
           5 0 5 0. 0. 0.
           6 0 0 0. 0. 3.
           7 0 7 0. 0. 0.
           8 0 0 0. 0. 4.
      (3) 4.
      (4) 1.
      (5) 1
      (6) 15
      (7 1 1) 14
      (8) 11
      (9) 10

CREATE 8 301 TRMB
      TRANSPORT MATERIALS 1 AND 2 FROM INPUT MEASUREMENT STATION TO THE
      STORAGE MEASUREMENT STATION

PARAMETER 8
      (1) 24.
      (2) 12.
      NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 9 301 TRMB
      TRANSPORT MATERIALS 3 AND 4 FROM INPUT MEASUREMENT STATION TO THE
```

```
     STORAGE MEASUREMENT STATION

PARAMETER 9
     (1) 48.
     (2) 24.
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES
          Taking the latest possible arrival time at receiving station 2
          (17.0), the longest possible measurement time in function 6 (4.5),
          and the longest processing or transport time in function 9 as
          specified by the parameters above (72.0), the latest time material
          4 will still be in the balance area where it is susceptible to
          diversion by adversary B is 93.5 hours or 9:30 p.m. on the fourth
          day of operation.  Therefore, unless adversary A is able to
          increase the transport time of function 9, adversary B will have
          no opportunity to remove material while it is in processing.

CREATE 10 301 TRMB
     TRANSPORT MATERIALS 5, 6, 7, AND 8 FROM INPUT MEASUREMENT STATIONS
     TO THE STORAGE MEASUREMENT STATION

PARAMETER 10
     (1) 48.
     (2) 12.
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 11 701 MZMB
     MEASURE OUTGOING MATERIALS 1 THROUGH 8 AND REPORT TO MATERIAL
     BALANCE COMPUTER

PARAMETER 11
     (1) 8
     (2 1 48)
          1 0 1 0. 0. 0.
          2 0 0 0. 0. 1.
          3 0 3 0. 0. 0.
          4 0 0 0. 0. 2.
          5 0 5 0. 0. 0.
          6 0 0 0. 0. 3.
          7 0 7 0. 0. 0.
          8 0 0 0. 0. 4.
     (3) 4.
     (4) 1.
     (5) 1
     (6) 15
     (7 1 1) 14
     (8) 13
     (9) 12

CREATE 12 301 TRMB
     TRANSPORT MATERIALS 1 THROUGH 8 FROM OUTPUT MEASUREMENT TO STORAGE

PARAMETER 12
```

```
     (1) 0.
     (2) 0.

CREATE 13 401 STOR
     STORE BULK AND CONTAINERIZED MATERIALS

PARAMETER 13
     (1) SINGLE DEPOSIT HOLDUP 1
     (2) END AREA OF BULK STORAGE 10.
     (3) VERTICAL SURFACE AREA CONTACTED PER UNIT MASS BULK STORAGE 1.
     (4) BULK STORAGE SURFACE HOLDUP COEFFICIENT .05
     (5 1 4) REPORT
          BULK STORAGE DATA 1
          CONTAINER STORAGE DATA 1
          MATERIAL IN STORAGE 1
          MATERIAL IN HOLDUP 1
     NO FUNCTIONS ARE NOTIFIED AT CONDITION TIMES

CREATE 14 702 CMBA
     MATERIAL BALANCE COMPUTATION

PARAMETER 14
     (1) NUMBER OF REPORTS 3
     (2 1 24) REPORT SPECIFICATIONS
          TYPE 4
          ERROR 3
          MASS 2
          REPLICATE SAMPLING 2
          SAMPLING TIME 89.
          NUMBER OF HISTOGRAM CELLS 40
          WIDTH OF HISTOGRAM CELLS 1.
          LOWER LIMIT OF FIRST HISTOGRAM CELL -20.
          4 3 2 2 113. 40 1. -20.
          4 3 2 2 137. 40 1. -20.
     (3 1 3) INPUT FUNCTIONS 5 6 7
     (4 1 1) OUTPUT FUNCTIONS 11

CREATE 15 601 TIMR
     TIMER FOR A STANDARD WORK WEEK WITH ONE 8 A.M. TO 5 P.M.
     SHIFT WEEKDAYS AND INTERVALS 8 A.M. TO 12 NOON AND 1 P.M.
     TO 5 P.M. EACH SHIFT

PARAMETER 15
     (1) PERIOD 168.
     (2) SHIFTS PER PERIOD 5
     (3 1 5) SHIFT STARTING TIMES 8. 32. 56. 80. 104.
     (4 1 5) SHIFT ENDING TIMES 17. 41. 65. 89. 113.
     (5) INTERVALS PER PERIOD 10
     (6 1 10) INTERVAL STARTING TIMES 8. 13. 32. 37. 56. 61. 80. 85.
          104. 109.
     (7 1 10) INTERVAL ENDING TIMES 12. 17. 36. 41. 60. 65. 84. 89.
          108. 113.
```

```
CREATE 20 102 IDAS
     INITIATE ACTION SEQUENCE

PARAMETER 20
     (1 1 40)
          DIVERSION OBJECTIVES
               MASS FROM CONTAINERS 4
               TYPE 4
               MEAN NUMBER OF COUNTABLE ITEMS 0
               MAX UNIFORM DEVIATION OF COUNTABLE ITEMS 0
               MEAN MASS 10.
               STANDARD DEVIATION OF MASS 2.
               MEAN NUMBER OF CONTAINERS 0
               MAX UNIFORM DEVIATION OF NUMBER OF CONTAINERS 0
          ACTION SEQUENCES
               FUNCTION (NEGATIVE FOR FIRST OF SUBSEQUENCE) -21
               STARTING TIME DELAY DISTRIBUTION UNIFORM 1
               STARTING TIME DELAY STATISTICS
                    MEAN 10.
                    MAX DEVIATION 2.
               22 1 0. 0.
               23 1 0. 0.
              -24 1 106. 2.
               25 1 0. 0.
               26 1 0. 0.
               27 1 0. 0.
               30 1 0. 0.
```

The first eight elements of list valued parameter 1 specify that the diversion objective is the removal of material type 4 from containers. The quantity actually removed in successful attempts is to be random with a mean of 10.0 and standard normal deviation of 2.0 mass units. The remaining elements specify the action functions, their time delay distribution types, and the statistics of the time delay distributions in the order of actions in the simulated sequences. The first action of a sequence is denoted by a negative function number. In this example the time delays of actions simulated by functions 21 and 24, the first actions respectively of adversaries A and B, are uniformly distributed with means of 10.0 and 106.0 and maximum deviations of 2.0 hours. The time delays of the other actions of the sequences are set to zero by specifying uniform time delay distribution types with zero means and zero maximum deviations.

```
CREATE 21 501 INDA
     INDEPENDENT ACTION

PARAMETER 21
     (1) DURATION TIME DISTRIBUTION UNIFORM 1
     (2 1 2) DURATION TIME STATISTICS
          MEAN 3.0
          MAX DEVIATION 1.
     (3 1 26) STIMULUS SPECIFICATIONS
```

```
          MONITOR FUNCTION 40
          TYPE 1
          DELAY TIME DISTRIBUTION UNIFORM 1
          DELAY TIME STATISTICS
               MEAN .5
               MAX DEVIATION .5
          DURATION TIME DISTRIBUTION UNIFORM 1
          DURATION TIME STATISTICS
               MEAN .5
               MAX DEVIATION .5
          INTENSITY DISTRIBUTION TRUNCATED NORMAL 3
          INTENSITY STATISTICS
               MEAN 1.
               STANDARD DEVIATION .2
               MAXIMUM 100.
               MINIMUM 0.
          41   1    1 .5 .5    1 .5 .5    3 1. .2 100. 0.

CREATE 22 503 DEPA
     DEPENDENT ACTION

PARAMETER 22
     (1) DURATION TIME DISTRIBUTION UNIFORM 1
     (2 1 2) DURATION TIME STATISTICS
          MEAN .5
          MAX DEVIATION .25
     (4) CONDITIONAL COMPLETION MODE 2
     (5) REFERENCE TIME 4.

CREATE 23 504 MODA
     MODIFICATION ACTION

PARAMETER 23
     (1) DURATION TIME DISTRIBUTION UNIFORM 1
     (2 1 2) DURATION TIME STATISTICS
          MEAN .5
          MAX DEVIATION .25
     (3 1 39) STIMULUS SPECIFICATIONS
          42   1    1 .1 .05    1 .5 .5    3 1. .2 100. 0.
          43   1    1 .1 .05    1 .5 .5    3 1. .2 100. 0.
          44   1    1 .1 .05    1 .5 .5    3 1. .2 100. 0.
     (4 1 4) MODIFICATION SPECIFICATIONS
          FUNCTION 9
          PARAMETER 1
          FIRST INDEX 0
          LAST INDEX 1
     (5 1 1) NEW VALUES 96.
```

Adversary A's delay of the processing operation is simulated by 504 MODA function 23 which increases the mean transport time of function 9 by assigning a new value of 96.0 to parameter 1. With the maximum deviation of the transport time of function 9 equal to 24.0, adversary B may or may not be able to successfully remove

material from the processing operation in the balance area. Successful diversion will depend upon the random material arrival time, the random time required to measure material batches entering the balance area, the random processing time, and the random times of the actions of adversary B. Taking the earliest arrival time (8.0), the shortest measurement time (3.5), and the shortest processing time (72.0), we see that the batch containing material type 4 may leave the processing operation (as it enters the outgoing measurement facility) as early as time 83.5, some 20.5 hours before adversary B can possibly begin the first action of the acquisition sequence. On the other hand, if we take the latest arrival time (17.0), the longest measurement time (4.5), and the longest processing time (120.0), the material may be in the processing area and accessible to adversary B as late as time 141.5 which would give B ample time to complete actions B1, B2, and B3 which are required to successfully acquire material from function 9.

```
CREATE 24 501 INDA
PARAMETER 24
     (1) 1
     (2 1 2) 1.5 .5
     (3 1 13)
          45   1   1 .5 .5   1 .5 .5   3 1. .2 100. 0.

CREATE 25 501 INDA
PARAMETER 25
     (1) 1
     (2 1 2) 1.5 .5

CREATE 26 502 MAQA
     MATERIAL AQUISITION ACTION

PARAMETER 26
     (1) DURATION TIME DISTRIBUTION TYPE 1
     (2 1 2) DURATION TIME STATISTICS
          MEAN 1.5
          MAX DEVIATION .5
     (3 1 13) STIMULUS SPECIFICATIONS
          46   1   1 .5 .5   1 .5 .5   3 1. .2 100. 0.
     (4 1 1) TARGET FUNCTIONS 9
          Any number of target functions may be specified in list valued
          parameter 4 of 502 MAQA functions. The objective of the attempted
          acquisition of material from each of the target functions is the
          same and is specified by the IDAS function, function 20 in this
          example, that initiated the diversion action sequence

CREATE 27 501 INDA
PARAMETER 27
     (1) 1
     (2 1 2) 1.5 .5
     (3 1 13)
```

```
          47   1   1 .5 .5   1 .5 .5   3 1. .2 100. 0.

CREATE 30 902 RMDS
     REPORT MATERIAL DIVERSION STATISTICS
PARAMETER 30
     (1 1 1) MAQA FUNCTIONS 26
     (2 1 3) TIME REPORT HISTOGRAM SPECIFICATIONS
          NUMBER OF CELLS 40
          WIDTH OF CELLS .5
          LOWER LIMIT OF FIRST CELL 100.
     (3 1 3) MATERIAL REPORT HISTOGRAM SPECIFICATIONS
          NUMBER OF CELLS 40
          WIDTH OF CELLS .5
          LOWER LIMIT OF FIRST CELL 0.

CREATE 40 703 MNTR
     MONITOR STIMULUS TYPE 1

PARAMETER 40
     (1 1 6) SENSITIVITY SPECIFICATIONS
          INTENSITY 0.    PROBABILITY .01
                    .5                .5
                    1.               .95
     (2 1 3) MONITOR TIME DELAY
          DISTRIBUTION TYPE UNIFORM 1
          STATISTICS
               MEAN 0.
               MAX DEVIATION 0.
     (3) LATCHING MODE 3
     (5) SIGNAL INDEX 1
     (6) DETECTION SIGNAL 1.
     (7 1 1) DECISION FUNCTIONS 61

CREATE 41 703 MNTR
PARAMETER 41
     (1 1 6) 0. .01   .5 .5   1. .95
          The sensitivity characteristics of all monitors in this example
          are the same.  Notice how the six elements of list valued
          parameter 1 are entered here on a single line without annotation
          to produce the same result as for function 40 above where they are
          entered in a tabular array.
     (2 1 3) 1 0. 0.
     (3) 3
     (5) 2
     (6) 1.
     (7 1 1) 61

CREATE 42 703 MNTR
PARAMETER 42
     (1 1 6) 0.  01   .5  5   1.  95
     (2 1 3) 1 0  0.
     (3) 3
```

```
      (5) 3
      (6) 1.
      (7 1 1) 60

CREATE 43 703 MNTR
PARAMETER 43
      (1 1 6) 0. .01    .5  5   1. .95
      (2 1 3) 1 0. 0.
      (3) 3
      (5) 4
      (6) 1.
      (7 1 1) 60

CREATE 44 703 MNTR
PARAMETER 44
      (1 1 6) 0. .01    .5  5   1. .95
      (2 1 3) 1 0. 0.
      (3) 3
      (5) 5
      (6) 1.
      (7 1 1) 60

CREATE 45 703 MNTR
PARAMETER 45
      (1 1 6) 0. .01    .5  5   1. .95
      (2 1 3) 1 0. 0.
      (3) 3
      (5) 6
      (6) 1.
      (7 1 1) 61

CREATE 46 703 MNTR
PARAMETER 46
      (1 1 6) 0. .01    .5  5   1. .95
      (2 1 3) 1 0. 0.
      (3) 3
      (5) 7
      (6) 0.
          Parameter 6 of functions 46 and 47 are assigned value zero to
          simulate initially inactive monitors.  These parameters are
          assigned value 1.0 by functions 52 and 53 to activate the monitors
          during a simulated control action sequence.
      (7 1 1) 61

CREATE 47 703 MNTR
PARAMETER 47
      (1 1 6) 0. .01    .5 .5   1. .95
      (2 1 3) 1 0. 0.
      (3) 3
      (5) 8
      (6) 0.
      (7 1 1) 61
```

```
CREATE 50 602 SCAS
     START ACTION SEQUENCE

PARAMETER 50
     (1 1 12) ACTION SEQUENCES
          FUNCTION (NEGATIVE FOR FIRST OF SUBSEQUENCE) -51
          STARTING TIME DELAY DISTRIBUTION UNIFORM 1
          STARTING TIME DELAY STATISTICS
               MEAN 8.
               MAX DEVIATION 4.
          52 1 0. 0.
          53 1 0. 0.

CREATE 51 501 INDA
PARAMETER 51
     (1) 1
     (2 1 2) 1. .5

CREATE 52 504 MODA
PARAMETER 52
     (1) 1
     (2 1 2) 1. .5
     (4 1 4) 46 6 0 1
     (5 1 1) 1.

CREATE 53 504 MODA
PARAMETER 53
     (1) 1
     (2 1 2) 1. .5
     (4 1 4) 47 6 0 1
     (5 1 1) 1.

