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INTERACTIONS AMONG THE VARIOUS
PHENOMENA INVOLVED IN THE DESIGN OF
DYNAMIC AND ROTARY MACHINERY AND
THEIR EFFECTS IN RELIABILITY. VOLUME II:
RESEARCH DATA

Dimitri Kececioglu, et al

Arizona University

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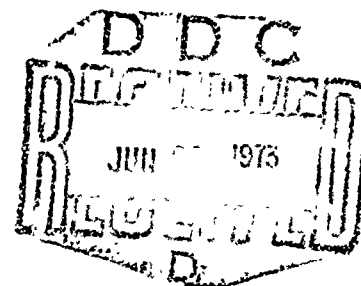
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OFFICE OF NAVAL RESEARCH

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VOL. II - RESEARCH DATA

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7.0 APPENDICES

APPENDIX APROGRAM WIEDEMANN
(MODIFIED MACHINE)

```
PROGRAM WIEDEMA (INPUT,OUTPUT,TAPE 5 = INPUT)
C LOADING PROGRAM FOR WIEDEMANN FATIGUE TEST MACHINE
C CALCULATION OF UPPER PAN LOAD SCHEDULE
C INITIALIZE STRESS CONCENTRATION DATA
  I = 1
C DETERMINE TEST SPECIMEN SECTION DIAMETER
  D = .0937
C PRINT TABLE HEADINGS
  3 PRINT 7
  7 FORMAT (1H1.7X,*RAD*.5X,*CKF*.8X,*SN*.8X,*SU*.6X,*WUPA*)
C INITIALIZE UNNOTCHED STRESS TO ZERO
  SU = 00000.
  READ(5,1) RAD,QEST,CKT
  1 FORMAT(3F10.3)
C COMPUTE REQUIRED UPPER PAN ADDED LOAD FOR AN APPLIED STRESS
  4 WUPA = 18.39 - ((SU)*(D**3))/23.73
C CALCULATE EFFECTS OF STRESS CONCENTRATION
C CALCULATE FATIGUE THEORETICAL STRESS CONCENTRATION FACTOR
  2 CKF = (QEST*(CKF-1.0)) + 1.0
C CALCULATE NOTCHED SPECIMEN ENDURANCE STRENGTH ≠ THEORETICAL
  SN = SU*CKF
  PRINT 8, RAD,CKF,SN,SU,WUPA
  8 FORMAT(1X.2F10.0,F10.2)
C INCREMENT STRESS IN STEPS OF 1000 PSI
  SU = SU + 1000.
  IF(SU.LE.60000.) GO TO 4
  IF(I.GE.5) GO TO 10
  9 I = I + 1
  GO TO 3
10 STOP
END
```

RAD	CKF	SN	SU	WUPA
1.870	1.000	1000	1000	18.34
1.870	1.000	2000	2000	18.36
1.870	1.000	3000	3000	18.32
1.870	1.000	4000	4000	18.29
1.870	1.000	5000	5000	18.25
1.870	1.000	6000	6000	18.22
1.870	1.000	7000	7000	18.18
1.870	1.000	8000	8000	18.15
1.870	1.000	9000	9000	18.11
1.870	1.000	10000	10000	18.08
1.870	1.000	11000	11000	18.04
1.870	1.000	12000	12000	18.01
1.870	1.000	13000	13000	17.97
1.870	1.000	14000	14000	17.94
1.870	1.000	15000	15000	17.90
1.870	1.000	16000	16000	17.87
1.870	1.000	17000	17000	17.84
1.870	1.000	18000	18000	17.80
1.870	1.000	19000	19000	17.77
1.870	1.000	20000	20000	17.73
1.870	1.000	21000	21000	17.70
1.870	1.000	22000	22000	17.66
1.870	1.000	23000	23000	17.63
1.870	1.000	24000	24000	17.59
1.870	1.000	25000	25000	17.56
1.870	1.000	26000	26000	17.52
1.870	1.000	27000	27000	17.49
1.870	1.000	28000	28000	17.45
1.870	1.000	29000	29000	17.42
1.870	1.000	30000	30000	17.38
1.870	1.000	31000	31000	17.35
1.870	1.000	32000	32000	17.32
1.870	1.000	33000	33000	17.28
1.870	1.000	34000	34000	17.25
1.870	1.000	35000	35000	17.21
1.870	1.000	36000	36000	17.18
1.870	1.000	37000	37000	17.14
1.870	1.000	38000	38000	17.11
1.870	1.000	39000	39000	17.07
1.870	1.000	40000	40000	17.04
1.870	1.000	41000	41000	17.00
1.870	1.000	42000	42000	16.97
1.870	1.000	43000	43000	16.93
1.870	1.000	44000	44000	16.90
1.870	1.000	45000	45000	16.86
1.870	1.000	46000	46000	16.83
1.870	1.000	47000	47000	16.80
1.870	1.000	48000	48000	16.76
1.870	1.000			16.73



APPENDIX BPROGRAM WIEDEMANN

(UNMODIFIED MACHINE)

```
PROGRAM RRMOORE (INPUT,OUTPUT,TAPE 5 = INPUT,TAPE 6 = OUTPUT)
C LOADING PROGRAM FOR RRMOORE FATIGUE TEST MACHINE
C INITIALIZE STRESS CONCENTRATION DATA
  I=1
C DETERMINE TEST SPELCIMEN SECTION DIAMETER
  D = .2700
C PRINT TABLE HEADINGS
  3 WRITE(6,8)
  8 FORMAT (1H1,6X,*RAD*,6X,*CKF*,8X,*SN*,8X,*SU*,6X,*WPA*/)
C INITIALIZE UNNOTCHED STRESS TO ZERO
  SU = 00000.
  READ(5,1) RAD,CKF
  1 FORMAT (2F10.3)
C COMPUTE REQUIRED ADDED PAN LOAD FOR AN APPLIED STRESS
  4 WPA =( (3.1416 * (D**3.) * SU)/64.) - 9.76
C CALCULATE NOTVEH SPECIMEN ENDURANCE STRENGTH - THEORETICAL
  SN = SU * CKF
  WRITE(6,9) RAD,CKF,SN,SU,WPA
  9 FORMAT (1X,2F9.3,2F10.0,F10.2)
C INCREMENT STRESS IN STEPS OF 1000 PSI
  SU = SU + 1000.
  IF(SU.LE.95000.) GO TO 4
  IF(I.GE.5) GO TO 10
11 1 = I+1
  GO TO 3
10 STOP
  END
```

RAD	CKF	SN	SU	WPA
.031	1.510	0	0	-9.76
.031	1.510	1510	1000	-8.79
.031	1.510	3020	2000	-7.83
.031	1.510	4530	3000	-6.86
M .031	1.510	6040	4000	-5.90
.031	1.510	7550	5000	-4.93
.031	1.510	9060	6000	-3.96
.031	1.510	10570	7000	-3.00
.031	1.510	12080	8000	-2.03
.031	1.510	13590	9000	-1.06
.031	1.510	15100	10000	-.10
.031	1.510	16610	11000	.87
.031	1.510	18120	12000	1.83
.031	1.510	19630	13000	2.80
.031	1.510	21140	14000	3.77
.031	1.510	22650	15000	4.73
.031	1.510	24160	16000	5.70
.031	1.510	25670	17000	6.67
.031	1.510	27180	18000	7.63
.031	1.510	28690	19000	8.60
.031	1.510	30200	20000	9.56
.031	1.510	31710	21000	10.53
.031	1.510	33220	22000	11.50
.031	1.510	34730	23000	12.46
.031	1.510	36240	24000	13.43
.031	1.510	37750	25000	14.39
.031	1.510	39260	26000	15.36
.031	1.510	40770	27000	16.33
.031	1.510	42280	28000	17.29
.031	1.510	43790	29000	18.26
.031	1.510	45300	30000	19.23
.031	1.510	46810	31000	20.19
.031	1.510	48320	32000	21.16
.031	1.510	49830	33000	22.12
.031	1.510	51340	34000	23.09
.031	1.510	52850	35000	24.06
.031	1.510	54360	36000	25.02
.031	1.510	55870	37000	25.99
.031	1.510	57380	38000	26.96
.031	1.510	58890	39000	27.92
.031	1.510	60400	40000	28.89
.031	1.510	61910	41000	29.85
.031	1.510	63420	42000	30.82
.031	1.510	64930	43000	31.79
.031	1.510	66440	44000	32.75
.031	1.510	67950	45000	33.72
.031	1.510	69460	46000	34.68

APPENDIX C

PROGRAM CYTOFR (Updated)

This program calculates estimates of the mean and standard deviation of the cycles-to-failure data for both the normal and the lognormal distributions, and calculates the moment coefficients of skewness and kurtosis. It also performs the Chi-squared and the Kolmogorov-Smirnov goodness-of-fit tests.

The program has been updated since it was previously reported.

The main program was revised to incorporate a sort routine to preclude the necessity for manually ordering the data inputs. Subroutine CHISQA (Chi-squared test) was modified to provide for automatic combining of cells at the tails of the distribution when the end cells do not contain at least five failure data points. Subroutine GRAPH was added to the program to plot a histogram of the cycles-to-failure data based on the cell widths and number of failure data points per cell computed by the CHISQA subroutine. The theoretical distribution curve represented by the parameters estimated by the main program is sketched and superimposed over the histogram. The plotting of the histogram and of the distribution is done by the Cal-Comp plotter from an output tape generated by the computer.

The data deck for operating program CYTOFR is in three logical sections per problem. The first section consists of two cards. Card one consists of three titles, while card two specifies the parameters necessary for the statistical calculations in CYTOFR.

The second, logical section is a variable number of cards, each specifying up to eight data points for analysis.

Section three provides parameters for plotting the normal and lognormal distributions. The first card is a parameter list for the normal distribution plot, followed by exactly six cards of footnotes. Next is a parameter list card for the lognormal distribution.

Multiple problems may be executed by stacking complete data sets behind each other. A list of important variables and symbols in program CYTOFR using Fortran language follows:

List of Definitions for Program to fit Normal
and Log-Normal Distributions to Cycles-
to-Failure Data (PROGRAM CYTOFR)

Main Program:

NDATA = DATA = number of observations.
 STRLV = stress level in psi.
 AKURCY = accuracy to which cycles-to-failure data are known.
 RATIO = stress ratio
 X(I) = cycles-to-failure data
 CUMFRQ(I) = cumulative frequency of each X(I); ie, number of
 X's less than or equal to X(I).
 PCAREA(I) = CUMFRQ(I)/NDATA

Subroutine to calculate the mean and standard deviation of the
cycles-to-failure data (SUBROUTINE MEAN)

SIGMA = sum of the X(I)'s
 XMEAN = average of the X(I)'s

$$TOP2 = \sum_{i=1}^n (X(I) - XMEAN)^2$$

 DEV = standard deviation of the X(I)'s

Function subroutine to find the area under the normal curve
(FUNCTION PROB(X)).

X = abscissa value for which corresponding area
 is desired.
 PROB = desired area.

Subroutine for Chi-square goodness-of-fit test (SUB-ROUTINE CHISQA).

K = number cells.
XMAX = largest value of cycles-to-failure.
XMIN = smallest value of cycles-to-failure.
CSV = cell starting value.
CEV = cell end value.
CLB = cell lower bound.
CUB = cell upper bound.
FREQ(J) = number of observations in Jth cell.
REQAREA(J) = expected value of Jth cell.
CHISQR = total Chi-square value.
U(I) = Chi-square value of Ith cell.

Subroutine for Kolmogorov-Smirnov test (SUBROUTINE DTEST).

Z(I) = abscissa value on standard normal curve for a
given X(I).
ARUNCN = area under standard normal curve from - to Z(I).
DSTAT(I) = absolute difference between the data cumulative
frequency and the hypothesized cumulative frequency.
XMEAN = average of the X(I)'s.
DEV = standard deviation of the X(I)'s
PROB(T) = area under the standard normal curve from -T to
+T.

Subroutine to calculate the moment coefficients of skewness and kurtosis (SUBROUTINE ALPHA).

ALPHA3 = moment coefficient of skewness.

ALPHA4 = moment coefficient of skewness.

$$\text{VAR} = \sum_{i=1}^n (X(I) - \bar{X})^2$$

$$\text{TOP3} = \sum_{i=1}^n (X(I) - \bar{X})^3$$

SKEW = third moment of the data.

STDEV = biased estimator for standard deviation.

$$\text{TOP4} = \sum_{i=1}^n (X(I) - \bar{X})^4$$

TKURT = fourth moment of the data.

DATA DECK STRUCTURE

<u>Card</u>	<u>Columns</u>	<u>Description</u>
1	1-20	Twenty character descriptive title to appear at the top of each printed output page.
	21-40	Twenty character descriptive title of the input data will appear on printed output, as well as the X-axis label for both slots.
	41-50	Unit of data measurement (cycles, inches, etc.).
2	1-10	Number of data points on following card(s). Must have a decimal point.
	11-20	Stress level. Must have a decimal point.
	21-30	Stress ratio. Must have a decimal point.
	31-40	Accuracy. Must have a decimal point.
3 to n**	1-10, 11-20, ..., 71-80	Data points, punched eight per card until all points are exhausted. Must have decimal points.
n + 1	1-10	The letters "NORMAL" followed by four blank spaces.
	11-20	Length of the X-axis in inches. If zero or blank, 6.0 is assumed. Decimal point is necessary.
	21-30	Length of the X-axis in inches. If zero or blank, 5.0 is assumed; if greater than 5.0, 5.0 is assumed. Decimal point is necessary.

**The notation 3rd to n is intended to mean from the third card to the nth card. In the case of 34 data points, the second section of data would stretch from the 3rd to 7th card .

<u>Card</u>	<u>Columns</u>	<u>Description</u>
	31-40	Minimum X-axis value. The plotting program may find it necessary to alter this value slightly. If absent or zero, a reasonable maximum will be assumed. The decimal point is necessary.
	41-50	Minimum Y-axis value. This should be blank or 0.
	51-60	Maximum X-axis value. Follow same rules as minimum X-axis value.
	61-70	Maximum Y-axis value. If absent or zero, the plotting program will search for the smallest even number greater than (or equal to) the height of the tallest histogram block, an automatic adjustment will be made. The decimal point is necessary.
	71-80	Height of lettering on graph, if $0 < \text{height} < .15$. Otherwise this parameter will be set to equal .15.
n + 2 to n + 7	1-50	Footnotes punched as they will appear on the normal graph.
n + 8	1-10	The letters "LOG-NORMAL." Otherwise the same as card n + 1.

The program for CYTOFR listing in Fortran language follows:

```

      PROGRAM CYTCFR (INPUT,OUTPUT,TAPE1=INPUT,TAPE2)
C-----PROGRAM TO FIT NORMAL AND LOG-NORMAL CURVE TO DATA AND CHECK
C-----GOODNESS OF FIT.
      COMMON CUMFRQ(100),NDATA,X(100),DEV,XMEAN,CLB(9),CUR(9),FREQ(9),K,
1 CHISQR,TITLE(2),SUBTITL(2),CSV(9),CEV(9),PCAREA(100),DSTAT(100),
2 AREA(9),REQAREA(9),EXFREQ(9),U(9),Z(100),NX(100),DATA,AKURCY,
3 XMAX,XMIN,PSI,CD,D,RATIO,XLENGTH,YLENGTH,YMAX,YMIN,XMA,XMI,
4 HLETTEF,COM(3),W,ALPHA3,ALPHA4,FOOT(30),IT,SKS,UNIT
      INTEGER TITLE,SUBTITL,FOOT
      EXTERNAL PRGR
C
C      INITIALIZE PLOTTER
C
      CALL INITIAL (0,2,0.3,0)
710 PRINT 1
C-----NDATA=DATA=NUMBER OF OBSERVATIONS
C-----STRLV = STRESS LEVEL IN PSI.
C      X=NUMBER OF CYCLES TO FAILURE
      READ 500,TITLE,SUBTITL,UNIT
500 FORMAT(8A10)
      IF(.NOT.(1)) 55,5
5 READ 501,DATA,S1PLEV,RATIO,AKURCY
501 FORMAT(8F10.0)
      NDATA=DATA
      READ 501,(X(I),I=1,NDATA)
C
C      SORT X(I) TERMS IN ASCENDING ORDER.
C
      K=NDATA-1
      IF(K.LE.0) GO TO 30
      DO 20 I=1,K
      N=NDATA-I
      ISTOP=0
      DO 10 J=1,N
      IF(X(J).LE.X(J+1)) GO TO 10
      SAVE=X(J)
      X(J)=X(J+1)
      X(J+1)=SAVE
      ISTOP=ISTOP+1
10 CONTINUE
      IF(ISTOP.EQ.0) GO TO 30
20 CONTINUE
C
C      SET CUMFRQ(I) ARRAY
C
30 DO 40 I=1,NDATA
40 CUMFRQ(I)=I
C
C      RESET SOME CUMFRQ(I) ENTRYS IF X(I)=X(I+1) OCCURS

```

```

C
DO 53 I=2, NDATA
  FC CONTINUE
)-----PCAREA = F(N) OF OBSERVATIONS
DO 759 I=1, NDATA
759  PCAREA(I) = CUMFRQ(I)/DATA
  PRINT 408, TITLE, SUBTITL
408  FORMAT(*1*, 55X, 2A10, /, 42X, *NORMAL DISTRIBUTION FITTED TO *, 2A10,
1//)
  IF (RATIO.EQ.0.0) GO TO 414
  PRINT 402, STRLEV, RATIO
402  FORMAT(29X, *STRESS LEVEL =*, F7.1, * PSI.*, 16X
1, 14HSTRESS RATIO =, F6.3//)
  GO TO 415
414  PRINT 416, STRLEV

416  FORMAT(29X, *STRESS LEVEL =*, F7.1, * PSI.*, 16X
1, 23HSTRESS RATIO = INFINITY//)
417  PRINT 404, SUBTITL
404  FORMAT(56X, 2A10, /)
  PRINT 403, (X(I), I=1, NDATA)
403  FORMAT(6F21.4)
  PRINT 3
3    FORMAT (1H0)
  CALL MEAN
  CALL CHISQA
  CALL QTEST
  CALL ALPHA
  READ 502, IT, XLENGTH, YLENGTH, XM1, YMIN, XMA, YMAX, HLETTER
502  FORMAT(A1, 9X, 7F10.0)
  READ 503, FOOT
503  FORMAT(EA10)
  IF (IT.NE.1HN) GO TO 57
  CALL GRAPH
53  AKURCY=.00001
  DO 54 I=1, NDATA
  NX(I) = (ALOG(X(I)/20.)+ALOG(20.))*100000. + .5
  X(I) = NX(I)
54  X(I) = X(I)/100000.
  PRINT 1, TITLE
  1  FORMAT(*1*, 55X, 2A10)
  PRINT 401, SUBTITL
401  FORMAT(38X, *LOG-NORMAL DISTRIBUTION FITTED TO *, 2A10, ///)
  IF (RATIO.EQ.0.0) GO TO 417
  PRINT 402, STRLEV, RATIO
  GO TO 418
417  PRINT 416, STRLEV
418  PRINT 2, SUBTITL
  2  FORMAT(49X, *LOGS OF THE *, 4A10, /)
  PRINT 413, (X(I), I=1, NDATA)

```

```

413 FORMAT(6(8X,F12.4))
PRINT 3
CALL MEAN
CALL CHISQA
CALL DTEST
CALL ALPHA
READ 502,IT,XLENGTH,YLENGTH,XMI,YMIN,XMA,YMAX
IF(IT.NE.1HL) GO TO 57
CALL GRAPH
GO TO 710
56 CALL PLOT (0.,0.,999)
CALL EXIT
57 CALL PLOT (0.,0.,999)
STOP 1111
END
SUBROUTINE MEAN
C-----SUBROUTINE TO CALCULATE THE MEAN AND STANDARD DEVIATION OF DATA.
COMMON CUMFRT(100),NDATA,X(100),DEV,XMEAN,CLB(9),CUB(9),FREQ(9),K,
1 CHISQR,TITLE(2),SUBTITL(2),CSV(9),DEV(9),PCAREA(100),DSTAT(100),
2 AREA(9),REQAREA(9),EXFREQ(9),U(9),Z(100),NX(100),DATA,AKURCY,
3 XMAX,XMIN,PSI,CD,D,R,XLENGTH,YLENGTH
SIGMA= 0.0
DO 3 I=1, NDATA
3 SIGMA=SIGMA+ X(I)
XMEAN = SIGMA/DATA
TOP2 = 0.0
DO 9 I=1,NDATA
9 TOP2 = TOP2 + (X(I) - XMEAN)**2
DEV =SQRT(TOP2/(DATA - 1.0))
PRINT 14, XMEAN

PRINT 15, DEV
14 FORMAT(10X,*SAMPLE MEAN =*,F14.4)
15 FORMAT(10X,*STD. DEVIATION=*,F12.4)
RETURN
END
FUNCTION PROB(X)
C-----THIS SUBROUTINE GIVES AREA UNDER NORMAL CURVE FROM -Z TO +Z
C WITH AN ACCURACY OF 0.00005
C-----Z VALUE GIVEN BY CALLING PPROGRAM MUST BE A POSITIVE NUMBER.
IF (X-1.2) 11,11,12
11 XSQ=X*X
PROB= 0.79788455*X*(0.99999774-XSQ*(0.16659433-XSQ*(0.024638310-XS
10*(0.0023974867)))
RETURN
12 IF(X-2.9) 13,14,14
13 XSQ=X*X
PROB=1.0
PTERM=1.0
FACTOR=1.0

```



```

000141=3.0
970 PTERM=-PTERM*XSQ/(2.0*FACTOR)
    TERM=PTERM/000INT
    PROB=PROB+TERM
    IF( ABS (TERM) - 0.00007 ) 80,90,90
90  FACTOR =FACTOR+1.0
    000INT=000INT+2.0
    GO TO 970
80  PROB=0.79788455*X*PROB
    RETURN
14  RECSQ= 1.0 / (X*X)
    PROB= 1.0 - 0.79788453*EXP(-X*X/2.0)/X*(1.0-RECSQ*(1. -RECSQ*(3.
1 - RECSQ*(15. - RECSQ*105. )))
    RETURN
    END
SUBROUTINE CHISQA
C-----SUBROUTINE TO FIT A HISTOGRAM TO THE DATA AND PERFORM THE CHI-SQUA
C-----TEST FOR THE NORMAL OR LOG-NORMAL DISTRIBUTIONS.
    COMMON CUMFREQ(100),NDATA,X(100),DEV,XMEAN,CLB(9),CUB(9),FREQ(9),K,
1  CHISQR,TITLE(2),SUBTITL(2),CSV(9),CEV(9),PCAREA(100),DSTAT(100),
2  AREA(9),REQAREA(9),EXFREQ(9),U(9),Z(100),NX(100),DATA,AKURCY,
3  XMAX,XMIN,PSI,CD,D,R,XLENGTH,YLENGTH,YMAX,YMIN,XMA,XMI,H,COM(3),W
    DIMENSION XFREQ(9)
    CHISQR= .0
C-----TO DETERMINE THE NUMRER OF CLASS INTERVALS,K
    K= 1 +3.3 *ALOG10(DATA)
    REALK=K
C-----IN ORDER TO DETERMINE THE RANGE,FIND X(MAX) AND X(MIN)
    XMAX=X(1)
    XMIN= X(1)
    DO 17 I=1,NDATA
    IF( X(I).GT.XMAX ) XMAX = X(I)
17  IF(X(I).LT. XMIN) XMIN=X(I)
    RANGE= XMAX- XMIN
C-----TO DETERMINE THE CLASS INTERVAL WIDTH,W
C-----ROUTINE TO ROUND OFF CLASS WIDTH TO SAME NUMBER OF PLACES AS THE A
    DIVIDE = 1.0/AKURCY
20  KW=((RANGE+AKURCY)/REALK)+.5*AKURCY)*DIVIDE
    RK1 = KW
    W = RK1/DIVIDE
    DO 22 I=1,K
    A=I
    R = 0.5*AKURCY
    CSV(I)= XMIN+(A-1.0)*W
    CEV(I)= CSV(I)+W-AKURCY
    CLB(I)= CSV(I)-R
22  CUB(I) = CEV(I)+R
    CEV(K) = XMAX
    CUB(K) = CEV(K) +R
    DO 23 J=1,K

```

```

      XFREQ(J)=0.0
23  FREQ(J)=0.0
      DO 24 I=1,NDATA
      DO 24 J=1,K
      IF(X(I).GE.CL9(J).AND.X(I).LT.CUB(J)) FREQ(J)=FREQ(J)+1.0
24  CONTINUE
      DO 25 J=1,K
25  XFREQ(J)=FREQ(J)
      Y=0.
      PRINT 62,XMAX
      PRINT 63,XMIN
      PRINT 65,W
0-----CHI-SQUARE TEST
26  PRINT 41
      PRINT 406
      DO 31 I=1,K
      Z(I)=(CUR(I)-XMEAN)/DEV
      T=ABS(Z(I))
30  AREA(I)=PROB(T)/2.0
      REQAREA(1)=0.5-AREA(1)
      MANU=K-1
      DO 32 I=2,MANU
      M=I-1
      IF( (Z(I).GE.0.0.AND.Z(M).GE.0.0).OR.(Z(I).LE.0.0.AND.Z(M).LE.0.
1 ) ) GO TO 31
      REQAREA(I)=AREA(I)+AREA(M)
      GO TO 32
31  REQAREA(I)=ABS(AREA(I)-AREA(M))
32  CONTINUE
      REQAREA(K)=0.5-AREA(K-1)
      DO 80 M=1,K
80  EXFREQ(M)=DATA*REQAREA(M)
      I=1
2420 IF(FREQ(I).GE.5.) GO TO 2430
      EXFREQ(I+1)=EXFREQ(I+1)+EXFREQ(I)
      FREQ(I+1)=FREQ(I+1)+FREQ(I)
      J=I
      DO 2425 L=1,J
      EXFREQ(L)=0.
2425 FREQ(L)=0.
      I=I+1
      GO TO 2420
2430 I=K
2440 IF(FREQ(I).GE.5.) GO TO 2450
      EXFREQ(I-1)=EXFREQ(I-1)+EXFREQ(I)
      FREQ(I-1)=FREQ(I-1)+FREQ(I)
      DO 2445 L=I,K
      EXFREQ(L)=0.
2445 FREQ(L)=0.
      I=I-1

```

```

      GO TO 2443
2450 CONTINUE
      DO 85 M=1,K
      U(M)=0.0
      IF (EXFREQ(M).EQ.0.) GO TO 85
      U(M)=((EXFREQ(M)-FREQ(M))*2)/EXFREQ(M)
      85 CONTINUE
      DO 90 M=1,K
      90 CHISQR=CHISQR+U(M)
C-----TO PRINT THE TABLE FOR CHI-SQUARE TEST
      DO 33 I=1,K
33      PRINT 34,I,CLR(I),CUR(I), EXFREQ(I),FREQ(I),U(I)
      PRINT 35, CHISQR
      DO 150 I=1,K
150      FREQ(I)=XFREQ(I)
      62 FORMAT(10X,*MAXIMUM VALUE=*,F13.4)
      63 FORMAT(10X*MINIMUM VALUE=*,F13.4)
      65 FORMAT(10X,*CLASS WIDTH=*,F15.4)
      41 FORMAT(1H0)
406      FORMAT (8X,5H CELL,10X,10HLOWER CELL,11X,10HUPPER CELL,13X,9HEXPEC
      1TED,13X,8HOBSEVED,13X,11HCHI-SQUARED/8X,6HNUMBER,13X,5HBOUNDARY,
      213X, 8HBOUNDARY,13X,9HFREQUENCY,12X,9HFREQUENCY,12X,13HVALUE OF CE
      3LL/)
      34 FORMAT(10X,I2,F20.4,4F21.4)
      35 FORMAT(*0*,77X,*TOTAL CHI-SQUARED VALUE =*,F13.4)
      RETURN
      END
      SUBROUTINE DTEST
C-----SUBROUTINE TO CALCULATE THE KOLMOGOROV-SHIRNOV D-VALUES.
      COMMON CUMFRO(100),NDATA,X(100),DEV,XMEAN,CLR(9),CUR(9),FREQ(9),K,
      1 CHISQR,TITLE(2),SUBTITL(2),CSV(9),CEV(9),PCAREA(100),DSTAT(100),
      2 AREA(9),REOAREA(9),EXFREQ(9),U(9),7(100),NX(100),DATA,AKURCY,
      3 XMAX,XMIN,PSI,CD,D,R,XLENGTH,YLENGTH,YMAX,YMIN,XMA,XM1,
      4 I,COM(3),W,ALPHA3,ALPHA4,FOOT(30),IT,SKS
      INTEGER TITLE,SUBTITL
      DO 706 I=1, NDATA
      7(1) = (X(I) - XMEAN)/DEV
      IF (Z(I)) 703, 704, 705
703      T =ABS(Z(I))
C-----ARUNCN=AREA UNDER THE NORMAL CURVE TO LEFT OF Z FOR NEGATIVE Z.
      APUNCN = (1.0-PROB(T))/2.0
      DSTAT(I) = APUNCN - PCAREA(I)
      GO TO 706
704      DSTAT(I) = .5 - PCAREA(I)
      GO TO 706
705      T = 7(I)
C-----ARUNCN=AREA UNDER THE NORMAL CURVE TO LEFT OF Z FOR POSITIVE Z.
      ARUNCN = PROB(T)/2.0 + .500
      DSTAT(I) = (ARUNCN - PCAREA(I))
706 CONTINUE

```



```

DO 90 I=1,NDATA
90 DSTAT(I)=ABS(DSTAT(I))
   SKS=DSTAT(1)
DO 100 I=2,NDATA
   IF(DSTAT(I).GT.SKS) SKS=DSTAT(I)
100 CONTINUE
   PRINT 708,SUBTITL
   PRINT 707, (DSTAT(I),I=1,NDATA)
707 FORMAT(FF20.5)
708 FORMAT (//40X,53H D VALUES FOR KOLMOGOROV-SHIRNOV GOODNESS OF FIT
11-ST,/,44X,*LISTED IN THE SAME ORDER AS *,2A10,/)
   RETURN
   END
   SUBROUTINE ALPHA
   COMMON CUMFREQ(100),NDATA,X(100),DEV,XMEAN,CL3(9),CU3(9),FREQ(9),K,
1 CHISQR,TITLE(2),SUBTITL(2),CSV(9),CEV(9),PCAREA(100),DSTAT(100),
2 AREA(9),REQAREA(9),EXFREQ(9),U(9),Z(100),NX(100),DATA,AKURCY,
3 XMAX,XMIN,PSI,CD,D,RATIO,XLENGTH,YLENGTH,YMAX,YMIN,XMA,XMI,
+ H,COM(3),W,ALPHA3,ALPHA4,FOOT(30),IT,SKS
C-----SUBROUTINE TO CALCULATE THE COEFFICIENTS OF SKEWNESS AND KURTOSIS
C-----CALCULATE THE THIRD MOMENT OF THE DATA (SKEWNESS)
   TOP3 = 0.0
   VAR = 0.0
DO 710 I = 1, NDATA
   VAR = VAR + (X(I) - XMEAN)**2
710 TOP3 = TOP3 + (X(I) - XMEAN)**3
   SKEW = TOP3 / DATA
   STDEV = SQRT(VAR/DATA)
C-----ALPHA3 = MOMENT COEFFICIENT OF SKEWNESS.
   ALPHA3 = SKEW/(STDEV**3)
C-----CALCULATE THE FOURTH MOMENT OF THE DATA (KURTOSIS).
   TOP4 = 0.0
DO 711 I = 1, NDATA
711 TOP4 = TOP4 + (X(I) - XMEAN)**4
   TKURT = TOP4 / DATA
C-----ALPHA4 = MOMENT COEFFICIENT OF KURTOSIS.
   ALPHA4 = TKURT/(STDEV**4)
   PRINT 712
   PRINT 713
   PRINT 714, ALPHA3, ALPHA4
712 FORMAT (///19X,39HMOMENT COEFFICIENT OF SKEWNESS (ALPHA3),18X,39HM
1OMENT COEFFICIENT OF KURTOSIS (ALPHA4)/)
713 FORMAT(21X,*FOR NORMAL DISTRIBUTION ALPHA3 = 0.0*,21X,*FOR NORMAL
1DISTRIBUTION ALPHA4 = 3.0*,/)
714 FORMAT (28X,25HFOR ABOVE DATA---ALPHA3 =F6.3,26X,25HFOR ABOVE DATA
1---ALPHA4 =,F6.3)
   RETURN
   END
   SUBROUTINE GRAPH
   COMMON CUMFREQ(100),NDATA,X(100),DEV,XMEAN,CL3(9),CU3(3),FREQ(9),K,

```

```

1  CHID(1),TITLE(2),SUBTITL(2),CSV(9),CEV(9),PCAP(4(100),DSTAT(100),
2  AREA(9),REQAREA(9),EXFREQ(9),U(9),Z(100),NX(100),DATA,AKU=CY,
3  XMAX,XMIN,PSI,CD,D,P,XLENGTH,YLENGTH,YMAX,YMIN,XMA,XMI,
4  H,DOM(3),W,ALPHA3,ALPHA4,FOOT(30),IT,SKS,UNIT
C   DETERMINE DEFAULTS OR SPECIFIED PARAMETERS
C
   IF(XLENGTH.EQ.0.) XLENGTH=6.
   IF(YLENGTH.EQ.0.) YLENGTH=5.
   IF(YLENGTH.GT.5.) YLENGTH=5.
   DO 1 I=1,K
   IF(YMAX.LT.FREQ(I)) YMAX=FREQ(I)
1  CONTINUE
   I=YMAX
   IF((I/2*2).NE.I) YMAX=YMAX+1.
6  XMIN = XMIN - 0.10 * (XMAX - XMIN)
8  IF(XMIN.LT. 0.0) XMIN = 0.0
   XDIF=XMAX-YMIN
   H = 0.15
C
C   DETERMINE SCALING FACTORS
C
   XSCALE = (XMAX - XMIN) / XLENGTH
   YSCALE = YMAX / YLENGTH
   E = IFIX(4LOG10(XMAX - XMIN))
   STP = 10.0 ** E
C
C   LOCATE PLOTTER PEN
C
   CALL PLOT(XLENGTH+2.,0.,-3)
   CALL PLCT(0.,-11.,-3)
   CALL PLCT(0.,5.,-3)
C
C   CONSTRUCT Y-AXIS
C
   CALL PLOT(0.,YLENGTH,2)
   DIV=1./YSCALE
21 IF(DIV.GE.(2.*H)) GO TO 22
   DIV=2.*DIV
   GO TO 21
22 STEP=DIV
   YY=0.
23 CALL PLOT(.05,YY,3)
   CALL PLCT(-.05,YY,2)
   YN=YY*YSCALE
   CALL NUMBER(-.3,YY,H,YN,0.,-1)
   YY=YY+STEP
   IF(YY.LE.(YLENGTH+.01)) GO TO 23
   YY=(YLENGTH-3.75)/2.
   IF(YY.LT.0.) YY=0.
   CALL SYMBOL(-.4,YY,H,30HFREQUENCY/CLASS INTERVAL WIDTH,90.,30)

```

C
C
C

CONSTRUCT, DRAW, AND LABEL X-AXIS

```

CALL PLOT (0.,0.,3)
IF(IT.EQ.1HL) GO TO 25
XMIN=IFIX(XMIN/STP)
XMAX=IFIX(XMAX/STP+1.0)
XSCALE = ( XMAX - XMIN ) / XLENGTH * STP
25 XDIF=XMAX-XMIN
DIV=10.*XDIF/XLENGTH
IF(XMIN.EQ.0.) GO TO 26
CALL PLOT (.3,0.,2)
CALL PLOT (.35,0.,3)
CALL PLOT (XLENGTH,0.,2)
CALL PLOT (.35,.05,3)
CALL PLOT (.25,-.05,2)
CALL PLOT (.3,-.05,3)
CALL PLOT (.4,.05,2)
GO TO 28
26 CALL PLOT (XLENGTH,0.,2)
28 IF(DIV.LT.12.7) GO TO 30
DIV=DIV/10.
GO TO 28
30 DIV=DIV/10.
IF(DIV.LT.0.2) DIV=DIV*10.
32 CALL NUMBER (0.,-.2,H,0.,0.,0)
XX=0.
DO 35 I=1,25
XX=XX+1./DIV
IF(XX.GT.XLENGTH) 40,33
33 CALL PLOT (XX,.05,3)
CALL PLOT (XX,-.05,2)
XN=XMIN+I*XDIF/(DIV*XLENGTH)
IF(IT.EQ.1HL) GO TO 37
CALL NUMBER (XX-.1,-.2,H,XN,0.,0)
35 CONTINUE
40 DO 41 I=1,2
IF(SUBTITL(I).EQ.1H ) GO TO 42
41 CONTINUE
I=2
GO TO 43
37 CALL NUMBER (XX-.2,-.2,H,XN,0.,2)
GO TO 35
42 I=I-1
43 XX=(XLENGTH-I)/2.
I=I*10
CALL SYMBOL (XX,-.5,.15,SUBTITL(1),0.,I)
IF(IT.EQ.1HL) GO TO 46
IF(STP.LT.1.01) GO TO 48 .
CALL WHERE (XX,YY)
CALL SYMBOL (XX,-.5,H,5H X 10,0.,5)

```

```
CALL WHERE (XX,YY)
CALL NUMBER (XX+H,YY+.5*H,.5*H,E,0.,-1)
```

```
C
C   CONSTRUCT AND DRAW HISTOGRAM
C
```

```
GO TO 48
46 DO 47 I=1,K
   CLB(I)=(CLB(I)-XMIN)/XSCALE
47 CUB(I)=(CUB(I)-XMIN)/XSCALE
   GO TO 52
48 DO 53 I=1,K
   CLF(I)=(CLF(I)/STP)-XMIN)/(XSCALE/STP)
50 CUF(I)=(CUF(I)/STP)-XMIN)/(XSCALE/STP)
52 CALL PLOT (CLB(I),0.,3)
   DO 55 I=1,K
   Y=FREQ(I)/YSCALE
   CALL PLOT (CLB(I),Y,2)
   CALL PLOT (CUB(I),Y,2)
54 CALL PLOT (CUF(I),0.,2)
55 CONTINUE
```

```
C
C   COMPUTE AND DRAW NORMAL CURVE ONE POINT AT A TIME
C
```

```
60 STEP=XDIF*STP/100.
   IF(IT.EQ.1HL) STEP=STEP/STP
   C=1./((DEV*2.50665)
   XX=XMIN
   IF(IT.EQ.1HL) XX=XMIN*STP
   CALL PLOT(C.,0.,3)
   DO 100 I=1,100
   Y=C*EXP(-.5*(XX-XMEAN)**2/DEV**2)/YSCALE*NDATA*W
   XU=(XX-XMIN*STP)/XSCALE
   IF(IT.EQ.1HL) XU=(XX-XMIN)/XSCALE
   IF(XU.GT.20.) GO TO 100
   IF(XMIN.EQ.0.) 80,70
70 IF(XU.GE.0.4) 80,90
80 CALL PLOT (XU,Y,2)
   GO TO 100
90 CALL PLOT (XU,Y,3)
100 XX=XX+STEP
```

```
C
C   OTHER ALPHA-NUMERIC COMMENTARY
C
```

```
130 CALL PLOT(C.,-1.,-3)
   CALL SYMBOL (0.,0.,H,11HMEAN VALUE:,0.,11)
   CALL SYMBOL(0.,-2.*H,H,19HSTANDARD DEVIATION:,0.,19)
   CALL SYMBOL (0.,-4.*H,H,24HKOLMOGOROV-SMIRNOV TEST:,0.,24)
   CALL WHERE(XX,YY)
   XX=XX+H
   CALL SYMBOL (0.,-6.*H,H,17HCHI-SQUARED TEST:,0.,17)
   CALL SYMBOL (0.,-8.*H,H,9HSKEWNESS:,0.,9)
```

```

CALL SYMBOL(0.,-10.*H,H,9HKURTOSIS,0.,9)
IF(IT.EQ.1HN) CALL NUMBER (XX,0.,H,XMEAN,0.,1)
IF(IT.EQ.1HL) CALL NUMBER(XX,0.,H,XMEAN,0.,3)
CALL WHERE(XIN,YY)
XIN=XIN+2.*H
IF(IT.EQ.1HN) CALL NUMBER(XX,-2.*H,H,DEV,0.,1)
IF(IT.EQ.1HL) CALL NUMBER(XX,-2.*H,H,DEV,0.,3)
CALL NUMBER(XX,-4.*H,H,SKS,0.,3)
CALL NUMBER(XX,-6.*H,H,CHISQ,0.,3)
CALL NUMBER(XX,-8.*H,H,ALPHA3,0.,3)
CALL NUMBER(XX,-10.*H,H,ALPHA4,0.,3)
CALL SYMBOL (XIN,0.,H,UNIT,0.,10)
CALL SYMBOL (XIN,-2.*H,H,UNIT,0.,10)
CALL SYMBOL(0.,-14.*H,H,FOOT(1),0.,50)
CALL SYMBOL(0.,-16.*H,H,FOOT(6),0.,50)
CALL SYMBOL(0.,-18.*H,H,FOOT(11),0.,50)
CALL SYMBOL(0.,-20.*H,H,FOOT(16),0.,50)
CALL SYMBOL(0.,-22.*H,H,FOOT(21),0.,50)
CALL SYMBOL(0.,-24.*H,H,FOOT(26),0.,50)
CALL PLOT(XLENGTH+2.,0.,3)
IF(IT.EQ.1HL) GO TO 150
XX=(XLENGTH-3.75)/2.
IF(XX.LT.0.) XX=0.
CALL SYMBOL (XX,6.25,H,30NORMAL DISTRIBUTION PARAMETERS,0.,30)
RETURN
150 XX=(XLENGTH-4.25)/2.
IF(XX.LT.0.) XX=0.
CALL SYMBOL (XX,6.25,H,34HLOG NORMAL DISTRIBUTION PARAMETERS,0.,
1 34)
RETURN
END

```


APPENDIX D

PROGRAM WEIBULL

This program calculates the three Weibull distribution parameters (β , η , and γ) from cycles-to-failure data. It uses those parameters to calculate cycle life for 99% and 90% reliability with a 90% confidence interval. It also performs the Chi-squared and Kolmogorov-Smirnov goodness-of-fit tests.

The program input consists of:

1. A header card - to identify the data block.
2. A set of data cards (in increasing order of cycles-to-failure)
3. Trailer card - to separate data blocks.

The input format for the header card is:

- a. Columns 2-7 date code in alphameric format
- b. 8-9 blank
- c. 10-40 run identification in alphameric format
- d. 41-46 number of data (sample size) in fixed point format
- e. 48-52 minimum life increment in fixed point format
- f. 53-80 not used

Example:

Dec 71 WEIBULL SL = 100,000 SR = Infinity 35 100

The input format for the data cards is:

- a. Columns 2-7 cycles to failure in fixed point format
- b. 9-15 component life in fixed point format (same as for individual fatigue life tests).

- c. 20-23 date code (prints out only) in alphameric format
- d. 25-27 number of suspensions in fixed point format (either failures just removed from test, or remaining good items when testing by groups).
- e. 28-31 blank.
- 32-35 test code in alphameric format (Note: 28-42 simply prints as punched and can all be left blank or used as comments space).
- 36-39 lot code in alphameric format.
- 40-43 blank.
- 44-80 not used.

The input format for the trailer card is:

- a. Columns 1-8 not used.
- 9-12 punched: - 1.0 in floating point format.
- 13-80 not used.

By use of the trailer card, the program is written to process as many sets of data as desired. An end of file card is used to signal the end of the last data deck.

Following is a list of important variables and symbols used in program WEIBULL:

List of Definitions for Program WEIBULL

Main Program:

NDAT = number of data points

W = NDATA + NODATA = DATA = W = V = J = K = FNZ = NODAT

IAC TL = cycles of test at which a failure occurs

IX=Z = cycles of life of specimen at failure

MINL = IAC TL

INCR = minimum life increment

C = cumulative life increment

R = median rank

R_1 = log(log) median rank

Q_1 = log (X - G)

B_1 = B = weibull slope, β

BETA = inverse of slope

E_1 = E = goodness of fit of regression line

G_1 = minimum life parameter, γ

U = median life

ETA = scale parameter = η

CG = plus confidence interval

ONE = 1% life = 99% reliability

CONE = upper confidence limit on 1% life

CONM = lower confidence limit on 1% life

TEN = 10% life = 90% reliability

CTEN = upper confidence limit on 10% life

CTENM = lower confidence limit on 10% life

CU = upper confidence limit on median life (U)

CUM = lower confidence limit on median life

Subroutine for Kolmogorov-Smirnov Test

(Subroutine DTEST)

Z(I) = Weibull cumulative frequency distribution
CUMFREQ(I) = cumulative observations (number of failures)
PERCF(I) = data cumulative frequency as percentage of failures
DSTAT(I) = absolute difference between the data cumulative frequency
and the hypothesized cumulative frequency

Subroutine for Chi-squared test (Subroutines CHISQA and CHISQB)

K = number of cells
XMAX = largest value of cycles to failure
XMIN = smallest value of cycles to failure
CSV = cell starting value
CEV = cell end value
CLB = cell lower bound
CUB = cell upper bound
FREQ(J) = number of observations in J^{th} cell
REQAREA(J) = expected value of J^{th} cell (percentage)
EXFREQ(J) = expected number of observations

The program WEIBULL listing in Fortran language follows:

C-----WEIBULL

C-----WEIBULL

C-----WEIBULL

PROGRAM WEIBULL (INPUT,OUTPUT,TAPE2=INPUT,TAPE3=OUTPUT,

1 TAPE1,TAPE4,TAPE5,PLOT=TAPE1)

DIMENSION Y(100),FREQ(9),CLB(9),CUB(9),DSTAT(100),CUMFRQ(100),

1 PERCF(100)

COMMON/N4/ X, R

COMMON /N5/ IACTL, IX, A1, A2, NOR, A3, A4, A5, A6

1 J = 0

K = 0

I = 0

ICOUN = 0

NOD = 0

XPREV = 0.0

RPREV = 0.0

REWIND 4

REWIND 5

READ (2,10) NODAT, INCR,M

IF(EOF(2)) 83,80

10 FORMAT (40H

,2I6,I8)

80 IF (NODAT=50) 82,83,83

82 WRITE (3,40)

40 FORMAT (5H1DATE,15X,9HRUN IDENT)

WRITE (3,10)

7 READ(2,20) IACTL, IX, A1, A2, NOR, A3, A4, A5, A6

20 FORMAT (I7, 1X, I7, 1X, 2A4, I3, 4A4, F16.6)

IF (IX) 4, 3, 2

2 J = J + 1

3 K = K + 1

I = I + 1

Y(I) = IACTL

IF (NOR) 6, 6, 5

6 NOR = 1

5 NOD = NOD + NOR

WRITE (4) IACTL, IX, A1, A2, NOR, A3, A4, A5, A6

GO TO 7

4 IF (NODAT = NOD) 8, 9, 8

C-----

C----- ERROR STOP - NO. OF DATA NOT CORRECT

C-----

8 WRITE (3,30) NODAT, NOD

30 FORMAT (22H1NO. OF DATA INCORRECT /1H0, I6, 5X, I6 / 1H1)

REWIND 4

GO TO 83

9 REWIND 4

WRITE (3,220) NODAT, J, INCR,M

220 FORMAT (1H0,4X,11HNO. OF DATA I6,10X,13H NO. OF FAIL I6,10X,

115H MIN LIFE INCR I6,5X,5H M = ,I6//)

WRITE (3,230)

```

230  FORMAT (2X,6HACTUAL,3X,4HCOMP,56X,4HCOMP/
      13X,4HLIFE ,4X,4HLIFE ,9H P  DATE ,4H NOR,6X,10HTEST  LOT
      211X,11HMEDIAN RANK,8X,4HLIFE //)
      Z = 0.0
      W = NODAT
      NDATA = NODAT
      NODATA = NODAT
      DATA = NODAT
      AKURCY = 1,
      V = W
      READ (4)      IACTL, IX, A1, A2, NOR, A3, A4, A5, A6
      REWIND 4
      MINL = IACTL
      FNZ = J
      IF (MINL - 1) 11, 11, 12
11  MINL = 1
      INCR = 1
      GO TO 13
12  MINL = MINL - 1
13  R1 = 1.0 - 2.0**(-1.0/W) + (1.0 - 2.0**(1.0 - 1.0/W))/(W - 1.0)
      REWIND 4
      DO 14 I = 1, K
      READ (4)      IACTL, IX, A1, A2, NOR, A3, A4, A5, A6
      X = IX
      IF(X) 16, 16, 17
16  IF(I - 1) 18, 18, 19
19  IF(XPREV) 18, 18, 21
21  R1 = RPREV
18  K1 = NOR
      DO 22 K2 = 1, K1
      V = V - 1.0
      RINV = 1.0 + (W - 1.0)*(R1 - 1.0 + 2.0**(-1.0/W))/(2.0**((1.0 - 1.0/W) - 1.0))
22  Z = RINV + (W + 1.0 - RINV)/(1.0 + V)
      R = 0.
      GO TO 15
17  IF(I - 1) 24, 24, 23
23  IF(XPREV) 26, 26, 24
24  Z = Z + (W + 1.0 - Z)/(1.0 + V)
26  R = 1.0 - 2.0**(-1.0/W) + ((Z - 1.0)/(W - 1.0))*(2.0**((1.0 - 1.0/W) - 1.0))
      V = V - 1.0
15  XPREV = X
      RPREV = R
      WRITE(3,241) IACTL, IX, A1, A2, NOR, A3, A4, A5, A6, R, X
241  FORMAT(1X,I7,1X,I7,1X,2A4,1X,I3,3X,4A4,F16.6,F12.0)
      ICOUN = ICOUN + 1
      IF (ICOUN - 68) 14, 41, 41
41  ICOUN = 0
      WRITE(3,400)
400  FORMAT (1H1)
14  WRITE (5) X, R
      REWIND 4

```

```

REWIND 5
E1 = 0.0
IF(Y(1) .LE. 1000) GO TO 117
IF(Y(1) .GT. 1000 .AND. Y(1) .LE. 10000) GO TO 116
IF(Y(1) .GT. 10000) INCR = 10000
GO TO 127
116 INCR = 1000
GO TO 127
117 INCR = 100
IF(M .GT. 1000) M = M - 1000
127 E1 = 0.0
DO 27 KN=M,MINL,INCR
  QSUM = 0.0
  RSUM = 0.0
  QSOS = 0.0
  RSOS = 0.0
  PROD = 0.0
  G = KN - 1
  DO 28 I = 1, K
    READ (5) X,R
    IF(X) 28, 28, 29
  29 IF(X - G) 31, 31, 32
C-----
C----- NEGATIVE ARGUMENT IN LOG. FUNCTION
C-----
  31 WRITE (3,100)
100 FORMAT(1H1,26HNEG, ARG. IN LOG. FUNCTION /,1H1)
GO TO 83
  32 Q1 = ALOG(X - G)
  IF(R) 31, 31, 34
C-----
C----- NEGATIVE ARGUMENT IN LOG. FUNCTION
C-----
  34 R1 = ALOG(ALOG(1.0/(1.0 - R)))
  QSUM = QSUM + Q1
  RSUM = RSUM + R1
  QSOS = QSOS + Q1 * Q1
  RSOS = RSOS + R1 * R1
  PROD = PROD + Q1 * R1
28 CONTINUE
REWIND 5
B = (FNZ * PROD - QSUM * RSUM)/(FNZ * QSOS - QSUM * QSUM)
A = (RSUM - B * QSUM) / FNZ
C = SQRT((FNZ * QSOS - QSUM * QSUM) * (FNZ * RSOS - RSUM * RSUM))
E = (FNZ*PROD - QSUM * RSUM)/C
IF(E - E1) 37, 36, 36
36 E1 = E
G1 = G
B1 = B
A1 = A

```

27 CONTINUE

37 M = G + 1 - INCR

39 IF(INCR = 1000) 38,117,116

38 ARG = EXP (-A1)

BETA = 1.0/B1

ETA = (0.99967*ARG)**BETA

U = G1 + (0.69315*ARG)**BETA

ONE = G1 + (0.01005*ARG)**BETA

TEN = G1 + (0.105*ARG)**BETA

B = B1 * (1.0 + 1.163 / SQRT(W))

CG=G1+.5*(U-G1)*(4.32159**((1.0/B)-0.074**((1.0/B)))/(W**((1.0/B)))

CONST = (1.645 * U) / (SQRT(W) * 0.69315 ** BETA)

FACT = CONST * 10.010038 * (0.995E-02**BETA/B1)

CONE = ONE + FACT

CONM = ONE - FACT

EACT = CONST * 3.1924748 * (0.104360**BETA/B1)

CTEN = TEN + FACT

CTENM = TEN - FACT

EACT = CONST * 0.69315**BETA/(B1 * 0.69315)

CU = U + FACT

CUM = U - FACT

WRITE (3,450) B1, E1, ETA, G1, CG, ONE, CONE, CONM

WRITE (3,451) TEN, CTEN, CTENM, U, CU, CUM

450 FORMAT (// 12X,13HWEIBULL SLOPE,5X,15HGOODNESS OF FIT ,5X,
11HSCALE PARAMETER, /5X,3F20.5, //

213X,12HMINIMUM LIFE ,11X,9HPLUS CONF, /

35X,2F20.5, //

49X,16HONE PERCENT LIFE ,11X,9HPLUS CONF ,10X,10HMINUS CONF , /

55X,3F20.5 //)

451 FORMAT (1H+,9X,16HTEN PERCENT LIFE,11X,9HPLUS CONF,10X,
11H MINUS CONF , /5X,3F20.5, //

214X,11HMEDIAN LIFE ,11X,9HPLUS CONF ,10X, 10HMINUS CONF , /

35X,3F20.5 //)

CALL DTEST (Y,B1,G1,U,NODATA,DSTAT,PERCE,CUMERO,ETA,SKSTAT)

CALL CHISQA (Y,DATA,NDATA,PROB,AKURCY,XMEAN,DEV,Z,G1,B1,ETA,FREQ,
1 XMAX,XMIN,CLB,CUB,NUMINTS,CELLWD)

CALL CHISQB (Y,NDATA,G1,B1,ETA,CHISQR)

CALL GRAPH (FREQ,XMAX,XMIN,CLB,CUB,SKSTAT,CHISQR,B1,ETA,G1,NDATA,
1 NUMINTS,CELLWD)

GO TO 1

83 CALL PLOT (0.0, 0.0, 999)

CALL EXIT

END


```

SUBROUTINE DTEST (Y,B1,G1,U,NODATA,DSTAT,PERCF,CUMFRQ,ETA,SKSTAT)
DIMENSION Z(100),Y(100),DSTAT(100),PERCF(100),CUMFRQ(100)
C
C SUBROUTINE TO CALCULATE THE KOLMOGOROV-SMIRNOW D-VALUES
C
DO 500 I=1,NODATA
Z(I) = 1.0 - EXP (-(((Y(I)-G1)/ETA)**B1))
500 CONTINUE
C
C SET CUMFRQ(2) ARRAY
C
DO 501 I=1,NODATA
501 CUMFRQ(I) = I
C
C PERCF = F(N) OF THE NUMBER OF DATA
C
DO 502 I=1,NODATA
502 PERCF(I) = CUMFRQ(I)/NODATA
DO 503 I=1,NODATA
503 DSTAT(I) = Z(I) - PERCF(I)
PRINT 520
PRINT 521, (DSTAT(I),I=1,NODATA)
521 FORMAT (6(10X,F10.5))
520 FORMAT (//40X,53H D VALUES FOR KOLMOGOROV-SMIRNOV GOODNESS OF FIT
1TEST/41X,52H(LISTED IN THE SAME ORDER AS CYCLES-TO-FAILURE DATA)/)
SKSTAT = 0.0
DO 10 I=1,NODATA
IF(ABS(DSTAT(I)).GT.SKSTAT) SKSTAT = ABS(DSTAT(I))
10 CONTINUE
PRINT 400, SKSTAT
400 FORMAT(//,10X,*KOLMOGOROV-SMIRNOV TEST RESULT = *,F8.5,/)
RETURN
END

```

```

SUBROUTINE CHISQA(X,DATA,NDATA,PROB,AKURCY,XMEAN,DEV,Z
1,G1,B1,ETA,FREQ,XMAX,XMIN,CLB,CUB,K,W)
C-----SUBROUTINE TO FIT A HISTOGRAM TO THE DATA AND PERFORM THE CHI-SQUA
C-----TEST FOR THE WEIBULL DISTRIBUTION
DIMENSION X(50),CSV(9),CEV(9),CLB(9),CUB(9),
1REQAREA(9),AREA(9),EXFREQ(9),FREQ(9),U(9)
CHISQR=.0
C-----TO DETERMINE THE NUMBER OF CLASS INTERVALS,K
K = 1.0 + 3.3*ALOG10(DATA)
REALK=K
C-----IN ORDER TO DETERMINE THE RANGE,FIND X(MAX) AND X(MIN)
XMAX=X(1)
XMIN= X(1)
DO 17 I=1,NDATA
17 IF( X(I).GT.XMAX ) XMAX = X(I)
IF(X(I).LT. XMIN) XMIN=X(I)
RANGE= XMAX- XMIN
C-----TO DETERMINE THE CLASS INTERVAL WIDTH,W
C-----ROUTINE TO ROUND OFF CLASS WIDTH TO SAME NUMBER OF PLACES AS THE A
DIVIDE = 1.0/AKURCY
KW =(((RANGE+AKURCY)/REALK)+.5*AKURCY)*DIVIDE
RK1 = KW
W = RK1/DIVIDE
PRINT 141
PRINT 241
PRINT 177, NDATA, G1, B1, ETA
PRINT 41
PRINT 62,XMAX
PRINT 63,XMIN
PRINT 65,W
B = 0.5*AKURCY
DO 22 I=1,K
A=I
CSV(I)= XMIN+(A-1.0)*W
CEV(I)= CSV(I)+W*AKURCY
CLB(I)= CSV(I)-B
CUB(I) = CEV(I) +B
22 CONTINUE
CEV(K) = XMAX
CUB(K) = CEV(K) +B
DO 23 J=1,K
23 FREQ(J)=0.0
DO 24 I=1,NDATA
DO 24 J=1,K
IF(X(I).GE.CLB(J).AND.X(I).LE.CUB(J)) FREQ(J) = FREQ(J) + 1.0
24 CONTINUE
C-----CHI-SQUARE TEST
PRINT 406
DO 30 I=1,K
AREA(I) = 1.0 -EXP(-(((CUB(I)-G1)/ETA)**B1))

```

```

IF (I .EQ. 1) GO TO 51
IF (I .GT. 1 .AND. I .LT. K) GO TO 52
REQAREA(K) = 1.0 - AREA(K)
GO TO 30
51 REQAREA(I) = AREA(I)
GO TO 30
52 REQAREA(I) = AREA(I) - AREA(I-1)
30 CONTINUE
76 DO 80 M = 1, K
EXFREQ(M) = DATA * REQAREA(M)
U(M) = (( EXFREQ(M) - FREQ(M)) ** 2) / EXFREQ(M)
80 CHISQR = CHISQR + U(M)
C-----TO PRINT THE TABLE FOR CHI-SQUARE TEST
88 DO 33 I = 1, K
33 PRINT 34, I, CLB(I), CUB(I), EXFREQ(I), FREQ(I), U(I)
PRINT 35, CHISQR
62 FORMAT( 10X, 14HMAXIMUM VALUE=, F15.6)
63 FORMAT( 10X, 14HMINIMUM VALUE=, F15.6)
65 FORMAT( 10X, 12HCLASS WIDTH=, F17.6)
41 FORMAT(1H0)
406 FORMAT (8X, 5H CELL, 10X, 10HLOWER CELL, 11X, 10HUPPER CELL, 13X, 8HEXPEC
1TED, 13X, 8HOBSERVED, 13X, 11HCHI-SQUARED/8X, 6HNUMBER, 10X, 8HBOUNDARY,
213X, 8HBOUNDARY, 13X, 9HFREQUENCY, 12X, 9HFREQUENCY, 12X, 13HVALUE OF CE
3LL/)
34 FORMAT (10X, 12.5F21.6)
35 FORMAT (1H0, 81X, 25HTOTAL CHI-SQUARED VALUE =, F10.6//)
141 FORMAT (1H0, 70X, *CHI-SQUARED TEST*, //)
241 FORMAT(1H0, 70X, *FIXED CELL WIDTHS*, //)
177 FORMAT (1H0, 10X, *INPUTS = *, 110, 3F15.3, //)
78 CONTINUE
RETURN
END

```

```

SUBROUTINE CHISQB (X, NDATA, G1, B1, ETA, CHISQR)
  DIMENSION X(50), CLB(9), CUB(9), REQAREA(9), AREA(9), FREQ(9),
  2EXFREQ(9), U(9)
C-----SUBROUTINE TO FIT A HISTOGRAM TO THE DATA AND PERFORM THE
C-----CHI-SQUARED TEST FOR THE WEIBULL DISTRIBUTION
  PRINT 341
  CHISQR = 0.0
  J = 0
  DO 26 K=5, NDATA, 5
    J = J+1
    IF (K .LT. NDATA) CUB(J) = (X(K) + X(K+1)) / 2.0
    IF (K .EQ. 5) CLB(J) = X(1)
    IF (K .GT. 5 .AND. K .LT. NDATA) CLB(J) = CUB(J-1)
    L = (NDATA - K)
    IF (L .NE. 0) AREA(J) = 1.0 - EXP(-(((CUB(J) - G1) / ETA) ** B1))
    IF (L .EQ. 0) AREA(J) = 1.0
    FREQ(J) = 5.0
    IF (J .EQ. 1) REQAREA(J) = AREA(J)
    IF (J .GT. 1 .AND. L .NE. 0) REQAREA(J) = AREA(J) - AREA(J-1)
    IF (L .LT. 5) GO TO 27
  GO TO 26
27 IF (L .NE. 0) J = J+1
  CUB(J) = X(NDATA)
  CLB(J) = CUB(J-1)
  REQAREA(J) = 1.0 - AREA(J-1)
  IF (L .NE. 0) FREQ(J) = L
26 CONTINUE
  I = J
  DO 25 J=1, I
    EXFREQ(J) = NDATA * REQAREA(J)
25 CONTINUE
  K = 1
  62 I = 1
  2420 IF (EXFREQ(I) .GE. 5.) GO TO 2430
    EXFREQ(I+1) = EXFREQ(I+1) + EXFREQ(I)
    FREQ(I+1) = FREQ(I+1) + FREQ(I)
    J = I
    DO 2425 L=1, J
      EXFREQ(L) = 0.
  2425 FREQ(L) = 0.
    I = I+1
    GO TO 2420
  2430 I = K
  2440 IF (EXFREQ(I) .GE. 5.) GO TO 2450
    EXFREQ(I-1) = EXFREQ(I-1) + EXFREQ(I)
    FREQ(I-1) = FREQ(I-1) + FREQ(I)
    DO 2445 L=1, K
      EXFREQ(L) = 0.
  2445 FREQ(L) = 0.

