WASTE ISOLATION PILOT PLANT

Sandia National Laboratories

Software Cover Sheet

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(1) Choose from classifications in Appendix A.

(2) If there are more than one preparer or reviewer, each person's responsibilities shall be delineated in the document. Each reviewer shall complete a reviewer's form which applies to the document reviewed, or document their review in a memorandum. The review documentation shall be included in the document. Attach additional Software Cover Sheets if there are more than three Code Sponsor/preparers or reviewers.

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WIPP PA

User's Manual

for

LHS

Version 2.41

Version 1.00

WPO #30732

JANUARY 31, 1996

CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

This document is the User's Manual for the Latin Hypercube Sampling code, LHS, (version number 2.41) in the context in which it is envisaged for the 1996 Waste Isolation Pilot Project (WIPP) Compliance Certification Application (CCA) Performance Assessment (PA), and in that context only. LHS is the WIPP's constrained-Monte-Carlo-sampling code. Several WIPP codes, including LHS, are exercised sequentially as triads of codes. In each such case, the three codes are QAed individually, although they are exercised in sequence, as a group. It is recommended that they be learned as a group. The main code, treated herein, is called LHS. Its preprocessor code is called PRELHS, and its post processor is called POSTLHS. This manual identifies LHS's sponsors and its expert consultants (Section 1). It describes the code's WIPP-PA purposes and functions (Section 2), provides recommended user training (Section 3), outlines the code's mathematical basis and numerical methods (Section 4), its capabilities and limitations (Section 5), describes user interactions (Section 6), input files (Section 7), error messages (Section 8), and output files (Section 9), and provides examples of relevant input, output, and debug files in its Appendices as well as calculations of interest (distributed throughout).

1.1 Software Identifier:

Code Name:	LHS, a constrained Monte-Carlo sampling code.
WIPP Prefix:	LHS2
Version Number:	2.41
Date:	03/06/96
Platform:	FORTRAN 77 for OpenVMS AXP, ver. 6.1, on a DEC Alpha

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2.0 FUNCTIONAL REQUIREMENTS

Section 2.1 lists LHS's WIPP-relevant Functional Requirements as taken from the code's Requirements Document (known as the RD/VVP document).

2.1 Functional Requirements of LHS

LHS is required to:.

1. Perform Latin Hypercube Sampling.

2. Generate a data distribution for each parameter that is to be sampled, including: NORMAL, LOGNORMAL, UNIFORM, LOGUNIFORM, CUMULATIVE USER DISTRIBUTION, DATA USER DISTRIBUTION, DELTA USER DISTRIBUTION, STUDENT, LOGSTUDENT, and TRIANGULAR.

3. Correctly use the general-input data sets used for WIPP-PA analysis, namely: TITLE, NOBS, RANDOM SEED, OUTPUT.

4. Generate a correlation matrix as requested.

3.0 REQUIRED USER TRAINING AND/OR BACKGROUND

To exercise LHS, users should have basic knowledge of (1) OpenVMS, (2) Digital Command Language, and (3) an overall understanding of the WIPP PA database, which is used in virtually every WIPP code set (Rechard, 1992; Rechard et al. 1992). They should also have (4) access to the WIPP cluster of Alpha computers with an OpenVMS AXP (ver 6.1) operating system, or their functional equivalents.

To manipulate and/or interpret the results of LHS, users should have (1) a basic understanding of introductory probability theory, and especially sampling theory and probability distribution functions, (2) a fairly complete, if basic, overview understanding of the WIPP PA process, and especially of, the uncertain physical parameters that are used, the data distributions they lead to, how distributions for different physical parameters are either related or not related, the rational basis of uncertainty sampling methods, and the use of input-data vectors in WIPP PAs (WIPP PA Dept. [5 volumes], 1992), and (3) an operational familiarity with and general understanding of LHS's preprocessor code, PRELHS (see the QA document WPO#: 30714).

4.0 DESCRIPTION OF THE MODELS AND METHODS

4.1 Description of the Model

LHS neither models physical phenomena nor solves differential equations that model physical process. It's principal role in WIPP PAs is to sample, using Latin-Hypercube Sampling methods, distributions that represent reasonable values of WIPP input-parameter data. LHS treats each parameter independently, but permits user-specified correlations (restricted pairings) between parameters. Latin Hypercube sampling reduces the minimum number of sample vectors [nv] required to assure representative sampling. The minimum is roughly [(4/3) na], where na is the number of uncertain parameters.

More specifically, LHS is designed to generate multivariate samples by a constrained randomization method known as Latin-hypercube sampling. LHS is capable of sampling using unconstrained random methods, but such applications are unforeseen in regulatory applications.

The situation generally addressed by LHS is the following. We are given a variable of interest, Y, that is a dependent function of several other variables, including a discrete set of physical parameters $X_1, X_2,...,X_k$. The Xs are independent, but may be pairwise correlated. However, due to unresolvable uncertainties, the physical parameters are not specifiable as single, unique numbers. Rather, they are characterized by ranges or distributions of values together with probabilities of occurrence associated with the values included in the distributions. These so-called distributions of uncertain data (i.e., one for each of the X_ks) are specified in the WIPP PA database. The function that maps the Xs into Y may be quite complicated. For example, in the case at hand, the function involved may be any of the WIPP-PA computer models (in which case, Y could be any of the output CAMDAT Data-Base [CDB] files they produce) or it may be the entire collection of WIPP-PA computer models in sequence (in which case Y would be a total-release, complementary cumulative distribution function). The question of central interest is: How does Y change when the k X's vary over their ranges of allowable values according to a given joint probability distribution?

The conventional approach to the above question is provided by Monte Carlo sampling. By sampling repeatedly from the given joint-probability-density function of the X's and evaluating Y for each sample, the distribution of Y, its mean, percentiles, etc., can be estimated. However, Monte-Carlo sampling is inefficient in the sense that most of its samples will be taken from the higher probability-of-occurrence portions of the distributions, which makes sense. Thus, extreme values, which usually reside toward the outer wings of the distributions, tend to be ignored for all but very large samples. To remedy that shortcoming, an alternative, so-called "constrained sampling system" was introduced. The particular system selected is known as Latin-Hypercube sampling.

In Latin-Hypercube sampling, one selects n different values of each of k variables $X_1, ..., X_k$, but one does not sample according to the joint probability distribution, as would be the case for Monte-Carlo sampling. Rather, the sampling is as follows: The range of each variable is divided into n non-overlapping intervals. To accomplish that, the probability axis of the cumulative probability distribution of that variable is divided into n bands of equal width, where n is the number of samples to be made (see Figure 1). The n bandwidths of equal change in probability are then reflected through the cumulative probability distribution function so as to divide the parameter axis into n non-overlapping but unequal (in width) intervals of parameter values. One value of the parameter from each such interval is selected at random with respect to the probability density in that interval. Thus, one acquires n samples of that parameter with absolute certainty that samples from the wings of the distribution will be included.

It remains only to combine the samples so as to form n *different* sets of k-many variables. That can be accomplished as a fully random process, as follows: the n values obtained for the first parameter, X_1, are paired in a random manner (equally likely combinations) with the n similarly-sampled values of X_2. These n pairs are combined in the same random manner with the n sampled values of X_3 to form n triplets, and so on, until n k-tuplets are formed. The n k-tuplets comprise the Latin-Hypercube sample. LHS is also capable of pairing parameters so they are correlated by rank. That feature is absolutely necessary because certain parameter pairs are indeed correlated in nature. For example, it would be wholly aphysical to pair high porosities with low permeabilities, or vice versa. It is a well known fact that porosity and permeability are usually correlated in nature. Other WIPP parameter pairs are also correlated in nature. It is convenient to treat the n k-tuplets as an (n x k) matrix of input data where the ith row contains one specific sampled value for each of the k input variables and can therefore be used to specify completely a sampled realization of the input data for the ith run of the computer model. There are, of course, many details in actual practice. For example, the 1.0% probability wings are often clipped from normal distributions to make them numerically more manageable. Without that precaution, sampled values would lie between plus and minus infinity. Details are presented in full by Iman and Shortencarrier (1984).

4.2 DESCRIPTION OF THE METHODS

LHS performs Latin-hypercube sampling on input data furnished directly from PRELHS's output transfer file. Once all input-file information has been successfully read, the execution keywords, data-distribution information, and distribution correlation-structure information are echoed to LHS's output files for reference. If the input file specifies a distribution correlation structure, the correlation matrix will be echoed and checked to assure that it is positive definite. The Cholesky factorization is then computed. It will be used subsequently in the process that induces the desired correlation structure. Once that is completed, subroutines will be called to generate each requested distribution in the order in which it is listed in the input file.

For the certification calculation, the distribution types that may be generated are: NORMAL, LOGNORMAL, UNIFORM, LOGUNIFORM, CUMULATIVE USER DISTRIBUTION, DATA USER DISTRIBUTION, DELTA USER DISTRIBUTION, STUDENT, LOGSTUDENT, and TRIANGULAR.

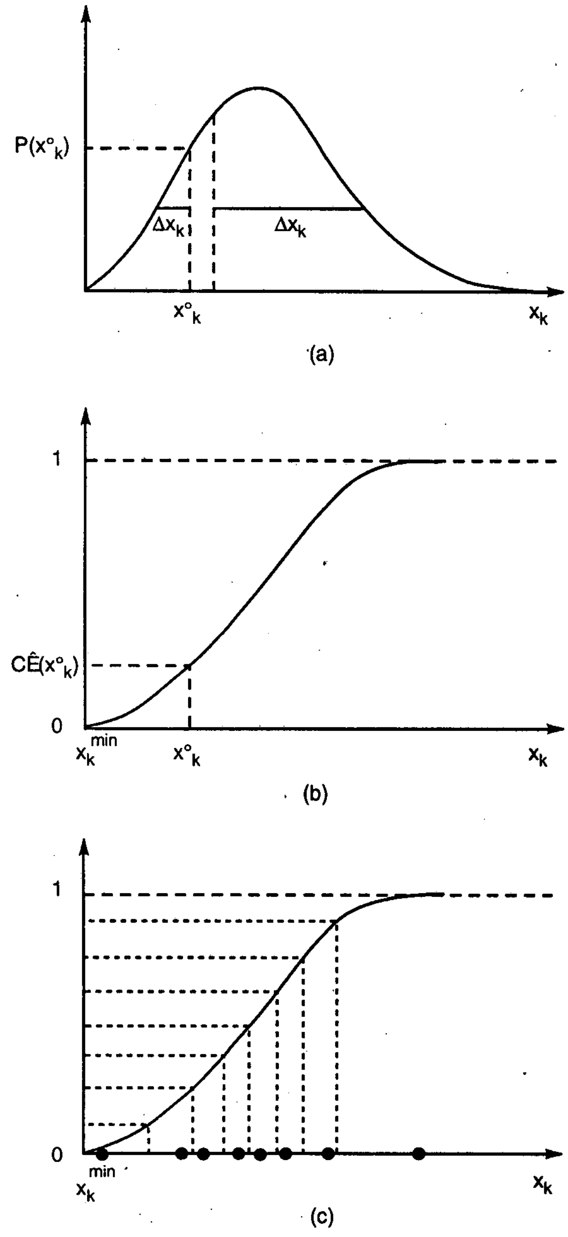

Figure 1. Graphical Representation of the LHS Sampling Technique for a Single Uncertain Variable x_k, where k = 1, 2, ..., N. The uncertain variable is depicted in part (a) as nearly normally distributed. $P(x^*_k)\Delta x$ is the probability that the value of the uncertain parameter lies between x^*_k and $x^*_k + \Delta x$. The integral of the part-(a) distribution is shown in part (b). It is the cumulative distribution function (CDF). The ordinate represents the probability that x_k is less than or equal to the value of the abscissa. In LHS sampling, the ordinate of the CDF (part (c)) is divided into n equally-sized bins. For simplicity, n is here taken to be 8. In the 1992 PA, n was 70. Those bins are reflected through the CDF to the abscissa, where they form n unequally-sized bins. One value of the abscissa is selected randomly from each bin. These are depicted as solid dots on the x axis. The dots are the 8, LHS-sampled values of the uncertain parameter x_k.