CREATE 60 801 DTBL
     DECISION TABLE

PARAMETER 60
     (1 1 3) INPUT SIGNAL INDEXES 3 4 5
     (2) NUMBER OF CONDITION ROWS 3
     (3 1 9) CONDITIONS
          SIGNAL 3   EQ VK RELATION 7   VALUE 0.
          4 7 0.
          5 7 0.
     (4 1 1) OUTPUT SIGNAL INDEXES 9
     (5) NUMBER OF ACTION ROWS 4
     (6 1 8) ACTIONS
          SIGNAL 9      VALUE 0.
          SIGNAL 9      VALUE 1.
          SIGNAL 9      VALUE 2.
          START ACTION SEQUENCE -50      DUMMY VALUE 0.
     (7) NUMBER OF DECISION RULES 8
     (8 1 56) DECISION RULES
          -1  1  1        0  1  0  0
```

```
          1 -1  1        0  1  0  0
          1  1 -1        0  1  0  0
         -1 -1  1        0  1  0  1
         -1  1 -1        0  1  0  1
          1 -1 -1        0  1  0  1
         -1 -1 -1        0  0  1  0
          0  0  0        1  0  0  0
    (9 1 1) FUNCTIONS TO RECEIVE OUTPUT SIGNALS 61
    (10) NUMBER OF REPORTS 2
    (11 1 10) REPORT SPECIFICATIONS
         SIGNAL 9
         SAMPLING TIME 12.
         NUMBER OF CELLS 3
         WIDTH OF CELLS 1.
         LOWER LIMIT OF FIRST CELL 0.
         9 17. 3 1. 0.

VARIABLE 60
    (1 1 3) 0. 0. 0.
    (2 1 1) 0.

CREATE 61 801 DTBL
PARAMETER 61
    (1 1 6) 1 2 9 6 7 8
    (2) 8
    (3 1 24)
         1 7 0.
         2 7 0.
         9 7 0.
         9 7 1.
         9 7 2.
         6 7 0.
         7 7 0.
         8 7 0.
    (4 1 4) 1 2 3 4
    (5) 8
    (6 1 16)
         1 0
         2 0
         3 0
         4 0
         1 1
         2 1
         3 1
         4 1
    (7) 10
    (8 1 160)
          -1  0  1 -1 -1  1  1  1        0  1  1  1  1  0  0  0
           0 -1  1 -1 -1  1  1  1        0  1  1  1  1  0  0  0
           0  0 -1  1 -1  1  1  1        1  0  1  1  0  1  0  0
           0  0 -1  1 -1 -1  0  0        1  1  0  1  0  0  1  0
           0  0 -1  1 -1  0 -1  0        1  1  0  1  0  0  1  0
```

```
          0  0 -1  1 -1  0  0 -1        1  1  0  1  0  0  1  0
          0  0 -1 -1  1 -1  0  0        1  1  1  0  0  0  0  1
          0  0 -1 -1  1  0 -1  0        1  1  1  0  0  0  0  1
          0  0 -1 -1  1  0  0 -1        1  1  1  0  0  0  0  1
          0  0  0  0  0  0  0  0        1  1  1  1  0  0  0  0
     (10) 8
     (11 1 40)
          1 17. 2 1. 0.
          1 41. 2 1. 0.
          2 17. 2 1. 0.
          2 41. 2 1. 0.
          3 89. 2 1. 0.
          3 113. 2 1. 0.
          4 89. 2 1. 0.
          4 113. 2 1. 0.
VARIABLE 61
     (1 1 6) 0. 0. 0. 0. 0. 0
     (2 1 4) 0. 0. 0. 0.

     SIMULATE 137. HOURS OF OPERATION WITH A DUMP, LEVEL 1 TRACE, AND
     A REPORT OF FUNCTION 26
RUN 1 137. 1 1 0
CONTION
          MTO          61
        MFROM           0
       ICTYPE          -6
       IPOINT           0
        IDUMP           1
        ISECA         100
       ITRACE           1
           LB        2591
         LBCA        3437
       LBLIST        2913
         LBPT           1
         LBUF         650
         LCSB         104
           LE        2616
          LEC         148
         LFFB        3437
         LFFE         255
           LI        2613
          LLE         175
         LLFB        3437
         LLFE         345
          LMS         104
          LNE         180
           LP        2596
           LV        2609
       MINNFL       16562
         MNSE          21
          NFE          79
          NFL       16562
```

```
          NI1              5
          NI2             59
          NO1              6
          NO2             59
         NREP              1
         NRUN              1
          NSE             21
         TIME   0.
        TSTOP   1.3700E+02
FUNCTION        1
LB+00         732            101
   + 1        733             22
   + 2        734              1
   + 3        735             15
   + 4        736              2
LP+ 0     1  737              0
   + 1     3  738   2.4000E+01
   + 2     1  739              2
   + 3     4  740            756
                                    8.0000E+00  1.3000E+01
   + 4     3  741   2.0000E+00
   + 5     1  742              2
   + 6     4  743            766
                                    1.0000E+00  1.0000E+02  5.0000E+01  0.          0.
                                    0.          0.          2.0000E+00  0.          0.
                                    2.0000E+01  5.0000E+00  1.0000E+03  0.
   + 7     1  744              0
   + 8     4  745              0
   + 9     3  746   0.
   +10     3  747   0.
   +11     1  748              1
   +12     1  749             15
   +13     1  750              5
   +14     1  751              4
LV+ 0     1  752              1
   + 1     1  753              0
LI+ 0     1  754              0
   + 1     1  755              0
FUNCTION        2
LB+00         784            101
   + 1        785             22
   + 2        786              2
   + 3        787             13
   + 4        788              2
LP+ 0     1  789              0
   + 1     3  790   1.6800E+02
   + 2     1  791              1
   + 3     4  792            808
                                    1.2500E+01
   + 4     3  793   4.5000E+00
   + 5     1  794              0
   + 6     4  795              0
```

```
   + 7     1   796              2
   + 8     4   797            818
                                    3.0000E+00  3.0000E+02  1.0000E+02  0.          0
                                    0.          0.          4.0000E+00  0.          0
                                    4.0000E+01  2.0000E+01  1.0000E+03  0.
   + 9     3   798  2.0000E+00
   +10     3   799  1.0000E+00
   +11     1   800              1
   +12     1   801             15
   +13     1   802              6
   +14     1   803              4
LV+ 0      1   804              1
   + 1     1   805              0
LI+ 0      1   806              0
   + 1     1   807              0
FUNCTION       3
LB+00          836            101
   + 1         837             22
   + 2         838              3
   + 3         839             15
   + 4         840              2
LP+ 0      1   841              0
   + 1     3   842  2.4000E+01
   + 2     1   843              2
   + 3     4   844            860
                                    1.0000E+01  1.5000E+01
   + 4     3   845  2.0000E+00
   + 5     1   846              2
   + 6     4   847            870
                                    5.0000E+00  5.0000E+02  1.0000E+01  0.          0
                                    0.          0.          6.0000E+00  0.          0
                                    6.0000E+01  6.0000E+00  1.0000E+03  0.
   + 7     1   848              2
   + 8     4   849            888
                                    7.0000E+00  7.0000E+02  5.0000E+01  0.          0
                                    0.          0.          8.0000E+00  0.          0
                                    8.0000E+01  8.0000E-01  1.0000E+03  0.
   + 9     3   850  2.0000E+00
   +10     3   851  0.
   +11     1   852              1
   +12     1   853             15
   +13     1   854              7
   +14     1   855              4
LV+ 0      1   856              1
   + 1     1   857              0
LI+ 0      1   858              0
   + 1     1   859              0
FUNCTION       4
LB+00          906            301
   + 1         907             18
   + 2         908              4
   + 3         909              5
```

+ 4		910		5					
LP+ 0	1	911		0					
+ 1	3	912	0.						
+ 2	3	913	0.						
+ 3	2	914		0					
+ 4	1	915		0					
LV+ 0	1	916		1					
+ 1	1	917		0					
+ 2	1	918		0					
+ 3	3	919	0.						
+ 4	1	920		0					
LI+ 0	1	921		0					
+ 1	1	922		0					
+ 2	1	923		0					
+ 3	3	924	0.						
+ 4	1	925		0					
FUNCTION		5							
LB+00		926		701					
+ 1		927		25					
+ 2		928		5					
+ 3		929		12					
+ 4		930		5					
LP+ 0	1	931		0					
+ 1	1	932		2					
+ 2	4	933		953					
					1.0000E+00	0.	1.0000E+00	0.	0.
					0.	2.0000E+00	0.	0.	0.
					0.	1.0000E+00			
+ 3	3	934	4.0000E+00						
+ 4	3	935	5.0000E-01						
+ 5	1	936		1					
+ 6	1	937		15					
+ 7	2	938		959					
					14				
+ 8	1	939		11					
+ 9	1	940		8					
+10	2	941		0					
+11	1	942		0					
LV+ 0	1	943		1					
+ 1	1	944		0					
+ 2	1	945		0					
+ 3	3	946	0.						
+ 4	1	947		0					
LI+ 0	1	948		0					
+ 1	1	949		0					
+ 2	1	950		0					
+ 3	3	951	0.						
+ 4	1	952		0					
FUNCTION		6							
LB+00		979		701					
+ 1		980		25					
+ 2		981		6					

```
   + 3          982            12
   + 4          983             5
LP+ 0     1     984             0
   + 1     1    985             2
   + 2     4    986          1006
                                    3.0000E+00   0.           3.0000E+00   0.           0.
                                    0.           4.0000E+00   0.           0.           0.
                                    0.           2.0000E+00
   + 3     3    987   4.0000E+00
   + 4     3    988   5.0000E-01
   + 5     1    989             1
   + 6     1    990            15
   + 7     2    991          1022
                                                14
   + 8     1    992            11
   + 9     1    993             9
  +10      2    994          1032
                                                22
  +11      1    995             0
LV+ 0      1    996             1
   + 1     1    997             0
   + 2     1    998             0
   + 3     3    999   0.
   + 4     1   1000             0
LI+ 0      1   1001             0
   + 1     1   1002             0
   + 2     1   1003             0
   + 3     3   1004   0.
   + 4     1   1005             0
FUNCTION       7
LB+00          1042           701
   + 1         1043            25
   + 2         1044             7
   + 3         1045            12
   + 4         1046             5
LP+ 0     1    1047             0
   + 1     1   1048             4
   + 2     4   1049          1069
                                    5.0000E+00   0.           5.0000E+00   0.           0.
                                    0.           6.0000E+00   0.           0.           0.
                                    0.           3.0000E+00   7.0000E+00   0.           7.0000E+00
                                    0.           0.           0.           8.0000E+00   0.
                                    0.           0.           0.           4.0000E+00
   + 3     3   1050   4.0000E+00
   + 4     3   1051   1.0000E+00
   + 5     1   1052             1
   + 6     1   1053            15
   + 7     2   1054          1097
                                                14
   + 8     1   1055            11
   + 9     1   1056            10
  +10      2   1057             0
```

```
   +11      1 1058                    0
LV+ 0       1 1059                    1
   + 1      1 1060                    0
   + 2      1 1061                    0
   + 3      3 1062  0.
   + 4      1 1063                    0
LI+ 0       1 1064                    0
   + 1      1 1065                    0
   + 2      1 1066                    0
   + 3      3 1067  0.
   + 4      1 1068                    0
FUNCTION      8
LB+00           1107                301
   + 1          1108                 18
   + 2          1109                  8
   + 3          1110                  5
   + 4          1111                  5
LP+ 0       1 1112                    0
   + 1      3 1113  2.4000E+01
   + 2      3 1114  1.2000E+01
   + 3      2 1115                    0
   + 4      1 1116                    0
LV+ 0       1 1117                    1
   + 1      1 1118                    0
   + 2      1 1119                    0
   + 3      3 1120  0.
   + 4      1 1121                    0
LI+ 0       1 1122                    0
   + 1      1 1123                    0
   + 2      1 1124                    0
   + 3      3 1125  0.
   + 4      1 1126                    0
FUNCTION      9
LB+00           1127                301
   + 1          1128                 18
   + 2          1129                  9
   + 3          1130                  5
   + 4          1131                  5
LP+ 0       1 1132                    0
   + 1      3 1133  4.8000E+01
   + 2      3 1134  2.4000E+01
   + 3      2 1135                    0
   + 4      1 1136                    0
LV+ 0       1 1137                    1
   + 1      1 1138                    0
   + 2      1 1139                    0
   + 3      3 1140  0.
   + 4      1 1141                    0
LI+ 0       1 1142                    0
   + 1      1 1143                    0
   + 2      1 1144                    0
   + 3      3 1145  0.
```

```
   + 4     1 1146              0
FUNCTION    10
LD+00       1147            301
   + 1      1148             18
   + 2      1149             10
   + 3      1150              5
   + 4      1151              5
LP+ 0     1 1152              0
   + 1     3 1153   4.8000E+01
   + 2     3 1154   1.2000E+01
   + 3     2 1155              0
   + 4     1 1156              0
LV+ 0     1 1157              1
   + 1     1 1158              0
   + 2     1 1159              0
   + 3     3 1160   0.
   + 4     1 1161              0
LI+ 0     1 1162              0
   + 1     1 1163              0
   + 2     1 1164              0
   + 3     3 1165   0.
   + 4     1 1166              0
FUNCTION    11
LD+00       1167            701
   + 1      1168             25
   + 2      1169             11
   + 3      1170             12
   + 4      1171              5
LP+ 0     1 1172              0
   + 1     1 1173              8
   + 2     4 1174           1194
                    1.0000E+00  0.          1.0000E+00  0.          0.
                    0.          2.0000E+00  0.          0.          0.
                    0.          1.0000E+00  3.0000E+00  0.          3.0000E+00
                    0.          0.          0.          4.0000E+00  0.
                    0.          5.0000E+00  0.          2.0000E+00  5.0000E+00
                    6.0000E+00  0.          0.          0.          0.
                    3.0000E+00  7.0000E+00  0.          7.0000E+00  0.
                    0.          0.          8.0000E+00  0.          0.
                    0.          0.          4.0000E+00
   + 3     3 1175   4.0000E+00
   + 4     3 1176   1.0000E+00
   + 5     1 1177              1
   + 6     1 1178             15
   + 7     2 1179           1246
                           14
   + 8     1 1180             13
   + 9     1 1181             12
   +10     2 1182              0
   +11     1 1183              0
LV+ 0     1 1184              1
```

```
   + 1     1 1185                0
   + 2     1 1186                0
   + 3     3 1187  0.
   + 4     1 1188                0
LI+ 0      1 1189                0
   + 1     1 1190                0
   + 2     1 1191                0
   + 3     3 1192  0.
   + 4     1 1193                0
FUNCTION   12
LB+00         1256              301
   + 1        1257               18
   + 2        1258               12
   + 3        1259                5
   + 4        1260                5
LP+ 0      1 1261                0
   + 1     3 1262  0.
   + 2     3 1263  0.
   + 3     2 1264                0
   + 4     1 1265                0
LV+ 0      1 1266                1
   + 1     1 1267                0
   + 2     1 1268                0
   + 3     3 1269  0.
   + 4     1 1270                0
LI+ 0      1 1271                0
   + 1     1 1272                0
   + 2     1 1273                0
   + 3     3 1274  0.
   + 4     1 1275                0
FUNCTION   13
LB+00         1276              401
   + 1        1277               44
   + 2        1278               13
   + 3        1279                9
   + 4        1280               16
LP+ 0      1 1281                0
   + 1     1 1282                1
   + 2     3 1283  1.0000E+01
   + 3     3 1284  1.0000E+00
   + 4     3 1285  5.0000E-02
   + 5     2 1286             1322
                                     1          1          1          1
   + 6     2 1287                0
   + 7     1 1288             2955
   + 8     1 1289             2965
LV+ 0      1 1290                1
   + 1     1 1291                0
   + 2     1 1292                0
   + 3     3 1293  0.
   + 4     1 1294                0
   + 5     3 1295  0.
```