```

```

      I = I-1
      GO TO 2440
2450 CONTINUE
      DO 85 M=1,K
      U(M) = 0.0
      IF (EXFREQ(M) .EQ. 0.) GO TO 85
      U(M) = ((EXFREQ(M) - FREQ(M))**2/EXFREQ(M))
85 CONTINUE
      CHISQR = 0.0
      DO 90 M=1,K
90 CHISQR = CHISQR + U(M)
      J = K
88 DO 33 I = 1,J
33 PRINT 34,I,CLB(I),CUB(I), EXFREQ(I),FREQ(I),U(I)
      PRINT 35, CHISQR
34 FORMAT (10X,I2,5F21.6)
35 FORMAT (1H0,81X,25HTOTAL CHI-SQUARED VALUE =,F10.6)
341 FORMAT(1H0,65X,*VARIABLE CELL WIDTHS*,//)
78 CONTINUE
      RETURN
      END

```

```

SUBROUTINE GRAPH (FREQ,XMAX,XMIN,CLB,CUB,SKS,CHISOR,BETA,ETA,
1 GAMMA,NDATA,K,CELLWD)
DIMENSION FREQ(9),CLB(9),CUB(9)
INTEGER FOOT(30),SUBTITL(2)
LOGICAL NITIAL
DATA NITIAL / .TRUE. /

```

```

C
C READ PLOT CARD
C
READ(2,400) IPLOT,SUBTITL,IPEN
400 FORMAT(4A10)
IF(EOF(2)) 999,3
3 IF(IPLOT.NE.7HWEIBULL) GO TO 999
IF(NITIAL) 4,5
4 NITIAL = .FALSE.
PEN = 0.3
IF(IPEN.EQ.10HBALL POINT) PEN = 0.0
CALL INITIAL(0,1,PEN,0)
5 READ(2,401) FOOT
401 FORMAT(5A10)
C
C DETERMINE DISTANCES
C
2 XLENGTH = 6.0
YLENGTH = 5.0
H = 0.15
YMAX = 0.0
DO 1 I=1,K
IF(YMAX.LT.FREQ(I)) YMAX=FREQ(I)
1 CONTINUE
FRINGE = 0.40*NDATA
FRINL = 0.25*NDATA
IF(YMAX.GE.FRINL.AND.YMAX.LT.FRINL) GO TO 7
IF(YMAX.GE.FRINL) YMAX = IFIX(YMAX + FRINL)
GO TO 6
7 YMAX = IFIX(YMAX + FRINL)
6 CONTINUE
I=YMAX
IF((I/2*2).NE.I) YMAX=YMAX+1.
XMIN = XMIN - 0.10 * (XMAX - XMIN)
XDIF = XMAX - XMIN
C
C DETERMINE SCALING FACTORS
C
XSCALE = (XMAX - XMIN) / XLENGTH
YSCALE = YMAX / YLENGTH
E = IFIX(ALOG10(XMAX - XMIN))
STP = 10.0 ** E

```

```

CALL PLOT(XLENGTH+2.,0.,-3)
CALL PLOT(0.,-11.,-3)
CALL PLOT(0.,5.,-3)
C
CONSTRUCT Y-AXIS
C
CALL PLOT(0.,YLENGTH,2)
DIV=1./YSCALE
21 IF(DIV.GE.(2.*H)) GO TO 22
DIV=2.*DIV
GO TO 21
22 STEP=DIV
YY=0.
23 CALL PLOT(.05,YY,3)
CALL PLOT(-.05,YY,2)
YN=YY*YSCALE
CALL NUMBER(-.3,YY,H,YN,0.,-1)
YY=YY+STEP
IF(YY.LE.(YLENGTH+.01)) GO TO 23
YY=(YLENGTH-3.75)/2.
IF(YY.LT.0.) YY=0.
CALL SYMBOL(-.4,YY,H,30HFREQUENCY/CLASS INTERVAL WIDTH,90.,30)
C
CONSTRUCT, DRAW, AND LABEL X-AXIS
C
CALL PLOT(0.,0.,3)
XMIN=IFIX(XMIN/STP)
XMAX = IFIX(XMAX / STP + 1.0)
XDIF = XMAX - XMIN
XSCALE = XDIF / XLENGTH * STP
DIV=10.*XDIF/XLENGTH
IF(XMIN.EQ.0.) GO TO 26
CALL PLOT(.3,0.,2)
CALL PLOT(.35,0.,3)
CALL PLOT(XLENGTH,0.,2)
CALL PLOT(.35,.05,3)
CALL PLOT(.25,-.05,2)
CALL PLOT(.3,-.05,3)
CALL PLOT(.4,.05,2)
GO TO 28
26 CALL PLOT(XLENGTH,0.,2)
28 IF(DIV.LT.12.7) GO TO 30
DIV=DIV/10.
GO TO 28
30 DIV=DIV/10.
IF(DIV.LT.0.2) DIV=DIV*10.
32 CALL NUMBER(0.,-.2,H,0.,0.,0)
XX=0.
DO 35 I=1,25
XX=XX+1./DIV
IF(XX.GT.XLENGTH) 40,33

```

```

33 CALL PLOT (XX,.05,3)
CALL PLOT (XX,-.05,2)
XN=XMIN+I*XDIF/(DIV*XLENGTH)
CALL NUMBER (XX=-.1,-.2,H,XN,0.,0)

```

```

35 CONTINUE

```

```

40 DO 41 I=1,2

```

```

IF (SUBTITL(I).EQ.1H ) GO TO 42

```

```

41 CONTINUE

```

```

I=2

```

```

GO TO 43

```

```

42 I=I-1

```

```

43 XX=(XLENGTH-I)/2.

```

```

I=I*10

```

```

CALL SYMBOL (XX,-.5,.15,SUBTITL(I),0.,I)

```

```

IF (STP.LT.1.01) GO TO 48

```

```

CALL WHERE (XX, YY, IFAKE)

```

```

CALL SYMBOL (XX=-.5,H,5H X 10,0.,5)

```

```

CALL WHERE (XX, YY, IFAKE)

```

```

CALL NUMBER (XX+H,YY+.5*H,.5*H,E,0.,-1)

```

C

C

```

CONSTRUCT AND DRAW HISTOGRAM

```

C

```

48 DO 50 I=1,K

```

```

CLB(I)=((CLB(I)/STP)-XMIN)/(XSCALE/STP)

```

```

50 CUB(I)=((CUB(I)/STP)-XMIN)/(XSCALE/STP)

```

```

52 CALL PLOT (CLB(I),0.,3)

```

```

DO 55 I=1,K

```

```

Y=FREQ(I)/YSCALE

```

```

CALL PLOT (CLB(I),Y,2)

```

```

CALL PLOT (CUB(I),Y,2)

```

```

54 CALL PLOT (CUB(I),0.,2)

```

```

55 CONTINUE

```

C

C

```

COMPUTE AND DRAW NORMAL CURVE ONE POINT AT A TIME

```

C

```

60 STEP = XDIF * STP / 150.0

```

```

XX = XMIN * STP

```

```

CALL PLOT(0.,0.,3)

```

```

EACT = EXP(-BETA)

```

```

CHK = EXP(-1.0)

```

```

IF (BETA .LT. 1.0) YSCALE=YSCALE*EACT/CHK

```

```

BE = BETA / ETA

```

```

IDOIT = 2HNO

```

```

DO 100 I = 1,150

```

```

IF (GAMMA .GT. XX) GO TO 100

```

```

Z = (XX - GAMMA) / ETA

```

```

Y = BE * Z ** (BETA - 1.0) * EXP( - 1.0 * Z ** BETA)

```



```

      Y = Y / YSCALE * NDATA * CELLWD
      XU=(XX-XMIN*STP)/XSCALE
      IF(IDOIT.EQ. 2HNO) GO TO 90
      IF(XU.GT.20.) GO TO 100
      IF(XMIN.EQ.0.) 80,70
70  IF(XU.GE.0.4) 80,90
80  CALL PLOT (XU,Y,2)
      GO TO 100
90  CALL PLOT (XU,Y,3)
      IDOIT = 3HYES
100 XX=XX+STEP
C
C   OTHER ALPHA-NUMERIC COMMENTARY
C
130 CALL PLOT(0.,-1.,-3)
CALL SYMBOL (0.0,0.0,H,24HKOLMOGOROV-SMIRNOV TEST:,0.0,24)
CALL WHERE (XX, YY, IEAKE)
XX=XX+H
CALL SYMBOL (0.0,-2.0*H,H,17HCHI-SQUARED TEST:,0.0,17)
CALL SYMBOL (0.0,-4.0*H,H,21HWEIBULL SLOPE (BETA):,0.0,21)
CALL SYMBOL (0.0,-6.0*H,H,21HMINIMUM LIFE (GAMMA):,0.0,21)
CALL SYMBOL (0.0,-8.0*H,H,22HSCALE PARAMETER (ETA):,0.0,22)
CALL NUMBER (XX,0.0,H,SKS,0.0,3)
CALL NUMBER (XX,-2.0*H,H,CHISQR,0.0,3)
CALL NUMBER (XX,-4.0*H,H,BETA,0.0,3)
CALL NUMBER (XX,-6.0*H,H,GAMMA,0.0,-1)
CALL NUMBER (XX,-8.0*H,H,ETA,0.0,-1)
CALL SYMBOL (0.,-14.*H,H,FOOT(1),0.,50)
CALL SYMBOL (0.,-16.*H,H,FOOT(6),0.,50)
CALL SYMBOL (0.,-18.*H,H,FOOT(11),0.,50)
CALL SYMBOL (0.,-20.*H,H,FOOT(16),0.,50)
CALL SYMBOL (0.,-22.*H,H,FOOT(21),0.,50)
CALL SYMBOL (0.,-24.*H,H,FOOT(26),0.,50)
XX=(XLENGTH-3.75)/2.
IF(XX.LT.0.) XX=0.
999 CALL SYMBOL (XX,6.25,H,31HWEIBULL DISTRIBUTION PARAMETERS,0.0,31)
RETURN
END

```

PDP PROGRAM TO CALCULATE ENDURANCE STRENGTH
PARAMETERS FROM STAIRCASE TESTS

225

C-FOCAL, 1969

```
01.10 A "MINIMUM STRESS LEVEL", YP, !
01.20 A "STRESS INCREMENT", DP, !
01.30 A "NO OF SPECIMENS", NS, !
01.40 T "IF TEST IS BASED ON FAILURES THE CODE IS 0", !
01.50 T "IF BASED ON SUCCESSES THE CODE IS 1", !
01.60 A "WHAT IS THE CODE?", Co, !
01.70 A "NO OF STRESS LEVELS IN TEST", I, !, !
01.74 S CU = 0
01.75 S A = 0
01.76 S B = 0
01.77 T "NO OF SPEC IN EACH LEVL STARTING FROM THE 2ND LOWEST", !
01.80 FOR J = 1, 1, I-1; DO 4.0

02.10 S SD = 1.62*DP*((NS*B-A+2)/NS 2+0.029)
02.20 IF (Co) 2.3,2.3,2.4
02.30 S MU = YP+DP*(A/NS-.5)
02.35 GOTO 2.7
02.40 S MU = YP+DP*(A/NS-.5)
02.70 T %10.03 "MEAN", MU, !, "STD DEVIATION", SD, !
02.80 Q

04.10 A NI, !
04.20 S CU = CU+1
04.30 S A = A+CU*NI
04.40 S B = B+CU 2*NI
```

APPENDIX - F

PDP-8 PROGRAM TO FIND POINTS ON THE GERBER
PARABOLA AND THE VON MISES-HENCKY ELLIPSE
FOR A GIVEN MATERIAL AND STRESS RATIO

Symbols:

$r_s = R$ = Stress ratio

$S_u = SU$ = Mean of static ultimate strength

$S_e = SE$ = Mean of endurance strength

$S_{m_e} = ME$ = Mean stress corresponding to S_{v_e} .

$S_{v_e} = SV$ = Stress vector mean on von Mises-Hencky
 ellipse for stress ratio, r_s .

$S_{m_p} = MP$ = Mean stress corresponding to S_{v_p} .

$S_{v_p} = SP$ = Stress vector mean on Gerber parabola
 for stress ratio, r_s .

```

01.10 A "STRESS RATIO", R, !
01.20 A "SU", SU, !
01.30 A "SE", SE, !
01.40 S A=FSQT((SE+2)+(R+2)*(SU+2))
01.50 S ME=SU*SE/A
01.60 S AE=R*ME
01.70 S SV=FSQT((ME+2)+(AE+2))
01.80 S B=FSQT((R 2)*(SU+4)/(SE+2)+4*(SU+2))
01.90 S MP=(-R/2)*((SU+2)/SE)+B/2

02.10 S AP= R*MP
02.20 S SP=FSQT((AP+2)+(MP+2))
02.30 T % 9.5, ME, AE, SV,! MP, AP, SP,!!
02.40 GO TO 1.10

```

APPENDIX - G

PDP-8 PROGRAM TO FIND THE ESTIMATE OF THE MEAN
STRENGTH, THE CORRESPONDING MEAN AND ALTERNATING
LOADS, AND A SUITABLE MEAN LOAD INCREMENT USING
THE VON MISES-HENCKY FAILURE CRITERION

* W A
C-FOCAL, 1969

01.10 A "DIAMETER",D,!
01.20 A "STRESS INCREMENT",IS,!
01.30 A "ULTIMATE STRENGTH",SU,!
01.40 A "ENDURANCE STRENGTH",SE,!
01.50 A "STRESS RATIO",R,!
01.60 S $A=3.1416*(D+2)/4$
01.70 S $SM=(SE*SU)/FSQT(((SU+2)*(R+2)) + (SE+2))$
01.80 S $PM=SM*A$

02.10 S $IM=IS/FSQT(1 + (R+2))$
02.20 S $IP = IM*A$
02.30 T " MEAN STRESS STRESS INC MEAN LOAD LOAD INC.",!!
02.40 T %9.03, SM, IM, PM, IP,!!
02.50 GO TO 1.50

APPENDIX - HPDP-8 PROGRAM TO FIND THE MEAN AND ALTERNATINGLOAD STEPS FOR STRESS RATIOS, $r_s = \infty$, FORSTAIRCASE TESTING WITH THE AXIALFATIGUE RELIABILITY RESEARCH MACHINE

Symbols:

S_v = Stress vector

S_n = Mean stress

S_a = Alternating stress

PM = Mean load

PA = Alternating load

*W A

C-FOCAL, 1969

01.10 A "DIAMETER",D,!

01.20 A "STRESS RATIO",R,!

01.25 A "MAX MEAN LOAD",PM,!

01.30 S A = $3.1416 \cdot D^{2/4}$

01.35 T A SV " SM " PM " SA " PA,!

02.10 S PM = PM-1

02.15 S SM = PM/A

02.20 S SA = SM*R

02.25 S PA = SA*A

02.30 S SV = $SM \cdot \sqrt{1+(R^2)}$

02.40 T %9.03, SV, SM, PM, SA, PA,!!

02.50 GO TO 2.10

*

APPENDIX - IPDP-8 PROGRAM TO CALCULATE THE LOAD FORSTAIRCASE TESTING AT THE STRESS RATIO, $r_s = \infty$, FOR THE AXIAL FATIGUE RELIABILITYRESEARCH MACHINE

*W A

C-FOCAL, 1969

01.10 A "DIAMETER",D,!

01.20 A "ULTIMATE STRENGTH",SU,!

01.30 A "STRESS INCREMENT",IS,!

01.35 S SM=0

01.40 S PM=0

01.45 S SE=0.45*SU

01.50 S A=3.1416*(D+2)/4

01.55 S P=SE*A

01.60 S IPA=IS*A

01.65 T "LOAD",%9.03,P,!

01.70 T "LOAD INCREMENT",%9.03,IPA,!

01.75 A "ROUNDED ALT LOAD",P,!

01.80 A "ROUNDED ALT LOAD INC",PAI,!

02.10 S SA=P/A

02.20 S SI=PAI/A

02.30 S SA=SA+6*SI

02.40 S P=P+6*PAI

02.50 T " DIA SV SA PA SM PM",!!!

02.60 FOR I=1,1,11; DO 3.0

03.10 S SA=SA-SI

03.20 S P=P-PAI

03.30 S SV=SA

03.40 T %7.03, D, SV, SA, P, SM, PM,!!

8.0 DETAILED TEST DATA

This section contains the detailed test data which were used in the analyses discussed in Section 2 to determine the results and conclusions of Sections 3 and 4. Included are the calibration and experimental data for the Wire Fatigue Machines, Wiedemann Fatigue Machines, and the Axial Fatigue Machine.

8.1 WIRE FATIGUE MACHINE DATA

Table 8.1-1 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-1 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-1 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-1 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. <u>1</u>			Group No. <u>1</u>		
Wire Diameter <u>.040</u> in.			Date <u>Feb. 26, 1972</u>		
Material <u>AISI 4340</u>			Deflection Angle <u>26</u> deg.		
Remarks: _____					
NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1			1,250	2,980	1,730
2			1,295	2,980	1,685
3			1,295	2,985	1,690
4			1,295	2,985	1,690
5			1,295	2,985	1,690
6			1,305	2,985	1,680
7			1,305	2,990	1,635
8			1,305	2,940	1,635
9			1,305	2,985	1,680
10			1,310	2,985	1,675
			Mean Measured	Strain 1,679	μ - in/in.

—

[illegible]

Table 8 .1-2 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-3 Wire Fatigue Research Machines

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-3 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. <u>3</u>			Group No. <u>3</u>		
Wire Diameter <u>.040</u> in.			Date <u>Feb. 26, 1972</u>		
Material <u>AISI 4340 Steel</u>			Deflection Angle <u>12</u> deg.		
Remarks: _____					
NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1			1,330	2,075	745
2			1,385	2,080	695
3			1,385	2,065	680
4			1,405	2,080	675
5			1,405	2,070	665
6			1,415	2,100	675
7			1,415	2,075	660
8			1,420	2,095	675
9			1,420	2,080	660
10			1,420	2,100	680
			Mean Measured	Strain = 681	u- in/in.

Table 8.1-3 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-3 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. <u>3</u>				Group No. <u>3</u>	
Wire Diameter <u>.040</u> in.				Date <u>Feb. 26, 1972</u>	
Material <u>AISI 4340 Steel</u>				Deflection Angle <u>26</u> deg.	
Remarks: _____					
NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1			1,330	3,210	1,880
2			1,385	3,210	1,825
3			1,385	3,200	1,815
4			1,405	3,200	1,795
5			1,405	3,220	1,815
6			1,415	3,220	1,805
7			1,415	3,215	1,800
8			1,420	3,215	1,795
9			1,420	3,225	1,805
10			1,420	3,225	1,805
			Mean Measured	Strain = 1,814 μ - in/in.	

Table 8.1-4 Wire Fatigue Research Machines

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. <u>4</u>			Group No. <u>4</u>		
Wire Diameter <u>.040</u> in.			Date <u>Feb. 26, 1972</u>		
Material <u>AISI 4340 Steel</u>			Deflection Angle <u>4</u> deg.		
Remarks: _____					
NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1			1,210	1,335	125
2			1,280	1,395	115
3			1,280	1,385	105
4			1,295	1,410	115
5			1,295	1,405	110
6			1,300	1,415	115
7			1,300	1,410	110
8			1,310	1,420	110
9			1,310	1,410	100
10			1,310	1,420	110
			Mean Measured	Strain = 111.5 μ in/in.	

Wire Fatigue Machine No. 4 Group No. 4
Wire Diameter .040 in. Date Feb. 26, 1972
Material AISI 4340 Steel Deflection Angle 12 deg.
Remarks:

[illegible]

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

[illegible]

Table 8.1-5 Static Calibration Data for Wire Fatigue Research
Machine Calibration Specimen

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. _____			Group No. <u>1</u>		
Wire Diameter <u>.040</u> in.			Date <u>12/13/71</u>		
Material <u>AISI 4340 Steel</u>			Deflection Angle _____ deg.		
Remarks: <u>Static Axial Load Test for Calibration Specimen</u>					

NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1	0.00	0.00	3804	----	0.00
2	7.00	5,573	3804	3830	26
3	10.50	8,360	3804	3875	71
4	14.00	11,146	3804	3921	117
5	17.50	13,933	3804	3972	168
6	21.00	16,720	3804	4019	215
7	24.50	19,506	3804	4069	265
8	28.00	22,293	3804	4121	317
9	31.50	25,080	3804	4175	371
10	35.00	27,866	3804	4227	423
11	35.00	27,866	3801	4227	426
12	31.50	25,080	3801	4175	374
13	28.00	22,293	3801	4124	323
14	24.50	19,506	3801	4073	272
15	21.00	16,720	3801	4023	222
16	17.50	13,933	3801	3975	174
17	14.00	11,146	3801	3922	121
18	10.50	8,360	3801	3870	69
19	7.00	5,573	3801	3829	28
20	0.00	0	3801	----	0.00

Table 8.1-5 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. _____			Group No. <u>2</u>		
Wire Diameter <u>.040</u> in.			Date <u>12/13/71</u>		
Material <u>AISI 4340 Steel</u>			Deflection Angle _____ deg.		
Remarks: <u>Static Axial Load Test for Calibration Specimen</u>					

NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1	0.00	0.00	3802	-----	0.00
2	7.00	5,573	3802	3827	25
3	10.50	8,360	3802	3869	67
4	14.00	11,146	3802	3918	116
5	17.50	13,933	3802	3968	166
6	21.00	16,720	3802	4015	213
7	24.50	19,506	3802	4062	260
8	28.00	22,293	3802	4118	316
9	31.50	25,080	3802	4170	368
10	35.00	27,866	3802	4222	420
11	35.00	27,866	3798	4222	424
12	31.50	25,080	3798	4170	372
13	28.00	22,293	3798	4118	320
14	24.50	19,506	3798	4070	272
15	21.00	16,720	3798	4017	219
16	17.50	13,933	3798	3968	170
17	14.00	11,146	3798	3916	118
18	10.50	8,360	3798	3870	72
19	7.00	5,573	3798	3825	27
20	0.00	0	3798	-----	0.00

Table 8.1-5 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. _____			Group No. <u>3</u>		
Wire Diameter <u>.040</u> in.			Date <u>12/14/71</u>		
Material <u>AISI 4340 Steel</u>			Deflection Angle _____ deg.		
Remarks: <u>Static Axial Load Test for Calibration Specimen</u>					

NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1	0.00	0.00	3810	----	0.00
2	7.00	5,573	3810	3835	25
3	10.50	8,360	3810	3879	69
4	14.00	11,146	3810	3925	115
5	17.50	13,933	3810	3975	165
6	21.00	16,720	3810	4022	212
7	24.50	19,506	3810	4071	261
8	28.00	22,293	3810	4121	311
9	31.50	25,080	3810	4174	364
10	35.00	27,866	3810	4221	411
11	35.00	27,866	3800	4225	414
12	31.50	25,080	3800	4174	374
13	28.00	22,293	3800	4121	321
14	24.50	19,506	3800	4072	272
15	21.00	16,720	3800	4023	223
16	17.50	13,933	3800	3973	173
17	14.00	11,146	3800	3972	122
18	10.50	8,360	3800	3875	75
19	7.00	5,573	3800	3829	29
20	0.00	0.00	3800	----	0.00

Table 8.1-5 Continued

FATIGUE RELIABILITY RESEARCH CALIBRATION DATA SHEET

Wire Fatigue Machine No. _____			Group No. <u>4</u>		
Wire Diameter <u>.040</u> in.			Date <u>12/14/71</u>		
Material <u>AISI 4340 Steel</u>			Deflection Angle _____ deg.		
Remarks: <u>Static Axial Load Test for Calibration Specimen</u>					

NO.	Pan Weight	Axial Stress (P/A)	B.L.H. Strain Ind. Reading (reference)	B.L.H. Strain Ind. Reading	Measured Strain Micro in/in
1	0.00	0.00	3800	----	0.00
2	7.00	5,573	3800	3828	28
3	10.50	8,360	3800	3875	75
4	14.00	11,146	3800	3921	121
5	17.50	13,933	3800	3969	169
6	21.00	16,720	3800	4018	218
7	24.50	19,506	3800	4070	270
8	28.00	22,293	3800	4120	320
9	31.50	25,080	3800	4174	374
10	35.00	27,866	3800	4226	426
11	35.00	27,866	3796	4226	430
12	31.50	25,080	3796	4174	378
13	28.00	22,293	3796	4120	324
14	24.50	19,506	3796	4072	276
15	21.00	16,720	3796	4021	225
16	17.50	13,933	3796	3970	174
17	14.00	11,146	3796	3918	122
18	10.50	8,360	3796	3872	76
19	7.00	5,573	3796	3825	29
20	0.00	0.00	3796	----	0.000

Table 8.1-6 Cycles-to-Failure Data of Group No. 129 Using Wire
 Fatigue Machine No. 1 for 35 Specimens of .040
 in. Diameter AISI 4130 Steel Wire. Fixed Alternating
 Stress Level of 67.7 Kpsi. Bend Angle 19.5
 Coast-Down Cycles 200 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
May 1	1	732,700	4.5469	
2	2	408,400	4.4531	
2	3	465,400	4.4219	
2	4	726,500	4.5312	
3	5	400,300	4.3594	
3	6	365,100	4.3750	
4	7	1,371,400	4.5312	
5	8	1,152,700	4.0000	
8	9	571,700	4.9062	
8	10	384,500	4.5625	
9	11	158,300	4.9688	
9	12	511,200	4.5000	
9	13	940,500	4.5625	
10	14	940,400	5.1250	
10	15	505,200	4.1875	
10	16	1,376,600	4.4062	
12	17	456,900	4.2031	
12	18	608,300	4.6562	
15	19	643,000	4.5438	
15	20	483,900	4.5938	
15	21	715,200	4.0000	
15	22	270,600	4.9219	
15	23	372,300	4.7188	
16	24	395,900	5.0625	
16	25	831,400	4.6250	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-7 Cycles-to-Failure Data of Group No. 130 Using Wire
 Fatigue Machine No. 1 for 35 Specimens of .040
 in. Diameter AISI 4130 Steel Wire. Fixed Alternating
 Stress Level of 70,000 psi. Bend Angle 20.^o
 Coast-Down Cycles 200 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
July 1	1	419,600	4.0000	
2	2	818,700	4.0469	
2	3	1,321,600	4.3594	
5	4	332,000	4.0000	
5	5	557,500	5.0312	
6	6	713,600	4.5000	
6	7	287,400	4.4219	
7	8	451,500	5.2188	
7	9	875,800	4.1562	
8	10	213,400	4.5312	
8	11	287,600	4.8125	
8	12	412,900	5.3125	
9	13	286,500	4.4062	
12	14	369,200	4.3594	
12	15	381,700	5.4375	
13	16	968,100	4.2969	
13	17	303,200	4.4062	
13	18	346,200	4.5625	
14	19	592,100	4.3281	
14	20	684,200	4.3750	
15	21	573,500	4.500	
15	22	362,500	4.7656	
17	23	582,800	3.9062	
17	24	136,700	4.9375	
18	25	376,800	4.0000	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-7 Cycles-to-Failure Data of Group No. 130 Using Wire Fatigue Machine No. 1 for 35 Specimens of .040 in. Diameter AISI 4130 Steel Wire. Fixed Alternating Stress Level of 70,000 psi. Bend Angle 20°. Coast-Down Cycles 200.*

Operator: Chet Nolf

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-8 Cycles-to-Failure Data of Group No. 131 Using Wire
 Fatigue Machine No. 1 for 35 Specimens of 0.40
 in. Diameter AISI 4130 Steel Wire. Fixed Alternating
 Stress Level of 72,500 psi. Bend Angle 20.5°
 Coast-Down Cycles 200 .*

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Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
June 72				
22	1	384,100	4.8906	
23	2	141,800	5.1094	
23	3	392,100	4.4375	
23	4	220,500	4.2969	
24	5	186,600	5.0000	
24	6	100,300	5.1875	
24	7	181,000	4.5312	
26	8	476,400	4.5000	
26	9	150,600	4.7812	
27	10	151,700	4.7812	
27	11	433,700	5.2412	
28	12	469,100	4.5469	
28	13	143,200	4.1093	
29	14	289,800	4.4062	
29	15	201,900	5.0000	
29	16	272,600	4.8438	
29	17	113,800	4.7969	
30	18	693,000	4.9062	
July 72				
1	19	433,400	4.5000	
3	20	657,200	4.0156	
3	21	158,200	5.2188	
3	22	164,000	5.0938	
5	23	342,100	4.4375	
5	24	318,300	4.5938	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-9 Cycles-to-Failure Data of Group No. 132 Using Wire
 Fatigue Machine No. 1 for 35 Specimens of .040
 in. Diameter AISI 4130 Steel Wire. Fixed Alternating
 Stress Level of 74,700 psi. Bend Angle 21.0°
 Coast-Down Cycles 200 *

Oper- ator	Date of Test	Spec. No.	Cycles-to- Failure	Break Length from Scribed End inches	Remarks
C.N.	July 24	1	207,100	4.6250	
	25	2	146,800	4.5312	
	25	3	104,700	4.2500	
	25	4	190,500	4.9219	
	25	5	224,800	4.7344	
	26	6	178,700	5.2656	
	26	7	137,800	5.0312	
	26	8	125,700	4.8906	
	27	9	237,700	5.0312	
	27	10	108,400	5.0000	
	27	11	191,700	4.5000	
	27	12	115,900	4.9219	
	28	13	127,400	5.1719	
	28	14	214,000	3.8750	
	28	15	73,100	4.6250	
	30	16	102,200	4.4062	
	31	17	101,400	4.9062	
	31	18	140,900	5.3750	
	31	19	173,700	4.7500	
	31	20	100,400	4.7656	
	31	21	369,800	4.5312	
	Aug. 1	22	100,500	4.6875	
	1	23	214,400	4.8281	
	1	24	119,800	4.9375	
✓	1	25	179,900	4.2969	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-9 Cycles-to-Failure Data of Group No. 132 Using Wire Fatigue Machine No. 1 for 35 Specimens of .040 in. Diameter AISI 4130 Steel Wire. Fixed Alternating Stress Level of 74,700 psi. Bend Angle 21.0° Coast-Down Cycles 200 .*

[illegible]

* Subtract from counter reading **200** cycles and enter in "Cycles to Failure" column.

Table 8.1-10 Cycles-to-Failure Data of Group No. 133 Using Wire
 Fatigue Machine No. 1 for 35 Specimens of .040
 in. Diameter AISI 4130 Steel Wire. Fixed Alternating
 Stress Level of 77,800 psi. Bend Angle 21.5°
 Coast-Down Cycles 200 *

Operator	Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
Oct. 72 C.N.	1	1	56,900	5.0938	
	1	2	105,400	5.1250	
	1	3	125,100	4.5312	
	2	3	93,800	4.8281	
	2	5	247,100	4.6719	
	3	6	76,700	4.5312	
	3	7	71,800	4.5938	
	4	8	133,400	4.4375	
	4	9	137,500	4.5000	
	5	10	84,900	5.2188	
	5	11	111,300	4.5625	
	5	12	257,200	4.6719	
	6	13	137,100	5.0312	
	7	14	78,400	4.9375	
	7	15	120,200	4.4219	
	9	16	289,000	4.0469	
	9	17	106,300	4.9219	
	9	18	194,200	5.2812	
	10	19	96,200	4.9688	
	10	20	102,100	4.9375	
	11	21	196,900	5.2500	
	12	22	185,500	4.9062	
	12	23	197,200	5.1875	
	13	24	135,400	4.7812	
	13	25	112,700	5.1562	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-11 Static Ultimate Strength Test Data of Group No. 134 Using the Riehle Machine
35 Specimens of AISI 4130 Steel.

Date of Test: April 22, 1972

Specimen Number	Original Diameter in.	Original Cross Section Area in.	Yield Load lbs	Yield Stress psi	Ultimate Load lbs	Ultimate Stress psi	Breaking Load lbs	Breaking Diameter in.	Breaking Area in.	Breaking Stress psi
1	.0401	.001262			109	86,370	99	.0401	.001262	78,446
2	.0401	.001262			108	85,578	97	.0401	.001262	76,862
3	.0401	.001262			110	87,163	96	.0401	.001262	76,069
4	.0401	.001262			110	87,163	98	.0401	.001262	77,654
5	.0401	.001262			109	86,370	93	.0401	.001262	73,692
6	.0401	.001262			107	84,786	96	.0401	.001262	76,069
7	.0401	.001262			109	86,370	96	.0401	.001262	76,069
8	.0401	.001262			111	87,955	99	.0401	.001262	78,446
9	.0399	.001249			110	88,070	98	.0399	.001249	78,462
10	.0400	.001256			110	87,579	99	.0400	.001256	78,821
11	.0401	.001262			111	87,955	98	.0401	.001262	77,654
12	.0401	.001262			109	86,370	99	.0401	.001262	78,446
13	.0400	.001256			110	87,579	94	.0400	.001256	74,840
14	.0400	.001256			108	85,987	94	.0400	.001256	74,840
15	.0400	.001256			111	88,375	99	.0400	.001256	78,821
16	.0401	.001262			111	87,955	101	.0401	.001262	80,031
17	.0402	.001268			112	88,748	98	.0402	.001268	77,287
18	.0401	.001262			112	88,748	100	.0401	.001262	79,239
19	.0401	.001262			109	86,370	94	.0401	.001262	74,484
20	.0401	.001262			113	89,540	101	.0401	.001262	80,031
21	.0401	.001262			107	84,786	97	.0401	.001262	76,862

Table 8.1-12 Test Data for Hardness and Ultimate Strength
 Elongation of Group No. 134. 35 Specimens of
 AISI 4130 Steel. D = .040 in. ; L = 10 in.
 Drawing No. ; Date of Test April 22, 1972

Specimen Number	CHARACTERISTIC			
	Rockwell Hardness Scale	Brinell Hardness BHN	ΔL on 8 in. Gage Length	Elongation %
1			.9219	11.523
2			.9375	11.718
3			.8750	10.937
4			.8437	10.546
5			.7187	8.984
6			.9375	11.718
7			.8594	10.742
8			1.0625	13.281
9			.8125	10.156
10			.9531	11.914
11			.9375	11.718
12			1.2187	15.234
13			1.0938	13.671
14			.8437	10.546
15			.9687	12.109
16			.9062	11.328
17			.9375	11.718
18			.9531	11.914
19			.8281	10.351
20			.9687	12.109
21			.8125	10.156
22			.9062	11.328
23			1.0625	13.381
24			1.1719	14.648
25			1.1875	14.843

Table 8.1-13 Cycles-to-Failure Data of Group No. 136 Using Wire
 Fatigue Machine No. 2 for 35 Specimens of .040
 in. Diameter AISI 1038 Steel Wire. Fixed Alternating
 Stress Level of 64,500 psi. Bend Angle 17
 Coast-Down Cycles 200 .*

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
May				
10	1	515,200	4.7812	
10	2	327,800	4.9219	
11	3	515,600	4.7188	
11	4	826,000	4.6406	
12	5	391,500	5.0000	
12	6	1,316,500	4.5000	
15	7	228,900	4.9062	
15	8	400,000	4.8438	
15	99	843,500	4.5625	
16	10	196,100	4.6875	
16	11	340,000	4.8125	
18	12	677,600	4.6094	
19	13	454,800	4.8438	
22	14	413,400	4.2500	
22	15	372,600	4.7969	
23	16	732,600	4.5938	
24	17	1,651,000	4.5000	
25	18	995,300	4.4219	
26	19	666,200	4.6719	
30	20	637,300	4.5000	
30	21	1,166,600	4.9688	
31	22	667,300	4.4688	
June				
1	23	263,800	4.0000	
2	24	1,438,500	4.8906	
3	25	245,700	5.0000	

*. Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-14 Cycles-to-Failure Data of Group No. 137 Using Wire 288
 Fatigue Machine No. 2 for 35 Specimens of 0.40
 in. Diameter AISI 1038 Steel Wire. Fixed Alternating
 Stress Level of 67,200 psi. Bend Angle 17.5°
 Coast-Down Cycles 200 .*

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
June 72				
27	1	782,500	4.9531	
27	2	776,100	5.1406	
27	3	237,900	5.1250	
27	4	209,800	5.0000	
27	5	635,800	5.3125	
28	6	243,100	4.6875	
28	7	799,500	5.0468	
29	8	267,000	4.1250	
30	9	483,700	4.8125	
30	10	299,800	5.0468	
30	11	243,100	4.8593	
July 72				
1	12	213,700	4.8750	
3	13	224,600	4.3750	
3	14	267,000	4.9375	
5	15	305,500	5.4219	
5	16	426,800	4.7500	
6	17	614,700	4.0000	
7	18	381,300	4.7031	
7	19	486,700	4.8125	
8	20	497,500	4.1250	
9	21	164,300	4.9531	
10	22	329,400	5.1562	
10	23	269,200	4.7969	
11	24	394,600	5.1094	
11	25	439,000	4.9375	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-15 Cycles-to-Failure Data of Group No. 138 Using Wire
 Fatigue Machine No. 2 for 35 Specimens of .040
 in. Diameter AISI 1038 Steel Wire. Fixed Alternating
 Stress Level of 69,200 psi. Bend Angle 18.0°
 Coast-Down Cycles 200 .*

Operator	Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
Chet	July 17	1	204,000	5.0000	
	17	2	291,400	5.0156	
	17	3	163,200	5.0469	
	17	4	105,400	5.0156	
	17	5	214,400	5.1094	
	18	6	90,800	5.1250	
	18	7	444,800	4.6250	
	18	8	207,200	4.8125	
	18	9	140,000	4.7656	
	19	10	150,300	4.8906	
	19	11	301,800	4.3906	
	19	12	388,000	4.6250	
	20	13	556,200	4.7188	
	20	14	207,400	5.0000	
	20	15	336,100	4.8438	
	21	16	834,500	4.6562	
	24	17	348,400	5.0469	
	24	18	129,700	4.7812	
	24	19	221,300	4.8594	
	25	20	208,700	4.7188	
	25	21	214,200	4.7344	
	25	22	163,500	4.7969	
	25	23	276,600	4.7031	
	26	24	177,200	4.1250	
	26	25	107,300	4.7500	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-15 Cycles-to-Failure Data of Group No. 138 Using Wire Fatigue Machine No. 2 for 35 Specimens of .040 in. Diameter AISI 1038 Steel Wire. Fixed Alternating Stress Level of 69,200 psi. Bend Angle 18.0° Coast-Down Cycles 200 .*

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-16 Cycles-to-Failure Data of Group No. 139 Using Wire
 Fatigue Machine No. 2 for 35 Specimens of .040
 in. Diameter AISI 1038 Steel Wire. Fixed Alternating
 Stress Level of 72,300 psi. Bend Angle 18.5°
 Coast-Down Cycles 200 *

Operator	Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
C.N.	July 72				
	31	1	110,900	5.0000	
	31	2	213,400	5.3125	
	31	3	351,300	4.6562	
	Aug. 72				
	1	4	121,400	4.9062	
	1	55	83,700	5.2031	
	1	6	124,700	4.7656	
	1	7	118,400	5.0781	
	2	8	140,100	5.0000	
	2	9	95,400	4.8281	
	3	10	98,400	5.0469	
	3	11	105,500	5.2500	
	8	12	130,900	5.0000	
	8	13	108,100	4.8750	
	8	14	240,100	5.0000	
	9	15	104,800	4.9062	
	9	16	369,700	4.5000	
	9	17	250,900	4.8750	
	10	18	215,500	4.7969	
	10	19	200,600	4.8750	
	10	20	154,000	4.6094	
	11	21	137,000	4.3438	
	11	22	191,900	4.6250	
	14	23	338,500	4.3438	
	14	24	232,900	4.7344	
✓	16	25	281,000	4.7500	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-17 Static Ultimate Strength Test Data of Group No. 141 Using the Richle Machine
35 Specimens of AISI 1038 Steel.

Date of Test: April 8, 1972

Specimen Number	Original Diameter in.	Original Cross Section 2 Area in.	Yield Load lbs	Yield Stress psi	Ultimate Load lbs	Ultimate Stress psi	Breaking Load lbs	Breaking Diameter in.	Breaking Area in.	Breaking Stress psi
1	.0398	.001243			99	79,646	81	.0398	.001243	65,164
2	.0398	.001243			92	74,014	70	.0398	.001243	63,555
3	.0397	.001237			92	74,373	78	.0397	.001237	63,055
4	.0398	.001243			97	78,037	81	.0398	.00143	63,055
5	.0397	.001237			93	75,181	81	.0397	.001237	65,481
6	.0397	.001237			92	74,373	74	.0397	.001237	59,822
7	.0397	.001237			99	80,032	81	.0397	.001237	65,481
8	.0397	.001237			98	79,223	82	.0397	.00137	66,289
9	.0397	.001237			94	75,990	79	.0397	.001237	63,864
10	.0398	.001243			98	78,841	80	.0398	.001243	64,360
11	.0397	.001237			95	76,798	78	.0397	.001237	63,055
12	.0397	.001237			96	77,607	78	.0397	.001237	63,055
13	.0397	.001237			96	77,607	79	.0397	.001237	63,864
14	.0398	.001243			94	75,623	80	.0398	.011243	64,360
15	.0397	.001237			94	75,990	77	.0397	.001237	62,247
16	.0396	.001231			96	77,985	80	.0296	.001230	64,987
17	.0397	.001237			92	74,373	77	.0397	.001237	62,247
18	.0396	.001231			95	79,200	79	.0396	.001231	64,175
19	.0397	.001237			98	79,223	81	.0397	.001237	65,481
20	.0397	.001237			96	77,607	81	.0397	.001237	65,481
21	.0395	.001224			97	79,248	80	.0395	.001224	65,359

Table

Date of Test:

[illegible]

Table 8.1-18 Test Data for Hardness and Ultimate Strength
 Elongation of Group No. 141. 35 Specimens of
 AISI 1038 Steel. D = .040 in. ; L = 10 in.
 Drawing No. ; Date of Test April 8, 1972

Specimen Number	CHARACTERISTIC			
	Rockwell Hardness Scale	Brinell Hardness BHN	ΔL on 8 in. Gage Length	Elongation %
1			1.8437	23.046
2			1.6562	20.703
3			1.5625	19.531
4			1.7500	21.875
5			1.8437	23.046
6			1.3437	16.796
7			1.9375	24.218
8			1.8594	23.242
9			1.5000	18.750
10			1.7500	21.875
11			1.7187	21.484
12			1.5000	18.750
13			1.5000	18.750
14			1.5625	19.531
15			1.5937	19.921
16			1.6562	20.703
17			1.7969	22.460
18			1.7500	21.875
19			1.9687	24.609
20			1.8750	23.437
21			1.6250	20.312
22			1.7187	21.484
23			1.6094	20.117
24			1.5312	19.147
25			1.6250	20.312

Table 8.1-19 Cycles-to-Failure Data of Group No. 143 Using Wire
 Fatigue Machine No. 3 for 35 Specimens of .040
 in. Diameter AISI 1018 Steel Wire. Fixed Alternating
 Stress Level of 57,200 psi. Bend Angle 15.5°
 Coast-Down Cycles 200 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
May 10	1	242,100	4.3750	
10	2	419,100	4.8281	
11	3	668,200	4.0312	
11	4	1,294,700	4.6250	
12	5	419,400	4.9219	
12	6	668,500	4.6875	
15	7	357,500	4.6719	
15	8	368,900	4.4375	
15	9	478,400	5.0312	
16	10	381,400	4.7969	
17	11	1,265,700	4.1250	
18	12	1,664,000	4.6406	
19	13	682,600	4.0312	
22	14	908,500	4.3594	
26	15	502,900	4.7031	
26	16	299,400	5.0312	
30	17	588,300	4.5938	
31	18	942,300	4.5781	
June 1	19	853,100	4.6406	
2	20	756,600	5.1250	
5	21	1,214,200	4.2656	
5	22	293,300	4.6719	
7	23	348,300	4.5469	
7	24	423,400	4.9688	
8	25	1,141,700	4.2344	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-20 Cycles-to-Failure Data of Group No. 144 Using Wire
 Fatigue Machine No. 3 for 35 Specimens of .040
 in. Diameter AISI 1018 Steel Wire. Fixed Alternating
 Stress Level of 60,000 psi. Bend Angle 16.0°
 Coast-Down Cycles 200 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
July 72				
1	1	436,700	4.8125	
1	22	405,400	4.1406	
.3	3	326,300	4.9219	
4	4	726,400	4.6250	
5	5	538,700	4.7344	
6	6	922,100	4.0000	
6	7	569,400	4.8281	
6	8	784,100	4.4688	
7	9	630,400	4.7500	
8	10	256,400	4.7969	
10	11	1,160,700	4.5000	
10	12	419,300	4.5625	
11	13	387,500	4.9219	
11	14	283,000	4.7969	
11	15	1,072,000	3.9375	
12	16	417,600	4.5625	
12	17	368,100	4.6875	
12	18	529,700	4.6250	
12	19	436,900	5.0000	
13	20	646,000	4.3750	
13	21	478,600	4.7500	
13	22	378,000	4.6875	
13	23	493,600	4.5469	
14	24	501,800	4.7344	
14	25	268,200	4.7500	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Operator: Chet Nolf

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-21 Cycles-to-Failure Data of Group No. 145 Using Wire
 Fatigue Machine No. 3 for 35 Specimens of .040
 in. Diameter AISI 1018 Steel Wire. Fixed Alternating
 Stress Level of 62,800 psi. Bend Angle 16.5°
 Coast-Down Cycles 200 *

Operator	Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
C.N.	July 72 28	1	535,600	4.5838	
	30	2	415,100	4.8125	
	31	3	228,500	4.7969	
	31	4	272,600	4.6250	
	31	5	169,300	4.8750	
	31	6	516,300	4.6875	
	Aug. 72 1	7	159,100	5.0000	
	1	8	141,000	5.2500	
	1	9	176,500	4.8750	
	1	10	251,500	4.6562	
	2	11	417,700	4.7188	
	2	12	159,900	4.5000	
	3	13	487,300	4.8750	
	3	14	187,200	4.8906	
	8	15	295,100	5.0469	
	8	16	162,000	4.9062	
	9	17	344,100	4.6250	
	9	18	398,400	4.9062	
	9	19	459,000	4.7188	
	10	20	308,300	4.7969	
	11	21	258,900	4.5000	
	11	22	259,900	4.6562	
	14	23	484,900	4.3750	
	14	24	519,800	4.7188	
✓	16	25	329,500	4.4062	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-22 Static Ultimate Strength Test Data of Group No. 148 Using the Riehle Machine
35 Specimens of AISI 1018 Steel.

Date of Test: April 29, 1972

Specimen Number	Original Diameter in.	Original Cross Section 2 Area in.	Yield load lbs	Yield Stress psi	Ultimate load lbs	Ultimate Stress psi	Breaking load lbs	Breaking Diameter in.	Breaking Area in.2	Breaking Stress psi
1	.0398	.001243			77	61,946	58	.0398	.001243	46,661
2	.0398	.001243			77	61,946	61	.0398	.001243	49,074
3	.0397	.001237			78	63,055	59	.0397	.001237	47,696
4	.0396	.001231			78	63,363	60	.0396	.001231	48,740
5	.0397	.001237			78	63,055	62	.0397	.001237	50,121
6	.0393	.001212			76	62,706	59	.0393	.001212	48,679
7	.0396	.001231			75	60,926	56	.0396	.001231	45,491
8	.0398	.001243			76	61,142	59	.0398	.001243	47,465
9	.0397	.001237			77	62,247	60	.0397	.001237	48,504
10	.0396	.001231			76	61,738	52	.0396	.001231	42,242
11	.0398	.001243			78	62,751	60	.0398	.001243	48,270
12	.0398	.001243			78	62,751	61	.0398	.001243	49,074
13	.0395	.001224			81	65,164	65	.0398	.001224	53,104
14	.0397	.001237			80	64,672	63	.0397	.001237	50,929
15	.0398	.001243			79	63,555	64	.0398	.001243	51,488
16	.0396	.001231			79	64,175	60	.0396	.001231	48,740
17	.0398	.001243			76	61,142	59	.0398	.001243	47,465
18	.0395	.001224			78	63,725	60	.0395	.001224	49,195
19	.0396	.001231			78	63,363	61	.0396	.001231	49,553
20	.0395	.001224			81	66,176	66	.0395	.001231	53,921
21	.0398	.001243			79	63,555	60	.0398	.001243	48,270

Table 8.1-22 Static Ultimate Strength Test Data of Group No. 148 Using the Riehle Machine
35 Specimens of AISI 1018 Steel.

Date of Test:

[illegible]

Table S.1-23 Test Data for Hardness and Ultimate Strength
 Elongation of Group No.143 . 35 Specimens of
 AISI 1018 Steel. D = .040 in. ; L = 10 in.
 Drawing No. ; Date of Test April 29, 1972

Specimen Number	CHARACTERISTIC			
	Rockwell Hardness Scale	Brinell Hardness BHN	ΔL on 8 in. Gage Length	Elongation %
1			.9062	11.327
2			.8125	10.156
3			1.2343	15.428
4			.7500	9.375
5			1.0781	13.476
6			.9687	12.108
7			.8906	11.132
8			.9375	11.718
9			1.0156	12.695
10			.8437	10.546
11			.9843	12.303
12			1.1718	14.647
13			.8125	10.156
14			1.2656	15.820
15			1.3758	17.187
16			.7812	9.765
17			.9375	11.718
18			.8750	10.937
19			.8750	10.937
20			1.0315	12.893
21			1.2500	15.625
22			.9843	12.303
23			.8593	10.7412
24			1.1562	14.452
25			.9687	12.108

Table 8.1-23 Test Data for Hardness and Ultimate Strength
Elongation of Group No. 148. 35 Specimens of
AISI 1018 Steel. D = .040 in. ; L = 10 in.
Drawing No. ; Date of Test April 29, 1972

[illegible]

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[illegible]

Table 8.1-25 Cycles-to-Failure Data of Group No. 150 Using Wire
 Fatigue Machine No. 4 for 35 Specimens of .040
 in. Diameter AISI 4340 Steel Wire. Fixed Alternating
 Stress Level of 73,500 psi. Bend Angle 20.5°
 Coast-Down Cycles 100 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
March 72				
9	1	475,900	4.2188	
10	2	535,700	5.0000	
10	3	304,900	4.0938	
10	4	531,600	3.5200	
10	5	345,000	4.5000	
11	6	240,000	5.625	
12	7	410,900	4.6719	
13	8	334,100	5.4375	
13	9	335,100	4.7969	
14	10	260,500	4.0000	
14	11	709,800	5.1250	
14	12	463,800	4.3200	
14	13	342,700	5.0156	
15	14	312,300	4.5781	
15	15	571,400	4.5200	
15	16	126,300	4.6094	
16	17	375,400	4.3438	
16	18	258,900	4.7812	
16	19	214,900	4.2656	
16	20	234,300	4.375	
16	21	200,900	4.0312	
17	22	413,200	5.0120	
17	23	441,200	3.9531	
19	24	282,100	5.0000	

* Subtract from counter reading 100 cycles and enter in "Cycles to Failure" column.

[illegible]

* Subtract from counter reading 100 cycles and enter in "Cycles to Failure" column.

Table 8.1-26 Cycles-to-Failure Data of Group No. 151 Using Wire 311
 Fatigue Machine No. 4 for 35 Specimens of .040
 in. Diameter AISI 4340 Steel Wire. Fixed Alternating
 Stress Level of 78,100 psi. Bend Angle 21.5°
 Coast-Down Cycles 100 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
April 1	1	128,100	4.1875	
4	2	155,600	5.1875	
5	3	294,200	4.9219	
5	4	355,000	5.0312	
5	5	216,300	4.6719	
5	6	270,300	4.3281	
5	7	136,300	4.7344	
5	8	230,700	4.4375	
6	9	302,200	4.6250	
6	10	222,500	4.1562	
6	11	255,500	4.3438	
6	12	510,900	4.0000	
6	13	313,600	4.4606	
7	14	860,400	4.4375	
7	15	243,900	4.3438	
7	16	237,600	4.1875	
7	17	526,000	4.2656	
8	18	171,300	4.0469	
8	19	223,400	4.8750	
8	20	166,200	4.7812	
8	21	233,000	5.1250	
8	22	310,500	4.2188	
10	23	278,300	4.9688	
10	24	335,300	4.3750	
10	25	153,500	4.0000	

* Subtract from counter reading 100 cycles and enter in "Cycles to Failure" column.

Table 8.1-27 Cycles-to-Failure Data of Group No. 152 Using Wire
 Fatigue Machine No. 4 for 35 Specimens of .040
 in. Diameter AISI 4340 Steel Wire. Fixed Alternating
 Stress Level of 80,100 psi. Bend Angle 22.0
 Coast-Down Cycles 100 *

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
April 13	1	185,800	4.2500	
13	2	229,000	4.5312	
13	3	254,000	4.0625	
13	4	205,500	4.0469	
13	5	163,400	4.5938	
14	6	114,000	4.4219	
14	7	382,000	4.4375	
14	8	507,700	4.4844	
14	9	114,700	4.1562	
14	10	161,900	4.2969	
17	11	176,800	4.3750	
17	12	536,200	4.2188	
17	13	679,500	4.8750	
17	14	253,900	4.1562	
18	15	148,800	4.7188	
18	16	401,100	4.9844	
18	17	87,500	4.5781	
18	18	283,300	4.6562	
19	19	245,500	4.2344	
19	20	215,000	4.3906	
19	21	306,600	4.3906	
19	22	227,400	4.7188	
19	23	188,000	4.3125	
19	24	241,000	3.8594	
21	25	80,000	4.5312	

* Subtract from counter reading 100 cycles and enter in "Cycles to Failure" column.

Table 8.1-28 Cycles-to-Failure Data of Group No. 153 Using Wire 315
 Fatigue Machine No. 4 for 35 Specimens of .040
 in. Diameter AISI 4340 Steel Wire. Fixed Alternating
 Stress Level of 84,700 psi. Bend Angle 23.0°
 Coast-Down Cycles 200 .*

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
April 72				
27	1	918,000	3.9688	
27	2	93,000	4.0000	
27	3	223,400	4.2812	
27	4	182,000	4.8595	
27	5	63,200	4.8438	
28	6	152,300	4.5624	
28	7	321,900	4.9219	
28	8	178,500	5.0000	
28	9	172,200	4.8281	
29	10	164,600	4.7656	
29	11	130,900	4.1250	
May 72				
1	12	117,500	4.750	
1	13	187,500	4.2188	
1	14	150,900	4.3438	
1	15	143,200	4.6875	
1	16	116,100	4.7500	
1	17	206,400	5.0090	
2	18	198,400	4.5000	
2	19	175,000	4.4688	
2	20	219,600	4.0312	
2	21	165,100	4.0469	
2	22	72,400	4.9219	
2	23	100,600	4.4219	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-28 Cycles-to-Failure Data of Group No. 153 Using Wire Fatigue Machine No. 4 for 35 Specimens of .040 in. Diameter AISI 4340 Steel Wire. Fixed Alternating Stress Level of 84,700 psi. Bend Angle 23.0° Coast-Down Cycles 200 .*

[illegible]

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-29 Cycles-to-Failure Data of Group No. 154 Using Wire 317
 Fatigue Machine No. 4 for 35 Specimens of .040
 in. Diameter AISI 4340 Steel Wire. Fixed Alternating
 Stress Level of 90,000 psi. Bend Angle 24.0°
 Coast-Down Cycles 200 .*

Operator: Chet Nolf

Date of Test	Spec. No.	Cycles-to-Failure	Break Length from Scribed End inches	Remarks
May 5	1	105,200	4.0938	
5	2	116,500	5.0000	
8	3	102,900	5.2500	
8	4	92,800	4.3906	
9	5	99,400	4.0000	
9	6	127,600	4.2812	
9	7	108,500	5.0000	
9	8	100,900	4.4062	
9	9	72,000	4.2031	
9	10	173,800	4.2188	
10	11	113,800	4.8594	
10	12	178,500	4.9688	
10	13	99,000	5.1250	
10	14	94,500	4.6094	
10	15	91,100	4.0469	
11	16	93,700	5.0625	
11	17	98,900	4.5312	
11	18	70,100	5.0781	
11	19	155,600	4.8438	
11	20	196,200	4.4375	
12	21	276,900	4.8281	
12	22	154,200	5.4375	
12	23	90,800	4.8281	
12	24	92,000	4.4375	
15	25	163,700	4.5625	

* Subtract from counter reading 200 cycles and enter in "Cycles to Failure" column.

Table 8.1-30 Static Ultimate Strength Test Data of Group No. 155 Using the Riehle Machine
35 Specimens of AISI 4340 Steel.

Date of Test: April 30, 1972

Specimen Number	Original Diameter in.	Original Cross Section Area in.	Yield Load lb	Yield Stress psi	Ultimate Load lb	Ultimate Stress psi	Breaking Load lb	Breaking Diameter in.	Breaking Area in.	Breaking Stress psi
1	.0403	.001276			132	103,448	116	.0403	.001276	90,909
2	.0403	.001276			134	105,016	120	.0403	.001276	94,044
3	.0402	.001269			133	104,807	117	.0402	.001269	92,199
4	.0403	.001276			135	105,799	121	.0403	.001276	94,828
5	.0402	.001269			132	104,019	117	.0402	.001269	92,199
6	.0402	.001269			134	105,595	121	.0402	.001269	95,351
7	.0403	.001276			134	105,016	121	.0403	.001276	94,828
8	.0403	.001276			134	105,016	120	.0403	.001276	94,044
9	.0403	.001276			137	107,367	119	.0403	.001276	93,260
10	.0403	.001276			134	105,016	115	.0403	.001276	90,125
11	.0402	.001269			134	105,595	122	.0402	.001269	96,139
12	.0403	.001276			138	108,150	123	.0403	.001276	96,395
13	.0403	.001276			137	107,367	112	.0403	.001276	87,774
14	.0403	.001276			134	105,016	117	.0403	.001276	91,693
15	.0403	.001276			135	105,799	121	.0403	.001276	94,828
16	.0403	.001276			137	107,367	121	.0403	.001276	94,828
17	.0402	.001269			134	105,595	119	.0402	.001269	93,775
18	.0402	.001269			133	104,807	114	.0402	.001269	89,835
22	.0403	.001276			136	106,583	122	.0403	.001276	95,611
23	.0402	.001269			135	106,583	117	.0402	.001269	91,693
24	.0402	.001269			133	104,907	118	.0402	.001269	92,987

Table 8.1-31 Test Data for Hardness and Ultimate Strength
 Elongation of Group No. 155. 35 Specimens of
 AISI 4340 Steel. D = .040 in. ; L = 10 in.
 Drawing No. ; Date of Test March 4, 1972

Specimen Number	CHARACTERISTIC			
	Rockwell Hardness Scale	Brinell Hardness BHN	ΔL on 8 in. Gage Length	Elongation %
37			.8573	10.741
25			.7500	9.375
24			.7812	9.765
2			.6406	8.007
12			.8281	10.351
32			.7343	9.178
18			.7656	9.570
16			.8593	10.741
22			.7500	9.375
4			.7968	9.960
8			.8593	10.741
5			.8750	10.071
23			.6250	7.812
39			.7656	9.570
34			.6875	8.593
40			.8437	10.546
33			.7500	9.375
7			.8437	10.546
6			.7968	9.960
14			.5937	7.421
15			.8281	10.351
1			.7181	8.976
9			.7343	9.178
3			.6718	8.397
30			.7500	9.375

Table 8.1-31 Test Data for Hardness and Ultimate Strength
Elongation of Group No.155 . 35 Specimens of
AISI 4340 Steel. D = .040 in. ; L = 10 in.
Drawing No. ; Date of Test March 4, 1972

[illegible]

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[illegible]

8.2 WIEDEMANN FATIGUE MACHINE DATA

Table 8.2-1 Cycles-to-Failure Data of Group No. 89 Using the Wiedemann Machine. 36 Specimens of AISI 4130 Steel Rod of Test Section Diameter, $d = .0937$ in., Radius, $r = .125$ in. Added Pan Load = 15.79 lbs. Alternating Stress = 75,000^{Upper} psi.

Date of Test	Specimen Number	Cycles-to-Failure	Remarks*
May 1972			
10	7	149,000	F
11	25	161,000	F
11	29	211,000	F
11	35	337,000	F
11	23	291,000	F
11	36	313,000	F
11	27	147,000	F
15	14	222,000	F
15	32	206,000	F
15	13	381,000	F
15	33	249,000	F
15	12	478,000	F
15	11	175,000	F
16	15	410,000	F
16	22	163,000	F
16	21	141,000	F
16	8	91,000	F
16	30	143,000	F
16	18	123,000	F
June 1972			
6	16	170,000	F
6	10	345,000	F
6	1	680,000	F
6	28	253,000	F
6	26	122,000	F
6	24	157,000	F

* F - Failure

NF - No Failure

Table 8.2-2 Inspection Data for Critical and Major Characteristics
 of Group No. 89 . 36 Specimens of AISI 4130 Steel
 D = .375 in. ; L = 3.50 in.
 Drawing No. 200. ; Date of Inspection 4/1/72

Specimen Number	CHARACTERISTIC			
	Hardness	d= .0937 ± .0005 in.	r= .125 ± .002 in.	Surface Finish μ-in.
1		.0937	GO	4
2		.0937		
3		.0937		
4		.0937		
5		.0934		
6		.0935		
7		.0940		
8		.0939		
9		.0939		
10		.0937		
11		.0937		
12		.0938		
13		.0940		
14		.0937		
15		.0939		
16		.0941		
17		.0933		
18		.0936		
19		.0937		
20		.0933		
21		.0940		
22		.0939		
23		.0939		
24		.0936		
25		.0937	✓	✓

Table 8.2-2 Inspection Data for Critical and Major Characteristics
of Group No. 89 . 36 Specimens of AISI 4130 Steel
D = .375 in. ; L = 3.50 in.
Drawing No. 200 ; Date of Inspection 4/1/72 .

[illegible]

Table 8.2-3 Inspection Data for Critical and Major Characteristics
 of Group No. 90 . 37 Specimens of AISI 4130 Steel
 D = .375 in. ; L = 3.5 in.
 Drawing No. 200 ; Date of Inspection April 3, 1972

Specimen Number	CHARACTERISTIC			
	Hardness	d=.0937 + .0005 - in.	r= .125 + .002 - in.	Surface Finish μ-in.
1		.0940	.125	4
2		.0937		
3		.0938		
4		.0937		
5		.0940		
6		.0939		
7		.0937		
8		.0937		
9		.0939		
10		.0940		
11		.0937		
12		.0940		
13		.0940		
14		.0937		
15		.0939		
16		.0937		
17		.0937		
18		.0937		
19		.0937		
20		.0940		
21		.0937		
22		.0940		
23		.0939		
24		.0938		
25		.0939		

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Table 8.2-4 Cycles-to-Failure Data of Group No. 90 Using the Wiedemann
Machine. 37 Specimens of AISI 4130 Steel Rod of Test Section
Diameter, $d = .0937$ in., Radius, $r = .125$ in. Upper
Added Pan Load = 15.44 lbs. Alternating Stress = 85,000 psi.

Date of Test	Specimen Number	Cycles-to-Failure	Remarks*
May 1972			
2	30	49,000	F
2	32	109,000	F
2	23	77,000	F
2	10	130,000	F
2	12	67,000	F
3	26	123,000	F
3	31	44,000	F
3	16	87,000	F
3	19	30,000	F
3	5	328,000	F
3	8	151,000	F
3	2	84,000	F
4	9	162,000	F
4	28	112,000	F
4	13	46,000	F
4	20	111,000	F
5	22	112,000	F
5	33	95,000	F
5	7	81,000	F
5	36	47,000	F
8	3	93,000	F
8	34	59,000	F
8	6	45,000	F
8	29	113,000	F
8	37	158,000	F

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[illegible]

Table 8.2-5 Inspection Data for Critical and Major Characteristics
 of Group No. 91 . 36 Specimens of AISI 4130 Steel
 D = .375 in. ; L = 3.50 in.
 Drawing No. 200 ; Date of Inspection April 4, 1972

Specimen Number	CHARACTERISTIC			
	Hardness	d= .0937 + .0005 - in.	r= .125 + .002 - in.	Surface Finish μ-in.
1		.0937	.125	4
2		.0938		
3		.0937		
4		.0937		
5		.0939		
6		.0937		
7		.0937		
8		.0937		
9		.0937		
10		.0938		
11		.0937		
12		.0937		
13		.0937		
14		.0937		
15		.0937		
16		.0937		
17		.0937		
18		.0939		
19		.0937		
20		.0935		
21		.0935		
22		.0937		
23		.0937		
24		.0939		
25		.0937		

Table 8.2-6 Cycles-to-Failure Data of Group No. 91 Using the Wiedemann Machine. ³⁷ Specimens of AISI 4130 Steel Rod of Test Section Diameter, $d = .0937$ in., Radius, $r = .125$ in. Upper Added Pen Load = 15.10 lbs. Alternating Stress = 95,000 psi.