In addition, LHS is capable of generating BETA, UNIFORM*, LOGUNIFORM*, HISTOGRAM USER, EXPONENTIAL, RAYLEIGH, and RAYLEXP distributions, but their use is not anticipated in certification calculations and consequently they will not be discussed herein.

When all the distributions given in the input file have been sampled, subroutines are called to arrange the sampled outcomes for each distribution type according to the correlation structure specified in the input file. The completed sample is then written to the output files.

Two output files are created. One ASCII output file contains the values of all of the distribution samples on a vector-by-vector basis. The other ASCII output file contains echoed input-file information, the raw values for the sampled-distribution outcomes in tabular format for each distribution type, and tables of rank values for the sampled distribution outcomes. Depending on the output keywords specified, additional output tables may be generated showing raw and rank correlation tables for the sampled distributions, and histogram plots of each sampled distribution. Included with the distribution histograms is a listing of statistical information applicable to the distribution portrayed in the plot.

Each distribution is sampled in a slightly different way, but the basic process used is the same for all. It is the sampling process outlined above in terms of a normal distribution and described in full by Iman and Shortencarrier (1984).

5.0 CAPABILITIES AND LIMITATIONS INHERENT IN THE SOFTWARE

LHS is capable of performing Latin-hypercube sampling, a form of stratified Monte Carlo sampling. It can sample 17 distribution types, although only 10 of those are contemplated for use in the WIPP PA certification calculations. The chosen 10 are: NORMAL, LOGNORMAL, UNIFORM, LOGUNIFORM, CUMULATIVE USER, DATA USER, DELTA USER, STUDENT, LOGSTUDENT, and TRIANGULAR distributions. The other seven distribution types (which LHS can sample, but which are *not* contemplated for WIPP-PA certification calculations) are BETA, UNIFORM*, LOGUNIFORM*, HISTOGRAM USER, EXPONENTIAL, RAYLEIGH, and RAYLEXP.

For purposes of the WIPP PA certification calculations, sampled values for STUDENT and LOGSTUDENT distributions are constrained to be no smaller than the smallest input value and no larger than the largest input value, even though those values represent 1st an 99th percentiles.

To execute, LHS reads the ASCII text output transfer file exactly as it was produced by PRELHS (see the WIPP PA User's Manual for PRELHS, Version 2.10; WPO#: 30714. [1996]). Contained in that file are input records describing the various types of distributions to be generated and keywords used to control the run, including, for example: TITLE, NOBS, RANDOM SEED, and OUTPUT.

LHS is capable of generating a correlation matrix of sampled distribution data as directed by input from PRELHS's ASCII text transfer file. Specific keywords that can be read and acted upon by LHS, but will *not* be used for the certification calculation, are: NREPS, RANDOM PAIRING, and RANDOM SAMPLE.

LHS produces two ASCII output files during each run. (i) The main ASCII output file serves solely as the input control file for POSTLHS. It contains echoed input file information, the raw values for the sampled distribution outcomes in tabular format for each distribution type, and tables of rank values for the sampled distribution outcomes. Depending on the keywords provided, additional output tables may be present showing raw and rank correlation tables for the sampled distributions, and histogram plots of each sampled distribution. Included with the distribution histograms is a listing of statistical information applicable to the distribution portrayed in the plot. (ii) The secondary ASCII text output file contains the raw sampled distribution data on a vector-by-vector basis. No other information is present in the second file.

LHS has considerable error-checking capability. It performs a number of internal checks to ensure that execution keywords and distribution input parameters have been specified correctly. In the event that an improper specification is detected, an appropriate message is printed and the execution of the program is terminated.

LHS is programmed using ANSI X3.9-1978 FORTRAN 77, except that comments are written in lower-case characters. At present, LHS is limited to the generation of 100 parameter distributions, 10,000 outcome vectors for a single sampling run, and 50 distribution correlations specified in the input file. These limits may be increased, but the code would have to be recompiled.

6.0 USER INTERACTIONS WITH THE SOFTWARE

LHS requires the user to specify the names of (i) certain already-existent input files and of (ii) the output files the code will create as a result of being exercised. Before reviewing the methods by which LHS is exercised, we will discuss in the subsection that follows the file specification requirements of LHS.

6.1 LHS's Input/Output File Structure

The section that follows is a brief discussion of LHS's input and output files.

6.1.1 LHS's Input TEXT TRANSFER File

LHS's input file is, verbatim, the ASCII text output file from PRELHS. LHS does have the possibility of running with a user-generated input file, but **that option will not be used for regulatory calculations and therefore it will not be discussed herein.** LHS's input file is thus dual purpose. It serves (i) as a control file that directs LHS's function by specifying the code-execution keywords in a format suitable for direct usage by LHS, and (ii) as a data file that provides the parameter-distribution data on which LHS will operate.

An example of an LHS input file is the PRELHS output transfer file :

LHS2_T1.INP .

It is described in detail in Section 7.0, below, and listed in full in Appendix A.

6.1.2 LHS's Output TEXT File

LHS's results are written to an ASCII text file, which, in turn, is forwarded to LHS's post processor. It contains the outcomes of the Latin-Hypercube sampling procedure, it echoes LHS's input file, and it shows parameter-correlation tables and histogram plots of each sampled distribution.

An example of LHS's output text file is given in:

LHS2_T1.OUT .

That file is described in detail in Section 9.0, below, and listed in full in Appendix B.

6.1.3 LHS's Output DEBUG File

The optional output debugging text file contains the actual numerical values LHS produces for each sampled parameter, on an outcome-by-outcome basis. The information in this file is the same as that available in the output ASCII text file, but without the inclusion of descriptive text or plots.

An example of a LHS debugging text file is:

LHS2_T1.DBG.

It is reproduced in full in Appendix C of this document.

6.2 Exercising LHS

LHS can be run by COMMAND file, or it can be run interactively if the user types the proper commands directly. In COMMAND-file mode, LHS can execute either interactively or in batch mode. Given those capabilities, it is recommended that COMMAND-file mode be employed as a rule. It is the method that will be applied in regulatory calculations.

A COMMAND file that runs LHS is show below:

```
$!
$! DEFINE INPUT, OUTPUT, & SCRATCH FILES.  RUN THE LHS CODE.
$!
$  DEFINE LHS2_UIF$INPUT        LHS2_T1.INP
$  DEFINE LHS2_OUT$OUTPUT       LHS2_T1.OUT
$  DEFINE LHS2_DBG$OUTPUT       LHS2_T1.DBG
$  DEFINE LHS2_NO2$SCRTCH       FOR002.DAT
$  DEFINE LHS2_NO3$SCRTCH       FOR003.DAT
$  DEFINE LHS2_NO4$SCRTCH       FOR004.DAT
$  DEFINE LHS2_NO7$SCRTCH       FOR007.DAT
$  DEFINE LHS2_NO8$SCRTCH       FOR008.DAT
$  DEFINE LHS2_NO9$SCRTCH       FOR009.DAT
$!
$  RUN WP$PRODROOT:[LHS.EXE]LHS_PA96.EXE
$!
$  DEASSIGN LHS2_UIF$INPUT
$  DEASSIGN LHS2_OUT$OUTPUT
$  DEASSIGN LHS2_DBG$OUTPUT
$  DEASSIGN LHS2_NO2$SCRTCH
$  DEASSIGN LHS2_NO3$SCRTCH
$  DEASSIGN LHS2_NO4$SCRTCH
$  DEASSIGN LHS2_NO7$SCRTCH
$  DEASSIGN LHS2_NO8$SCRTCH
$  DEASSIGN LHS2_NO9$SCRTCH
$!
$  EXIT
```

In the above COMMAND file, nine VMS "DEFINE" commands are used to link the names of user-selected input and output files (far right side of the DEFINE statements) with the logical symbols that define those same files internally within LHS (near right side of the DEFINE statements). The first three DEFINE commands link LHS's input and output files with their corresponding logical symbols. The remaining six DEFINE commands link LHS's internal scratch-file logical symbols with their corresponding internally-chosen file names. The scratch-file names are designed to indicate the unit number of each file. Since scratch files are opened, used, closed, and deleted during execution of LHS, they are of no consequence to users.

The DEFINE commands are followed by a RUN command that directs the computer to run the LHS executable located in the "PRODUCTION" directory. That command is followed by a series of DEASSIGN commands that deactivate the logical-symbol/file-assignment matches made prior to the run. The DEASSIGN step is primarily a *good housekeeping* policy. It is not a requirement. However, if DEASSIGN commands are not implemented and the code is then run interactively, it is possible that subsequent runs might access the wrong input files. For that reason, it is prudent to apply the DEASSIGN commands.

Any COMMAND file similar to the one listed above can be run interactively. If the file is named LHS.COM , it can be executed at the VMS $ prompt as follows:

$ **@LHS.COM**

Command files may be executed in batch mode by tying the following construction at the VMS prompt, "$":

$ **SUBMIT/QUEUE=BEATLE$BATCH LHS.COM**

Batch-mode runs allow the terminal to be used for other independent purposes during execution. However, because LHS normally executes in only a minute or two, it is unlikely that a user would run in batch mode. Batch mode is applied routinely in regulatory calculations.

Interactive runs without command files are possible, but they are not recommended. Nor are they anticipated in regulatory calculations. To execute LHS interactively, the user, at a minimum, must type the following VMS commands after the system prompt:

$ DEFINE LHS2_UIF$INPUT LHS2_T1.INP

$ DEFINE LHS2_OUT$OUTPUT LHS2_T1.OUT

$ DEFINE LHS2_DBG$OUTPUT LHS2_T1.DBG

$ RUN WP$PRODROOT:[LHS.EXE]LHS_PA96.EXE

Since the user never sees LHS's scratch files, it is quite acceptable that they be defined internally. LHS will assign them the names corresponding to their logical symbols.

7.0 DESCRIPTION OF THE INPUT FILES

PRELHS creates an ASCII output transfer file (see the WIPP PA PRELHS User's Manual, WPO#: 30714) that ordinarily serves as LHS's input control file. That file is described in detail in the paragraphs that follow. A sample listing of the LHS input file is given in Appendix A of this manual. It contains all of the information necessary for LHS to exercise and thereby create a sample. The input file has as its first and last record a title line created by PRELHS from information found in the WIPP PA database identifying the database's title and version number. Also included is the date and time stamp signifying when PRELHS created the LHS input file. This title record is carried through to the completion of the LHS run and appears on the ASCII text output file. After the initial title record, a second title record gives a descriptive title that identifies the LHS input file. It serves no other purpose.

Following the two title records, the LHS input file lists code execution keywords. In the case of the sample file in Appendix A, keywords NOBS and RANDOM SEED appear and specify that a sample of 75 outcomes will be created by LHS, along with specifying the value of the starting random seed as 933090934. Next comes the information necessary to calculate each of the distributions to be included in the sample. For the example file in Appendix A, ten data distribution types are included. They are NORMAL, LOGNORMAL, UNIFORM, LOGUNIFORM, CUMULATIVE USER DISTRIBUTION, DATA USER DISTRIBUTION, DELTA USER DISTRIBUTION, STUDENT, LOGSTUDENT, and TRIANGULAR. These 10 distributions correspond to the data distribution types that will be utilized for the regulatory calculation.