```
   + 6     3 1296   0.
   + 7     3 1297   0.
   + 8     3 1298   0.
   + 9     3 1299   0.
   +10     3 1300   0.
   +11     1 1301          0
   +12     3 1302   0.
   +13     3 1303   0.
   +14     3 1304   0.
   +15     3 1305   0.
LI+ 0      1 1306          0
   + 1     1 1307          0
   + 2     1 1308          0
   + 3     3 1309   0.
   + 4     1 1310          0
   + 5     3 1311   0.
   + 6     3 1312   0.
   + 7     3 1313   0.
   + 8     3 1314   0.
   + 9     3 1315   0.
   +10     3 1316   0.
   +11     1 1317          0
   +12     3 1318   0.
   +13     3 1319   0.
   +14     3 1320   0.
   +15     3 1321   0.
FUNCTION     14
LB+00        1332         702
   + 1       1333          11
   + 2       1334          14
   + 3       1335           6
   + 4       1336           1
LP+ 0      1 1337           0
   + 1     1 1338           3
   + 2     4 1339       1145
                    4.0000E+00  3.0000E+00  2.0000E+00  2.0000E+00  8.9000E+01
                    4.0000E+01  1.0000E+00 -2.0000E+01  4.0000E+00  3.0000E+00
                    2.0000E+00  2.0000E+00  1.1300E+02  4.0000E+01  1.0000E+00
                   -2.0000E+01  4.0000E+00  3.0000E+00  2.0000E+00  2.0000E+00
                    1.3700E+02  4.0000E+01  1.0000E+00 -2.0000E+01
   + 3     2 1340       1373
                              5           6           7
   + 4     2 1341       1383
                             11
   + 5     1 1342       2975
LV+ 0      1 1343          1
LI+ 0      1 1344          0
FUNCTION     15
LB+00        1393         601
   + 1       1394          27
   + 2       1395          15
   + 3       1396           8
```

```
   + 4          1397             8
LP+ 0       1   1398             0
   + 1      3   1399    1.6800E+02
   + 2      1   1400             5
   + 3      4   1401          1422
                                    8.0000E+00  3.2000E+01  5.6000E+01  8.0000E+01  1.0400E+02
   + 4      4   1402          1432
                                    1.7000E+01  4.1000E+01  6.5000E+01  8.9000E+01  1.1300E+02
   + 5      1   1403            10
   + 6      4   1404          1442
                                    8.0000E+00  1.3000E+01  3.2000E+01  3.7000E+01  5.6000E+01
                                    6.1000E+01  8.0000E+01  8.5000E+01  1.0400E+02  1.0900E+02
   + 7      4   1405          1456
                                    1.2000E+01  1.7000E+01  3.6000E+01  4.1000E+01  6.0000E+01
                                    6.5000E+01  8.4000E+01  8.9000E+01  1.0800E+02  1.1300E+02
LV+ 0       1   1406             1
   + 1      3   1407    1.6800E+02
   + 2      1   1408             0
   + 3      3   1409    0.
   + 4      3   1410    8.0000E+00
   + 5      1   1411             0
   + 6      3   1412    0.
   + 7      3   1413    8.0000E+00
LI+ 0       1   1414             0
   + 1      3   1415    1.6800E+02
   + 2      1   1416             0
   + 3      3   1417    0.
   + 4      3   1418    8.0000E+00
   + 5      1   1419             0
   + 6      3   1420    0.
   + 7      3   1421    8.0000E+00
FUNCTION        20
LB+00           1470           102
   + 1          1471             8
   + 2          1472            20
   + 3          1473             2
   + 4          1474             1
LP+ 0       1   1475             0
   + 1      4   1476          1480
                                    4.0000E+00  4.0000E+00  0.          0.          1.0000E+01
                                    2.0000E+00  0.          0.          -2.1000E+01 1.0000E+00
                                    1.0000E+01  2.0000E+00  2.2000E+01  1.0000E+00  0.
                                    0.          2.3000E+01  1.0000E+00  0.          0.
                                    -2.4000E+01 1.0000E+00  1.0600E+02  2.0000E+00  2.5000E+01
                                    1.0000E+00  0.          0.          2.6000E+01  1.0000E+00
                                    0.          0.          2.7000E+01  1.0000E+00  0.
                                    0.          3.0000E+01  1.0000E+00  0.          0.
LV+ 0       1   1477             1
LI+ 0       1   1478             0
FUNCTION        21
LB+00           1524           501
   + 1          1525            10
```

```
   + 2        1526            21
   + 3        1527             5
   + 4        1526             1
LP+ 0     1  1529             0
   + 1     1  1530             1
   + 2     4  1531          1536
                        3.0000E+00   1.0000E+00
   + 3     4  1532          1546
                        4.0000E+01   1.0000E+00   1.0000E+00   5.0000E-01   5.0000E-01
                        1.?000E+00   5.0000E-01   5.0000E-01   3.0000E+00   1.0000E+00
                        2. .000E-01   1.0000E+02   0.           4.1000E+01   1.0000E+00
                        1. .000E+00   5.0000E-01   5.0000E-01   1.0000E+00   5.0000E-01
                        5. .000E-01   3.0000E+00   1.0000E+00   2.0000E-01   1.0000E+02
                        0.
   + 4     2  1533             0
LV+ 0     1  1534             1
LI+ 0     1  1535             0
FUNCTION     22
LB+00        1576           503
   + 1       1577            27
   + 2       1578            22
   + 3       1579             8
   + 4       1580             8
LP+ 0     1  1581             0
   + 1     1  1582             1
   + 2     4  1583          1605
                        5.0000E-01   2.5000E-01
   + 3     4  1584             0
   + 4     1  1585             2
   + 5     3  1586  4.0000E+00
   + 6     2  1587             0
   + 7     1  1588          3135
LV+ 0     1  1589             1
   + 1     3  1590 -2.0000E+00
   + 2     3  1591 -1.0000E+00
   + 3     3  1592 -1.0000E+00
   + 4     1  1593             0
   + 5     1  1594             0
   + 6     1  1595             0
   + 7     3  1596  1.0000E+00
LI+ 0     1  1597             0
   + 1     3  1598 -2.0000E+00
   + 2     3  1599 -1.0000E+00
   + 3     3  1600 -1.0000E+00
   + 4     1  1601             0
   + 5     1  1602             0
   + 6     1  1603             0
   + 7     3  1604 -1.0000E+00
FUNCTION     23
LB+00        1615           504
   + 1       1616            12
   + 2       1617            23
```

```
   + 3        1618          7
   + 4        1619          1
LP+ 0     1   1620          0
   + 1     1  1621          1
   + 2     4  1622       1629
                      5.0000E-01  2.5000E-01
   + 3     4  1623       1639
                      4.2000E+01  1.0000E+00  1.0000E+00  1.0000E-01  5.0000E-02
                      1.0000E+00  5.0000E-01  5.0000E-01  3.0000E+00  1.0000E+00
                      2.0000E-01  1.0000E+02  0.          4.3000E+01  1.0000E+00
                      1.0000E+00  1.0000E-01  5.0000E-02  1.0000E+00  5.0000E-01
                      5.0000E-01  3.0000E+00  1.0000E+00  2.0000E-01  1.0000E+02
                      0.          4.4000E+01  1.0000E+00  1.0000E+00  1.0000E-01
                      5.0000E-02  1.0000E+00  5.0000E-01  5.0000E-01  3.0000E+00
                      1.0000E+00  2.0000E-01  1.0000E+02  0.
   + 4     2  1624       1682
                                9           1           0           1
   + 5     4  1625       1692
                      9.6000E+01
   + 6     2  1626          0
LV+ 0     1  1627          1
LI+ 0     1  1628          0
FUNCTION     24
LB+00        1702        501
   + 1       1703         10
   + 2       1704         24
   + 3       1705          5
   + 4       1706          1
LP+ 0     1  1707          0
   + 1     1  1708          1
   + 2     4  1709       1714
                      1.5000E+00  5.0000E-01
   + 3     4  1710       1724
                      4.5000E+01  1.0000E+00  1.0000E+00  5.0000E-01  5.0000E-01
                      1.0000E+00  5.0000E-01  5.0000E-01  3.0000E+00  1.0000E+00
                      2.0000E-01  1.0000E+02  0.
   + 4     2  1711          0
LV+ 0     1  1712          1
LI+ 0     1  1713          0
FUNCTION     25
LB+00        1741        501
   + 1       1742         10
   + 2       1743         25
   + 3       1744          5
   + 4       1745          1
LP+ 0     1  1746          0
   + 1     1  1747          1
   + 2     4  1748       1753
                      1.5000E+00  5.0000E-01
   + 3     4  1749          0
   + 4     2  1750          0
LV+ 0     1  1751          1
```

```
LI+ 0     1 1752          0
FUNCTION    26
LB+00       1763        502
  + 1       1764         12
  + 2       1765         26
  + 3       1766          7
  + 4       1767          1
LP+ 0     1 1768          0
  + 1     1 1769          1
  + 2     4 1770       1777
                  1.5000E+00  5.0000E-01
  + 3     4 1771       1787
                  4.6000E+01  1.0000E+00  1.0000E+00  5.0000E-01  5.0000E-01
                  1.0000E+00  5.0000E-01  5.0000E-01  3.0000E+00  1.0000E+00
                  2.0000E-01  1.0000E+02  0.
  + 4     2 1772       1804
                        9
  + 5     2 1773          0
  + 6     1 1774       3145
LV+ 0     1 1775          1
LI+ 0     1 1776          0
FUNCTION    27
LB+00       1814        501
  + 1       1815         10
  + 2       1816         27
  + 3       1817          5
  + 4       1818          1
LP+ 0     1 1819          0
  + 1     1 1820          1
  + 2     4 1821       1826
                  1.5000E+00  5.0000E-01
  + 3     4 1822       1836
                  4.7000E+01  1.0000E+00  1.0000E+00  5.0000E-01  5.0000E-01
                  1.0000E+00  5.0000E-01  5.0000E-01  3.0000E+00  1.0000E+00
                  2.0000E-01  1.0000E+02  0.
  + 4     2 1823          0
LV+ 0     1 1824          1
LI+ 0     1 1825          0
FUNCTION    30
LB+00       1853        902
  + 1       1854         11
  + 2       1855         30
  + 3       1856          6
  + 4       1857          1
LP+ 0     1 1858          0
  + 1     2 1859       1866
                       26
  + 2     4 1860       1876
                  4.0000E+01  5.0000E-01  1.0000E+02
  + 3     4 1861       1886
                  4.0000E+01  5.0000E-01  0.
  + 4     1 1862       3155
```

```
  + 5     1 1863        3205
LV+ 0     1 1864           1
LI+ 0     1 1865           0
FUNCTION    40
LB+00       1896         703
  + 1       1897          16
  + 2       1898          40
  + 3       1899           9
  + 4       1900           2
LP+ 0     1 1901           0
  + 1     4 1902        1914
                               0.            1.0000E-02   5.0000E-01   5.0000E-01   1.0000E+00
                               9.5000E-01

  + 2     4 1903        1924
                               1.0000E+00    0.           0.

  + 3     1 1904           3
  + 4     4 1905           0
  + 5     1 1906           1
  + 6     3 1907  1.0000E+00
  + 7     2 1908        1934
                                         61

  + 8     3 1909  0.
LV+ 0     1 1910           1
  + 1     1 1911           0
LI+ 0     1 1912           0
  + 1     1 1913           0
FUNCTION    41
LB+00       1944         703
  + 1       1945          16
  + 2       1946          41
  + 3       1947           9
  + 4       1948           2
LP+ 0     1 1949           0
  + 1     4 1950        1962
                               0.            1.0000E-02   5.0000E-01   5.0000E-01   1.0000E+00
                               9.5000E-01

  + 2     4 1951        1972
                               1.0000E+00    0.           0.

  + 3     1 1952           3
  + 4     4 1953           0
  + 5     1 1954           2
  + 6     3 1955  1.0000E+00
  + 7     2 1956        1982
                                         61

  + 8     3 1957  0.
LV+ 0     1 1958           1
  + 1     1 1959           0
LI+ 0     1 1960           0
  + 1     1 1961           0
FUNCTION    42
LB+00       1992         703
  + 1       1993          16
```

```
   + 2         1994         42
   + 3         1995          9
   + 4         1996          2
 LP+ 0       1 1997          0
   + 1       4 1998       2010
                                  0.            1.0000E-02   5.0000E-01   5.0000E-01   1.0000E+00
                                  9.5000E-01
   + 2       4 1999       2020
                                  1.0000E+00    0.           0.
   + 3       1 2000          3
   + 4       4 2001          0
   + 5       1 2002          3
   + 6       3 2003 1.0000E+00
   + 7       2 2004       2030
                                          60
   + 8       3 2005 0.
 LV+ 0       1 2006          1
   + 1       1 2007          0
 LI+ 0       1 2008          0
   + 1       1 2009          0
 FUNCTION      43
 LB+00         2040        703
   + 1         2041         16
   + 2         2042         43
   + 3         2043          9
   + 4         2044          2
 LP+ 0       1 2045          0
   + 1       4 2046       2058
                                  0.            1.0000E-02   5.0000E-01   5.0000E-01   1.0000E+00
                                  9.5000E-01
   + 2       4 2047       2068
                                  1.0000E+00    0.           0.
   + 3       1 2048          3
   + 4       4 2049          0
   + 5       1 2050          4
   + 6       3 2051 1.0000E+00
   + 7       2 2052       2078
                                          60
   + 8       3 2053 0.
 LV+ 0       1 2054          1
   + 1       1 2055          0
 LI+ 0       1 2056          0
   + 1       1 2057          0
 FUNCTION      44
 LB+00         2088        703
   + 1         2089         16
   + 2         2090         44
   + 3         2091          9
   + 4         2092          2
 LP+ 0       1 2093          0
   + 1       4 2094       2106
                                  0.            1.0000E-02   5.0000E-01   5.0000E-01   1.0000E+00
```

```
                                             9.5000E-01
   + 2     4 2095              2116
                                             1.0000E+0C  O.          O.
   + 3     1 2096                 3
   + 4     4 2097                 0
   + 5     1 2098                 5
   + 6     3 2099       1.0000E+00
   + 7     2 2100              2126
                                                     60
   + 8     3 2101       0.
 LV+ 0     1 2102                 1
   + 1     1 2103                 0
 LI+ 0     1 2104                 0
   + 1     1 2105                 0
 FUNCTION    45
 LB+00       2136               703
   + 1       2137                16
   + 2       2138                45
   + 3       2139                 9
   + 4       2140                 2
 LP+ 0     1 2141                 0
   + 1     4 2142              2154
                                             0.          1.0000E-02  5.0000E-01  5.0000E-01  1.0000E+00
                                             9.5000E-01
   + 2     4 2143              2164
                                             1.0000E+00  0.          0.
   + 3     1 2144                 3
   + 4     4 2145                 0
   + 5     1 2146                 6
   + 6     3 2147       1.0000E+00
   + 7     2 2148              2174
                                                     61
   + 8     3 2149       0.
 LV+ 0     1 2150                 1
   + 1     1 2151                 0
 LI+ 0     1 2152                 0
   + 1     1 2153                 0
 FUNCTION    46
 LB+00       2184               703
   + 1       2185                16
   + 2       2186                46
   + 3       2187                 9
   + 4       2188                 2
 LP+ 0     1 2189                 0
   + 1     4 2190              2202
                                             0.          1.0000E-02  5.0000E-01  5.0000E-01  1.0000E+00
                                             9.5000E-01
   + 2     4 2191              2212
                                             1.0000E+00  0.          0.
   + 3     1 2192                 3
   + 4     4 2193                 0
   + 5     1 2194                 7
```

```
   + 6     3 2195   0.
   + 7     2 2196          2222
                                    61
   + 8     3 2197   0.
LV+ 0     1 2198             1
   + 1     1 2199             0
LI+ 0     1 2200             0
   + 1     1 2201             0
FUNCTION    47
LB+00       2202           703
   + 1      2233            16
   + 2      2234            47
   + 3      2235             9
   + 4      2236             2
LP+ 0     1 2237             0
   + 1     4 2238          2250
                    0.              1.0000E-02  5.0000E-01  5.0000E-01  1.0000E+00
                    9.5000E-01
   + 2     4 2239          2260
                    1.0000E+00      0.          0.
   + 3     1 2240             3
   + 4     4 2241             0
   + 5     1 2242             8
   + 6     3 2243   0.
   + 7     2 2244          2270
                                    61
   + 8     3 2245   0.
LV+ 0     1 2246             1
   + 1     1 2247             0
LI+ 0     1 2248             0
   + 1     1 2249             0
FUNCTION    50
LB+00       2280           602
   + 1      2281             8
   + 2      2282            50
   + 3      2283             2
   + 4      2284             1
LP+ 0     1 2285             0
   + 1     4 2286          2290
                   -5.1000E+01  1.0000E+00  8.0000E+00  4.0000E+00  5.2000E+01
                    1.0000E+00  0.          0.          5.3000E+01  1.0000E+00
                    0.          0.
LV+ 0     1 2287             1
LI+ 0     1 2288             0
FUNCTION    51
LB+00       2306           501
   + 1      2307            10
   + 2      2308            51
   + 3      2309             5
   + 4      2310             1
LP+ 0     1 2311             0
   + 1     1 2312             1
```