Date of Test	Specimen Number	Cycles-to-Failure	Remarks
April 1972			
12	25	21,000	F
12	16	34,000	F
12	14	13,000	F
13	35	12,000	F
13	20	16,000	F
13	4	8,000	F
13	1	39,000	F
13	23	31,000	F
14	32	32,000	F
14	3	12,000	F
14	17	34,000	F
17	31	18,000	F
17	37	23,000	F
17	6	18,000	F
17	15	21,000	F
17	35	34,000	F
18	5	14,000	F
18	7	13,000	F
18	34	16,000	F
19	8	25,000	F
19	19	17,000	F
20	18	20,000	F
20	26	27,000	F
24	13	17,000	F
24	24	33,000	F

Table 8.2-7 Inspection Data for Critical and Major Characteristics
of Group No. 93 . 35 Specimens of AISI 4130 Steel
D = .375 in. ; L = 3.50 in.
Drawing No. 200 ; Date of Inspection March 30, 1972

Specimen Number	CHARACTERISTIC			
	Hardness	d = .0937 + .0005 - in.	r = .250 + .002 - in.	Surface Finish μ-in.
1		.0937	.250	4
2		.0936		
3		.0939		
4		.0940		
5		.0937		
6		.0937		
7		.0939		
8		.0936		
9		.0937		
10		.0939		
11		.0939		
12		.0937		
13		.0937		
14		.0937		
15		.0938		
16		.0937		
17		.0937		
18		.0937		
19		.0937		
20		.0937		
21		.0936		
22		.0937		
23		.0937		
24		.0940		
25		.0937		

Table 8.2-8 Cycles-to-Failure Data of Group No. 93 Using the Wiedemann Machine. 35 Specimens of AISI 4130 Steel Rod of Test Section Diameter, $d = .0937$ in., Radius, $r = .250$ in. Added Pan Load = 15.96 lbs. Alternating Stress = $70,000^{\text{Upper}}$ psi.

Date of Test 1972	Specimen Number	Cycles-to-Failure	Remarks
4/3	29	37,000	F
4/3	21	52,000	F
4/3	16	53,000	F
4/3	24	67,000	F
4/3	19	60,000	F
4/3	26	94,000	F
4/4	12	81,000	F
4/4	13	133,000	F
4/4	32	122,000	F
4/4	4	147,000	F
4/4	10	149,000	F
4/4	28	163,000	F
4/4	33	38,000	F
4/4	8	24,000	F
4/5	20	36,000	F
4/5	25	34,000	F
4/6	30	64,000	F
4/6	14	193,000	F
4/6	34	50,000	F
4/6	27	123,000	F
4/6	23	97,000	F
4/6	6	106,000	F
4/7	15	61,000	F
4/7	22	116,000	F
4/7	9	45,000	F -

*F = Failure

NF = No Failure

Table 8.2-9 Inspection Data for Critical and Major Characteristics
 of Group No. 94 . 35 Specimens of AISI 4130 Steel
 D = .375 in. ; L = 3.50 in.
 Drawing No. 200 ; Date of Inspection March 29, 1972.

Specimen Number	CHARACTERISTIC			
	Hardness	d = .0937 + .0005 - in.	r = .250 + .002 - in.	Surface Finish μ-in.
1		.0939	GO	4
2		.0937		
3		.0937		
4		.0937		
5		.0933		
6		.0938		
7		.0937		
8		.0937		
9		.0937		
10		.0938		
11		.0937		
12		.0938		
13		.0933		
14		.0937		
15		.0938		
16		.0937		
17		.0938		
18		.0937		
19		.0935		
20		.0937		
21		.0937		
22		.0940		
23		.0937		
24		.0938		
25		.0940		

[illegible]

Table 8.2-10 Cycles-to-Failure Data of Group No. 94 Using the Wiedemann Machine. 35 Specimens of AISI 4130 Steel Rod of Test Section Diameter, $d = .0937$ in., Radius, $r = .250$ in. Upper Added Pan Load = 15.62lbs. Alternating Stress = 80,000 psi.

Date of Test 1972	Specimen Number	Cycles-to-Failure	Remarks
3/29	9	26,000	F
3/29	18	18,000	F
3/29	5	16,000	F
3/29	17	28,000	F
3/30	13	19,000	F
3/30	26	12,000	F
3/30	27	19,000	F
3/30	29	23,000	F
3/30	15	29,000	F
3/30	4	27,000	F
3/30	22	31,000	F
3/30	26	16,000	F
3/30	31	22,000	F
3/30	16	59,000	F
3/30	35	31,000	F
3/31	19	29,000	F
3/31	10	40,000	F
3/31	14	32,000	F
3/31	21	36,000	F
3/31	30	41,000	F
3/31	33	32,000	F
3/31	28	31,000	F
3/31	7	19,000	F
3/31	32	19,000	F
3/31	2	34,000	F

* F = Failure

NF = No Failure

Table 8.2-11 Cycles-to-Failure Data of Group No. 95 Using the Wiedemann Machine. 34 Specimens of AISI 4130 Steel Rod of Test Section Diameter, $d = .0937$ in., Radius, $r = .250$ in. Upper Added Pan Load = 15.10 lbs. Alternating Stress = 95,000 psi.

Date of Test 1972	Specimen Number	Cycles-to-Failure	Remarks
3/10	18	8,000	F
3/10	15	7,000	F
3/10	10	5,000	F
3/10	21	9,000	F
3/13	12	13,000	F
3/13	11	3,000	F
3/13	17	2,000	F
3/14	14	9,000	F
3/14	20	5,000	F
3/14	13	2,000	F
3/14	4	3,000	F
3/15	22	7,000	F
3/16	7	9,000	F
3/16	23	6,000	F
3/17	34	11,000	F
3/17	3	5,000	F
3/17	33	6,000	F
3/17	31	4,000	F
3/17	25	11,000	F
3/24	4	2,000	F
3/24	32	5,000	F
3/24	26	11,000	F
3/24	27	3,000	F
3/29	29	6,000	F
3/29	2	4,000	F

* F - Failure
NF. = No Failure

Table 8.2-12 Inspection Data for Critical and Major Characteristics
 of Group No. 95 . 34 Specimens of AISI 4130 Steel
 D = .375 in. ; L = 3.00 in.
 Drawing No. 200 ; Date of Inspection 3/8/72 .

Specimen Number	CHARACTERISTIC			
	Hardness	d= .0937 + .0005 - in.	r= .250" + .002 - in.	Surface Finish μ-in.
1		.0941	GO	4
2		.0937		
3		.0936		
4		.0937		
5		.0937		
6		.0934		
7		.0937		
8		.0933		
9		.0938		
10		.0939		
11		.0937		
12		.0937		
13		.0937		
14		.0940		
15		.0938		
16		.0937		
17		.0935		
18		.0937		
19		.0937		
20		.0935		
21		.0937		
22		.0936		
23		.0934		
24		.0937		
25		.0937	↓	↓

Table 8.2-13 Staircase Method Data of Group No. 162 Using the P. R. Moore Machine. 35 Specimens of AISI 1038 Steel Rod with Test Section Diameter, $d = .2700$ in., Radius $r = .031$ in. Cutoff at 3×10^5 cycles.

Date of Test	Spec. No.	Added Pan Load lbs	Alternating Stress	Cycles of Operation $\times 10^{-5}$	Remarks*
1972 3/7	37	8.36	19,000	3,108,000	N F
3/8	13	10.29	21,000	9,101,000	N F
3/9	11	12.22	23,000	3,429,000	N F
3/9	27	14.15	25,000	1,280,000	F
3/10	9	12.22	23,000	3,000,000	N F
3/16	14	14.15	25,000	1,438,000	F
3/17	5	12.22	23,000	3,442,000	N F
3/17	4	14.15	25,000	802,000	F
3/20	7	12.22	23,000	3,141,000	N F
3/21	6	14.15	25,000	1,347,000	F
3/21	25	12.22	23,000	3,560,000	N F
3/22	16	14.15	25,000	2,100,000	F
3/23	1	12.22	23,000	5,224,000	N F
3/24	34	14.15	25,000	1,464,000	F
3/24	12	12.22	23,000	2,564,000	F
3/29	29	10.29	21,000	3,020,000	N F
3/29	24	12.22	23,000	3,183,000	N F
3/29	15	14.15	25,000	1,285,000	F
3/30	26	12.22	23,000	3,097,000	N F
3/30	19	14.15	25,000	1,294,000	F
3/30	35	12.22	23,000	3,190,000	N F
3/30	30	14.15	25,000	781,000	F
3/31	18	12.22	23,000	3,043,000	N F
3/31	36	14.15	25,000	1,748,000	F
4/1	31	12.22	23,000	3,128,000	N F
4/3	33	14.15	25,000	865,000	F

* N F - No Failure
F - Failure

Table 8.2-14 Inspection Data for Critical and Major Characteristics
of Group No. 162 . 38 Specimens of AISI 1038 Steel 351
D = .375 in. ; L = 2.75 in.
Drawing No. 200 .

Date of Test: 3/7/72

Operator: J.D.S.

Specimen Number	CHARACTERISTIC			
	Hardness	d= .2700 ± .0010 in.	r= .031 in.	Surface Finish 4 μ-in.
1		.2700	GO	4
2		.2700		
3		.2706		
4		.2700		
5		.2700		
6		.2700		
7		.2700		
8		.2700		
9		.2703		
10		.2700		
11		.2705		
12		.2700		
13		.2700		
14		.2700		
15		.2700		
16		.2703		
17		.2700		
18		.2702		
19		.2698		
20		.2699		
21		.2703		
22		.2700		
23		.2700		
24		.2705		
25		.2700	✓	✓

Operator: J.D.S.

[illegible]

Table 8.2-15 Staircase Method Data of Group No. 163 Using the R. R. Moore Machine. 37 Specimens of AISI 1038 Steel Rod with Test Section Diameter, $d = .2700$ in., Radius $r = .062$ in. Cutoff at 3×10^6 cycles.

Date of Test	Spec. No.	Added Pan Load lbs	Alternating Stress	Cycles of Operation	Remarks*
April 72					
7	32	14.15	25,000	11,223,000	N F
11	19	16.09	27,000	3,000,000	N F
11	33	18.02	29,000	702,000	F
12	26	16.09	27,000	12,248,000	N F
13	23	18.02	29,000	1,426,000	F
13	3	16.09	27,000	3,452,000	N F
14	30	18.02	29,000	1,481,000	F
14	5	16.09	27,000	3,000,000	N F
17	10	18.02	29,000	1,522,000	F
17	31	16.09	27,000	4,729,000	N F
18	11	18.02	29,000	1,194,000	F
18	2	16.09	27,000	639,000	F
19	1	14.15	25,000	3,138,000	N F
19	24	16.09	27,000	2,474,000	F
20	26	14.15	25,000	2,769,000	F
24	4	12.22	23,000	3,091,000	N F
24	8	14.15	25,000	2,269,000	F
25	25	12.22	23,000	9,397,000	N F
26	36	14.15	25,000	3,859,000	N F
26	27	16.09	27,000	3,465,000	N F
28	35	18.02	29,000	1,721,000	F
28	14	16.09	27,000	11,890,000	N F
May 72					
1	37	18.02	29,000	1,881,000	F
1	12	16.09	27,000	1,386,000	F
2	34	14.15	25,000	3,045,000	N F
2	16	16.09	27,000	1,985,000	F

* N F - No Failure
F - Failure

* N F - No Failure
F - Failure

Table 8.2-16. Inspection Data for Critical and Major Characteristics
of Group No. 163 . 37 Specimens of AISI 1038 Steel
D = .375 in. ; L = 2.75 in.
Drawing No. 200

355

Date of Test: 3/31/72 Operator: J.D.S.

Specimen Number	CHARACTERISTIC			
	Hardness	d= .2700 ± .0005 in.	r= .062 ± .002 in.	Surface Finish 4 μ-in.
1		.2705	GO	4
2		.2705		
3		.2700		
4		.2700		
5		.2700		
6		.2700		
7		.2700		
8		.2700		
9		.2700		
10		.1700		
11		.2700		
12		.2700		
13		.2705		
14		.2700		
15		.2700		
16		.2703		
17		.2700		
18		.2703		
19		.2700		
20		.2700		
21		.2705		
22		.2700		
23		.2700		
24		.2700		
25		.2700	↓	↓

Drawing No. 200

Operator: J.D.S.

[illegible]

357

Table 8.2-17 Staircase Method Data of Group No. 164 Using the R. R. Moore Machine. 37 Specimens of AISI 1038 Steel Rod with Test Section Diameter, $d = 0.2700$ in., Radius $r = 0.125$ in. Cutoff at 3×10^6 cycles.

Operator:

Date of Test	Spec. No.	Added Pan Load lbs	Alternating Stress	Cycles of Operation	Remarks*
5/10/72	1	19.23	30,000	4,340,000	NF
5/11/72	22	21.16	32,000	949,000	F
5/11/72	37	19.23	30,000	12,873,000	NF
5/12/72	21	21.16	32,000	623,000	F
5/15/72	34	19.23	30,000	3,137,000	NF
5/15/72	13	21.16	32,000	3,773,000	NF
5/15/72	14	23.09	34,000	1,153,000	F
5/16/72	29	21.16	32,000	2,337,000	F
5/16/72	23	19.23	30,000	2,095,000	F
6/06/72	18	17.29	28,000	3,055,000	NF
6/06/72	9	19.23	30,000	313,000	F
6/06/72	8	17.29	28,000	3,122,000	NF
6/06/72	19	19.23	30,000	4,478,000	NF
6/07/72	36	21.16	32,000	3,097,000	NF
6/07/72	15	23.09	34,000	705,000	F
6/07/72	24	21.16	32,000	1,251,000	F
6/08/72	33	19.23	30,000	3,077,000	NF
6/08/72	11	21.16	32,000	1,922,000	F
6/09/72	25	19.23	30,000	3,546,000	NF
6/10/72	31	21.16	32,000	1,722,000	F
6/11/72	17	19.23	30,000	2,900,000	F
6/12/72	7	17.29	28,000	3,121,000	NF
6/12/72	30	19.23	30,000	3,139,000	NF
6/12/72	32	21.16	32,000	1,249,000	F
6/12/72	35	19.23	30,000	2,126,000	F
6/13/72	16	17.29	28,000	3,021,000	NF

* N F - No Failure
F - Failure

Table 8.2-18 Inspection Data for Critical and Major Characteristics
of Group No. 164 . 37 Specimens of AISI 1038 Steel 359
D = .375 in. ; L = 2.75 in.
Drawing No. 200 .

Date of Test: 3/7/72

Operator: J.D.S.

Specimen Number	CHARACTERISTIC			
	Hardness	d = .2700 ± .0090 in.	r = .1250 ± .002 in.	Surface Finish u-in.
1		.2695	GO	
2		.2703		
3		.2700		
4		.2700		
5		.2705		
6		.2700		
7		.2700		
8		.2700		
9		.2705		
10		.2703		
11		.2705		
12		.2705		
13		.2700		
14		.2700		
15		.2700		
16		.2700		
17		.2700		
18		.2705		
19		.2702		
20		.2700		
21		.2704		
22		.2698		
23		.2700		
24		.2700		
25		.2700	↓	

Date of Test: 3/7/72 Operator: J.D.S.

[illegible]

Table 8.2-19 Staircase Method Data of Group No. 165 Using the R. R. Moore Machine. 36 Specimens of AISI 1038 Steel Rod with Test Section Diameter, $d = .2700$ in., Radius $r = .250$ in. Cutoff at 3×10^6 cycles. 361

Date of Test	Spec. No.	Added Pan. Load lbs	Alternating Stress	Cycles of Operation	Remarks*
June 26	15	23.82	35,000	1,011,000	F
27	21	21.88	33,000	3,620,000	NF
27	18	23.82	35,000	959,000	F
28	11	21.88	33,000	3,411,000	NF
28	25	23.82	35,000	1,105,000	F
29	1	21.88	33,000	1,006,000	F
29	24	19.95	31,000	3,003,000	NF
29	23	21.88	33,000	1,544,000	F
30	19	19.95	31,000	4,203,000	NF
July 3	22	21.88	33,000	3,100,000	NF
3	26	23.82	35,000	1,423,000	F
3	34	21.88	33,000	1,329,000	F
5	16	19.95	31,000	998,000	F
5	14	18.02	29,000	3,163,000	NF
5	9	19.95	31,000	10,763,000	NF
6	17	21.88	33,000	2,725,000	F
6	2	19.95	31,000	1,960,000	F
7	13	18.02	29,000	3,073,000	NF
7	8	19.95	31,000	9,115,000	NF
10	10	21.88	33,000	1,706,000	F
10	36	19.95	31,000	13,035,000	NF
11	6	21.88	33,000	1,459,000	F
11	7	19.95	31,000	7,789,000	NF
12	20	21.88	33,000	3,042,000	NF
12	31	23.82	35,000	1,282,000	F
17	4	21.88	31,000	2,571,000	F

* N F - No Failure
F - Failure

Table 8.2-20 Inspection Data for Critical and Major Characteristics ³⁶³
of Group No. 165 . 36 Specimens of AISI 1038 Steel
D = .375 in. ; L = 2.75 in.
Drawing No. 200 ; Date of Inspection 6/26/72

Specimen Number	CHARACTERISTIC			
	Hardness	d= .2700 + .0010 - in.	r= .2500 + .002 - in.	Surface Finish μ-in.
1		.2709	GO	4
2		.2700		
3		.2705		
4		.2697		
5		.2700		
6		.2705		
7		.2700		
8		.2695		
9		.2698		
10		.2700		
11		.2708		
12		.2702		
13		.2700		
14		.2700		
15		.2700		
16		.2705		
17		.2693		
18		.2705		
19		.2700		
20		.2697		
21		.2698		
22		.2696		
23		.2700		
24		.2703		
25		.2700	↓	↓

Drawing No. 200 ; Date of Inspection 6/26/72

[illegible]

Table 8.2-21 Staircase Method Data of Group No. 166 Using the R. R. Moore Machine. 35 Specimens of AISI 1038 Steel Rod with Test Section Diameter, $d = .2700$ in., Radius $r = 1.87$ in. Cutoff at 3×10^6 cycles.

Date of Test	Spec. No.	Added Pan Load lbs	Alternating Stress	Cycles of Operation $\times 10^{-5}$	Remarks*
July 27 '72	2	26.72	38,000	1,061,000	F
28	5	24.77	36,000	3,011,000	N F
28	6	26.72	38,000	1,682,000	F
31	7	24.78	36,000	1,310,000	F
August 1	1	22.85	34,000	3,585,000	N F
2	3	24.78	36,000	3,072,000	N F
2	8	26.72	38,000	646,000	F
2	4	24.78	36,000	835,000	F
3	16	22.85	34,000	3,047,000	N F
3	11	24.78	36,000	11,784,000	N F
4	24	26.72	38,000	20,089,000	N F
7	29	28.65	40,000	3,072,000	N F
7	14	30.58	42,000	311,000	F
7	20	28.65	40,000	587,000	F
8	10	26.72	38,000	1,855,000	F
9	18	24.78	36,000	3,120,000	N F
9	19	26.72	38,000	733,000	F
10	12	24.78	36,000	1,726,000	F
14	27	22.85	34,000	3,213,000	N F
15	32	24.78	36,000	3,521,000	N F
16	17	26.72	38,000	3,102,000	N F
18	9	28.65	40,000	655,000	F
22	31	26.72	38,000	3,492,000	N F
25	23	28.65	40,000	637,000	F
25	26	26.72	38,000	1,390,000	F
28	37	24.78	36,000	3,171,000	N F

* N F - No Failure

F - Failure

Table 8.2-22 Inspection Data for Critical and Major Characteristics of Group No. 166 . 35 Specimens of AISI 1038 Steel 367
D = .373 in. ; L = 2.75 in.
Drawing No. 200 .

Operator: Joe Stultz Date of Test: July 27, 1972

Specimen Number	CHARACTERISTIC			
	Hardness	d= .2700 + .0010 - in.	r= 1.87 + .002 - in.	Surface Finish u-in.
1		.2703	60	4
2		.2705		
3		.2700		
4		.2705		
5		.2697		
6		.2700		
7		.2700		
8		.2705		
9		.2702		
10		.2700		
11		.2700		
12		.2700		
13		.2700		
14		.2705		
15		BAD SPECIMEN		
16		.2700		
17		.2700		
18		.2700		
19		.2698		
20		.2700		
21		.2705		
22		.2697		
23		.2700		
24		.2705		
25		.2700	✓	✓

Drawing No. 200

Operator: Joe Stultz Date of Test: July 27, 1972

[illegible]

8.3 AXIAL FATIGUE MACHINE DATA

Table 8.3-1 Static Ultimate Strength Test Data of Group No. 156 Using the Tinius Olsen Machine
35 Specimens of AISI 1018 Steel.

Date of Test: 10-24-70			Operator: R. W.		Observer(s):					
Specimen Number	Original Diameter in.	Original Cross Section Area in.	Yield Load lb	Yield Stress psi	Ultimate Load lb	Ultimate Stress psi	Breaking Load lb	Breaking Diameter in.	Breaking Area in.	Breaking Stress psi
1	.2500	.0491	2,250	45,825	2,920	59,470	1,750	.122	.0117	149,573
2	.2492	.0487	2,230	45,791	2,930	60,164	1,720	.119	.0111	154,955
3	.2497	.0490	2,300	46,939	2,960	60,408	1,750	.121	.0115	152,174
4	.2496	.0490	2,250	45,918	2,940	60,000	1,690	.124	.0121	139,669
5	.2497	.0490	2,260	46,122	2,940	60,000	1,720	.121	.0115	149,565
6	.2493	.0487	2,260	46,407	2,970	60,986	1,750	.124	.0121	144,628
7	.2494	.0487	2,240	45,996	2,960	60,780	1,710	.121	.0115	148,696
8	.2491	.0487	2,270	46,612	2,960	60,780	1,710	.123	.0119	143,697
9	.2500	.0491	2,230	45,418	2,910	59,267	1,720	.122	.0117	147,008
10	.2496	.0490	2,220	45,306	3,000	61,224	1,730	.120	.0113	153,097
11	.2500	.0491	2,210	45,010	2,940	59,878	1,750	.122	.0117	149,573
12	.2493	.0487	2,250	46,201	2,930	60,164	1,730	.121	.0115	150,435
13	.2497	.0490	2,270	46,327	2,980	60,816	1,740	.121	.0115	151,304
14	.2503	.0491	2,300	46,843	2,970	60,489	1,690	.125	.0123	137,398
15	.2503	.0491	2,260	46,029	2,970	60,489	1,720	.121	.0115	149,565
16	.2484	.0484	2,270	46,901	2,950	60,331	1,720	.121	.0115	149,565
17	.2503	.0491	2,230	45,418	2,970	60,489	1,730	.124	.0121	142,925
18	.2500	.0491	2,130	43,381	2,900	59,063	1,720	.120	.0113	152,212
19	.2495	.0489	2,200	44,990	2,970	60,736	1,730	.122	.0117	147,863
20	.2494	.0488	2,200	45,082	3,000	61,475	1,730	.122	.0117	147,863
21	.2489	.0486	2,230	45,885	2,970	61,111	1,760	.121	.0115	153,043

Table 8.3-1 Static Ultimate Strength Test Data of Group No. 156 Using the Tinius Olsen Machine
35 Specimens of AISI 1018 Steel.

Date of Test: 10-24-70				Operator: R. W.		Observer(s):				
Specimen Number	Original Diameter in.	Original Cross Section 2 Area in.	Yield Load lb	Yield Stress psi	Ultimate Load lb	Ultimate Stress psi	Breaking Load lb	Breaking Diameter in.	Breaking Area in.	Breaking Stress psi
22	.2497	.0489	2,250	46,012	2,970	60,736	1,770	.127	.0127	139,370
23	.2506	.0493	2,250	45,639	2,990	60,649	1,740	.122	.0117	148,718
24	.2492	.0489	2,270	46,421	2,990	61,145	1,760	.120	.0113	155,752
25	.2494	.0488	2,220	45,492	2,980	61,066	1,750	.121	.0115	152,174
26	.2491	.0487	2,210	45,380	2,980	61,191	1,740	.124	.0121	143,802
27	.2497	.0489	2,250	46,012	3,010	61,554	1,750	.120	.0113	154,867
28	.2486	.0485	2,180	44,948	2,900	59,794	1,680	.125	.0123	136,585
29	.2486	.0485	2,200	45,361	2,930	60,412	1,720	.019	.0111	154,955
30	.2493	.0488	2,200	45,082	2,960	60,656	1,760	.124	.0121	145,455
31	.2494	.0488	2,180	44,672	2,910	59,631	1,730	.124	.0121	142,975
32	.2491	.0487	2,180	44,764	2,930	60,164	1,690	.122	.0117	144,444
33	.2497	.0489	2,150	43,967	2,900	59,305	1,720	.121	0.115	149,565
34	.2496	.0489	2,210	45,194	2,980	60,941	1,730	.121	.0115	150,435
35	.2491	.0487	2,200	45,174	2,920	59,959	1,680	.117	.0108	155,555

Yield Stress

Mean* = 45,600 psi
Std. Dev ** = 780 psi

* rounded to nearest 100 psi
** rounded to nearest 10 psi

Ultimate Stress

Mean* = 60,400 psi
Std. Dev.** = 630 psi

Breaking Stress

Mean* = 148,300 psi
Std. Dev.** = 5,160 psi

Table 8.3-2 Test Data for Hardness and Ultimate Strength
 Elongation of Group No. 156 35 Specimens of
 AISI 1018 Steel. $D = .373$ in. ; $L = 9.0$ in. + $1/16$
 Drawing No. 100 ; Date of Test 10-22-70 .

Specimen Number	CHARACTERISTIC			
	Rockwell Hardness B Scale	Brinell Hardness BHN	ΔL on 2 in. Gage Length	Elongation %
1	72	126	0.988	24.4
2	69	118	B.O.	
3	72	126	0.655	32.7
4	73	128	0.548	27.4
5	69	118	0.593	29.6
6	70	121	0.616	30.8
7	74	131	0.634	31.7
8	73	128	0.597	29.9
9	75	134	0.598	29.9
10	74	131	0.588	29.4
11	72	126	B.O.	
12	76	137	0.552	27.6
13	74	131	0.560	28.0
14	70	121	0.530	26.6
15	71	124	0.564	28.7
16	74	131	0.564	28.7
17	66	111	0.672	33.6
18	70	121	0.630	31.5
19	71	124	0.538	26.9
20	72	126	0.639	31.9
21	70	121	0.519	25.9
22	73	128	0.540	27.0
23	74	131	0.559	27.9
24	72	126	0.514	25.7
25	74	131	0.582	29.1

[illegible]

Table S.3-3 Staircase Method Data of Group No. 159. Using the Axial Fatigue Machine.
 35 Specimens of AISI 1018 Steel Rod with Test Section Diameter, $d = 0.075$ in.,
 Radius $r = 2.70$ in. Stress Ratio $r_s = 1.0$. Cutoff at 2×10^6 Cycles.

Date of Test	Spec. No.	Mean Load lb	Mean Stress psi	Alternating Load lb	Alternating Stress psi	Stress Vector psi	Cycles of Operation	Operator	Remarks*
June 72									
11	1	94	21,281	94	21,281	30,096	2,017,000	A.N.V.	N F
12	2	97	21,960	97	21,960	31,057	1,030,000		F
13	3	94	21,281	94	21,281	30,096	2,612,000		N F
14	4	97	21,960	97	21,960	31,057	2,021,000		N F
17	5	100	22,639	100	22,639	32,017	2,325,000		N F
18	6	103	23,319	103	23,319	32,978	1,471,000		F
19	7	100	22,639	100	22,639	32,017	663,000		F
20	8	97	21,960	97	21,960	31,057	2,394,000		N F
21	9	100	22,639	100	22,639	32,017	500,000		F
21	10	97	21,960	97	21,960	31,057	2,025,000		N F
21	11	100	22,639	100	22,639	32,017	2,301,000		N F
23	12	103	23,319	103	23,319	32,978	2,321,000		N F
24	13	106	23,998	106	23,998	33,938	340,000		F
24	14	103	23,319	103	23,319	32,978	413,000		F
26	15	100	22,639	100	22,639	32,017	533,000		F
26	16	97	21,960	97	21,960	31,057	2,035,000		N F
27	17	100	22,639	100	22,639	32,017	366,000		F
27	18	97	21,960	97	21,960	31,057	2,122,000		N F
28	19	100	22,639	100	22,639	32,017	2,001,000		N F
29	20	103	23,319	103	23,319	32,978	841,000		F

* N F - No Failure
 F - Failure

Table 8.3-4 Staircase Method Data of Group No.160. Using the Axial Fatigue Machine.

35 Specimens of AISI 1018 Steel Rod with Test Section Diameter, $d = 0.075$ in.,Radius $r = 2.70$ in. Stress Ratio $r_s = 2.0$. Cutoff at 2×10^6 Cycles.

Date of Test	Spec. No.	Mean Load lb	Mean Stress psi	Alternating Load lb	Alternating Stress psi	Stress Vector psi	Cycles of Operation	Operator	Remarks*
Dec. 71	1	55.5	12,567	111.0	25,133	28,100	7,820,000	R.W.	N F
20	2	57.5	13,014	115.0	26,028	29,100	881,000	R.W.	F
21	3	55.5	12,567	111.0	25,133	28,100	671,000	R.W.	F
22	4	53.5	12,120	107.1	24,239	27,100	2,385,000	R.W.	N F
23	5	55.5	12,567	111.0	25,133	28,100	646,000	R.W.	F
Jan. 72	6	53.5	12,120	107.1	24,239	27,100	2,346,000	R.W.	N F
4	7	55.5	12,567	111.0	25,133	28,100	2,459,000	R.W.	N F
5	8	57.5	13,014	115.0	26,028	29,100	119,000	R.W.	F
6	9	55.5	12,567	111.0	25,133	28,100	568,100	R.W.	F
Feb. 72	10	53.5	12,120	107.1	24,239	27,100	304,000	A.N.V.	F
26	11	51.5	11,672	103.1	23,344	26,100	4,917,000	A.N.V.	N F
29	12	53.5	12,120	107.1	24,239	27,100	2,633,000	A.N.V.	N F
Mar. 72	13	55.5	12,567	111.0	25,133	28,100	2,462,000	A.N.V.	N F
2	14	57.5	13,014	115.0	26,028	29,100	638,000	A.N.V.	F
3	15	55.5	12,567	111.0	25,133	28,100	2,472,000	A.N.V.	N F
4	16	57.5	13,014	115.0	26,028	29,100	3,245,000	A.N.V.	N F
17	17	59.5	13,461	118.9	26,922	30,100	315,000	A.N.V.	F
18	18	57.5	13,014	115.0	26,028	29,100	582,000	A.N.V.	F
May 72	19	55.5	12,567	111.0	25,133	28,100	93,000	A.N.V.	F
22	20	53.5	12,120	107.1	24,239	27,100	247,000	A.N.V.	F

* N F - No Failure
F - Failure

Table 8.3-4

Staircase Method Data of Group No.160 . Using the Axial Fatigue Machine.

35 Specimens of AISI 1018 Steel Rod with Test Section Diameter, $d = 0.075$ in.,Radius $r = 2.70$ in. Stress Ratio $r_s = 2.0$. Cutoff at 2×10^6 Cycles.

Date of Test	Spec. No.	Mean Load lb	Mean Stress psi	Alternating Load lb	Alternating Stress psi	Stress Vector psi	Cycles of Operation	Operator	Remarks*
23	21	51.5	11,672	103.1	23,344	26,100	2,660,000	A.N.V.	N F
24	22	53.5	12,120	107.1	24,239	27,100	2,168,000	A.N.V.	N F
25	23	55.5	12,567	111.0	25,133	28,100	135,000	A.N.V.	F
26	24	53.5	12,120	107.1	24,239	27,100	627,000	A.N.V.	F
28	25	51.5	11,672	103.1	23,344	26,100	2,590,000	A.N.V.	N F
29	26	53.5	12,120	107.1	24,239	27,100	2,569,000	A.N.V.	N F
30	27	55.5	12,567	111.0	25,133	28,100	420,000	A.N.V.	F
July 72	28	53.5	12,120	107.1	24,239	27,100	568,000	A.N.V.	F
Aug. 72	29	51.5	11,672	103.1	23,334	26,100	2,315,000	A.N.V.	N F
9	30	53.5	12,120	107.1	24,239	27,100	2,656,000	A.N.V.	N F
10	31	55.5	12,567	111.0	25,133	28,100	2,427,000	A.N.V.	N F
11	32	57.5	13,014	115.0	26,028	29,100	301,000	A.N.V.	F
11	33	55.5	12,567	111.0	25,133	28,100	1,692,000	A.N.V.	F
13	34	53.5	12,120	107.1	24,239	27,100	2,269,100	A.N.V.	N F
14	35	55.5	12,567	111.0	25,133	28,100	1,098,000	A.N.V.	F

* N F - No Failure

F - Failure

Table 8.3-5

Staircase Method Data of Group No. 161. Using the Axial Fatigue Machine.

36 Specimens of AISI 1018 Steel Rod with Test Section Diameter, $d = 0.075$ in.,Radius $r = 2.70$ in. Stress Ratio $r_s = \infty$. Cutoff at 2×10^6 Cycles.

Date of Test	Spec. No.	Mean Load lb	Mean Stress psi	Alternating Load lb	Alternating Stress psi	Stress Vector psi	Cycles of Operation	Operator	Remarks*
Oct. 71	1	0	0	103.3	23,386	23,386	2,855,000	R.W.	N F
26	2			107.7	24,383	24,383	2,689,000	R.W.	N F
Nov. 71	3			112.1	25,379	25,379	689,000	R.W.	F
5	4			107.7	24,383	24,383	7,695,000	R.W.	N F
17	5			112.1	25,379	25,379	2,637,000	R.W.	N F
18	6			116.5	26,375	26,375	2,699,000	R.W.	N F
22	7			120.9	27,371	27,371	20,000	R.W.	F
23	8			116.5	26,375	26,375	585,000	R.W.	F
24	9			112.1	25,379	25,379	7,645,000	R.W.	N F
27	10			116.5	26,375	26,375	5,235,000	R.W.	N F
29	11			120.9	27,371	27,371	178,000	R.W.	F
30	12			116.5	26,375	26,375	681,000	R.W.	F
Dec. 71	13			112.1	25,379	25,379	2,593,000	R.W.	N F
2	14			116.5	26,375	26,375	109,000	R.W.	F
2	15			112.1	25,379	25,379	405,000	R.W.	F
3	16			107.7	24,383	24,383	2,364,000	R.W.	N F
4	17			112.1	25,379	25,379	5,552,000	R.W.	N F
6	18			116.1	26,375	26,375	186,000	R.W.	F
7	19			112.1	25,379	25,379	2,638,000	R.W.	N F
8	20			116.5	26,375	26,375	2,302,000	R.W.	N F

* N F - No Failure

F - Failure

Table 8.3-6 Staircase Method Data of Group No. 63. Using the Axial Fatigue Machine.
 25 Specimens of AISI 4130 Steel Rod with Test Section Diameter, $d = 0.047$ in.,
 Radius $r = 2.70$ in. Stress Ratio $r_s = 0.2$. Cutoff at 2×10^6 Cycles.

Date of Test	Spec. No.	Mean Load lb	Mean Stress psi	Alternating Load lb	Alternating Stress psi	Stress Vector psi	Cycles of Operation	Operator	Remarks*
Feb. 71	12	138	79,552	27.6	15,910	81,128	444,000	W.F.R.	F
28	30	134	77,246	26.8	15,449	78,776	2,257,000		N F
Mar. 71	31	138	79,552	27.6	15,910	81,128	2,078,000		N F
3	16	142	81,858	28.4	16,371	83,479	10,000		F
3	8	138	79,552	27.6	15,910	81,128	2,325,000		N F
4	11	142	81,858	28.4	16,371	83,479	5,000		F
4	5	138	79,552	27.6	15,910	81,128	2,020,000		N F
5	9	142	81,858	28.4	16,371	83,479	123,000		F
5	7	138	79,552	27.6	15,910	81,128	4,000		F
5	20	134	77,246	26.8	15,449	78,776	5,945,000		N F
7	36	138	79,552	27.6	15,910	81,128	3,000		F
7	37	134	77,246	26.8	15,449	78,776	2,118,000		N F
8	24	138	79,552	27.6	15,910	81,128	891,000		F
9	15	134	77,246	26.8	15,449	78,776	2,404,000		N F
10	19	138	79,552	27.6	15,910	81,128	2,019,000		N F
11	23	142	81,858	28.4	16,371	83,479	3,000		F
11	46	138	79,552	27.6	15,910	81,128	2,583,000		N F
12	42	142	81,858	28.4	16,371	83,479	14,000		F
12	25	138	79,552	27.6	15,910	81,128	259,000		F
12	41	134	77,246	26.8	15,449	78,776	2,167,000		N F

* NF - No Failure
 F - Failure

9.0 REDUCED TEST DATA

This section presents the results of processing test data experimental test data with the data reduction and analysis computer programs. Calibration data are presented in summary tables with the parameters calculated for the normal distribution. Results of cycles-to-failure testing are shown in histogram overscribed with distribution curves for the normal, lognormal (base e), and Weibull distributions. The calculated distribution parameters and goodness-of-fit test results are listed below the curves.

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9.1 WIRE FATIGUE MACHINE DATA

Table 9.1-1 Angle of Deflection Vs. Mean Measured Strain in Wire
Fatigue Research Machine Calibration Specimen for Each
One of the Four Machines.

Angle of Deflection Degrees	Mean Strain* - (μ -in/in.)			
	Machine #1	Machine #2	Machine #3	Machine #4
0	0	0	0	0
4	137.5	116.5	139	111.5
8	280.5	274.5	323	260.5
12	493.5	621	681	546.5
16	848	1,001	1012.5	880
18	1,025	1175.5	1,175	1056.5
20	1,202	1,346	1342.5	1,219
22	1365.5	1,517	1,501	1374.5
24	1,530	1,686	1,663	1539.5
26	1,679	1,834	1,814	1,696

*Data came from Tables 1 thru 4.

Table 9.1-2 Summary of Static Axial Calibration Data For The 0.040 in. Diameter Wire Specimen Used in Calibrating the Wire Fatigue Machines.

Pan Weight lb	Stress psi	Group #1 μ - in/in		Group #2 μ - in/in		Group #3 μ - in/in		Group #4 μ - in/in	
		L*	UL**	L	UL	L	UL	L	UL
0.00	0	0	0	0	0	0	0	0	0
7.00	5,499	26	28	25	27	25	29	28	29
10.50	8,248	71	69	67	72	69	75	75	76
14.00	10,997	117	121	116	118	115	122	121	122
17.50	13,746	168	174	166	170	165	173	169	174
21.00	16,496	215	222	213	219	212	223	218	225
24.50	19,245	265	272	260	272	261	272	270	276
28.00	21,995	317	323	316	320	311	321	320	324
31.50	24,744	371	374	368	372	364	374	374	378
35.00	27,493	423	426	420	424	411	414	426	430

*Loading cycle

**Unloading cycle

Table 9.1-3 Calculation of The Standard Deviation For Strain For Each Stress Level Given in Table 7.

5,499 psi		8,248 psi		10,997 psi		13,746 psi		16,496 psi	
Strain in μ -in/in		Strain in μ -in/in		Strain in μ -in/in		Strain in μ -in/in		Strain in μ -in/in	
$(X_i - \bar{X})$	$(X_i - \bar{X})^2$	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$
-1.125	1.265	-.75	.5625	-2	4	-1.875	3.515	-3.375	11.390
.875	.765	-2.75	7.5625	2	4	4.125	17.015	3.625	13.140
-2.125	4.515	-2.75	22.5625	-3	.9	-3.875	15.015	-5.375	28.890
-.125	.015	.25	.0625	-1	1	.125	.015	.625	.390
-2.125	4.515	-2.75	7.5625	-4	16	-4.875	23.765	-6.375	40.640
1.875	3.515	3.25	10.5625	3	9	3.125	9.765	4.625	21.390
.875	.765	3.25	10.5625	2	4	-.875	.765	-.375	.140
1.875	3.515	4.25	18.0625	3	9	4.125	17.015	6.625	43.890
$\frac{\Sigma(X-\bar{X})^2}{n} = 2.358$		$\frac{\Sigma(X-\bar{X})^2}{n} = 9.687$		$\frac{\Sigma(X-\bar{X})^2}{n} = 7$		$\frac{\Sigma(X-\bar{X})^2}{n} = 2.645$		$\frac{\Sigma(X-\bar{X})^2}{n} = 19.98$	
Std. Dev.=1.5		Std.Dev.= 3.1		Std. Dev. = 2.6		Std.Dev.= 3.3		Std.Dev. = 4.5	

Table 9.1-3 Continued

19,245 psi		21,995 psi		24,744 psi		27,493 psi	
Strain in μ -in/in ($X_i - \bar{X}$)	($X_i - \bar{X}$) ²	Strain in μ -in/in ($X_i - \bar{X}$)	($X_i - \bar{X}$) ²	Strain in μ -in/in ($X_i - \bar{X}$)	($X_i - \bar{X}$) ²	Strain in μ -in/in ($X_i - \bar{X}$)	($X_i - \bar{X}$) ²
-3.5	12.25	-2	4	-.875	.765	1.25	1.625
3.5	12.25	4	16	2.125	4.515	4.25	18.0625
-8.5	72.25	-3	9	-3.875	15.01	-1.75	3.0625
3.5	12.25	1	1	.125	.0156	2.25	5.0625
-7.5	56.25	-8	64	-7.875	62.01	-10.75	115.5625
3.5	12.25	2	4	2.125	4.515	7.75	60.0625
1.5	2.25	1	1	2.125	4.515	4.25	18.0625
7.5	56.25	5	25	6.125	39.51	8.25	68.0625
$\frac{\Sigma(X-\bar{X})^2}{n} = 29.5$		$\frac{\Sigma(X-\bar{X})^2}{n} = 15.5$		$\frac{\Sigma(X-\bar{X})^2}{n} = 16.356$		$\frac{\Sigma(X-\bar{X})^2}{n} = 36.18$	
Std.Dev. = 5.4		Std.Dev. = 3.9		Std.Dev. = 4.0		Std.Dev. = 6.0	

Table 9.1-4 Static Axial Stress Versus Measured Strain for The Wire Specimen Used in Calibrating The Wire Fatigue Research Machines. Mean wire diameter $\bar{D} = .040263$ in.

Pan Weight Pounds	Static Stress psi	Mean Strain* μ - in/in	Standard Deviation of Strain μ - in/in
0	0	0	0
7.00	5,499	27	1.5
10.50	8,248	72	3.1
14.00	10,997	119	2.6
17.50	13,746	170	3.3
21.00	16,496	218	4.5
24.50	19,245	269	5.4
28.00	21,995	319	3.9
31.50	24,744	372	4.0
35.00	27,493	422	6.0

*Average of values given in Table 9.1-5

Table 9.1-5 Actual Specimen Stress Versus Test Specimen Deflection Angle for Each Wire Fatigue Research Machine.

Angle of Deflection Degree	Stress in psi Using The Mean Strain From Calibration And The Static Axial Stress Versus Strain Calibration Chart.			
	Machine #1	Machine #2	Machine #3	Machine #4
0	0	0	0	0
4	11,882	10,714	11,965	10,442
8	19,801	19,469	22,154	18,695
12	31,597	38,657	41,980	34,532
16	51,228	59,701	60,338	53,001
18	61,030	69,365	69,337	62,775
20	70,833	78,807	78,613	71,774
22	79,887	88,277	87,391	80,385
24	88,997	97,636	96,362	89,523
26	97,248	105,832	104,725	98,190

Table. 9.1-6 Reduced Data for Group 87 , AISI 1038 Steel, Wire
Fatigue Machine No.2 .

Staircase method at 2×10^6 cycles
Specimen: D = 0.0626
Number of Useful Specimens: 69

Alternating Stress psi	i	n_i Failures	in_i	$i^2 n_i$
57,500	5	4	20	100
55,000	4	8	32	128
52,500	3	13	39	117
50,000	2	4	8	16
47,500	1	3	3	3
45,000	0	1	0	0
		N = 33	A = 102	B = 364

d = stress increment = 2,500 psi

X_0 = lowest stress level = 45,000 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N - 1/2] = 45,000 + 2,500 \left[\frac{102}{33} - \frac{1}{2} \right]$$

$$\bar{X} = 51,477 \text{ psi} \approx 51,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d[(NB-A^2)/N^2 + 0.029] = 1.620 (2,500) \left[\frac{(33)(364) - (102)^2}{(33)^2} + 0.029 \right]$$

$$s = 6,097.6 \text{ psi} \approx 6,100 \text{ psi}^{**}$$

This information supersedes the information reported in
Table 15.3.1.2.1, p. 392 of [IV] .

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

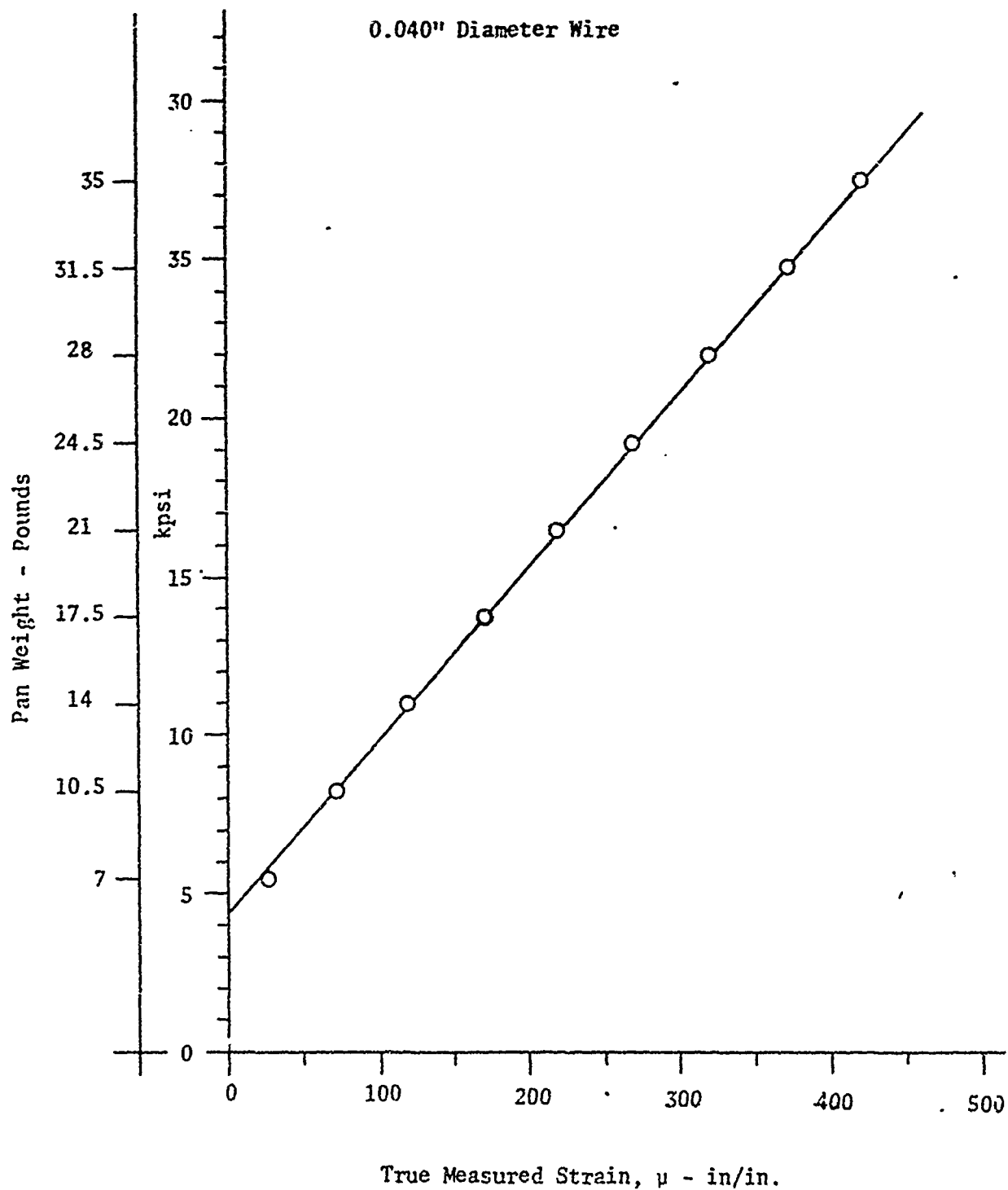
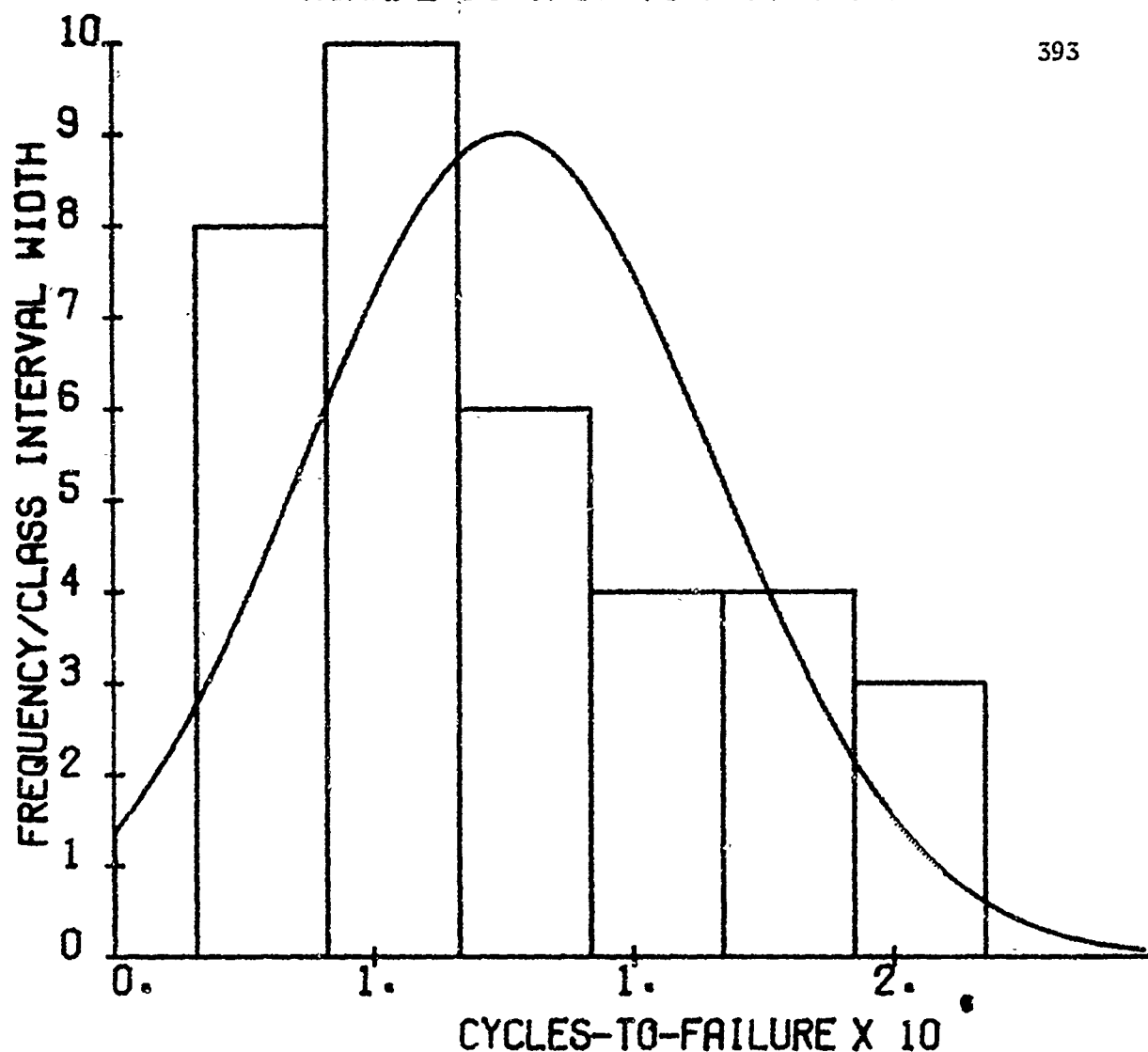


Fig. 9.1-1 Calibration Chart of Stress Vs. Measured Strain for Calibration of Fatigue Research Machines (See Table 9).

NORMAL DISTRIBUTION PARAMETERS

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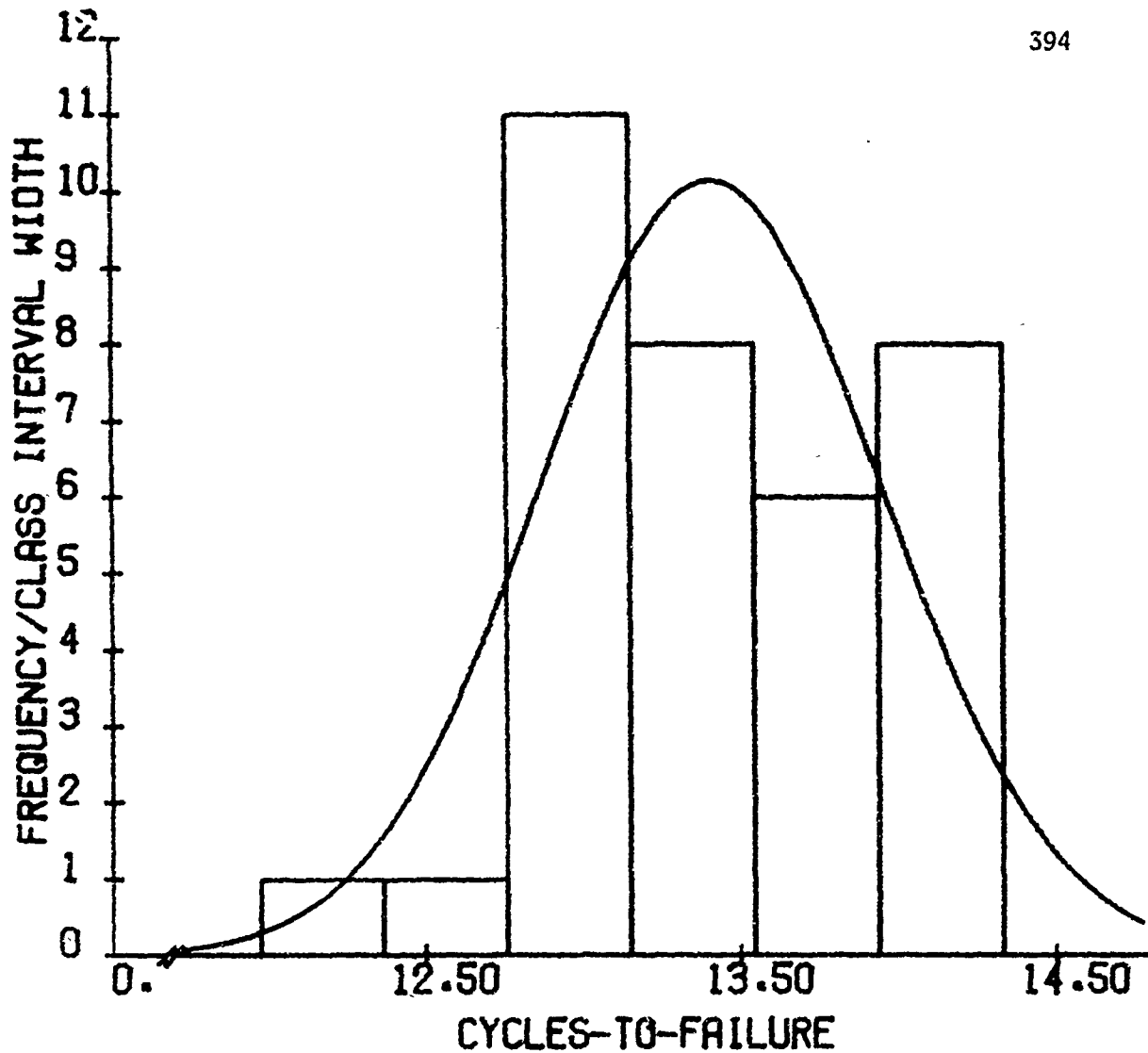


MEAN VALUE:	760785.7 CYCLES
STANDARD DEVIATION:	392078.4 CYCLES
KOLMOGOROV-SMIRNOV TEST:	0.132
CHI-SQUARED TEST:	3.870
SKEWNESS:	0.692
KURTOSIS:	2.452

FIG. 9.1-2 CYCLES-TO-FAILURE DIST OF GROUP NO. 129
 USING WIRE FATIGUE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 67,700 PSI. BEND ANGLE
 19.5 DEGREES. COAST-DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

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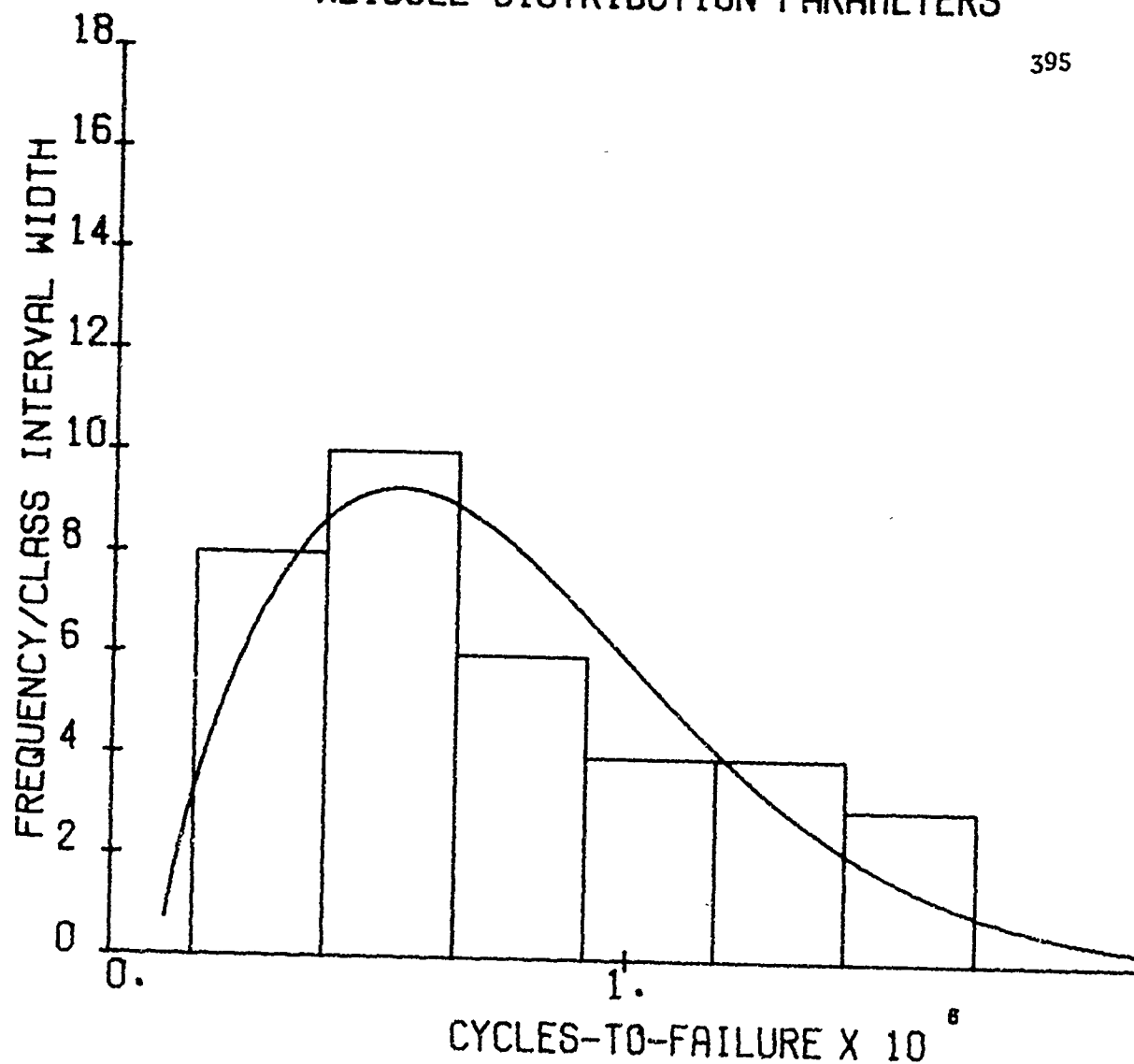


MEAN VALUE: 13.408 CYCLES
 STANDARD DEVIATION: 0.541 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.058
 CHI-SQUARED TEST: 2.208
 SKEWNESS: -0.288
 KURTOSIS: 2.805

FIG. 9.1-3 CYCLES-TO-FAILURE DIST OF GROUP NO. 129
 USING WIRE FATIGUE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 67,700 PSI. BEND ANGLE
 19.5 DEGREES. COAST-DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