After specification of the data distribution input, the LHS input file in Appendix A lists further input. The CORRELATION MATRIX keyword is listed, followed by the various correlation pairs and the desired correlation values. Next, the OUTPUT keyword is listed, followed by its attendant keywords: CORR, HIST, and DATA. These keywords are used to instruct LHS as to which of three types of output are to be prepared and written to one of the two LHS output files. The last record in the PRELHS output transfer file is a repeat of the title record found at the beginning of the file.

The LHS input file is designed to be used without modification. Therefore, for the purposes of regulatory calculations, it will not be edited or otherwise modified in any way after it has been created by PRELHS.

7.1 Detailed Description of LHS Input File Entries

The following is a description of LHS's input file entries. Each paragraph gives the entry name and a brief description of its function. Please note that some input keywords applicable to the LHS code are not used in regulatory calculations.

LHS KEYWORD COMMANDS USED IN REGULATORY CALCULATIONS

The following commands are used by LHS to set up the run or control its execution.

TITLE

The TITLE record specifies the title for the LHS run. The record after TITLE may contain up to 100 alphanumeric characters. An example of usage of this keyword follows:
TITLE CMS TEST INPUT FILE FOR THE LHS CODE

NOBS

The NOBS record is used, with its associated parameter value, *no._obs*, to specify the number of vectors to be created for a sample (sample size [n_V]). An example of usage of this keyword follows:
NOBS 75

RANDOM SEED

THE RANDOM SEED record, along with its associated parameter value, *number*, is used to specify the starting point for the random number generator. An example of usage of this keyword follows:
RANDOM SEED 933090934

CORRELATION MATRIX

The CORRELATION MATRIX record, along with its associated parameter values, establishes the desired rank correlation among variables. If this parameter is omitted, all pairwise correlations will be minimized. The CORRELATION MATRIX record is followed by one or more lines containing the number of pairs to be rank correlated, *no._rank_corr,* followed by that many ordered triplets *no._rank_corr* specifying the number IDs of the two variables being correlated and their rank correlation. An example of usage of this keyword follows:

```
CORRELATION MATRIX
    4
    1    3    0.999
    2    5    0.950
    4    6    0.800
    5    2    0.950
```

OUTPUT

The OUTPUT record, along with its associated parameter keywords CORR, HIST, and DATA, controls the amount and type of output generated. The parameter keywords are defined as follows:

CORR signifies that both the raw and rank correlation matrices of the sample will be printed out in tabular form.

HIST signifies that histograms and associated statistical information will be printed for each variable in the sample.

DATA signifies that the individual values of each sampled variable will be printed, followed by the ranks of each variable. For the regulatory calculation, this output control keyword must be specified in conjunction with the OUTPUT keyword.
Examples of usage of the OUTPUT keyword follow:

```
OUTPUT CORR HIST DATA
OUTPUT CORR DATA
OUTPUT HIST DATA
```

LHS COMMANDS *NOT* USED IN REGULATORY CALCULATIONS

The following LHS execution commands may be included in the input file, as described previously. **However, these particular commands are not to be used for regulatory calculations.**

NREPS — The NREPS record specifies the number of repetitions of the sample (each with a sample size of *no._obs*. If not specified, NREPS defaults to 1).

RANDOM PAIRING

When present, the RANDOM PAIRING record specifies that sample values are to be paired randomly; otherwise, sample values are restrictively paired subject to any conditions under the CORRELATION MATRIX parameter.
If both RANDOM PAIRING and CORRELATION MATRIX records appear, the former is ignored with a message to that effect printed after the correlation matrix.

RANDOM SAMPLE

When present, the RANDOM SAMPLE record specifies that a random sample is to be generated; otherwise, a Latin hypercube sample is generated.

A description of the input for the different distribution types capable of being sampled by LHS is included here. Since all of the distribution information will be present on the LHS input file generated by PRELHS, the treatment of the distribution parameters is brief. The first 10 distribution types listed cover the types used for the certification calculation. The remaining seven entries will pertain to distribution types that can be processed by LHS but will not be used for the final certification calculation.

LHS DISTRIBUTION TYPES *USED* IN THE REGULATORY CALCULATION

NORMAL

The NORMAL record specifies a truncated normal distribution. An example of the distribution format follows:

NORMAL material_name parameter_name
minimum maximum

LOGNORMAL

The LOGNORMAL record specifies a LOGNORMAL distribution. An example of the distribution format follows:

LOGNORMAL material_name parameter_name
minimum maximum

UNIFORM

The UNIFORM record specifies a uniform distribution. An example of the distribution format follows:

UNIFORM material_name parameter_name
minimum maximum

LOGUNIFORM

The LOGUNIFORM record specifies a loguniform distribution. An example of the distribution format follows:

LOGUNIFORM material_name parameter_name
minimum maximum

USER DISTRIBUTION (CUMULATIVE)

The USER DISTRIBUTION (CUMULATIVE) record specifies a cumulative user supplied distribution. An example of the distribution format follows:

USER DISTRIBUTION (CUMULATIVE) material_name parameter_name
nval SPECIFIED CONTINUOUS
$value_1$ $probability_1$
$value_2$ $probability_2$
... ...
$value_{nval}$ 0.

USER DISTRIBUTION (DATA)

The USER DISTRIBUTION (DATA) record specifies a data user supplied distribution. An example of the distribution format follows:

USER DISTRIBUTION (DATA) material_name parameter_name
nval EQUAL CONTINUOUS
$value_1$ $value_2$ ... $value_{nval}$

USER DISTRIBUTION (DELTA)

The USER DISTRIBUTION (DELTA) record specifies a delta user-supplied distribution. An example of the distribution format follows:

```
USER DISTRIBUTION (DELTA)   material_name   parameter_name
   nval        SPECIFIED     DISCRETE
   value1       probability1
   value2       probability2
   ...          ...
   valuenval    probabilitynval
```

STUDENT

The STUDENT record specifies a student-t distribution. An example of the distribution format follows:

```
STUDENT    material_name   parameter_name
   nval
   value1  value2 ... valuenval
```

LOGSTUDENT

The LOGSTUDENT record specifies a logstudent-t distribution. An example of the distribution format follows:

```
LOGSTUDENT    material_name   parameter_name
   nval
   value1  value2 ... valuenval
```

TRIANGULAR

The TRIANGULAR record specifies a triangular distribution. An example of the distribution format follows:

```
TRIANGULAR    material_name   parameter_name
   minimum  apex  maximum
```

LHS DISTRIBUTION TYPES *NOT USED* IN THE REGULATORY CALCULATION

BETA

The BETA record specifies a beta distribution. An example of the distribution format follows:

```
BETA          material_name   parameter_name
   minimum  maximum  shape_p  shape_q
```

EXPONENTIAL

The EXPONENTIAL record specifies an exponential distribution. An example of the distribution format follows:

```
EXPONENTIAL   material_name   parameter_name
   minimum  maximum  lambda
```

RAYLEIGH

The RAYLEIGH record specifies a Rayleigh distribution. An example of the distribution format follows:

```
RAYLEIGH      material_name   parameter_name
   minimum  maximum  lambda
```

RAYLEXP

The RAYLEXP record specifies a Rayleigh-exponential distribution. An example of the distribution format follows:

RAYLEXP material_name parameter_name
minimum crossover maximum lambda

UNIFORM*

The UNIFORM* record requests a uniform distribution with specific sampling frequencies on subintervals. An example of the distribution format follows:

UNIFORM* material_name parameter_name
m $freq_1$ ... $freq_m$ c_1 ... c_{m+1}

LOGUNIFORM*

The LOGUNIFORM* record requests a loguniform distribution with specific sampling frequency on subintervals. An example of the distribution format follows:

LOGUNIFORM* material_name parameter_name
m $freq_1$ ... $freq_m$ c_1 ... c_{m+1}

USER DISTRIBUTION (CUMHISTOGRAM)

The USER DISTRIBUTION (CUMHISTOGRAM) record specifies a cumhistogram user-supplied distribution. An example of the distribution format follows:

USER DISTRIBUTION (CUMHISTOGRAM) material_name parameter_name
nval SPECIFIED DISCRETE
$value_1$ $probability_1$
$value_2$ $probability_2$
... ...
$value_{nval}$ $probability_{nval}$

8.0 ERROR MESSAGES

Detailed error detection is implemented in LHS through an assortment of error-checking subroutines. Errors detected during execution result in the generation of corresponding error messages written to the ASCII text output file. If the code regards the error as serious, and that is generally the case, the run will abort after an error message has been written.

LHS's error messages are numerous and specific in nature. In most cases, the error message describes the subroutine where the error occurred, and is accompanied by text describing the error. Often that is sufficient to track the problem down, especially if a "debug" version of the code is available. "Debug" versions of LHS allow interaction with the code during its execution and facilitate tracking down errors. However, the user should always perform a detailed visual inspection of the *entire* ASCII output file to assure (i) the output looks as it should and (ii) that no error messages have appeared.

LHS error messages fall into several categories. Numerous error messages are devoted to improperly-specified input data records. All of the execution keywords, problem size specifications, and distribution input data are checked for proper form. LHS is unable to determine whether a particular data distribution accurately reflects the physical information it is supposed to portray in the real world, but it is quite able to determine whether that information is entered in a syntactically correct way. LHS easily detects errors such as the maximum range being smaller than the minimum range for a given distribution.

Once the input-file information has been successfully read, LHS checks to see if parameters set in the input file (such as the number of distributions to be sampled, the number of outcome vectors to be generated, and the number of distribution parameter correlations specified) exceed the limits imposed by maximum-value parameters specified internally. LHS also checks to see that at least a minimum number of distributions and sample outcome vectors have been specified.

As the code creates the sample for the various distributions, error checks are invoked that are internal to the subroutines used to calculate the distributions. This type of error checking is most prevalent in the generation of BETA distributions, distributions that will *not* be used in regulatory calculations. Lastly, LHS utilizes numerous error-checking routines to assure that the correlation table calculated during a run meets the mathematical tests it must pass to be deemed acceptable.

9.0 DESCRIPTION OF THE OUTPUT

The LHS code creates two output files during a run. The first is an ASCII text log file suitable for use as an input file to POSTLHS, and the second is an ASCII text debug file. Both files are described in detail in the paragraphs that follow. Sample listings of the LHS output files are given in Appendix B and Appendix C of this report.

9.1 LHS Output Log File

The LHS output log file is an ASCII text file created specifically for use as the input control file to POSTLHS. It contains all the LHS sampling information required by POSTLHS. Appendix B contains a sample output log file.

The first data block of LHS's output log file contains an echoed listing of the LHS input file, rearranged somewhat to be more understandable to the user. Included in the "echoed input" section are the LHS execution keywords, input execution-parameter data specifications, a recapitulation of the input information for the various distributions sampled, and information concerning the correlation matrix.

The next data block of the output log file is a group of tables showing resulting values over all outcomes for each of the distributions sampled. The table heading **RUN NO.** identifies the outcome vector number, there being 1 - 75 in the case of the sample problem in Appendix B. The headers **X(1) X(2) X(3) ...X(10)** identify each of the 10 distributions sampled, with the sampled values listed under these headings on a vector by vector basis. For the example in Appendix B, there were 75 outcome vectors and 10 sampled distributions. Since an LHS sample table can contain up to 10 distributions, a single table is sufficient to present the entire sample. The table contains 75 outcome vectors, each containing sampled results for distributions 1 - 10. The information in this table is used as input to POSTLHS.

