



AMSAA

TECHNICAL REPORT NO. 279
REVISED

A COMPUTER PROGRAM FOR ESTIMATION OF PARAMETERS OF THE
WEIBULL INTENSITY FUNCTION AND FOR THE CRAMER-VON MISES
GOODNESS OF FIT TEST

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EDWARD F. BELBOT

APRIL 1980

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A COMPUTER PROGRAM FOR ESTIMATION OF PARAMETERS FOR THE WEIBULL INTENSITY FUNCTION AND FOR THE CRAMER-VON MISES GOODNESS OF FIT TEST

1. INTRODUCTION

The Weibull intensity function

$$U(X) = \lambda \beta X^{\beta-1} \quad (1.1)$$

$\lambda > 0, \beta > 0, X > 0$, is frequently used as a model for the determination of reliability growth and wear-out characteristics for a wide variety of complex, repairable systems. The failure rates of military equipment such as vehicles, aircraft, guided missiles, electronic computer systems, and ammunition are being evaluated using this model.

Formulas have been developed by the Army Materiel Systems Analysis Activity (AMSAA) for the maximum likelihood estimation of the unknown parameters λ and β , based upon sample data. These estimation formulas for the Weibull process, found in Crow (1975), can be stated as

$$\hat{\beta} = \frac{\sum_{i=1}^K N_i}{\hat{\lambda} \sum_{i=1}^K [T_{i2}^{\hat{\beta}} \ln(T_{i2}) - T_{i1}^{\hat{\beta}} \ln(T_{i1})] - \sum_{i=1}^K \sum_{j=1}^{N_i} \ln(X_{ij})} \quad (1.2)$$

$$\hat{\lambda} = \frac{\sum_{i=1}^K N_i}{\sum_{i=1}^K (T_{i2}^{\hat{\beta}} - T_{i1}^{\hat{\beta}})} \quad (1.3)$$

where:

K is the number of systems under study;

N_i is the total number of failures (or occurrences of an event under study, such as unscheduled maintenance actions; etc.)

for the i^{th} system;

T_{i1} is the starting time of the period of continuous observation of the i^{th} system;

T_{i2} is the ending time of the period of continuous observation of the i^{th} system;

X_{ij} is the j^{th} time of occurrence of the failure (or event), for the i^{th} system;

$\ln$ is the natural logarithm, and $0 \cdot \ln(0)$ is defined to be 0.

To expedite the computation of these estimates, AMSAA developed a FORTRAN computer program to calculate $\hat{\beta}$ and $\hat{\lambda}$. That program, which was documented in Belbot (1974), was successfully employed by the U S Army Materiel Development and Readiness Command (DARCOM), various subordinate commands and several project managers' offices, as well as by AMSAA. After the parameters were determined by that program, a goodness of fit test was frequently used to test statistically the hypothesis that the failure times of the systems being analyzed followed a nonhomogeneous Poisson process with Weibull intensity function (see Crow [1975]). The modified Cramer-Von Mises goodness of fit statistic was computed, either by hand or by a separate computer program.

Obviously, the consolidation of an automated goodness of fit test with the computer routine which estimates the parameters $\hat{\beta}$ and $\hat{\lambda}$, would increase efficiency and accuracy. Either the manual calculations or the use of a separate program would be eliminated. To accomplish properly this consolidation, the estimation procedure was subordinated to a new main program which also controls the input of data and the execution of the goodness of fit test. Because of the radical nature of this redesign, it was appropriate to incorporate other new features at the same time. Principal among these new features are a simplified input procedure and dynamic data storage allocation. The resulting computer program is easier to use and provides more information than its antecedent program. This report will explain the structure and the use of this new program.

2. COMPUTING PROCEDURE

2.1 Estimation of Parameters

Since the formulas (1.2) and (1.3) do not, in general, yield $\hat{\beta}$ and $\hat{\lambda}$ in closed form, an iterative technique is required. Formula (1.2) may be recast as

$$\frac{\sum_{i=1}^K \sum_{j=1}^{N_i} \ln(x_{ij})}{\sum_{i=1}^K N_i} - \frac{\sum_{i=1}^K [T_{i2}^{\hat{\beta}} \ln(T_{i2}) - T_{i1}^{\hat{\beta}} \ln(T_{i1})]}{\sum_{i=1}^K (T_{i2}^{\hat{\beta}} - T_{i1}^{\hat{\beta}})} - \frac{1}{\hat{\beta}} = 0 \quad (2.1)$$

by replacing $\hat{\lambda}$ by its equivalent expression from equation (1.3), and by execution of a few simple algebraic operations. Equation (2.1) now consists of a constant with regard to $\hat{\beta}$, minus a function of $\hat{\beta}$, yielding 0, or simply

$$A - D(\hat{\beta}) = 0 \quad (2.2)$$

The correct value of $\hat{\beta}$ will satisfy equation (2.2) and can be used to calculate the corresponding value of $\hat{\lambda}$.

The solution for $\hat{\beta}$ is iteratively determined in the following way. For an initial estimate $\hat{\beta}_1$ which is assumed to be larger than the true $\hat{\beta}$, the expression $A-D(\hat{\beta}_1)$ is evaluated. For all values of $\hat{\beta}_1$ larger than the true $\hat{\beta}$, the subtraction yields a negative result. After each negative result, $\hat{\beta}_1$ is reduced by the initial step size of 1, and $A-D(\hat{\beta}_1)$ is again evaluated.

When a positive number results from the subtraction, indicating that $\hat{\beta}_1$ is too small, the step size is decreased to 0.10 of the present step size, the previous value of $\hat{\beta}_1$ which gave a negative result for $A-D(\hat{\beta}_1)$, is adjusted by the new step size and the evaluation process begins again.

The iteration procedure continues, adjusting $\hat{\beta}_1$ by the new step sizes, until the left side of equation (2.2) is within a specified tolerance ϵ of 0. $\hat{\lambda}$ is then calculated based on $\hat{\beta}$, using factors already computed in finding $\hat{\beta}$. This procedure is summarized by the state diagram (Figure 2.1).

2.2 Goodness of Fit Test

The Cramer-Von Mises Goodness of Fit Test is appropriate whenever the starting time of each system is equal to 0. To perform this test, the program first transforms the failure times. For time truncated testing, the failure times for each system are divided by the ending time of the test period for that system. In failure truncated testing, for every system, all the failure times except the last, are divided by the last failure time. The last failure time is thereafter excluded from the calculations and the number of transformed failures is one less than the original number of failures for each such system. All the transformed failure times are then sorted into increasing order.

Next, the unbiased estimate $\bar{\beta}$ of the estimated shape parameter β , is calculated using the relation:

$$\bar{\beta} = \frac{M-1}{\sum_{i=1}^K L_i \ln(T_{i2}) - \sum_{i=1}^K \sum_{j=1}^{L_i} \ln(X_{ij})} \quad (2.3)$$

where:

$$L_i = \begin{cases} N_i - 1 & \text{if the data for the } i^{\text{th}} \text{ system are failure truncated} \\ N_i & \text{if the data for the } i^{\text{th}} \text{ system are time truncated} \end{cases}$$

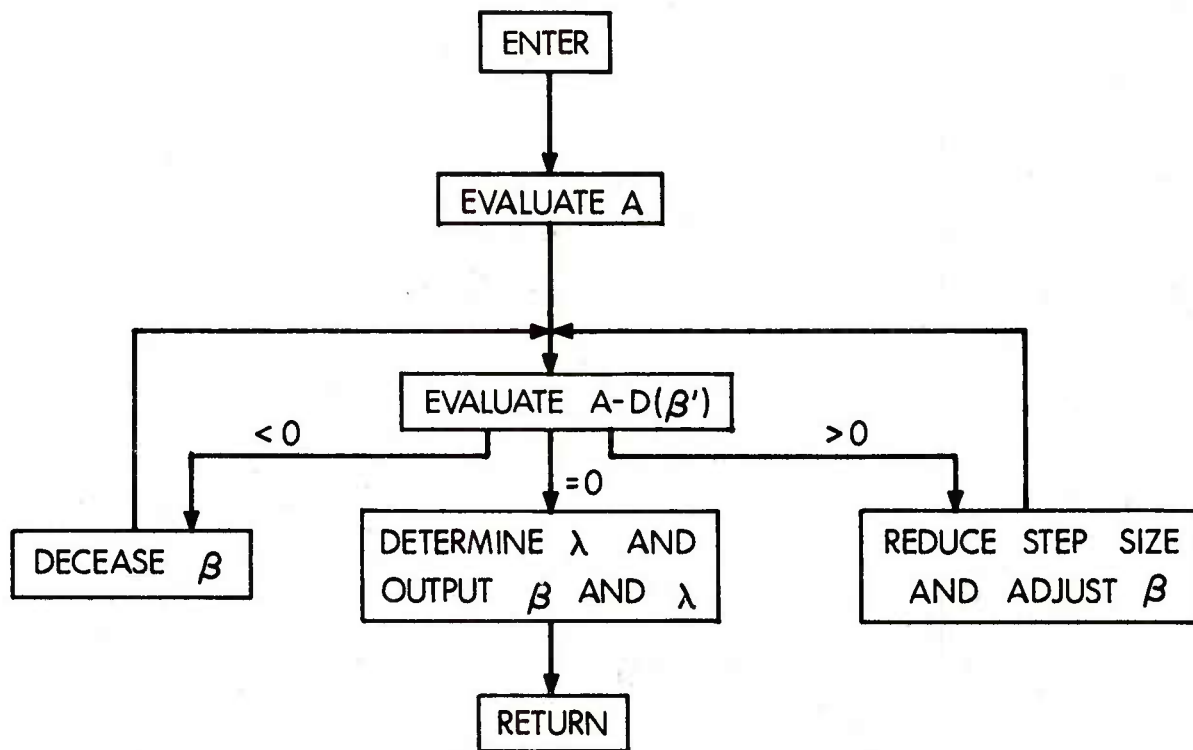


Figure 2.1 State Diagram

and M = total number of transformed failure times. (Note that

$$M = \sum_{i=1}^K L_i .)$$

Finally, the Cramer-Von Mises statistic C_M^2 is computed by the formula:

$$C_M^2 = \frac{1}{12M} + \sum_{i=1}^M \left(Z_i^{\bar{P}} - \frac{2i-1}{2M} \right)^2 \quad (2.4)$$

where the Z_i are the transformed failure times. An explanation of this test and a table of critical values of C_M^2 may be found in Crow (1975).

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3. DESCRIPTION OF PROGRAM

3.1 Major Features

The program, which is listed in Appendix A, has some important features. First, the program is written in American National Standards Institute (ANSI) FORTRAN X3.9-1966, and should therefore execute on any computer having a compiler for this language. Secondly, the amount of storage required to use this program should not cause difficulties since all data arrays are dynamically allocated under control of the main program (see Chung-Phillips, et al., 1975).

Finally, and perhaps most importantly for the user, this program uses free-field input, that is, no specific format is required for the input data. The time and the effort regularly expended in preparing data for input, are greatly reduced because of this feature. Moreover, the misalignment of data fields to formats, a frequent source of errors in using many computer programs, is eliminated entirely. While no input scheme can be regarded as foolproof, free-field input is much more flexible than fixed-field format specifications.

3.2 Overall Characteristics

All calculations in the program are made in double precision mode. Experience has shown that the use of single precision variables for these calculations often results in significant discrepancies in the estimates of the parameters due to errors accumulated during the iterative process.

The modular structure of the program (see Figure 3.1) reflects organization by functional purpose. The input of data, certain intermediate calculations, the estimation of parameters, and the goodness of fit test are each performed by an independent module. Major subprograms print their results as the values become available. Subroutines which detect errors, print diagnostic messages naming the detecting routine and briefly stating the difficulty, and then attempt to continue processing when possible. Independence of the subroutines is maintained by restricting communication between individual subprograms to the passage of formal parameters in argument lists. No COMMON statements are used.