395



KOLMOGOROV-SMIRNOV TEST: 0.078

CHI-SQUARED TEST: 2.127

WEIBULL SLOPE (BETA): 1.725

MINIMUM LIFE (GAMMA): 99000

SCALE PARAMETER (ETA): 751226

FIG. 9.1-4

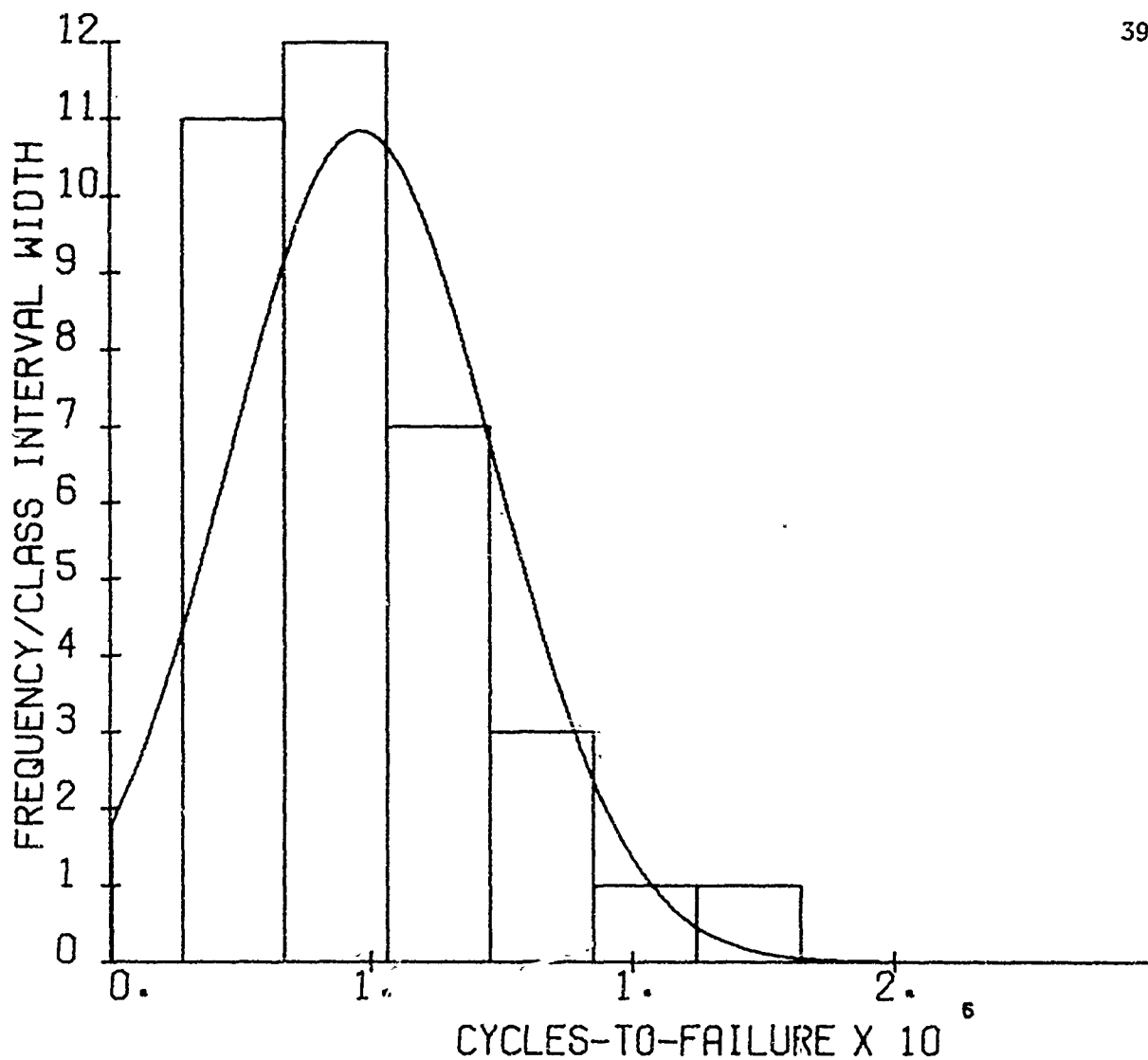
CYCLES-TO-FAILURE DISTRIBUTION

SL=67700 PSI

GROUP=129

NORMAL DISTRIBUTION PARAMETERS

396

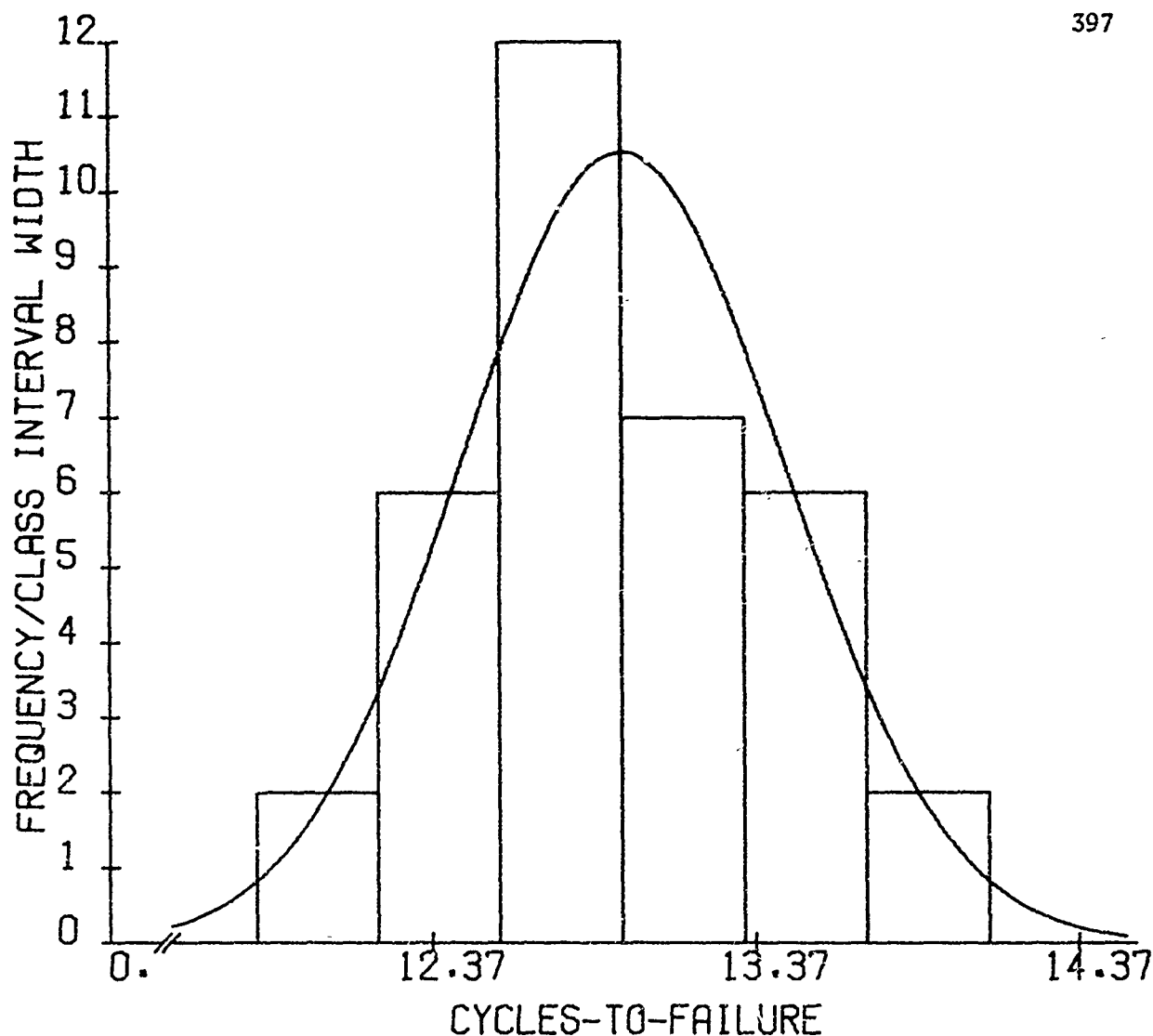


MEAN VALUE: 481634.3 CYCLES
 STANDARD DEVIATION: 254057.1 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.168
 CHI-SQUARED TEST: 0.931
 SKEWNESS: 1.299
 KURTOSIS: 4.752

FIG. 9.1-5 CYCLES-TO-FAILURE DIST OF GROUP NO= 130
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 70,000 PSI. BEND ANGLE
 20.0 DEGREES. COAST DOWN CYCLES 200

LOG NORMAL DISTRIBUTION PARAMETERS

397

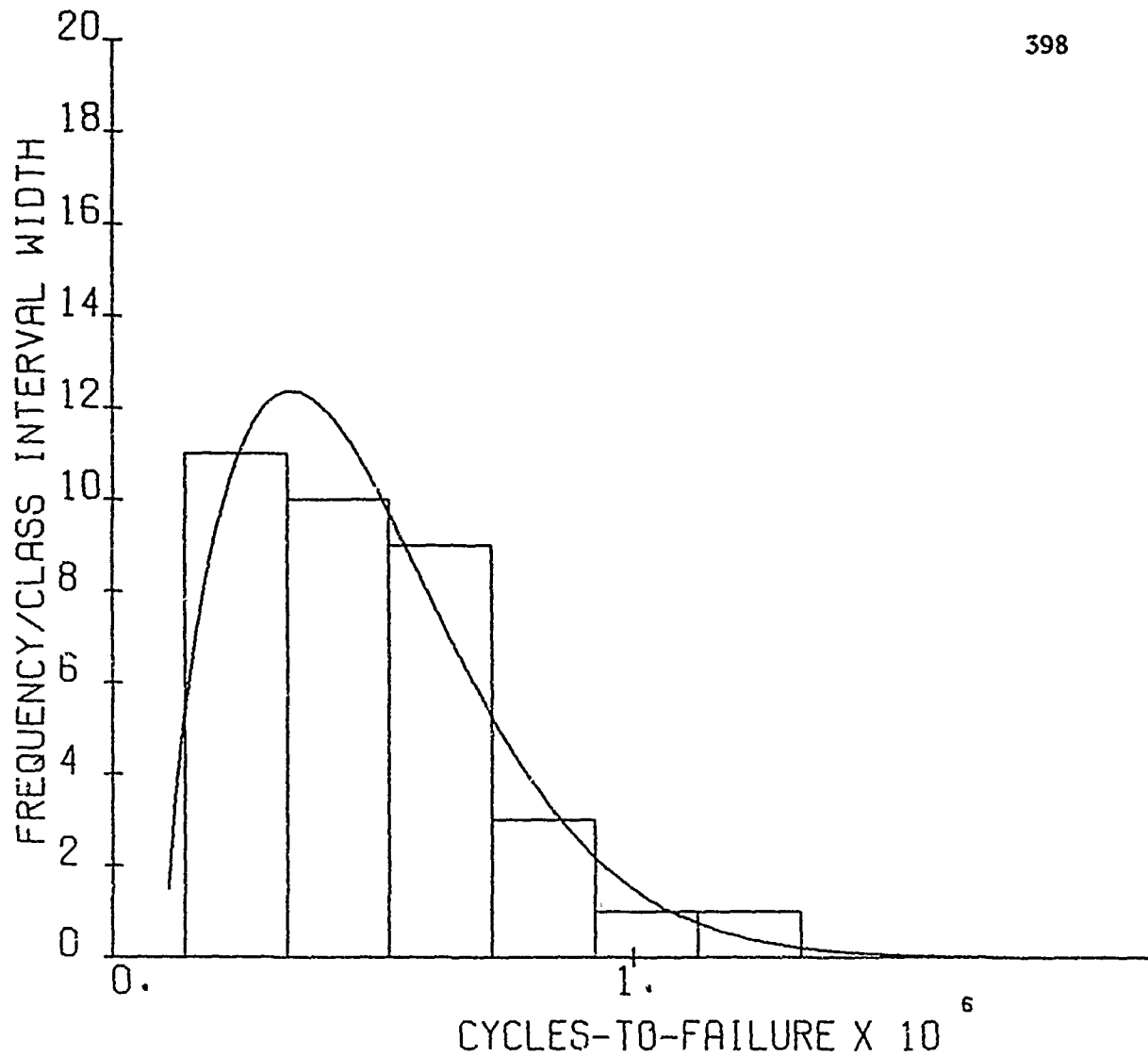


MEAN VALUE: 12.962 CYCLES
 STANDARD DEVIATION: 0.502 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.101
 CHI-SQUARED TEST: 1.323
 SKEWNESS: 0.065
 KURTOSIS: 2.731

FIG. 9.1-6 CYCLES-TO-FAILURE DIST OF GROUP NO= 130
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 70,000 PSI. BEND ANGLE
 20.0 DEGREES. COAST DOWN CYCLES 200

WEIBULL DISTRIBUTION PARAMETERS

398



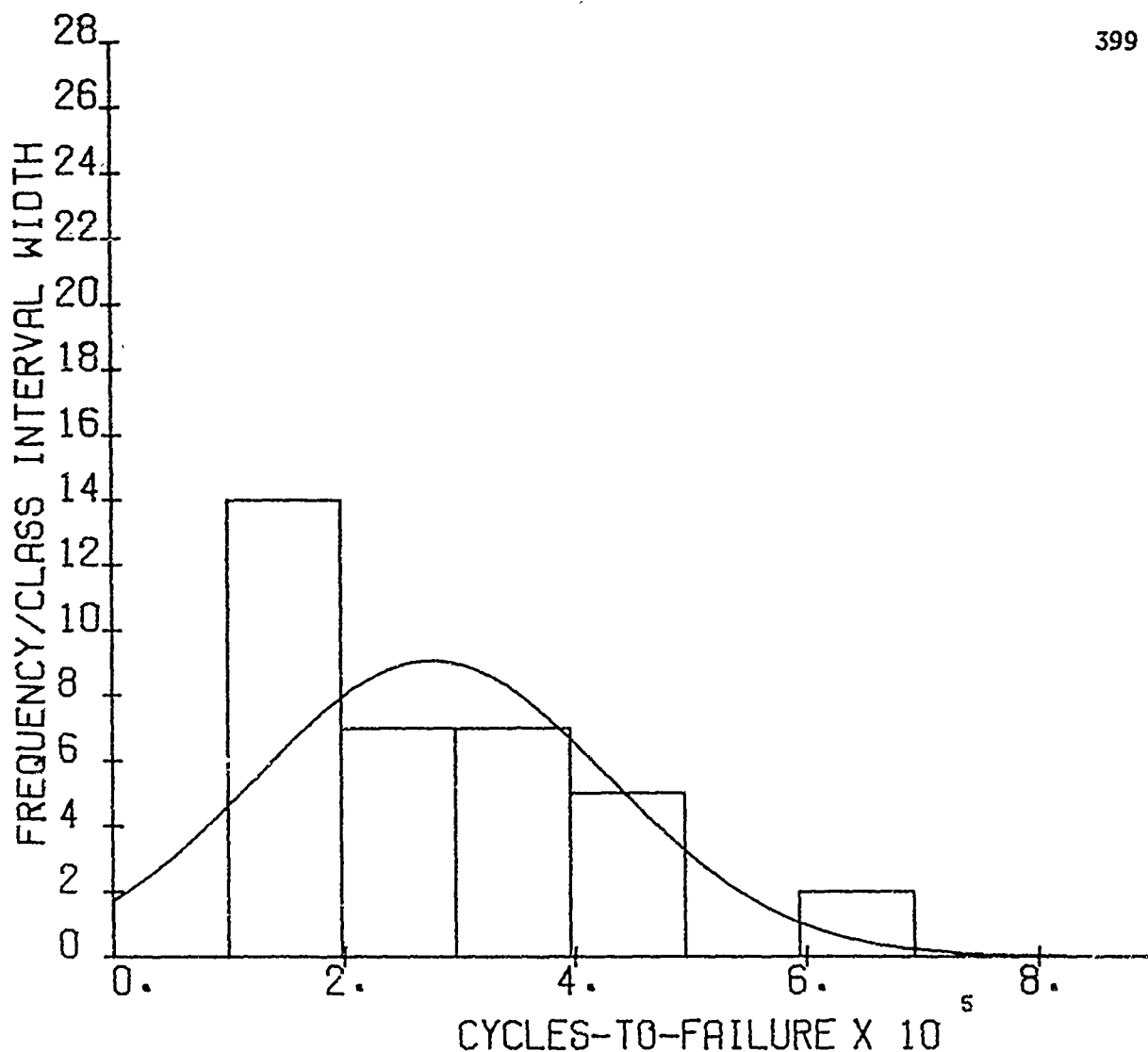
KOLMOGOROV-SMIRNOV TEST: 0.124
 CHI-SQUARED TEST: 8.102
 WEIBULL SLOPE (BETA): 1.638
 MINIMUM LIFE (GAMMA): 101899
 SCALE PARAMETER (ETA): 429638

FIG. 9.1-7

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=130
 SL=70000 PSI

NORMAL DISTRIBUTION PARAMETERS

399

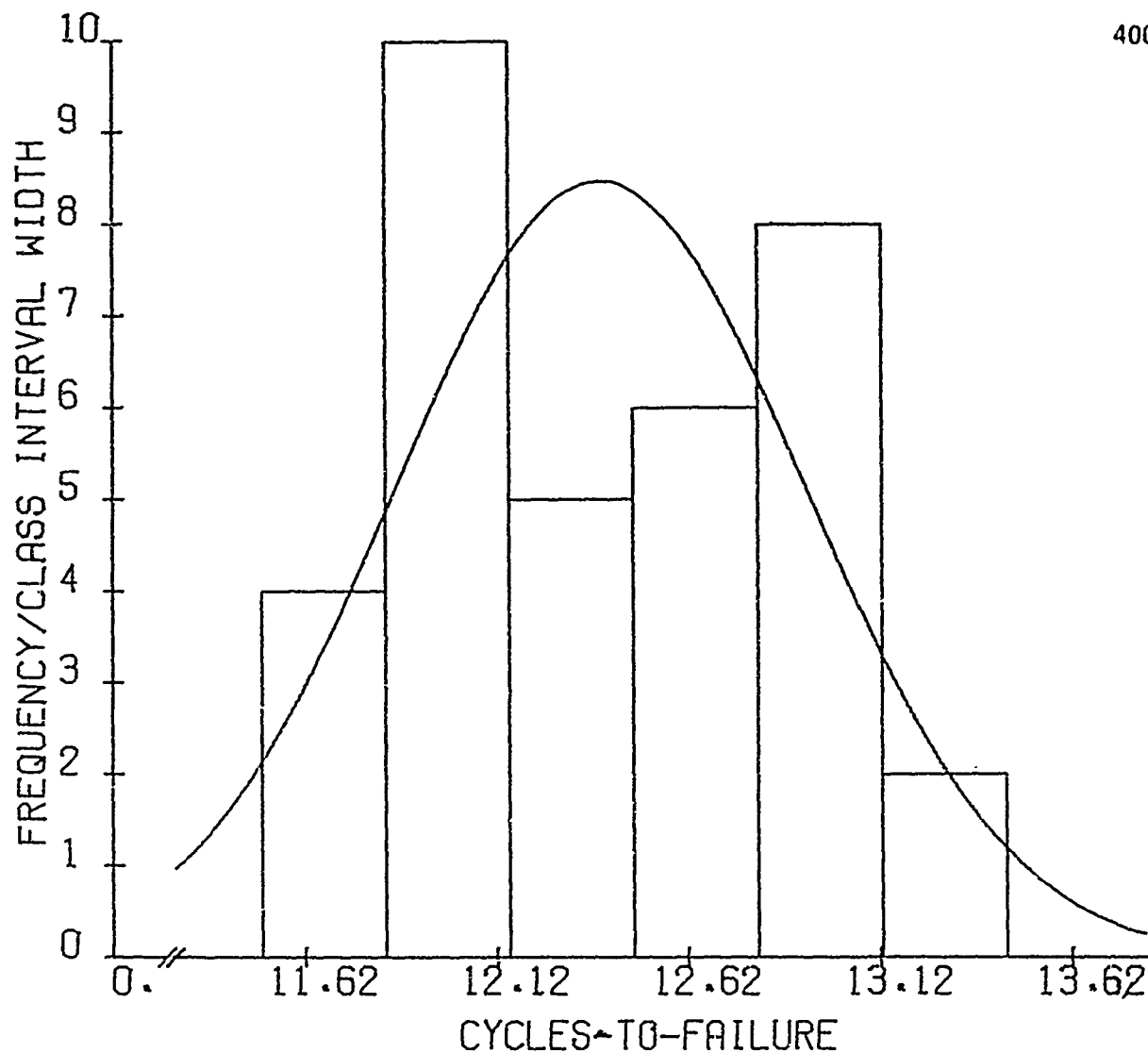


MEAN VALUE: 276888.6 CYCLES
 STANDARD DEVIATION: 152228.3 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.165
 CHI-SQUARED TEST: 1.624
 SKEWNESS: 1.025
 KURTOSIS: 3.491

FIG. 9.1-8 CYCLES-TO-FAILURE DIST OF GROUP NO. 131
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 72,500 PSI. BEND ANGLE
 20.5 DEGREES. COAST DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETER.

400

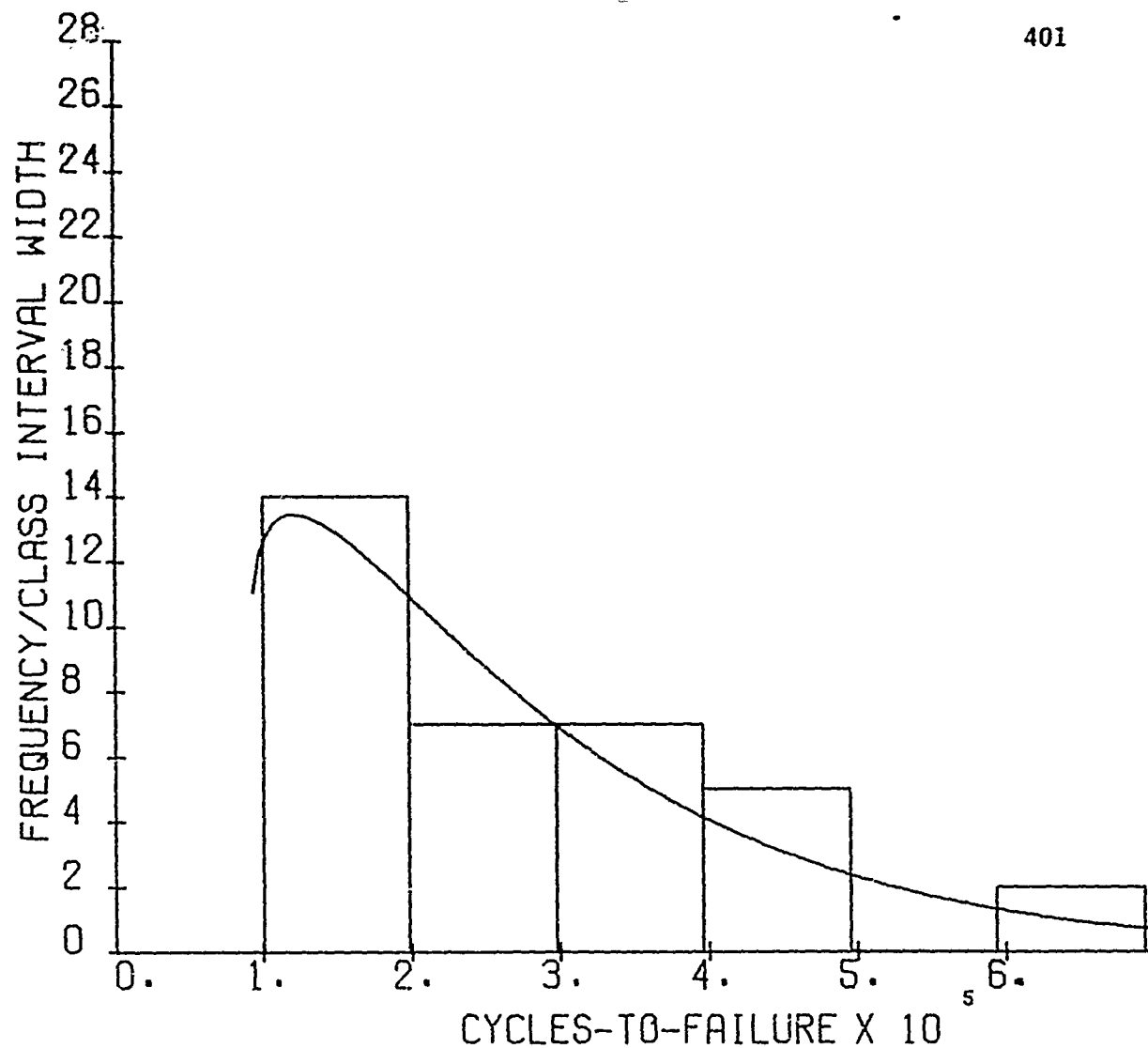


MEAN VALUE: 12.393 CYCLES
 STANDARD DEVIATION: 0.533 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.096
 CHI-SQUARED TEST: 2.801
 SKEWNESS: 0.146
 KURTOSIS: 2.062

FIG. 9.1-9 CYCLES-TO-FAILURE DIST OF GROUP NO. 131
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE, FIXED ALTERNATING
 STRESS LEVEL OF 72,500 PSI, BEND ANGLE
 20.5 DEGREES, COAST DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

401



KOLMOGOROV-SMIRNOV TEST: 0.066

CHI-SQUARED TEST: 3.674

WEIBULL SLOPE (BETA): 1.134

MINIMUM LIFE (GAMMA): 90099

SCALE PARAMETER (ETA): 201481

FIG. 9.1-10

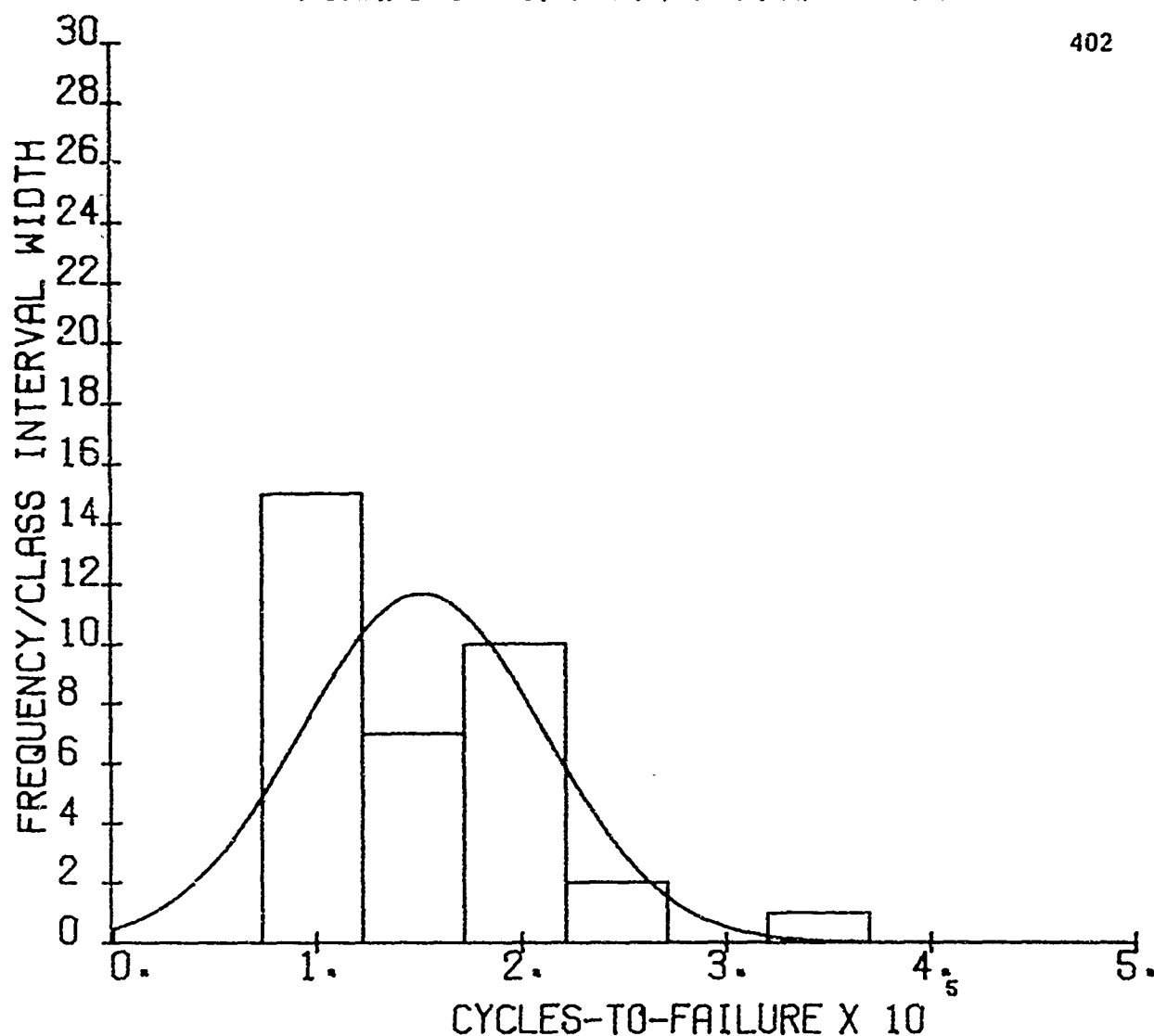
CYCLES-TO-FAILURE DISTRIBUTION

GROUP=131

SL=72500 PSI

NORMAL DISTRIBUTION PARAMETERS

402

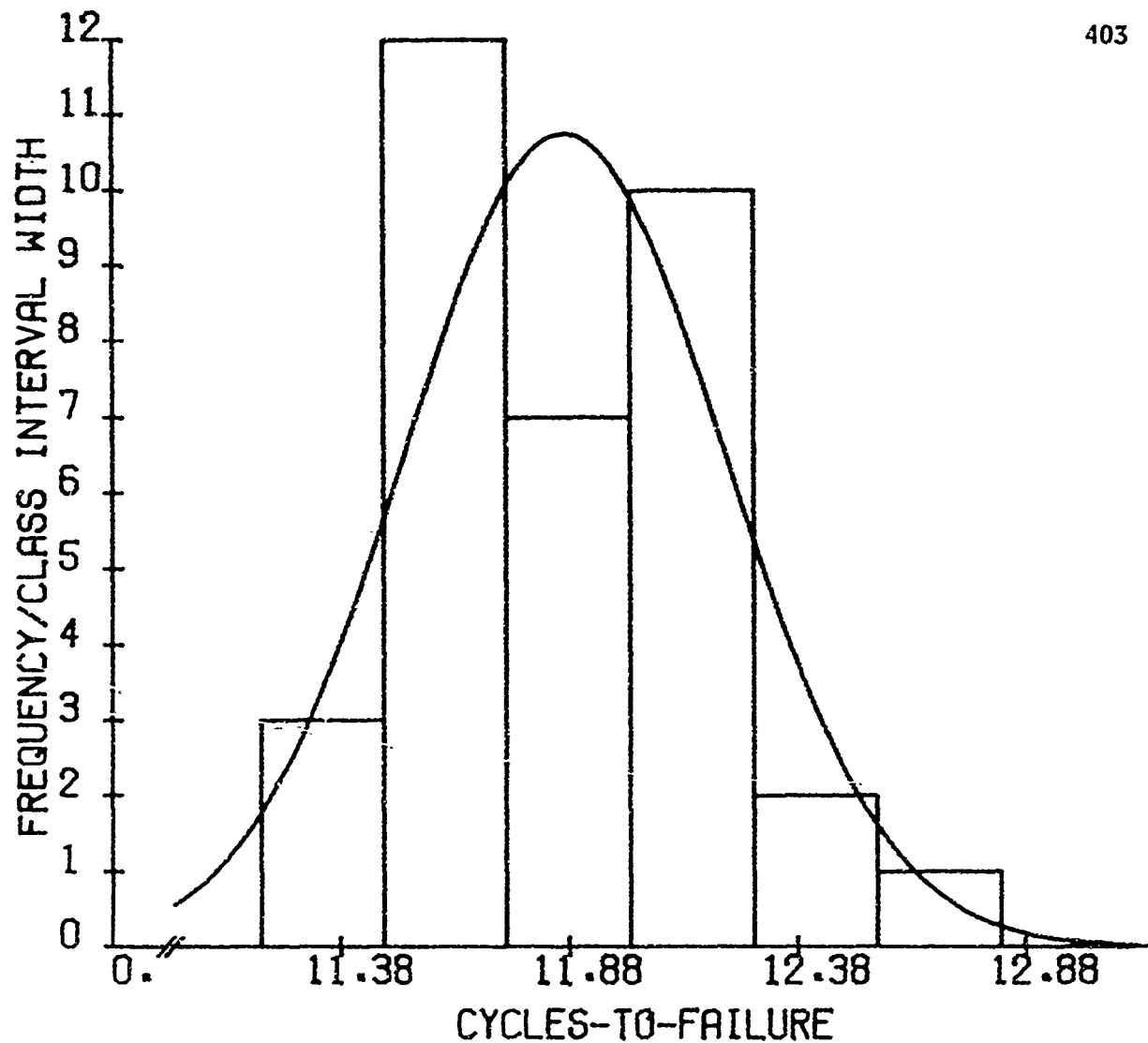


MEAN VALUE: 151697.1 CYCLES
 STANDARD DEVIATION: 59163.8 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.172
 CHI-SQUARED TEST: 3.204
 SKEWNESS: 1.526
 KURTOSIS: 6.232

FIG. 9.1-11 CYCLES-TO-FAILURE DIST OF GROUP NO= 132
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 74,700 PSI. BEND ANGLE
 21.0 DEGREES. COAST DOWN CYCLES 200

LOG NORMAL DISTRIBUTION PARAMETERS

403

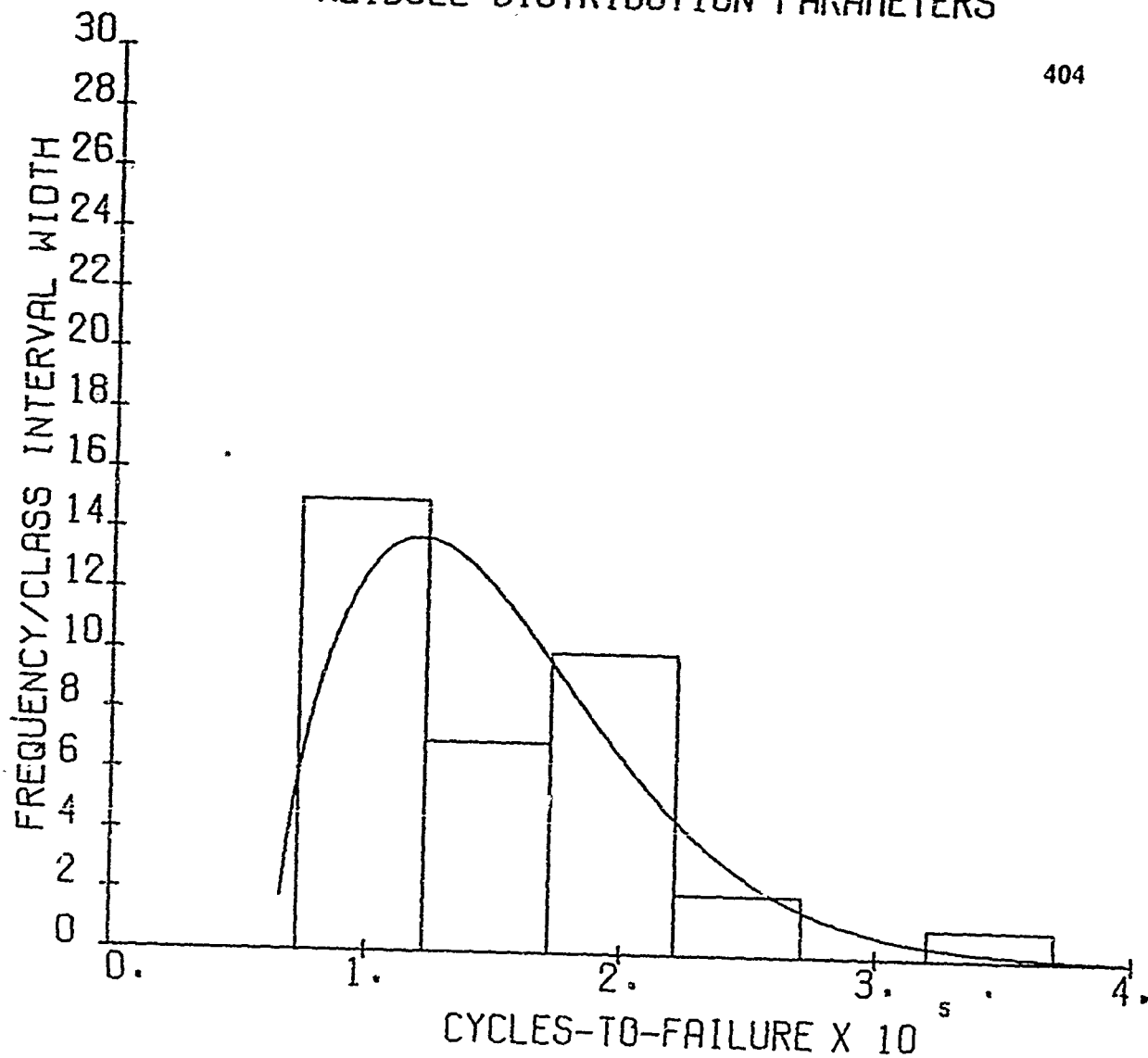


MEAN VALUE:	11.867	CYCLES
STANDARD DEVIATION:	0.351	CYCLES
KOLMOGOROV-SMIRNOV TEST:	0.112	
CHI-SQUARED TEST:	1.725	
SKEWNESS:	0.496	
KURTOSIS:	2.861	

FIG. 9.1-12 CYCLES-TO-FAILURE DIST OF GROUP NO= 132
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 74,700 PSI. BEND ANGLE
 21.0 DEGREES. COAST DOWN CYCLES 200

WEIBULL DISTRIBUTION PARAMETERS

404



KOLMOGOROV-SMIRNOV TEST: 0.114

CHI-SQUARED TEST: 4.097

WEIBULL SLOPE (BETA): 1.642

MINIMUM LIFE (GAMMA): 65399

SCALE PARAMETER (ETA): 96714

FIG. 9.1-13

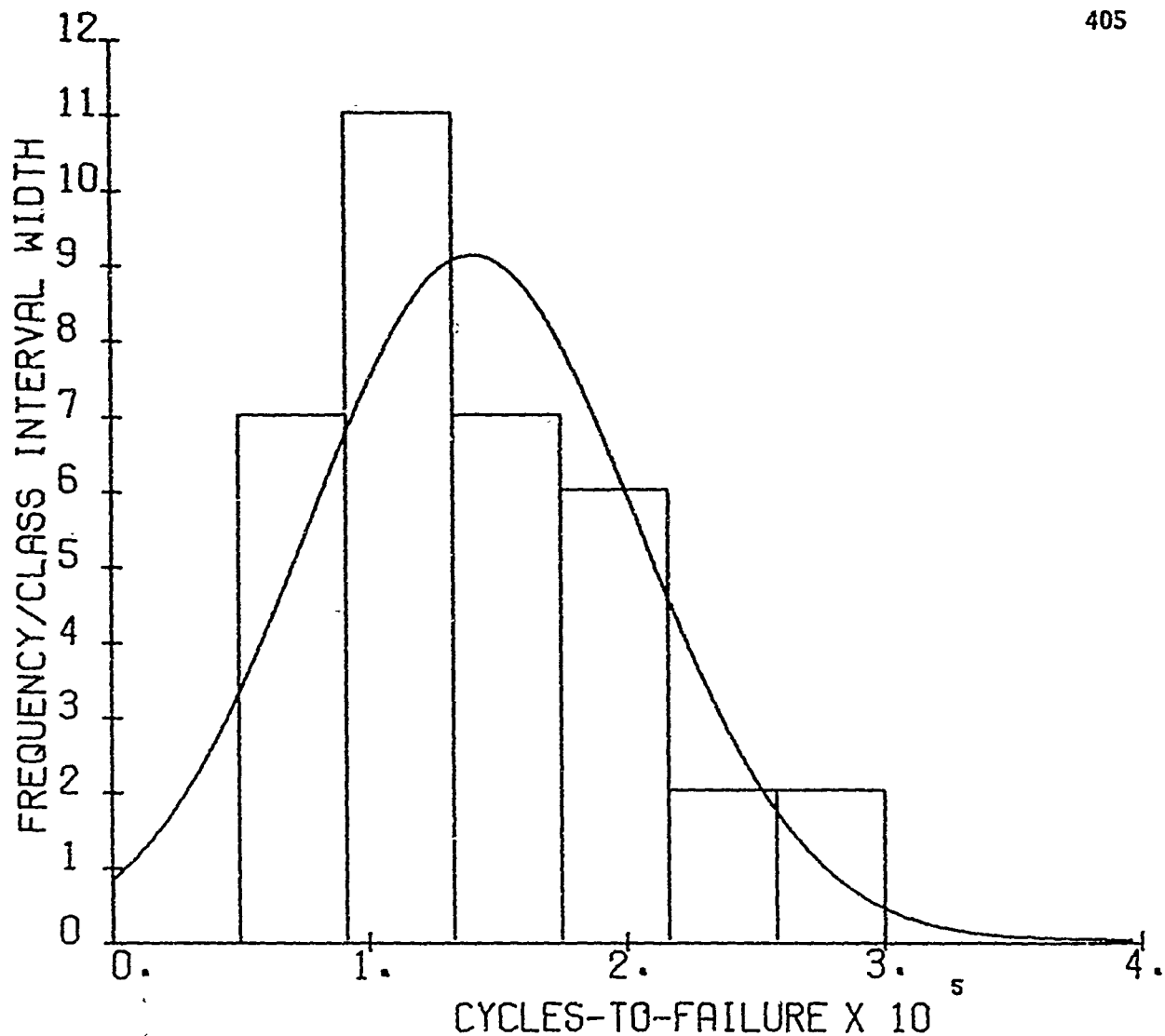
CYCLES-TO-FAILURE DISTRIBUTION

GROUP=132

SL=74700 PSI

NORMAL DISTRIBUTION PARAMETERS

405

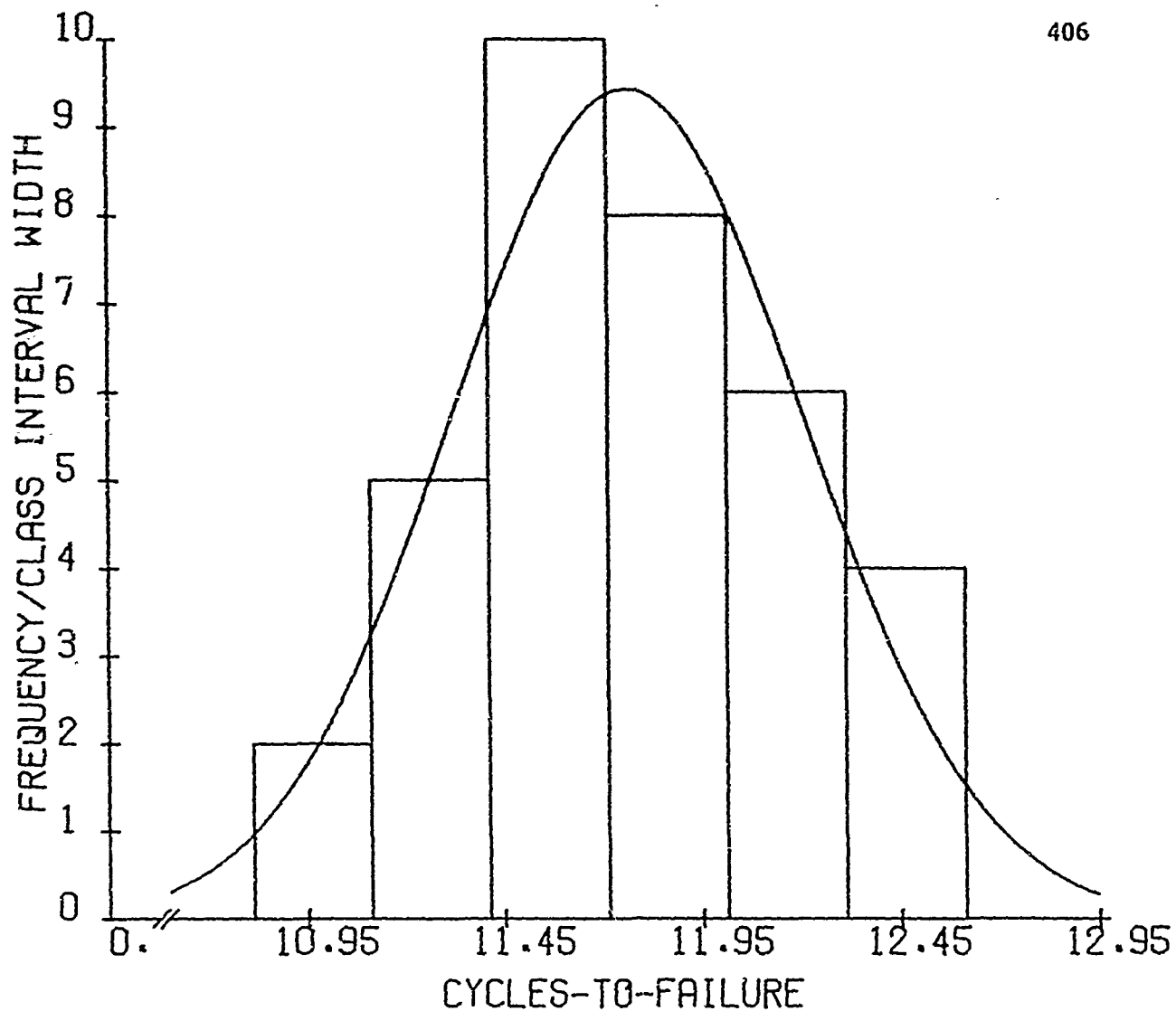


MEAN VALUE: 141077.1 CYCLES
 STANDARD DEVIATION: 64047.8 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.171
 CHI-SQUARED TEST: 1.462
 SKEWNESS: 0.905
 KURTOSIS: 3.091

FIG. 9.1-14 CYCLES-TO-FAILURE DIST OF GROUP NO= 133
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 77,800 PSI. BEND ANGLE
 21.5 DEGREES. COAST DOWN CYCLES 200

LOG NORMAL DISTRIBUTION PARAMETERS

406

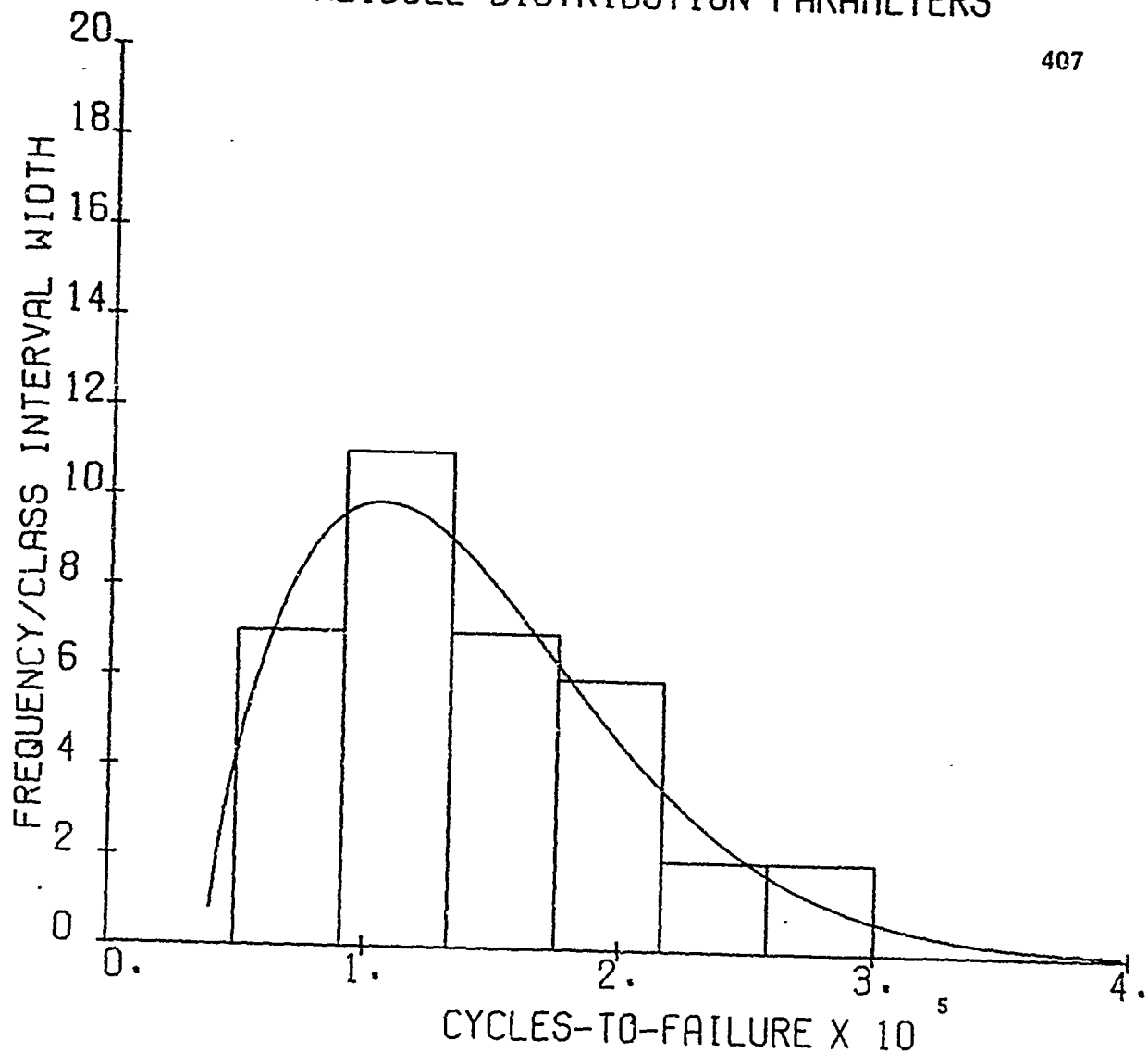


MEAN VALUE: 11.761 CYCLES
 STANDARD DEVIATION: 0.445 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.086
 CHI-SQUARED TEST: 0.464
 SKEWNESS: 0.029
 KURTOSIS: 2.497

FIG. 9.1-15 CYCLES-TO-FAILURE DIST OF GROUP NO= 133
 USING WIRE MACHINE NO. 1 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4130 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 77,800 PSI. BEND ANGLE
 21.5 DEGREES. COAST DOWN CYCLES 200

WEIBULL DISTRIBUTION PARAMETERS

407



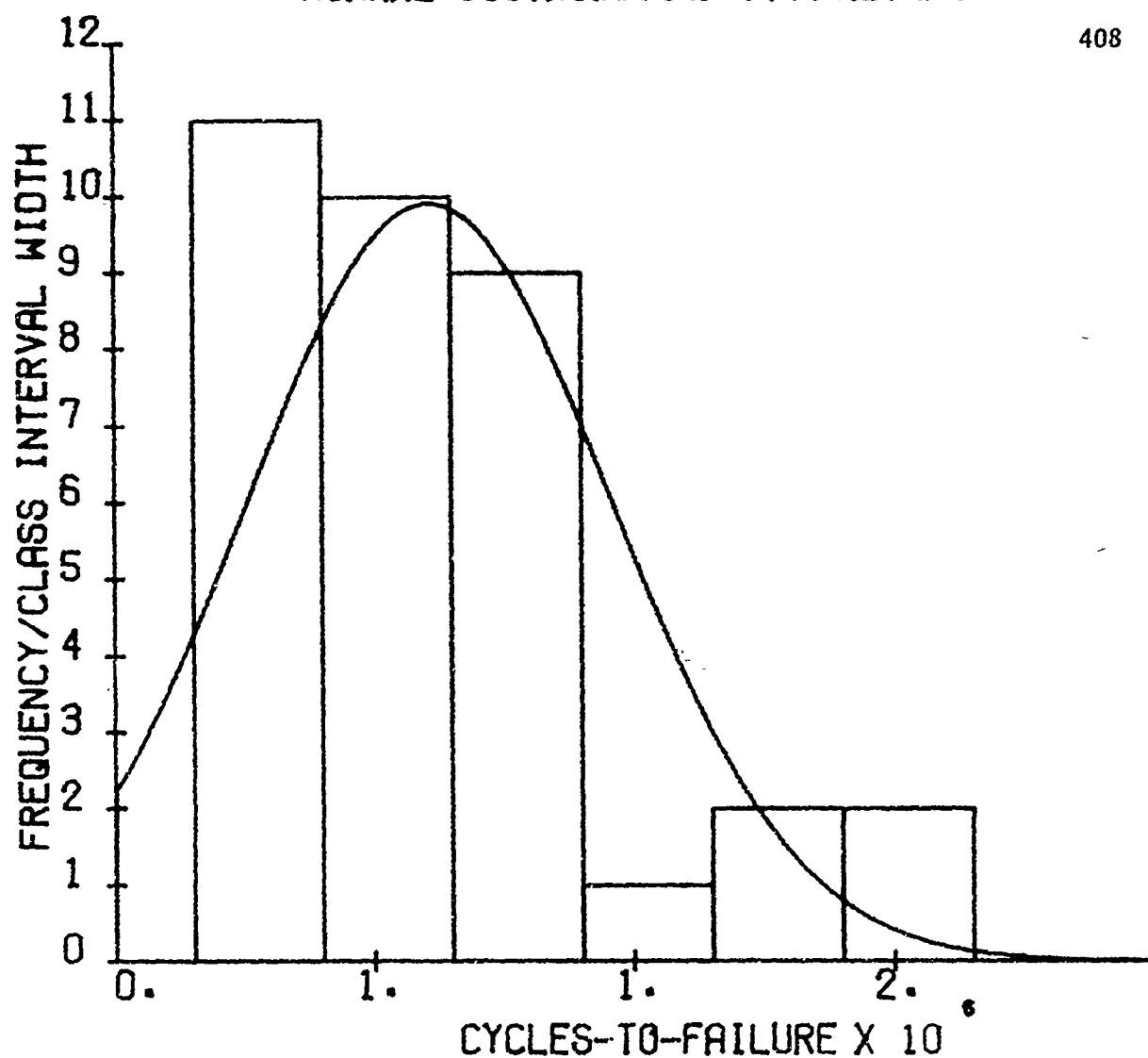
KOLMOGOROV-SMIRNOV TEST: 0.112
 CHI-SQUARED TEST: 3.390
 WEIBULL SLOPE (BETA): 1.670
 MINIMUM LIFE (GAMMA): 39099
 SCALE PARAMETER (ETA): 114833

FIG. 9.1-16

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=133
 SL=77800 PSI

NORMAL DISTRIBUTION PARAMETERS

408

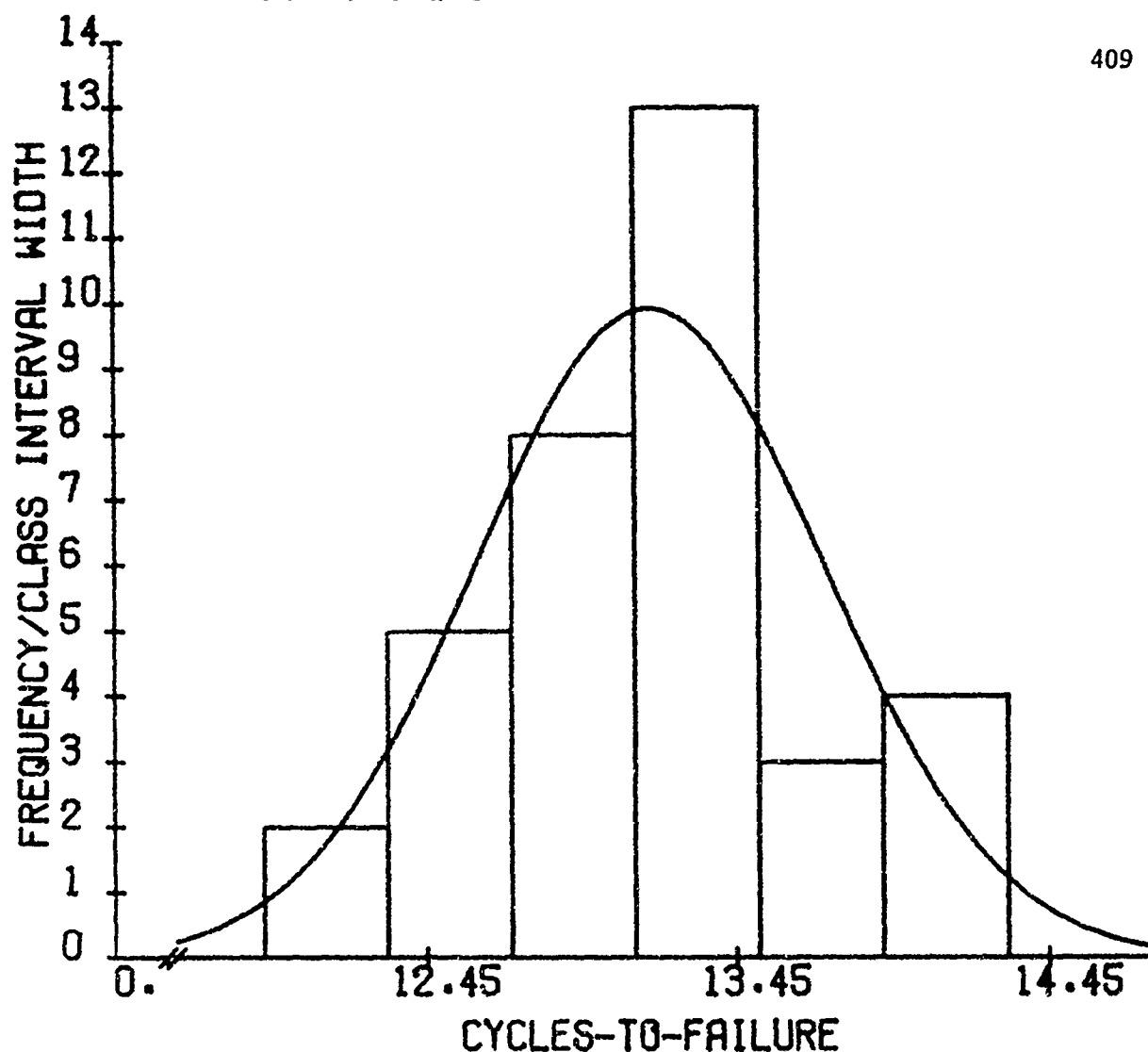


MEAN VALUE: 608431.4 CYCLES
 STANDARD DEVIATION: 352142.8 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.165
 CHI-SQUARED TEST: 0.828
 SKEWNESS: 1.284
 KURTOSIS: 4.315

FIG. 9.1-17 CYCLES-TO-FAILURE DIST. OF GROUP NO. 136
 USING WIRE FATIGUE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 64,500 PSI. BEND ANGLE
 17.0 DEGREES. COAST-DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

409

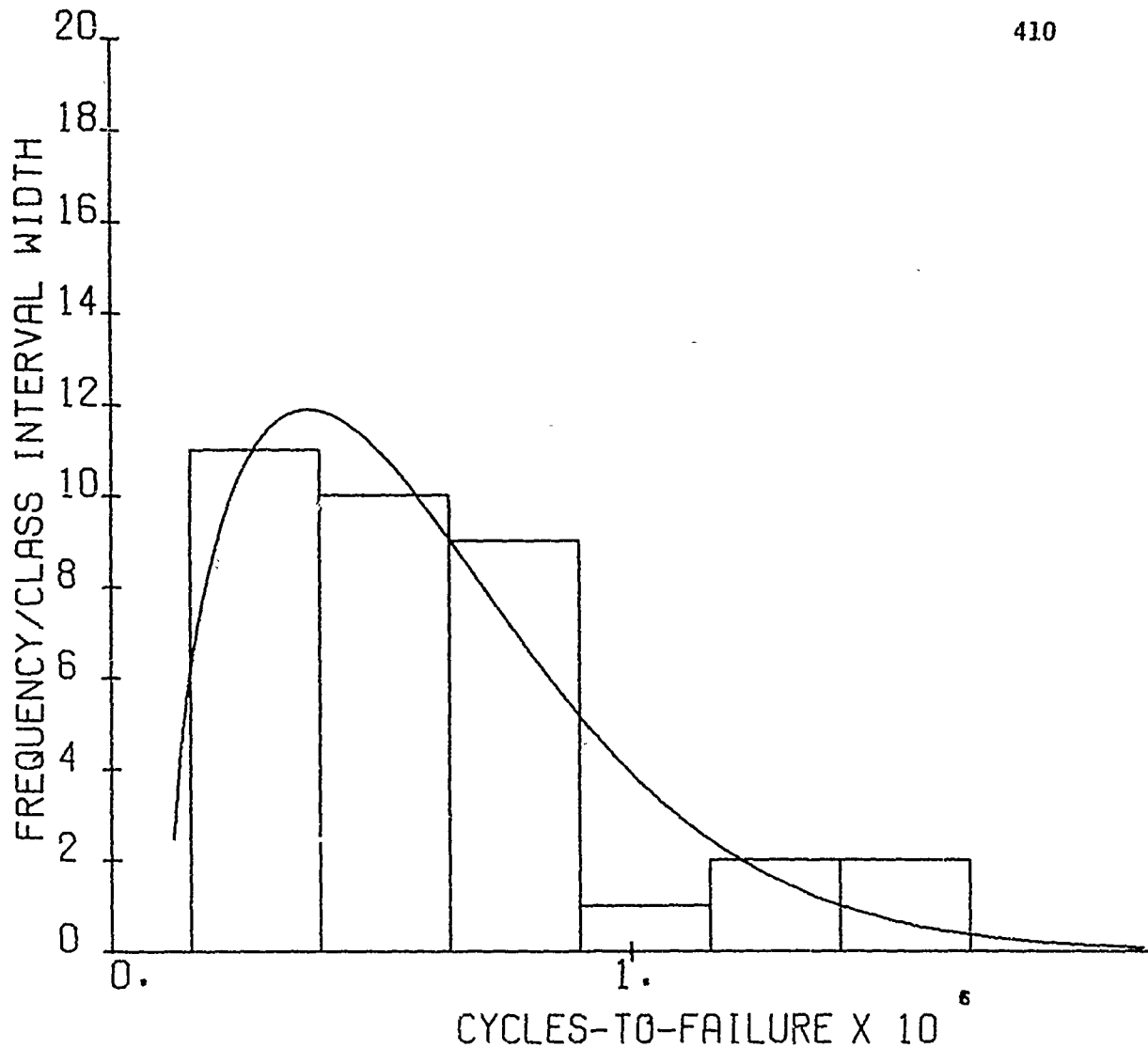


MEAN VALUE: 13.168 CYCLES
 STANDARD DEVIATION: 0.561 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.074
 CHI-SQUARED TEST: 2.072
 SKEWNESS: -0.042
 KURTOSIS: 2.704

FIG. 9-1-18 CYCLES-TO-FAILURE DIST. OF GROUP NO. 136
 USING WIRE FATIGUE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 64,500 PSI. BEND ANGLE
 17.0 DEGREES. COAST-DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