Once the *raw data* table has been presented, a similar table is written for the ranks of the Latin-hypercube sample values. This table shows the rank of a given distribution's sampled value in comparison to all the other values for that particular distribution over the entire 75-outcome vector sample. For example, in sampled distribution number **X(1)**, which is a normal distribution, outcome vector number 57 is ranked first. That means the actual sampled value for outcome vector number 57 of that distribution is the smallest of the entire 75-outcome sample (in this case it is -5.000E-02). At the other end of the spectrum, outcome vector number 15 is the largest value for that distribution (ranked 75th at a value of 2.000E-01). The minimum to maximum range for sample variable number 1 is 5.000E-02 - 2.000E-01. Since those bounds delimit the 99th percentile, the smallest sampled value may lie slightly to the left of the lower bound and the largest sampled value may lie slightly to the right of the upper bound. Correlations called for in LHS's input file are implemented on the basis of ranked data rather than raw data.

Since the OUTCOME keyword HIST was specified in the LHS input file, histogram density function plots, together with applicable statistical data, are presented for each of the 10 distributions generated in the example file given in Appendix B. A header at the top of each histogram identifies the distribution being displayed. The graphical plot gives a rough outline of the distribution shape and shows where the sampled values fall between the function's upper and lower bounds. For density, the distance between the function's bounds is subdivided into segments, and the sampled outcomes are allocated to their associated segment, depending on their value. Statistical data located directly beneath the histogram plots show the actual minimum and maximum values sampled for a given distribution, the mean and median values of the sampled distribution, and the associated variance. These statistical measures can assist users endeavoring to assure that a sampled distribution is correct.

The last data block found on the LHS log output file listed in Appendix B gives correlation tables for the raw sampled data, including ranks. These tables give the correlations between each distribution and all of the other distributions present in the sample. Positive correlations indicate that high values in one variable correlate with high variables in the other. Negative correlations indicate that high values in one variable correlate with low values in the other. The user *should* assure the suitability of the correlations by inspecting the rank-correlation table and determining whether the correlations specified in the LHS input file were implemented. The user *should* scour the entire table for spurious correlations. To accomplish that, users must have prior knowledge of the distributions being generated and their interrelationships.

9.2 LHS Output Debug File

The LHS output debug file is a simple free-formatted list containing the raw sampled values for each of the distributions over all of the vector outcomes. The sample file in Appendix C contains raw data for each of the 10 distributions, for each of the 75 outcome vectors. The first number listed is the outcome vector number. It is followed by the number of data entries in the outcome, and then by the sampled data values themselves. The sampled data are listed in the same order in which they were given in the LHS input file. For the sample output debug file in Appendix C, the first outcome vector lists the value 7.3280208E-02 as the value associated with distribution 1. The value of the last (or 10th) sampled distribution for outcome vector 1 is 1.8736359E-04. This first distribution is a NORMAL distribution with lower and upper bounds of 5.000E-02 and 0.2000. The tenth distribution is a LOGSTUDENT distribution with lower and upper bounds of 9.550E-07 and 9.525E-03.

10.0 REFERENCES

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APPENDIX A: EXAMPLE OF AN LHS INPUT TEXT FILE (LHS2_T1.INP)

Listed below is an example LHS input control file, as produced by PRELHS, and described in detail in Sec. 7.0.

```
TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4    02/13/96 14:31:39
TITLE CMS Test Input File for the LHS Code
NOBS                     75
RANDOM SEED       933090934
NORMAL                  GLOBAL    DISPPERC
    5.00000E-02    2.00000E-01
LOGNORMAL               COLLOID   CONC
    1.00000E-02    1.00000E+02
UNIFORM                 WAS_AREA  TAUFAIL
    4.80000E-02    9.60000E+00
LOGUNIFORM              WAS_AREA  SPPERM
    1.00000E-17    1.00000E-12
USER DISTRIBUTION  (CUMULATIVE)       BOREHOLE  DOMEGA
        20          SPECIFIED    CONTINUOUS
    4.20000E+00   0.00000
    4.20000E+00   0.15000
    6.30000E+00   0.00000
    6.30000E+00   0.50000
    8.40000E+00   0.00000
    8.40000E+00   0.15000
    1.05000E+01   0.00000
    1.05000E+01   0.10000
    1.26000E+01   0.00000
    1.26000E+01   0.05000
    1.47000E+01   0.00000
    1.47000E+01   0.02000
    1.68000E+01   0.00000
    1.68000E+01   0.01000
    1.88000E+01   0.00000
    1.88000E+01   0.01000
    2.09000E+01   0.00000
    2.09000E+01   0.01000
    2.30000E+01   0.00000
    2.30000E+01   0.00000
USER DISTRIBUTION  (DATA)          CULEBRA   POROSITY
        21          EQUAL        CONTINUOUS
  5.80563E-02  9.55000E-02  1.03330E-01  1.07400E-01  1.15000E-01  1.20500E-01
  1.22250E-01  1.23500E-01  1.29000E-01  1.38500E-01  1.44330E-01  1.46500E-01
  1.61600E-01  1.61800E-01  1.65170E-01  1.78000E-01  1.78400E-01  1.79600E-01
  2.02500E-01  2.07750E-01  2.52500E-01
```

```
USER DISTRIBUTION  (DELTA)         BOREHOLE  DIAMMOD
       14          SPECIFIED    DISCRETE
    5.08000E-02   0.07143
    1.01600E-01   0.07143
    1.52400E-01   0.07143
    1.93680E-01   0.07143
    2.19080E-01   0.07143
    2.28600E-01   0.07143
    2.50830E-01   0.07143
    2.79400E-01   0.07143
    3.04800E-01   0.07143
    3.49250E-01   0.07143
    3.81000E-01   0.07143
    4.44500E-01   0.07143
    5.58800E-01   0.07143
    6.09600E-01   0.07144
TRIANGULAR                 WAS_AREA   GRATCORI
    0.00000E+00    3.20000E-09    6.40000E-07
STUDENT                    S_MB139    POROSITY
       16
  4.00000E-03  5.00000E-03  5.00000E-03  8.00000E-03  1.00000E-02  1.10000E-02
  1.30000E-02  1.30000E-02  1.60000E-02  1.60000E-02  1.60000E-02  1.70000E-02
  1.80000E-02  1.90000E-02  2.10000E-02  2.70000E-02
LOGSTUDENT                 STULMAT1   STULPRP1
       20
  9.55000E-07  1.03330E-06  1.57400E-06  2.15000E-06  4.20500E-06  8.22250E-06
  2.23500E-05  4.29000E-05  7.38500E-05  9.44330E-05  1.46500E-04  3.61600E-04
  5.61800E-04  7.65170E-04  9.78000E-04  1.78400E-03  2.79600E-03  5.02500E-03
  7.07750E-03  9.52500E-03
CORRELATION MATRIX
    4
    1     3 0.999
    2     5 0.950
    4     6 0.800
    5     2 0.950
OUTPUT CORR HIST DATA
TITLE SDB: wipp::wipp_copy    Calc: PRELHS      Ver: ING6.4    02/13/96 14:31:39
```

END OF APPENDIX A

APPENDIX B: EXAMPLE OF AN LHS OUTPUT TEXT FILE (LHS2_T1.OUT)

Listed below is an example LHS ASCII text output log file, as described in detail in Sec. 9.1. This file is suitable in its present form for use as an input file to the POSTLHS code.

```
1

    TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16

    RANDOM SEED =    933090934

    NUMBER OF VARIABLES =  10

    NUMBER OF OBSERVATIONS =    75
0   AN INPUT CORRELATION MATRIX HAS BEEN SPECIFIED
0   THE SAMPLE INPUT VECTORS WILL BE PRINTED ALONG WITH THEIR CORRESPONDING RANKS
0   HISTOGRAMS OF THE ACTUAL SAMPLE WILL BE PLOTTED FOR EACH INPUT VARIABLE
0   THE CORRELATION MATRICES (RAW DATA AND RANK CORRELATIONS) WILL BE PRINTED
1

    TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16

    VARIABLE  DISTRIBUTION           RANGE            LABEL
0       1     NORMAL              5.0000E-02 TO   0.2000      GLOBAL    DISPPERC
0       2     LOGNORMAL           1.0000E-02 TO    100.0      COLLOID   CONC
0       3     UNIFORM             4.8000E-02 TO    9.600      WAS_AREA  TAUFAIL
0       4     LOGUNIFORM          1.0000E-17 TO   1.0000E-12  WAS_AREA  SPPERM
0       5     USER SUPPLIED DISTRIBUTION            (CUMULATIVE)        BOREHOLE  DOMEGA
0       6     USER SUPPLIED DISTRIBUTION            (DATA)          CULEBRA   POROSITY
0       7     USER SUPPLIED DISTRIBUTION            (DELTA)             BOREHOLE  DIAMMOD
0     8     TRIANGULAR        WITH PARAMETERS BELOW   WAS_AREA  GRATCORI
                       A=      0.0000E+00
                       B=      3.2000E-09
                       C=      6.4000E-07
0       9     STUDENT            WITH PARAMETERS BELOW     S_MB139   POROSITY
                        15 DEGREES OF FREEDOM
                       AVG=      1.3688E-02
                       STDDEV=    1.5857E-03
0      10     LOGSTUDENT         WITH PARAMETERS BELOW     STULMAT1  STULPRP1
                        19 DEGREES OF FREEDOM
                       LOG AVG=      -9.157
                       LOG STDDEV=    0.6912
```

```
1TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0INPUT RANK CORRELATION MATRIX                                                                      PAGE
1
0     1  1.0000
0     2  0.0000  1.0000
0     3  0.9990  0.0000  1.0000
0     4  0.0000  0.0000  0.0000  1.0000
0     5  0.0000  0.9500  0.0000  0.0000  1.0000
0     6  0.0000  0.0000  0.0000  0.8000  0.0000  1.0000
0             1       2       3       4       5       6
0VARIABLES
```

1TITLE SDB: wipp::wipp_copy   Calc: PRELHS   Ver: ING6.4   08/02/96 15:17:16
0LATIN HYPERCUBE SAMPLE INPUT VECTORS