3.3 Specific Details of Routines

In addition to controlling the major modules, the main program also allocates storage for data arrays, as stated in Section 3.1. The allocation is based upon the maximum number of failures, NFAIL, and the maximum number of systems, NSYS. The master data array, BLOCK, has a length of NTOTAL, equal to 1.5 times the value of NFAIL plus six times the value of NSYS. To redimension the entire program, one merely adjusts the values of NFAIL, NSYS and NTOTAL in the DATA statements at the beginning of the main routine and changes the size of the array BLOCK, also found at the beginning of the main program, to equal the new value of NTOTAL.

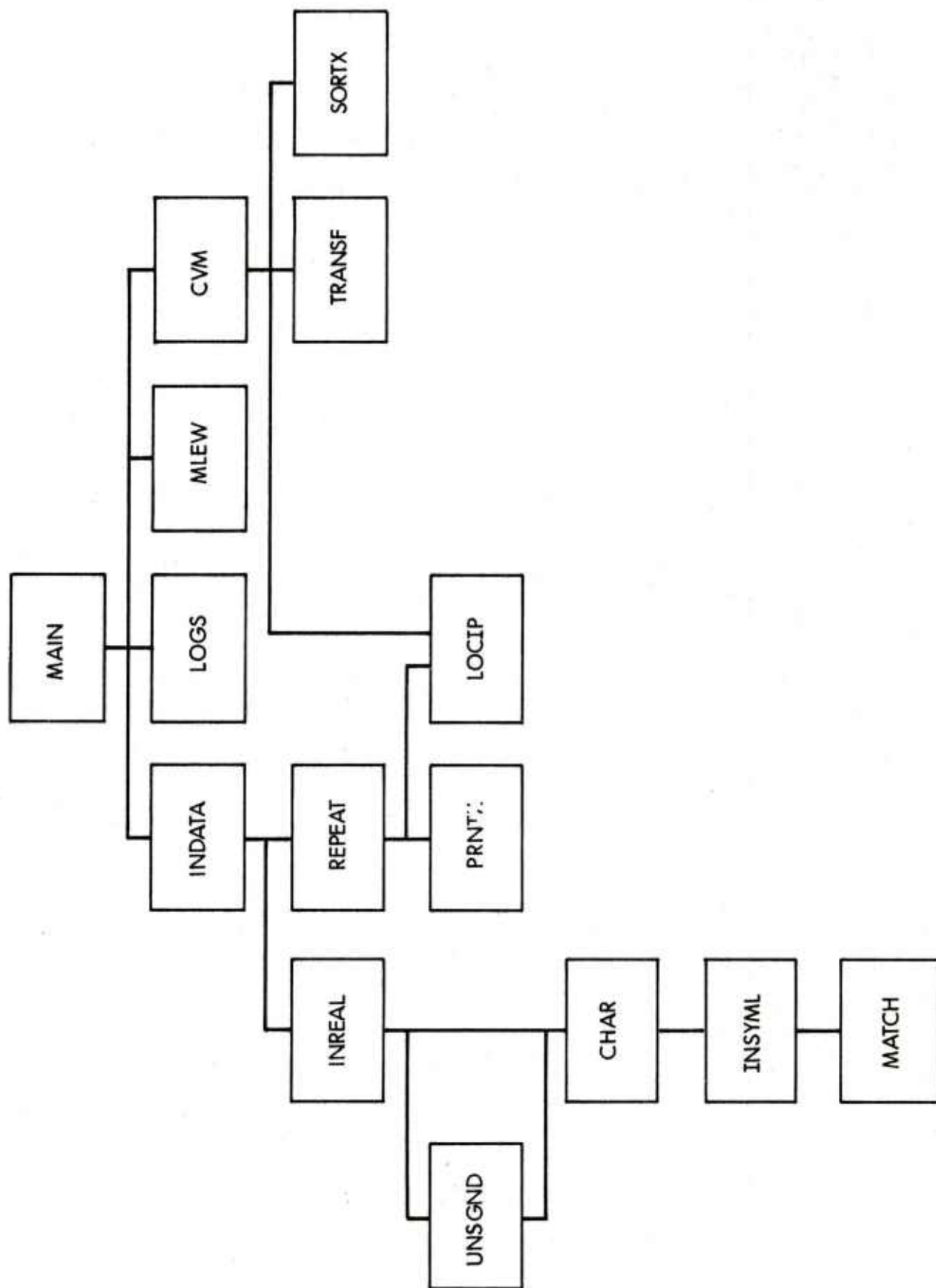


Figure 3.1 Module Organization Chart.

By these actions, all data arrays in all subroutines will be properly resized. Since the program size excluding data arrays, is less than 5,000 words, computer memory requirements can be scaled to problem size through use of this feature.

Also found in the DATA statements at the beginning of the main routine are the unit number for input, IUNIT, and the logical switch ECHO which controls the printing of the input data. Just as the storage allocation values, these values may be changed as needed.

The first major module is for the input of data. The INDATA module reads the beginning and the ending times and the failure times from the input unit, IUNIT. If the logical variable ECHO is true, the submodule REPEAT will print the input, using the LOCIP subroutine to isolate in storage the failures for each system and the PRNTX subroutines to print them. The failure times are stored in a linear array called X. Parallel to X, an integer array named MARKER identifies the failures with the respective systems, such that if failure X(I) occurred on system J, then MARKER(I) equals J.

The free-field reading of data is performed by the INREAL submodule. This submodule, consisting of the routines INREAL, CHAR, INSYML, MATCH and UNSGND, is a translation from ALGOL into FORTRAN of Algorithm 239 of the Association for Computing Machinery (see McKeeman [1964]). Specific details concerning the input arrangement are given in Section 4.

The INDATA subroutine also sets three logical variables depending on the input. If data errors are encountered, the variable NOGOOD is made true. If all systems start at 0.0, then the goodness of fit test will be appropriate and so the variable GOF is set to true. Lastly, when the end of input is reached, the logical variable HALT is returned as true.

The second principal module, LOGS, calculates the logarithms of the beginning and the ending times, and the sum of the logarithms of the failure times. For computational purposes, a beginning time of 0.0 is defined to have a logarithm of 0.0 instead of infinity. Note that failure times of 0.0 are not valid for this model and are flagged as errors by the preceding INDATA module.

The next major module, MLEW, computes the maximum likelihood estimates of the parameters of the Weibull intensity function for the given data, using the formulas discussed in Section 2.1. If unsuccessful, this module will report one of three possible error conditions. The first error message "BETA LESS THAN 0.0000001" indicates that the data should be rechecked for the reasonableness of a very small $\hat{\beta}$. The second error message is "INITIAL ESTIMATE OF BETA IS TOO SMALL." Since the initial estimate of BETA is set to 10 at the start of the MLEW subprogram, this message indicates some peculiarity of the data. (In general, $0 < \hat{\beta} < 10$.) The third message, "STEP-SIZE HAS BECOME INSIGNIFICANT - BETA NOT RESOLVABLE," indicates that the module has gone as far as

possible trying to meet the tolerance set for the difference $A-D(\hat{\beta})$. This tolerance, EPSILN, may be enlarged by changing the assignment statement also located at the beginning of the MLEW subprogram.

The last major module, CVM, performs the Cramér-Von Mises goodness of fit test, as described in Section 2.2. The failure times for each system are located in storage using the LOCIP subroutine, and examined to determine if the testing was time truncated or failure truncated. The failure times are then transformed by the TRANSF subroutine and sorted by the SORTX subroutine. (SORTX is a modification of an utility subprogram described in Campbell, et al., [1970].) The unbiased estimate of β , UNBETA, is calculated next, as explained earlier. The last phase depends on the system starting times. If any starting time is non-zero, the module terminates with a message stating that the Cramér-Von Mises goodness of fit test is not appropriate. Otherwise, the goodness of fit statistic, CM2, is computed and printed.

4. INPUT REQUIREMENTS

As stated previously, the input for this program is free-field. The only requirement regarding spacing is that at least one blank column separate adjacent values. The values must not run together. This means that the program generally takes the same view of the data that a person would, namely, that each cluster of numeric characters constitutes one data value. The only exception to this rule occurs at the boundaries of records. Since the input is treated as a continuous stream, a string of characters beginning in the first column of a record, is considered a continuation of the string of characters ending in the last column of the previous record, if any. Record boundaries are not delimiters; blanks are the only delimiters.

The data required for this program consist of the beginning and ending times of the test period for each system, and the failure times for each system. The arrangement of the input, (which is also stated in the comments of the INDATA subroutine), is by system. The first data value is the beginning time of the first system. The second data value is the ending time of the first system. Next is the failure times for the first system, followed by a negative value to mark the end of the first system. The same pattern, beginning time, ending time, failure times, and negative trailer, is repeated for each subsequent system in the first data case.

Another negative value (making two in a row), signals the end of input of the current data case, and the beginning of the computational procedures. The same arrangement may be repeated for as many cases as desired per program run. When the input routine encounters a negative value after completing a case, (that is, the third negative value in a row), the end of the program run is indicated.

Thus, as a simple example, if one desired to use this program for one run consisting of one case wherein one system experienced seven failures, the input data would be: the beginning time, the ending time, the seven failure times, and three negative values. To demonstrate the latitude of the input requirements, the data for a number of test cases are shown in Appendix B. Notice that any negative value is acceptable as a trailer and that data values may be entered with or without decimal points. Although not shown in the examples, data values may also be in exponential form, that is, containing 'E,' '+' or '-'.

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5. TRANSFERABILITY AND MODIFICATION

Since this program is written in standard FORTRAN, transfer to other computer systems should be straightforward. To assist in the transfer process, Appendix C contains the output produced by the program for the input shown in Appendix B. This output was generated on a Control Data Corporation (CDC) Cyber 76 Computer, using the program exactly as listed in Appendix A. (Note that non-standard PROGRAM statement required by the CDC Cyber.)

The input for these test cases came from records of eighty characters each. If the input record length is other than eighty, two changes may be required. The value of the variable LENGTH and, if necessary, the dimensioned size of the array BUFFER, should be adjusted in the INSYML subroutine.

Alternatively, one could replace the entire INREAL submodule. Although these routines were written to be fully transportable, running time might be saved by using the system defined free-field reading capability of any computer having such a feature. As an example, a substitute for the INREAL submodule, suitable for the CDC Cyber 76, is shown in Figure 5.1. Such substitutes, however, are system dependent and not readily transferable.

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FIGURE 5.1 SUBSTITUTE FOR INREAL SUBMODULE

```
SUBROUTINE INREAL (IU, X)
DOUBLE PRECISION X
READ (IU, *) X
RETURN
END
```

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3. Chung-Phillips, A. and Rosen, R. W., "A Note on Dynamic Data Storage in FORTRAN IV," Computer Journal, Volume 18, No. 4, 1975.
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6. USA Standard FORTRAN (USAS X3.9 - 1966). USA Standards Institute (now designated the American National Standards Institute, Inc.), 1966.

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APPENDIX A
LISTING OF PROGRAM

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```

10  MAIN (INPUT=60, OUTPUT=60, TAPE5=INPUT, TAPE6=OUTPUT)
20  MAIN
30  MAIN
40  MAIN
50  MAIN
60  MAIN
70  MAIN
80  MAIN
90  MAIN
100 MAIN
110 MAIN
120 MAIN
130 MAIN
140 MAIN
150 MAIN
160 MAIN
170 MAIN
180 MAIN
190 MAIN
200 MAIN
210 MAIN
220 MAIN
230 MAIN
240 MAIN
250 MAIN
260 MAIN
270 MAIN
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370 MAIN
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400 MAIN
410 MAIN
420 MAIN
430 MAIN
440 MAIN
450 MAIN
460 MAIN
470 MAIN
480 MAIN
490 MAIN
500 MAIN
510 MAIN
520 MAIN
530 MAIN
540 MAIN
550 MAIN
560 CVM
570 CVM
580 CVM
590 CVM
600 CVM
610 CVM
620 CVM
630 CVM
640 CVM
650 CVM
660 CVM
670 CVM
680 CVM
690 CVM
700 CVM
710 CVM
720 CVM
730 CVM
740 CVM
750 CVM
760 CVM
770 CVM
780 CVM
790 CVM
800 CVM
810 CVM
820 CVM
830 CVM
840 CVM
850 CVM
860 CVM
870 CVM
880 CVM
890 CVM
900 CVM
910 CVM
920 CVM
930 CVM
940 CVM
950 CVM
960 CVM
970 CVM
980 CVM
990 CVM
1000 CVM

PROGRAM MAIN (INPUT=60, OUTPUT=60, TAPE5=INPUT, TAPE6=OUTPUT)
THE ABOVE STATEMENT IS NON-STANDARD, BUT REQUIRED FOR
CDC FORTHAN.