```
   + 2     4 2313          2318
                                    1.0000E+00   5.0000E-01
   + 3     4 2314             0
   + 4     2 2315             0
LV+ 0     1 2316             1
LI+ 0     1 2317             0
FUNCTION    52
LB+00         2328           504
   + 1        2329            12
   + 2        2330            52
   + 3        2331             7
   + 4        2332             1
LP+ 0     1 2333             0
   + 1     1 2334             1
   + 2     4 2335          2342
                                    1.0000E+00   5.0000E-01
   + 3     4 2036             0
   + 4     2 2337          2352
                                          46             6             0             1
   + 5     4 2338          2362
                                    1.0000E+00
   + 6     2 2339             0
LV+ 0     1 2340             1
LI+ 0     1 2341             0
FUNCTION    53
LB+00         2372           504
   + 1        2373            12
   + 2        2374            53
   + 3        2375             7
   + 4        2376             1
LP+ 0     1 2377             0
   + 1     1 2378             1
   + 2     4 2379          2386
                                    1.0000E+00   5.0000E-01
   + 3     4 2380             0
   + 4     2 2381          2396
                                          47             6             0             1
   + 5     4 2382          2406
                                    1.0000E+00
   + 6     2 2383             0
LV+ 0     1 2384             1
LI+ 0     1 2385             0
FUNCTION    60
LB+00         2416           801
   + 1        2417            24
   + 2        2418            60
   + 3        2419            13
   + 4        2420             4
LP+ 0     1 2421             0
   + 1     2 2422          2442
                                           3             4             5
   + 2     1 2423             3
```

```
  + 3     4 2424           2452
                                  3.0000E+00  7.0000E+00  0.          4.0000E+00  7.0000E+00
                                  0.          5.0000E+00  7.0000E+00  0.
  + 4     2 2425           2465
                                           9
  + 5     1 2426              4
  + 6     4 2427           2475
                                  9.0000E+00  0.          9.0000E+00  1.0000E+00  9.0000E+00
                                  2.0000E+00 -5.0000E+01  0.
  + 7     1 2428              6
  + 8     2 2429           2487
                                          -1           1           1           0           1
                                           0           0           1          -1           1
                                           0           1           0           0           1
                                           1          -1           0           1           0
                                           0          -1          -1           1           0
                                           1           0           1          -1           1
                                          -1           0           1           0           1
                                           1          -1          -1           0           1
                                           0           1          -1          -1          -1
                                           0           0           1           0           0
                                           0           0           1           0           0
                                           0
  + 9     2 2430           2547
                                          61
  +10     1 2431              2
  +11     4 2432           2557
                                  9.0000E+00  1.2000E+01  3.0000E+00  1.0000E+00  0.
                                  9.0000E+00  1.7000E+01  3.0000E+00  1.0000E+00  0.
  +12     1 2433           3275
LV+ 0     1 2434              1
  + 1     4 2435           3255
                                  0.          0.          0.
  + 2     4 2436           3265
                                  0.
  + 3     3 2437    -1.0000E+00
LI+ 0     1 2438              0
  + 1     4 2439           2571
                                  0.          0.          0.
  + 2     4 2440           2581
                                  0.
  + 3     3 2441    0.
FUNCTION    61
LB+00       2591            801
  + 1       2592             24
  + 2       2593             61
  + 3       2594             13
  + 4       2595              4
LP+ 0     1 2596              0
  + 1     2 2597           2617
                                           1           2           9           6           7
                                           8
```

```
+ 2     1 2598          8
+ 3     4 2599       2627
                  1.0000E+00  7.0000E+00  0.          2.0000E+00  7.0000E+00
                  0.          9.0000E+00  7.0000E+00  0.          9.0000E+00
                  7.0000E+00  1.0000E+00  9.0000E+00  7.0000E+00  2.0000E+00
                  6.0000E+00  7.0000E+00  0.          7.0000E+00  7.0000E+00
                  0.          8.0000E+00  7.0000E+00  0.
+ 4     2 2600       2655
                           1           2           3           4
+ 5     1 2601          8
+ 6     4 2602       2665
                  1.0000E+00  0.          2.0000E+00  0.          3.0000E+00
                  0.          4.0000E+00  0.          1.0000E+00  1.0000E+00
                  2.0000E+00  1.0000E+00              1.0000E+00  4.0000E+00
                  1.0000E+00
+ 7     1 2603         10
+ 8     2 2604       2685
                        -1           0           1          -1          -1
                         1           1           1           0           1
                         1           1           1           0           0
                         0           0          -1           1          -1
                        -1           1           1           1           0
                         1           1           1           1           0
                         0           0           0           0          -1
                         1           1           1           1           1
                         1           1           1           1           0
                        -1           0           1          -1           0
                         0           1           1           0           1
                         0           0           1           0           0
                         0          -1           1           1           0
                        -1           0           1           1           0
                         1           0           1           0          -1
                         0           0           1          -1           1
                         0           0          -1           1           1
                         0           0          -1           1           1
                         0           1           0           0          -1
                         1          -1           0           0           1
                         1           1           0           0          -1
                         0           1           0           0           0
                        -1           1           0           1          -1
                        -1           1           1           0           0
                         0           0           1           1           0
                         0           0           1           0           0
                         1           0           0           1           0
+ 9     2 2605          0
+10     1 2606          8
+11     4 2607       2849
```

```
                                                1.0000E+00  1.7000E+01  2.0000E+00  1.0000E+00  0.
                                                1.0000E+00  4.1000E+01  2.0000E+00  1.0000E+00  0.
                                                2.0000E+00  1.7000E+01  2.0000E+00  1.0000E+00  0.
                                                2.0000E+00  4.1000E+01  2.0000E+00  1.0000E+00  0.
                                                3.0000E+00  8.9000E+01  2.0000E+00  1.0000E+00  0.
                                                3.0000E+00  1.1300E+02  2.0000E+00  1.0000E+00  0.
                                                4.0000E+00  8.9000E+01  2.0000E+00  1.0000E+00  0.
                                                4.0000E+00  1.1300E+02  2.0000E+00  1.0000E+00  0.
   +12     1 2608              3331
LV+ 0      1 2609                 1
   + 1     4 2610              3311
                                                0.          0.          0.          0.          0.
                                                0.
   + 2     4 2611              3321
                                                0.          0.          0.          0.
   + 3     3 2612 -1.0000E+00
LI+ 0      1 2613                 0
   + 1     4 2614              2893
                                                0.          0.          0.          0.          0.
                                                0.
   + 2     4 2615              2903
                                                0.          0.          0.          0.
   + 3     3 2616  0.
EVENT CHAIN
          LEC          148
          LNE          180
          LLE          175
         LFFE          255
         LLFE          645
          NSE           21
         MNSE           21
          NFE           79
        ISECA          100
          180          185          0.          15           1           0
          185          190  8.0050E+00          15           2           0
          190          150  8.0000E+00          15           3           0
          150          160  9.4375E+00           1           1           0
          160          195  1.1125E+01           3           1           0
          195          205  1.1937E+01          21           9        1480
          205          155  1.2000E+01          60           1           0
          155          210  1.5594E+01           2           1           0
          210          215  1.7000E+01          60           2           0
          215          225  1.7000E+01          61           1           0
          225          220  1.7000E+01          61           3           0
          220          230  4.1000E+01          61           2           0
          230          165  4.1000E+01          61           4           0
          165          235  8.9000E+01          14           1           0
          235          245  8.9000E+01          61           5           0
          245          200  8.9000E+01          61           7           0
          200          170  1.0506E+02          24          21        1480
          170          240  1.1300E+02          14           2           0
          240          250  1.1300E+02          61           6           0
```

```
       250          175       1.1300E+02          61          8          0
       175            0       1.3700E+02          14          3          0
FREE STORE
        LFFB         3437
        LLFB         3437
         NFL        16562
        LRCA         3437
      MINNFL        16562
        3497            0       16562
          The RUN line trace control parameter was set to value 1, so only
          event messages were written into the output file as they appear
          below.
0.            15  EVENT
0.            15  601 TIMR  BEGIN PERIOD
8.0000E+00    15  EVENT
8.0000E+00    15  601 TIMR  BEGIN SHIFT
8.0000E+00    15  EVENT
8.0000E+00    15  601 TIMR  BEGIN INTERVAL
9.4375E+00     1  EVENT
9.4375E+00     4  301 TRMB  TRANSPORT COMPLETED
9.4375E+00     1  101 RCMB  MATERIAL BATCH RECEIVED
1.1125E+01     3  EVENT
1.1125E+01     4  301 TRMB  TRANSPORT COMPLETED
1.1125E+01     3  101 RCMB  MATERIAL BATCH RECEIVED
1.1937E+01    21  EVENT
1.2000E+01    60  EVENT
1.2000E+01    15  EVENT
1.2000E+01    15  601 TIMR  END INTERVAL
1.2843E+01    40  EVENT
1.2843E+01    61  INPUT
  1.0000E+00  0.              0.          0.          0.
  0.
1.2843E+01    61  EVENT
1.2843E+01    61  RULE
       1
1.2843E+01    61  OUTPUT
  1.0000E+00  0.              0.          0.
1.2935E+01    41  EVENT
1.2935E+01    61  INPUT
  1.0000E+00  1.0000E+00      0.          0.          0.
  0.
1.2935E+01    61  EVENT
1.2935E+01    61  RULE
       1
1.2935E+01    61  OUTPUT
  1.0000E+00  0.              0.          0.
          Stimuli v1 and v2 generated by adversary action A1 were sensed by
          monitors 40 and 41 and their output signals were received by
          decision function &1 which set MC response component r1 to value 1
          in accordance with rule 1 of the decision table specification.
1.2940E+01     5  EVENT
1.2940E+01     5  701 MZMB  MEASUREMENT COMPLETED
```

```
1.3000E+01   15  EVENT
1.3000E+01   15  601 TIMR  BEGIN INTERVAL
1.3854E+01    3  EVENT
1.3854E+01    4  301 TRMB  TRANSPORT COMPLETED
1.3854E+01    3  101 RCMB  MATERIAL BATCH RECEIVED
1.4054E+01    1  EVENT
1.4054E+01    4  301 TRMB  TRANSPORT COMPLETED
1.4054E+01    1  101 RCMB  MATERIAL BATCH RECEIVED
1.4143E+01   22  EVENT
1.5502E+01    7  EVENT
1.5502E+01    7  701 MZMB  MEASUREMENT COMPLETED
1.5594E+01    2  EVENT
1.5594E+01    4  301 TRMB  TRANSPORT COMPLETED
1.5594E+01    2  101 RCMB  MATERIAL BATCH RECEIVED
1.5594E+01   23  EVENT
        Action A3 begins upon conditional completion of action A2 at time
        15.594 when the batch containing material 4 arrives at receiving
        station 2 and is immediately placed in the incoming measurement
        facility.  The interaction message indicating that the
        measurement has been started does not appear here because the run
        is being traced at event level 1.
1.5650E+01   44  EVENT
1.5650E+01   60  INPUT
  0.          0.          1.0000E+00
1.5650E+01   60  EVENT
1.5650E+01   60  RULE
          3
1.5650E+01   60  OUTPUT
  1.0000E+00
1.5650E+01   61  INPUT
  1.0000E+00  1.0000E+00  1.0000E+00  0.          0.
  0.
1.5650E+01   61  EVENT
1.5650E+01   61  RULE
          3
1.5650E+01   61  OUTPUT
  0.          1.0000E+00  0.          0.
1.5702E+01   43  EVENT
1.5702E+01   60  INPUT
  0.          1.0000E+00  1.0000E+00
1.5702E+01   60  EVENT
1.5702E+01   60  START
          50
1.5702E+01   60  RULE
          6
1.5702E+01   60  OUTPUT
  1.0000E+00
1.5702E+01   61  INPUT
  1.0000E+00  1.0000E+00  1.0000E+00  0.          0.
  0.
1.5702E+01   61  EVENT
1.5702E+01   61  RULE
```

```
          3
1.5702E+01   61  OUTPUT
  0.              1.0000E+00   0.              0.
```

Stimuli v4 and v5 are detected by monitors 43 and 44. Monitor signal q5 reaches decision function 60 at time 15.650. Decision function 60 then sets q9 to 1 as specified by rule 3. Upon receipt of the q9 signal, decision function 61 invokes rule 3, returning response signal r1 to zero and raising r2 to 1. Notice that the decisions of function 60 and 61 occur simultaneously in simulated time since negligible time delay is assumed for the transmission of signal q9 from function 60 to function 61.

At time 15.702, monitor signal q4 is received at decision function 60 which then applies rule 6, again setting signal q9 to 1 but also starting the control action sequence defined by 103 SCAS function 50. Since the updated input to function 61 is unchanged, it again applies rule 3, setting r2 to 1 and the other MC response signals to zero.

```
1.7000E+01   60  EVENT
1.7000E+01   61  EVENT
1.7000E+01   61  EVENT
```

The event occurring at time 17.000 in function 60 is the second of the two sampling events defined by the report specifications of list valued parameter 11 of function 60. The first of these two events occurred earlier at time 12.000. The two events occurring at time 17.000 in function 61 are sampling events for output variables r1 and r2 as specified by the report specifications of function 61.

```
1.7000E+01   15  EVENT
1.7000E+01   15  601 TIMR  END SHIFT
1.7000E+01   15  EVENT
1.7000E+01   15  601 TIMR  END INTERVAL
1.7593E+01    5  EVENT
1.7593E+01    5  701 M2MB  MEASUREMENT COMPLETED
1.8659E+01    7  EVENT
1.8659E+01    7  701 M2MB  MEASUREMENT COMPLETED
1.9904E+01    6  EVENT
1.9904E+01    6  701 M2MB  MEASUREMENT COMPLETED
2.5576E+01   51  EVENT
2.6955E+01   52  EVENT
2.8234E+01   53  EVENT
```

The control action of function 51 begins 9.874 hours after the control action sequence is started by function 50. The time delay of action 51, as specified in list valued parameter 1 of function 50, is uniformly distributed between 4.0 and 12.0 hours. Actions 52 and 53 begin at times 26.955 and 28.234 respectively so the actual durations of actions 51 and 52 were, in this instance, 1.379 and 1.279 hours respectively. The durations of actions simulated by functions 51, 52, and 53 were specified to be uniformly distributed between 0.5 and 1.5 hours. Since it is the last one of a sequence, no event occurs by which we can determine the duration of action 53 in this run.