410



KOLMOGOROV-SMIRNOV TEST: 0.102

CHI-SQUARED TEST: 3.708

WEIBULL SLOPE (BETA): 1.509

MINIMUM LIFE (GAMMA): 113600

SCALE PARAMETER (ETA): 549476

FIG. 9.1-19

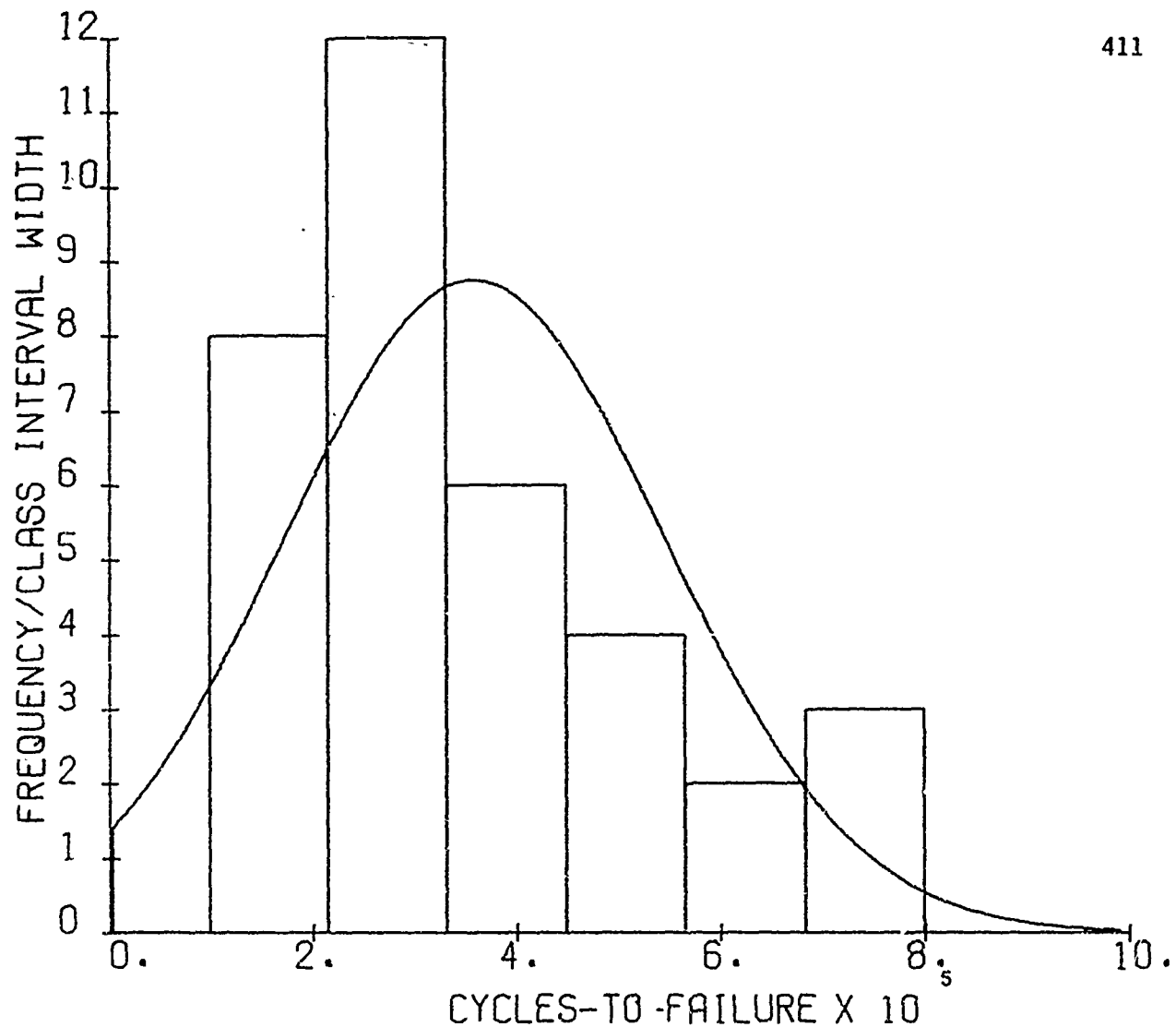
CYCLES-TO-FAILURE DISTRIBUTION

SL=64500 PSI

GROUP=136

NORMAL DISTRIBUTION PARAMETERS

411

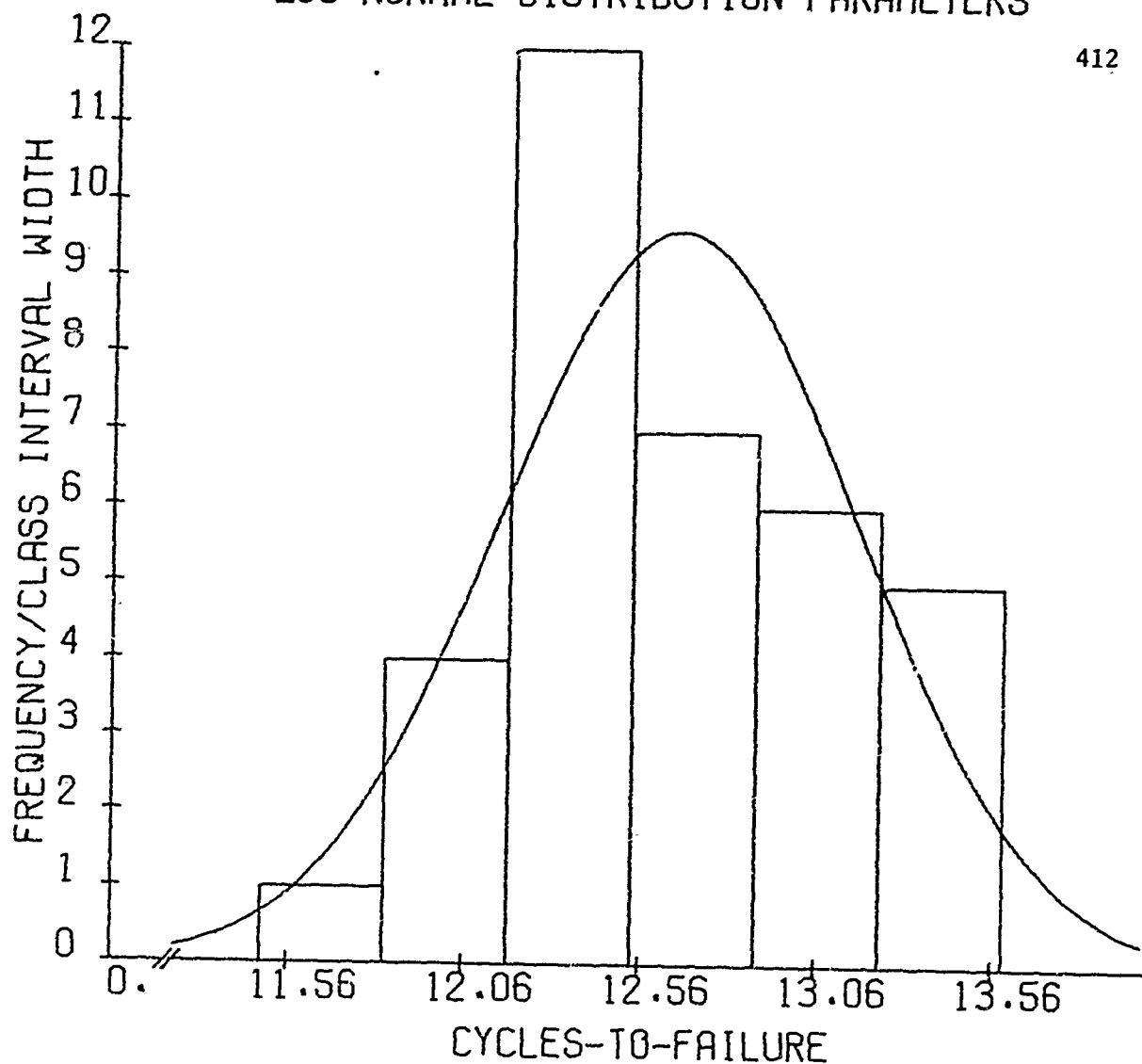


MEAN VALUE: 357925.7 CYCLES
 STANDARD DEVIATION: 186783.7 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.168
 CHI-SQUARED TEST: 3.907
 SKEWNESS: 0.980
 KURTOSIS: 3.137

FIG. 9.1-20 CYCLES-TO-FAILURE DIST OF GROUP NO. 137
 USING WIRE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 67,200 PSI. BEND ANGLE
 17.5 DEGREES. COAST DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

412

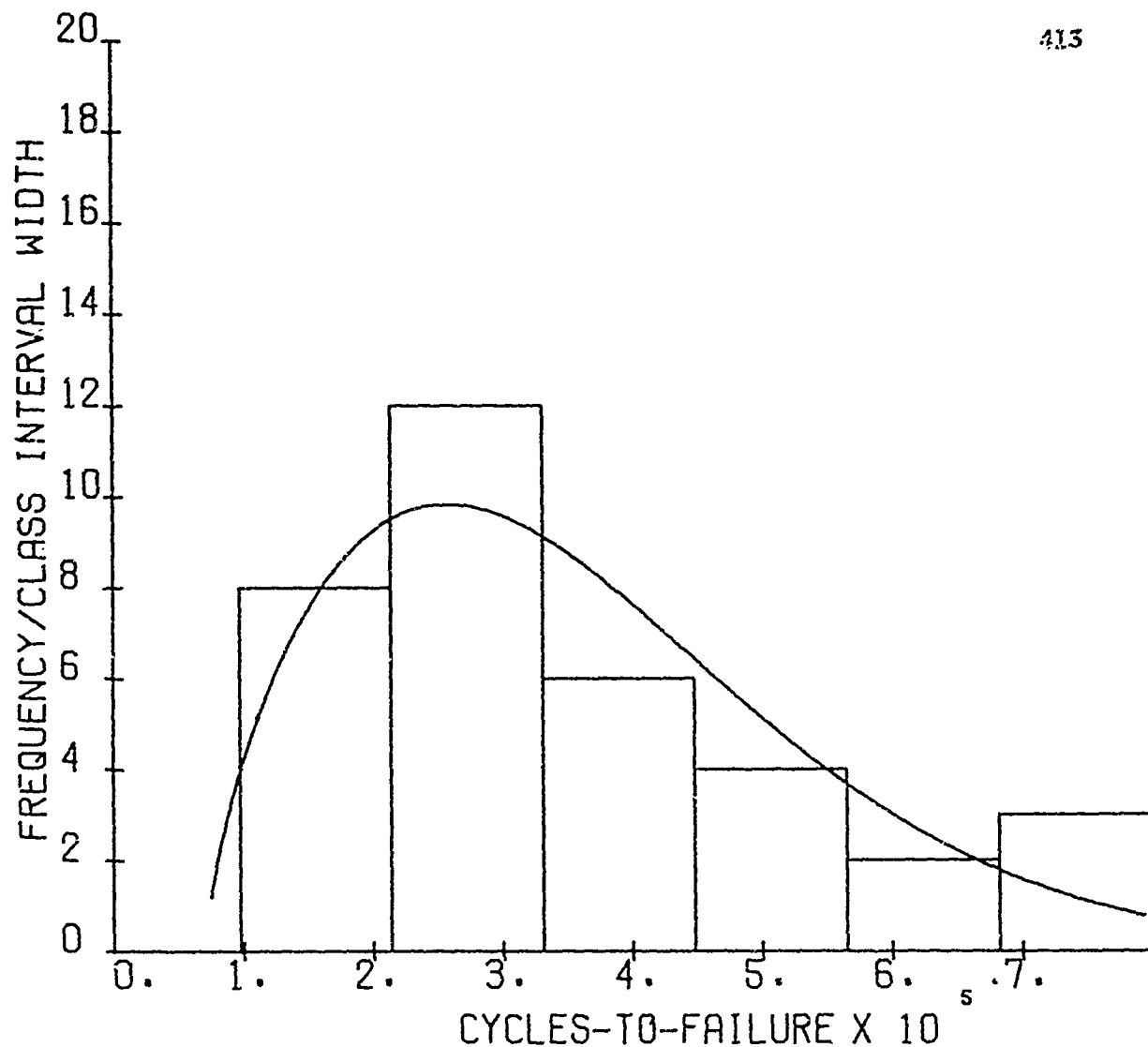


MEAN VALUE: 12.663 CYCLES
 STANDARD DEVIATION: 0.510 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.109
 CHI-SQUARED TEST: 3.034
 SKEWNESS: 0.041
 KURTOSIS: 2.497

FIG. 9.1-21 CYCLES-TO-FAILURE DIST OF GROUP NO. 137
 USING WIRE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 67,200 PSI. BEND ANGLE
 17.5 DEGREES. COAST DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

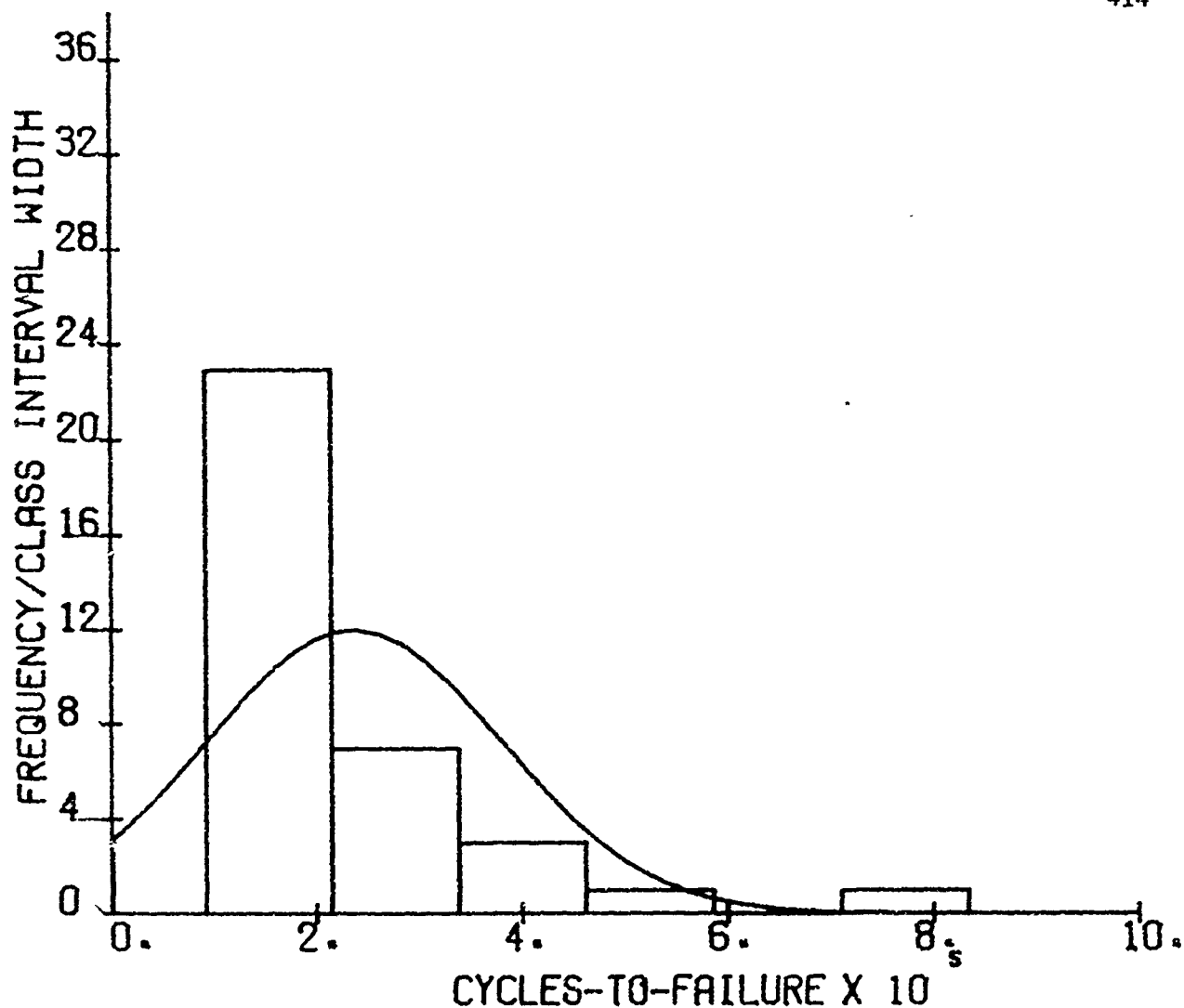
413



KOLMOGOROV-SMIRNOV TEST: 0.127
 CHI-SQUARED TEST: 4.044
 WEIBULL SLOPE (BETA): 1.674
 MINIMUM LIFE (GAMMA): 70099
 SCALE PARAMETER (ETA): 323481

FIG. 9.1-22

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=137
 SL=67200 PSI

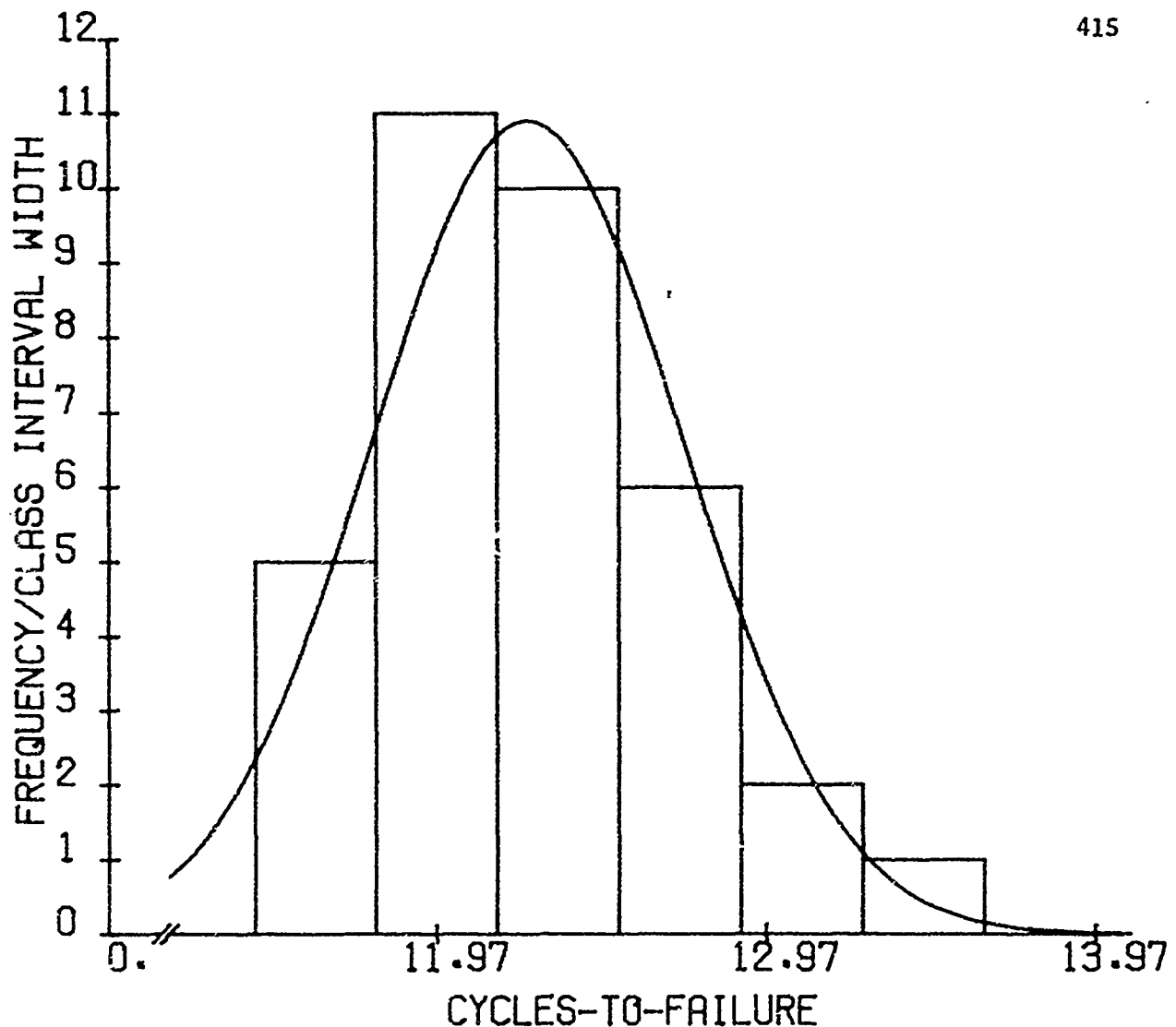


MEAN VALUE: 236162.9 CYCLES
STANDARD DEVIATION: 144220.2 CYCLES
KOLMOGOROV-SMIRNOV TEST: 0.255
CHI-SQUARED TEST: 6.637
SKEWNESS: 2.460
KURTOSIS: 10.014

FIG. 9.1-23 CYCLES-TO-FAILURE DIST OF GROUP NO. 138
USING WIRE MACHINE NO. 2 FOR
35 SPECIMENS OF .040 IN. DIAMETER AISI
1038 STEEL WIRE. FIXED ALTERNATING
STRESS LEVEL OF 69,200 PSI. BEND ANGLE
18.0 DEGREES. COAST DOWN CYCLES 200.

LOG NORMAL DISTRIBUTION PARAMETERS

415

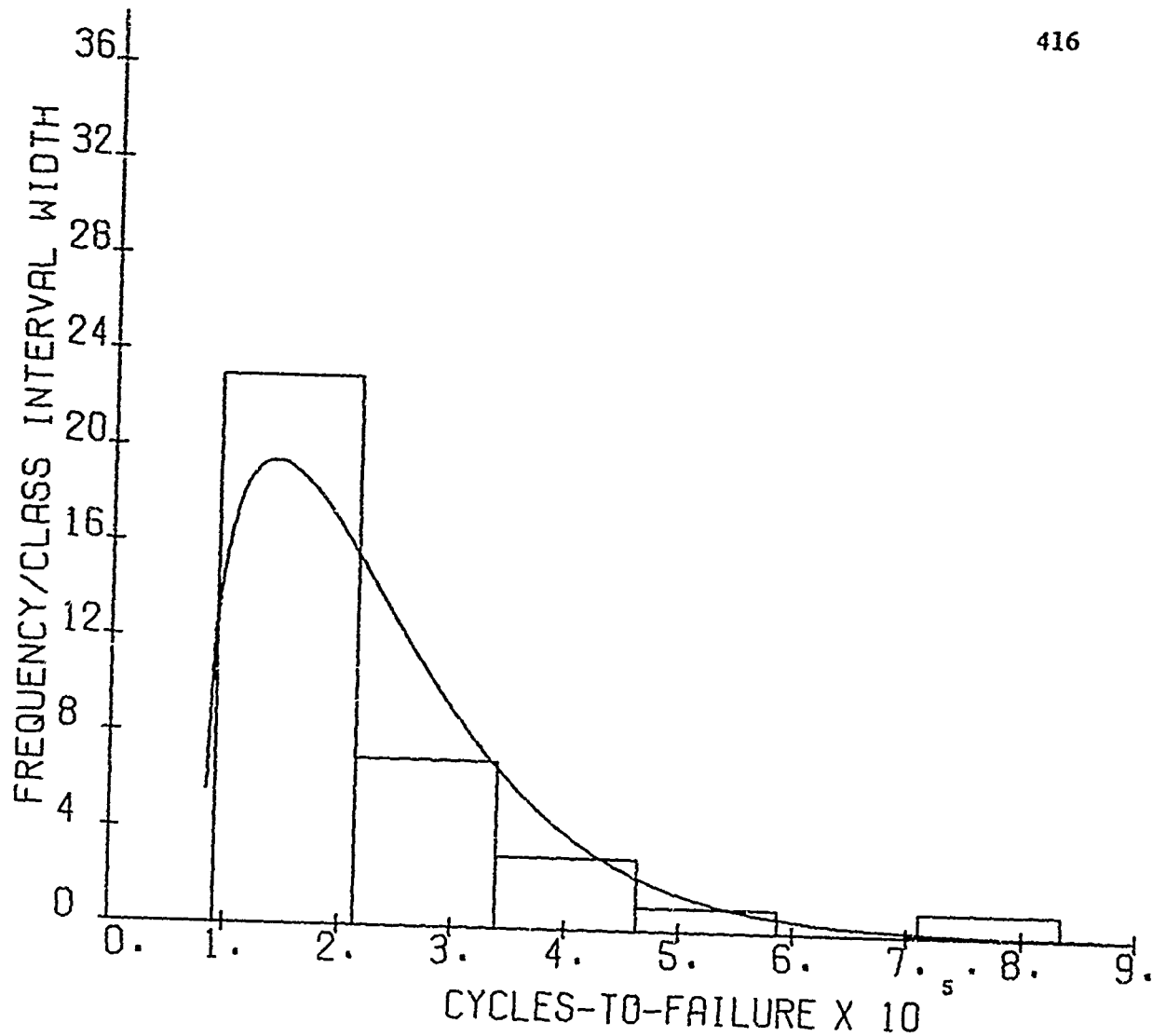


MEAN VALUE: 12.248 CYCLES
 STANDARD DEVIATION: 0.473 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.164
 CHI-SQUARED TEST: 0.605
 SKEWNESS: 0.834
 KURTOSIS: 3.831

FIG. 9.1-24 CYCLES-TO- FAILURE DIST OF GROUP NO. 138
 USING WIRE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 69,200 PSI. BEND ANGLE
 18.0 DEGREES. COAST DOWN CYCLES 200.

WEIBULL DISTRIBUTION PARAMETERS

416



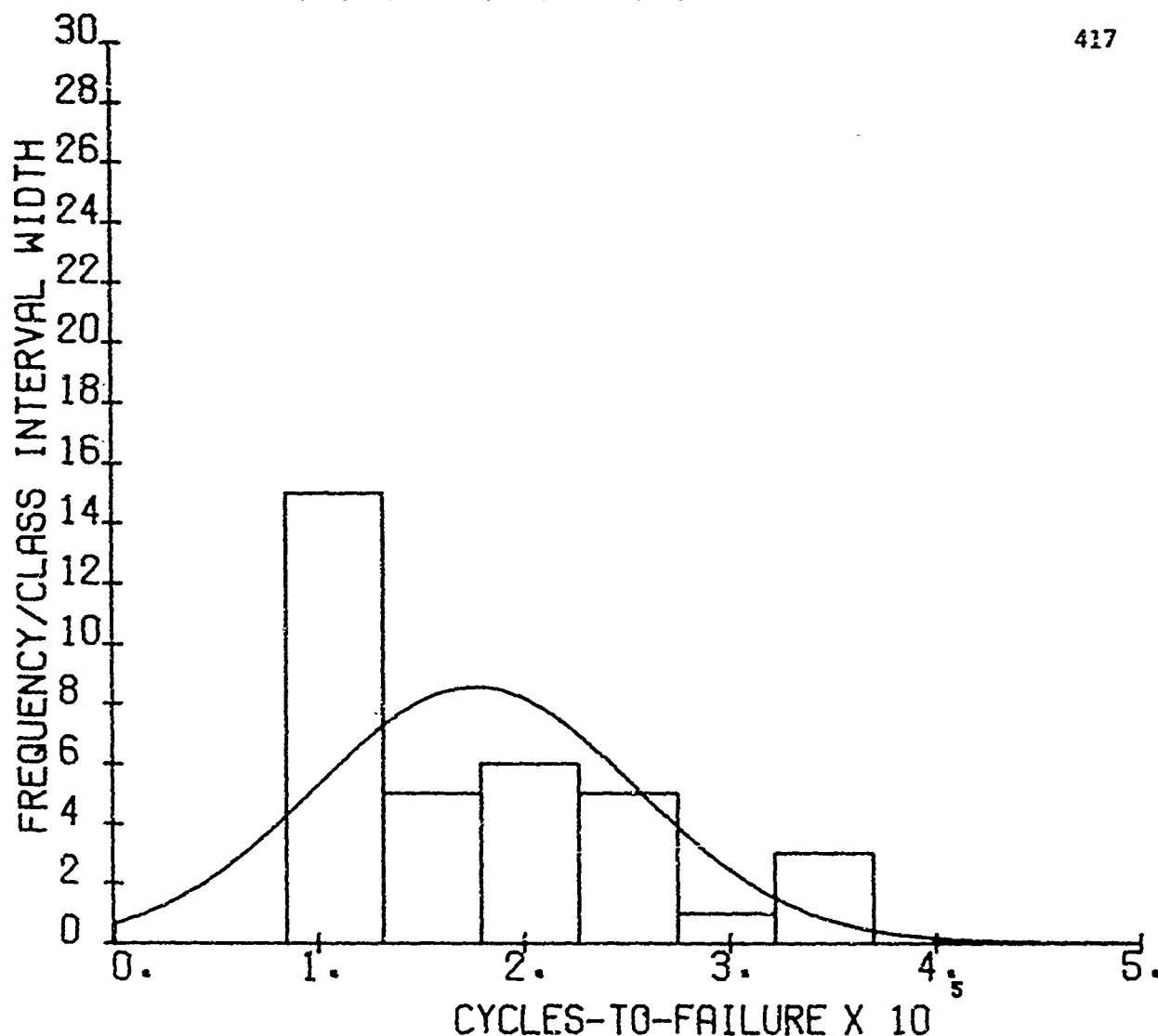
KOLMOGOROV-SMIRNOV TEST: 0.166
 CHI-SQUARED TEST: 5.267
 WEIBULL SLOPE (BETA): 1.328
 MINIMUM LIFE (GAMMA): 83399
 SCALE PARAMETER (ETA): 163986

FIG. 9.1-25

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=138
 SL=69200 PSI

NORMAL DISTRIBUTION PARAMETERS

417

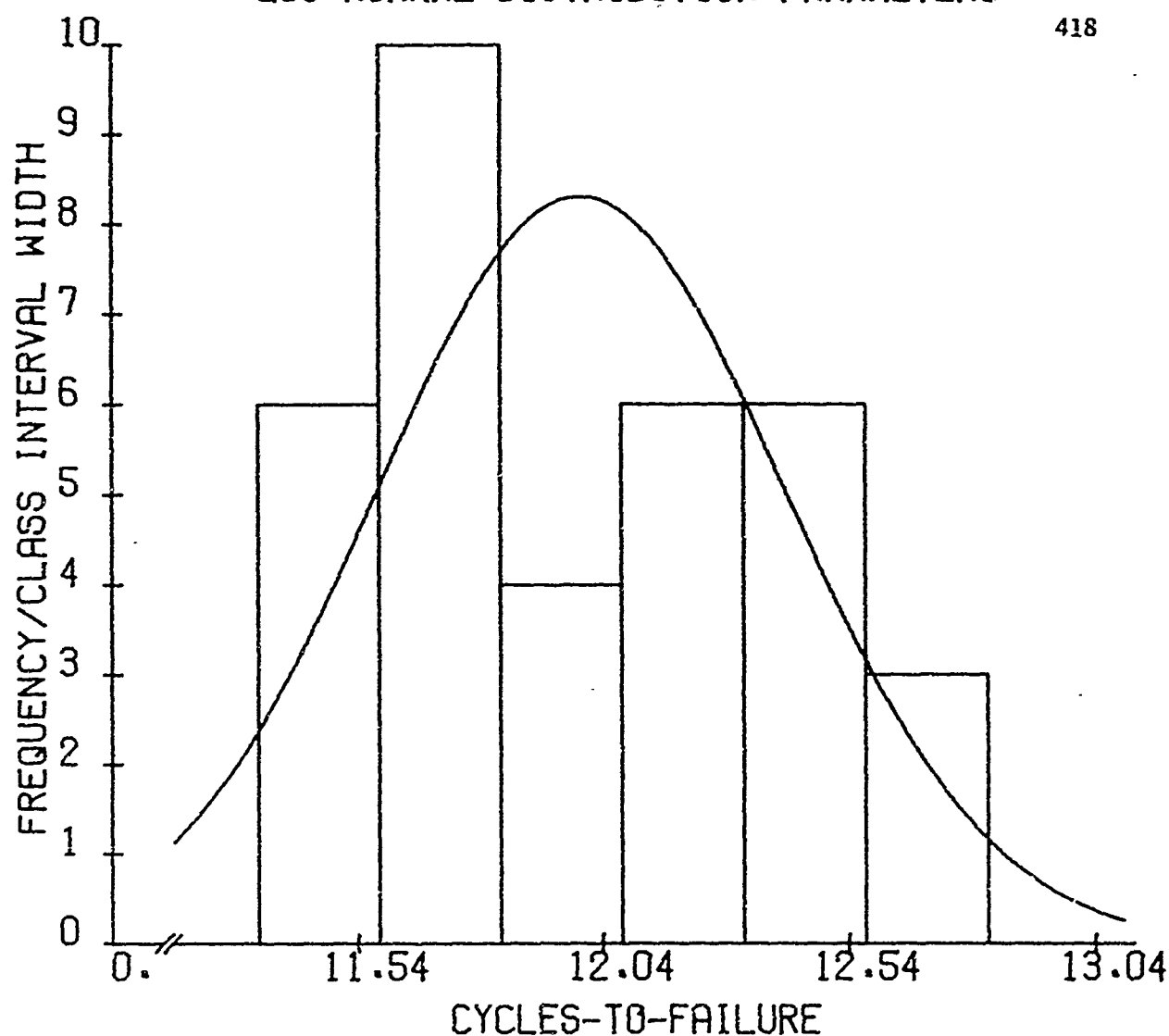


MEAN VALUE: 176505.7 CYCLES
 STANDARD DEVIATION: 77774.2 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.166
 CHI-SQUARED TEST: 4.418
 SKEWNESS: 0.929
 KURTOSIS: 2.997

FIG. 9-1-26 CYCLES-TO-FAILURE DIST OF GROUP NO= 139
 USING WIRE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 72,300 PSI. BEND ANGLE
 18.5 DEGREES. COAST DOWN CYCLES 200

LOG NORMAL DISTRIBUTION PARAMETERS

418

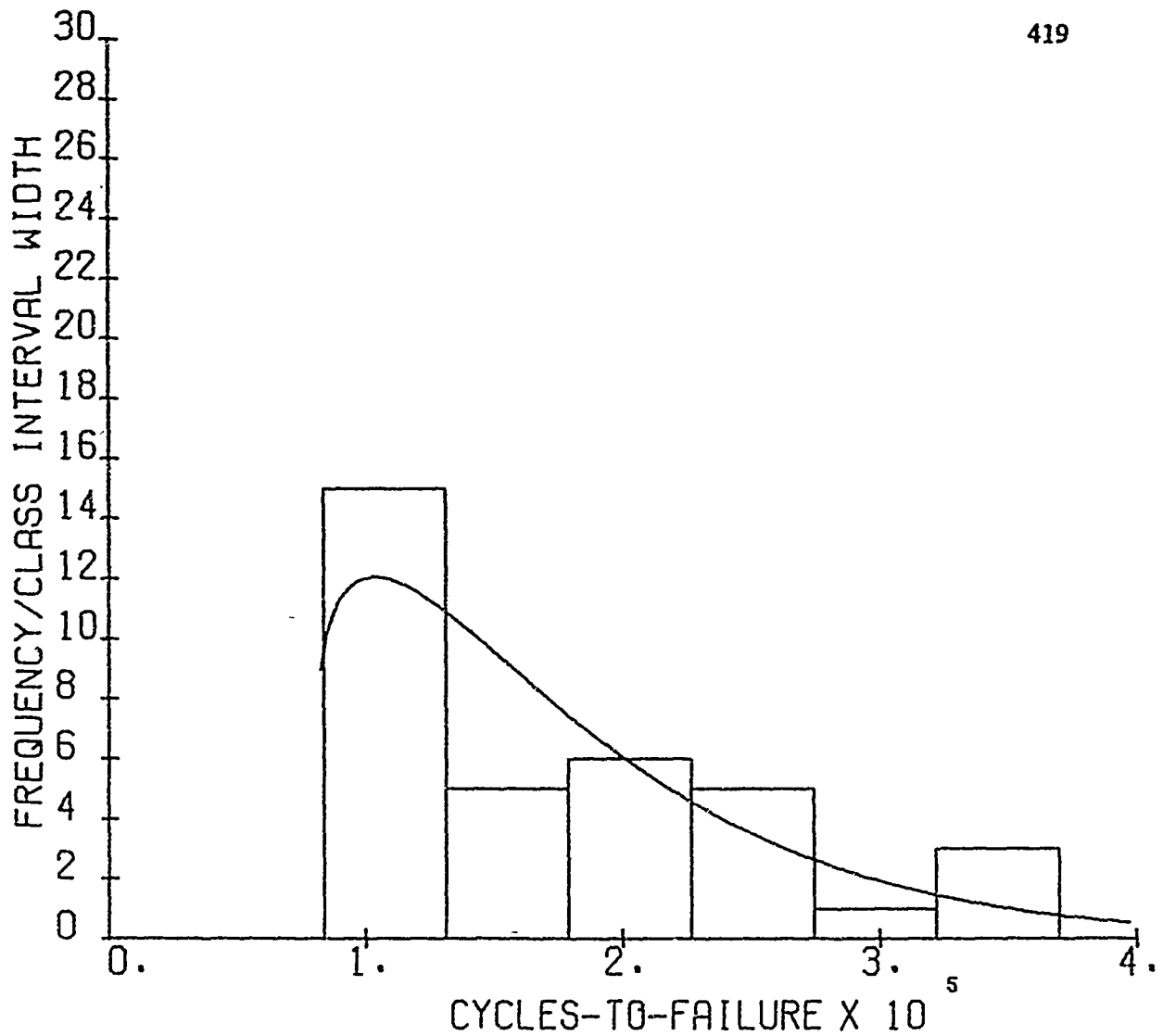


MEAN VALUE: 11.994 CYCLES
 STANDARD DEVIATION: 0.416 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.135
 CHI-SQUARED TEST: 4.574
 SKEWNESS: 0.348
 KURTOSIS: 1.985

FIG. 9.1-27 CYCLES-TO-FAILURE DIST OF GROUP NO= 139
 USING WIRE MACHINE NO. 2 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1038 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 72,300 PSI. BEND ANGLE
 18.5 DEGREES. COAST DOWN CYCLES 200

WEIBULL DISTRIBUTION PARAMETERS

419



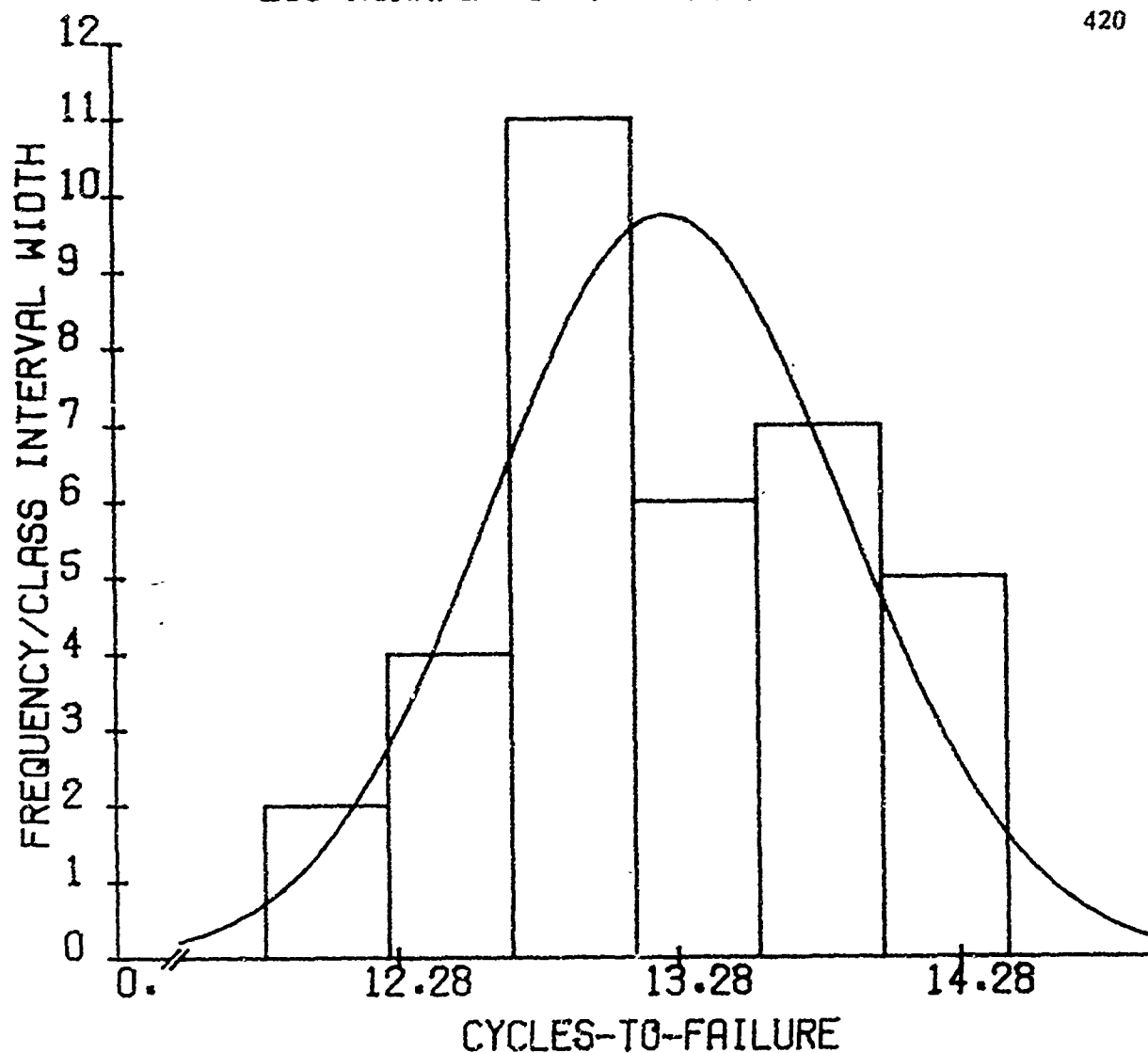
KOLMOGOROV--SMIRNOV TEST: 0.097
 CHI-SQUARED TEST: 3.863
 WEIBULL SLOPE (BETA): 1.204
 MINIMUM LIFE (GAMMA): 80099
 SCALE PARAMETER (ETA): 104054

FIG. 9.1-28

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=139
 SL=72300 PSI

LOG NORMAL DISTRIBUTION PARAMETERS

420

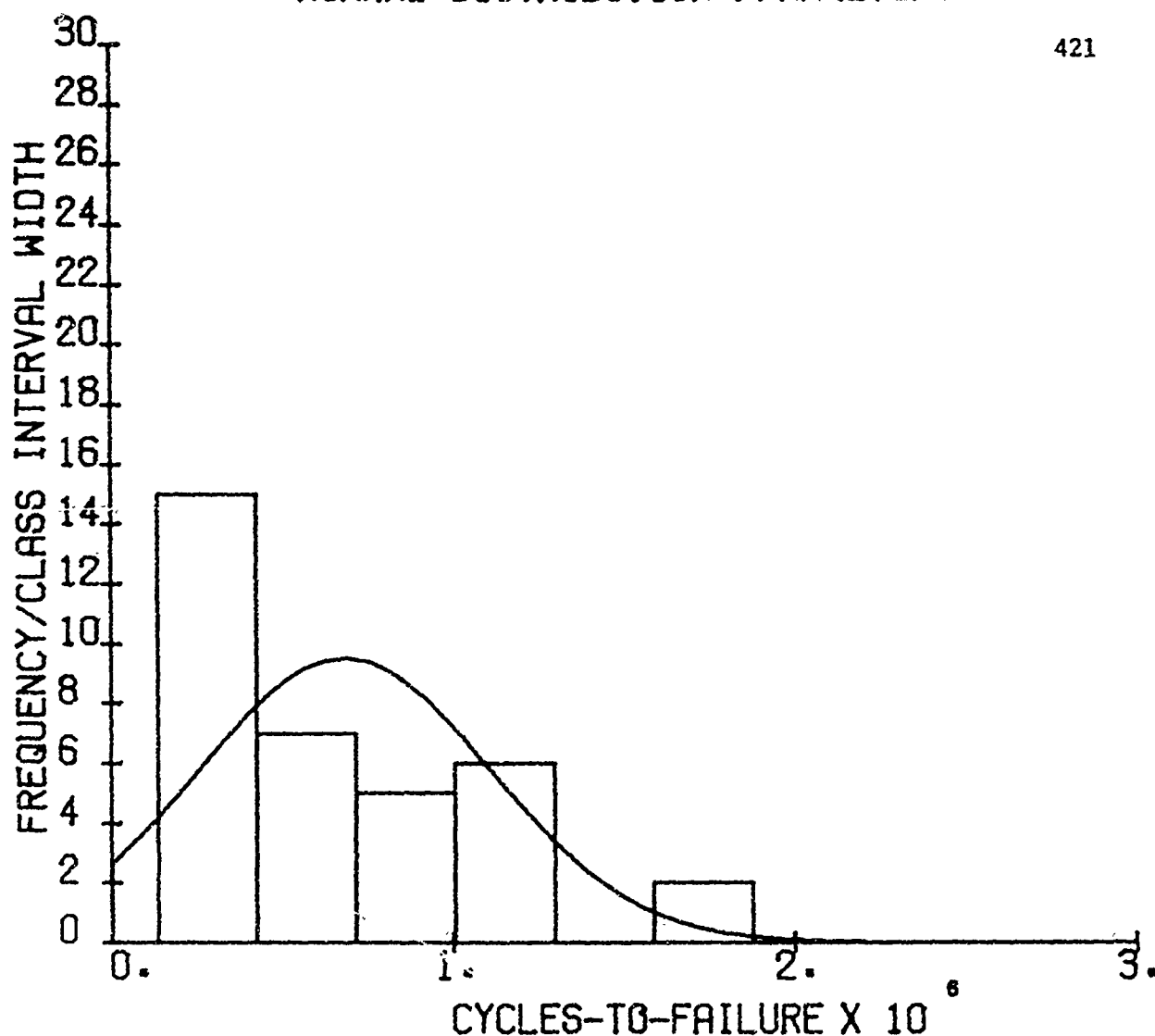


MEAN VALUE: 13.246 CYCLES
 STANDARD DEVIATION: 0.631 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.106
 CHI-SQUARED TEST: 2.436
 SKEWNESS: -0.066
 KURTOSIS: 2.397

FIG. 9.1-29 CYCLES-TO-FAILURE DIST OF GROUP NO. 143
 USING WIRE MACHINE NO. 3 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1018 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 57,200 PSI. BEND ANGLE
 15.5 DEGREES. COAST DOWN CYCLES 200.

NORMAL DISTRIBUTION PARAMETERS

421

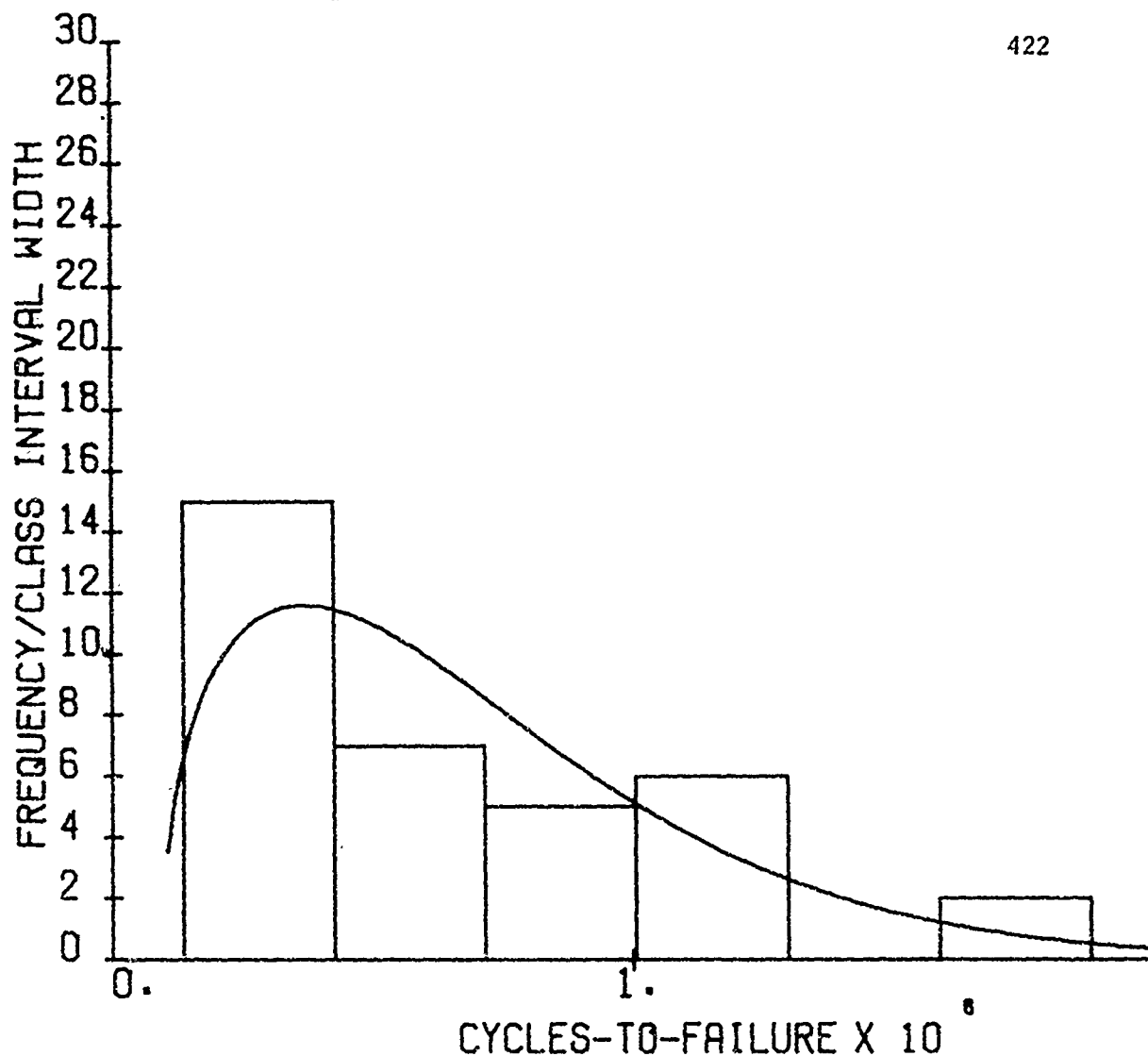


MEAN VALUE: 681940.0 CYCLES
 STANDARD DEVIATION: 427001.5 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.177
 CHI-SQUARED TEST: 5.029
 SKEWNESS: 1.034
 KURTOSIS: 3.416

FIG. 9.1-30 CYCLES-TO-FAILURE DIST OF GROUP NO. 143
 USING WIRE MACHINE NO. 3 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1018 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 57,200 PSI. BEND ANGLE
 15.5 DEGREES. COAST DOWN CYCLES 200.

WEIBULL DISTRIBUTION PARAMETERS

422



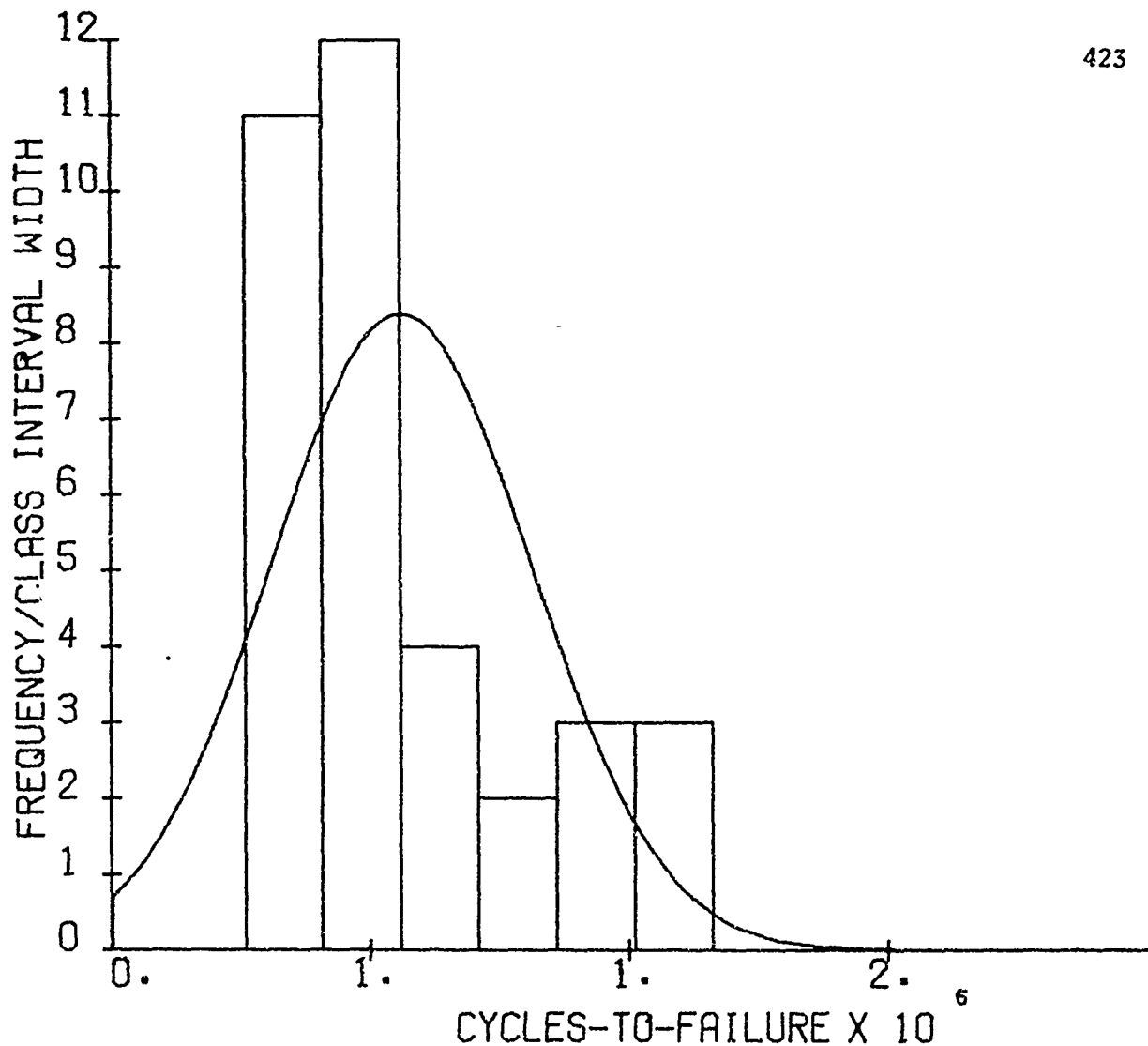
KOLMOGOROV-SMIRNOV TEST: 0.114
 CHI-SQUARED TEST: 3.724
 WEIBULL SLOPE (BETA): 1.415
 MINIMUM LIFE (GAMMA): 98999
 SCALE PARAMETER (ETA): 645345

FIG. 9.1-31

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=143
 SL=57200 PSI

NORMAL DISTRIBUTION PARAMETERS

423

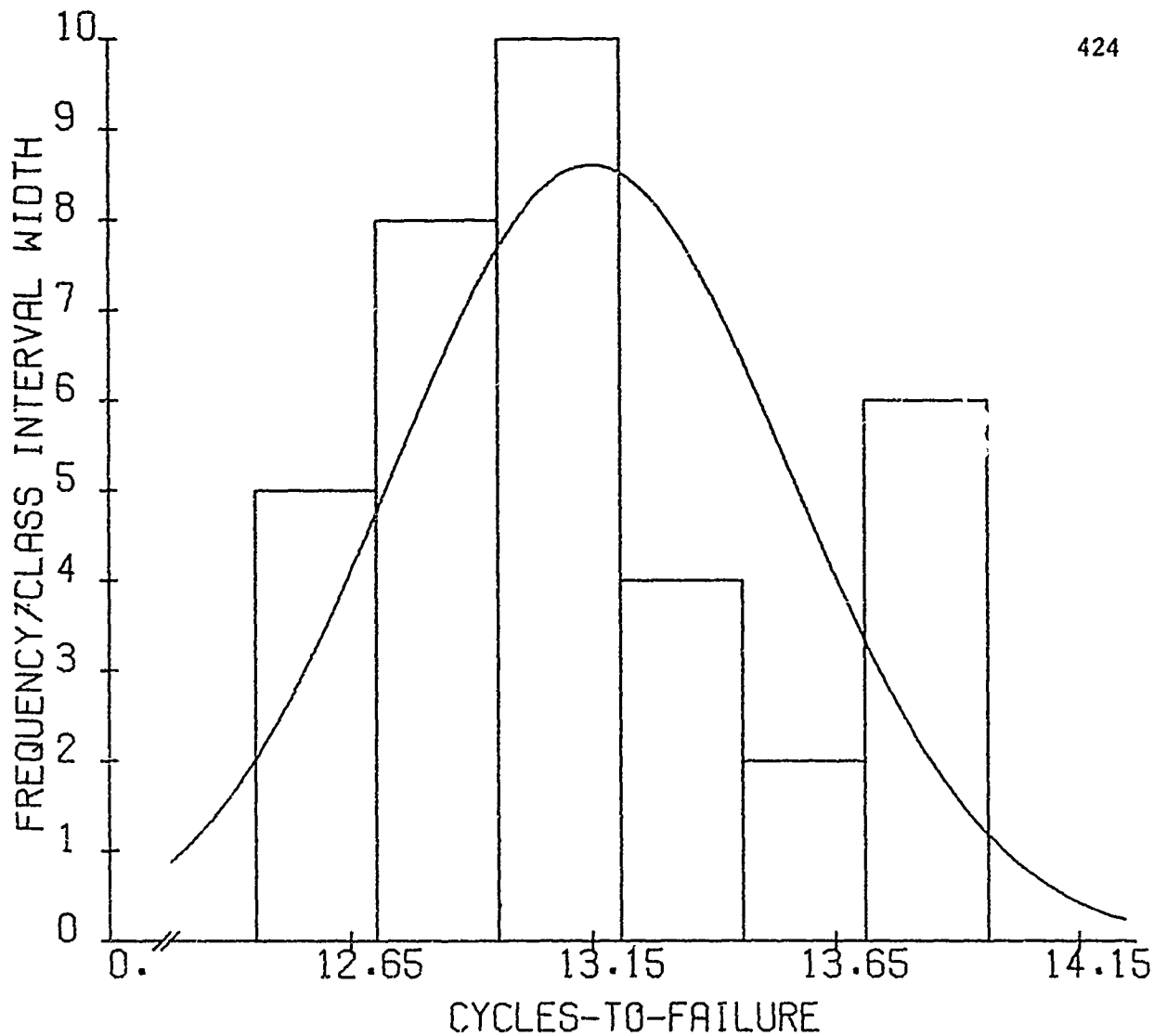


MEAN VALUE: 560405.7 CYCLES
 STANDARD DEVIATION: 251043.6 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.192
 CHI-SQUARED TEST: 7.570
 SKEWNESS: 1.126
 KURTOSIS: 3.245

FIG. 9.1-32 CYCLES-TO-FAILURE DIST OF GROUP NO. 144
 USING WIRE MACHINE NO. 3 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1018 STEEL WIRE . FIXED ALTERNATING
 STRESS LEVEL OF 60,000 PSI. BEND ANGLE
 16.0 DEGREES. COAST DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

424

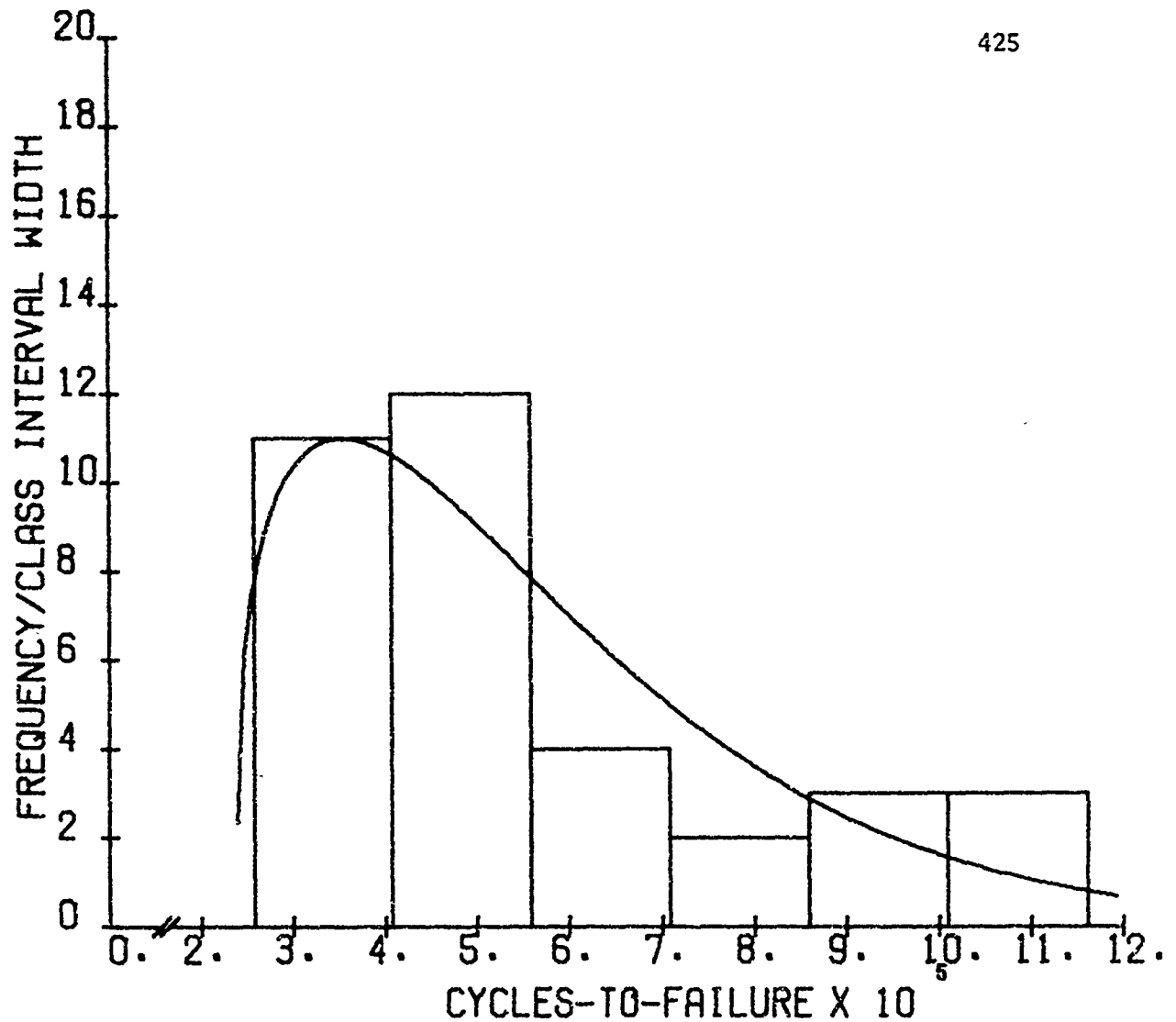


MEAN VALUE: 13.151 CYCLES
 STANDARD DEVIATION: 0.409 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.125
 CHI-SQUARED TEST: 7.380
 SKEWNESS: 0.466
 KURTOSIS: 2.464

FIG. 9.1-33 CYCLES-TO-FAILURE DIST OF GROUP NO. 144
 USING WIRE MACHINE NO. 3 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1018 STEEL WIRE . FIXED ALTERNATING
 STRESS LEVEL OF 60,000 PSI. BEND ANGLE
 16.0 DEGREES. COAST DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