MAIN DRIVER FOR WEIBULL INTENSITY MODEL PARAMETER
ESTIMATION AND GOODNESS OF FIT TEST. (12 NOV. 1979)
INPUT REQUIREMENTS ARE DESCRIBED IN THE 'INDATA'
SUBROUTINE.

DOUBLE PRECISION BLOCK(13500)
DOUBLE PRECISION BETA, SUMLNKX
LOGICAL ECHO, FAULT, GOF, HALT, NOGOOD

DATA IUNIT /5/
DATA ECHO /.TRUE./
DATA NFAIL, NSYS /5000, 1000/
TOTAL DATA STORAGE EQUALS 1.5 TIMES THE NUMBER OF FAILURES
PLUS 6 TIMES THE NUMBER OF SYSTEMS.
DATA NTOTAL /13500/
WRITE (6,20)

ALLOCATE STORAGE BASED ON MAXIMUM NUMBERS OF FAILURES
AND SYSTEMS.
NS2=NSYS*2
I1=1
I2=I1+NFAIL
I3=I2+NS2
I4=I3+NS2
I5=I4+NS2
ITOTAL=I5+(NFAIL/2)
IF (MOD(NFAIL,2).EQ.0) ITOTAL=ITOTAL-1
IF (ITOTAL.LE.NTOTAL) GO TO 10
WRITE (6,30) ITOTAL,NTOTAL
STOP

BEGIN PROCESSING.
10 CALL INDATA (BLOCK(11),BLOCK(12),BLOCK(15),NFAIL,NSYS,M,K,IUNIT,
1ECHO,GOF,HALT,NOGOOD)
IF (HALT) STOP
IF (NOGOOD) GO TO 10
CALL LOGS (BLOCK(11),BLOCK(12),BLOCK(14),NFAIL,NSYS,M,K,SUMLNKX)
CALL MLEN (SUMLNKX,BLOCK(12),BLOCK(13),BLOCK(14),NSYS,M,K,BETA,
1FAULT)
IF (.NOT.FAULT) CALL CVM (BLOCK(11),BLOCK(12),BLOCK(14),BLOCK(15),
1NFAIL,NSYS,M,K,GOF,SUMLNKX,BETA)
GO TO 10

20 FORMAT (26H1 WEIBULL INTENSITY MODEL //1H9.30X.47H PARAMETER ESTIM
ATION AND GOODNESS OF FIT TEST //26H0 VERSION OF 12 NOV. 1979 ///)
30 FORMAT (33H1 AMOUNT OF STORAGE REQUESTED IS ,16.40H WORDS, AMOUNT
1 OF STORAGE AVAILABLE IS ,15.25H WORDS, PROGRAM ABORTED./)
END
SUBROUTINE CVM (X,C,CLN,MARKER,NFAIL,NSYS,M,K,GOF,SUMLNKX,BETA)
COMMENT THIS SUBROUTINE PERFORMS THE CRAMER-VON MISES GOODNESS
OF FIT TEST.
DOUBLE PRECISION X(NFAIL), C(NSYS,2), CLN(NSYS,2), SUMLNKX, BETA
DOUBLE PRECISION CM2, DENOM, SUMSQS, TQ, TWOM, UNBETA
DOUBLE PRECISION TERM, TERM1, TERM2
INTEGER MARKER(NFAIL)
LOGICAL GOF

```

```

C      WRITE (6,66) BETA,M
C      DENOM=0.0D0
C      IPT=
C      MSAVE=M

C      DO 20 J=1,K
C      CALL LOCIP (MARKER,NFAIL,MSAVE,J,1B,1E)
C      IF (1E.LT.1B) GO TO 20
C      L=1E-1B+1
C      SORT THE FAILURES FOR EACH SYSTEM INTO INCREASING ORDER.
C      IF (L.GT.1) CALL SORTX (X(1B),L)
C      CHECK FOR TIME TRUNCATED TESTING.
C      TQ=C(J,2)
C      IF (DABS(X(1E)-TQ).GT.1.0D-08) GO TO 10
C      THE LAST FAILURE IS NOT USED FOR FAILURE TRUNCATED SYSTEMS.
C      SUMLNK-SUMLNK-DLOG(X(1E))
C      1E=1E-1
C      M=M-1
C      L=L-1
C      10 DENOM=DENOM+(DBLE(FLOAT(L))*CLN(J,2))
C      TRANSFORM THE FAILURES.
C      CALL TRANSF (X,NFAIL,TQ,1B,1E,IPT)
C      20 CONTINUE

C      SORT THE TRANSFORMED FAILURES INTO INCREASING ORDER.
C      CALL SORTX (X,M)
C      UNBIASED ESTIMATE OF BETA.
C      DENOM=DENOM-SUMLNK
C      UNBETA=DBLE(FLOAT(M-1))/DENOM
C      WRITE (6,90) UNBETA

C      IF (ACOF) GO TO 30
C      WRITE (6,80)
C      GO TO 50
C      30 SUMSQS=0.0D0
C      TWOM=DBLE(FLOAT(2*M))
C      DO 40 I=1,M
C      TERC1=X(1)**UNBETA
C      TERC2=DBLE(FLOAT(2*I-1))/TWOM
C      TERM1=TERM2
C      SUMSQS=SUMSQS+TERM**2
C      40 CONTINUE
C      CRAMER-VON MISES STATISTIC.
C      CM2=SUMSQS+(1.0D0/DBLE(FLOAT(12*M)))
C      WRITE (6,70) CM2,M

C      50 RETURN

C      60 FORMAT (42H1 CRAMER - VON MISES GOODNESS OF FIT TEST.///18H0ESTIMACVM
C      1TED BETA = ,1PD15.7/22H0NUMBER OF FAILURES = ,16)
C      70 FORMAT (32H0CRAMER - VON MISES STATISTIC = ,1PD15.7/32H0REJECT THECVH
C      1 WEIBULL INTENSITY MODEL IF THE STATISTIC/4BH EXCEEDS THE APPROPRICVM
C      2ATE CRITICAL VALUE FOR M = ,15/)
C      80 FORMAT (77H0THE CRAMER - VON MISES GOODNESS OF FIT TEST IS NOT APPVCVM
C      1ROPRATE FOR THIS CASE/5BH BECAUSE ONE OR MORE SYSTEMS HAVE NON-ZEVCVM
C      2RO STARTING TIMES./)
C      90 FORMAT (29H0UNBIASED ESTIMATE OF BETA = ,1PD15.7/11H)
C      END
C      SUBROUTINE INDATA (X,C,MARKER,NFAIL,NSYS,M,K,UNIT,ECHO,COF,HALT,
C      1 NOGOOD)
C      COMMENT THIS SUBROUTINE READS THE INPUT DATA ARRANGED AS
C      FOLLOWS:
C      INDAA 10
C      INDAA 20
C      INDAA 30
C      INDAA 40
C      INDAA 50

```

```

C BEGINNING AND ENDING TIMES FOR FIRST SYSTEM, FAILURE
C TIMES FOR FIRST SYSTEM, NEGATIVE VALUE AS TRAILER.
C BEGINNING AND ENDING TIMES FOR SECOND SYSTEM, FAILURE
C TIMES FOR SECOND SYSTEM, NEGATIVE VALUE FOR TRAILER.
C
C ...
C ...
C ...
C BEGINNING AND ENDING TIMES FOR K-TH SYSTEM, FAILURE
C TIMES FOR K-TH SYSTEM, NEGATIVE VALUE AS TRAILER.
C NEGATIVE VALUE TO MARK END OF CASE.
C (REPEAT ABOVE FOR AS MANY CASES AS NEEDED.)
C NEGATIVE VALUE TO MARK END OF RUN.
C
C INPUT IS FREE-FIELD, REQUIRING ONLY THAT AT LEAST ONE BLANK
C COLUMN SEPARATE ADJACENT VALUES.
C
C FOR CASES WITH MORE THAN ONE SYSTEM, THE ROUTINE WILL
C ACCEPT SOME (BUT NOT ALL) SYSTEMS WITH NO FAILURES.
C
C DOUBLE PRECISION X(NFAIL), C(NSYS,2)
C INTEGER MARKER(NFAIL)
C LOGICAL ECHO, GOF, HALT, NOGOOD
C
C GOF = .TRUE.
C HALT = .FALSE.
C NOGOOD = .FALSE.
C WRITE (6,136)
C
C J=1
C I=1
C
C ----- BEGIN INPUT CYCLE. -----
C
C 10 CALL INREAL (IUNIT,C(J,1))
C NEGATIVE VALUE TO MARK THE END OF THIS CASE.
C IF (C(J,1).LT.0.000) GO TO 50
C IF (DABS(C(J,1)).GT.1.00-00) GOF = .FALSE.
C CALL INREAL (IUNIT,C(J,2))
C J=J+1
C IF (J.LE.NSYS) GO TO 20
C WRITE (6,100) J
C NOGOOD = .TRUE.
C
C 20 CALL INREAL (IUNIT,X(1))
C NEGATIVE VALUE TO MARK THE END OF THIS SYSTEM.
C IF (X(1).LT.0.000) GO TO 10
C IF (X(1).GT.1.00-00) GO TO 30
C WRITE (6,110)
C NOGOOD = .TRUE.
C
C EACH FAILURE MUST FALL WITHIN THE TEST PERIOD.
C 30 IF (C(J-1,1).LE.X(1).AND.X(1).LE.C(J-1,2)) GO TO 40
C WRITE (6,120) X(1),C(J-1,1),C(J-1,2)
C NOGOOD = .TRUE.
C 40 MARKER(1)=J-1
C I=I+1
C IF (I.LE.NFAIL) GO TO 20
C WRITE (6,90) I
C NOGOOD = .TRUE.
C GO TO 20
C
C ----- END OF INPUT CYCLE. -----
C
C 50 M=

```