	RUN NO.	X(1)	X(2)	X(3)	X(4)	X(5)	X(6)	X(7)	X(8)	X(9)	X(10)
0	1	7.328E-02	6.363E+01	5.965E-01	1.923E-15	1.726E+01	1.223E-01	4.445E-01	2.629E-09	1.235E-02	1.874E-04
0	2	1.513E-01	7.549E-01	7.622E+00	2.151E-17	7.654E+00	9.729E-02	1.016E-01	8.057E-08	1.375E-02	8.714E-05
0	3	1.548E-01	1.292E+00	8.060E+00	1.412E-15	8.131E+00	1.203E-01	2.191E-01	5.673E-07	1.260E-02	1.742E-04
0	4	9.847E-02	1.365E+00	1.950E+00	1.881E-13	9.075E+00	2.048E-01	1.937E-01	3.641E-07	1.341E-02	2.744E-04
0	5	1.272E-01	3.940E+00	4.973E+00	4.368E-16	1.033E+01	9.193E-02	3.810E-01	1.809E-07	1.411E-02	7.108E-05
0	6	1.394E-01	3.218E-01	6.417E+00	1.288E-17	6.066E+00	7.738E-02	3.492E-01	1.863E-07	1.328E-02	1.841E-04
0	7	1.139E-01	8.697E-01	3.595E+00	9.036E-16	7.449E+00	1.641E-01	5.588E-01	2.344E-07	1.362E-02	7.714E-05
0	8	1.433E-01	1.975E+00	6.764E+00	8.606E-13	8.173E+00	2.311E-01	2.191E-01	1.718E-07	1.197E-02	4.134E-05
0	9	1.003E-01	2.068E-01	2.163E+00	5.227E-16	6.905E+00	1.185E-01	4.445E-01	4.915E-07	1.367E-02	6.875E-05
0	10	9.127E-02	1.777E-01	1.542E+00	5.768E-13	5.687E+00	1.653E-01	1.016E-01	3.392E-07	1.158E-02	6.490E-05
0	11	1.788E-01	2.063E+00	9.130E+00	2.381E-14	8.361E+00	1.633E-01	2.508E-01	1.223E-07	1.445E-02	2.476E-04
0	12	1.450E-01	5.165E+00	7.247E+00	2.650E-13	1.110E+01	1.535E-01	1.016E-01	8.441E-09	1.309E-02	5.240E-04
0	13	1.381E-01	5.735E-01	6.365E+00	4.207E-15	8.344E+00	1.311E-01	2.794E-01	3.019E-07	1.243E-02	4.912E-05
0	14	1.421E-01	1.041E+00	6.882E+00	7.603E-15	7.933E+00	1.232E-01	3.048E-01	4.136E-07	1.215E-02	9.461E-05
0	15	2.000E-01	7.332E-01	9.514E+00	4.210E-14	7.866E+00	1.788E-01	5.588E-01	1.283E-07	1.304E-02	1.288E-04
0	16	1.344E-01	3.026E+00	5.901E+00	1.112E-14	9.321E+00	1.446E-01	1.016E-01	7.644E-08	1.724E-02	9.964E-05
0	17	1.051E-01	3.152E-01	2.939E+00	2.967E-16	6.434E+00	1.709E-01	1.016E-01	4.222E-07	1.395E-02	3.198E-04
0	18	1.479E-01	2.132E-01	7.354E+00	8.350E-13	6.323E+00	1.792E-01	3.492E-01	2.825E-07	1.595E-02	1.922E-04
0	19	1.648E-01	1.220E+00	8.615E+00	3.386E-14	7.490E+00	1.371E-01	1.524E-01	4.815E-08	1.405E-02	1.316E-04
0	20	1.126E-01	7.694E+00	3.307E+00	5.245E-15	1.238E+01	1.619E-01	5.080E-02	3.032E-07	1.207E-02	9.045E-05
0	21	9.753E-02	6.905E-01	1.961E+00	1.109E-13	7.854E+00	2.028E-01	3.810E-01	7.095E-08	1.642E-02	1.661E-04
0	22	1.256E-01	9.872E-01	4.839E+00	2.600E-15	8.299E+00	1.397E-01	2.508E-01	3.960E-07	1.138E-02	1.985E-04
0	23	1.401E-01	4.778E-02	6.546E+00	1.465E-16	6.495E+00	1.214E-01	4.445E-01	3.178E-07	1.693E-02	2.372E-04
0	24	1.751E-01	2.691E+01	9.027E+00	7.047E-16	1.404E+01	1.617E-01	2.508E-01	3.551E-08	1.108E-02	6.078E-05
0	25	9.516E-02	1.576E-01	1.739E+00	1.761E-16	6.619E+00	1.049E-01	1.937E-01	4.600E-07	1.163E-02	1.031E-04
0	26	1.012E-01	2.679E-01	2.374E+00	8.854E-14	6.690E+00	1.787E-01	2.794E-01	2.864E-08	1.561E-02	1.720E-04
0	27	1.847E-01	4.285E-01	9.235E+00	1.308E-16	6.884E+00	1.622E-01	2.286E-01	1.540E-07	1.294E-02	1.630E-04
0	28	1.228E-01	1.000E+02	4.418E+00	2.514E-16	1.862E+01	1.440E-01	6.096E-01	5.525E-07	1.519E-02	1.255E-04
0	29	1.169E-01	8.488E-02	3.951E+00	6.471E-15	5.281E+00	1.326E-01	1.016E-01	1.059E-07	1.436E-02	9.560E-05
0	30	1.165E-01	3.573E+00	3.424E+00	7.758E-14	7.538E+00	2.063E-01	4.445E-01	5.622E-08	1.352E-02	2.180E-04
0	31	1.281E-01	2.871E+00	5.194E+00	4.117E-13	9.641E+00	1.917E-01	6.096E-01	1.298E-07	1.248E-02	1.490E-04
0	32	1.100E-01	3.781E-01	3.029E+00	1.561E-14	7.686E+00	1.617E-01	2.286E-01	3.469E-07	1.524E-02	2.959E-04
0	33	1.605E-01	1.763E-02	8.309E+00	2.222E-16	4.943E+00	1.225E-01	6.096E-01	1.359E-07	1.429E-02	6.283E-05
0	34	8.529E-02	1.858E+01	1.164E+00	1.307E-15	2.253E+01	1.559E-01	3.048E-01	3.350E-07	1.565E-02	5.169E-05
0	35	1.122E-01	2.813E-01	3.703E+00	6.329E-17	7.078E+00	1.252E-01	3.492E-01	6.236E-08	1.288E-02	3.772E-04
0	36	1.708E-01	6.707E+00	8.869E+00	2.567E-17	1.179E+01	1.038E-01	5.588E-01	2.387E-07	1.321E-02	1.029E-05
0	37	6.799E-02	2.482E+00	3.735E-01	1.079E-15	8.617E+00	1.953E-01	3.492E-01	1.135E-07	1.379E-02	1.067E-04
0	38	1.338E-01	6.294E+00	6.014E+00	1.593E-17	1.207E+01	1.091E-01	2.286E-01	1.141E-07	1.550E-02	4.357E-05
0	39	1.462E-01	4.445E+00	7.152E+00	3.866E-15	1.030E+01	1.464E-01	3.492E-01	2.484E-08	9.949E-03	1.422E-04
0	40	1.659E-01	1.340E-01	8.581E+00	2.106E-14	5.039E+00	1.783E-01	4.445E-01	2.737E-07	1.281E-02	8.556E-05
0	41	8.186E-02	1.310E+01	8.700E-01	5.577E-16	1.147E+01	1.410E-01	1.937E-01	9.889E-08	1.360E-02	7.847E-05
0	42	1.365E-01	1.511E+00	6.112E+00	2.744E-14	9.846E+00	1.752E-01	1.524E-01	2.566E-07	1.478E-02	1.376E-04
0	43	1.031E-01	3.131E-02	2.331E+00	4.156E-17	4.264E+00	1.289E-01	2.794E-01	2.708E-07	1.402E-02	1.343E-04
0	44	1.327E-01	2.214E+00	5.408E+00	1.341E-13	8.653E+00	1.455E-01	1.937E-01	6.645E-08	1.130E-02	9.126E-05

0	45	8.291E-02	5.315E-01	1.012E+00	2.416E-15	7.149E+00	1.136E-01	2.286E-01	1.859E-08	1.440E-02	2.941E-05
0	46	9.012E-02	6.120E-01	1.198E+00	1.803E-13	7.212E+00	1.783E-01	5.080E-02	2.476E-07	1.459E-02	5.364E-05
0	47	1.465E-01	2.335E-01	6.928E+00	2.033E-16	6.844E+00	9.960E-02	5.588E-01	2.077E-07	1.540E-02	1.174E-04
0	48	1.564E-01	1.478E-01	7.887E+00	3.799E-14	6.373E+00	1.781E-01	3.048E-01	2.601E-07	1.467E-02	6.619E-05
0	49	1.579E-01	8.908E-02	8.081E+00	3.579E-13	5.725E+00	1.866E-01	1.937E-01	3.797E-08	1.577E-02	1.555E-04
0	50	1.080E-01	1.179E-02	2.618E+00	3.257E-17	4.469E+00	1.061E-01	1.524E-01	4.489E-08	9.006E-03	1.507E-04
0	51	1.148E-01	5.629E+00	3.837E+00	5.699E-17	9.443E+00	1.084E-01	2.508E-01	3.709E-07	1.350E-02	2.558E-05
0	52	1.094E-01	4.127E-01	3.228E+00	5.136E-13	6.669E+00	2.483E-01	2.508E-01	8.724E-08	1.453E-02	8.363E-05
0	53	1.242E-01	1.449E+01	4.662E+00	1.076E-17	1.053E+01	5.871E-02	2.191E-01	9.657E-08	1.487E-02	3.914E-04
0	54	1.368E-01	8.148E-01	6.241E+00	1.029E-16	7.054E+00	1.219E-01	1.524E-01	9.267E-08	1.780E-02	8.084E-05
0	55	1.181E-01	2.590E-02	4.318E+00	7.707E-17	4.680E+00	1.773E-01	3.492E-01	1.495E-07	1.083E-02	1.105E-04
0	56	7.126E-02	2.160E+01	5.453E-01	1.652E-14	1.250E+01	1.126E-01	6.096E-01	4.458E-07	1.385E-02	8.890E-04
0	57	5.000E-02	4.771E-01	1.035E-01	3.896E-17	6.983E+00	1.177E-01	2.286E-01	2.279E-07	1.190E-02	5.691E-05
0	58	1.064E-01	1.010E+01	2.806E+00	3.814E-16	1.004E+01	1.238E-01	6.096E-01	1.571E-07	1.503E-02	1.202E-04
0	59	1.320E-01	1.641E+00	5.574E+00	5.846E-15	8.932E+00	1.231E-01	4.445E-01	2.280E-08	1.179E-02	4.712E-05
0	60	7.722E-02	2.580E+00	7.965E-01	7.787E-16	8.246E+00	1.209E-01	4.445E-01	1.751E-07	1.388E-02	1.134E-04
0	61	1.220E-01	1.801E+00	4.516E+00	1.708E-15	7.755E+00	1.460E-01	1.937E-01	4.409E-07	1.055E-02	1.085E-04
0	62	1.250E-01	5.108E-01	5.054E+00	6.536E-13	7.273E+00	1.795E-01	3.810E-01	3.926E-07	1.427E-02	3.705E-05
0	63	5.678E-02	6.967E-02	2.050E-01	6.213E-14	6.521E+00	1.433E-01	3.810E-01	1.193E-08	1.473E-02	5.481E-05
0	64	8.768E-02	9.451E-01	1.369E+00	1.504E-13	7.591E+00	2.075E-01	2.191E-01	3.764E-07	1.607E-02	5.880E-05
0	65	1.694E-01	4.333E+01	8.733E+00	1.214E-14	1.383E+01	1.698E-01	2.794E-01	1.412E-07	1.492E-02	4.028E-05
0	66	1.041E-01	3.279E+00	2.537E+00	2.243E-17	8.047E+00	1.009E-01	5.080E-02	2.157E-07	1.420E-02	7.534E-05
0	67	1.883E-01	1.764E+00	9.386E+00	8.626E-17	8.021E+00	1.153E-01	1.524E-01	5.089E-07	1.507E-02	2.257E-04
0	68	1.207E-01	1.083E-01	4.134E+00	1.441E-17	6.770E+00	8.579E-02	2.794E-01	5.100E-08	1.268E-02	9.817E-05
0	69	1.291E-01	5.560E-02	5.344E+00	3.404E-15	5.353E+00	1.261E-01	3.048E-01	1.623E-07	1.312E-02	2.232E-05
0	70	1.191E-01	1.241E-01	4.095E+00	5.381E-14	6.089E+00	1.617E-01	6.096E-01	2.914E-07	1.266E-02	2.595E-04
0	71	1.307E-01	1.124E+00	5.753E+00	3.323E-13	7.373E+00	1.596E-01	2.286E-01	5.354E-07	1.278E-02	7.279E-05
0	72	1.528E-01	3.562E-01	7.790E+00	5.164E-17	7.307E+00	1.051E-01	5.080E-02	3.216E-07	1.635E-02	3.434E-05
0	73	9.371E-02	1.107E+01	1.670E+00	2.411E-13	1.456E+01	2.035E-01	3.048E-01	2.037E-07	1.334E-02	1.147E-04
0	74	1.493E-01	8.812E+00	7.455E+00	9.780E-15	1.306E+01	1.355E-01	5.080E-02	1.976E-07	1.225E-02	2.096E-04
0	75	1.617E-01	4.291E+00	8.404E+00	6.583E-14	1.093E+01	2.178E-01	2.508E-01	2.225E-07	1.324E-02	1.446E-04