425



KOLMOGOROV-SMIRNOV TEST: 0.107

CHI-SQUARED TEST: 4.112

WEIBULL SLOPE (BETA): 1.303

MINIMUM LIFE (GAMMA): 238999

SCALE PARAMETER (ETA): 353483

FIG. 9.1-34

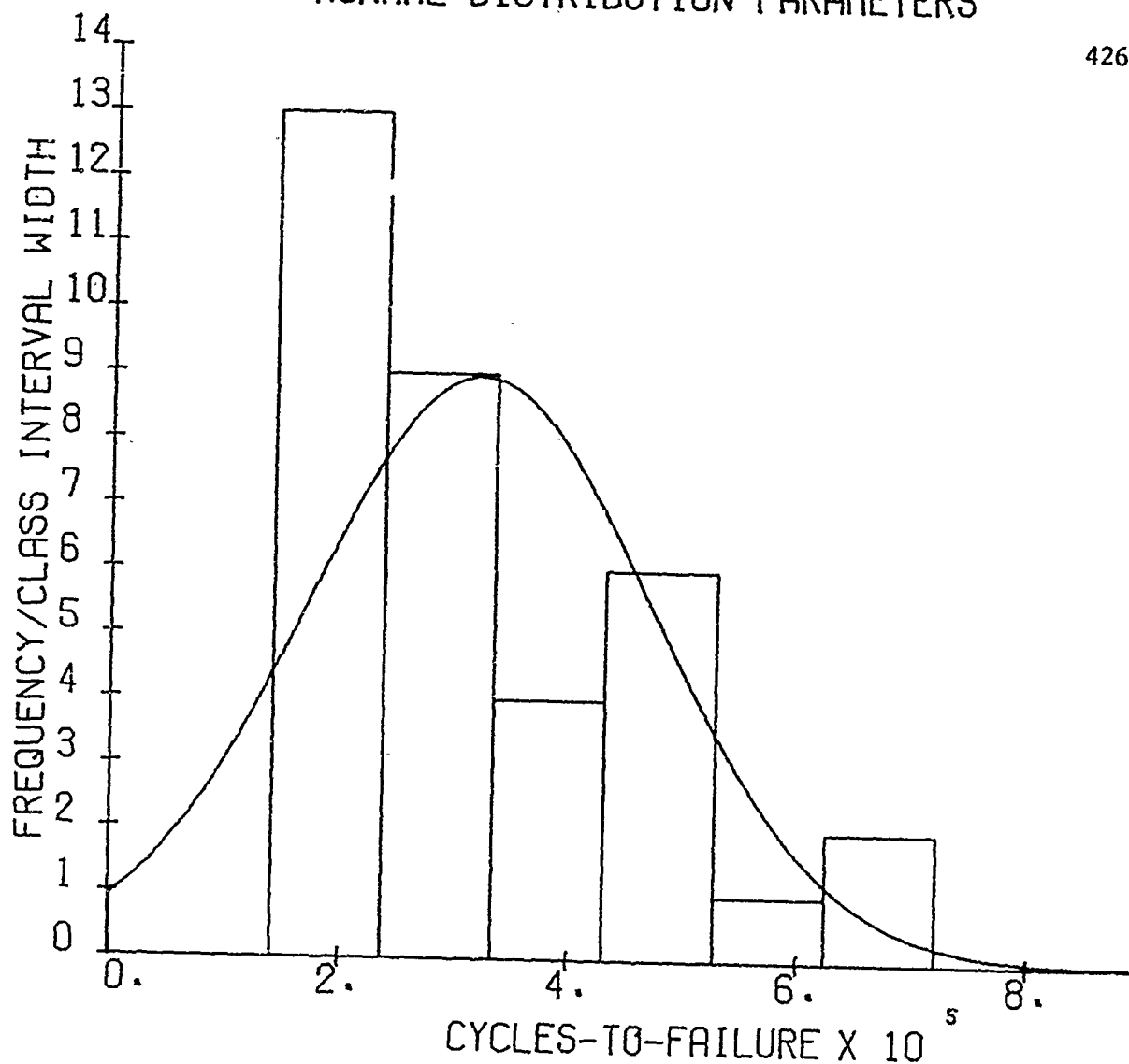
CYCLES-TO-FAILURE DISTRIBUTION

GROUP=144

SL=60000 PSI

NORMAL DISTRIBUTION PARAMETERS

426

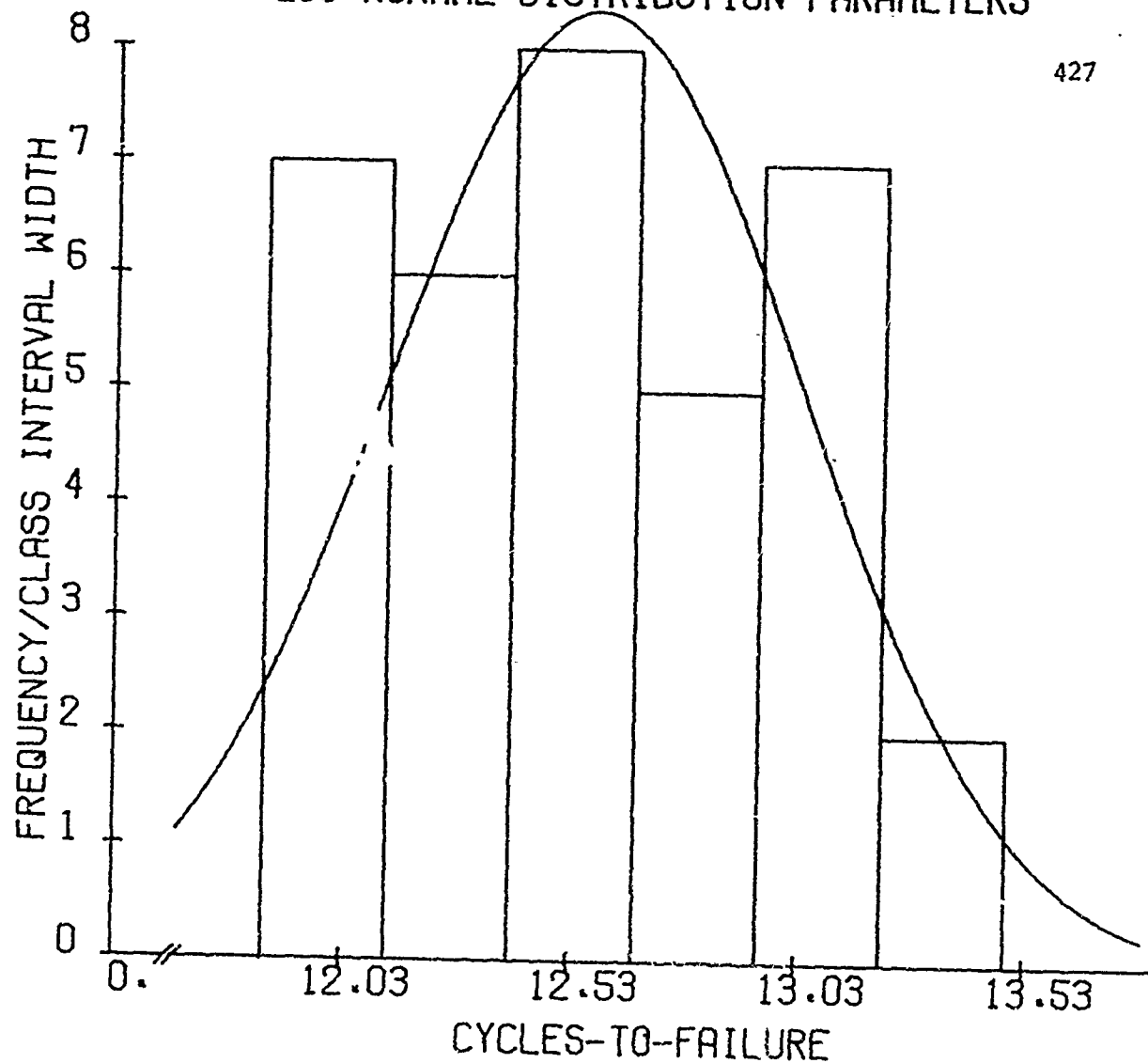


MEAN VALUE: 321568.6 CYCLES
 STANDARD DEVIATION: 150632.0 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.153
 CHI-SQUARED TEST: 3.037
 SKEWNESS: 0.821
 KURTOSIS: 2.824

FIG. 9.1-35 CYCLES-TO-FAILURE DIST OF GROUP NO= 145
 USING WIRE MACHINE NO. 3 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1018 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 62,800 PSI. BEND ANGLE
 16.5 DEGREES. COAST DOWN CYCLES 200

LOG NORMAL DISTRIBUTION PARAMETERS

427

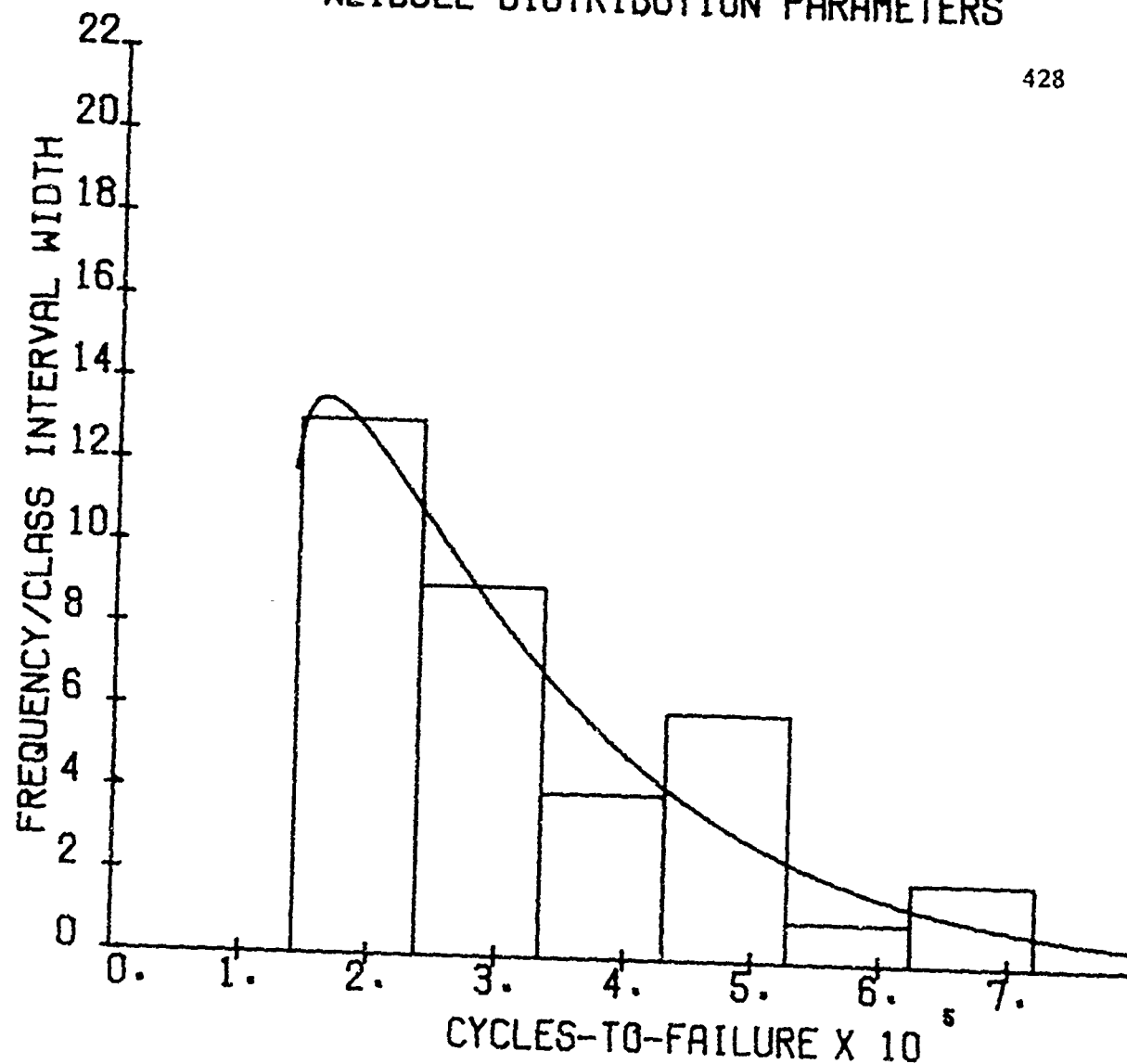


MEAN VALUE: 12.579 CYCLES
 STANDARD DEVIATION: 0.455 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.105
 CHI-SQUARED TEST: 1.435
 SKEWNESS: 0.205
 KURTOSIS: 1.885

FIG. 9.1-36 CYCLES-TO-FAILURE DIST OF GROUP NO= 145
 USING WIRE MACHINE NO. 3 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 1018 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 62,800 PSI. BEND ANGLE
 16.5 DEGREES. COAST DOWN CYCLES 200

WEIBULL DISTRIBUTION PARAMETERS

428



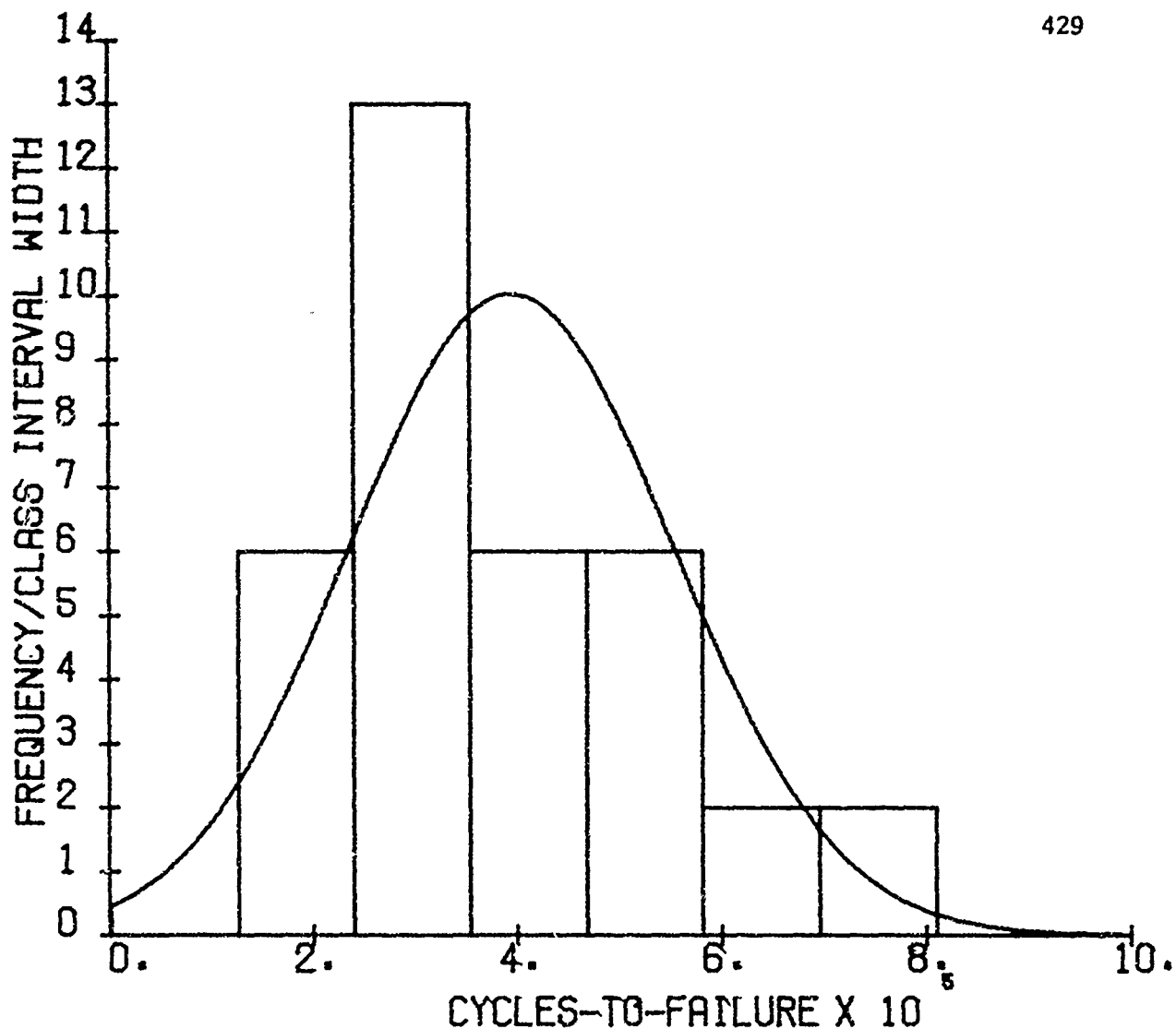
KOLMOGOROV-SMIRNOV TEST: 0.064
 CHI-SQUARED TEST: 2.546
 WEIBULL SLOPE (BETA): 1.111
 MINIMUM LIFE (GAMMA): 135499
 SCALE PARAMETER (ETA): 199629

FIG. 9.1-37

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=145
 SL=62800 PSI

NORMAL DISTRIBUTION PARAMETERS

429

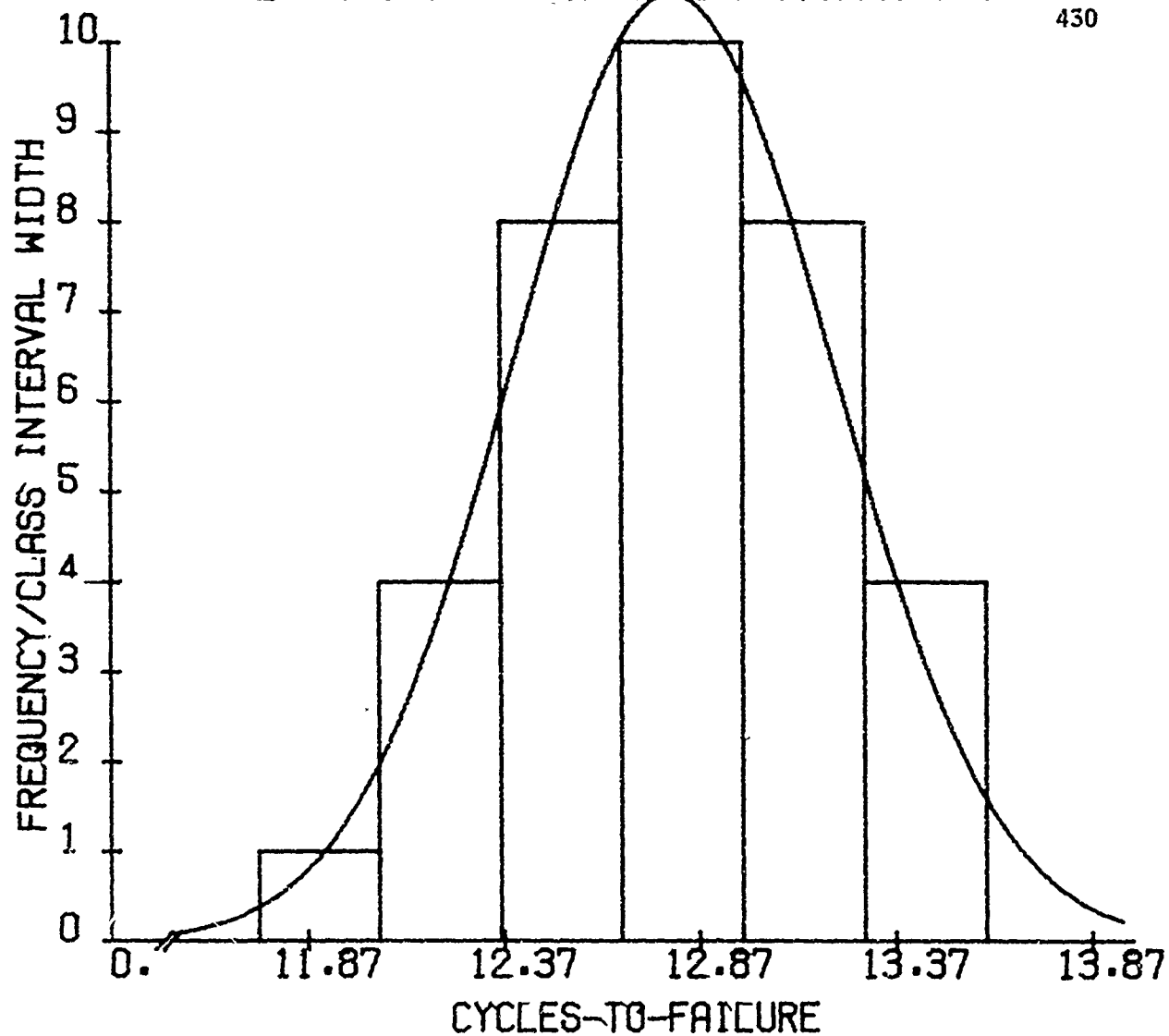


MEAN VALUE: 394545.7 CYCLES
 STANDARD DEVIATION: 158482.8 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.165
 CHI-SQUARED TEST: 4.420
 SKEWNESS: 0.717
 KURTOSIS: 2.993

FIG. 9.1-40 CYCLES-TO-FAILURE DIST OF GROUP NO. 150
 USING WIRE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 73,500 PSI. BEND ANGLE
 20.5 DEGREES. COAST DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

430

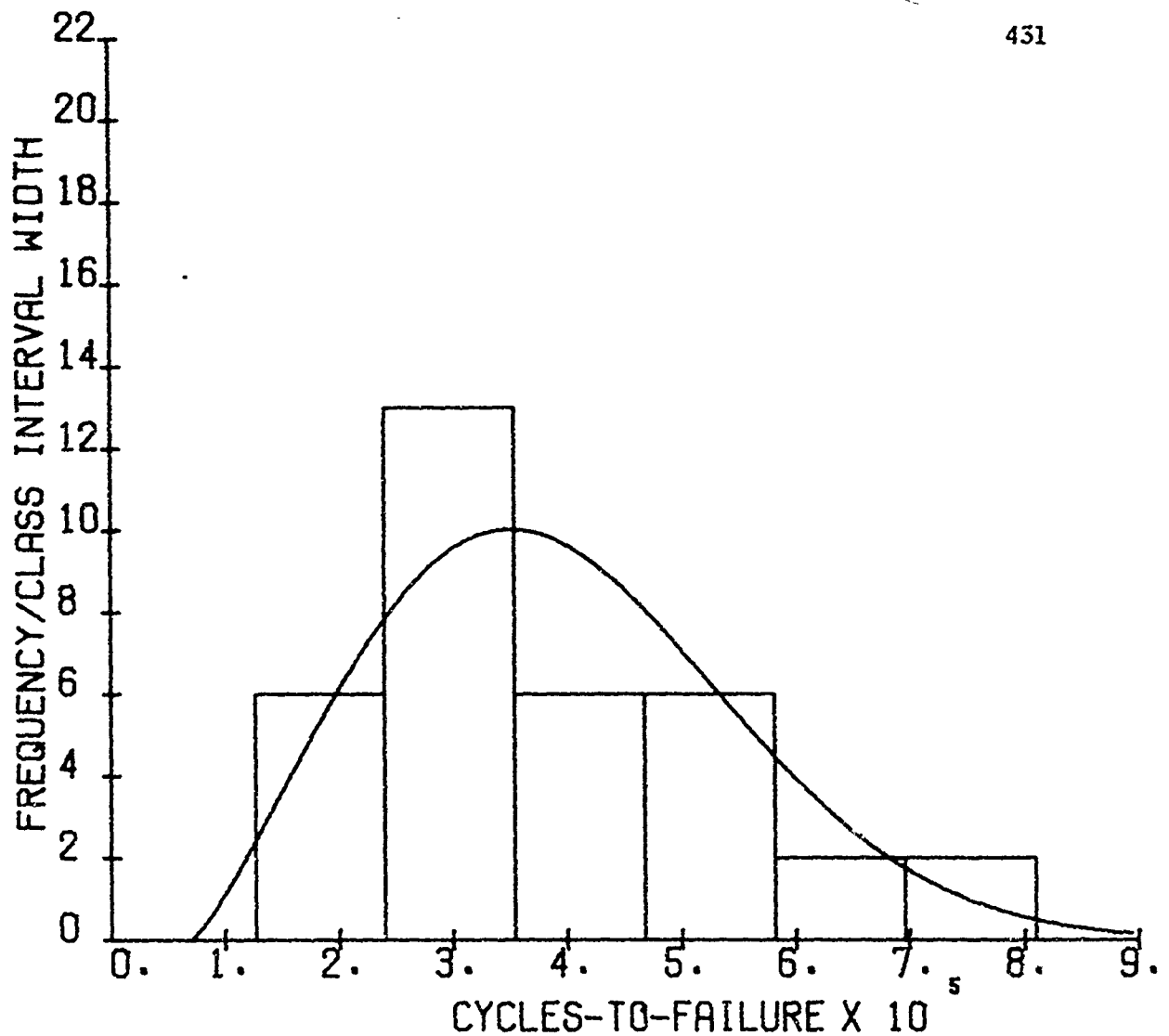


MEAN VALUE: 12.807 CYCLES
 STANDARD DEVIATION: 0.410 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.095
 CHI-SQUARED TEST: 0.026
 SKEWNESS: -0.236
 KURTOSIS: 2.905

FIG. 9.1-41 CYCLES-TO-FAILURE DIST OF GROUP NO. 150
 USING WIRE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE . FIXED ALTERNATING
 STRESS LEVEL OF 73,500 PSI. BEND ANGLE
 20.5 DEGREES. COAST DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

431



KOLMOGOROV-SMIRNOV TEST: 0.134

CHI-SQUARED TEST: 3.075

WEIBULL SLOPE (BETA): 2.230

MINIMUM LIFE (GAMMA): 69599

SCALE PARAMETER (ETA): 367757

FIG. 9.1-42

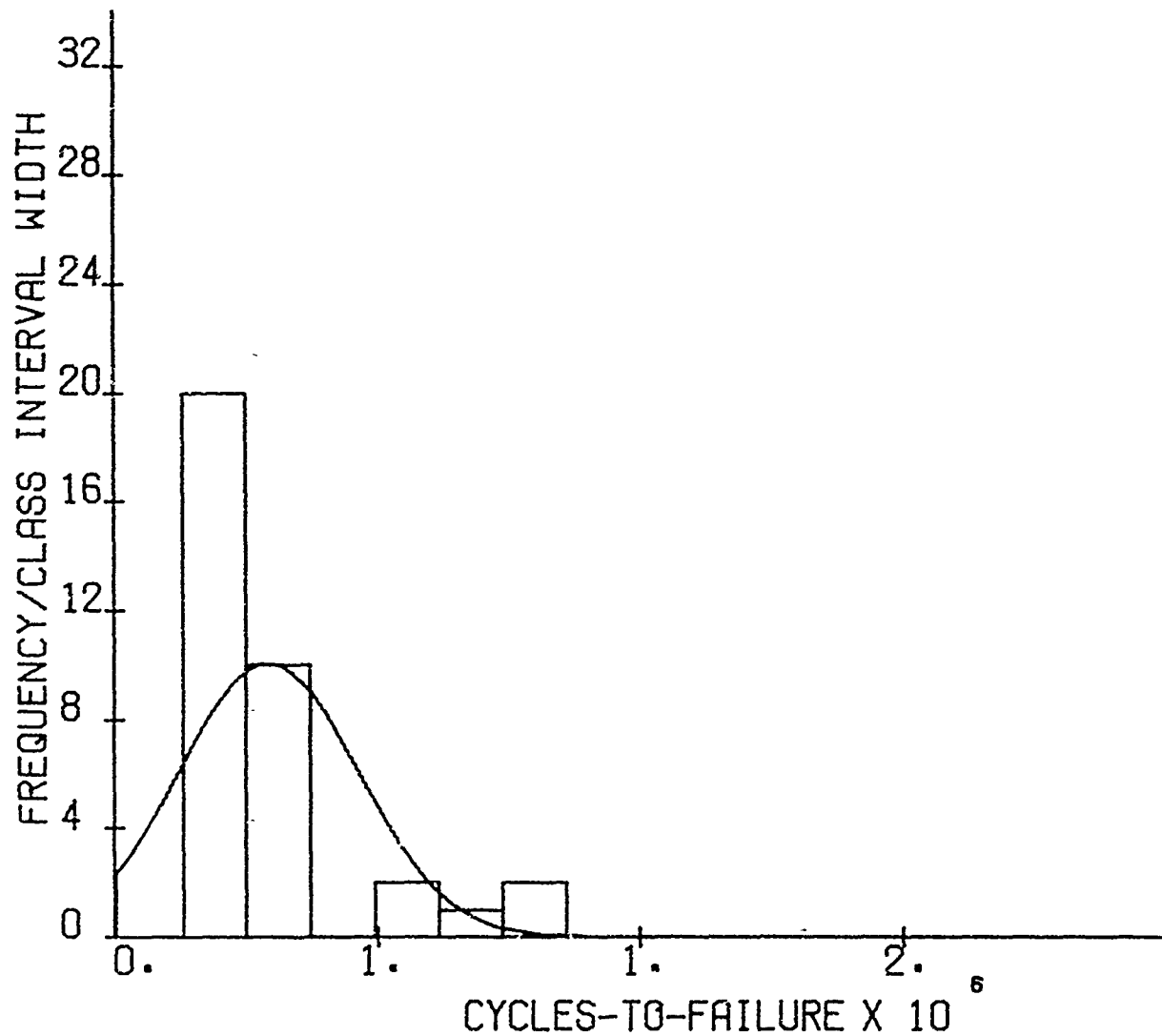
CYCLES-TO-FAILURE DISTRIBUTION

SL=73500 PSI

GROUP=150

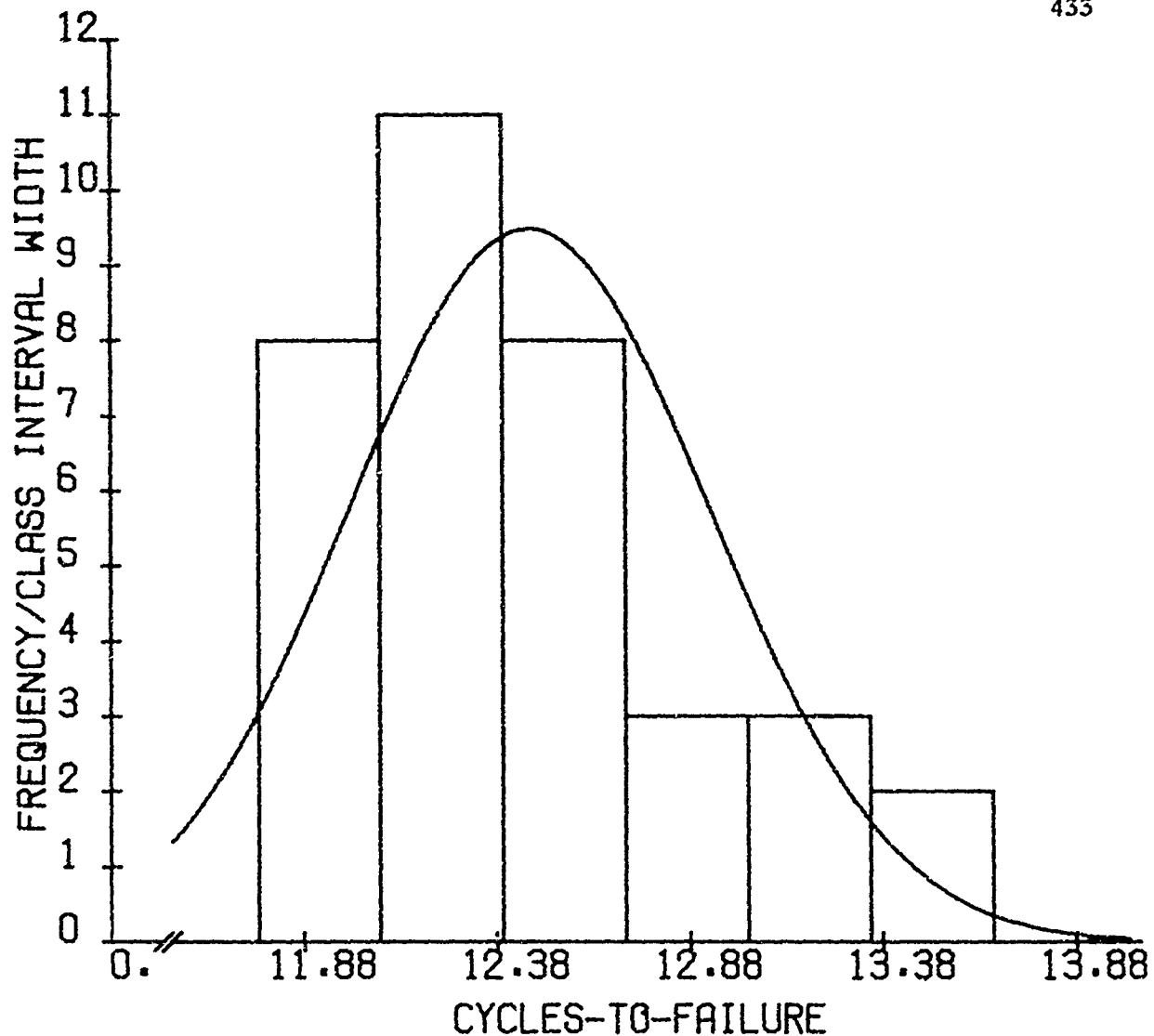
NORMAL DISTRIBUTION PARAMETERS

432



MEAN VALUE:	292180.0	CYCLES
STANDARD DEVIATION:	169598.8	CYCLES
KOLMOGOROV-SMIRNOV TEST:	0.221	
CHI-SQUARED TEST:	9.768	
SKEWNESS:	1.912	
KURTOSIS:	6.213	

FIG. 9.1-43 CYCLES-TO-FAILURE DIST OF GROUP NO. 151
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 78,100 PSI. BEND ANGLE
 21.5 DEGREES. COAST-DOWN CYCLES 100.

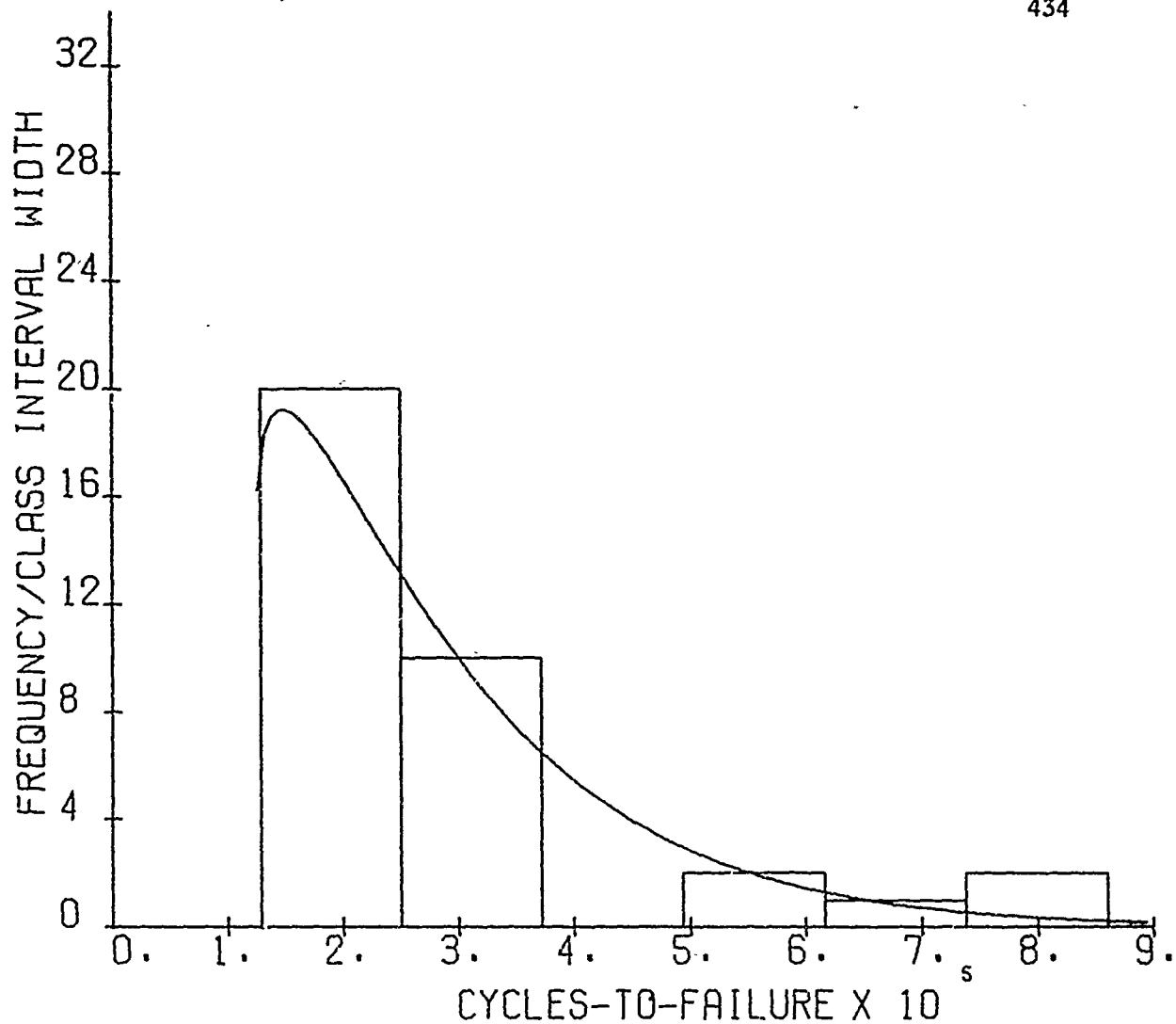


MEAN VALUE: 12.465 CYCLES
STANDARD DEVIATION: 0.467 CYCLES
KOLMOGOROV-SMIRNOV TEST: 0.123
CHI-SQUARED TEST: 3.262
SKEWNESS: 0.860
KURTOSIS: 3.335

FIG. 9.1-44 CYCLES-TO-FAILURE DIST OF GROUP NO. 151
USING WIRE FATIGUE MACHINE NO. 4 FOR
35 SPECIMENS OF .040 IN. DIAMETER AISI
4340 STEEL WIRE. FIXED ALTERNATING
STRESS LEVEL OF 78,100 PSI. BEND ANGLE
21.5 DEGREES. COAST-DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

434



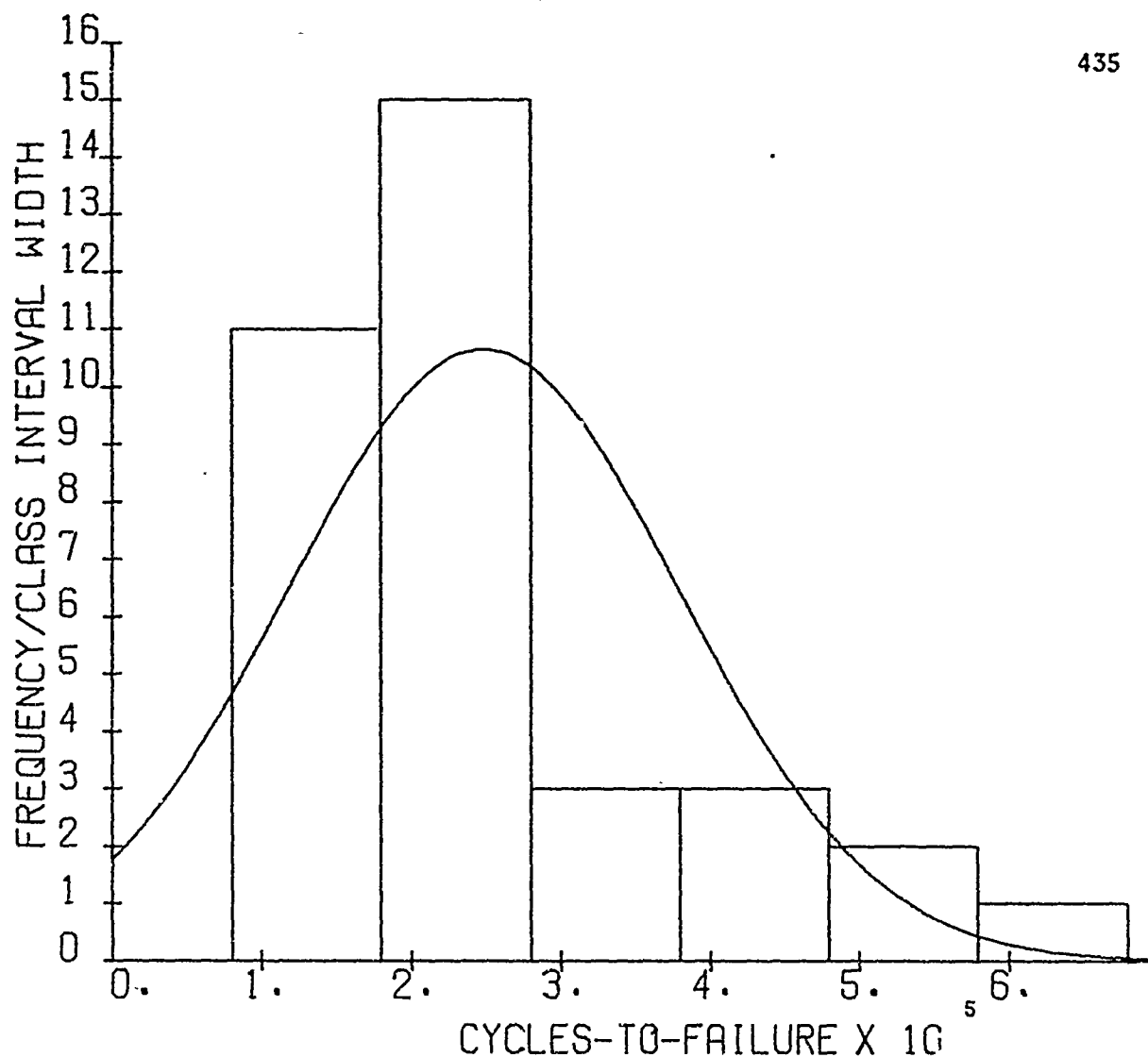
KOLMOGOROV-SMIRNOV TEST: 0.106
 CHI-SQUARED TEST: 4.993
 WEIBULL SLOPE (BETA): 1.123
 MINIMUM LIFE (GAMMA): 123199
 SCALE PARAMETER (ETA): 175551

FIG. 9.1-45

CYCLES-TO-FAILURE DISTRIBUTION
 SL=78100 PSI
 GROUP=151

NORMAL DISTRIBUTION PARAMETERS

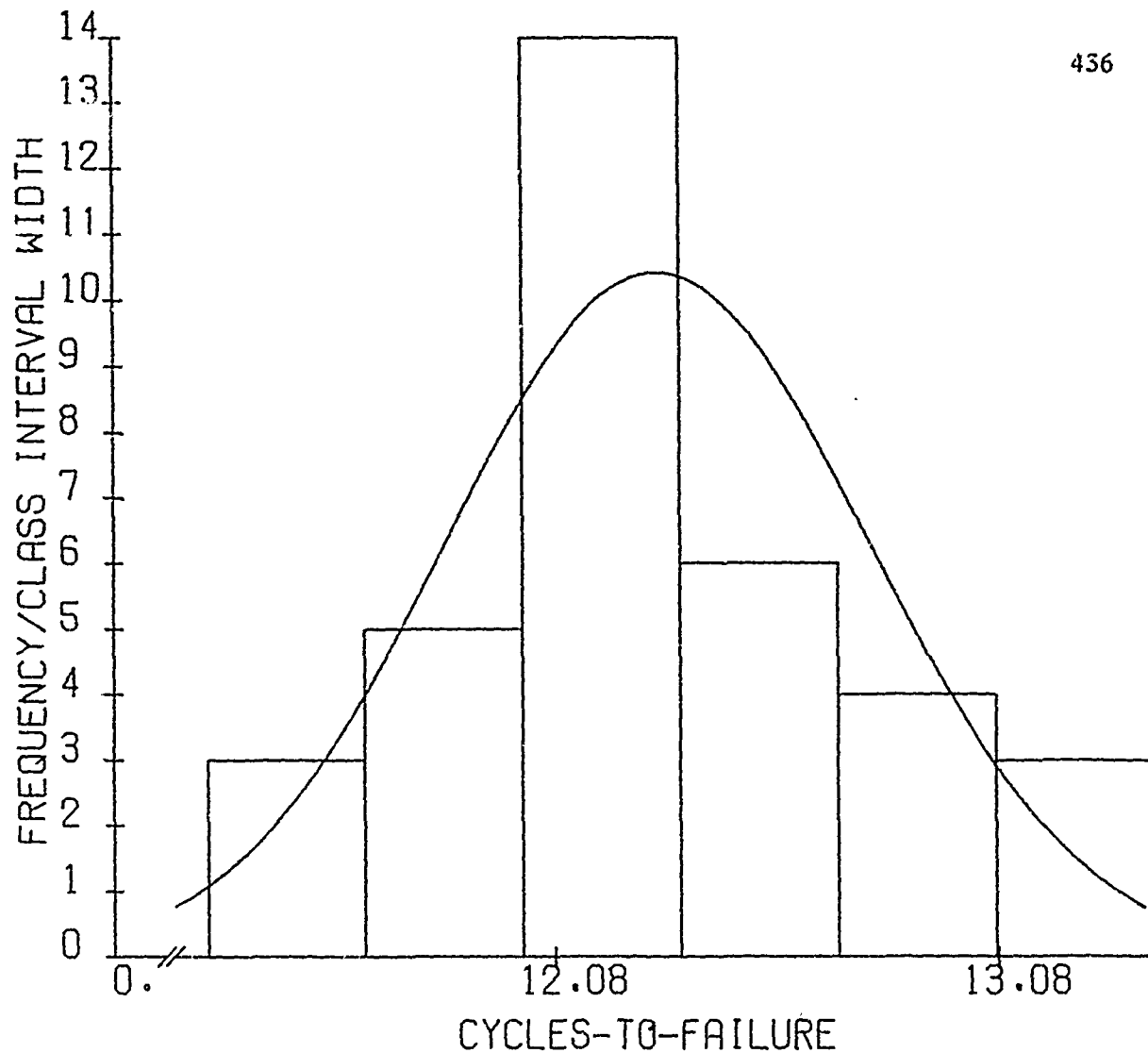
435



MEAN VALUE: 248517.1 CYCLES
 STANDARD DEVIATION: 130793.5 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.226
 CHI-SQUARED TEST: 5.902
 SKEWNESS: 1.524
 KURTOSIS: 5.204

FIG. 9.1-46 CYCLES-TO-FAILURE DIST OF GROUP NO. 152
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 80,100 PSI. BEND ANGLE
 22.0 DEGREES. COAST-DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

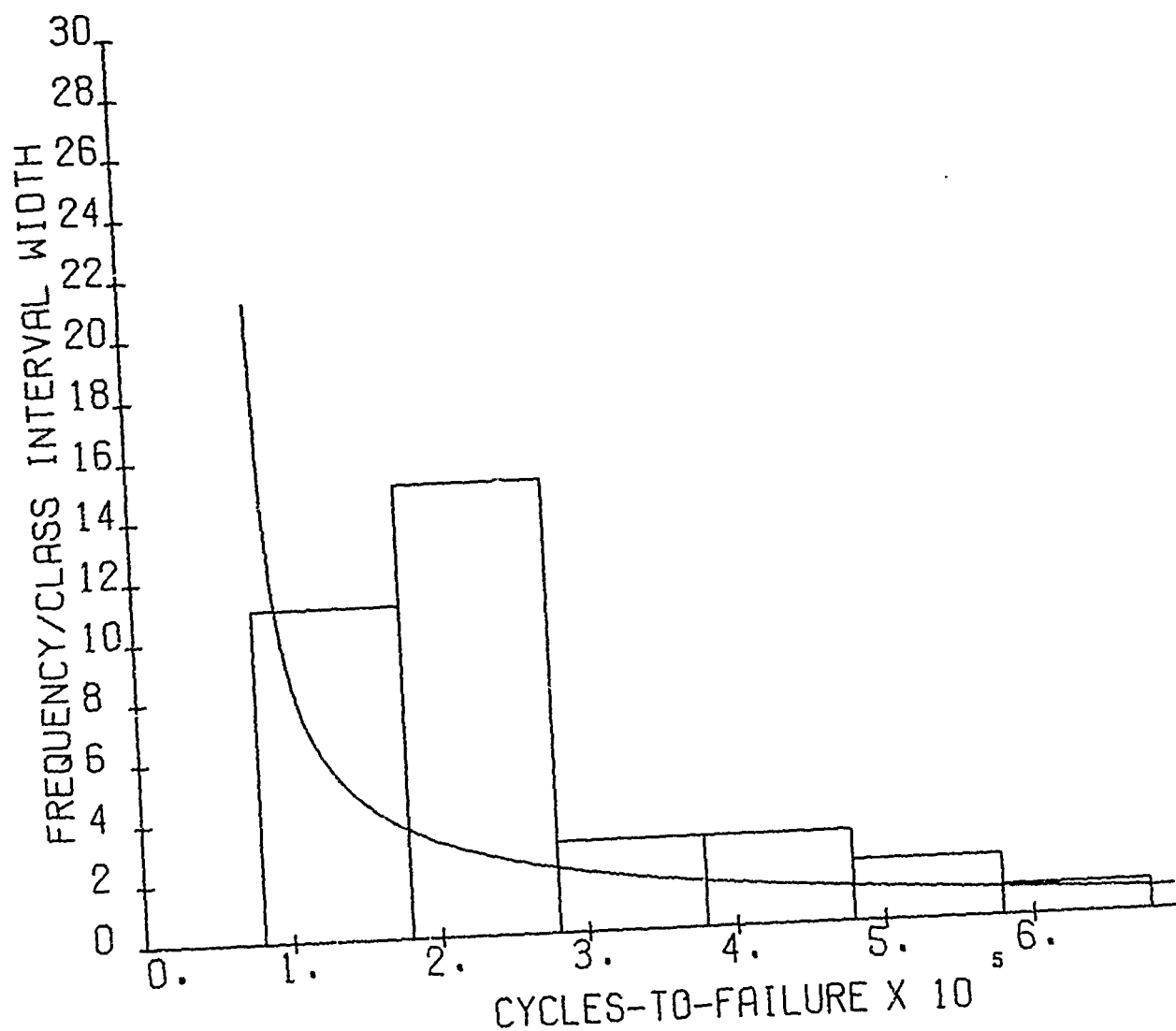


MEAN VALUE:	12.309	CYCLES
STANDARD DEVIATION:	0.478	CYCLES
KOLMOGOROV-SMIRNOV TEST:	0.131	
CHI-SQUARED TEST:	2.967	
SKEWNESS:	0.208	
KURTOSIS:	3.130	

FIG. 9.1-47 CYCLES-TO-FAILURE DIST OF GROUP NO. 152
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 80,100 PSI. BEND ANGLE
 22.0 DEGREES. COAST-DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

437



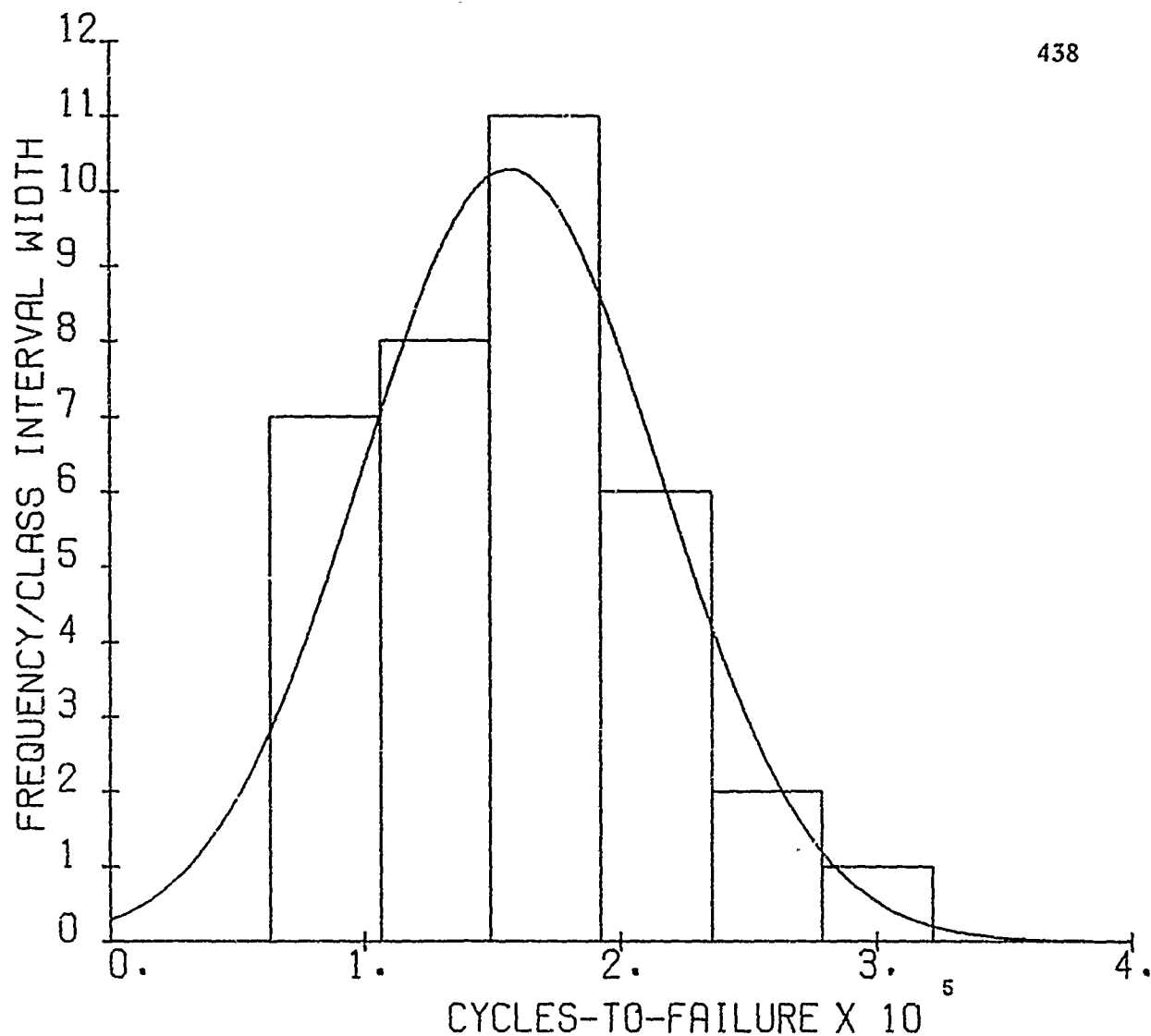
KOLMOGOROV-SMIRNOV TEST: 0.328
 CHI-SQUARED TEST: 69.373
 WEIBULL SLOPE (BETA): 0.559
 MINIMUM LIFE (GAMMA): 79899
 SCALE PARAMETER (ETA): 429256

FIG. 9.1-48

CYCLES-TO-FAILURE DISTRIBUTION
 GROUP=152
 SL=80100 PSI

NORMAL DISTRIBUTION PARAMETERS

438

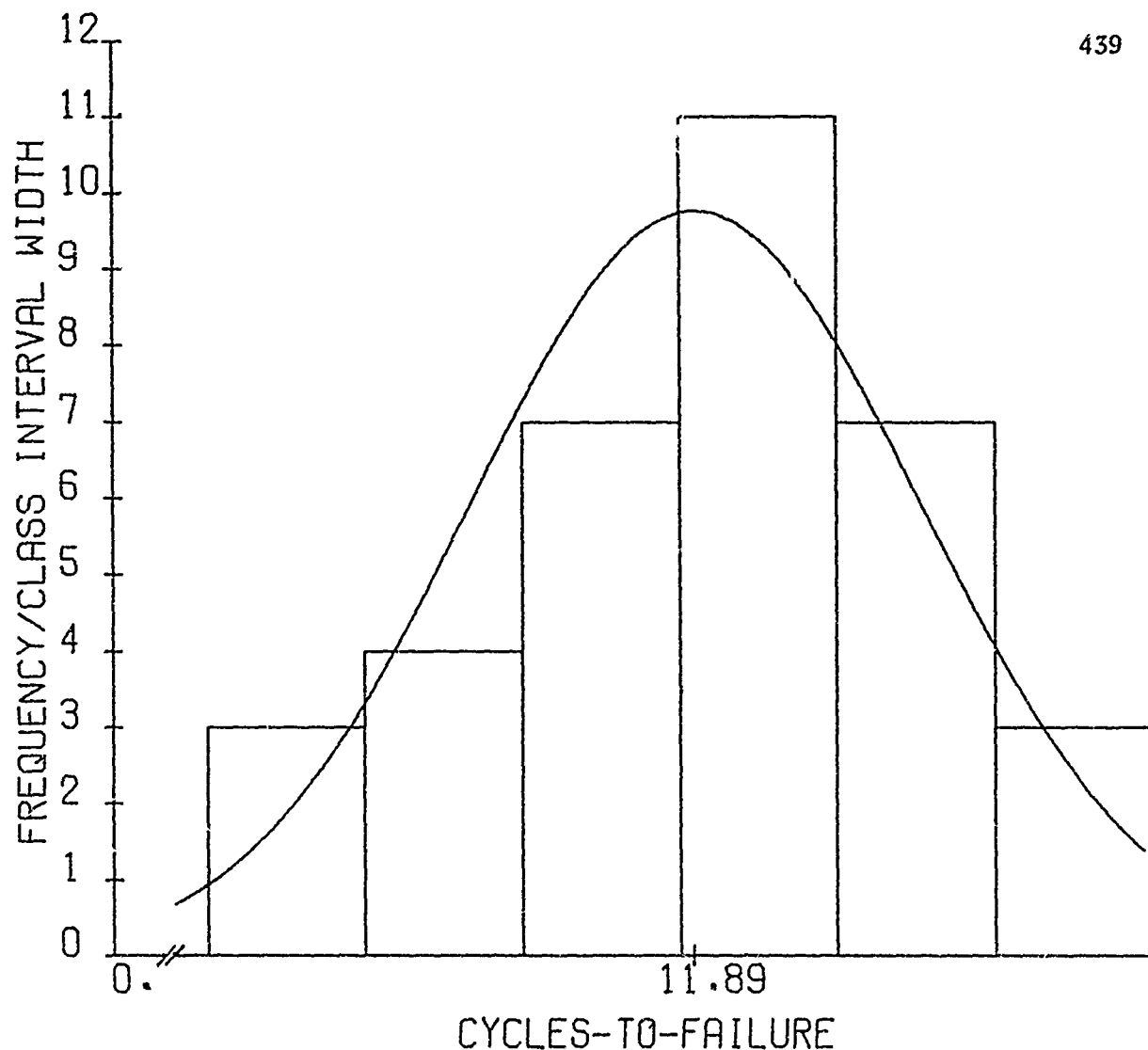


MEAN VALUE: 157314.3 CYCLES
 STANDARD DEVIATION: 58475.9 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.081
 CHI-SQUARED TEST: 0.288
 SKEWNESS: 0.585
 KURTOSIS: 3.241

FIG. 9-1-49 CYCLES-TO-FAILURE DIST OF GROUP NO. 153
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 84,700 PSI. BEND ANGLE
 23.0 DEGREES. COAST-DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

439

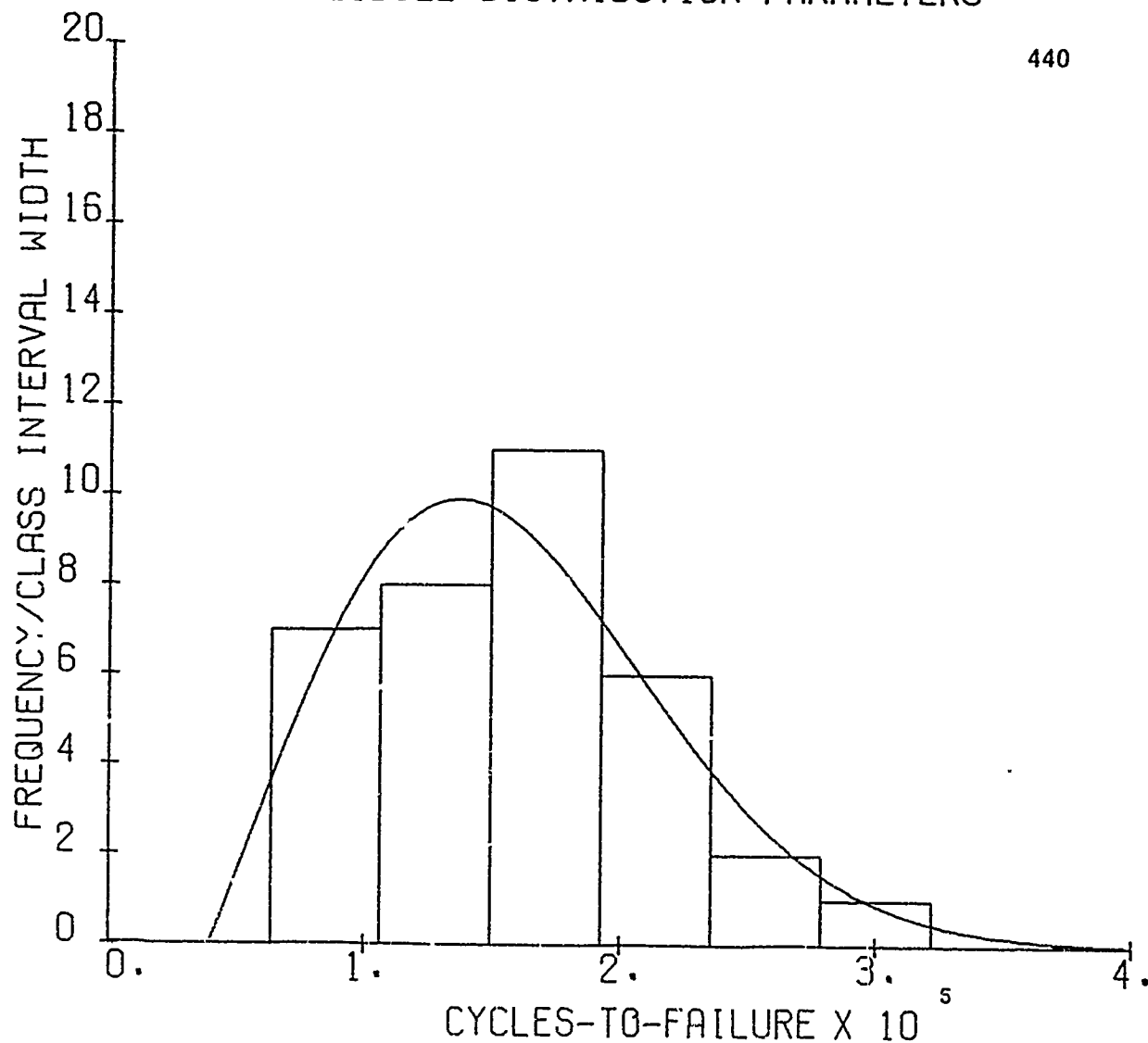


MEAN VALUE:	11.896	CYCLES
STANDARD DEVIATION:	0.388	CYCLES
KOLMOGOROV-SMIRNOV TEST:	0.067	
CHI-SQUARED TEST:	0.824	
SKEWNESS:	-0.330	
KURTOSIS:	2.643	

FIG. 9.1-50 CYCLES-TO-FAILURE DIST OF GROUP NO. 153
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 84,700 PSI. BEND ANGLE
 23.0 DEGREES. COAST-DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

440



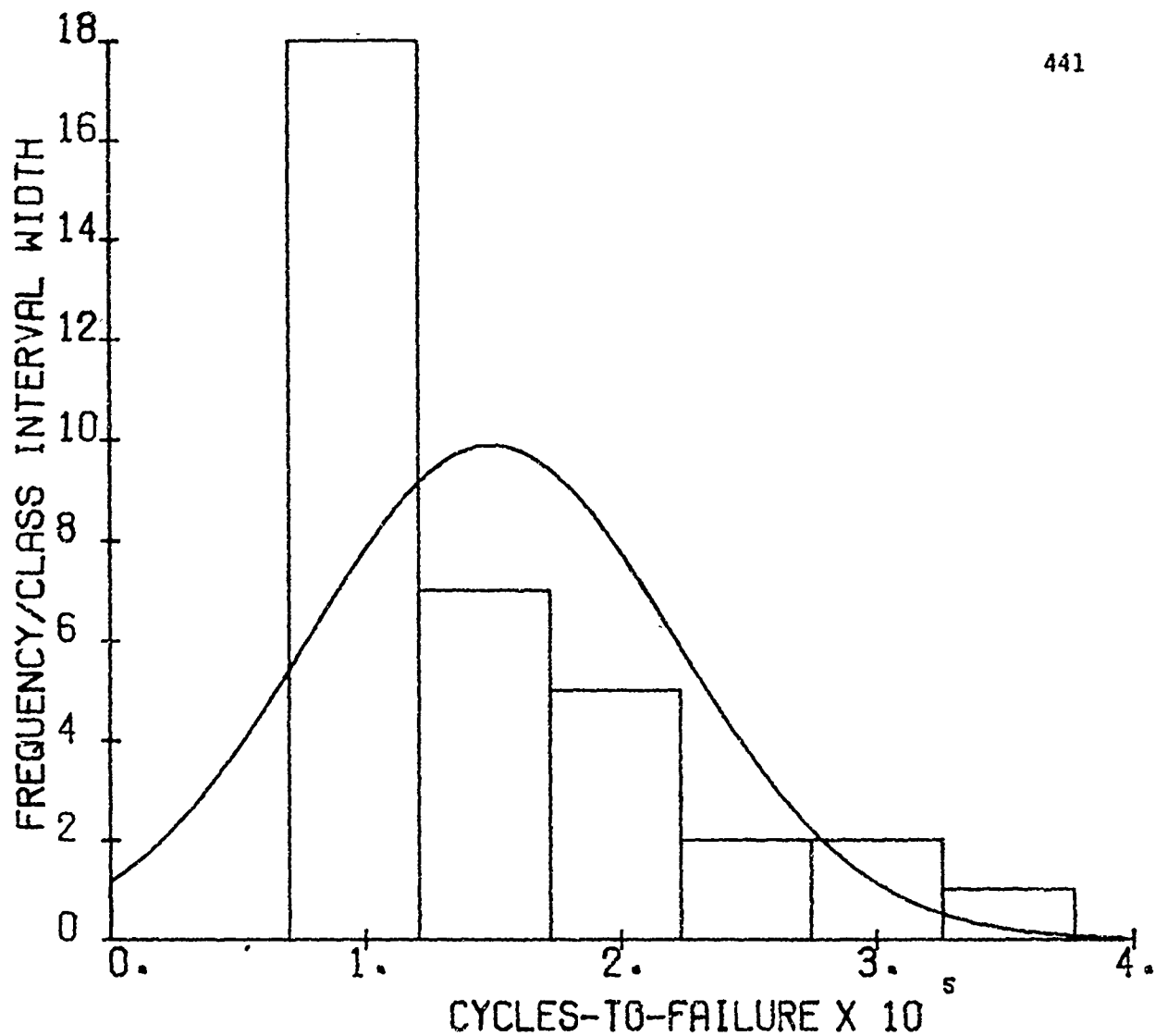
KOLMOGOROV-SMIRNOV TEST: 0.059
 CHI-SQUARED TEST: 1.227
 WEIBULL SLOPE (BETA): 2.081
 MINIMUM LIFE (GAMMA): 39099
 SCALE PARAMETER (ETA): 134262

FIG. 9.1-51

CYCLES-TO-FAILURE DISTRIBUTION
 SL=84700
 GROUP=153

NORMAL DISTRIBUTION PARAMETERS

441

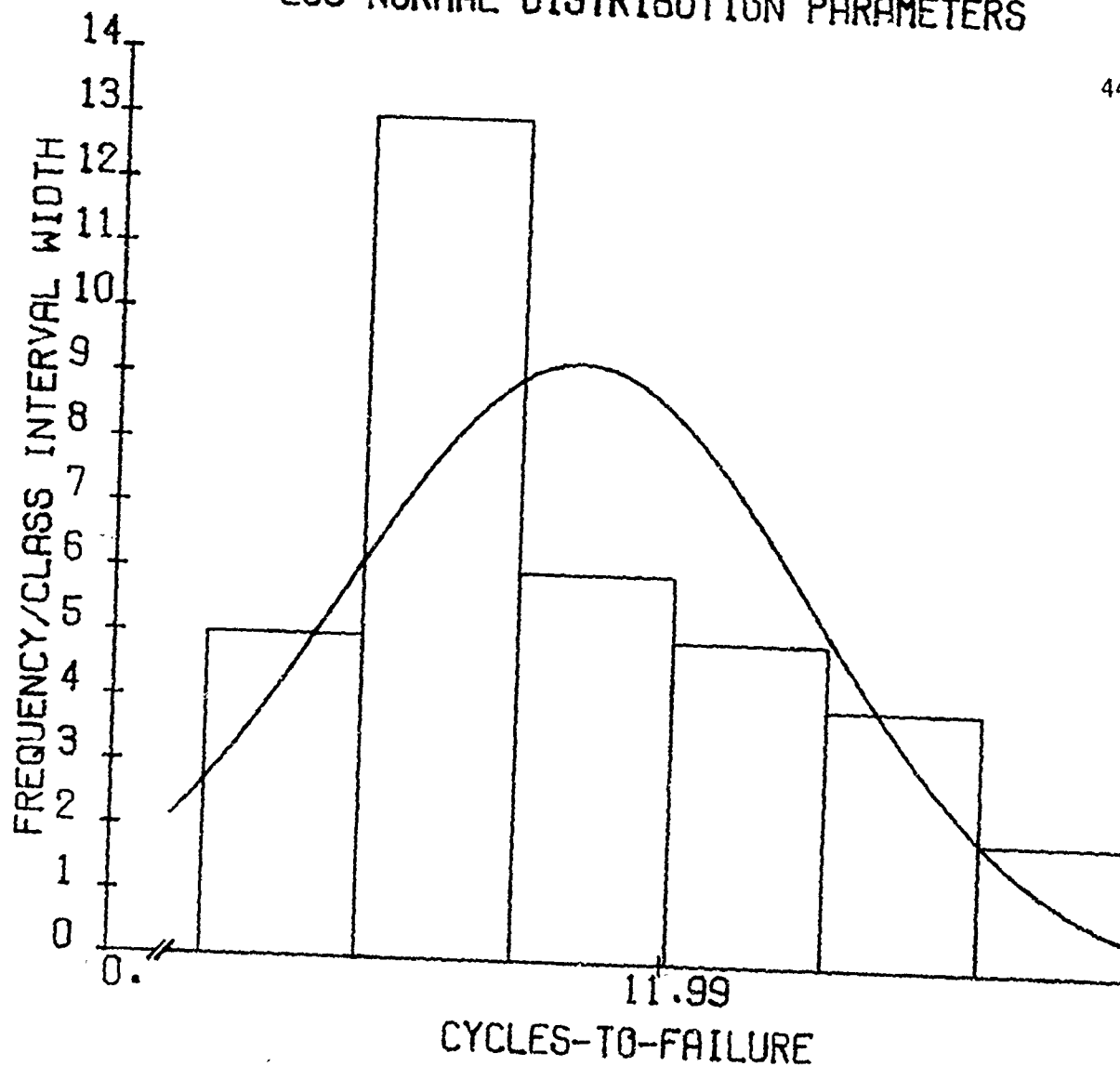


MEAN VALUE: 149548.6 CYCLES
 STANDARD DEVIATION: 72183.9 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.169
 CHI-SQUARED TEST: 4.601
 SKEWNESS: 1.440
 KURTOSIS: 4.638

FIG. 9.1-52 CYCLES-TO-FAILURE DIST OF GROUP NO. 154
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 90,000 PSI. BEND ANGLE
 24.0 DEGREES. COAST-DOWN CYCLES 100.