```

C      IF (M.LE.0) GO TO 60
C      TOTAL NUMBER OF FAILURES.
C      WRITE (6,70) N
C      K=J-1
C      TOTAL NUMBER OF SYSTEMS.
C      WRITE (6,80) K
C      IF (ECHO) CALL REPEAT (X,C,MARKER,NFAIL,NSYS,M,K)
C      RETURN
C      -----
C      1 END OF RUN.
C      -----
C      60 HALT=.TRUE.
C      WRITE (6,140)
C      RETURN
C
C      70 FORMAT (28H0TOTAL NUMBER OF FAILURES = ,15)
C      80 FORMAT (28H0TOTAL NUMBER OF SYSTEMS = ,15)
C      90 FORMAT (18H0 INDATA ERROR -- ,16.22H IS TOO MANY FAILURES./)
C      100 FORMAT (18H0 INDATA ERROR -- ,16.21H IS TOO MANY SYSTEMS./)
C      110 FORMAT (52H0 INDATA ERROR -- A FAILURE AT 0.0000000 WAS INPUT./71)
C      110 THE PROBABILITY OF SUCH A FAILURE TIME IS 0.0 ACCORDING TO THE
C      2MODEL./)
C      120 FORMAT (33H0 INDATA ERROR -- THE FAILURE AT ,1PD10.3/44H DOES NOT
C      1 FALL WITHIN THE TEST PERIOD FROM ,1PD10.3.4H TO ,1PD10.3./)
C      130 FORMAT (19H1 DATA INPUT PHASE./)
C      140 FORMAT (28H0 PROGRAM RUN ENDS NORMALLY./1H1)
C      END
C      SUBROUTINE LOCIP (MARKER,NFAIL,M,J,IB,IE)
C      COMMENT THIS SUBROUTINE LOCATES THE FIRST AND THE LAST FAILURES
C      C      ASSOCIATED WITH SYSTEM 'J'. ON RETURN, 'IB' AND 'IE' INDEX
C      C      THESE FAILURES.
C      C      INTEGER MARKER(NFAIL)
C      C      IB=0
C      C      IE=-1
C      C      DO 10 I=1,M
C      C      IF (MARKER(I).LT.J) GO TO 10
C      C      IF (MARKER(I).GT.J) GO TO 20
C      C      EQUALITY.
C      C      IE=I
C      C      IF (IB.EQ.0) IB=I
C      C      10 CONTINUE
C      C      20 RETURN
C      C      END
C      SUBROUTINE LOGS (X,C,CLN,NFAIL,NSYS,M,K,SUMLNX)
C      COMMENT THIS SUBROUTINE TAKES LOGARITHMS.
C      C      DOUBLE PRECISION X(NFAIL), C(NSYS,2), CLN(NSYS,2)
C      C      DOUBLE PRECISION SUMLNX
C      C      LOGARITHMS OF BEGINNING AND ENDING TIMES.
C      C      DO 20 I=1,K
C      C      CLN(I,2)=DLOG(C(I,2))
C      C      IF (C(I,1).LE.0.0D0) GO TO 10
C      C      CLN(I,1)=DLOG(C(I,1))
C      C      GO TO 20
C      C      10 C(I,1)=0.0D0
C      C      CLN(I,1)=0.0D0
C      C      20 CONTINUE
C      C      SUM OF LOGARITHMS OF FAILURES.
C      C      SUMLNX=0.0D0

```

```

DO 30 I=1,M
SUMLNK=SUMLNK+DLOG(X(I))
30 CONTINUE
C
RETURN
END
SUBROUTINE MLEW (SUMLNK,C,CB,CLN,NSYS,M,K,BETA,NOCOOD)
COMMENT
THIS SUBROUTINE CALCULATES THE MAXIMUM LIKELIHOOD
ESTIMATES OF THE PARAMETERS BETA AND LAMBDA OF THE WEIBULL
INTENSITY FUNCTION  $R(X) = \text{LAMBDA} * \text{BETA}^{XX} * (\text{BETA} - 1.0)$ .
BETA IS DETERMINED BY AN ITERATIVE PROCESS WHICH
EXAMINES THE SIGNED DIFFERENCE OF A CONSTANT MINUS A FUNCTION
OF BETA AS BETA IS DECREASED FROM A LARGE INITIAL ESTIMATE BY
NON-POSITIVE POWERS OF 10.0 UNTIL AN EPSILON TOLERANCE IS
SATISFIED OR BETA IS LESS THAN 0.00000001 IN VALUE.
LAMBDA IS CALCULATED BASED ON BETA.
C
DOUBLE PRECISION C(NSYS,2), CB(NSYS,2), CLN(NSYS,2)
DOUBLE PRECISION BETA, LAMBDA, EPSILN, SUMLNK
DOUBLE PRECISION DENOM, DENOM1, DENOM2, TOP, TOP1, TOP2
DOUBLE PRECISION A, ABDI, ADJ, D, DIFF, TOTAL
LOGICAL NOCOD
C
WRITE (6,110)
BETA=1.0D+01
EPSILN=1.0D-05
TOTAL=DBLE(FLOAT(M))
NPDIFF=0
NOCOD=.FALSE.
C
25
C
CONSTANT NOT INVOLVING BETA.
A=SUMLNK/TOTAL
WRITE (6,130) A
C
-----
BEGIN ITERATION PROCEDURE.
C
-----
ADJ=1.0D0
IZERO=0
WRITE (6,150)
C
10
TOP1=0.0D0
TOP2=0.0D0
DENOM1=0.0D0
DENOM2=0.0D0
DO 20 I=1,K
DO 20 J=1,2
CB(I,J)=C(I,J)**BETA
20 CONTINUE
C
DO 30 I=1,K
TOP1=TOP1+CB(I,1)*CLN(I,1)
TOP2=TOP2+CB(I,2)*CLN(I,2)
DENOM1=DENOM1+CB(I,1)
DENOM2=DENOM2+CB(I,2)
30 CONTINUE
C
TOP=TOP2-TOP1
DENOM=DENOM2-DENOM1
D=(TOP/DENOM)-(1.0D0/BETA)
DIFF=A-D
LAMBDA=TOTAL/DENOM
WRITE (6,120) BETA,D,DIFF,LAMBDA
ABDI=DABS(DIFF)
IF (ABDI.LE.EPSILN) GO TO 50
MLEW 190
LOGS 200
LOGS 210
LOGS 220
LOGS 230
LOGS 240
MLEW 10
MLEW 20
MLEW 30
MLEW 40
MLEW 50
MLEW 60
MLEW 70
MLEW 80
MLEW 90
MLEW 100
MLEW 110
MLEW 120
MLEW 130
MLEW 140
MLEW 150
MLEW 160
MLEW 170
MLEW 180
MLEW 190
MLEW 200
MLEW 210
MLEW 220
MLEW 230
MLEW 240
MLEW 250
MLEW 260
MLEW 270
MLEW 280
MLEW 290
MLEW 300
MLEW 310
MLEW 320
MLEW 330
MLEW 340
MLEW 350
MLEW 360
MLEW 370
MLEW 380
MLEW 390
MLEW 400
MLEW 410
MLEW 420
MLEW 430
MLEW 440
MLEW 450
MLEW 460
MLEW 470
MLEW 480
MLEW 490
MLEW 500
MLEW 510
MLEW 520
MLEW 530
MLEW 540
MLEW 550
MLEW 560
MLEW 570
MLEW 580

```



```

IT=0
20 CONTINUE
C
30 RETURN
C
40 WRITE (6,60)
   GO TO 30
C
50 FORMAT (1H ,30X,1P5D10.3)
60 FORMAT (1H ,30X,12H NO FAILURES)
END
SUBROUTINE REPEAT (X,C,MARKER,NFAIL,NSYS,M,K)
  COMMENT THIS SUBROUTINE REPEATS THE INPUT DATA.
C
  DOUBLE PRECISION X(NFAIL), C(NSYS,2)
  INTEGER MARKER(NFAIL)
  WRITE (6,20)
C
  DO 10 J=1,K
    WRITE (6,30) C(J,1),C(J,2)
    CALL LOCIP (MARKER,NFAIL,M,J,1B,1E)
    CALL PRNTX (X,NFAIL,1B,1E)
  10 CONTINUE
C
  RETURN
C
20 FORMAT (1H0/34H0SYSTEM STARTING AND ENDING TIMES./1H0,35X,10H FAILURES./)
30 FORMAT (1H ,1P2D12.3)
END
SUBROUTINE SORTX (X,N)
  COMMENT THIS SUBROUTINE SORTS THE VECTOR X INTO INCREASING ORDER.
C
  DOUBLE PRECISION X(N)
  DOUBLE PRECISION T
  M=N
  N=M/2
  IF (M.EQ.0) RETURN
  K=N-M+1
  J=1
  20 I=J
  30 L=1+M
  IF (X(I).GT.X(L)) GO TO 50
  40 J=J+1
  IF (J-K) 20,10,10
  50 T=X(L)
  X(L)=X(I)
  X(I)=T
  I=I-M
  IF (I) 40,40,30
  END
SUBROUTINE TRANSF (X,NFAIL,TQ,1B,1E,1PT)
  COMMENT THIS SUBROUTINE TRANSFORMS THE FAILURE TIMES.
C
  DOUBLE PRECISION X(NFAIL), TQ
  J=1PT
C
  DO 10 I=1B,1E
    X(J)=X(I)/TQ
    J=J+1
  10 CONTINUE
C

```

```

C      IPT=J
C      RETURN
C      END
C      SUBROUTINE INREAL (CHANNL,DESTIN)
C      COMMENT (A FORTRAN TRANSLATION OF ACM ALGORITHM 239.)
C      C
C      C      EACH CALL OF THIS SUBROUTINE WILL READ ONE REAL NUMBER
C      C      FROM UNIT 'CHANNL', CONVERT IT, AND STORE IT IN 'DESTIN'.
C      C
C      C      INTEGER CHANNL
C      C      DOUBLE PRECISION DESTIN
C      C      REAL SIG, FP, D
C      C      INTEGER ESIG, EP, IP, CH
C      C      INTEGER CHAR, UNSCND
C      C
C      C      SIG=1.0
C      C      EP=0
C      C      FP=0.0
C      C
C      C      10 CH=CHAR(CHANNL)
C      C      10 SUPPRESS INITIAL BLANKS.
C      C      IF (CH.EQ.14) GO TO 10
C      C      12 = '+' AND 11 = '-'.
C      C      IF (CH.NE.12) GO TO 20
C      C      CH=CHAR(CHANNL)
C      C      GO TO 30
C      C      20 IF (CH.NE.11) GO TO 30
C      C      SIG=-1.0
C      C      CH=CHAR(CHANNL)
C      C      30 CONTINUE
C      C      IF (CH.GT.10) GO TO 70
C      C      IF (CH.EQ.10) GO TO 40
C      C      IP=UNSCND(CHANNL,CH)
C      C      GO TO 50
C      C      40 CONTINUE
C      C      IP=0
C      C      50 CONTINUE
C      C      IF (CH.NE.10) GO TO 100
C      C      CH=CHAR(CHANNL)
C      C      FP=0.0
C      C      IF (CH.CE.10) GO TO 100
C      C      D=0.1
C      C      60 FP=FP+FLOAT(CH)*D
C      C      D=D*0.1
C      C
C      C      CH=CHAR(CHANNL)
C      C      IF (CH.LT.10) GO TO 60
C      C      GO TO 100
C      C      70 CONTINUE
C      C      IF (CH.NE.13) GO TO 80
C      C      IP=1
C      C      GO TO 90
C      C      80 CONTINUE
C      C      WRITE (6,180)
C      C      STOP
C      C      90 CONTINUE
C      C      100 CONTINUE
C      C
C      C      IF (CH.NE.13) GO TO 160
C      C      CH=CHAR(CHANNL)
C      C      ESIG=1

```

```

IF (CH.NE.12.AND.CH.NE.14) GO TO 110
CH=CHAR(CHANNL)
GO TO 130
110 CONTINUE
IF (CH.NE.11) GO TO 120
    NEGATIVE EXPONENT.
C
    ESIG=-1
    CH=CHAR(CHANNL)
120 CONTINUE
130 CONTINUE
IF (CH.GE.10) GO TO 140
EP=UNSGND(CHANNL,CH)*ESIG
GO TO 150
140 CONTINUE
    WRITE (6,190)
    STOP
150 CONTINUE
160 CONTINUE
C
IF (CH.NE.14) GO TO 170
C
DESTIN=DBLE(SIG*(FLOAT(IP)+FP)*(10.0**EP))
C
RETURN
170 WRITE (6,200)
    STOP
C
180 FORMAT (36H0 INREAL ERROR -- CH OUT OF RANGE. /)
190 FORMAT (41H0 INREAL ERROR -- EXPONENT NOT DIGIT. /)
200 FORMAT (53H0 INREAL ERROR -- NO BLANK FOUND BETWEEN DATA VALUES. /)
END
INTEGER FUNCTION CHAR(CHANNL)
COMMENT 'CHAR' RETURNS AN INTEGER VALUE FOR THE NEXT CHARACTER
C ON UNIT 'CHANNL'.
C
INTEGER C
INTEGER CHANNL
INTEGER STRING(15)
DATA STRING(1), STRING(2), STRING(3), STRING(4), STRING(5), STRING(6),
1(6), STRING(7), STRING(8), STRING(9), STRING(10), STRING(11), STRING(12),
2(12), STRING(13), STRING(14), STRING(15) /IH0, IH1, IH2, IH3, IHCHAR 84
14, IH5, IH6, IH7, IH8, IH9, IH-, IH+, IHE, IH /
DATA LSTR /15/
CALL INSYML (CHANNL,STRING,LSTR,C)
IF (C.LE.0) GO TO 10
CHAR=C-1
RETURN
10 WRITE (6,20)
    STOP
C
20 FORMAT (58H0 CHAR ERROR -- ILLEGAL INPUT CHARACTER. PROGRAM ABORT)
1ED./)
END
SUBROUTINE INSYML (JUNIT,STRING,LSTR,1)
COMMENT THIS SUBROUTINE EXAMINES THE NEXT CHARACTER ON 'JUNIT'
AND DETERMINES ITS POSITION NUMBER 'I' WITHIN THE 'STRING' OF
LENGTH 'LSTR'.
C
INTEGER STRING(LSTR)
INTEGER BUFFER(160)
DATA IP /0/
DATA LENGTH /80/

```