```
3.1584E+01    1  EVENT
```

```
3.1534E+01    4  301 TRMB  TRANSPORT COMPLETED
3.1581E+01    1  101 RCMB  MATERIAL BATCH RECEIVED
3.2000E+01   15  EVENT
3.2000E+01   15  601 TIMR  BEGIN SHIFT
3.2000E+01   15  EVENT
3.2000E+01   15  601 TIMR  BEGIN INTERVAL
3.4414E+01    3  EVENT
3.4414E+01    4  301 TRMC  TRANSPORT COMPLETED
3.4444E+01    3  101 RCMB  MATERIAL BATCH RECEIVED
3.5000E+01    5  EVENT
3.5973E+01    5  701 MZMB  MEASUREMENT COMPLETED
3.6000E+01   15  EVENT
3.6000E+01   15  601 TIMR  END INTERVAL
3.6054E+01    1  EVENT
3.6054E+01    1  301 TRMB  TRANSPORT COMPLETED
3.6054E+01    1  101 RCMB  MATERIAL BATCH RECEIVED
3.7000E+01   15  EVENT
3.7000E+01   15  601 TIMR  BEGIN INTERVAL
3.7755E+01    3  EVENT
3.7755E+01    4  301 TRMB  TRANSPORT COMPLETED
3.7755E+01    3  101 RCMB  MATERIAL BATCH RECEIVED
3.8100E+01    7  EVENT
3.8100E+01    7  701 MZMB  MEASUREMENT COMPLETED
4.0831E+01    5  EVENT
4.0831E+01    5  701 MZMB  MEASUREMENT COMPLETED
4.1000E+01   61  EVENT
4.1000E+01   61  EVENT
          Output variables r1 and r2 of decision function 61 are sampled at
          time 41.000.
4.1000E+01   15  EVENT
4.1000E+01   15  601 TIMR  END SHIFT
4.1000E+01   15  EVENT
4.1000E+01   15  601 TIMR  END INTERVAL
4.1011E+01    7  EVENT
4.1011E+01    7  701 MZMB  MEASUREMENT COMPLETED
4.4948E+01    8  EVENT
4.4948E+01    8  301 TRMB  TRANSPORT COMPLETED
4.8054E+01   11  EVENT
4.8054E+01   11  701 MZMB  MEASUREMENT COMPLETED
4.8054E+01   12  301 TRMC  TRANSPORT COMPLETED
5.3059E+01    8  EVENT
5.3059E+01    8  301 TRMB  TRANSPORT COMPLETED
5.6000E+01   15  EVENT
5.6000E+01   15  601 TIMR  BEGIN SHIFT
5.6000E+01   15  EVENT
5.6000E+01   15  601 TIMR  BEGIN INTERVAL
5.6338E+01    1  EVENT
5.6352E+01    4  301 TRMB  TRANSPORT COMPLETED
5.6338E+01    1  101 RCMB  MATERIAL BATCH RECEIVED
5.8465E+01   11  EVENT
5.8465E+01   11  701 MZMB  MEASUREMENT COMPLETED
5.8465E+01   12  301 TRMB  TRANSPORT COMPLETED
```

```
5.8033E+01    3  EVENT
5.8033E+01    4  301 TRMB  TRANSPORT COMPLETED
5.8033E+01    3  101 RCMB  MATERIAL BATCH RECEIVED
5.9174E+01    1  EVENT
5.9174E+01    4  301 TRMB  TRANSPORT COMPLETED
5.9174E+01    1  101 RCMB  MATERIAL BATCH RECEIVED
6.0000E+01   15  EVENT
6.0000E+01   15  601 TIMR  END INTERVAL
6.0219E+01    5  EVENT
6.0219E+01    5  701 MZMB  MEASUREMENT COMPLETED
6.1000E+01   15  EVENT
6.1000E+01   15  601 TIMR  BEGIN INTERVAL
6.1695E+01    7  EVENT
6.1695E+01    7  701 MZMB  MEASUREMENT COMPLETED
6.2204E+01    3  EVENT
6.2204E+01    4  301 TRMB  TRANSPORT COMPLETED
6.2204E+01    3  101 RCMB  MATERIAL BATCH RECEIVED
6.3430E+01    5  EVENT
6.3430E+01    5  701 MZMB  MEASUREMENT COMPLETED
6.3629E+01   10  EVENT
6.3629E+01   10  301 TRMB  TRANSPORT COMPLETED
6.4177E+01    8  EVENT
6.4177E+01    8  301 TRMB  TRANSPORT COMPLETED
6.4844E+01    8  EVENT
6.4844E+01    8  301 TRMB  TRANSPORT COMPLETED
6.5000E+01   15  EVENT
6.5000E+01   15  601 TIMR  END SHIFT
6.5000E+01   15  EVENT
6.5000E+01   15  601 TIMR  END INTERVAL
6.6810E+01    7  EVENT
6.6840E+01    7  701 MZMB  MEASUREMENT COMPLETED
6.8161E+01   10  EVENT
6.8161E+01   10  301 TRMB  TRANSPORT COMPLETED
6.8472E+01   11  EVENT
6.8472E+01   11  701 MZMB  MEASUREMENT COMPLETED
6.8472E+01   12  301 TRMB  TRANSPORT COMPLETED
6.8532E+01   11  EVENT
6.8532E+01   11  701 MZMB  MEASUREMENT COMPLETED
6.8560E+01   12  301 TRMB  TRANSPORT COMPLETED
6.8616E+01   11  EVENT
6.8616E+01   11  701 MZMB  MEASUREMENT COMPLETED
6.8710E+01   12  301 TRMB  TRANSPORT COMPLETED
7.2815E+01   11  EVENT
7.2815E+01   11  701 MZMB  MEASUREMENT COMPLETED
7.2815E+01   12  301 TRMB  TRANSPORT COMPLETED
7.8252E+01    1  EVENT
7.8252E+01    4  301 TRMB  TRANSPORT COMPLETED
7.8252E+01    1  101 RCMB  MATERIAL BATCH RECEIVED
8.0000E+01   15  EVENT
8.0000E+01   15  601 TIMR  BEGIN SHIFT
8.0000E+01   15  EVENT
8.0000E+01   15  601 TIMR  BEGIN INTERVAL
```

```
8.2009E+01    3  EVENT
8.2009E+01    4  301 TRMB   TRANSPORT COMPLETED
8.2009E+01    3  101 RCMB   MATERIAL BATCH RECEIVED
8.2152E+01    5  EVENT
8.2152E+01    5  701 MZMB   MEASUREMENT COMPLETED
8.4000E+01   15  EVENT
8.4000E+01   15  601 TIMR   END INTERVAL
8.4306E+01    1  EVENT
8.4306E+01    4  301 TRMB   TRANSPORT COMPLETED
8.4306E+01    1  101 RCMB   MATERIAL BATCH RECEIVED
8.4499E+01    8  EVENT
8.4499E+01    8  301 TRMB   TRANSPORT COMPLETED
8.5000E+01   15  EVENT
8.5000E+01   15  601 TIMR   BEGIN INTERVAL
8.5800E+01    3  EVENT
8.5800E+01    4  301 TRMB   TRANSPORT COMPLETED
8.5800E+01    3  101 RCMB   MATERIAL BATCH RECEIVED
8.6944E+01    7  EVENT
8.6944E+01    7  701 MZMB   MEASUREMENT COMPLETED
8.7122E+01    8  EVENT
8.7122E+01    8  301 TRMB   TRANSPORT COMPLETED
8.7417E+01   10  EVENT
8.7417E+01   10  301 TRMB   TRANSPORT COMPLETED
8.8232E+01   11  EVENT
8.8232E+01   11  701 MZMB   MEASUREMENT COMPLETED
8.8232E+01   12  301 TRMB   TRANSPORT COMPLETED
8.8755E+01    5  EVENT
8.8755E+01    5  701 MZMB   MEASUREMENT COMPLETED
8.9000E+01   14  EVENT
8.9000E+01   14  702 CMBA   REPLICATE SAMPLE TAKEN
8.9000E+01   61  EVENT
8.9000E+01   61  EVENT
8.9000E+01   15  EVENT
8.9000E+01   15  601 TIMR   END SHIFT
8.9000E+01   15  EVENT
8.9000E+01   15  601 TIMR   END INTERVAL
9.0677E+01    7  EVENT
9.0677E+01    7  701 MZMB   MEASUREMENT COMPLETED
9.1872E+01   11  EVENT
9.1872E+01   11  701 MZMB   MEASUREMENT COMPLETED
9.1872E+01   12  301 TRMB   TRANSPORT COMPLETED
9.1980E+01   11  EVENT
9.1980E+01   11  701 MZMB   MEASUREMENT COMPLETED
9.1980E+01   12  301 TRMB   TRANSPORT COMPLETED
9.5940E+01   10  EVENT
9.5940E+01   10  301 TRMB   TRANSPORT COMPLETED
9.6983E+01   11  EVENT
9.6983E+01   11  701 MZMB   MEASUREMENT COMPLETED
9.6983E+01   12  301 TRMB   TRANSPORT COMPLETED
1.0357E+02    8  EVENT
1.0357E+02    8  301 TRMB   TRANSPORT COMPLETED
1.0382E+02    1  EVENT
```

```
1.0382E+02   4  301 TRMB  TRANSPORT COMPLETED
1.0382E+02   1  101 RCMB  MATERIAL BATCH RECEIVED
1.0400E+02  15  EVENT
1.0400E+02  15  601 TIMR  BEGIN SHIFT
1.0400E+02  15  EVENT
1.0400E+02  15  601 TIMR  BEGIN INTERVAL
1.0451E+02   3  EVENT
1.0451E+02   4  301 TRMB  TRANSPORT COMPLETED
1.0451E+02   3  101 RCMB  MATERIAL BATCH RECEIVED
1.0506E+02  24  EVENT
1.0630E+02  25  EVENT
1.0731E+02  26  EVENT
1.0737E+02  46  EVENT
1.0737E+02  61  INPUT
  1.0000E+00  1.0000E+00  1.0000E+00  0.          1.0000E+00
  0.
1.0737E+02  61  EVENT
1.0737E+02  61  RULE
       5
1.0737E+02  61  OUTPUT
  0.          0.          1.0000E+00  0.
```

Action B1 begins at time 105.06 with the occurrence of an event in function 24. In this case, stimulus v6 is not detected by monitor function 45 so q6 remains unchanged. However, monitor 46 does detect stimulus v7 at time 107.37 and transmits signal q7 to function 61 which applies rule 5 of the decision table, raising MC response signal r3 to 1 and returning r2 to zero. Monitor 46, which was initially inactive, was turned on by control action 52 at time 26.955 when two of the three monitor signal inputs to decision function 60 indicated the detection of stimuli generated by the action of adversary A.

```
1.0800E+02  15  EVENT
1.0800E+02  15  601 TIMR  END INTERVAL
1.0826E+02   5  EVENT
1.0826E+02   5  701 MZMB  MEASUREMENT COMPLETED
1.0853E+02  11  EVENT
1.0853E+02  11  701 MZMB  MEASUREMENT COMPLETED
1.0853E+02  12  301 TRMB  TRANSPORT COMPLETED
1.0877E+02   1  EVENT
1.0877E+02   4  301 TRMB  TRANSPORT COMPLETED
1.0877E+02   1  101 RCMB  MATERIAL BATCH RECEIVED
1.0893E+02  27  EVENT
1.0900E+02  15  EVENT
1.0900E+02  15  601 TIMR  BEGIN INTERVAL
1.0922E+02  47  EVENT
1.0922E+02  61  INPUT
  1.0000E+00  1.0000E+00  1.0000E+00  0.          1.0000E+00
  1.0000E+00
1.0922E+02  61  EVENT
1.0922E+02  61  RULE
       5
1.0922E+02  61  OUTPUT
```

```
  0.          0.          1.0000E+00  0.
        Stimulus r9 generated by function 27 which simulates adversary
        action B4 is detected by monitor function 47, but the transmission
        of signal q8 to decision function 61 does not change its output
        which already had r3 set to 1 and the other MC response signals
        set to zero.
1.0922E+02   7  EVENT
1.0922E+02   7  701 MZMB  MEASUREMENT COMPLETED
1.0980E+02   3  EVENT
1.0980E+02   4  301 TRMB  TRANSPORT COMPLETED
1.0980E+02   3  701 BCMD  MATERIAL BATCH RECEIVED
1.1055E+02  30  EVENT
        The diversion action sequence of adversary B is completed at time
        110.65.  In this event, function 30 records the completion time of
        the attempt and the quantity of material successfully acquired by
        function 26 as specified by list valued parameter 1.  This
        completes the adversary and control action sequences.  Except for
        sampling events in function 61 that record the values of MC
        response signals r3 and r4 at time 113.00, no other events occur
        in functions that simulate actions, monitors, or decision
        functions of the MC system.
1.1240E+02   5  EVENT
1.1240E+02   5  701 MZMB  MEASUREMENT COMPLETED
1.1295E+02   9  EVENT
1.1295E+02   9  301 TRMB  TRANSPORT COMPLETED
1.1300E+02  14  EVENT
1.1300E+02  14  702 CMBA  REPLICATE SAMPLE TAKEN
1.1300E+02  61  EVENT
1.1300E+02  61  EVENT
1.1300E+02  15  EVENT
1.1300E+02  15  601 TIMR  END SHIFT
1.1300E+02  15  EVENT
1.1300E+02  15  601 TIMR  END INTERVAL
1.1450E+02   7  EVENT
1.1450E+02   7  701 MZMB  MEASUREMENT COMPLETED
1.1518E+02  10  EVENT
1.1518E+02  10  301 TRMB  TRANSPORT COMPLETED
1.1723E+02   8  EVENT
1.1723E+02   8  301 TRMB  TRANSPORT COMPLETED
1.1770E+02  11  EVENT
1.1770E+02  11  701 MZMB  MEASUREMENT COMPLETED
1.1770E+02  12  301 TRMB  TRANSPORT COMPLETED
1.1940E+02  11  EVENT
1.1940E+02  11  701 MZMB  MEASUREMENT COMPLETED
1.1940E+02  12  301 TRMB  TRANSPORT COMPLETED
1.2033E+02  11  EVENT
1.2033E+02  11  701 MZMB  MEASUREMENT COMPLETED
1.2033E+02  12  301 TRMB  TRANSPORT COMPLETED
1.2130E+02  10  EVENT
1.2130E+02  10  301 TRMB  TRANSPORT COMPLETED
1.2473E+02  11  EVENT
1.2473E+02  11  701 MZMB  MEASUREMENT COMPLETED
```

```
1 2.172E+02  12  301 TRMB  TRANSPORT COMPLETED
1 2.515E+02   8  EVENT
1 2.515E+02   8  301 TRMB  TRANSPORT COMPLETED
1 2.515E+02   8  EVENT
1 2.518E+02   5  301 TRMB  TRANSPORT COMPLETED
1 2.518E+02   1  EVENT
1 2.527E+02   4  301 TRMB  TRANSPORT COMPLETED
1 2.527E+02   1  101 RCMB  MATERIAL BATCH RECEIVED
1 2.535E+02  11  EVENT
1 2.865E+02  11  701 MZMB  MEASUREMENT COMPLETED
1 2.865E+02  12  301 TRMB  TRANSPORT COMPLETED
1 2.950E+02   3  EVENT
1 2.950E+02   4  301 TRMB  TRANSPORT COMPLETED
1 2.950E+02   3  101 RCMB  MATERIAL BATCH RECEIVED
1 2.131E+02   5  EVENT
1 3.131E+02   5  701 MZMB  MEASUREMENT COMPLETED
1 3.215E+02  11  EVENT
1 3.313E+02  11  701 MZMB  MEASUREMENT COMPLETED
1 3.313E+02  12  301 TRMB  TRANSPORT COMPLETED
1 3.395E+02   1  EVENT
1 3.395E+02   4  301 TRMB  TRANSPORT COMPLETED
1 3.426E+02   1  101 RCMB  MATERIAL BATCH RECEIVED
1 3.432E+02   7  EVENT
1 3.432E+02   7  701 MZMB  MEASUREMENT COMPLETED
1 3.478E+02   3  EVENT
1 3.478E+02   4  301 TRMB  TRANSPORT COMPLETED
1 3.478E+02   3  101 RCMB  MATERIAL BATCH RECEIVED
1 3.700E+02  14  EVENT
1 3.700E+02  14  702 CMBA  REPLICATE SAMPLE TAKEN
```

This is the end of the chronological tracing of events during the single diversion attempt. A standard report of all functions of the model system was suppressed by the preceding RUN line. The following line is a copy of the input line requesting a report of function 26, the 502 MAGA function that simulates the material acquisition action of adversary B.