LOG NORMAL DISTRIBUTION PARAMETERS

442

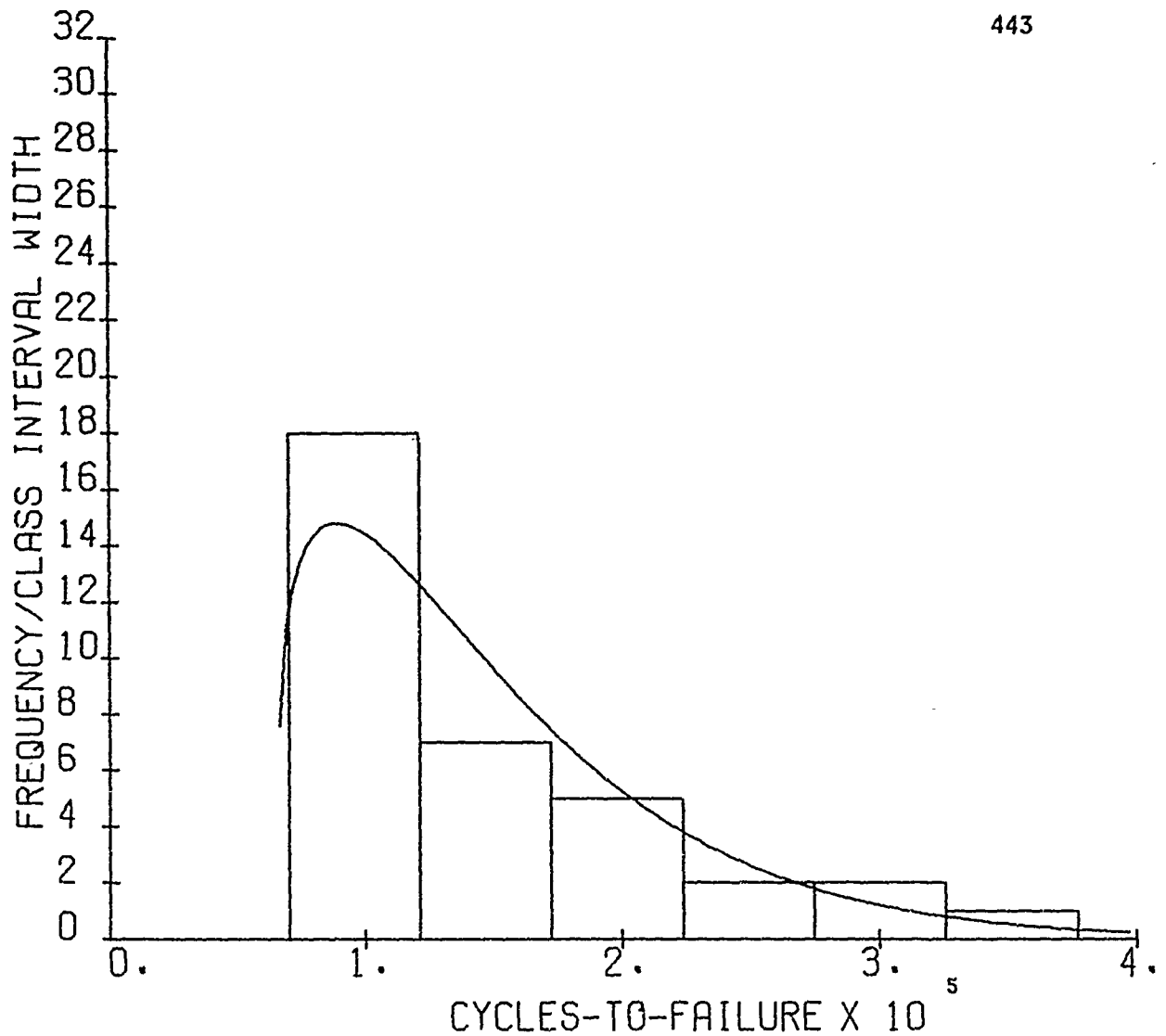


MEAN VALUE: 11.822 CYCLES
 STANDARD DEVIATION: 0.423 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.133
 CHI-SQUARED TEST: 5.678
 SKEWNESS: 0.632
 KURTOSIS: 2.607

FIG. 9.1-53 CYCLES-TO-FAILURE DIST OF GROUP NO. 154
 USING WIRE FATIGUE MACHINE NO. 4 FOR
 35 SPECIMENS OF .040 IN. DIAMETER AISI
 4340 STEEL WIRE. FIXED ALTERNATING
 STRESS LEVEL OF 90.000 PSI. BEND ANGLE
 24.0 DEGREES. COAST-DOWN CYCLES 100.

WEIBULL DISTRIBUTION PARAMETERS

443



KOLMOGOROV-SMIRNOV TEST: 0.102

CHI-SQUARED TEST: 7.581

WEIBULL SLOPE (BETA): 1.231

MINIMUM LIFE (GAMMA): 66100

SCALE PARAMETER (ETA): 90019

FIG. 9.1-54

CYCLES-TO-FAILURE DISTRIBUTION

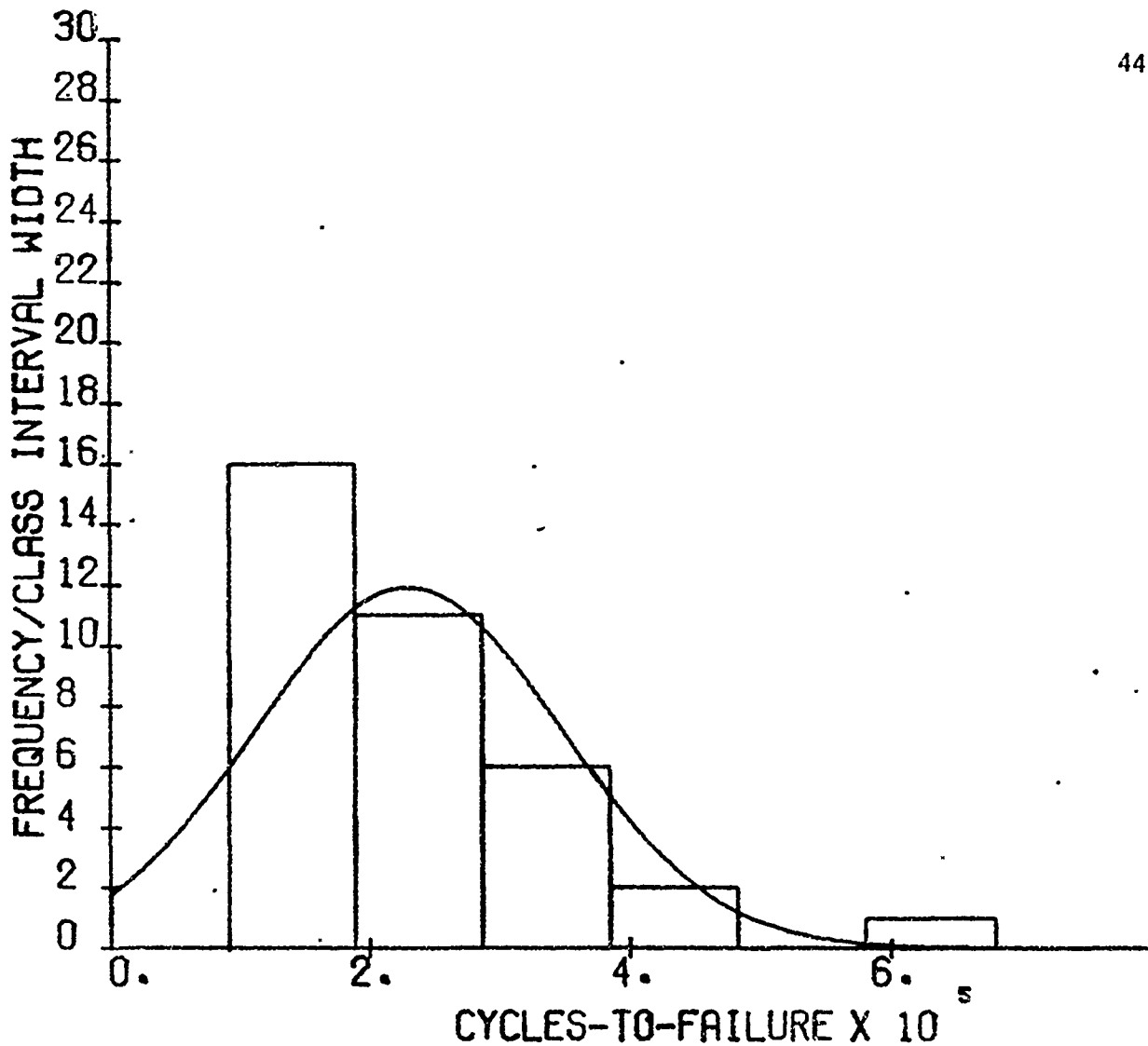
SL=90000 PSI

GROUP=154

9.2 WIEDEMANN FATIGUE MACHINE DATA

NORMAL DISTRIBUTION PARAMETERS

445

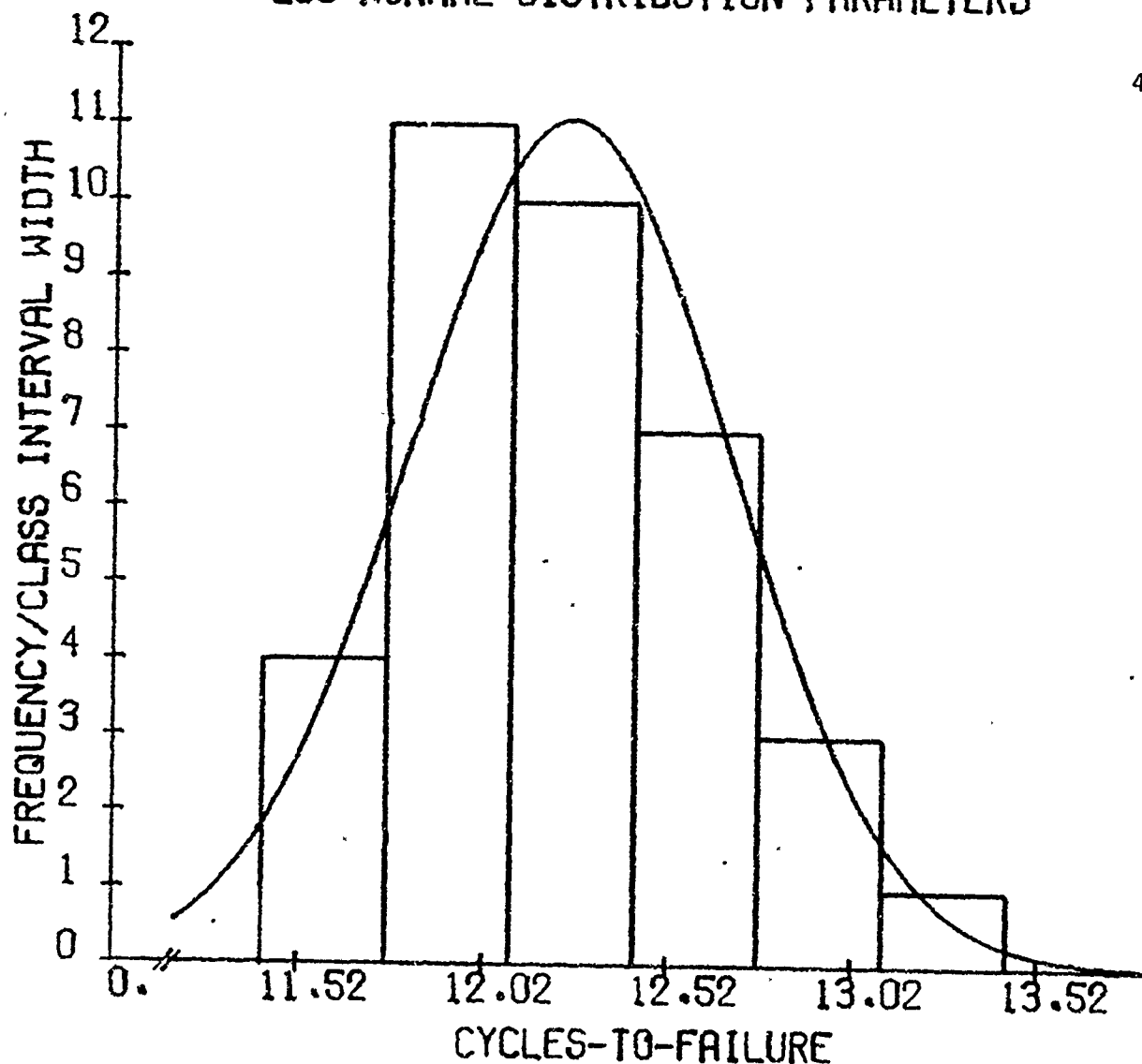


MEAN VALUE: 229777.8 CYCLES
 STANDARD DEVIATION: 118013.8 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.183
 CHI-SQUARED TEST: 1.169
 SKEWNESS: 1.900
 KURTOSIS: 7.284

FIG. 9.2-1 CYCLES-TO-FAILURE DIST OF GROUP NO. 89
 USING THE WEIDEMANN FATIGUE MACHINE
 FOR 36 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .125 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 75000 PSI.

LOG NORMAL DISTRIBUTION PARAMETERS

446

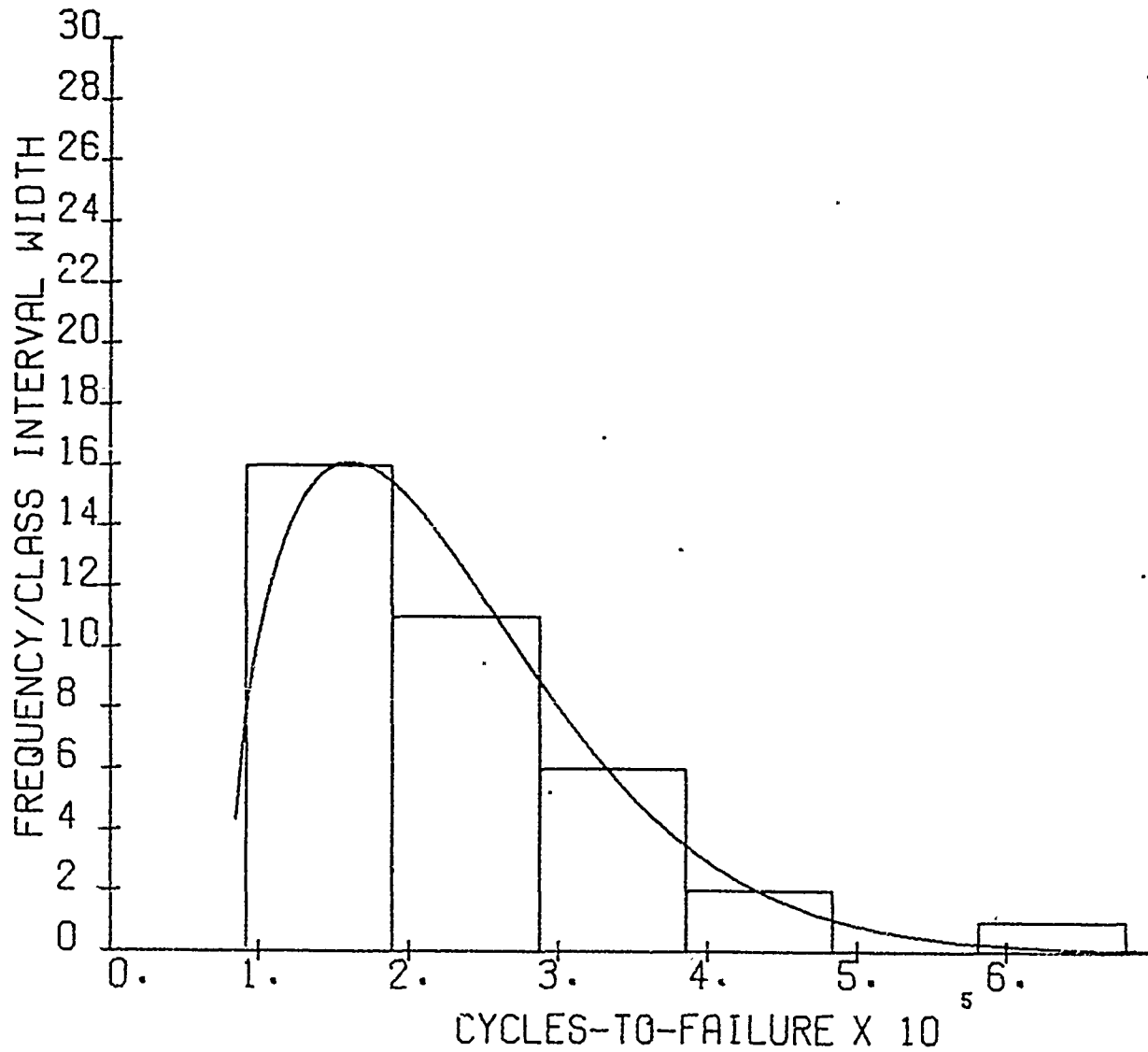


MEAN VALUE: 12.245 CYCLES
 STANDARD DEVIATION: 0.434 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.095
 CHI-SQUARED TEST: 0.508
 SKEWNESS: 0.628
 KURTOSIS: 3.155

FIG. 9.2-2 CYCLES-TO-FAILURE DIST OF GROUP NO. 89
 USING THE WEIDEMANN FATIGUE MACHINE
 FOR 36 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .125 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 75000 PSI.

WEIBULL DISTRIBUTION PARAMETERS

447



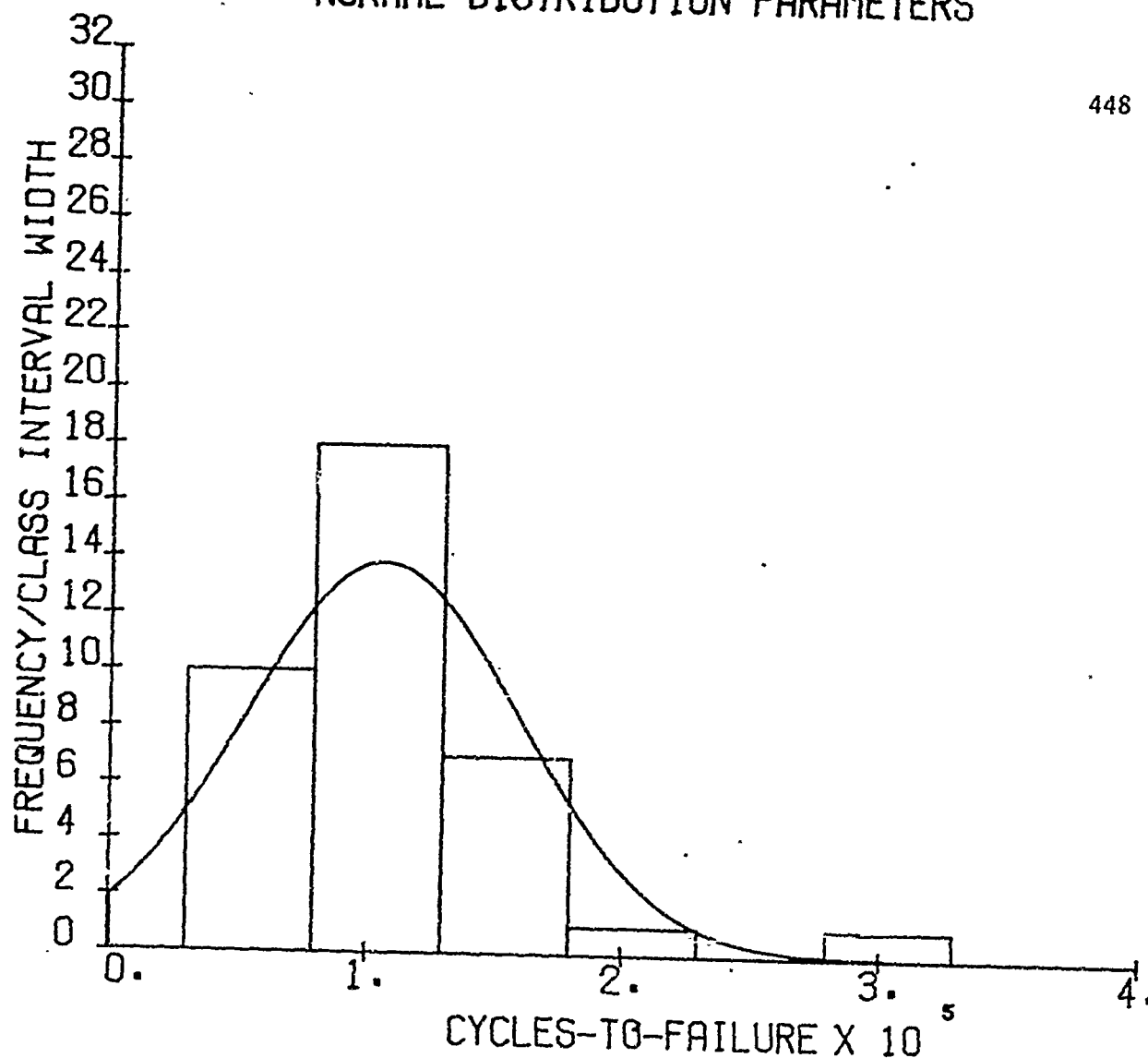
KOLMOGOROV-SMIRNOV TEST: 0.106
 CHI-SQUARED TEST: 4.389
 WEIBULL SLOPE (BETA): 1.513
 MINIMUM LIFE (GAMMA): 80800
 SCALE PARAMETER (ETA): 164090

FIG. 9.2-3

CYCLES-TO-FAILURE DISTRIBUTION
 SL=75000
 GROUP=89

NORMAL DISTRIBUTION PARAMETERS

448

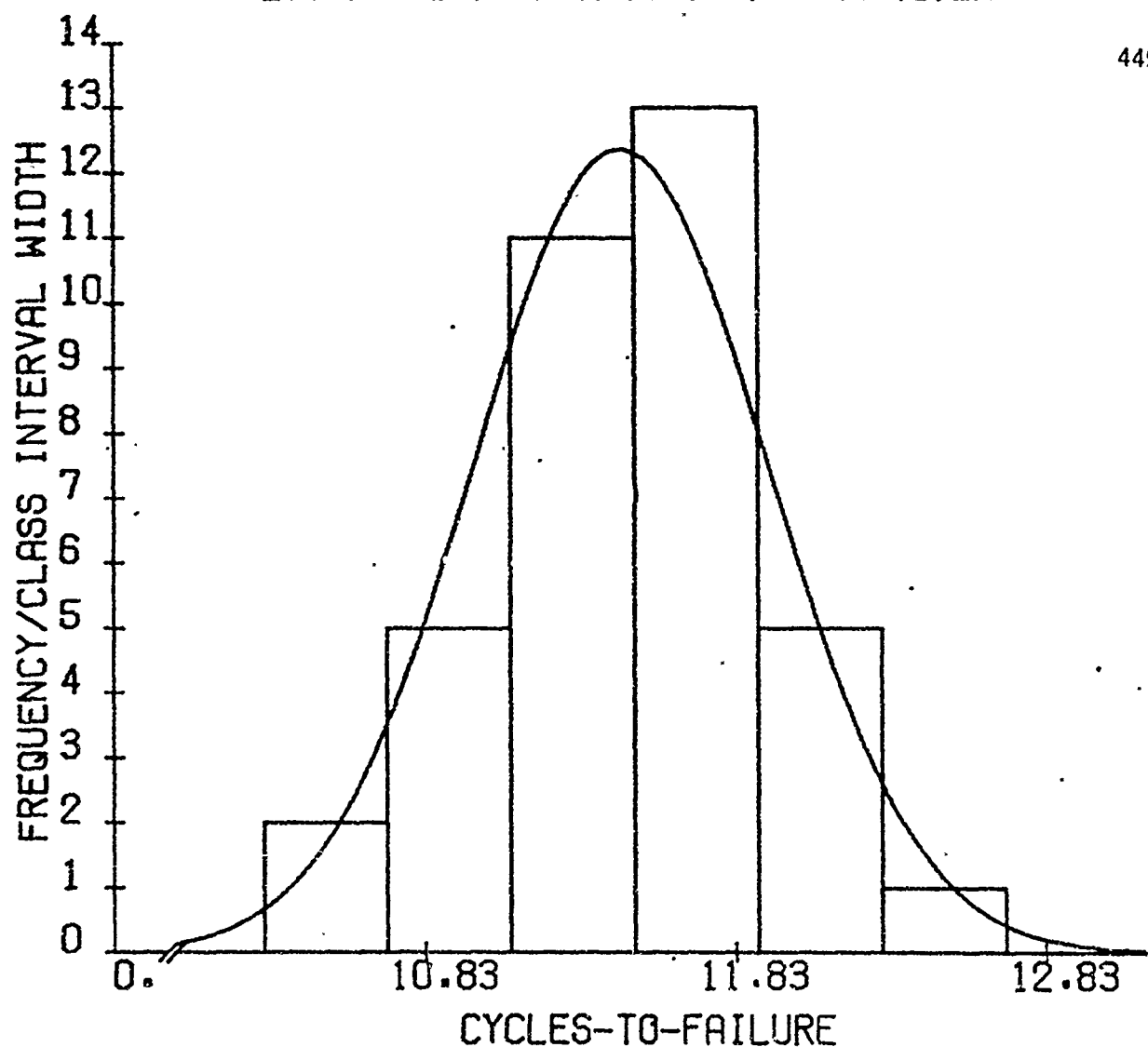


MEAN VALUE: 105837.8 CYCLES
 STANDARD DEVIATION: 53222.0 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.143
 CHI-SQUARED TEST: 2.610
 SKEWNESS: 1.944
 KURTOSIS: 9.326

FIG. 9.2-4 CYCLES-TO-FAILURE DIST OF GROUP NO. 90
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 37 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .125 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 85000 PSI.

LOG NORMAL DISTRIBUTION PARAMETERS

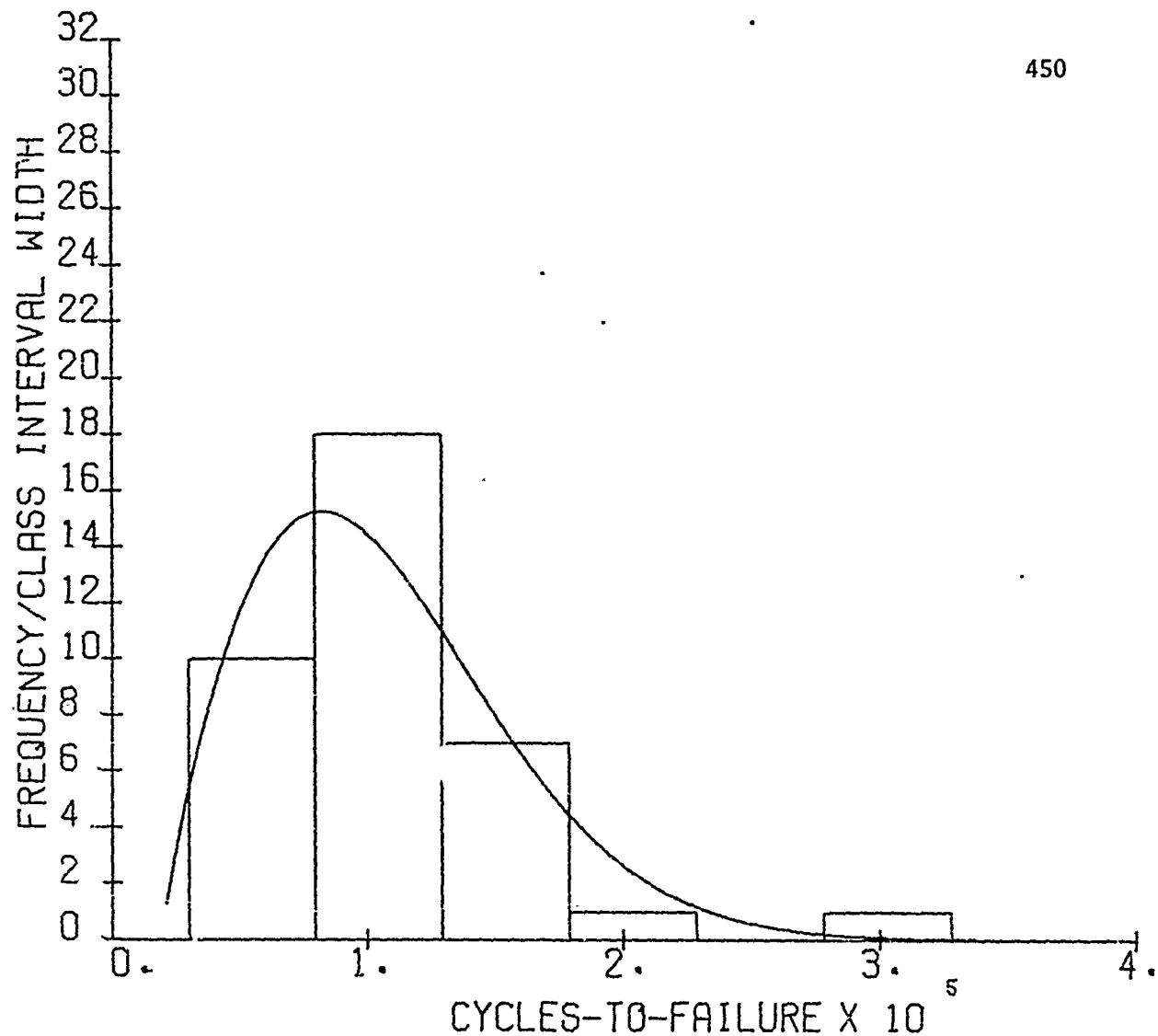
449



MEAN VALUE: 11.461 CYCLES
 STANDARD DEVIATION: 0.476 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.086
 CHI-SQUARED TEST: 0.832
 SKEWNESS: -0.175
 KURTOSIS: 3.401

FIG. 9.2-5 CYCLES-TO-FAILURE DIST OF GROUP NO. 90
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 37 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .125 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 85000 PSI.

WEIBULL DISTRIBUTION PARAMETERS



KOLMOGOROV-SMIRNOV TEST: 0.107

CHI-SQUARED TEST: 8.507

WEIBULL SLOPE (BETA): 1.825

MINIMUM LIFE (GAMMA): 19500

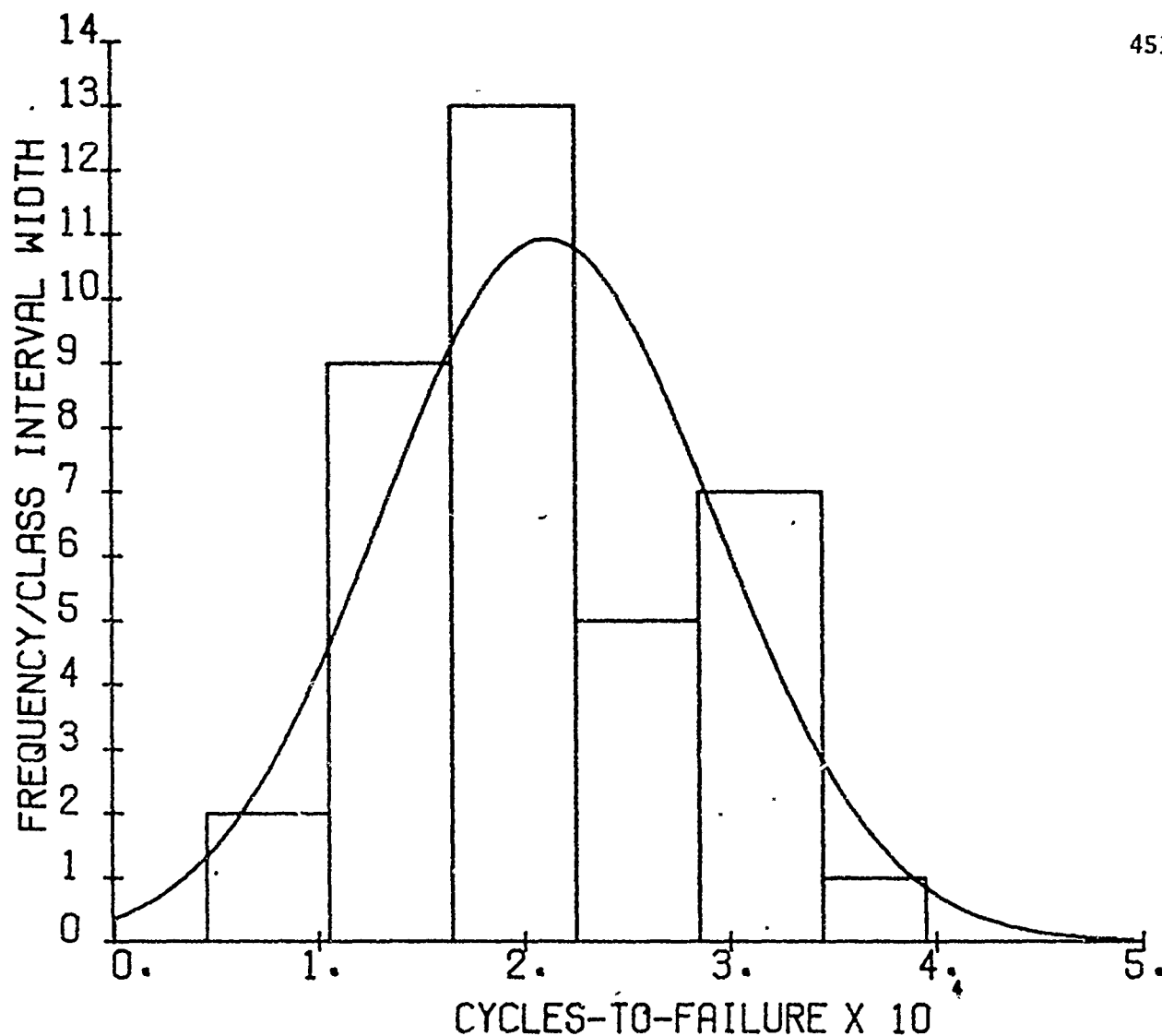
SCALE PARAMETER (ETA): 97719

FIG. 9.2-6

CYCLES-TO-FAILURE DISTRIBUTION
SL=85000 PSI
GROUP=90

NORMAL DISTRIBUTION PARAMETERS

451

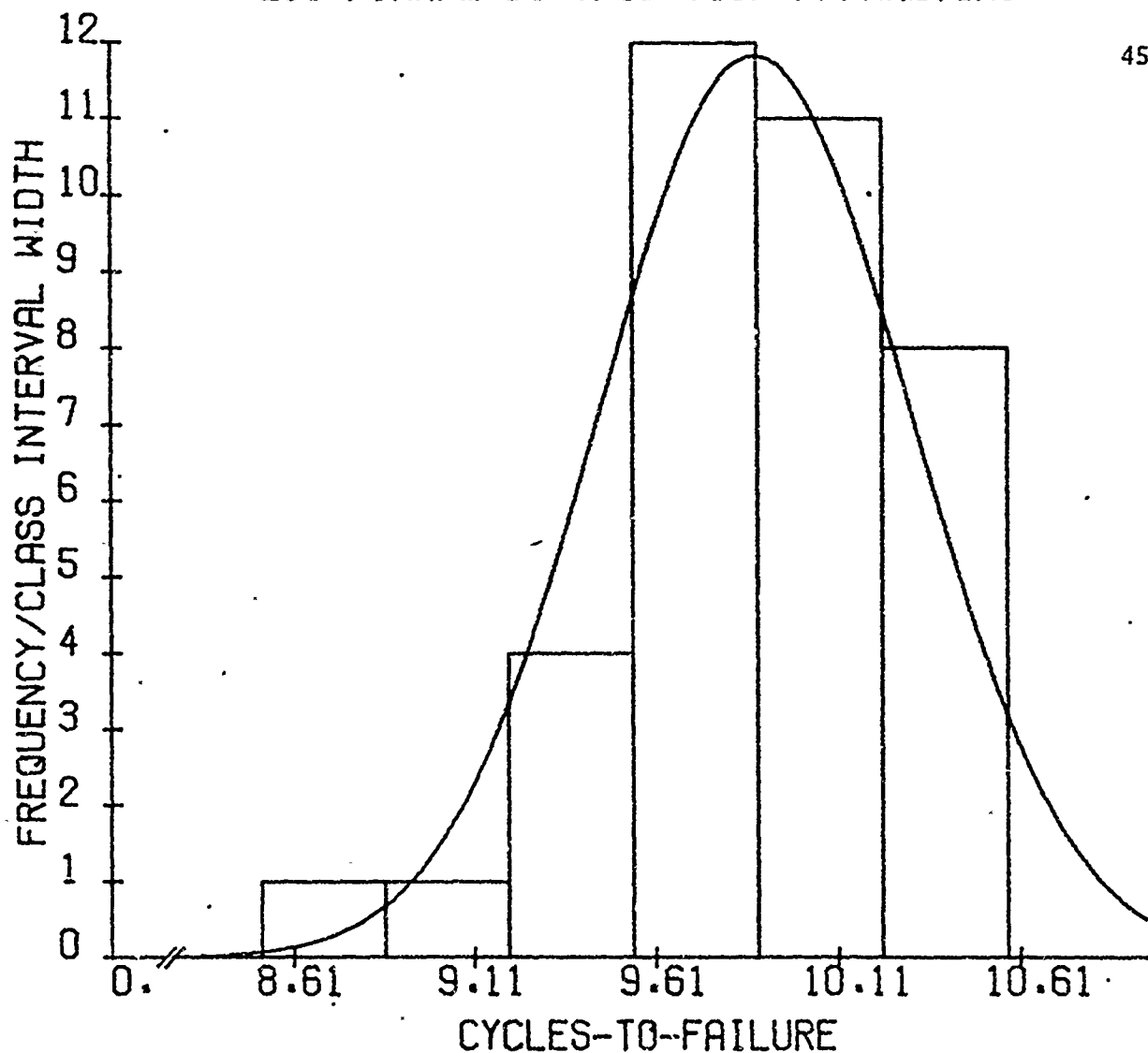


MEAN VALUE: 21162.2 CYCLES
 STANDARD DEVIATION: 8095.0 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.138
 CHI-SQUARED TEST: 2.873
 SKEWNESS: 0.374
 KURTOSIS: 2.458

FIG. 9.2-7 CYCLES-TO-FAILURE DIST OF GROUP NO. 91
 USING THE WEIDEMANN FATIGUE MACHINE
 FOR 37 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .125 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 90000.

LOG NORMAL DISTRIBUTION PARAMETERS

452

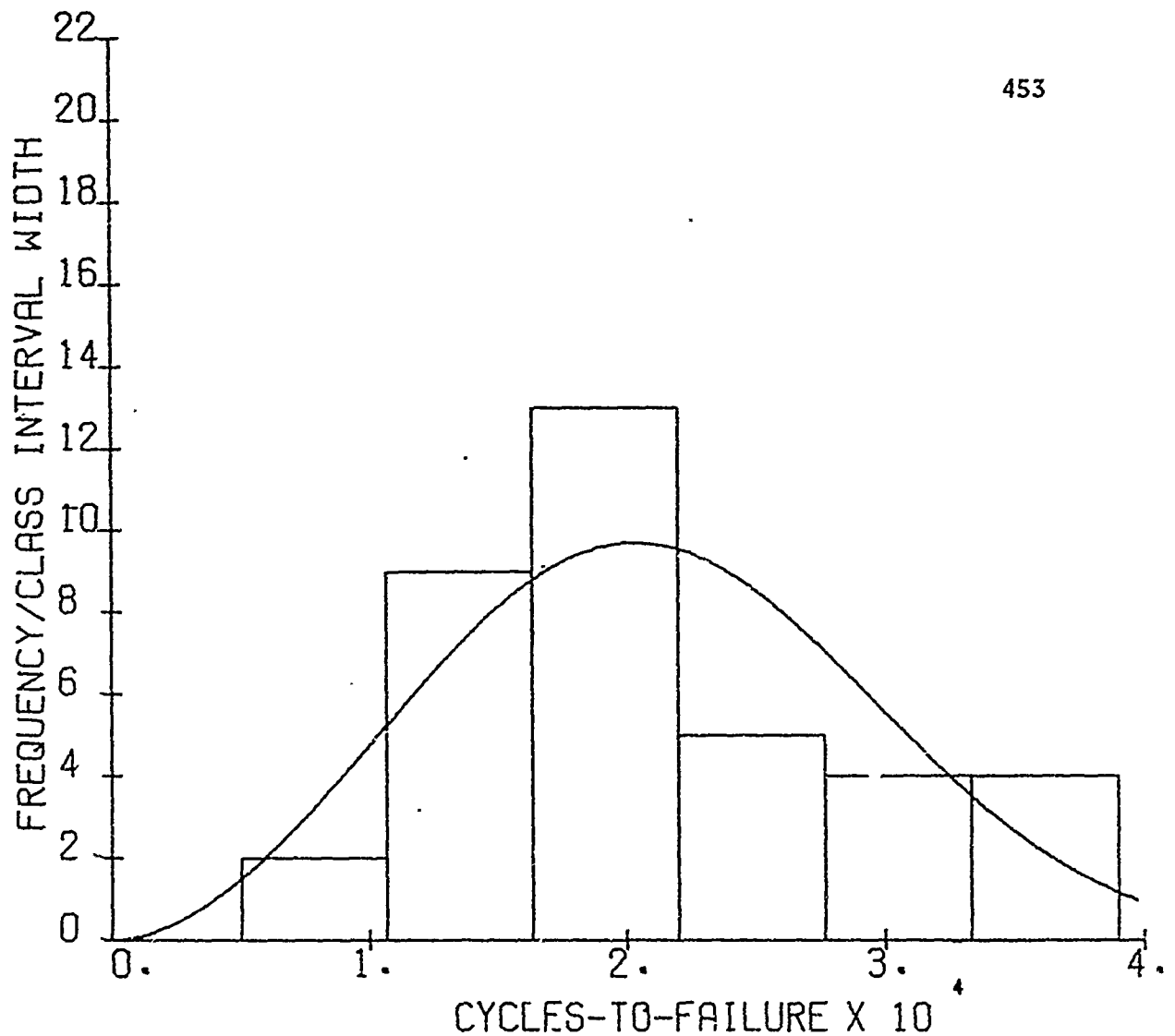


MEAN VALUE: 9.880 CYCLES
 STANDARD DEVIATION: 0.427 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.077
 CHI-SQUARED TEST: 0.668
 SKEWNESS: -0.831
 KURTOSIS: 4.341

FIG. 9.2-8 CYCLES-TO-FAILURE DIST OF GROUP NO. 91
 USING THE WEIDEMANN FATIGUE MACHINE
 FOR 37 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .125 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 90000.

WEIBULL DISTRIBUTION PARAMETERS

453



KOLMOGOROV-SMIRNOV TEST: 0.120

CHI-SQUARED TEST: 1.950

WEIBULL SLOPE (BETA): 2.786

MINIMUM LIFE (GAMMA): 0

SCALE PARAMETER (ETA): 23860

FIG. 9.2-9

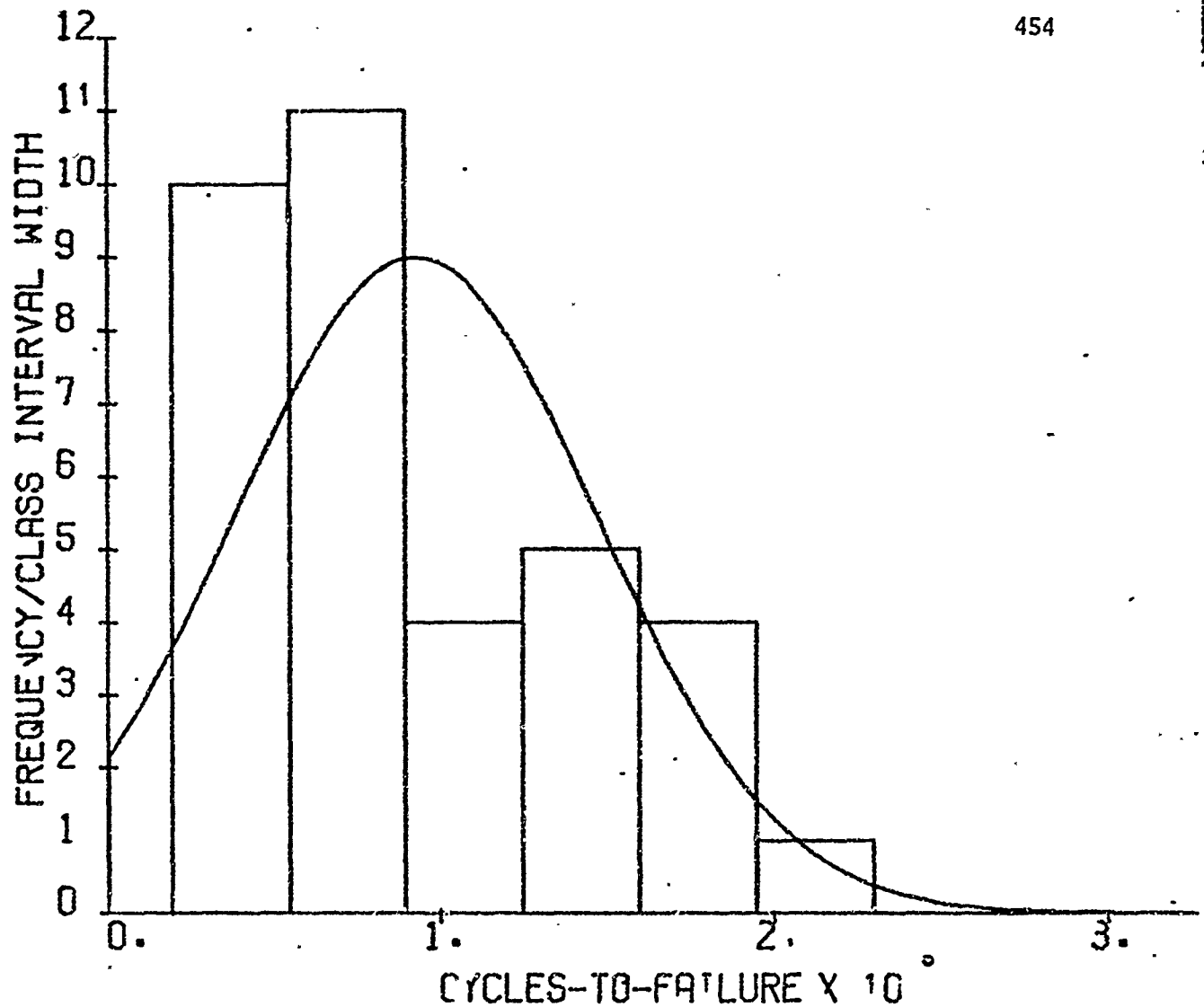
CYCLES-TO-FAILURE DISTRIBUTION

SL=95000 PSI

GROUP=91

NORMAL DISTRIBUTION PARAMETERS

454

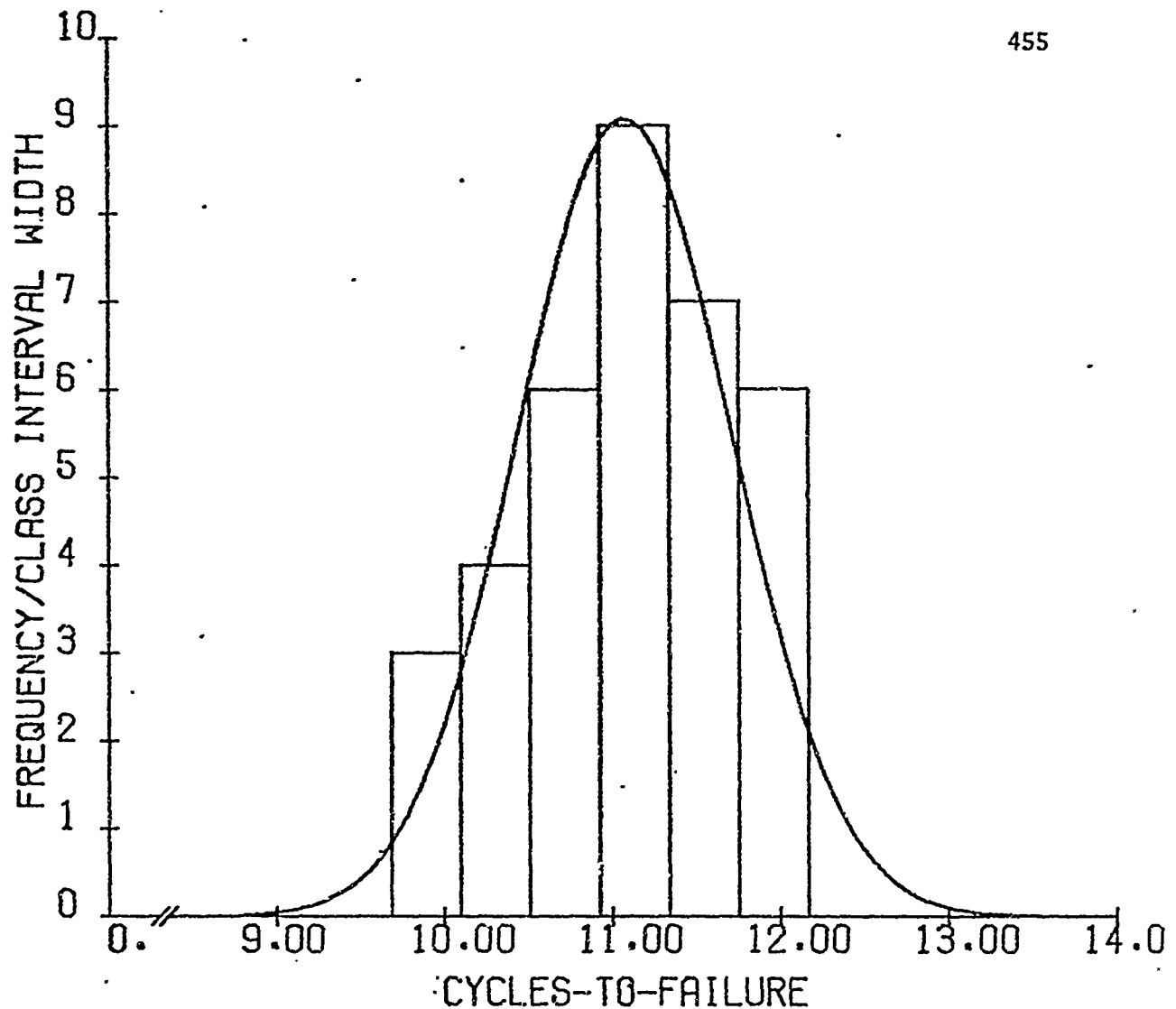


MEAN VALUE: 77600.0 CYCLES
 STANDARD DEVIATION: 45797.6 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.192
 CHI-SQUARED TEST: 4.128
 SKEWNESS: 0.732
 KURTOSIS: 2.601

FIG. 9.2-10 CYCLES-TO-FAILURE DIST OF GROUP NO. 93
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 35 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .250 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 70000 PSI.

LOG NORMAL DISTRIBUTION PARAMETERS

455

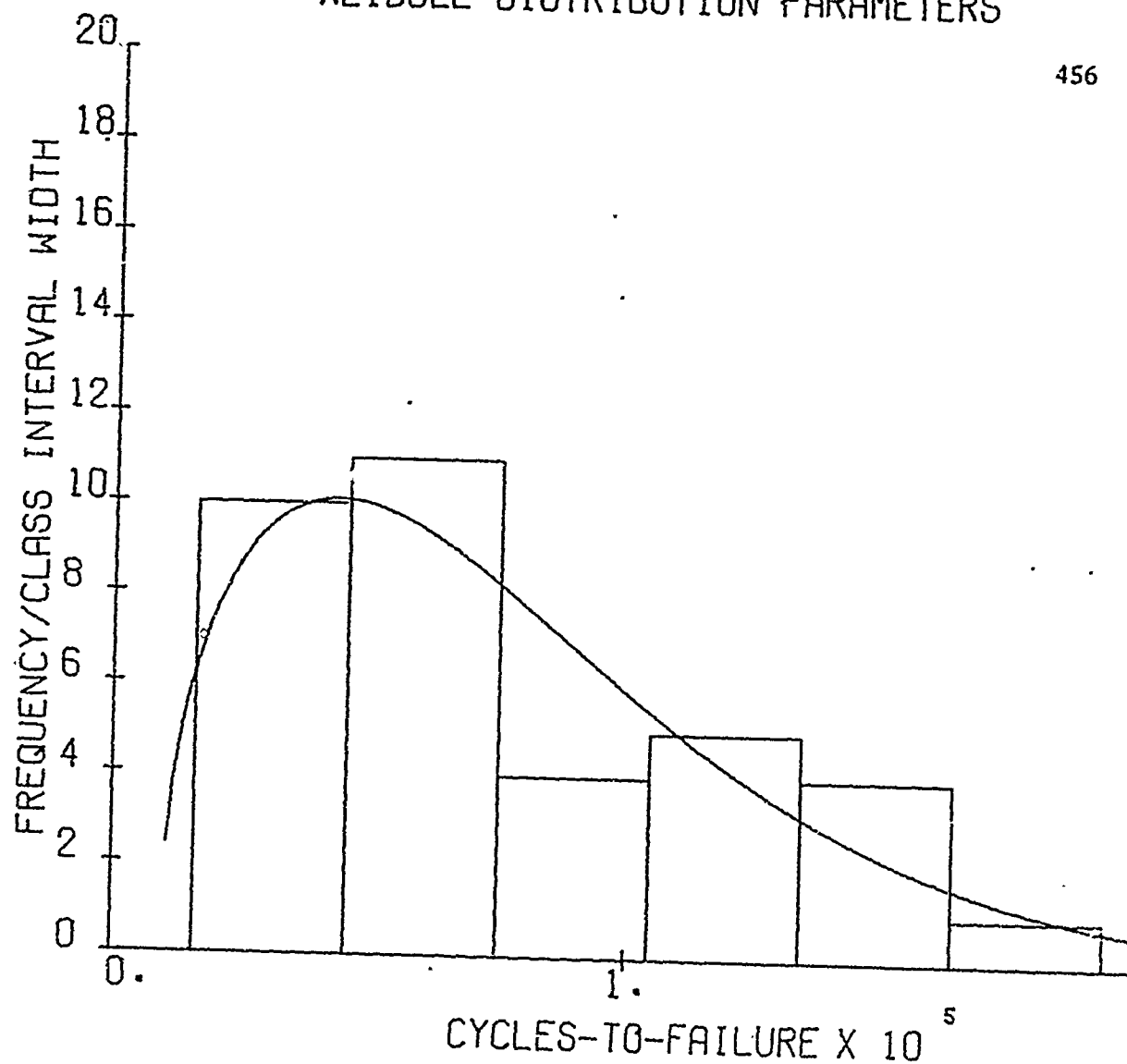


MEAN VALUE: 11.077 CYCLES
 STANDARD DEVIATION: 0.639 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.078
 CHI-SQUARED TEST: 0.574
 SKEWNESS: -0.307
 KURTOSIS: 2.438

FIG. 9.2-11 CYCLES-TO-FAILURE DIST OF GROUP NO. 9
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 35 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .250 IN. NOTCH RADIUS AIS
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 70000 PSI.