```

C
C
C      IF (IP.NE.0) GO TO 10
C          FILL INPUT BUFFER.
C      READ (IUNIT,20) (BUFFER(J),J=1,LENGTH)
C 10 CONTINUE
C
C      IP=IP+1
C      IC=IP
C
C          MATCH THE CHARACTER.
C      CALL MATCH (BUFFER(IC),STRING,LSTR,1)
C
C      IF POINTER 'IP' HAS REACHED THE END OF A LINE, RESET IT.
C      IF (IP.EQ.LENGTH) IP=0
C
C      RETURN
C
C 20 FORMAT (128A1)
C      END
C      SUBROUTINE MATCH (CHAR,STRING,LSTR,IP)
C      COMMENT 'THIS SUBROUTINE FINDS THE POSITION 'IP' OF 'CHAR' IN
C      COMMENT 'STRING' WHICH HAS A LENGTH OF 'LSTR'.'
C
C      INTEGER CHAR, STRING(LSTR)
C      IP=0
C      DO 10 I=1,LSTR
C      IF (STRING(I).NE.CHAR) GO TO 10
C      IP=I
C      GO TO 20
C 10 CONTINUE
C      WRITE (6,30) CHAR
C 20 RETURN
C
C 30 FORMAT (31H0 MATCH ERROR -- THE CHARACTER ,A1,16H IS NOT MATCHED.
C      1)
C      END
C      INTEGER FUNCTION UNSGND(CHANNEL,CH)
C      COMMENT 'THIS FUNCTION RETURNS THE NEXT UNSIGNED INTEGER FROM
C      COMMENT 'CHANNEL'.'
C
C      INTEGER CHANNEL, CH
C      INTEGER CHAR
C      INTEGER U
C      U=0
C 10 U=10*U+CH
C      CH=CHAR(CHANNEL)
C      IF (CH.LT.10) GO TO 10
C      UNSGND=U
C      RETURN
C      END

```

```

INSYL110
INSYL120
INSYL130
INSYL140
INSYL150
INSYL160
INSYL170
INSYL180
INSYL190
INSYL200
INSYL210
INSYL220
INSYL230
INSYL240
INSYL250
INSYL260
INSYL270
INSYL280
INSYL290
INSYL300
INSYL310
MATCH 10
MATCH 20
MATCH 30
MATCH 40
MATCH 50
MATCH 60
MATCH 70
MATCH 80
MATCH 90
MATCH100
MATCH110
MATCH120
MATCH130
MATCH140
MATCH150
MATCH160
MATCH170
UNSC 10
UNSC 20
UNSC 30
UNSC 40
UNSC 50
UNSC 60
UNSC 70
UNSC 80
UNSC 90
UNSC 100
UNSC 110
UNSC 120
UNSC 130
UNSC 140

```

APPENDIX B
INPUT FOR TEST CASES

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INPUT DATA

```

0.0 200.0 4.3 4.4 10.2 23.5 23.8 26.4 74.0 77.1 92.1 197.2
-999.
0.0 200.0 0.1 5.6 18.6 19.5 24.2 26.7 45.1 45.8 75.7 79.7 98.6
120.1 161.8 180.6 190.8
-999
0.0 200.0 8.4 32.5 44.7 48.4 50.6 73.6 98.7 112.2 129.8 136.0
195.8
-999
-999
0.0 197.2 4.3 4.4 10.2 23.5 23.8 26.4 74.0 197.2 77.1 92.1
-999.
0.0 190.8 0.1 5.6 18.6 19.5 24.2 26.7 45.1 45.8 75.7 79.7 98.6
120.1 161.8 180.6 190.8
-999
0.0 195.8 195.8
8.4 32.5 44.7 48.4 50.6 73.6 98.7 112.2 129.8 136.0
-999
-999
0 10 -99 15 -99 0 20 4 12 17 -99 0 20 -99 0 10 -99
-99
1.0 100.0 32. 44. 56. 75. 95. -99. -99.
12.2 45.3 10.0 14.5 16.8 457.9 -99 -99
0.0 3256.3 .7 3.7 13.2 17.6 54.5 99.2 112.2 120.9 151.0 163.0
174.5 191.6 282.8
355.2 486.3 490.5 513.3 558.4 678.1 688.0 785.9 887.0 1010.7
1129.1 1134.4 1136.1 1178.9 1259.7 1297.9 1419.7 1571.7
1629.8 1702.3 1928.9 2072.3 2525.2 2928.5 3016.4 3181.0
3256.3
-99. -99.
0.0 79.0 0.0 20 45. 62 64 79 68 -8 -7
456. 789. 456 456.1 457 458 489 -99 -99
0.0 800.0 45. 456. 467. 477. 484. 492.
0.12 564.0 65.0 78. 89. 99.1 -99 -99
0. 10. 2. 3. 4. 5. 6. 8. -99. 0. 30. -99. 0. 50. 41. 42. 43. 44. -99
0. 60. 51. 52. 53. -99. -99.
-99

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APPENDIX C
OUTPUT FOR TEST CASES

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WEIBULL INTENSITY MODEL

PARAMETER ESTIMATION AND GOODNESS OF FIT TEST

VERSION OF 12 NOV. 1979

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES = 36

TOTAL NUMBER OF SYSTEMS = 3

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0.	2.000D+02	4.300D+00	4.400D+00	1.020D+01	2.350D+01	2.380D+01
		2.640D+01	7.400D+01	7.710D+01	9.210D+01	1.972D+02
0.	2.000D+02	1.000D-01	5.600D+00	1.860D+01	1.950D+01	2.420D+01
		2.670D+01	4.510D+01	4.580D+01	7.570D+01	7.970D+01
		9.860D+01	1.201D+02	1.618D+02	1.806D+02	1.908D+02
0.	2.000D+02	8.400D+00	3.250D+01	4.470D+01	4.840D+01	5.060D+01
		7.360D+01	9.870D+01	1.122D+02	1.298D+02	1.360D+02
		1.958D+02				

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 3.67318960+00

ESTIMATED BETA	FUNCTION D(8°)	A - D(8°)	ESTIMATED LAMBDA
1.000000000D+01	5.198317367D+00	-1.525127718D+00	1.171875000D-22
9.000000000D+00	5.187206255D+00	-1.514016607D+00	2.343750000D-20
8.000000000D+00	5.173317367D+00	-1.500127718D+00	4.687500000D-18
7.000000000D+00	5.155460224D+00	-1.482270575D+00	9.375000000D-16
6.000000000D+00	5.131650700D+00	-1.458461051D+00	1.875000000D-13
5.000000000D+00	5.098317367D+00	-1.425127718D+00	3.750000000D-11
4.000000000D+00	5.048317367D+00	-1.375127718D+00	7.500000000D-09
3.000000000D+00	4.964984033D+00	-1.291794384D+00	1.500000000D-06
2.000000000D+00	4.798317367D+00	-1.125127718D+00	3.000000000D-04
1.000000000D+00	4.298317367D+00	-6.251277178D-01	6.000000000D-02
9.000000000D-01	4.187206255D+00	-5.140166067D-01	1.019187879D-01
8.000000000D-01	4.048317367D+00	-3.751277178D-01	1.731239887D-01
7.000000000D-01	3.869745938D+00	-1.965562892D-01	2.940764514D-01
6.000000000D-01	3.631650700D+00	4.153894890D-02	4.995319244D-01
6.900000000D-01	3.849042004D+00	-1.758523554D-01	3.100777107D-01
6.800000000D-01	3.827729131D+00	-1.545394825D-01	3.269496291D-01
6.700000000D-01	3.805780053D+00	-1.325904043D-01	3.447395806D-01
6.600000000D-01	3.783165851D+00	-1.099762026D-01	3.634975173D-01
6.500000000D-01	3.759855828D+00	-8.666617931D-02	3.832761089D-01
6.400000000D-01	3.735817367D+00	-6.262771777D-02	4.041308914D-01
6.300000000D-01	3.711015779D+00	-3.782613047D-02	4.261204223D-01
6.200000000D-01	3.685414141D+00	-1.222449196D-02	4.493064454D-01
6.100000000D-01	3.658973104D+00	1.421654453D-02	4.737540642D-01
6.190000000D-01	3.682808481D+00	-9.618832469D-03	4.516933312D-01
6.180000000D-01	3.680194389D+00	-7.004740422D-03	4.540928971D-01
6.170000000D-01	3.677571824D+00	-4.382174819D-03	4.565052103D-01
6.160000000D-01	3.674940743D+00	-1.751094392D-03	4.589303387D-01
6.150000000D-01	3.672301106D+00	8.885423943D-04	4.613683502D-01
6.159000000D-01	3.674677165D+00	-1.487516437D-03	4.591735590D-01
6.158000000D-01	3.674413502D+00	-1.223852877D-03	4.594169082D-01
6.157000000D-01	3.674149752D+00	-9.601036705D-04	4.596603863D-01
6.156000000D-01	3.673885918D+00	-6.962687754D-04	4.599039935D-01
6.155000000D-01	3.673621997D+00	-4.323481501D-04	4.601477298D-01
6.154000000D-01	3.673357991D+00	-1.683417527D-04	4.603915953D-01
6.153000000D-01	3.673093898D+00	9.575045862D-05	4.606355900D-01
6.153900000D-01	3.673331585D+00	-1.419363938D-04	4.604159889D-01
6.153800000D-01	3.673305179D+00	-1.155301769D-04	4.604403839D-01
6.153700000D-01	3.673278772D+00	-8.912310164D-05	4.604647801D-01
6.153600000D-01	3.673252364D+00	-6.271516816D-05	4.604891776D-01
6.153500000D-01	3.673225955D+00	-3.630637637D-05	4.605135765D-01
6.153400000D-01	3.673199546D+00	-9.896726236D-06	4.605379766D-01

THE FINAL ESTIMATE OF BETA = 6.1534000D-01.
THE FINAL ESTIMATE OF LAMBDA = 4.6053798D-01
CONVERGENCE TO 9.8967262D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05
THE FINAL STEP SIZE IS 1.0000000D-05

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 6.1534000D-01

NUMBER OF FAILURES = 36

UNBIASED ESTIMATE OF BETA = 5.9824358D-01

CRAMER - VON MISES STATISTIC = 6.9530891D-02

REJECT THE WEIBULL INTENSITY MODEL IF THE STATISTIC
EXCEEDS THE APPROPRIATE CRITICAL VALUE FOR M = 36

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES = 36

TOTAL NUMBER OF SYSTEMS = 3

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0.	1.972D+02	4.300D+00	4.400D+00	1.020D+01	2.350D+01	2.380D+01
		2.640D+01	7.400D+01	1.972D+02	7.710D+01	9.210D+01
0.	1.908D+02	1.000D-01	5.600D+00	1.860D+01	1.950D+01	2.420D+01
		2.670D+01	4.510D+01	4.580D+01	7.570D+01	7.970D+01
		9.860D+01	1.201D+02	1.618D+02	1.806D+02	1.908D+02
0.	1.958D+02	1.958D+02	8.400D+00	3.250D+01	4.470D+01	4.840D+01
		5.060D+01	7.360D+01	9.870D+01	1.122D+02	1.298D+02
		1.360D+02				