```
REPORT 26

FUNCTION  26 502 MAGA
          DIVERTED MATERIAL
            4837     0  4827      0     0  0  4          0  1.1384E+01
            4827  4637     0   4837     0  0  3        126  0.
            4637  3145     0      0  4827  1  0        126  1.1384E+01
            3145     0     0      0  4637  2  0        126  1.1384E+01
```

The report by function 26 indicates that in the simulated diversion attempt 11.384 mass units of material type 4 were successfully removed from the processing area by adversary B. Notice that 126 items of material 3 were also removed because they were homogeneously mixed with the material 4 found in the container at the time of the material acquisition action

MAKE 50 REPLICATIONS OF THE SAME RUN WITH NO DUMP OR TRACE BUT WITH A

STANDARD REPORT
RUN 50 137 0 0 1

FUNCTION	TYPE	ENTRIES	FRACTION
1	101	24	0.0282
2	101	2	0.0024
3	101	24	0.0282
4	301	50	0.0588
5	701	60	0.0705
6	701	7	0.0082
7	701	78	0.0917
8	301	30	0.0353
9	301	4	0.0047
10	301	25	0.0294
11	701	187	0.2197
12	301	34	0.0400
13	401	17	0.0200
14	702	209	0.2456
15	601	31	0.0364
20	102	0	0.
21	501	3	0.0035
22	503	3	0.0035
23	504	4	0.0047
24	501	2	0.0024
25	501	1	0.0012
26	502	4	0.0047
27	501	2	0.0024
30	902	2	0.0024
40	703	1	0.0012
41	703	1	0.0012
42	703	3	0.0035
43	703	3	0.0035
44	703	3	0.0035
45	703	1	0.0012
46	703	1	0.0012
47	703	3	0.0035
50	602	1	0.0012
51	501	1	0.0012
52	504	1	0.0012
53	504	1	0.0012
60	801	12	0.0141
61	801	16	0.0188

FUNCTION 1 101 RCMB
NUMBER OF BATCHES RECEIVED 12

FUNCTION 2 101 RCMB
NUMBER OF BATCHES RECEIVED 1

FUNCTION 3 101 RCMB
NUMBER OF BATCHES RECEIVED 12

FUNCTION 4 301/TRMB
MAXIMUM NUMBER OF BATCHES IN TRANSPORT 1
TIME MAXIMUM FIRST OCCURRED 8.0409E+00

FUNCTION 5 701/MZMB
MAXIMUM NUMBER OF BATCHES IN MEASUREMENT 2
TIME MAXIMUM FIRST OCCURRED 5.9012E+01

FUNCTION 6 701/MZMB
MAXIMUM NUMBER OF BATCHES IN MEASUREMENT 1
TIME MAXIMUM FIRST OCCURRED 1.4376E+01

FUNCTION 7 701/MZMB
MAXIMUM NUMBER OF BATCHES IN MEASUREMENT 2
TIME MAXIMUM FIRST OCCURRED 3.9207E+01

FUNCTION 8 301/TRMB
MAXIMUM NUMBER OF BATCHES IN TRANSPORT 4
TIME MAXIMUM FIRST OCCURRED 4.0750E+01

FUNCTION 9 301/TRMB
MAXIMUM NUMBER OF BATCHES IN TRANSPORT 1
TIME MAXIMUM FIRST OCCURRED 1.8742E+01

FUNCTION 10 301/TRMB
MAXIMUM NUMBER OF BATCHES IN TRANSPORT 5
TIME MAXIMUM FIRST OCCURRED 6.0452E+01

FUNCTION 11 701/MZMB
MAXIMUM NUMBER OF BATCHES IN MEASUREMENT 2
TIME MAXIMUM FIRST OCCURRED 6.3792E+01

FUNCTION 12 301/TRMB
MAXIMUM NUMBER OF BATCHES IN TRANSPORT 1
TIME MAXIMUM FIRST OCCURRED 4.9454E+01

FUNCTION 13 401 STOM
BULK STORAGE

```
CURRENTLY IN STORAGE 6.1057E+02
MAXIMUM NUMBER STORED  6.1057E+02 AT TIME  1.3113E+02
NUMBER OF OBSERVATIONS          16
MEAN                    2.0049E+02
STANDARD DEVIATION      2.0177E+02

CONTAINER STORAGE
CURRENTLY IN STORAGE            15
MAXIMUM NUMBER STORED           15 AT TIME  2.2855E+02
NUMBER OF OBSERVATIONS           8
MEAN                    5.3732E+00
STANDARD DEVIATION      4.7983E+00

MATERIAL IN STORAGE
10887     0  9077     0     0  0  6        0  2.7806E+02
 9077     0  8607 10887     0  0  5     2379  0.
 8607     0  9777  9077     0  0  2        0  1.2848E+02
 9777 10387     0  8607     0  0  1      524  0.
10117     0 10517     0     0  0  8        0  7.9967E+01
10517  9717     0 10117     0  0  7      739  0.
 9717  7307     0     0 10517  1  0      739  7.9967E+01
10097     0  5867     0     0  0  8        0  7.9780E+01
 5867  9957     0 10097     0  0  7      666  0.
 9957 10237     0     0  5867  1  0      666  7.9780E+01
10377     0 10017     0     0  0  8        0  7.8802E+01
10017 10347     0 10377     0  0  7      662  0.
10347  9957     0     0 10017  1  0      662  7.8802E+01
10637     0  6777     0     0  0  8        0  8.0181E+01
 6777 10777     0 10637     0  0  7      657  0.
10777 10687     0     0  6777  1  0      657  8.0181E+01
10447     0  9127     0     0  0  8        0  8.0209E+01
 9127 10337     0 10447     0  0  7      658  0.
10337  9817     0     0  9127  1  0      658  8.0209E+01
 7347     0 10597     0     0  0  8        0  8.0073E+01
10597  3627     0  7347     0  0  7      669  0.
 3627  9177     0     0 10597  1  0      669  8.0073E+01
10367     0 10057     0     0  0  8        0  8.0659E+01
10057  9017     0 10367     0  0  7      678  0.
 9017 10307     0     0 10357  1  0      678  8.0659E+01
 9187     0  9037     0     0  0  8        0  8.1181E+01
 9037  4157     0  9187     0  0  7      740  0.
 4157  9577     0     0  9037  1  0      740  8.1181E+01
10047     0 10587     0     0  0  4        0  3.6965E+01
10587  9367     0 10047     0  0  3      244  0.
 9367 10197     0     0 10587  1  0      244  3.6965E+01
10677     0  6617     0     0  0  8        0  8.0456E+01
 6617 10297     0 10877     0  0  7      671  0.
10297 10677     0     0  6617  1  0      671  8.0456E+01
10547     0  8417     0     0  0  8        0  8.0005E+01
 8417  8127     0 10547     0  0  7      662  0.
 8127  9897     0     0  8417  1  0      662  8.0005E+01
10077     0 10287     0     0  0  8        0  8.0193E+01
```

10287	6817	0	10077	0	0	7	650	0.
6817	4267	0	0	10287	1	0	650	8.0193E+01
10527	0	10127	0	0	0	8	0	7.9837E+01
10727	10707	0	10527	0	0	7	700	0.
10707	10867	0	0	10727	1	0	700	7.9837E+01
4787	0	6057	0	0	0	8	0	7.6962E+01
6057	9567	0	4787	0	0	7	737	0.
9567	9477	0	0	6057	1	0	737	7.8962E+01
9707	0	9637	0	0	0	8	0	8.1143E+01
9637	7647	0	9707	0	0	7	667	0.
7647	9887	0	0	9637	1	0	667	8.1143E+01
9887	0	8477	0	7647	2	0	667	8.1143E+01
8477	0	10867	9887	9567	2	0	737	7.8962E+01
10867	0	8287	8477	10707	2	0	700	7.9837E+01
6817	0	9637	10867	6817	2	0	650	8.0193E+01
9057	0	10677	8287	8127	2	0	662	8.0005E+01
10677	0	10197	9897	10797	2	0	671	8.0450E+01
10197	0	8577	10677	9367	2	0	244	3.6965E+01
8577	0	10307	10197	4157	2	0	740	8.1181E+01
10307	0	9177	8577	9017	2	0	678	8.0653E+01
9177	0	3617	10307	3627	2	0	669	8.0073E+01
3617	0	10687	9177	10337	2	0	658	8.0209E+01
10687	0	9967	9817	10777	2	0	657	8.0181E+01
9967	0	10237	10697	10347	2	0	662	7.8802E+01
10257	0	7307	9967	9957	2	0	666	7.9780E+01
7307	0	10387	10237	9717	2	0	739	7.9967E+01
10787	2965	0	7307	9777	1	0	2903	4.0618E+02
2965	0	0	0	10387	2	0	12703	1.5649E+03

MATERIAL IN HOLDUP

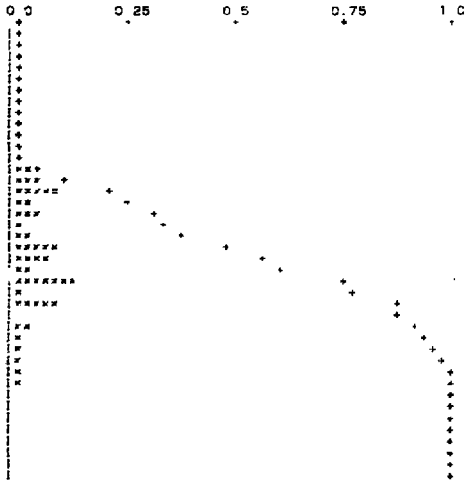
8917	0	7527	0	0	0	6	0	1.3379E+02
7527	0	10357	8917	0	0	5	1142	0.
10857	0	10847	7527	0	0	2	0	7.0301E+01
10847	2965	0	10857	0	0	1	275	0
2965	0	0	0	10847	1	0	1417	2.0409E+02

REPORT TIME INTERVAL 0. TO 1.3700E+02

FUNCTION 14 782 CMBA REPORT NO. 1

MATERIAL TYPE	4		
DATA	ERROR (OBSERVED - TRUE)		
VARIABLE	MASS		
SAMPLING	REPLICATE		
REPLICATE SAMPLING TIME	8.9000E+01	NUMBER OF OBSERVATIONS	50
MEAN VALUE	1.2424E-02	STANDARD DEVIATION	5.2252E+00
MAXIMUM VALUE	1.1305E+01	TIME OF MAXIMUM VALUE	8.9000E+01
MINIMUM VALUE	-1.3507E+01	TIME OF MINIMUM VALUE	8.9000E+01

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
-2.0000E+01	0	0.	0.
-1.9000E+01	0	0.	0.
-1.8000E+01	0	0.	0.
-1.7000E+01	0	0.	0.
-1.6000E+01	0	0.	0.
-1.5000E+01	0	0.	0.
-1.4000E+01	1	0.0200	0.0200
-1.3000E+01	0	0.	0.0200
-1.2000E+01	0	0.	0.0200
-1.1000E+01	0	0.	0.0200
-1.0000E+01	0	0.	0.0200
-9.0000E+00	0	0.	0.0200
-8.0000E+00	2	0.0400	0.0600
-7.0000E+00	3	0.0600	0.1200
-6.0000E+00	5	0.1000	0.2200
-5.0000E+00	2	0.0400	0.2600
-4.0000E+00	3	0.0600	0.3200
-3.0000E+00	1	0.0200	0.3400
-2.0000E+00	2	0.0400	0.3800
-1.0000E+00	5	0.1000	0.4800
0.	4	0.0800	0.5600
1.0000E+00	2	0.0400	0.6000
2.0000E+00	7	0.1400	0.7400
3.0000E+00	1	0.0200	0.7600
4.0000E+00	5	0.1000	0.8600
5.0000E+00	0	0.	0.8600
6.0000E+00	2	0.0400	0.9000
7.0000E+00	1	0.0200	0.9200
8.0000E+00	1	0.0200	0.9400
9.0000E+00	1	0.0200	0.9600
1.0000E+01	1	0.0200	0.9800
1.1000E+01	1	0.0200	1.0000
1.2000E+01	0	0.	1.0000
1.3000E+01	0	0.	1.0000
1.4000E+01	0	0.	1.0000
1.5000E+01	0	0.	1.0000
1.6000E+01	0	0.	1.0000
1.7000E+01	0	0.	1.0000
1.8000E+01	0	0.	1.0000
1.9000E+01	0	0.	1.0000



FUNCTION 14.702 CMBA
MATERIAL TYPE
DATA
VARIABLE
SAMPLING
REPLICATE SAMPLING TIME
MEAN VALUE
MAXIMUM VALUE
MINIMUM VALUE

REPORT NO. 2
4
ERROR (OBSERVED - TRUE)
MASS
REPLICATE
1.1300E+02
3.0575E-02
1.5503E+01
-1.4311E+01

NUMBER OF OBSERVATIONS 50
STANDARD DEVIATION 6.4339E-00
TIME OF MAXIMUM VALUE 1.1300E+02
TIME OF MINIMUM VALUE 1.1300E+02

UPPER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION	0.0 0.25 0.5 0.75 1.0
-2.0000E+01	0	0.	0.	I+
-1.9000E+01	0	0.	0.	I+
-1.8000E+01	0	0.	0.	I+
-1.7000E+01	0	0.	0.	I+
-1.6000E+01	0	0.	0.	I+
-1.5000E+01	1	0.0200	0.0200	I+
-1.4000E+01	1	0.0200	0.0400	I+
-1.3000E+01	0	0.	0.0400	I +
-1.2000E+01	0	0.	0.0400	I +
-1.1000E+01	0	0.	0.0400	I +
-1.0000E+01	3	0.0600	0.1000	I*** +
-9.0000E+00	0	0.	0.1000	I +
-8.0000E+00	2	0.0400	0.1400	I** +
-7.0000E+00	0	0.	0.1400	I +
-6.0000E+00	0	0.	0.1400	I +
-5.0000E+00	5	0.1000	0.2400	I***** +
-4.0000E+00	5	0.1000	0.3400	I***** +
-3.0000E+00	3	0.0600	0.4000	I*** +
-2.0000E+00	4	0.0800	0.4800	I**** +
-1.0000E+00	3	0.0600	0.5400	I*** +
0.	4	0.0800	0.6200	I**** +
1.0000E+00	2	0.0400	0.6600	I** +
2.0000E+00	3	0.0600	0.7200	I*** +
3.0000E+00	3	0.0600	0.7800	I*** +
4.0000E+00	0	0.	0.7800	I +
5.0000E+00	1	0.0200	0.8000	I* +
6.0000E+00	4	0.0800	0.8800	I**** +
7.0000E+00	0	0.	0.8800	I +
8.0000E+00	1	0.0200	0.9000	I* +
9.0000E+00	0	0.	0.9000	I +
1.0000E+01	3	0.0600	0.9600	I*** +
1.1000E+01	0	0.	0.9600	I +
1.2000E+01	0	0.	0.9600	I +
1.3000E+01	1	0.0200	0.9800	I* +
1.4000E+01	0	0.	0.9800	I +
1.5000E+01	1	0.0200	1.0000	I* +
1.6000E+01	0	0.	1.0000	I +
1.7000E+01	0	0.	1.0000	I +
1.8000E+01	0	0.	1.0000	I +
1.9000E+01	0	0.	1.0000	I +

This report of function 14 describes the uncertainty of material balance accountability at time 113.00 (5:00 p.m. on the fifth day of operation) which is just slightly later than the average completion time of the diversion action sequence which is shown in the following report of function 30 to be at time 111.93. The histogram above shows that in 5 of the 50 replications of the diversion attempt, the uncertainty of accountability for material 4 due to measurement error was greater than the 10.0 mass units removed on the average in successful diversion attempts.

We can interpret these results as follows. If, due to possible adversary activity indicated by the MC response signals r1 through r4, a balance of material 4 is closed at the end of the normal operating shift (5 p.m.) on the fifth day, the probability is approximately 0.1 that the measurement uncertainty would completely obscure as much as a 10.0 mass unit discrepancy due to an actual diversion. This could mean that the measurement errors of functions 6 and 11 (set arbitrarily for this example by standard normal deviations of 5 percent of the mean amount of material 4 received in incoming batches) would have to be substantially reduced, or that checking for missing material by accountability measurements should not be used in the event of indicated diversion activity.

[illegible]	REPORT NO 3	
	4	
	ERROR (OBSERVED - TRUE)	
VARIABLE	MASS	
	REPLICATE	
[illegible] TIME	1.3700E+02	NUMBER OF OBSERVATIONS 50
[illegible]	8.4300E-03	STANDARD DEVIATION [illegible]
[illegible] VALUE	2.1191E+01	TIME OF MAXIMUM VALUE [illegible]
[illegible] VALUE	-1.7240E+01	TIME OF MINIMUM VALUE [illegible]

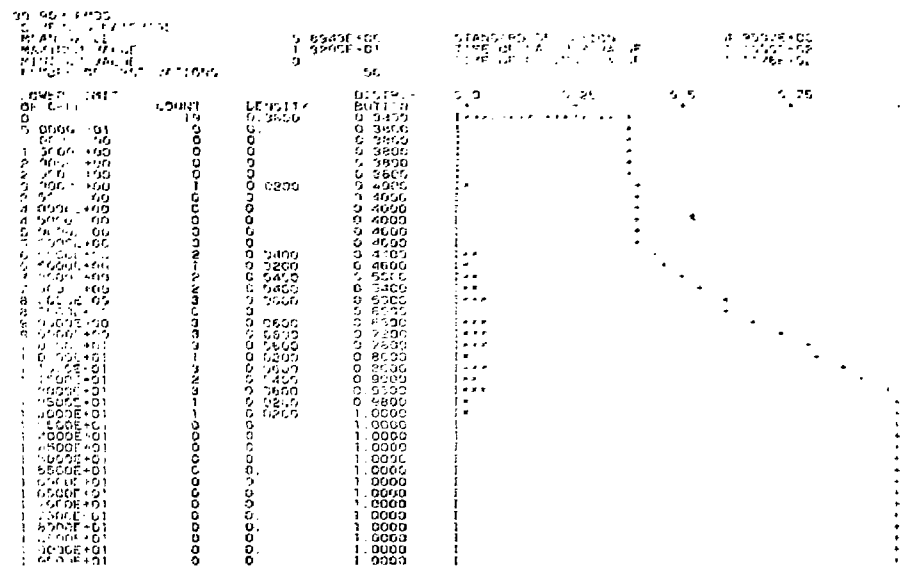
LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
[illegible]	0	0.	0.
[illegible]	0	0.	0.
[illegible]	1	0.0200	0.0200
[illegible]	1	0.0200	0.0400
[illegible]	0	0.	0.0400
[illegible]	1	0.0200	0.0600
[illegible]	0	0.	0.0600
[illegible]	0	0.	0.0600
[illegible]	0	0.	0.0600
[illegible]	1	0.0200	0.0800
[illegible]	4	0.0800	0.1600
[illegible]	1	0.0200	0.1800
[illegible]	0	0.	0.1800
[illegible]	3	0.0600	0.2400
[illegible]	2	0.0400	0.2800
[illegible]	1	0.0200	0.3000
[illegible]	3	0.0600	0.3600
[illegible]	2	0.0400	0.4000
[illegible]	5	0.1000	0.5000
[illegible]	5	0.1000	0.6000
[illegible]	2	0.0400	0.6400
1.07…E+00	0	0.	0.6400
[illegible]	0	0.	0.6400
[illegible]	2	0.0400	0.6800
[illegible]	3	0.0600	0.7400
[illegible]	1	0.0200	0.7600
[illegible]	1	0.0200	0.7800
[illegible]	2	0.0400	0.8200
[illegible]	2	0.0400	0.8600
[illegible]	0	0.	0.8600
[illegible]	1	0.0200	0.8800
[illegible]	3	0.0600	0.9400
[illegible]	0	0.	0.9400
[illegible]	1	0.0200	0.9600
[illegible]	0	0.	0.9600
[illegible]	0	0.	0.9600
[illegible]	0	0.	0.9600
[illegible]	0	0.	0.9600
[illegible]	0	0.	0.9600
[illegible]	2	0.0400	1.0000

0.0 0.25 0.5 0.75 1.0