1TITLE SDB: wipp::wipp_copy Calc: PRELHS Ver: ING6.4 08/02/96 15:17:16
0RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

	RUN NO.	X(1)	X(2)	X(3)	X(4)	X(5)	X(6)	X(7)	X(8)	X(9)	X(10)
0	1	5.	74.	5.	35.	73.	23.	62.	1.	16.	60.
0	2	60.	34.	60.	5.	36.	5.	9.	18.	39.	30.
0	3	62.	42.	63.	33.	44.	19.	25.	75.	19.	58.
0	4	16.	43.	15.	65.	53.	70.	20.	61.	33.	69.
0	5	40.	57.	39.	25.	60.	4.	57.	37.	46.	22.
0	6	51.	22.	51.	2.	10.	2.	52.	38.	31.	59.
0	7	28.	36.	28.	30.	32.	52.	68.	45.	37.	25.
0	8	54.	48.	53.	75.	45.	74.	25.	35.	12.	8.
0	9	17.	16.	17.	26.	23.	18.	62.	71.	38.	21.
0	10	12.	15.	12.	72.	8.	53.	9.	59.	8.	19.
0	11	72.	49.	72.	51.	49.	51.	36.	26.	52.	67.
0	12	55.	60.	57.	67.	63.	43.	9.	2.	27.	74.
0	13	50.	30.	50.	40.	48.	31.	41.	54.	17.	11.
0	14	53.	39.	54.	44.	41.	26.	46.	66.	14.	33.
0	15	75.	33.	75.	55.	40.	62.	68.	27.	26.	46.
0	16	47.	54.	46.	46.	54.	39.	9.	17.	74.	36.
0	17	21.	21.	23.	23.	14.	55.	9.	67.	43.	71.
0	18	58.	17.	58.	74.	12.	63.	52.	52.	69.	61.
0	19	67.	41.	68.	53.	33.	34.	14.	11.	45.	47.
0	20	27.	64.	26.	41.	67.	49.	3.	55.	13.	31.
0	21	15.	32.	16.	61.	39.	68.	57.	16.	72.	56.
0	22	39.	38.	38.	37.	47.	35.	36.	65.	7.	62.
0	23	52.	5.	52.	18.	15.	21.	62.	56.	73.	66.
0	24	71.	72.	71.	28.	71.	46.	36.	8.	5.	17.
0	25	14.	14.	14.	19.	17.	9.	20.	70.	9.	37.
0	26	18.	19.	19.	60.	19.	61.	41.	7.	66.	57.
0	27	73.	26.	73.	17.	22.	50.	30.	32.	25.	55.
0	28	36.	75.	35.	22.	74.	38.	73.	74.	62.	45.
0	29	31.	8.	31.	43.	6.	32.	9.	23.	50.	34.
0	30	30.	56.	27.	59.	34.	71.	62.	13.	35.	64.
0	31	41.	53.	41.	70.	56.	66.	73.	28.	18.	52.
0	32	25.	24.	24.	48.	37.	47.	30.	60.	63.	70.
0	33	65.	2.	65.	21.	4.	24.	73.	29.	49.	18.
0	34	9.	70.	9.	32.	75.	44.	46.	58.	67.	12.
0	35	26.	20.	29.	13.	26.	28.	52.	14.	24.	72.
0	36	70.	63.	70.	7.	65.	8.	68.	46.	29.	1.
0	37	3.	51.	3.	31.	50.	67.	52.	24.	40.	38.
0	38	46.	62.	47.	4.	66.	13.	30.	25.	65.	9.
0	39	56.	59.	56.	39.	59.	42.	52.	6.	2.	50.
0	40	68.	12.	67.	50.	5.	59.	62.	51.	23.	29.
0	41	7.	68.	7.	27.	64.	36.	20.	22.	36.	26.
0	42	48.	44.	48.	52.	57.	56.	14.	48.	57.	49.
0	43	19.	4.	18.	10.	1.	30.	41.	50.	44.	48.
0	44	45.	50.	43.	62.	51.	40.	20.	15.	6.	32.

0	45	8.	29.	8.	36.	27.	15.	30.	4.	51.	4.
0	46	11.	31.	10.	64.	28.	60.	3.	47.	54.	13.
0	47	57.	18.	55.	20.	21.	6.	68.	41.	64.	43.
0	48	63.	13.	62.	54.	13.	58.	46.	49.	55.	20.
0	49	64.	9.	64.	69.	9.	65.	20.	9.	68.	54.
0	50	23.	1.	21.	8.	2.	11.	14.	10.	1.	53.
0	51	29.	61.	30.	12.	55.	12.	36.	62.	34.	3.
0	52	24.	25.	25.	71.	18.	75.	36.	19.	53.	28.
0	53	37.	69.	37.	1.	61.	1.	25.	21.	58.	73.
0	54	49.	35.	49.	16.	25.	22.	14.	20.	75.	27.
0	55	32.	3.	34.	14.	3.	57.	52.	31.	4.	40.
0	56	4.	71.	4.	49.	68.	14.	73.	69.	41.	75.
0	57	1.	27.	1.	9.	24.	17.	30.	44.	11.	15.
0	58	22.	66.	22.	24.	58.	27.	73.	33.	60.	44.
0	59	44.	45.	44.	42.	52.	25.	62.	5.	10.	10.
0	60	6.	52.	6.	29.	46.	20.	62.	36.	42.	41.
0	61	35.	47.	36.	34.	38.	41.	20.	68.	3.	39.
0	62	38.	28.	40.	73.	29.	64.	57.	64.	48.	6.
0	63	2.	7.	2.	57.	16.	37.	57.	3.	56.	14.
0	64	10.	37.	11.	63.	35.	72.	25.	63.	70.	16.
0	65	69.	73.	69.	47.	70.	54.	41.	30.	59.	7.
0	66	20.	55.	20.	6.	43.	7.	3.	42.	47.	24.
0	67	74.	46.	74.	15.	42.	16.	14.	72.	61.	65.
0	68	34.	10.	33.	3.	20.	3.	41.	12.	21.	35.
0	69	42.	6.	42.	38.	7.	29.	46.	34.	28.	2.
0	70	33.	11.	32.	56.	11.	48.	73.	53.	20.	68.
0	71	43.	40.	45.	68.	31.	45.	30.	73.	22.	23.
0	72	61.	23.	61.	11.	30.	10.	3.	57.	71.	5.
0	73	13.	67.	13.	66.	72.	69.	46.	40.	32.	42.
0	74	59.	65.	59.	45.	69.	33.	3.	39.	15.	63.
0	75	66.	58.	66.	58.	62.	73.	36.	43.	30.	51.

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS        Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  1     NORMAL           DISTRIBUTION

     MIDPOINT          FREQ.

   0.4874997E-01         1    X
   0.5624997E-01         1    X
   0.6374996E-01         0
   0.7124995E-01         3    XXX
   0.7874995E-01         2    XX
   0.8624994E-01         3    XXX
   0.9374993E-01         4    XXXX
   0.1012499             6    XXXXXX
   0.1087499             6    XXXXXX
   0.1162499             7    XXXXXXX
   0.1237499             7    XXXXXXX
   0.1312499             7    XXXXXXX
   0.1387499             6    XXXXXX
   0.1462499             6    XXXXXX
   0.1537499             4    XXXX
   0.1612499             4    XXXX
   0.1687499             3    XXX
   0.1762499             2    XX
   0.1837499             1    X
   0.1912498             1    X
   0.1987498             1    X
0                       75

      MIN            MAX           RANGE          MEAN          MEDIAN        VARIANCE

   0.4999998E-01  0.2000000     0.1500000     0.1248673     0.1250420     0.1003930E-02
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  2      LOGNORMAL       DISTRIBUTION

     MIDPOINT          FREQ.