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 3.6731896D+00

ESTIMATED BETA	FUNCTION D(B')	A - D(B')	ESTIMATED LAMBDA
1.000000000D+01	5.172764354D+00	-1.499574705D+00	1.527402235D-22
9.000000000D+00	5.161470246D+00	-1.488280598D+00	2.977461975D-20
8.000000000D+00	5.147396282D+00	-1.474206633D+00	5.803087229D-18
7.000000000D+00	5.129352022D+00	-1.456162373D+00	1.130813934D-15
6.000000000D+00	5.105353381D+00	-1.432163732D+00	2.203137001D-13
5.000000000D+00	5.071828974D+00	-1.398639326D+00	4.291501795D-11
4.000000000D+00	5.021635991D+00	-1.348446342D+00	8.357833094D-09
3.000000000D+00	4.938107813D+00	-1.264918165D+00	1.627398353D-06
2.000000000D+00	4.771244493D+00	-1.098054844D+00	3.168174072D-04
1.000000000D+00	4.271046084D+00	-5.978564354D-01	6.166495375D-02
9.000000000D-01	4.159915038D+00	-4.867253891D-01	1.044615824D-01
8.000000000D-01	4.021006197D+00	-3.478165480D-01	1.769595169D-01
7.000000000D-01	3.842414799D+00	-1.692251504D-01	2.997715275D-01
6.000000000D-01	3.604299575D+00	6.889007354D-02	5.078155206D-01
6.900000000D-01	3.821708868D+00	-1.485192188D-01	3.159962865D-01
6.800000000D-01	3.800393997D+00	-1.272043479D-01	3.330991836D-01
6.700000000D-01	3.778442920D+00	-1.052532716D-01	3.511277462D-01
6.600000000D-01	3.755826720D+00	-8.263707150D-02	3.701320741D-01
6.500000000D-01	3.732514698D+00	-5.932504969D-02	3.901649784D-01
6.400000000D-01	3.708474238D+00	-3.528458948D-02	4.112821287D-01
6.300000000D-01	3.683670652D+00	-1.048100334D-02	4.335422075D-01
6.200000000D-01	3.658067015D+00	1.512263417D-02	4.570070733D-01
6.290000000D-01	3.681146920D+00	-7.957271513D-03	4.358334296D-01
6.280000000D-01	3.678615152D+00	-5.425502957D-03	4.381367604D-01
6.270000000D-01	3.676075308D+00	-2.885659220D-03	4.404522640D-01
6.260000000D-01	3.673527350D+00	-3.377016037D-04	4.427800047D-01
6.250000000D-01	3.670971240D+00	2.218408839D-03	4.451200472D-01
6.259000000D-01	3.673272107D+00	-8.245808135D-05	4.430134543D-01
6.258000000D-01	3.673016782D+00	1.728670081D-04	4.432470270D-01
6.258900000D-01	3.673246578D+00	-5.692924357D-05	4.430368061D-01
6.258800000D-01	3.673221048D+00	-3.139959008D-05	4.430601590D-01
6.258700000D-01	3.673195518D+00	-5.869120840D-06	4.430835132D-01

THE FINAL ESTIMATE OF BETA = 6.2587000D-01
THE FINAL ESTIMATE OF LAMBDA = 4.4308351D-01
CONVERGENCE TO 5.8691208D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05
THE FINAL STEP SIZE IS 1.0000000D-05

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 6.2587000D-01

NUMBER OF FAILURES = 36

UNBIASED ESTIMATE OF BETA = 5.5726048D-01

CRAMER - VON MISES STATISTIC = 1.3643898D-01

REJECT THE WEIBULL INTENSITY MODEL IF THE STATISTIC
EXCEEDS THE APPROPRIATE CRITICAL VALUE FOR M = 33

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES ■ 3

TOTAL NUMBER OF SYSTEMS ■ 5

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0.	1.000D+01	
0.	1.500D+01	NO FAILURES
0.	2.000D+01	NO FAILURES
0.	2.000D+01	4.000D+00 1.200D+01 1.700D+01
0.	1.000D+01	NO FAILURES
0.	1.000D+01	NO FAILURES

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 2.2348048D+00

ESTIMATED BETA	FUNCTION D(B')	A - D(B')	ESTIMATED LAMBDA
1.000000000D+01	2.887203645D+00	-6.523988600D-01	1.423376079D-13
9.000000000D+00	2.872928892D+00	-6.381241070D-01	2.818374480D-12
8.000000000D+00	2.854500246D+00	-6.196954611D-01	5.559376018D-11
7.000000000D+00	2.829967336D+00	-5.951625507D-01	1.090568288D-09
6.000000000D+00	2.796084828D+00	-5.612800428D-01	2.121781412D-08
5.000000000D+00	2.747210761D+00	-5.124059755D-01	4.076433121D-07
4.000000000D+00	2.672959541D+00	-4.381547563D-01	7.680000000D-06
3.000000000D+00	2.552119579D+00	-3.173147936D-01	1.403508772D-04
2.000000000D+00	2.329725823D+00	-9.492103762D-02	2.448979592D-03
1.000000000D+00	1.753356611D+00	4.814481741D-01	4.000000000D-02
1.900000000D+00	2.296695350D+00	-6.189056461D-02	3.248879162D-03
1.800000000D+00	2.260528724D+00	-2.572393895D-02	4.307107646D-03
1.700000000D+00	2.220711095D+00	1.409368974D-02	5.706009308D-03
1.790000000D+00	2.256720743D+00	-2.191595789D-02	4.430107818D-03
1.780000000D+00	2.252875780D+00	-1.807099482D-02	4.556588426D-03
1.770000000D+00	2.248993245D+00	-1.418846036D-02	4.686646926D-03
1.760000000D+00	2.245072537D+00	-1.026775178D-02	4.820383476D-03
1.750000000D+00	2.241113038D+00	-6.308252638D-03	4.957901000D-03
1.740000000D+00	2.237114117D+00	-2.309332347D-03	5.099305272D-03
1.730000000D+00	2.233075131D+00	1.729654209D-03	5.244704988D-03
1.739000000D+00	2.236712032D+00	-1.907247446D-03	5.113663630D-03
1.738000000D+00	2.236309546D+00	-1.504761241D-03	5.128062049D-03
1.737000000D+00	2.235906658D+00	-1.101873078D-03	5.142500642D-03
1.736000000D+00	2.235503367D+00	-6.985823011D-04	5.156979518D-03
1.735000000D+00	2.235099673D+00	-2.948882514D-04	5.171498790D-03
1.734000000D+00	2.234695575D+00	1.092097299D-04	5.186058568D-03
1.734900000D+00	2.235059282D+00	-2.544966411D-04	5.172952943D-03
1.734800000D+00	2.235018886D+00	-2.141009908D-04	5.174407501D-03
1.734700000D+00	2.234978486D+00	-1.737012999D-04	5.175862465D-03
1.734600000D+00	2.234938083D+00	-1.332975676D-04	5.177317834D-03
1.734500000D+00	2.234897675D+00	-9.288979346D-05	5.178773609D-03
1.734400000D+00	2.234857263D+00	-5.247797667D-05	5.180229789D-03
1.734300000D+00	2.234816847D+00	-1.206211661D-05	5.181686375D-03
1.734200000D+00	2.234776427D+00	2.835778740D-05	5.183143366D-03
1.734290000D+00	2.234812805D+00	-8.020308194D-06	5.181832056D-03

THE FINAL ESTIMATE OF BETA = 1.7342900D+00
THE FINAL ESTIMATE OF LAMBDA = 5.1818321D-03
CONVERGENCE TO 8.0203082D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05
THE FINAL STEP SIZE IS 1.0000000D-05

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 1.7342900D+00

NUMBER OF FAILURES = 3

UNBIASED ESTIMATE OF BETA = 8.7612378D-01

CRAMER - VON MISES STATISTIC = 5.4305758D-02

REJECT THE WEIBULL INTENSITY MODEL IF THE STATISTIC
EXCEEDS THE APPROPRIATE CRITICAL VALUE FOR M = 3

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES = 5

TOTAL NUMBER OF SYSTEMS = 1

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

1.000D+00 1.000D+02

3.200D+01 4.400D+01 5.600D+01 7.500D+01 9.500D+01

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 4.02932840+00

ESTIMATED BETA	FUNCTION D(B')	A - D(B')	ESTIMATED LAMBOA
1.000000000D+01	4.505170186D+00	-4.758417395D-01	5.000000000D-20
9.000000000D+00	4.494059075D+00	-4.647306284D-01	5.000000000D-18
8.000000000D+00	4.480170186D+00	-4.508417395D-01	5.000000000D-16
7.000000000D+00	4.462313043D+00	-4.329845966D-01	5.000000000D-14
6.000000000D+00	4.438503519D+00	-4.091750728D-01	5.000000000D-12
5.000000000D+00	4.405170186D+00	-3.758417399D-01	5.000000001D-10
4.000000000D+00	4.355170232D+00	-3.258417855D-01	5.000000050D-08
3.000000000D+00	4.271841458D+00	-2.425130113D-01	5.000005000D-06
2.000000000D+00	4.105630749D+00	-7.630230255D-02	5.000500050D-04
1.000000000D+00	3.651687057D+00	3.776413900D-01	5.050505051D-02
1.900000000D+00	4.079584382D+00	-5.025593598D-02	7.925722105D-04
1.800000000D+00	4.050771688D+00	-2.144324100D-02	1.256258774D-03
1.700000000D+00	4.018768973D+00	1.055947321D-02	1.991328615D-03
1.790000000D+00	4.047722570D+00	-1.839412345D-02	1.315480002D-03
1.780000000D+00	4.044641152D+00	-1.531270529D-02	1.377493745D-03
1.770000000D+00	4.041526963D+00	-1.219851680D-02	1.442431753D-03
1.760000000D+00	4.038379527D+00	-9.051080574D-03	1.510432003D-03
1.750000000D+00	4.035198358D+00	-5.869911384D-03	1.581638988D-03
1.740000000D+00	4.031982963D+00	-2.654516074D-03	1.656204028D-03
1.730000000D+00	4.028732840D+00	5.956065495D-04	1.734285593D-03
1.739000000D+00	4.031659521D+00	-2.331074881D-03	1.663851262D-03
1.738000000D+00	4.031335732D+00	-2.007285916D-03	1.671533818D-03
1.737000000D+00	4.031011595D+00	-1.683148672D-03	1.679251859D-03
1.736000000D+00	4.030687109D+00	-1.358662642D-03	1.687005549D-03
1.735000000D+00	4.030362274D+00	-1.033827318D-03	1.694795052D-03
1.734000000D+00	4.030037089D+00	-7.086421920D-04	1.702620534D-03
1.733000000D+00	4.029711553D+00	-3.831067529D-04	1.710482162D-03
1.732000000D+00	4.029385667D+00	-5.722049074D-05	1.718380103D-03
1.731000000D+00	4.029059429D+00	2.690171060D-04	1.726314523D-03
1.731900000D+00	4.029353059D+00	-2.461254957D-05	1.719171900D-03
1.731800000D+00	4.029320448D+00	7.998905460D-06	1.719964063D-03

THE FINAL ESTIMATE OF BETA = 1.7318000D+00
THE FINAL ESTIMATE OF LAMBDA = 1.7199641D-03
CONVERGENCE TO 7.9989055D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05
THE FINAL STEP SIZE IS 1.0000000D-04

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 1.7318000D+00

NUMBER OF FAILURES = 5

UNBIASED ESTIMATE OF BETA = 1.3892706D+00

THE CRAMER - VON MISES GOODNESS OF FIT TEST IS NOT APPROPRIATE FOR THIS CASE
BECAUSE ONE OR MORE SYSTEMS HAVE NON-ZERO STARTING TIMES.