```
FUNCTION  15 601 TIMR
          NO REPORT

FUNCTION  20 102 IDAS
          NO REPORT

FUNCTION  21 501 INDA
          NO REPORT

FUNCTION  22 503 DEPA
          MEAN TIME OF CONDITION   1.4620E+01
          STANDARD DEVIATION  3.4910E+00
          NUMBER OF OBSERVATIONS        100
          MAXIMUM TIME   2.0951E+01
          MINIMUM TIME   9.1631E+00

FUNCTION  23 504 MODA
          NO REPORT

FUNCTION  24 501 INDA
          NO REPORT

FUNCTION  25 501 INDA
          NO REPORT

FUNCTION  26 502 MAOA
          DIVERTED MATERIAL
           3145      0      0      0      0  2  0          0  0.

FUNCTION  27 501 INDA
          NO REPORT
```

FUNCTION 50 902 RMDS
SEQUENCE COMPLETION TIME
MEAN VALUE 1.1193E+02 STANDARD DEVIATION 1.1515E+00
MAXIMUM VALUE 1.1459E+02
MINIMUM VALUE 1.0967E+02
NUMBER OF OBSERVATIONS 50

LOWER LIMIT OF CELL	COUNT	DENSITY	DISTRIBUTION
1.0000E+02	0	0.	0.
1.0050E+02	0	0.	0.
1.0100E+02	0	0.	0.
1.0150E+02	0	0.	0.
1.0200E+02	0	0.	0.
1.0250E+02	0	0.	0.
1.0300E+02	0	0.	0.
1.0350E+02	0	0.	0.
1.0400E+02	0	0.	0.
1.0450E+02	0	0.	0.
1.0500E+02	0	0.	0.
1.0550E+02	0	0.	0.
1.0600E+02	0	0.	0.
1.0650E+02	0	0.	0.
1.0700E+02	0	0.	0.
1.0750E+02	0	0.	0.
1.0800E+02	0	0.	0.
1.0850E+02	0	0.	0.
1.0900E+02	0	0.	0.
1.0950E+02	1	0.0200	0.0200
1.1000E+02	6	0.1200	0.1400
1.1050E+02	5	0.1000	0.2400
1.1100E+02	5	0.1000	0.3400
1.1150E+02	11	0.2200	0.5600
1.1200E+02	3	0.0600	0.6200
1.1250E+02	9	0.1800	0.8000
1.1300E+02	6	0.1200	0.9200
1.1350E+02	2	0.0400	0.9600
1.1400E+02	1	0.0200	0.9800
1.1450E+02	1	0.0200	1.0000
1.1500E+02	0	0.	1.0000
1.1550E+02	0	0.	1.0000
1.1600E+02	0	0.	1.0000
1.1650E+02	0	0.	1.0000
1.1700E+02	0	0.	1.0000
1.1750E+02	0	0.	1.0000
1.1800E+02	0	0.	1.0000
1.1850E+02	0	0.	1.0000
1.1900E+02	0	0.	1.0000
1.1950E+02	0	0.	1.0000



The histogram generated by SSP RMDS function 30 shows the

observed distribution of the quantity of material removed over the 50 nonlucky diversion attempts. In 36 percent (18 of the 50 replications) of the diversion attempts no material was removed. The distribution of material removed in successful attempts may be seen to have a mean of approximately 10.0 mass units as specified by the parameters of function 20

FUNCTION 40 703 MNTR
NO REPORT

FUNCTION 41 703 MNTR
NO REPORT

FUNCTION 42 703 MNTR
NO REPORT

FUNCTION 43 703 MNTR
NO REPORT

FUNCTION 44 703 MNTR
NO REPORT

FUNCTION 45 703 MNTR
NO REPORT

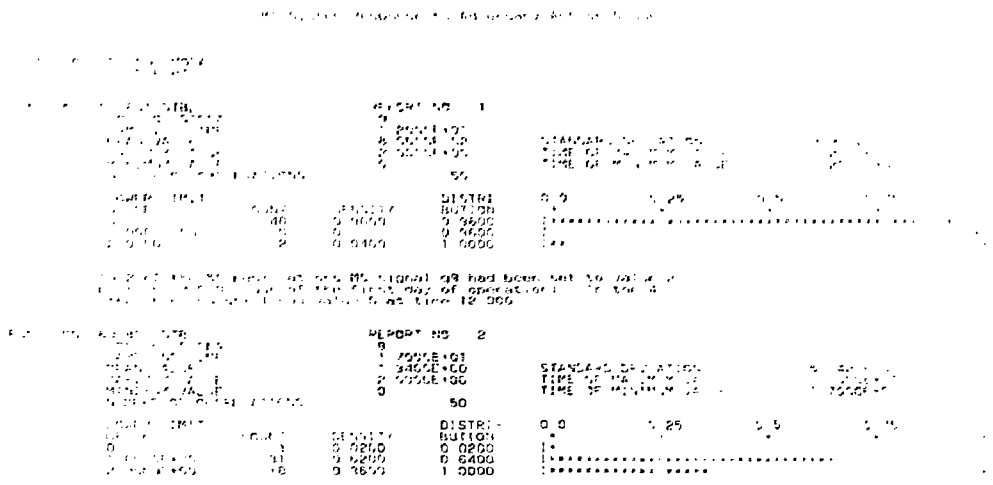
FUNCTION 46 703 MNTR
NO REPORT

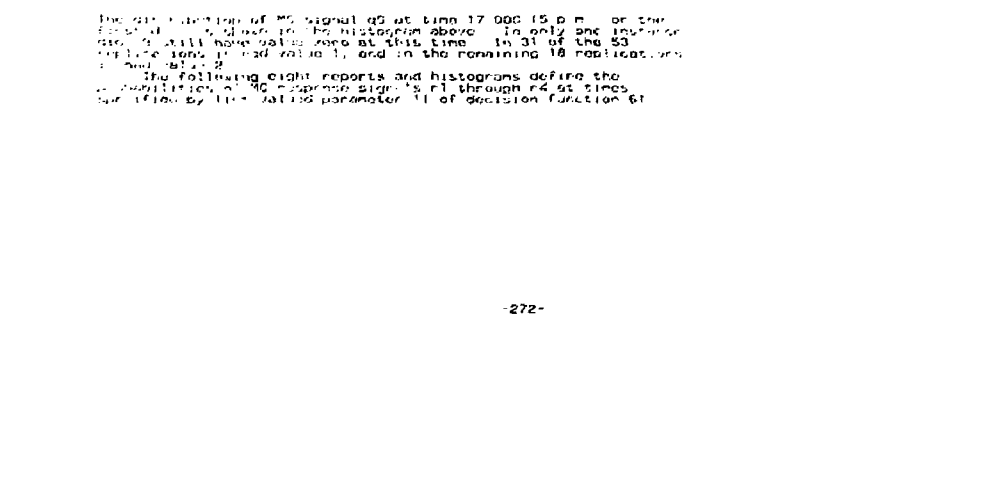
FUNCTION 47 703 MNTR
NO REPORT

FUNCTION 50 602 SCAS
NO REPORT

FUNCTION 51 501 INDA
NO REPORT

FUNCTION 52 504 MODA
NO REPORT





```
[illegible]  61 801 DTBL                         REPORT NO   [illegible]
   CONTROL SIGNAL                                1
   SAMPLING TIME                                 1 7000E+01
   MEAN VALUE                                    2 0000E-02       STANDARD DEVIATION          [illegible]
   MAXIMUM VALUE                                 1 0000E+00       TIME OF MAXIMUM VALUE       [illegible]
   MINIMUM VALUE                                 0                TIME OF MINIMUM VALUE       [illegible]
   NUMBER OF OBSERVATIONS                              50

   LOWER LIMIT                                         DISTRI-    0 0        0 25       0 5
   OF CELL           COUNT      DENSITY                BUTION      +          -          +          +          +
   0                    49      0 9800                 0 9800     I*******************  *****  ****          *  *
   1 0000E+00            1      0 0200                 1 0000     I*

FUNCTION  61 801 DTBL                         REPORT NO   2
   CONTROL SIGNAL                                1
   SAMPLING TIME                                 4 1000E+01
   MEAN VALUE                                    0                STANDARD DEVIATION          [illegible]
   MAXIMUM VALUE                                 0                TIME OF MAXIMUM VALUE       [illegible]
   MINIMUM VALUE                                 0                TIME OF MINIMUM VALUE       4 1000E+01
   NUMBER OF OBSERVATIONS                              50

   LOWER LIMIT                                         DISTRI-    0 0        0 25       [illegible]      75
   OF CELL           COUNT      DENSITY                BUTION      +          -          +          +          +
   0                    50      1 0000                 1 0000     I*****************************  *******  *************I
   1 0000E+00            0      0                      1 0000     I                                                     +

FUNCTION  61 801 DTBL                         REPORT NO   3
   CONTROL SIGNAL                                2
   SAMPLING TIME                                 1 7000E+01
   MEAN VALUE                                    6 2000E-01       STANDARD DEVIATION          4 8539E-01
   MAXIMUM VALUE                                 1 0000E+00       TIME OF MAXIMUM VALUE       1 7000E+01
   MINIMUM VALUE                                 0.               TIME OF MINIMUM VALUE       1 7000E+01
   NUMBER OF OBSERVATIONS                              50

   LOWER LIMIT                                         DISTRI-    0.0        0 25       0 5        0 75       1 0
   OF CELL           COUNT      DENSITY                BUTION      +          -          +          -          +
   0                    19      0 3800                 0 3800     I*******************
   1 0000E+00           31      0 6200                 1 0000     I*******************************                  +
```

REPORT NO 4

	4
	4 1000E+01
	5 2000E-01
	1 0000E+00
	0
	50

STANDARD DEVIATION 4 6539E-01
TIME OF MAXIMUM VALUE 4 1000E+01
TIME OF MINIMUM VALUE 4 1000E+01

	COUNT	DENSITY	DISTRIBUTION
	19	0 3800	0 3800
	31	0 6200	1 0000

0.0 0.25 0.5 0.75 1.0

REPORT NO 5

	1
	6 9000E+01
	0
	0
	0
	50

STANDARD DEVIATION 0
TIME OF MAXIMUM VALUE 0
TIME OF MINIMUM VALUE 6 9000E+01

	COUNT	DENSITY	DISTRIBUTION
	50	1 0000	1 0000
	0	0	1 0000

0.0 0.25 0.5 0.75 1.0

REPORT NO 6

	3
	1 1300E-02
	5 2000E-01
	1 0000E+00
	0
	50

STANDARD DEVIATION 4 6539E-01
TIME OF MAXIMUM VALUE 1 1300E+02
TIME OF MINIMUM VALUE 1 1300E-02

	COUNT	DENSITY	DISTRIBUTION
	19	0 3800	0 3800
1 0000E+00	31	0 6200	1 0000

0.0 0.25 0.5 0.75 1.0

```
FUNCTION   61 BC1 DTBL                      REPORT NO    7
           CONTROL SIGNAL                   4
           SAMPLING TIME                    8 9000E+01
           MEAN VALUE                       0.                   STANDARD DEVIATION          0
           MAXIMUM VALUE                    0                    TIME OF MAXIMUM VALUE       0
           MINIMUM VALUE                    0                    TIME OF MINIMUM VALUE       8 9000E+01
           NUMBER OF OBSERVATIONS                     50

           LOWER LIMIT                              DISTRI-      0.0        0.25        0.5        0.75        1.0
           OF CELL          COUNT     DENSITY       BUTION        +          +           +          +           +
           0                   50     1 0000        1 0000       I********************************************** I
           1 0000E+00           0     0.            1 0000       I                                               +

FUNCTION   61 201 DTBL                      REPORT NO    8
           CONTROL SIGNAL                   4
           SAMPLING TIME                    1.1300E+02
           MEAN VALUE                       3.8000E-01           STANDARD DEVIATION          4 8539E-01
           MAXIMUM VALUE                    1 0000E+00           TIME OF MAXIMUM VALUE       1 1300E+02
           MINIMUM VALUE                    0.                   TIME OF MINIMUM VALUE       1 1300E+02
           NUMBER OF OBSERVATIONS                     50