    2.499999             59   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    7.499997              6   XXXXXX
    12.50000              4   XXXX
    17.49999              1   X
    22.49999              1   X
    27.49999              1   X
    32.49999              0
    37.49999              0
    42.49999              1   X
    47.49999              0
    52.49999              0
    57.49999              0
    62.49999              1   X
    67.49998              0
    72.49998              0
    77.49998              0
    82.49998              0
    87.49998              0
    92.49998              0
    97.49998              0
    102.5000              1   X
0                        75
```

MIN	MAX	RANGE	MEAN	MEDIAN	VARIANCE
0.1179351E-01	100.0001	99.98830	5.677361	0.9872297	214.3602

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS        Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  3      UNIFORM         DISTRIBUTION

     MIDPOINT           FREQ.

   0.2349999              3     XXX
   0.7049998              4     XXXX
    1.175000              4     XXXX
    1.645000              3     XXX
    2.115000              4     XXXX
    2.584999              4     XXXX
    3.054999              3     XXX
    3.524999              4     XXXX
    3.994999              4     XXXX
    4.464999              4     XXXX
    4.934999              3     XXX
    5.404998              4     XXXX
    5.874998              3     XXX
    6.344998              5     XXXXX
    6.814998              3     XXX
    7.284997              4     XXXX
    7.754997              3     XXX
    8.224998              4     XXXX
    8.694998              4     XXXX
    9.164998              4     XXXX
    9.634998              1     X
0                        75


      MIN           MAX          RANGE          MEAN          MEDIAN        VARIANCE

   0.1035329     9.514432     9.410899      4.824547      4.839019      7.577834
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  4      LOGUNIFORM       DISTRIBUTION

     MIDPOINT           FREQ.

   0.2149999E-13        55    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.6449998E-13         4    XXXX
   0.1075000E-12         2    XX
   0.1505000E-12         2    XX
   0.1934999E-12         2    XX
   0.2364999E-12         1    X
   0.2794999E-12         1    X
   0.3224999E-12         1    X
   0.3654999E-12         1    X
   0.4084999E-12         1    X
   0.4514999E-12         0
   0.4944999E-12         1    X
   0.5374999E-12         0
   0.5804999E-12         1    X
   0.6234999E-12         0
   0.6664999E-12         1    X
   0.7095000E-12         0
   0.7525000E-12         0
   0.7955000E-12         0
   0.8385000E-12         1    X
   0.8815000E-12         1    X
0                       75

      MIN             MAX             RANGE            MEAN            MEDIAN          VARIANCE

   0.1076223E-16   0.8605560E-12   0.8605453E-12   0.8621589E-13   0.3403765E-14   0.3457749E-25
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  5     USER SUPPLIED    DISTRIBUTION

     MIDPOINT           FREQ.

    4.094997              2   XX
    5.004997              5   XXXXX
    5.914996              5   XXXXX
    6.824996             17   XXXXXXXXXXXXXXXXX
    7.734995             16   XXXXXXXXXXXXXXXX
    8.644995              8   XXXXXXXX
    9.554995              4   XXXX
    10.46499              4   XXXX
    11.37499              4   XXXX
    12.28499              3   XXX
    13.19499              1   X
    14.10499              2   XX
    15.01499              1   X
    15.92499              0
    16.83499              1   X
    17.74499              0
    18.65499              1   X
    19.56499              0
    20.47499              0
    21.38499              0
    22.29499              1   X
0                        75

     MIN          MAX          RANGE         MEAN         MEDIAN       VARIANCE

    4.263539     22.53333     18.26979     8.638453     7.755095     10.28359
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4    08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  6      USER SUPPLIED   DISTRIBUTION

     MIDPOINT          FREQ.

    0.6174996E-01        1    X
    0.7124996E-01        0
    0.8074996E-01        1    X
    0.9024996E-01        2    XX
    0.9974995E-01        4    XXXX
    0.1092499            7    XXXXXXX
    0.1187499           11    XXXXXXXXXXX
    0.1282499            6    XXXXXX
    0.1377499            4    XXXX
    0.1472499            6    XXXXXX
    0.1567499            3    XXX
    0.1662499           10    XXXXXXXXXX
    0.1757499            9    XXXXXXXXX
    0.1852499            1    X
    0.1947499            2    XX
    0.2042499            5    XXXXX
    0.2137499            1    X
    0.2232499            0
    0.2327499            1    X
    0.2422499            0
    0.2517499            1    X
0                       75


      MIN            MAX          RANGE          MEAN          MEDIAN        VARIANCE

    0.5870640E-01  0.2482859    0.1895795     0.1467121     0.1439527     0.1413787E-02
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  7     USER SUPPLIED   DISTRIBUTION

     MIDPOINT           FREQ.

   0.4200000E-01          5    XXXXX
   0.7000001E-01          0
   0.9800001E-01          6    XXXXXX
   0.1260000              0
   0.1540000              5    XXXXX
   0.1820000              6    XXXXXX
   0.2100000              4    XXXX
   0.2380000             12    XXXXXXXXXXXX
   0.2660000              5    XXXXX
   0.2940000              5    XXXXX
   0.3220000              0
   0.3500000              6    XXXXXX
   0.3780000              4    XXXX
   0.4060000              0
   0.4340000              7    XXXXXXX
   0.4620000              0
   0.4900000              0
   0.5180000              0
   0.5460000              4    XXXX
   0.5740000              0
   0.6020000              6    XXXXXX
0                        75

     MIN            MAX           RANGE          MEAN           MEDIAN        VARIANCE

   0.5080000E-01  0.6096000     0.5588000     0.2944717      0.2508300     0.2432861E-01
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS        Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  8      TRIANGULAR       DISTRIBUTION

     MIDPOINT           FREQ.

   0.1400000E-07          6    XXXXXX
   0.4200001E-07          6    XXXXXX
   0.7000001E-07          6    XXXXXX
   0.9800002E-07          5    XXXXX
   0.1260000E-06          6    XXXXXX
   0.1540000E-06          5    XXXXX
   0.1820000E-06          4    XXXX
   0.2100000E-06          5    XXXXX
   0.2380000E-06          4    XXXX
   0.2660000E-06          4    XXXX
   0.2940000E-06          4    XXXX
   0.3220001E-06          3    XXX
   0.3500001E-06          2    XX
   0.3780001E-06          3    XXX
   0.4060001E-06          3    XXX
   0.4340001E-06          3    XXX
   0.4620001E-06          1    X
   0.4900002E-06          1    X
   0.5180001E-06          1    X
   0.5460001E-06          2    XX
   0.5740001E-06          1    X
0                        75

      MIN            MAX            RANGE          MEAN           MEDIAN         VARIANCE

   0.2629106E-08  0.5672543E-06  0.5646252E-06  0.2144814E-06  0.1862856E-06  0.2256038E-13
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO.  9     STUDENT         DISTRIBUTION

     MIDPOINT          FREQ.

   0.9019998E-02         1    X
   0.9459998E-02         0
   0.9899997E-02         1    X
   0.1034000E-01         1    X
   0.1078000E-01         1    X
   0.1122000E-01         3    XXX
   0.1166000E-01         3    XXX
   0.1210000E-01         5    XXXXX
   0.1253999E-01         6    XXXXXX
   0.1297999E-01         7    XXXXXXX
   0.1341999E-01         9    XXXXXXXXX
   0.1385999E-01         8    XXXXXXXX
   0.1429999E-01         7    XXXXXXX
   0.1473999E-01         7    XXXXXXX
   0.1517999E-01         4    XXXX
   0.1561999E-01         5    XXXXX
   0.1605999E-01         2    XX
   0.1649999E-01         2    XX
   0.1693999E-01         1    X
   0.1737999E-01         1    X
   0.1781999E-01         1    X
0                       75

      MIN            MAX            RANGE           MEAN           MEDIAN         VARIANCE

   0.9006235E-02  0.1779700E-01  0.8790762E-02  0.1367153E-01  0.1367379E-01  0.2835058E-05
```

```
1   TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4    08/02/96 15:17:16
0  HISTOGRAM FOR VARIABLE NO. 10      LOGSTUDENT       DISTRIBUTION

      MIDPOINT           FREQ.

    0.2199999E-04          9    XXXXXXXXX
    0.6599998E-04         21    XXXXXXXXXXXXXXXXXXXXX
    0.1100000E-03         17    XXXXXXXXXXXXXXXXX
    0.1540000E-03         11    XXXXXXXXXXX
    0.1979999E-03          6    XXXXXX
    0.2419999E-03          4    XXXX
    0.2859999E-03          2    XX
    0.3299999E-03          1    X
    0.3739999E-03          2    XX
    0.4179999E-03          0
    0.4619999E-03          0
    0.5059998E-03          1    X
    0.5499998E-03          0
    0.5939998E-03          0
    0.6379998E-03          0
    0.6819998E-03          0
    0.7259998E-03          0
    0.7699998E-03          0
    0.8139997E-03          0
    0.8579997E-03          0
    0.9019997E-03          1    X
0                         75

      MIN            MAX            RANGE          MEAN           MEDIAN         VARIANCE

    0.1028524E-04  0.8890320E-03  0.8787468E-03  0.1395047E-03  0.1067194E-03  0.1615176E-07
```

```
1TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW DATA                    PAGE   1
0    1  1.0000
0    2 -0.0686  1.0000
0    3  0.9827 -0.0725  1.0000
0    4  0.0112 -0.1254  0.0260  1.0000
0    5 -0.0728  0.7182 -0.0720 -0.1281  1.0000
0    6  0.0011 -0.0498 -0.0279  0.5423  0.0065  1.0000
0    7 -0.0122  0.2493 -0.0188 -0.0543  0.0979 -0.0055  1.0000
0    8 -0.0261  0.0863 -0.0390  0.0366  0.0444 -0.0307  0.0146  1.0000
0    9  0.0090  0.0449  0.0151  0.0195  0.0449  0.0354  0.0144  0.0035  1.0000
0   10 -0.0744  0.0827 -0.0771 -0.0462  0.0858 -0.0601  0.1137  0.0808  0.0187  1.0000
0             1       2       3       4       5       6       7       8       9      10
0VARIABLES
1TITLE SDB: wipp::wipp_copy    Calc: PRELHS       Ver: ING6.4   08/02/96 15:17:16
0CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RANK DATA                   PAGE   1
0    1  1.0000
0    2  0.0033  1.0000
0    3  0.9989  0.0027  1.0000
0    4 -0.0090  0.0281 -0.0087  1.0000
0    5  0.0215  0.9540  0.0210  0.0416  1.0000
0    6 -0.0109  0.0051 -0.0083  0.7826 -0.0041  1.0000
0    7 -0.0360 -0.0173 -0.0392  0.0023  0.0048  0.0287  1.0000
0    8 -0.0408 -0.0357 -0.0382 -0.0213 -0.0200 -0.0161 -0.0129  1.0000
0    9 -0.0125 -0.0399 -0.0117  0.0127 -0.0463  0.0313  0.0051  0.0030  1.0000
0   10  0.0393  0.0104  0.0389  0.0614  0.0061  0.1036  0.0294 -0.0200 -0.0031  1.0000
0             1       2       3       4       5       6       7       8       9      10
0VARIABLES
```

END OF APPENDIX B

APPENDIX C: EXAMPLE OF AN LHS DEBUG FILE (LHS2_T1.DBG)