DATA INPUT PHASE.

INDATA ERROR -- THE FAILURE AT 1.000D+01
DOES NOT FALL WITHIN THE TEST PERIOD FROM 1.220D+01 TO 4.530D+01

INDATA ERROR -- THE FAILURE AT 4.579D+02
DOES NOT FALL WITHIN THE TEST PERIOD FROM 1.220D+01 TO 4.530D+01

TOTAL NUMBER OF FAILURES = 4

TOTAL NUMBER OF SYSTEMS = 1

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

1.220D+01 4.530D+01

1.000D+01 1.450D+01 1.680D+01 4.579D+02

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES = 40

TOTAL NUMBER OF SYSTEMS = 1

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0. 3.256D+03

7.000D-01	3.700D+00	1.320D+01	1.760D+01	5.450D+01
9.920D+01	1.122D+02	1.209D+02	1.510D+02	1.630D+02
1.745D+02	1.916D+02	2.828D+02	3.552D+02	4.863D+02
4.905D+02	5.133D+02	5.584D+02	6.781D+02	6.880D+02
7.859D+02	8.870D+02	1.011D+03	1.029D+03	1.034D+03
1.136D+03	1.179D+03	1.260D+03	1.298D+03	1.420D+03
1.572D+03	1.630D+03	1.702D+03	1.929D+03	2.072D+03
2.525D+03	2.929D+03	3.016D+03	3.181D+03	3.256D+03

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 6.0464988D+00

ESTIMATED BETA	FUNCTION D(B')	A - D(B')	ESTIMATED LAMDA
1.000000000D+01	7.988346860D+00	-1.941848101D+00	2.984117360D-34
9.000000000D+00	7.977235749D+00	-1.930736990D+00	9.717181358D-31
8.000000000D+00	7.963346860D+00	-1.916848101D+00	3.164205766D-27
7.000000000D+00	7.945489718D+00	-1.898990958D+00	1.030360323D-23
6.000000000D+00	7.921680194D+00	-1.875181434D+00	3.355162321D-20
5.000000000D+00	7.888346860D+00	-1.841848101D+00	1.092541507D-16
4.000000000D+00	7.838346860D+00	-1.791848101D+00	3.557642908D-13
3.000000000D+00	7.755013527D+00	-1.708514768D+00	1.158475260D-09
2.000000000D+00	7.588346860D+00	-1.541848101D+00	3.772342990D-06
1.000000000D+00	7.088346860D+00	-1.041848101D+00	1.228388048D-02
9.000000000D-01	6.977235749D+00	-9.307369898D-01	2.758087392D-02
8.000000000D-01	6.838346860D+00	-7.918481009D-01	6.192706024D-02
7.000000000D-01	6.659775432D+00	-6.132766723D-01	1.390442087D-01
6.000000000D-01	6.421680194D+00	-3.751814342D-01	3.121945705D-01
5.000000000D-01	6.088346860D+00	-4.184810091D-02	7.009673453D-01
4.000000000D-01	5.588346860D+00	4.581518991D-01	1.573874966D+00
4.900000000D-01	6.047530534D+00	-1.031774382D-03	7.600200173D-01
4.800000000D-01	6.005013527D+00	4.148523242D-02	8.240475545D-01
4.890000000D-01	6.043357085D+00	3.141674139D-03	7.661922507D-01
4.899000000D-01	6.047113956D+00	-6.151962382D-04	7.606349965D-01
4.898000000D-01	6.046697208D+00	-1.984479930D-04	7.612504734D-01
4.897000000D-01	6.046280289D+00	2.184704576D-04	7.618664482D-01
4.897900000D-01	6.046655523D+00	-1.567638089D-04	7.613120484D-01
4.897800000D-01	6.046613837D+00	-1.150779227D-04	7.613736285D-01
4.897700000D-01	6.046572150D+00	-7.339033417D-05	7.614352135D-01
4.897600000D-01	6.046530461D+00	-3.170104328D-05	7.614968035D-01
4.897500000D-01	6.046488770D+00	9.989950085D-06	7.615583985D-01

THE FINAL ESTIMATE OF BETA = 4.8975000D-01

THE FINAL ESTIMATE OF LAMBDA = 7.6155840D-01

CONVERGENCE TO 9.9899501D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05

THE FINAL STEP SIZE IS 1.0000000D-05

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 4.8975000D-01

NUMBER OF FAILURES = 40

UNBIASED ESTIMATE OF BETA = 4.6526478D-01

CRAMER - VON MISES STATISTIC = 6.8282282D-02

REJECT THE WEIBULL INTENSITY MODEL IF THE STATISTIC
EXCEEDS THE APPROPRIATE CRITICAL VALUE FOR M = 39

DATA INPUT PHASE.

INDATA ERROR -- A FAILURE AT 0.0000000 WAS INPUT.

THE PROBABILITY OF SUCH A FAILURE TIME IS 0.0 ACCORDING TO THE MODEL.

TOTAL NUMBER OF FAILURES = 7

TOTAL NUMBER OF SYSTEMS = 1

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0. 7.900D+01

0. 2.000D+01 4.500D+01 6.200D+01 6.400D+01
7.900D+01 6.800D+01

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES ■ 5

TOTAL NUMBER OF SYSTEMS ■ 1

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

4.560D+02 7.890D+02

4.560D+02 4.561D+02 4.570D+02 4.580D+02 4.890D+02

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 6.1378240D+00

ESTIMATED BETA	FUNCTION O(B*)	A - D(B*)	ESTIMATEO LAMBOA
1.000000000D+01	6.5730555290+00	-4.352315370D-01	5.370435537D-29
9.000000000D+00	6.5636282560+00	-4.258042640D-01	4.250232894D-26
8.000000000D+00	6.552677307D+00	-4.148533158D-01	3.371273954D-23
7.000000000D+00	6.5399780970+00	-4.021541058D-01	2.684647236D-20
6.000000000D+00	6.5253232290+00	-3.874992378D-01	2.152792775D-17
5.000000000D+00	6.5085569710+00	-3.707329793D-01	1.747965628D-14
4.000000000D+00	6.4896198020+00	-3.517958100D-01	1.452242925D-11
3.000000000D+00	6.468596384D+00	-3.307723920D-01	1.261510485D-08
2.000000000D+00	6.4457540820+00	-3.079300902D-01	1.206025302D-05
1.000000000D+00	6.4215552730+00	-2.837312818D-01	1.501501502D-02
9.000000000D-01	6.419083888D+00	-2.812598969D-01	3.170401197D-02
8.000000000D-01	6.416605856D+00	-2.787818649D-01	6.776262633D-02
7.000000000D-01	6.414121892D+00	-2.762979005D-01	1.470949998D-01
6.000000000D-01	6.411632718D+00	-2.738087267D-01	3.258760473D-01
5.000000000D-01	6.409139065D+00	-2.713150738D-01	7.423918966D-01
4.000000000D-01	6.406641670D+00	-2.688176787D-01	1.761304281D+00
3.000000000D-01	6.404141275D+00	-2.663172833D-01	4.456108471D+00
2.000000000D-01	6.401638625D+00	-2.638146339D-01	1.268005091D+01
1.000000000D-01	6.399134472D+00	-2.613104802D-01	4.809680779D+01
9.000000000D-02	6.398884003D+00	-2.610600110D-01	5.697237019D+01
8.000000000D-02	6.398633527D+00	-2.608095350D-01	6.832918901D+01
7.000000000D-02	6.398383045D+00	-2.605590530D-01	8.325044844D+01
6.000000000D-02	6.398132557D+00	-2.603085657D-01	1.035429781D+02
5.000000000D-02	6.397882066D+00	-2.600580740D-01	1.324610187D+02
4.000000000D-02	6.397631570D+00	-2.598075784D-01	1.765156468D+02
3.000000000D-02	6.397381071D+00	-2.595570799D-01	2.509030623D+02
2.000000000D-02	6.397130571D+00	-2.593065790D-01	4.012177610D+02
1.000000000D-02	6.396880068D+00	-2.590560767D-01	8.554447923D+02
9.000000000D-03	6.396855018D+00	-2.590310264D-01	9.565938878D+02
8.000000000D-03	6.396829968D+00	-2.590059761D-01	1.083074267D+03
7.000000000D-03	6.396804917D+00	-2.589809258D-01	1.245742517D+03
6.000000000D-03	6.396779867D+00	-2.589558755D-01	1.462692950D+03
5.000000000D-03	6.396754817D+00	-2.589308252D-01	1.766495336D+03
4.000000000D-03	6.396729766D+00	-2.589057749D-01	2.222289211D+03
3.000000000D-03	6.396704716D+00	-2.588807246D-01	2.982066840D+03
2.000000000D-03	6.396679666D+00	-2.588556743D-01	4.501805016D+03
1.000000000D-03	6.396654616D+00	-2.588306240D-01	9.061387723D+03
9.000000000D-04	6.396652110D+00	-2.588281189D-01	1.007465093D+04
8.000000000D-04	6.396649605D+00	-2.588256139D-01	1.134123456D+04
7.000000000D-04	6.396647100D+00	-2.588231089D-01	1.296970454D+04
6.000000000D-04	6.396644595D+00	-2.588206038D-01	1.514100403D+04
5.000000000D-04	6.396642090D+00	-2.588180988D-01	1.818083075D+04
4.000000000D-04	6.396639585D+00	-2.588155938D-01	2.274058011D+04
3.000000000D-04	6.396637080D+00	-2.588130887D-01	3.034017479D+04
2.000000000D-04	6.396634575D+00	-2.588105837D-01	4.553938276D+04
1.000000000D-04	6.396632070D+00	-2.588080787D-01	9.113704390D+04
9.000000000D-05	6.396631820D+00	-2.588078282D-01	1.012698598D+05
8.000000000D-05	6.396631569D+00	-2.588075777D-01	1.139358801D+05
7.000000000D-05	6.396631319D+00	-2.588073272D-01	1.302207638D+05
6.000000000D-05	6.396631068D+00	-2.588070767D-01	1.519339428D+05

5.000000000D-05	6.396630818D+00	-2.588068262D-01	1.823323941D+05
4.000000000D-05	6.396630567D+00	-2.588065756D-01	2.279300721D+05
3.000000000D-05	6.396630317D+00	-2.588063251D-01	3.039262031D+05
2.000000000D-05	6.396630066D+00	-2.588060746D-01	4.559184672D+05
1.000000000D-05	6.396629816D+00	-2.588058241D-01	9.118952631D+05
9.000000000D-06	6.396629791D+00	-2.588057991D-01	1.013223440D+06
8.000000000D-06	6.396629766D+00	-2.588057740D-01	1.139883662D+06
7.000000000D-06	6.396629741D+00	-2.588057490D-01	1.302732518D+06
6.000000000D-06	6.396629715D+00	-2.588057239D-01	1.519864326D+06
5.000000000D-06	6.396629690D+00	-2.588056989D-01	1.823848858D+06
4.000000000D-06	6.396629665D+00	-2.588056738D-01	2.279825655D+06
3.000000000D-06	6.396629640D+00	-2.588056488D-01	3.039786985D+06
2.000000000D-06	6.396629615D+00	-2.588056237D-01	4.559709644D+06
1.000000000D-06	6.396629590D+00	-2.588055987D-01	9.119477621D+06
9.000000000D-07	6.396629588D+00	-2.588055962D-01	1.013275939D+07
8.000000000D-07	6.396629585D+00	-2.588055937D-01	1.139936161D+07
7.000000000D-07	6.396629583D+00	-2.588055912D-01	1.302785017D+07
6.000000000D-07	6.396629580D+00	-2.588055887D-01	1.519916826D+07
5.000000000D-07	6.396629578D+00	-2.588055862D-01	1.823901358D+07
4.000000000D-07	6.396629575D+00	-2.588055837D-01	2.279878155D+07
3.000000000D-07	6.396629573D+00	-2.588055812D-01	3.039839485D+07
2.000000000D-07	6.396629570D+00	-2.588055786D-01	4.559762144D+07
1.000000000D-07	6.396629568D+00	-2.588055761D-01	9.119530122D+07
9.000000000D-08	6.396629567D+00	-2.588055759D-01	1.013281189D+08
8.000000000D-08	6.396629567D+00	-2.588055756D-01	1.139941411D+08
7.000000000D-08	6.396629567D+00	-2.588055754D-01	1.302790267D+08
6.000000000D-08	6.396629567D+00	-2.588055751D-01	1.519922076D+08
5.000000000D-08	6.396629566D+00	-2.588055749D-01	1.823906608D+08
4.000000000D-08	6.396629566D+00	-2.588055746D-01	2.279883406D+08
3.000000000D-08	6.396629566D+00	-2.588055744D-01	3.039844735D+08
2.000000000D-08	6.396629566D+00	-2.588055741D-01	4.559767394D+08
1.000000000D-08	6.396629565D+00	-2.588055739D-01	9.119535372D+08