           LOWER LIMIT                              DISTRI-      0.0        0.25        0.5        0.75        1.0
           OF CELL          COUNT     DENSITY       BUTION        +          +           +          +           +
           0                   31     0 6200         6200        I*******************************
           1 0000E+00          19     0 3800        1 0000       I*******************                            +
END
MINIMUM NUMBER OF FREE LOCATIONS =   8962
```

REFERENCES

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3. O. J. Dahl, E. W. Dijkstra, and C. A. R. Hoare, Structured Programming, Academic Press, New York, 1972

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5. R. B. Hollstien, Material Control System Simulator: Program Reference Manual, Lawrence Livermore Laboratory, January 1978

6. S. L. Pollack, H. T. Hicks, and W. J. Harrison, Decision Tables: Theory and Practice, Wiley-Interscience, New York, 1971

Appendix A
RANDOM VARIABLES

Random variables of MCSS functions are specified by an integer value indicating the probability distribution type and the numerical values of statistics associated with the probability distribution. The following distribution types and statistics may be used in the specification of those parameters that define random variables with optional probability distributions:

Uniform
distribution type: 1
statistics: mean and maximum deviation from the mean value

Normal
distribution type: 2
statistics: mean and standard deviation

Truncated normal
distribution type: 3
statistics: mean, standard deviation, maximum value, minimum value

Exponential
distribution type: 4
statistics: mean

Appendix B
MATERIAL DATA STRUCTURE

TYPE

Material types are identified by positive, non-zero integer names. Any number of different material types may exist simultaneously in a model system, and their names need not begin at 1 nor be contiguous.

QUANTITY

Distinct quantities of each material type are represented by an integer count of discrete items and/or the real value of material mass.

CONTAINMENT

The type, count, and mass of distinguishable material quantities are stored in a recursive data structure that represents the transitive enclosure of materials in various types of containment configurations. The structure of material data blocks is shown in Figure B.1, and linkage of adjacent blocks in the material data structure is shown in Figure B.2. The first word of each material data block points to additional data that may describe physical, chemical, or other properties of the material represented by the data block. The second word contains the integer 8, the number of useable locations in the block allocated from free store. The third, fourth, fifth, and sixth words contain pointers to the adjacent blocks in the material data structure as shown in Figure B.2. The seventh word contains an integer 0, 1, or 2 indicating the containment level of the

material quantity. The last three words of material data blocks contain respectively the integer material type, the count of discrete items, and the mass of material represented.

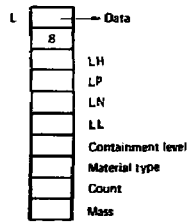

FIGURE B.1 Material data block.

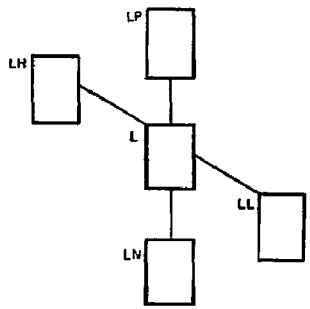

FIGURE B.2 Linkage of adjacent material data blocks.

A recursive definition of material containment is shown in Figure B.3. In any container A there may be any number of bulk materials 1, 2, ... and any number of containers B, C, ... The bulk materials in any container are assumed to be homogeneously mixed, so they can be removed only in combination with other bulk materials in the container at the time of removal. The block chain data structure representing the recursive definition of material containment is shown in Figure B.4. To simplify the figure, only the 7th and 8th words of material data blocks are shown; multi-way linkages defined by pointers LH, LP, LN, and LL are indicated by the lines connecting the simplified material data blocks, and locations LA, LBULKA, etc. are the locations of the first word of each material data block.

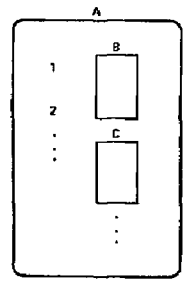

FIGURE B.3 Recursive definition of material containment.

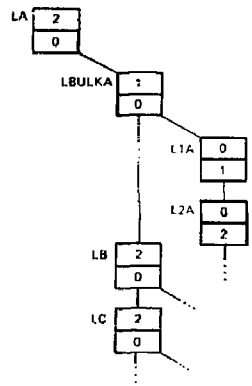

FIGURE B.4 Data structure representing the recursive definition of material containment in Figure B.3.

The block at LA represents all of the material in container A. The containment level is 2 because container A "contains" other containers. The material type is null (indicated by material type zero, which is otherwise an illegal material type code) because container A may contain more than one type of material. The last two words of the material data block at LA contain respectively the count of all discrete material items of all types in container A and the total mass of all materials of all types in container A.

The material data block at LBULKA represents all of the bulk materials

in container A. Its containment level of 1 distinguishes the collection of bulk materials in container A from containers B, C, .. and indicates that the block is one level above blocks that represent specific material quantities. The last two words of the block at LBULKA contain respectively the count of all discrete material items of all types in bulk form within container A but outside containers B, C, ... and the total mass of all materials of all types in bulk form within container A but outside containers B, C, ...

The blocks at L1A, L2A, ... represent the distinct types of bulk material in container A but outside containers B, C, ... The containment level 0 of these blocks indicates that the material they represent can not be further subdivided into lower hierarchical levels of containment and by definition represent a quantity of a specific material type.

The material data blocks at LB, LC, ... represent the containers within container A and are roots of subtrees which have the recursive data structure shown in Figure B.4. Thus, each of the containers B, C, ... may contain bulk materials and/or other containers, etc. etc. to any depth of nested material containment and data structure.

Figure B.3 and 4 represent the most general material containment configuration which subsumes the special containment configurations shown in Figures B.5 through B.9.

Figure B.5 shows a schematic representation and the data structure for a container A of bulk materials 1, 2, ... In this case, the LM pointer in the fifth word of the material data block at LBULKA contains a zero indicating there are no containers within container A.

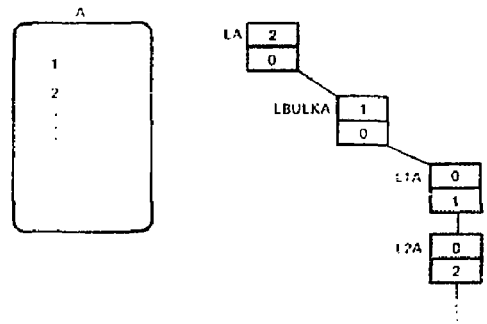

FIGURE B 5 Container of bulk materials 1, 2, ...

A container that contains only other containers is illustrated in Figure B.6. Here the LL pointer of the material data block at LA points to the block at LB which represents the first of containers B, C, ...

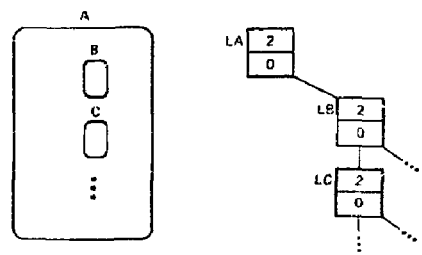

FIGURE B.6 Container of other containers.

Figure B.7 shows the representation of an empty container. The containment level is 2 because the container could contain other containers. The linkage pointers, material type, count, and mass of the data block at LA are set to zero.

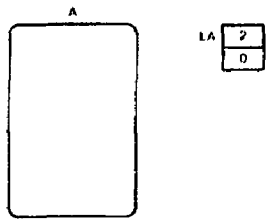

FIGURE B.7 Empty container.

Figure B.8 shows the representation of free bulk materials 1, 2, ... that are not in a container. The data structure representing these materials is at location LBULK. Free bulk materials are represented by the same sub-tree data structure that represents bulk materials within containers.

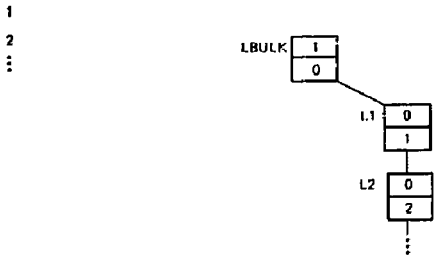

FIGURE B.8 Free bulk materials 1, 2, ...

The containment configuration and data structure representing free containers B, C, ... is shown in Figure B.9. Free containers are represented by the same sub-tree data structure that represents containers within other containers.

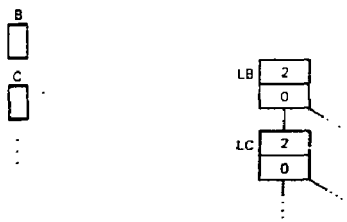

FIGURE B.9 Free containers.

EXAMPLE

In a container A, as shown in Figure B.10, there are four bulk

materials 1, 2, 5, and 6 and four other containers B, C, D, and E. Containers B and C hold the same amounts of bulk materials 3 and 4, and D and E contain the same amounts of bulk materials 7 and 8. Odd material types are counted as discrete items, even material types are measured in mass units, and the amounts of all materials are indicated in Figure B.10.

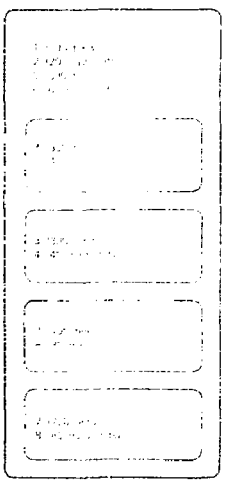

FIGURE B.10 Example material containment configuration.

The data structure for this example is shown in Figure B.11, where the material data blocks now include the last two words that contain the count

and mass of material represented. As before, the pointers to adjacent blocks are represented by the lines that connect the blocks. And locations indicated at the top left of each block are locations of the first word of the ten-word material data blocks allocated by control program ASTORE

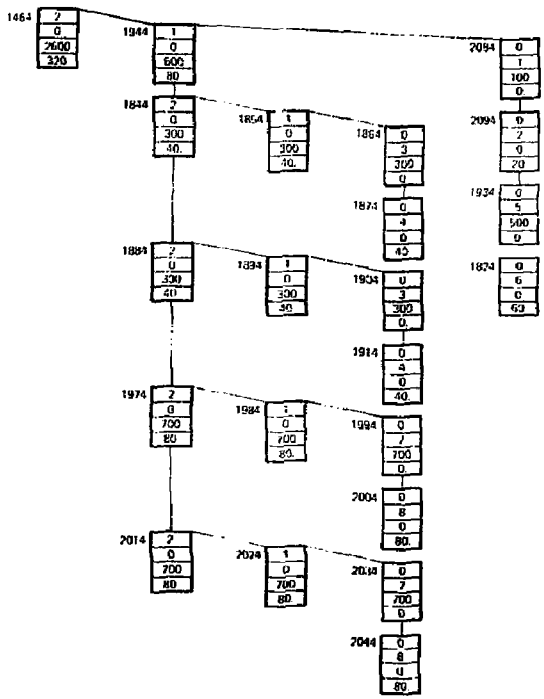

FIGURE B.11 Data structure for the example material containment configuration in Figure B.10.

Figure B.12 shows the material data structure of the example containment configuration as it is printed out by control program WRMD. From left to right, each line of Figure B.12 contains the following:

L	Location of a material data block.
LH, LP, LN, LL	Locations of blocks adjacent to the block at L.
Level	Containment level of the block at L.
Type	Material type represented by the block at L.
Count	Item count of the quantity of material represented by the block at L.
Mass	Mass of the quantity of material represented by the block at L.

L	LH	LP	LN	LE	Level	Type	Count	Mass
1524	0	1334	0	0	0	6	0	0.000000E+00
1334	0	2474	1524	0	0	5	500	0.
2894	0	2884	1934	0	0	2	0	0.000000E+00
2084	1944	0	2334	0	0	1	100	0.
1674	0	1484	0	0	0	4	0	0.000000E+00
1664	1654	0	1674	0	0	3	300	0.
1854	1844	0	0	1454	1	0	300	0.000000E+00
1914	0	1904	0	0	0	4	0	0.000000E+00
1904	1894	0	1914	0	0	3	300	0.
1894	1884	0	0	1904	1	0	300	0.000000E+00
2004	0	1994	0	0	0	5	0	0.000000E+00
1974	1964	0	2024	0	0	7	700	0.
1964	1974	0	0	1994	1	0	700	0.000000E+00
2044	0	2034	0	0	0	5	0	0.000000E+00
2034	2024	0	2044	0	0	7	700	0.
2024	2014	0	0	2034	1	0	700	0.000000E+00
2014	0	1974	0	2024	2	0	700	0.000000E+00
1974	0	1654	2014	1954	2	0	700	0.000000E+00
1654	0	1844	1974	1394	2	0	300	0.000000E+00
1844	0	1944	1584	1654	2	0	300	0.000000E+00
1944	1464	0	1844	2084	1	0	600	0.000000E+00
1464	0	0	0	1344	2	0	2600	0.000000E+00

FIGURE B.12 Material data for the example material containment configuration printed by control program WRMD.

Appendix C
STIMULI GENERATED BY ADVERSARY ACTIONS

Action functions may generate various types of stimuli as specified by the user. The stimuli are specified by list valued parameters of the action functions and must be consistent with the monitor functions assigned to them. At present, two types of stimuli have been defined and are described below. Other types may be defined as required by future addition of monitor functions.

STIMULUS TYPE 1: Rectangular Pulse Signal

This stimulus is a rectangular pulse signal characterized, as shown in Figure C.1, by a time delay after which the leading edge of the pulse follows the beginning of the adversary action that generates the stimulus, by the duration of the stimulus signal, and by the intensity of the stimulus.

Specifications of type 1 stimuli are supplied by the user as list valued parameters of action functions. The number of the monitor function that senses the stimulus in the model system is first specified. Then the stimulus type (integer 1) is followed by the desired delay time distribution type (see Appendix A) and delay time statistics, the duration time distribution type and statistics, and the intensity distribution type and statistics. For example, the list

41 1 1 .5 .5 1 .5 .5 3 1. .2 100. 0.

specifies that a stimulus of type 1 is to be generated and sensed by monitor

function 41. The delay and duration times are uniformly distributed (distribution type 1) with mean value and maximum deviations of 0.5. The stimulus intensity has a truncated normal distribution (type 3) with mean value 1.0, standard deviation 0.2, maximum value 100.0, and minimum value 0. The parameter list above specifies the second of two stimuli generated by the SOI INDA action function 21 of the MC System Response to Adversary Action Sequences example of Section 4.

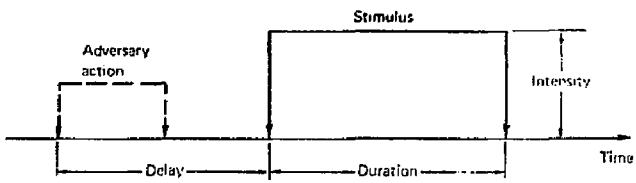

FIGURE C.1 Stimulus type 1: rectangular pulse signal.

STIMULUS TYPE 2: Absence of Acquired Material

Stimuli of this type may be generated by material acquisition actions that remove material from the normal process containment. These stimuli will be sensed by monitor functions that represent material loss detection devices or subsystems based on either conventional material accounting methods or estimation techniques now under development.

Type 2 stimuli are characterized by a delay time, removal time, and quantity of material removed as illustrated in Figure C.3. The delay time is the interval following the start of the material acquisition action after which removal of material begins. The removal time is that required to

actually acquire the material from the process containment. And the quantity of material is the total amount removed during the acquisition action. Notice that the sum of the delay time and removal time may not exceed the duration of the material acquisition activity

The monitor function number, stimulus type (integer 2), delay distribution type and statistics, removal time distribution type and statistics, and the quantity of material acquired are entered as list valued parameters of action functions in the manner described above for stimulus type 1.

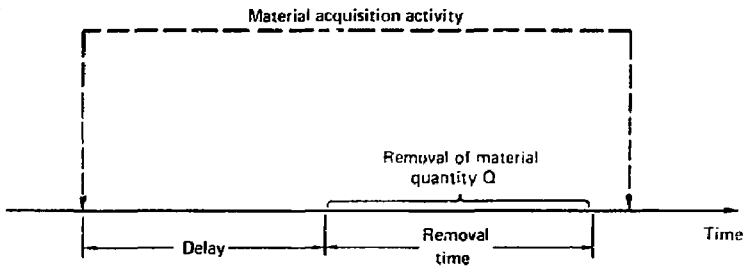

FIGURE C.3 Stimulus type 2: absence of acquired material.