Listed below is a Sample LHS ASCII output debug file, as described in Sec. 9.2. This file contains 75 outcome vectors, each with a parameter value for the 10 distributions sampled in the LHS run.

```
           1          10  7.3280208E-02   63.62719        0.5965481
 1.9234693E-15   17.25994       0.1222811       0.4445000       2.6291065E-09
 1.2351096E-02   1.8736359E-04
           2          10  0.1513023      0.7549241       7.622032
 2.1510625E-17   7.653979       9.7291164E-02  0.1016000       8.0574807E-08
 1.3748049E-02   8.7144545E-05
           3          10  0.1547620       1.291858        8.060068
 1.4121704E-15   8.131407       0.1202511       0.2190800       5.6725429E-07
 1.2599414E-02   1.7419629E-04
           4          10  9.8472208E-02   1.364809        1.949686
 1.8812747E-13   9.074726       0.2047509       0.1936800       3.6406450E-07
 1.3414560E-02   2.7439915E-04
           5          10  0.1272122       3.939600        4.972763
 4.3676931E-16   10.33499       9.1931529E-02  0.3810000       1.8091364E-07
 1.4108853E-02   7.1080416E-05
           6          10  0.1393572      0.3218293       6.417160
 1.2884437E-17   6.066162       7.7384807E-02  0.3492500       1.8628558E-07
 1.3280113E-02   1.8411643E-04
           7          10  0.1139428      0.8696704       3.594928
 9.0359061E-16   7.448952       0.1640890       0.5588000       2.3438116E-07
 1.3624636E-02   7.7143821E-05
           8          10  0.1433487       1.975383        6.764272
 8.6055604E-13   8.172999       0.2311309       0.2190800       1.7183234E-07
 1.1969556E-02   4.1344047E-05
           9          10  0.1002728      0.2068393       2.163121
 5.2274210E-16   6.904873       0.1184673       0.4445000       4.9153317E-07
 1.3673788E-02   6.8749374E-05
          10          10  9.1272287E-02  0.1777283       1.541897
 5.7680152E-13   5.687442       0.1653022       0.1016000       3.3924158E-07
 1.1576778E-02   6.4900800E-05
          11          10  0.1788063       2.062759        9.130220
 2.3811680E-14   8.360855       0.1633120       0.2508300       1.2229651E-07
 1.4454444E-02   2.4764022E-04
          12          10  0.1450122       5.164643        7.247185
 2.6499159E-13   11.09884       0.1534645       0.1016000       8.4405656E-09
 1.3093968E-02   5.2400021E-04
          13          10  0.1380753      0.5735260       6.365110
 4.2065325E-15   8.344289       0.1310873       0.2794000       3.0192336E-07
 1.2428843E-02   4.9119513E-05
          14          10  0.1420696       1.041418        6.882150
 7.6025205E-15   7.933139       0.1231620       0.3048000       4.1357589E-07
 1.2147442E-02   9.4606061E-05
          15          10  0.2000000      0.7332190       9.514432
 4.2101275E-14   7.865863       0.1788032       0.5588000       1.2830606E-07
 1.3044660E-02   1.2883257E-04
          16          10  0.1344257       3.026037        5.900851
 1.1123850E-14   9.321473       0.1446289       0.1016000       7.6443996E-08
 1.7239949E-02   9.9636345E-05
          17          10  0.1050506      0.3152083       2.939006
 2.9671117E-16   6.434052       0.1709154       0.1016000       4.2217133E-07
 1.3952975E-02   3.1982482E-04
          18          10  0.1478584      0.2131960       7.353649
 8.3503424E-13   6.322580       0.1792119       0.3492500       2.8246518E-07
 1.5949475E-02   1.9219682E-04
          19          10  0.1647849       1.220067        8.615486
 3.3859702E-14   7.490495       0.1370754       0.1524000       4.8151549E-08
 1.4054120E-02   1.3162589E-04
          20          10  0.1126464       7.693554        3.307041
 5.2453587E-15   12.38025       0.1619413       5.0799999E-02  3.0323781E-07
 1.2068865E-02   9.0445908E-05
```

```
            21          10  9.7526789E-02  0.6905217        1.961471
 1.1094089E-13   7.853586      0.2028429      0.3810000      7.0950023E-08
 1.6421216E-02  1.6613670E-04
            22          10  0.1256319      0.9872297        4.839019
 2.6003592E-15   8.298799      0.1396629      0.2508300      3.9597117E-07
 1.1381858E-02  1.9851123E-04
            23          10  0.1401118      4.7778096E-02    6.545784
 1.4649925E-16   6.495473      0.1213904      0.4445000      3.1782619E-07
 1.6929649E-02  2.3722368E-04
            24          10  0.1750996       26.91002        9.026862
 7.0465057E-16   14.03529      0.1616529      0.2508300      3.5513779E-08
 1.1084677E-02  6.0778246E-05
            25          10  9.5157012E-02  0.1576021        1.738652
 1.7612964E-16   6.619277      0.1049080      0.1936800      4.5995870E-07
 1.1633033E-02  1.0307696E-04
            26          10  0.1011820      0.2678545        2.374225
 8.8539656E-14   6.690193      0.1787046      0.2794000      2.8640841E-08
 1.5610156E-02  1.7199584E-04
            27          10  0.1846934      0.4285355        9.234701
 1.3078763E-16   6.883809      0.1622201      0.2286000      1.5395500E-07
 1.2939489E-02  1.6299590E-04
            28          10  0.1228471       100.0001        4.418132
 2.5135838E-16   18.62215      0.1439527      0.6096000      5.5252661E-07
 1.5192318E-02  1.2548563E-04
            29          10  0.1168638      8.4877029E-02    3.951081
 6.4709696E-15   5.280710      0.1325730      0.1016000      1.0586962E-07
 1.4361119E-02  9.5595082E-05
            30          10  0.1165486       3.572831        3.423500
 7.7583021E-14   7.537965      0.2063324      0.4445000      5.6224849E-08
 1.3520175E-02  2.1800031E-04
            31          10  0.1280610       2.871041        5.194157
 4.1166858E-13   9.640755      0.1916573      0.6096000      1.2981957E-07
 1.2480060E-02  1.4899854E-04
            32          10  0.1099633      0.3780648        3.028706
 1.5609601E-14   7.686137      0.1616584      0.2286000      3.4690783E-07
 1.5244467E-02  2.9593604E-04
            33          10  0.1605444      1.7633129E-02    8.309432
 2.2224758E-16   4.942587      0.1224670      0.6096000      1.3593086E-07
 1.4287069E-02  6.2830208E-05
            34          10  8.5289389E-02   18.58241        1.164329
 1.3073077E-15   22.53333      0.1558513      0.3048000      3.3502957E-07
 1.5648989E-02  5.1689276E-05
            35          10  0.1122020      0.2812901        3.703261
 6.3289620E-17   7.077895      0.1251658      0.3492500      6.2363824E-08
 1.2877205E-02  3.7722473E-04
            36          10  0.1708282       6.706886        8.869353
 2.5674614E-17   11.79441      0.1037802      0.5588000      2.3866812E-07
 1.3214274E-02  1.0285244E-05
            37          10  6.7988425E-02   2.481652       0.3734520
 1.0793520E-15   8.617097      0.1953429      0.3492500      1.1351756E-07
 1.3794910E-02  1.0671940E-04
            38          10  0.1338438       6.294404        6.013595
 1.5930748E-17   12.06803      0.1091249      0.2286000      1.1410077E-07
 1.5496394E-02  4.3570009E-05
            39          10  0.1462499       4.445203        7.152253
 3.8664864E-15   10.30315      0.1464209      0.3492500      2.4841427E-08
 9.9487221E-03  1.4223793E-04
            40          10  0.1659205      0.1339801        8.580676
 2.1057842E-14   5.038733      0.1782897      0.4445000      2.7371919E-07
 1.2806865E-02  8.5564461E-05
            41          10  8.1863850E-02   13.09887       0.8699561
 5.5769777E-16   11.46535      0.1409624      0.1936800      9.8887426E-08
 1.3595122E-02  7.8473153E-05
            42          10  0.1365243       1.511392        6.111771
 2.7443010E-14   9.845539      0.1751550      0.1524000      2.5655095E-07
 1.4779377E-02  1.3755888E-04
```

```
         43              10  0.1030995      3.1308506E-02   2.330700
  4.1561614E-17   4.263539       0.1288913       0.2794000       2.7075896E-07
  1.4021403E-02   1.3431942E-04
         44              10  0.1327458        2.213681      5.407843
  1.3412305E-13   8.653215       0.1454658       0.1936800       6.6447683E-08
  1.1299099E-02   9.1260445E-05
         45              10  8.2906216E-02  0.5315294       1.012496
  2.4158873E-15   7.148599       0.1136251       0.2286000       1.8593823E-08
  1.4401330E-02   2.9413122E-05
         46              10  9.0117767E-02  0.6120414       1.197986
  1.8028972E-13   7.212472       0.1783139       5.0799999E-02   2.4756423E-07
  1.4587302E-02   5.3642085E-05
         47              10  0.1464944      0.2335171       6.928454
  2.0330873E-16   6.844434       9.9600650E-02  0.5588000       2.0766581E-07
  1.5402320E-02   1.1744622E-04
         48              10  0.1564112      0.1477797       7.886711
  3.7985304E-14   6.373179       0.1781164       0.3048000       2.6012063E-07
  1.4667201E-02   6.6187415E-05
         49              10  0.1579363      8.9082204E-02   8.080680
  3.5787939E-13   5.725170       0.1866331       0.1936800       3.7967766E-08
  1.5768245E-02   1.5546622E-04
         50              10  0.1079620      1.1793508E-02   2.617618
  3.2567828E-17   4.469033       0.1061364       0.1524000       4.4892431E-08
  9.0062348E-03   1.5065874E-04
         51              10  0.1148041        5.628944      3.837155
  5.6989707E-17   9.443014       0.1083585       0.2508300       3.7088330E-07
  1.3496452E-02   2.5576459E-05
         52              10  0.1093676      0.4127070       3.228415
  5.1356917E-13   6.669279       0.2482859       0.2508300       8.7244132E-08
  1.4528912E-02   8.3627012E-05
         53              10  0.1242053        14.49025      4.662136
  1.0762231E-17   10.53202       5.8706399E-02  0.2190800       9.6569408E-08
  1.4865128E-02   3.9140976E-04
         54              10  0.1367780      0.8148080       6.240638
  1.0285855E-16   7.054192       0.1218744       0.1524000       9.2669154E-08
  1.7796997E-02   8.0840939E-05
         55              10  0.1181085      2.5895631E-02   4.318312
  7.7071574E-17   4.680175       0.1772722       0.3492500       1.4951024E-07
  1.0833760E-02   1.1053683E-04
         56              10  7.1257107E-02    21.60214     0.5453258
  1.6519887E-14   12.50172       0.1126175       0.6096000       4.4580383E-07
  1.3852228E-02   8.8903203E-04
         57              10  4.9999982E-02  0.4771105     0.1035329
  3.8962493E-17   6.982884       0.1176726       0.2286000       2.2788998E-07
  1.1899312E-02   5.6912944E-05
         58              10  0.1063877        10.10114      2.805689
  3.8143699E-16   10.04485       0.1238157       0.6096000       1.5705666E-07
  1.5025233E-02   1.2019412E-04
         59              10  0.1319585        1.640603      5.573914
  5.8459389E-15   8.932034       0.1230750       0.4445000       2.2803476E-08
  1.1789343E-02   4.7118636E-05
         60              10  7.7220090E-02    2.579523     0.7965167
  7.7874727E-16   8.245615       0.1209193       0.4445000       1.7510411E-07
  1.3884971E-02   1.1344437E-04
         61              10  0.1219810        1.800795      4.516323
  1.7079580E-15   7.755095       0.1460320       0.1936800       4.4088267E-07
  1.0551646E-02   1.0850145E-04
         62              10  0.1250420      0.5108180       5.053633
  6.5358618E-13   7.273052       0.1794562       0.3810000       3.9259916E-07
  1.4266257E-02   3.7045967E-05
         63              10  5.6780986E-02  6.9671281E-02  0.2050413
  6.2133173E-14   6.520731       0.1433461       0.3810000       1.1932570E-08
  1.4729307E-02   5.4807544E-05
         64              10  8.7681592E-02  0.9450914       1.368773
  1.5041724E-13   7.590703       0.2074768       0.2190800       3.7642897E-07
  1.6072515E-02   5.8800248E-05
```

```
              65          10  0.1694444      43.32738       8.733203
  1.2136436E-14   13.83318      0.1697805      0.2794000      1.4116557E-07
  1.4918862E-02   4.0280109E-05
              66          10  0.1040974      3.278795       2.537466
  2.2426594E-17   8.047125      0.1009143      5.0799999E-02  2.1568516E-07
  1.4197263E-02   7.5344571E-05
              67          10  0.1882886      1.764420       9.385925
  8.6262021E-17   8.020835      0.1153496      0.1524000      5.0891452E-07
  1.5070859E-02   2.2566486E-04
              68          10  0.1206580      0.1082716      4.133991
  1.4413632E-17   6.770254      8.5789055E-02  0.2794000      5.1004463E-08
  1.2680155E-02   9.8165649E-05
              69          10  0.1291035      5.5597901E-02  5.343535
  3.4037646E-15   5.352950      0.1260840      0.3048000      1.6228006E-07
  1.3115174E-02   2.2318589E-05
              70          10  0.1190686      0.1241056      4.094585
  5.3811607E-14   6.089011      0.1617419      0.6096000      2.9141935E-07
  1.2656707E-02   2.5947127E-04
              71          10  0.1306657      1.124214       5.753356
  3.3229620E-13   7.372777      0.1595809      0.2286000      5.3539804E-07
  1.2775521E-02   7.2786097E-05
              72          10  0.1528356      0.3562421      7.790301
  5.1642921E-17   7.306887      0.1050647      5.0799999E-02  3.2159124E-07
  1.6351957E-02   3.4336434E-05
              73          10  9.3713492E-02  11.06588       1.669584
  2.4111122E-13   14.56196      0.2034764      0.3048000      2.0370047E-07
  1.3335303E-02   1.1474429E-04
              74          10  0.1493086      8.811837       7.455116
  9.7797306E-15   13.06471      0.1355448      5.0799999E-02  1.9755512E-07
  1.2246166E-02   2.0962505E-04
              75          10  0.1617232      4.291430       8.404033
  6.5828033E-14   10.93172      0.2177944      0.2508300      2.2250225E-07
  1.3243208E-02   1.4461970E-04
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END OF APPENDIX C

APPENDIX D: QA REVIEW FORMS

As a convenience to users, this section contains a complete history of all the Quality-Assurance Review Forms issued during the review of this User's Manual. Review forms are issued after the User's Manual has been completed and reviewed. Thus, they will be appended to the manual after it has been paginated and therefore they may not, themselves, be paginated.

END OF APPENDIX D

END OF THE USER'S MANUAL