MLEW ERROR -- BETA LESS THAN 0.00000001

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES = 12

TOTAL NUMBER OF SYSTEMS = 1

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0. 8.000D+02

4.500D+01 4.560D+02 4.670D+02 4.770D+02 4.840D+02
4.920D+02 1.200D-01 5.640D+02 6.500D+01 7.800D+01
8.900D+01 9.910D+01

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 4.7045181D+00

ESTIMATED BETA	FUNCTION D(B')	A - D(B')	ESTIMATED LAMBDA
1.000000000D+01	6.584611728D+00	-1.880093620D+00	1.117587090D-28
9.000000000D+00	6.573500617D+00	-1.868982509D+00	8.940696716D-26
8.000000000D+00	6.559611728D+00	-1.855093620D+00	7.152557373D-23
7.000000000D+00	6.541754585D+00	-1.837236477D+00	5.722045898D-20
6.000000000D+00	6.517945061D+00	-1.813426953D+00	4.577636719D-17
5.000000000D+00	6.484611728D+00	-1.780093620D+00	3.662109375D-14
4.000000000D+00	6.434611728D+00	-1.730093620D+00	2.929687500D-11
3.000000000D+00	6.351278394D+00	-1.646760287D+00	2.343750000D-08
2.000000000D+00	6.184611728D+00	-1.480093620D+00	1.875000000D-05
1.000000000D+00	5.684611728D+00	-9.800936198D-01	1.500000000D-02
9.000000000D-01	5.573500617D+00	-8.689825087D-01	2.926848599D-02
8.000000000D-01	5.434611728D+00	-7.300936198D-01	5.710961816D-02
7.000000000D-01	5.256040299D+00	-5.515221913D-01	1.114341373D-01
6.000000000D-01	5.017945061D+00	-3.134269532D-01	2.174338991D-01
5.000000000D-01	4.684611728D+00	1.990638017D-02	4.242640687D-01
5.900000000D-01	4.989696473D+00	-2.851783656D-01	2.324653100D-01
5.800000000D-01	4.960473797D+00	-2.559556888D-01	2.485358565D-01
5.700000000D-01	4.930225763D+00	-2.257076549D-01	2.657173750D-01
5.600000000D-01	4.898897442D+00	-1.943793341D-01	2.840866682D-01
5.500000000D-01	4.866429909D+00	-1.619118017D-01	3.037258479D-01
5.400000000D-01	4.832759876D+00	-1.282417680D-01	3.247227028D-01
5.300000000D-01	4.797819275D+00	-9.330116700D-02	3.471710900D-01
5.200000000D-01	4.761534805D+00	-5.701669676D-02	3.711713554D-01
5.100000000D-01	4.723827414D+00	-1.930930611D-02	3.968307819D-01
5.000000000D-01	4.684611728D+00	1.990638017D-02	4.242640687D-01
5.090000000D-01	4.719975185D+00	-1.545707759D-02	3.994923273D-01
5.080000000D-01	4.716107791D+00	-1.158968283D-02	4.021717238D-01
5.070000000D-01	4.712225140D+00	-7.707032063D-03	4.048690910D-01
5.060000000D-01	4.708327143D+00	-3.809034854D-03	4.075845495D-01
5.050000000D-01	4.704413708D+00	1.043999676D-04	4.103182205D-01
5.059000000D-01	4.707936495D+00	-3.418387575D-03	4.078570950D-01
5.058000000D-01	4.707545694D+00	-3.027585829D-03	4.081298228D-01
5.057000000D-01	4.707154737D+00	-2.636629524D-03	4.084027329D-01
5.056000000D-01	4.706763626D+00	-2.245518569D-03	4.086758256D-01
5.055000000D-01	4.706372361D+00	-1.854252871D-03	4.089491008D-01
5.054000000D-01	4.705980940D+00	-1.462832339D-03	4.092225588D-01
5.053000000D-01	4.705589365D+00	-1.071256882D-03	4.094961996D-01
5.052000000D-01	4.705197634D+00	-6.795264061D-04	4.097700235D-01
5.051000000D-01	4.704805749D+00	-2.876408204D-04	4.100440304D-01
5.050000000D-01	4.704413708D+00	1.043999676D-04	4.103182205D-01
5.050900000D-01	4.704766552D+00	-2.484437272D-04	4.100714412D-01
5.050800000D-01	4.704727353D+00	-2.092450819D-04	4.100988538D-01
5.050700000D-01	4.704688153D+00	-1.700448844D-04	4.101262682D-01
5.050600000D-01	4.704648951D+00	-1.308431346D-04	4.101536845D-01
5.050500000D-01	4.704609748D+00	-9.163983243D-05	4.101811026D-01
5.050400000D-01	4.704570543D+00	-5.243497777D-05	4.102085225D-01
5.050300000D-01	4.704531336D+00	-1.322857053D-05	4.102359442D-01
5.050200000D-01	4.704492128D+00	2.597938938D-05	4.102633678D-01
5.050290000D-01	4.704527416D+00	-9.307844409D-06	4.102386865D-01

THE FINAL ESTIMATE OF BETA = 5.0502900D-01
THE FINAL ESTIMATE OF LAMBDA = 4.1023869D-01
CONVERGENCE TO 9.3078444D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05
THE FINAL STEP SIZE IS 1.0000000D-06

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 5.0502900D-01

NUMBER OF FAILURES = 12

UNBIASED ESTIMATE OF BETA = 4.6294107D-01

CRAMER - VON MISES STATISTIC = 1.4645334D-01

REJECT THE WEIBULL INTENSITY MODEL IF THE STATISTIC
EXCEEDS THE APPROPRIATE CRITICAL VALUE FOR M = 12

DATA INPUT PHASE.

TOTAL NUMBER OF FAILURES = 13

TOTAL NUMBER OF SYSTEMS = 4

SYSTEM STARTING AND ENDING TIMES.

FAILURES.

0. 1.000D+01

2.000D+00 3.000D+00 4.000D+00 5.000D+00 6.000D+00
8.000D+00

0. 3.000D+01

NO FAILURES

0. 5.000D+01

4.100D+01 4.200D+01 4.300D+01 4.400D+01

0. 6.000D+01

5.100D+01 5.200D+01 5.300D+01

ESTIMATION OF THE PARAMETERS OF THE WEIBULL INTENSITY FUNCTION.

CONSTANT NOT INVOLVING BETA: A = 2.7314373D+00

ESTIMATED BETA	FUNCTION D(B')	A - D(B')	ESTIMATED LAMBDA
1.000000000D+01	3.968432009D+00	-1.236994667D+00	1.849458331D-17
9.000000000D+00	3.952550770D+00	-1.221113428D+00	1.078792963D-15
8.000000000D+00	3.932861136D+00	-1.201423794D+00	6.259621158D-14
7.000000000D+00	3.907735525D+00	-1.176298182D+00	3.608615152D-12
6.000000000D+00	3.874419411D+00	-1.142982068D+00	2.063131834D-10
5.000000000D+00	3.827948744D+00	-1.096511402D+00	1.166442351D-08
4.000000000D+00	3.758529458D+00	-1.027092115D+00	6.490264603D-07
3.000000000D+00	3.643675381D+00	-9.122380383D-01	3.523035230D-05
2.000000000D+00	3.417047055D+00	-6.856097124D-01	1.830985915D-03
1.000000000D+00	2.775490643D+00	-4.405330001D-02	8.666666667D-02
9.000000000D-01	2.641348518D+00	9.008882500D-02	1.262779044D-01
9.900000000D-01	2.763183818D+00	-3.174647579D-02	9.000032102D-02
9.800000000D-01	2.750649704D+00	-1.921236129D-02	9.346013376D-02
9.700000000D-01	2.737881746D+00	-6.444403620D-03	9.705077775D-02
9.600000000D-01	2.724873127D+00	6.564215663D-03	1.007770941D-01
9.690000000D-01	2.736591829D+00	-5.154486343D-03	9.741722276D-02
9.680000000D-01	2.735299498D+00	-3.862155711D-03	9.778502929D-02
9.670000000D-01	2.734004747D+00	-2.567404728D-03	9.815420229D-02
9.660000000D-01	2.732707569D+00	-1.270226370D-03	9.852474672D-02
9.650000000D-01	2.731407956D+00	2.938641763D-05	9.889666758D-02
9.659000000D-01	2.732577717D+00	-1.140374757D-03	9.856187678D-02
9.658000000D-01	2.732447841D+00	-1.010498793D-03	9.859902062D-02
9.657000000D-01	2.732317941D+00	-8.805984704D-04	9.863617822D-02
9.656000000D-01	2.732188016D+00	-7.506737824D-04	9.867334961D-02
9.655000000D-01	2.732058067D+00	-6.207247218D-04	9.871053478D-02
9.654000000D-01	2.731928094D+00	-4.907512815D-04	9.874773374D-02
9.653000000D-01	2.731798096D+00	-3.607534545D-04	9.878494650D-02
9.652000000D-01	2.731668074D+00	-2.307312337D-04	9.882217305D-02
9.651000000D-01	2.731538027D+00	-1.006846121D-04	9.885941341D-02
9.650000000D-01	2.731407956D+00	2.938641763D-05	9.889666758D-02
9.650900000D-01	2.731525021D+00	-8.767860756D-05	9.886313820D-02
9.650800000D-01	2.731512015D+00	-7.467235898D-05	9.886686314D-02
9.650700000D-01	2.731499008D+00	-6.166586631D-05	9.887058821D-02
9.650600000D-01	2.731486002D+00	-4.865912954D-05	9.887431342D-02
9.650500000D-01	2.731472995D+00	-3.565214866D-05	9.887803877D-02
9.650400000D-01	2.731459987D+00	-2.264492366D-05	9.888176425D-02
9.650300000D-01	2.731446980D+00	-9.637454539D-06	9.888548988D-02

THE FINAL ESTIMATE OF BETA = 9.6503000D-01

THE FINAL ESTIMATE OF LAMBDA = 9.8885490D-02

CONVERGENCE TO 9.6374545D-06
WHICH IS LESS THAN EPSILON = 1.0000000D-05

THE FINAL STEP SIZE IS 1.0000000D-05

CRAMER - VON MISES GOODNESS OF FIT TEST.

ESTIMATED BETA = 9.6503000D-01

NUMBER OF FAILURES = 13

UNBIASED ESTIMATE OF BETA = 1.9237087D+00

CRAMER - VON MISES STATISTIC = 1.6179976D-01

REJECT THE WEIBULL INTENSITY MODEL IF THE STATISTIC
EXCEEDS THE APPROPRIATE CRITICAL VALUE FOR M = 13

DATA INPUT PHASE.

PROGRAM RUN ENDS NORMALLY.

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