WEIBULL DISTRIBUTION PARAMETERS

456



KOLMOGOROV-SMIRNOV TEST: 0.114

CHI-SQUARED TEST: 6.484

WEIBULL SLOPE (BETA): 1.444

MINIMUM LIFE (GAMMA): 10000

SCALE PARAMETER (ETA): 75545

FIG. 9.2-12

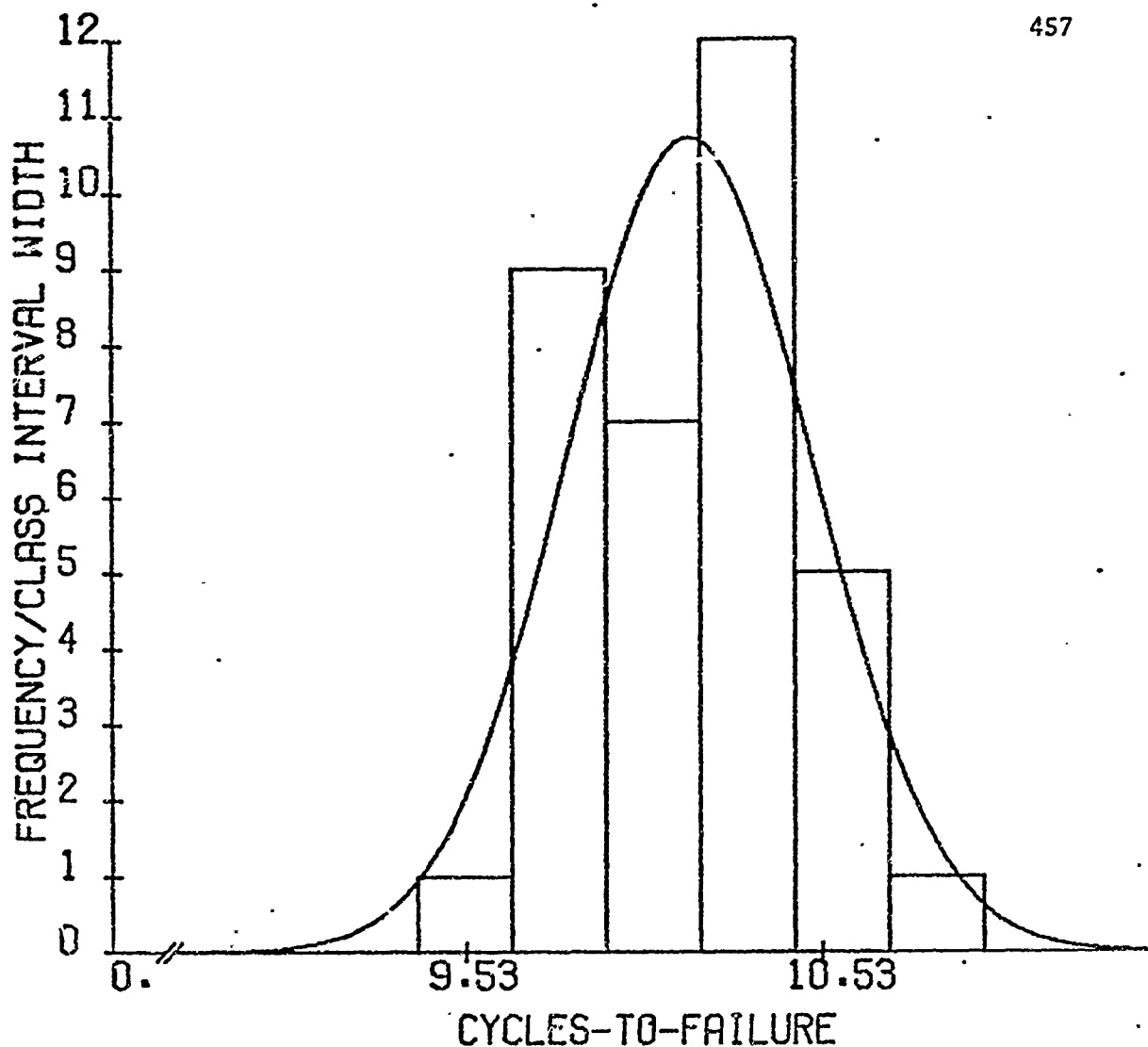
CYCLES-TO-FAILURE DISTRIBUTION

SL=70000 PSI

GROUP=93

LOG-NORMAL DISTRIBUTION PARAMETERS

457

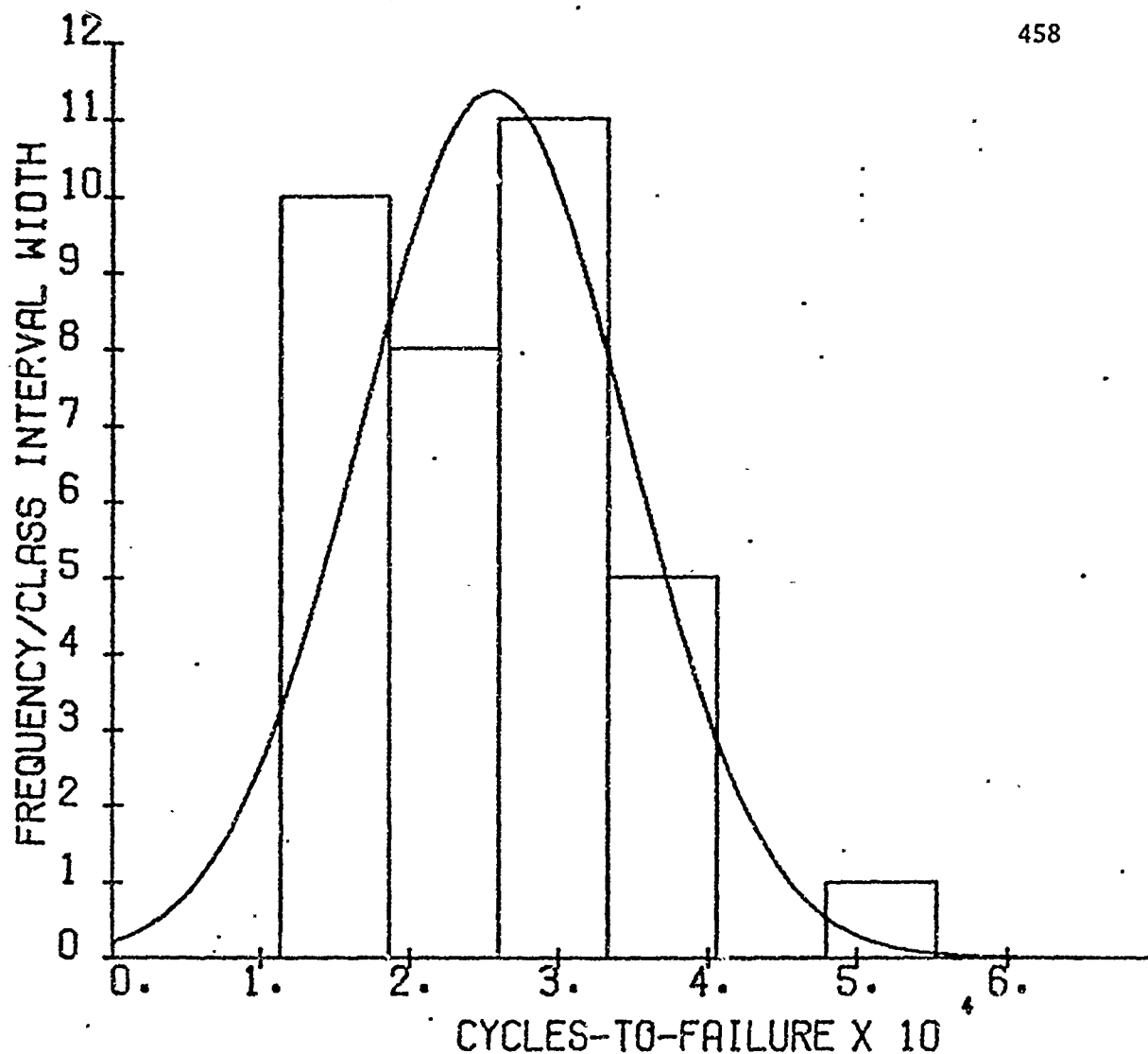


MEAN VALUE: 10.157 CYCLES
 STANDARD DEVIATION: 0.346 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.097
 CHI-SQUARED TEST: 1.931
 SKEWNESS: -0.012
 KURTOSIS: 2.691

FIG. 9.2-13 CYCLES-TO-FAILURE DIST OF GROUP NO. 94
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 35 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .250 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 80000 PSI.

NORMAL DISTRIBUTION PARAMETERS

458

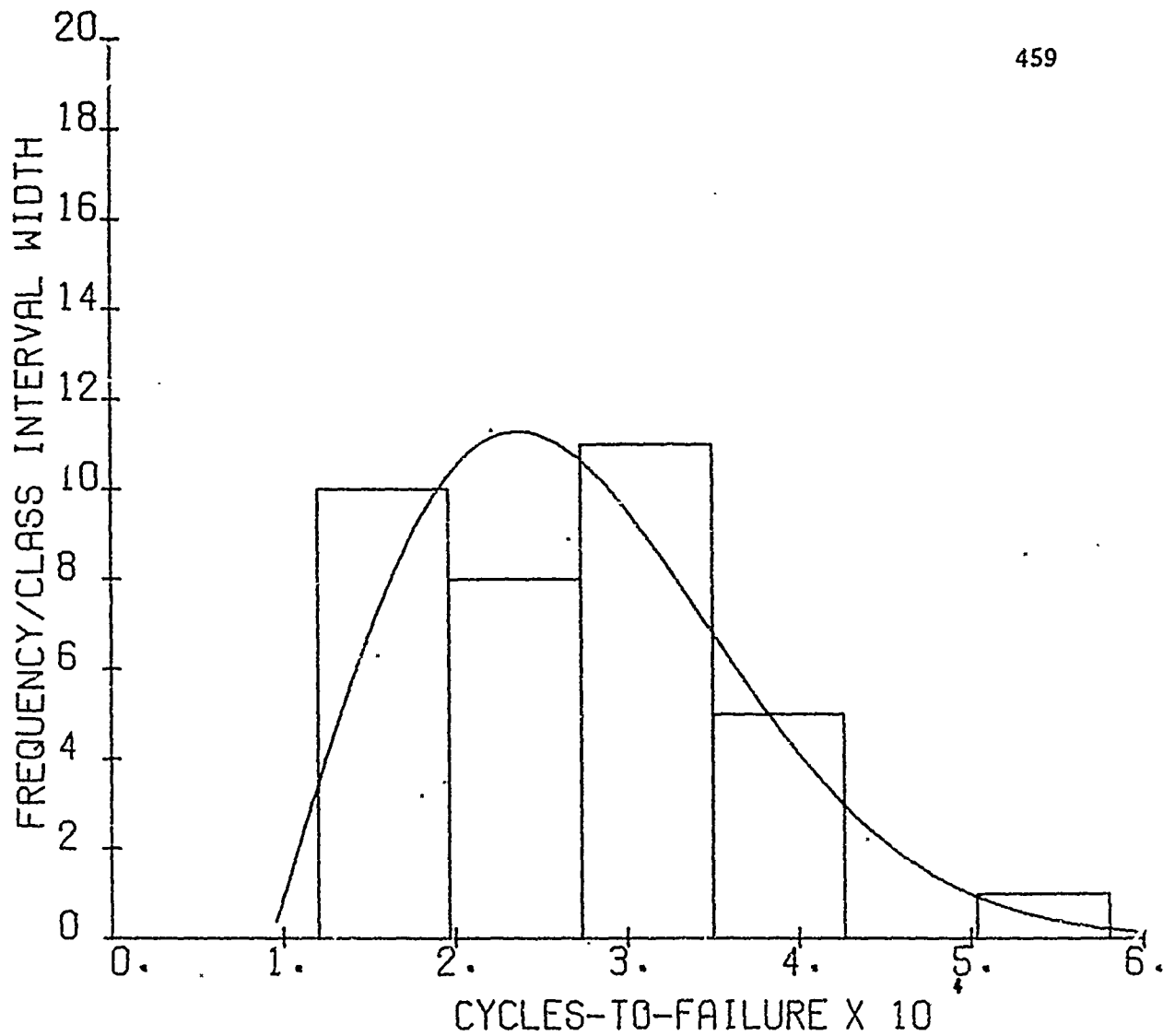


MEAN VALUE: 27314.3 CYCLES
 STANDARD DEVIATION: 9627.7 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.113
 CHI-SQUARED TEST: 1.466
 SKEWNESS: 0.978
 KURTOSIS: 4.546

FIG. 9.2-14 CYCLES-TO-FAILURE DIST OF GROUP NO. 94
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 35 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .250 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 80000 PSI.

WEIBULL DISTRIBUTION PARAMETERS

459



KOLMOGOROV-SMIRNOV TEST: 0.090

CHI-SQUARED TEST: 4.731

WEIBULL SLOPE (BETA): 2.001

MINIMUM LIFE (GAMMA): 9300

SCALE PARAMETER (ETA): 20415

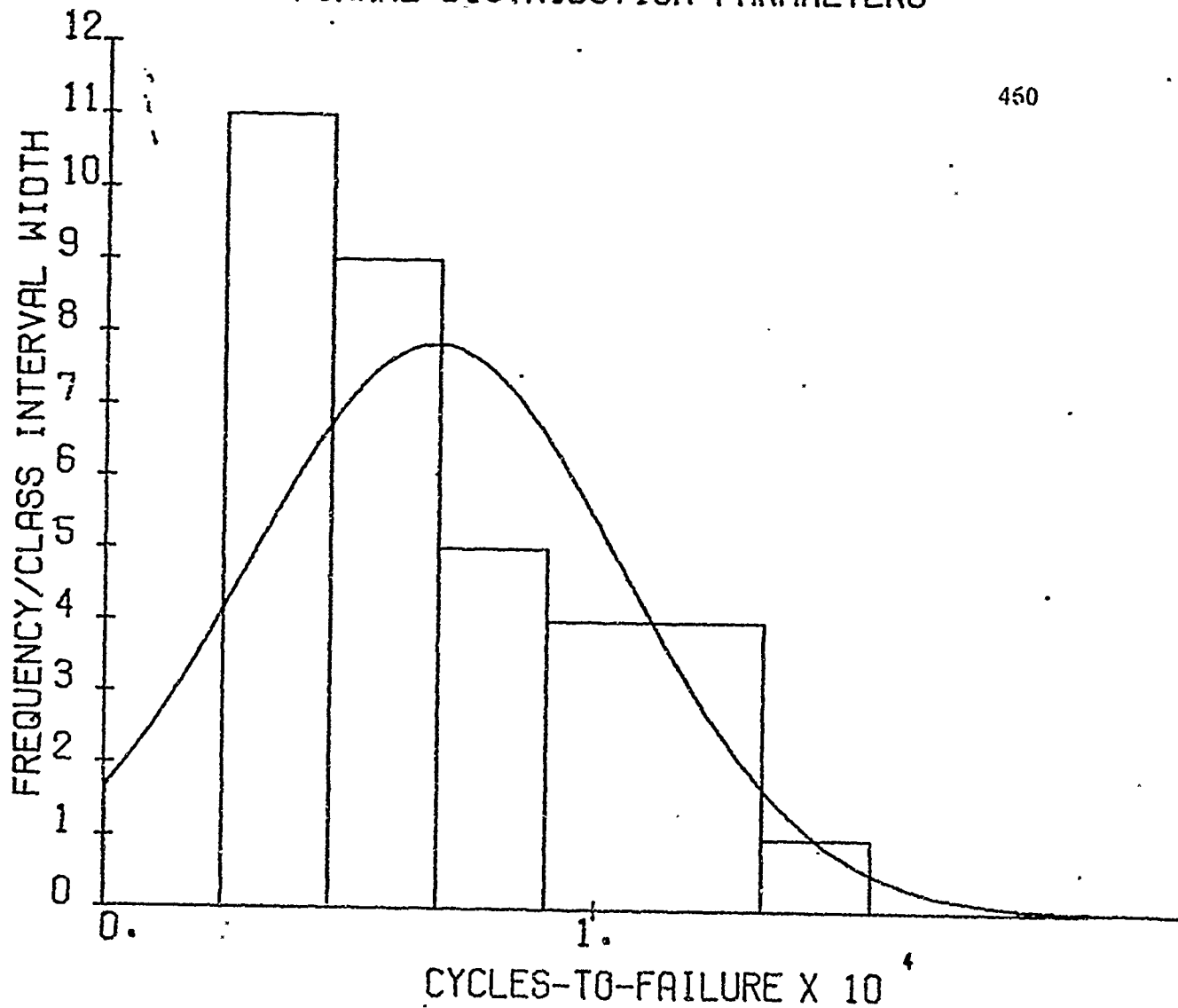
FIG. 9.2-15

CYCLES-TO-FAILURE DISTRIBUTION

SL=80000 PSI

GROUP=94

NORMAL DISTRIBUTION PARAMETERS

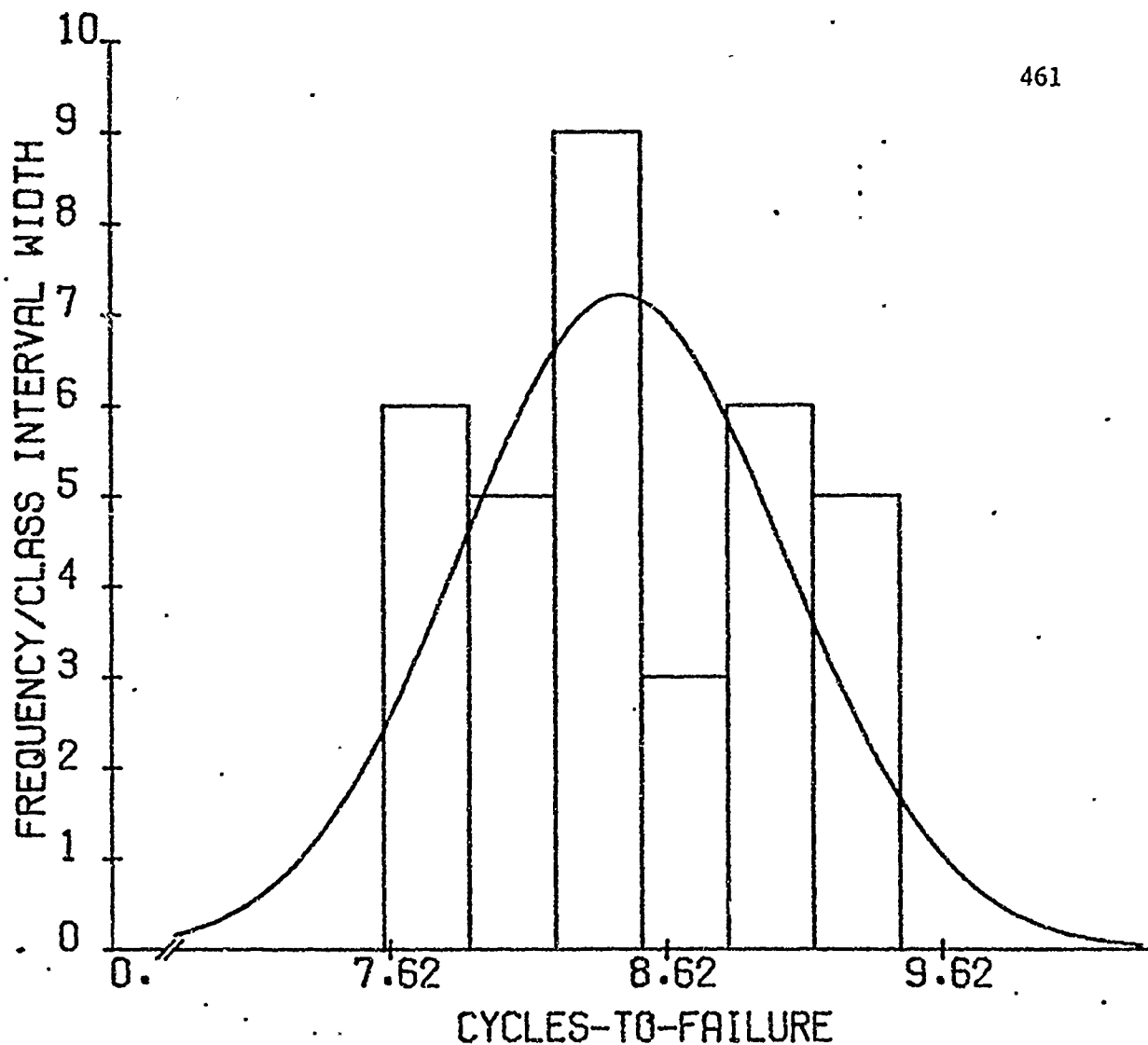


MEAN VALUE: 5588.2 CYCLES
 STANDARD DEVIATION: 3173.0 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.162
 CHI-SQUARED TEST: 1.729
 SKEWNESS: 0.696
 KURTOSIS: 2.362

FIG. 9.2-16 CYCLES-TO-FAILURE DIST OF GROUP NO. 95
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 34 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .250 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 95000 PSI.

LOG NORMAL DISTRIBUTION PARAMETERS

461

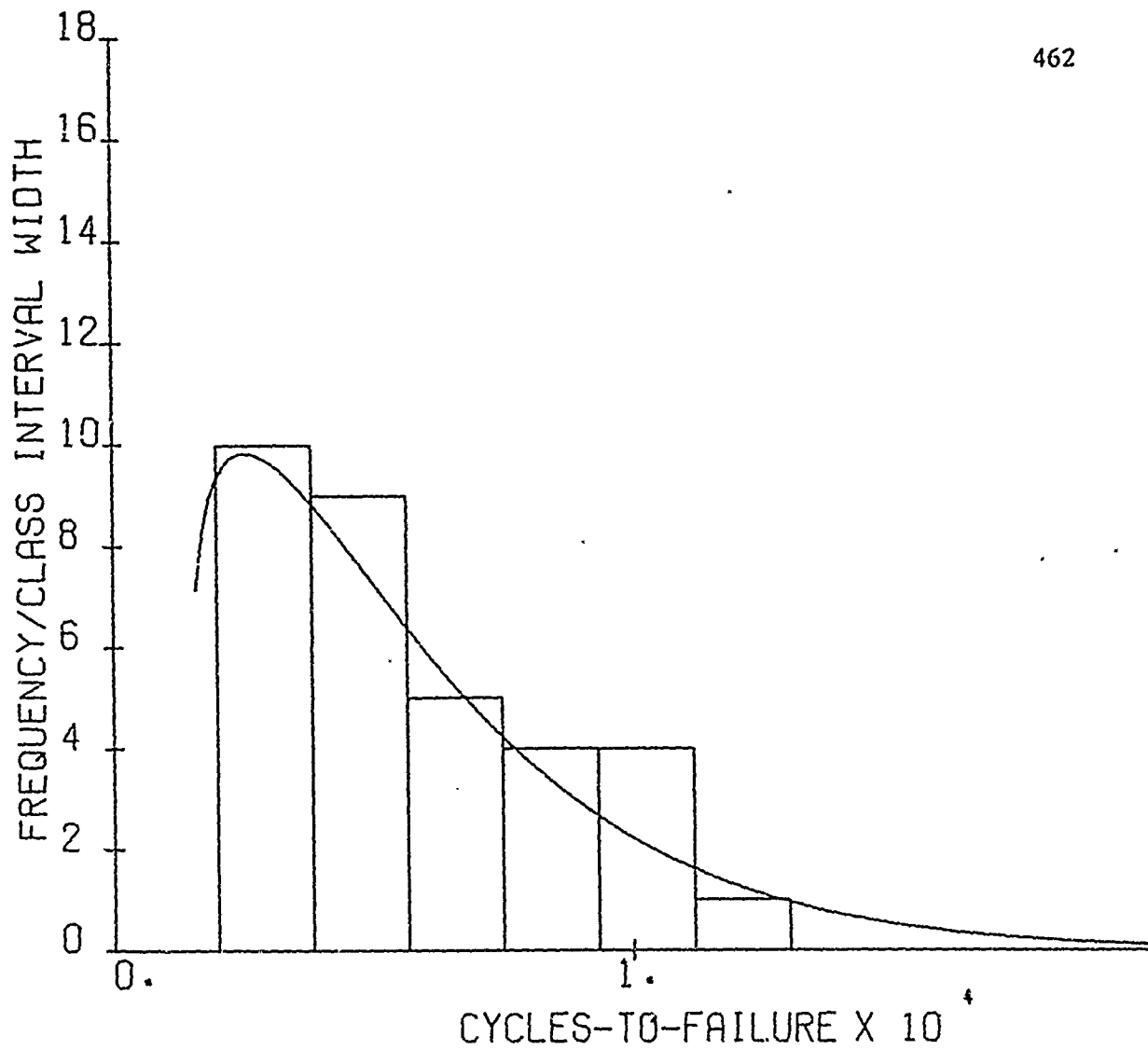


MEAN VALUE: 8.467 CYCLES
 STANDARD DEVIATION: 0.586 CYCLES
 KOLMOGOROV-SMIRNOV TEST: 0.108
 CHI-SQUARED TEST: 3.189
 SKEWNESS: -0.023
 KURTOSIS: 1.859

FIG. 9.2-17 CYCLES-TO-FAILURE DIST OF GROUP NO. 95
 USING THE WIEDEMANN FATIGUE MACHINE
 FOR 34 SPECIMENS OF .0937 IN. NOTCH
 DIAMETER AND .250 IN. NOTCH RADIUS AISI
 4130 STEEL ROD. FIXED ALTERNATING
 STRESS LEVEL OF 95000 PSI.

WEIBULL DISTRIBUTION PARAMETERS

462



KOLMOGOROV-SMIRNOV TEST: 0.085

CHI-SQUARED TEST: 0.751

WEIBULL SLOPE (BETA): 1.203

MINIMUM LIFE (GAMMA): 1500

SCALE PARAMETER (ETA): 4625

FIG. 9.2-18

CYCLES-TO-FAILURE DISTRIBUTION

SL=95000 PSI

GROUP=95

Table 9.2-1 Reduced Data for Group 162, AISI 1038 Steel. Wiedemann Fatigue Machine. See Table 8.2-13.

Staircase method at 3×10^6 cycles

Number of Useful Specimens: 33

Specimen geometry: $D = 0.375$ in.

$d = 0.2700$ in.

$r = 0.031$ in.

Alternating Stress	i	n_i	in_i	$i^2 n_i$
		Failures		
25,000	1	14	14	14
23,000	0	2	0	0
		N = 16	A = 14	B = 14

$d = \text{stress increment} = 2,000$ psi

$X_0 = \text{lowest stress level} = 23,000$ psi

$\bar{X} = \text{mean (estimate)}$

$\bar{X} = X_0 + d[A/N - 1/2] = 23,000 + 2,000 \left[\frac{14}{16} - \frac{1}{2} \right]$

$\bar{X} = 23,750$ psi $\approx 24,000$ psi*

$s = \text{standard deviation (estimate)}$

$s = 1.620 d [(NB - A^2)/N^2 + 0.029] = 1.620(2,000) \left[\frac{16(14) - 14^2}{16^2} + 0.029 \right]$

$s = 447$ psi ≈ 400 psi**

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

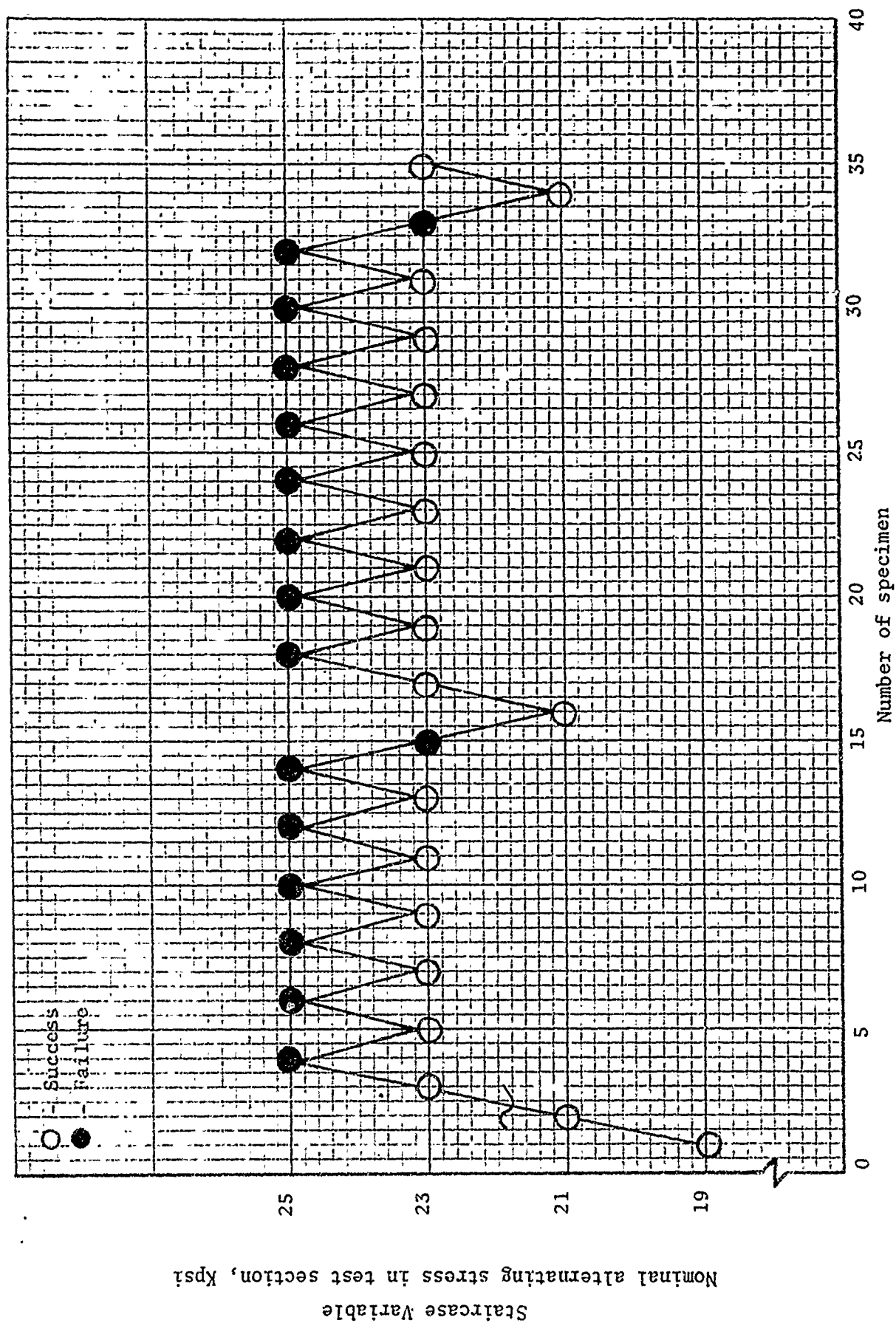


Fig. 9.2-19 Endurance strength data for AISI 1038 steel rod, Group No. 162, groove diameter $d = 0.2700$ in., groove radius $r = 0.31$ in. with cut-off at 3×10^6 cycles.

Table 9.2-2 Reduced Data for Group 163, AISI 1038 Steel. Wiedemann Fatigue Machine. See Table 8.2-15

Staircase method at 3×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in.

$d = 0.2700$ in.

$r = 0.062$ in

Alternating Stress psi	i	n_i Successes	in_i	$i^2 n_i$
27,000	2	9	18	36
25,000	1	5	5	5
23,000	0	3	0	0
		$N = 17$	$A = 23$	$B = 41$

$d = \text{stress increment} = 2,000$ psi

$X_0 = \text{lowest stress level} = 23,000$ psi

$\bar{X} = \text{mean (estimate)}$

$$\bar{X} = X_0 + d A/N + 1/2 = 23,000 + 2,000 \left[\frac{23}{17} + \frac{1}{2} \right]$$

$\bar{X} = 26,706$ psi

$s = \text{standard deviation (estimate)}$

$$s = 1.620 d (NB - A^2)/N^2 + 0.029 = 1.620 (2,000) \left[\frac{(17 \times 41 - 23^2)}{17^2} + 0.029 \right]$$

$s = 1,976$ psi

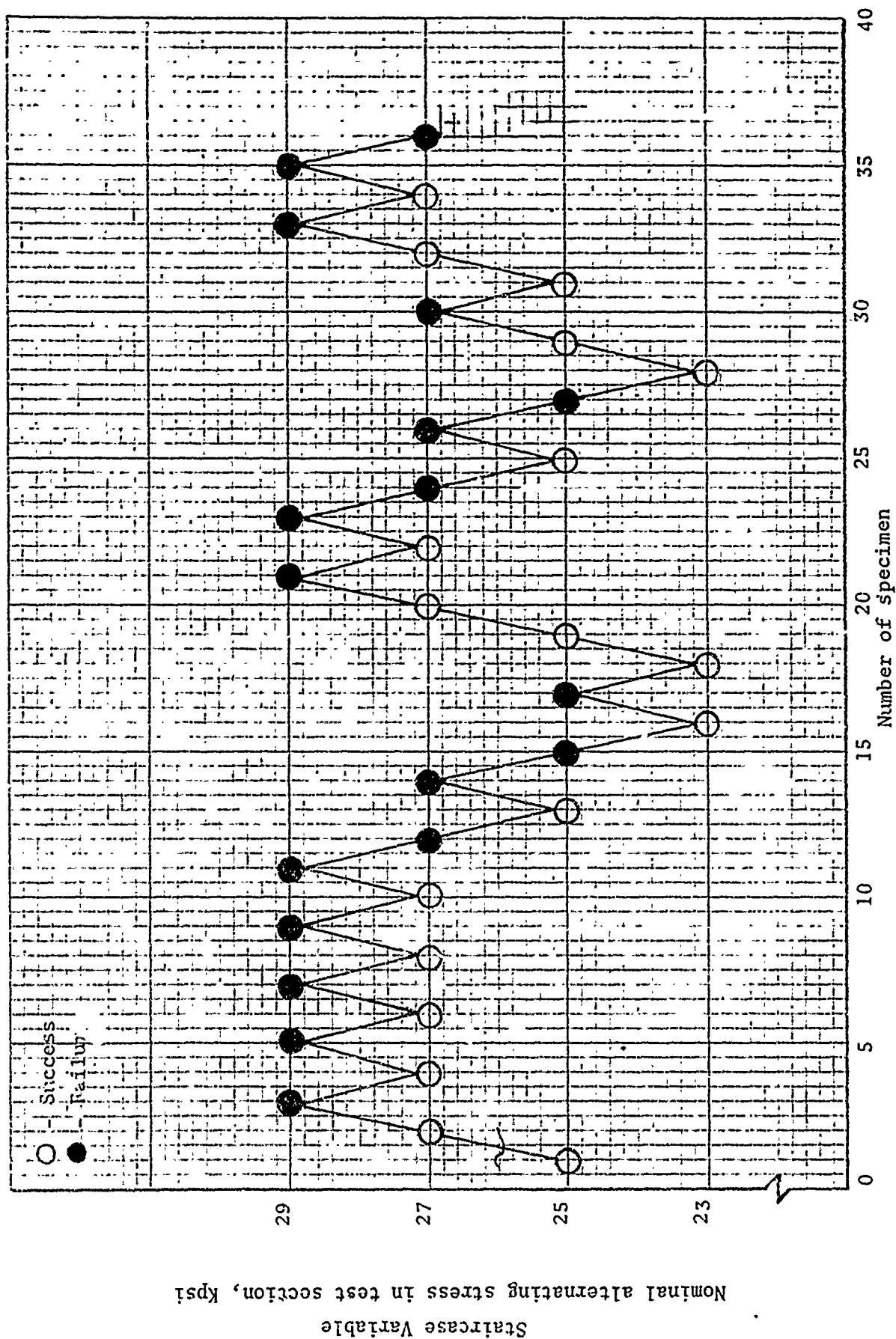


Fig. 9.2-20 Endurance strength data for AISI 1038 steel rod, Group No. 163, groove diameter $d = 0.2700$ in., groove radius $r = 0.062$ in. with cut-off at 3×10^6 cycles.

Table 9.2-3 Reduced Data for Group 164, AISI 1038 Steel. Wiedemann Fatigue Machine. See Table 8.2-17.

Staircase method at 3×10^6 cycles

Number of Useful Specimens: 37

Specimen geometry: $D = 0.375$ in.

$d = 0.2700$ in.

$r = 0.125$ in.

Alternating Stress	i	n_i Failures	in_i	$i^2 n_i$
34,000	2	2	4	8
32,000	1	9	9	9
30,000	0	7	0	0
		$N = 18$	$A = 13$	$B = 17$

$d = \text{stress increment} = 2,000$ psi

$X_0 = \text{lowest stress level} = 30,000$ psi

$\bar{X} = \text{mean (estimate)}$

$$\bar{X} = X_0 + d[A/N - 1/2] = 30,000 + 2,000 \left[\frac{13}{18} - \frac{1}{2} \right]$$

$$\bar{X} = 30,444 \text{ psi} \approx 30,000 \text{ psi}^*$$

$s = \text{standard deviation (estimate)}$

$$s = 1.620 d [(NB - A^2)/N^2 + 0.029] = 1.620 (2,000) \left[\frac{(18 \times 17 - 13^2)}{18^2} + 0.029 \right]$$

$$s = 1,464 \text{ psi} \approx 1,500 \text{ psi}^{**}$$

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

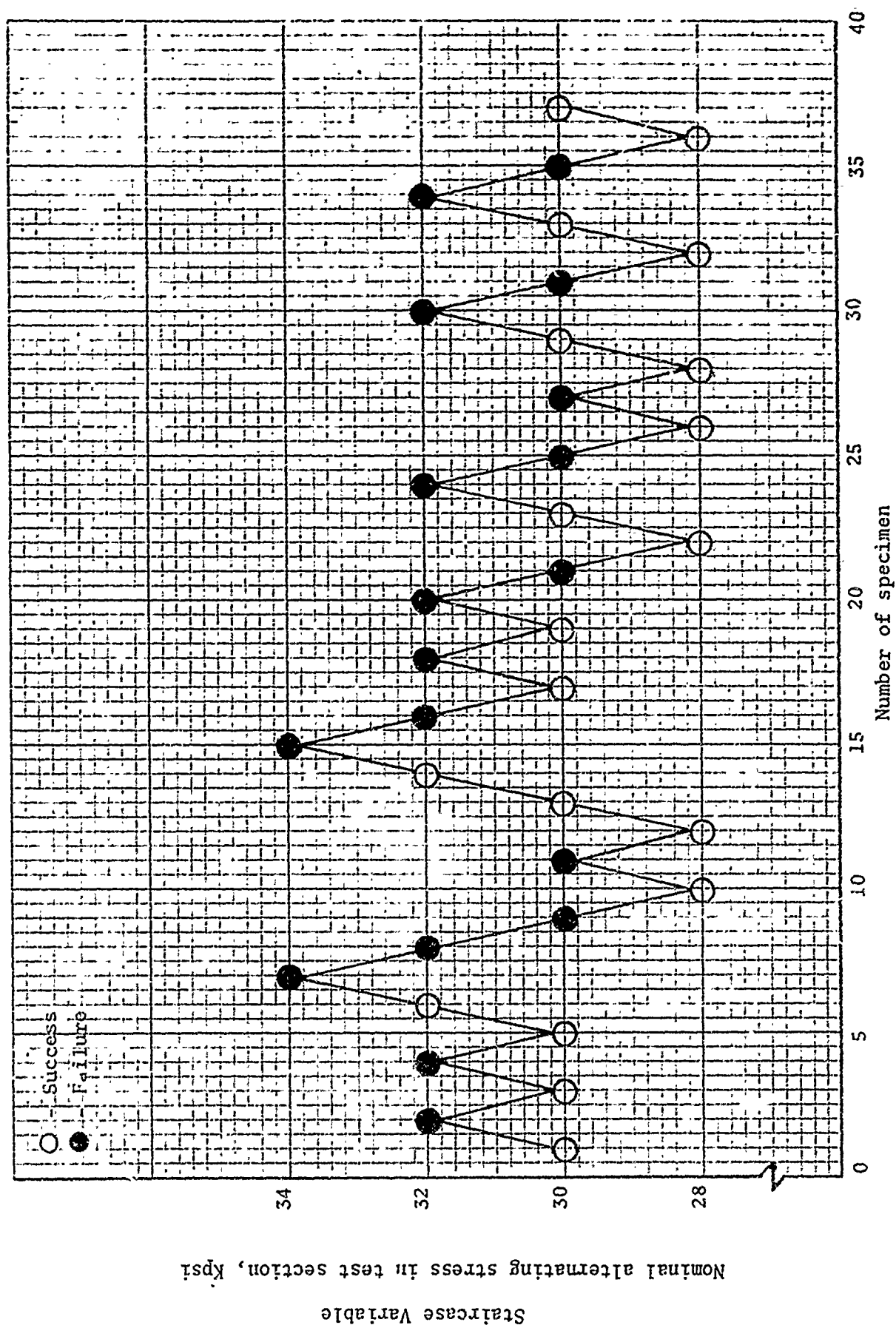


Fig. 9.2-21 Endurance strength data for AISI 1038 steel rod, Group No. 164, groove diameter $d = 0.2700$ in., groove radius $r = 0.125$ in. with cut-off at 3×10^6 cycles.

Table 9.2-4 Reduced Data for Group 165, AISI 1038 Steel. Wiedemann Fatigue Machine. See Table 8.2-19.

Staircase method at 3×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in.

$d = 0.2700$ in.

$r = 0.250$ in.

Alternating Stress	i	n_i successes	in_i	$i^2 n_i$
33,000	2	4	8	16
31,000	1	11	11	11
29,000	0	2	0	0
		$N = 17$	$A = 19$	$B = 27$

d = stress increment = 2,000 psi

X_0 = lowest stress level = 29,000 psi

$\bar{X}$ = mean (estimate)

$\bar{X} = X_0 + d[A/N + 1/2] = 29,000 + 2,000 \left[\frac{19}{17} + \frac{1}{2} \right]$

$\bar{X} = 32,240$ psi $\approx 32,000$ psi*

s = standard deviation (estimate)

$s = 1.620 d [(NB - A^2)/N^2 + 0.029] = 1.620(2,000) \left[\frac{(17 \times 27 - 19^2)}{17^2} + 0.029 \right]$

$s = 1,192$ psi $\approx 1,200$ psi**

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

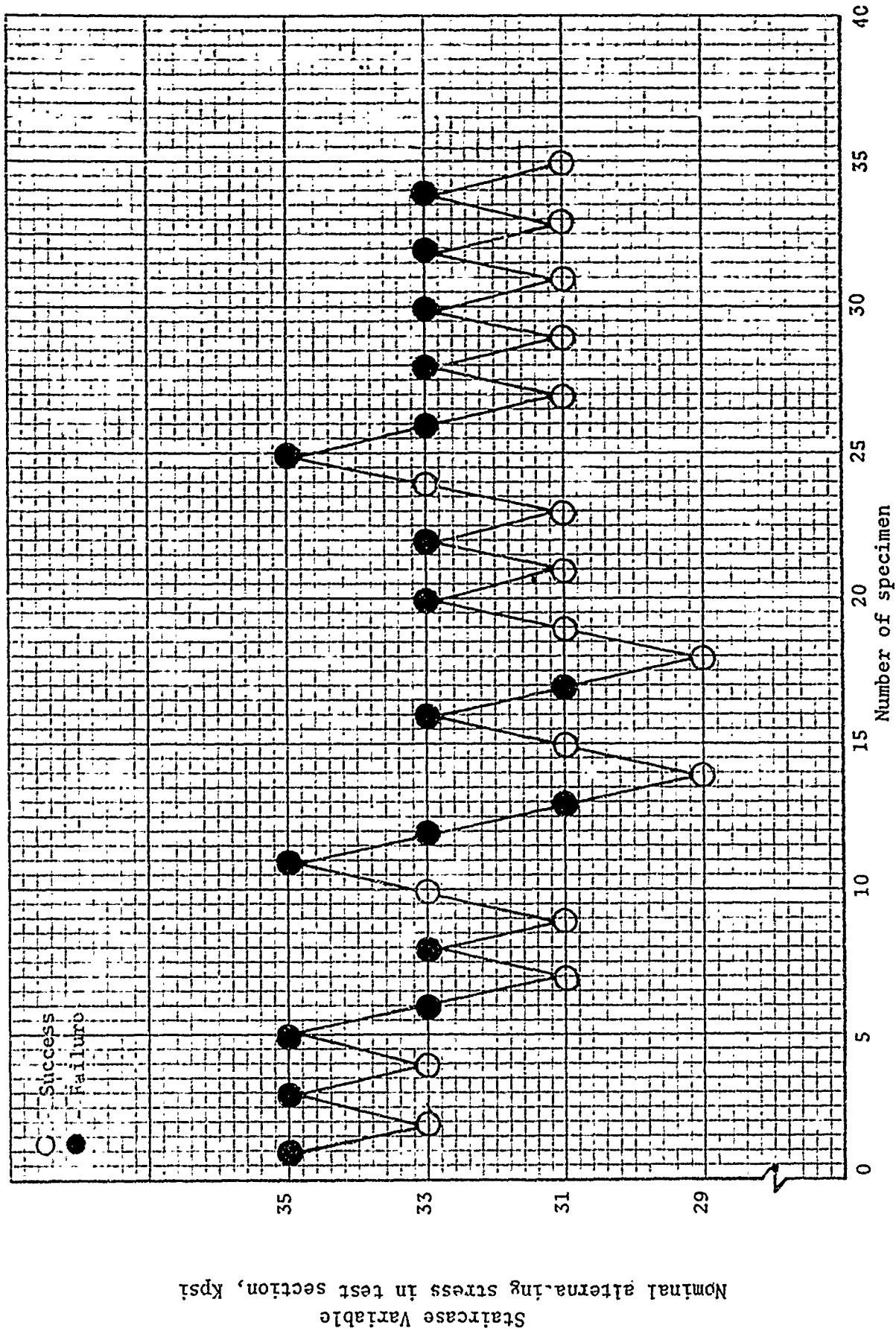


Fig. 9.2-22 Endurance strength data for AISI 1038 steel rod, Group No. 165, groove diameter $d = 0.2700$ in., groove radius $r = 0.250$ in., cut-off at 3×10^6 cycles.

Table. 9.2-5 Reduced Data for Group 166, AISI 1038 Steel. Wiedemann
Fatigue Machine See Table 8.2-21.

Staircase method at 3×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in.
 $d = 0.2700$ in.
 $r = 1.870$ in.

Alternating Stress psi	i	n_i Successes	in_i	$i^2 n_i$
40,000	3	1	3	9
38,000	2	3	6	12
36,000	1	9	9	9
34,000	0	4	0	0
		$N = 17$	$A = 18$	$B = 30$

d = stress increment = 2,000 psi

X_0 = lowest stress level = 34,000 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 34,000 + 2,000 \left[\frac{18}{17} + \frac{1}{2} \right]$$

$\bar{X} = 37,118$ psi

s = standard deviation (estimate)

$$s = 1.620 d[(NB - A^2) / N^2 + 0.029] = 1.620(2,000) \left[\frac{(17 \times 30 - 18^2)}{17^2} + 0.029 \right]$$

$s = 2.141$ psi

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

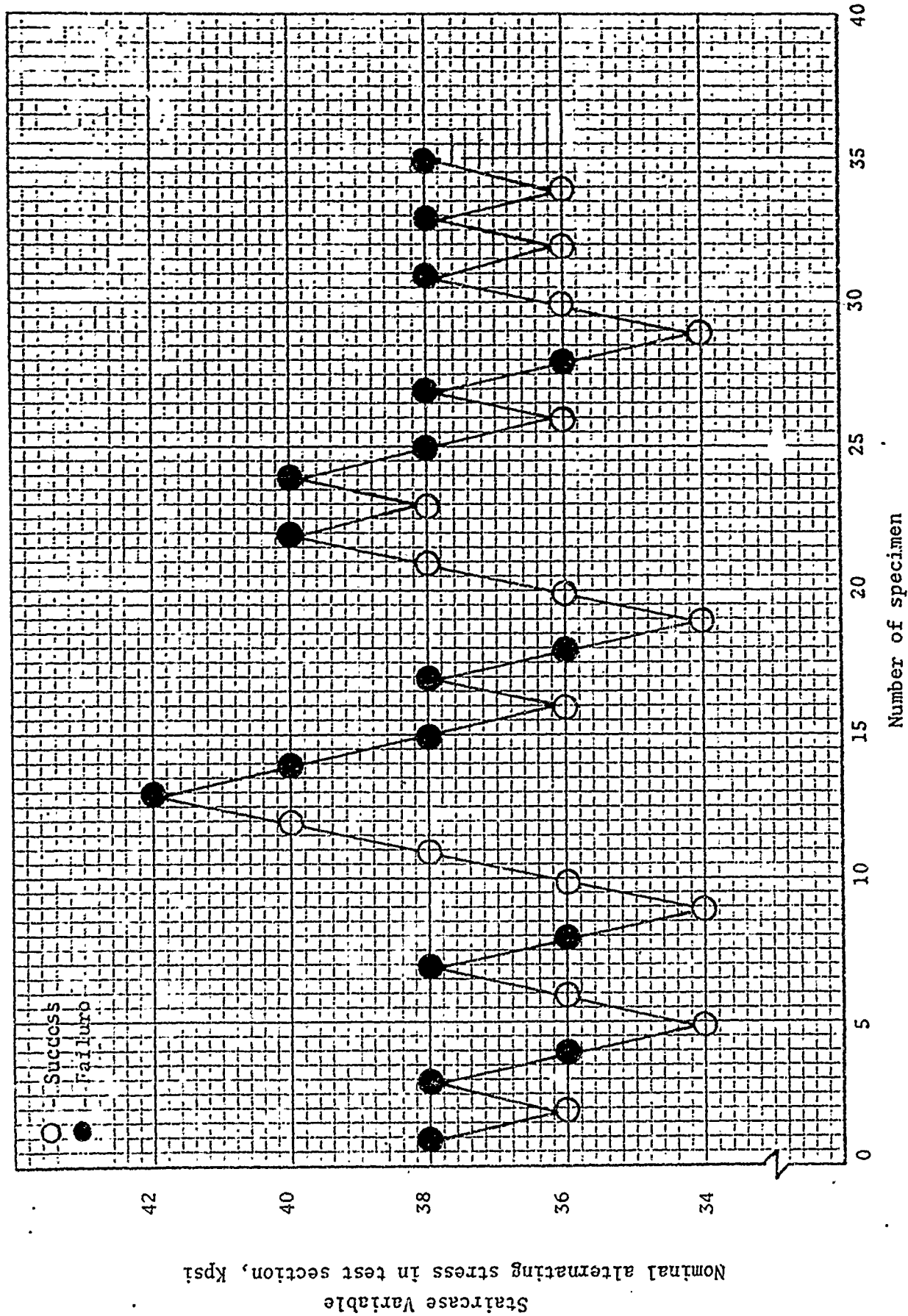


Fig. 9.2-23 Endurance strength data for AISI 1038 steel rod, Group No. 166, groove diameter $d = 0.2700$ in., groove radius $r = 1.87$ in. with cut-off at 3×10^6 cycles.

9.3 AXIAL FATIGUE MACHINE DATA

Table 9.3-1 Reduced Data for Group 159, AISI 1018 Steel. Axial Fatigue Machine, See Table 8.3-3.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in.

$d = 0.075$ in.

$r = 2.700$ in.

Stress Ratio: $r_s = 1.0$

Stress Vector psi	i	n_i Failures	in_i	$i^2 n_i$
33,940	3	2	6	18
32,980	2	7	14	28
32,020	1	6	6	6
31,060	0	1	0	0
		$N = 16$	$A = 26$	$B = 52$

d = stress increment = 960 psi

X_0 = lowest stress level = 31,060 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N - 1/2] = 31,060 + 960 \left[\frac{26}{16} - 0.5 \right]$$

$$\bar{X} = 32,140 \text{ psi} \approx 32,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d \left[\frac{(NB - A^2)}{N^2} + 0.029 \right] = 1.620 \times 960 \left[\frac{832 - 676}{256} + 0.029 \right]$$

$$s = 992.68 \text{ psi} \approx 1,000 \text{ psi}^{**}$$

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

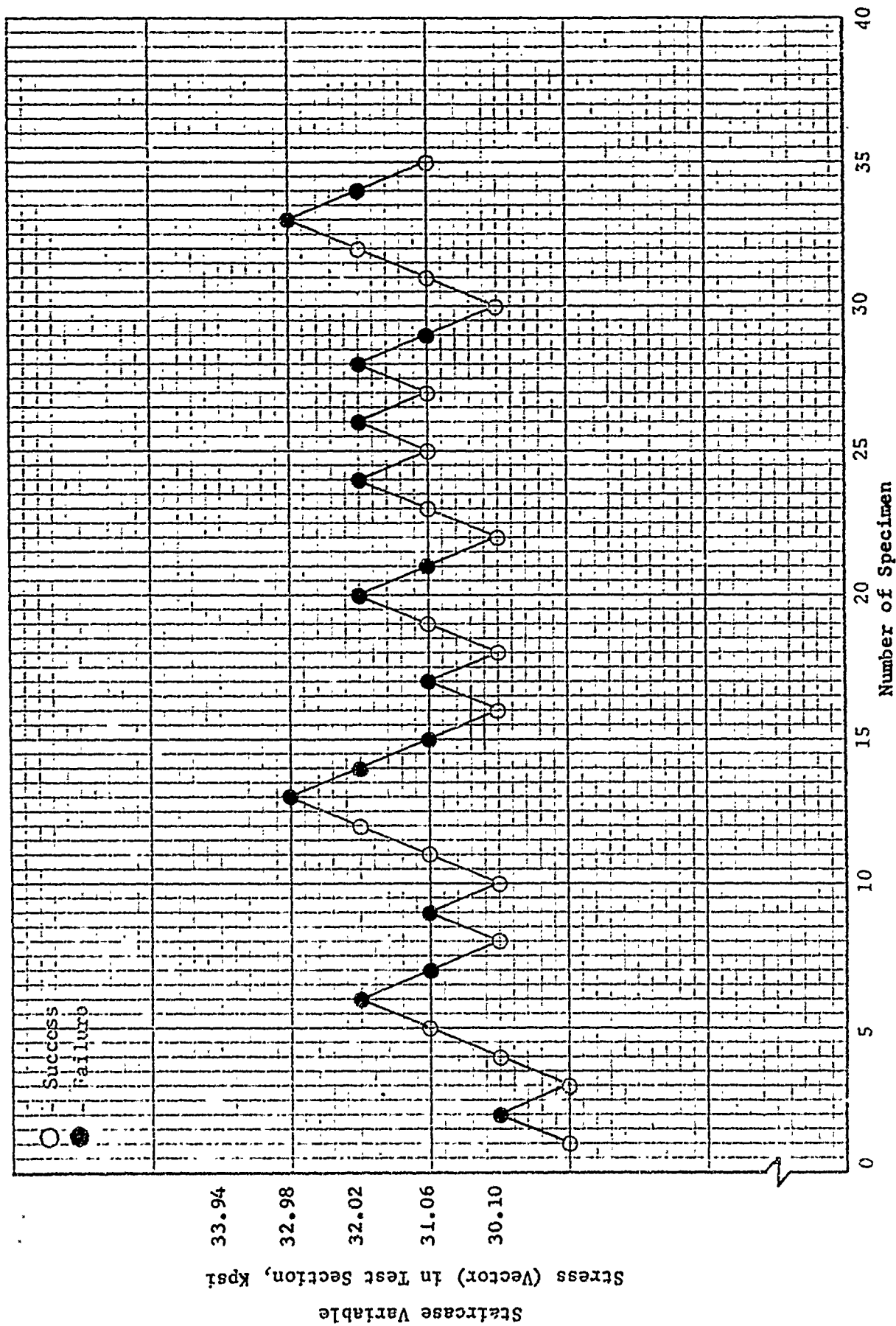


Fig. 9.3-1 Staircase plot of endurance strength data for Group 159, AISI 1018 steel specimens:
 $d = 0.075$ inches and groove radius = 2.70 inches tested at stress ratio $r_s = 1.0$.

Table 9.3-2 Reduced Data for Group 16Q AISI 1018 Steel. Axial Fatigue Machine, See Table 8.3-4.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in.

$d = 0.075$ in.

$r = 2.70$ in.

Stress Ratio: $r_s = 2.0$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
29,100	3	1	3	9
28,100	2	5	10	20
27,100	1	7	7	7
26,100	0	4	0	0
		$N = 17$	$A = 20$	$B = 36$

d = stress increment = 1,000 psi

X_0 = lowest stress level = 26,100psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 26,100 + (2,000) \left[\frac{20}{17} + \frac{1}{2} \right]$$

$$\bar{X} = 27,777 \text{ psi} \approx 28,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.620 (1,000) \left[\frac{17 \times 36 - (20)^2}{(17)^2} + 0.029 \right]$$

$$s = 1,235 \text{ psi} \approx 1,200 \text{ psi}^{**}$$

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

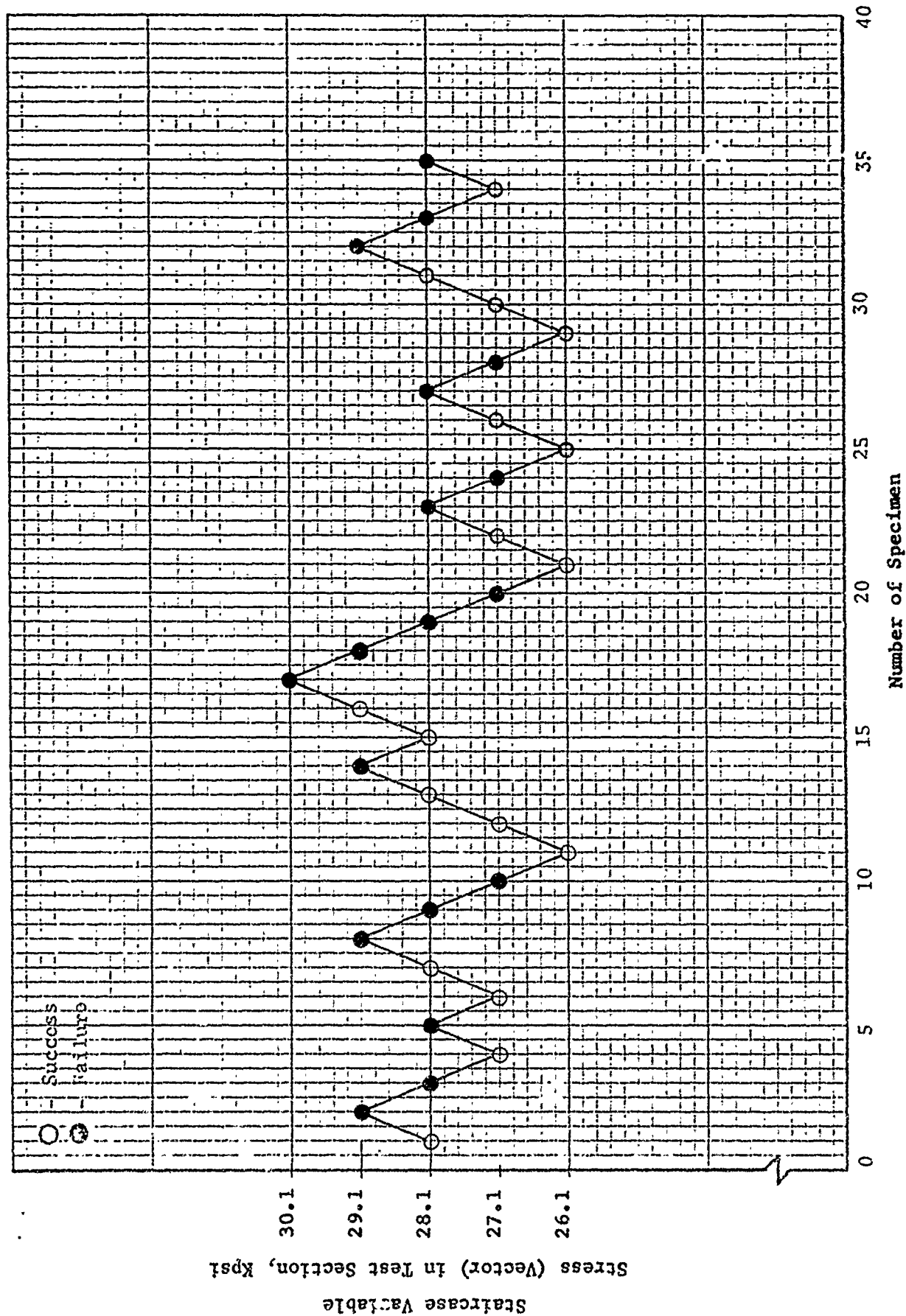


Fig. 9.3-2 Staircase plot of endurance strength data for Group 160, AISI 1018 steel specimens:
 $d = 0.075$ inches and groove radius ≈ 2.70 inches; tested at a stress ratio $r_s = 2.0$

Table 9.3-3 Reduced Data for Group 161, AISI 1018 Steel. Axial Fatigue Machine, See Table 8.3-5.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 36

Specimen geometry: $b = 0.375$ in.

$d = 0.075$ in.

$r = 2.700$ in.

Stress Ratio: $r_s = \infty$

Stress Vector psi	i	n_i Failures	in_i	$i^2 n_i$
27,380	2	7	14	28
26,380	1	7	7	7
25,380	0	2	0	0
		N = 16	A = 21	B = 35

d = stress increment = 1,000 psi

X_c = lowest stress level = 25,380 psi

$\bar{X}$ = mean (estimate)

$\bar{X} = X_c + d[A/N - 1/2] = 25,380 + 1,000[\frac{21}{16} - 0.5]$

$\bar{X} = 26,192$ psi $\approx 26,000$ psi*

s = standard deviation (estimate)

$s = 1.620 d[(NB - A^2)/N^2 + 0.029] = 1.620[\frac{(560 - 441)}{256} + 0.029]$

$s = 799.96$ psi ≈ 800 psi**

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

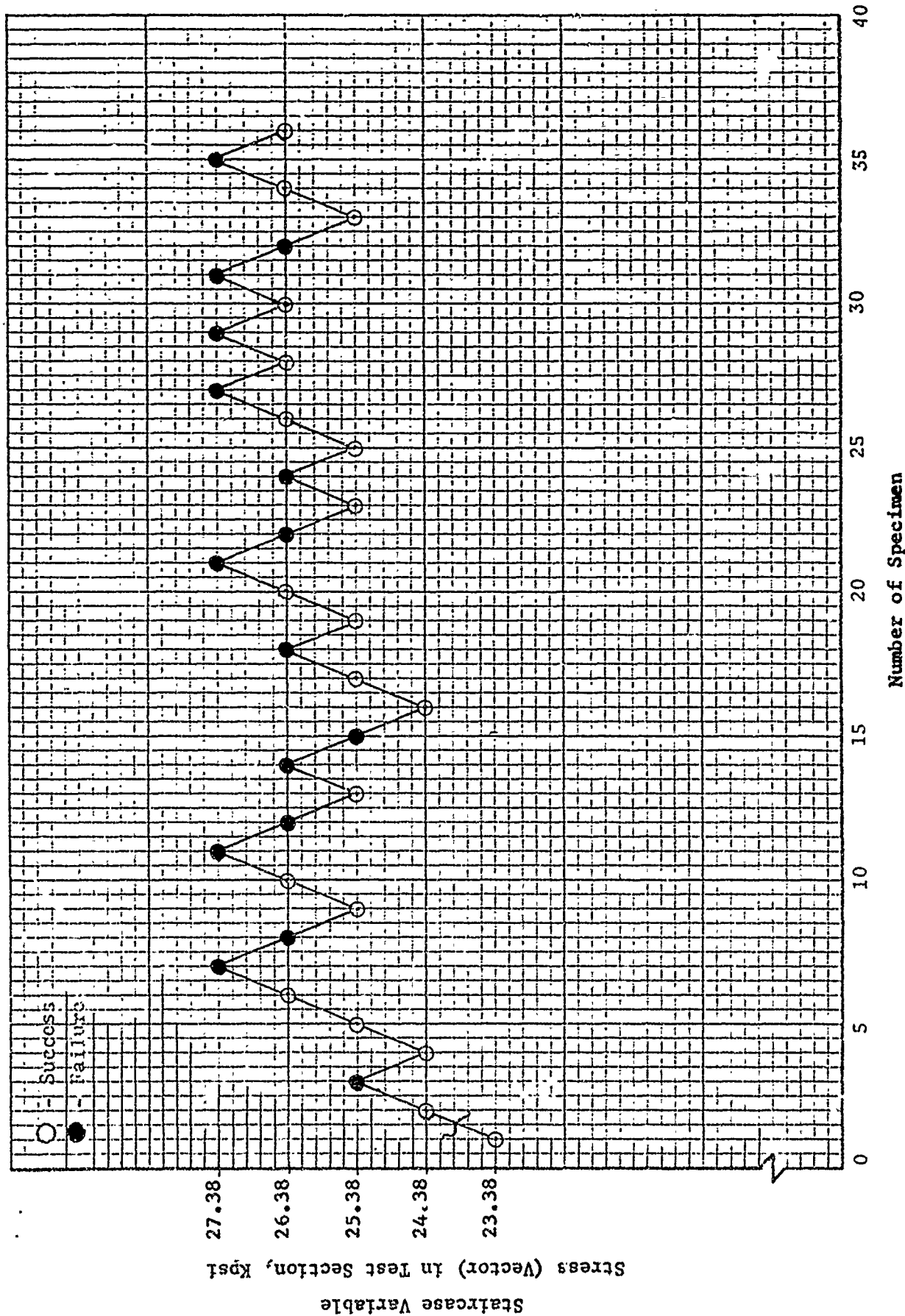


Fig. 9.3-3 Staircase plot of endurance strength data for Group 161, AISI 1018 steel specimens: $d \approx 0.075$ inches and groove radius ≈ 2.70 inches; tested at a stress ratio of infinity.

Table 9.3-4 Reduced Data for Group 32, AISI 4130 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 27

Specimen geometry: $D = 0.3750$ in.

$d = 0.0651$ in.

$r = 1.87$ in.

Stress Ratio: $r_s = 2.0$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
45,665	3	1	3	9
43,650	2	3	6	12
41,635	1	7	7	7
39,620	0	2	0	0
		$N = 13$	$A = 16$	$B = 28$

d = stress increment = 2,015 psi

X_0 = lowest stress level = 39,620 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 39,620 + 2,015 \left[\frac{16}{13} + \frac{1}{2} \right]$$

$$\bar{X} = 43,107.5 \text{ psi} \approx 43,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (2,015) \left[\frac{13 \times 28 - (16)^2}{(13)^2} + 0.029 \right]$$

$$s = 2,180.7 \text{ psi} \approx 2,200 \text{ psi}^{**}$$

This information supersedes the information reported in Table 4-20, p. 298 of [].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-5 Reduced Data for Group 33, AISI 4130 Steel. Axial Fatigue Machine,

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 23

Specimen geometry: $D = 0.3750$ in.

$d = 0.0647$ in.

$r = 1.87$ in.

Stress Ratio: $r_s = 1.0$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
53,731	2	4	8	16
51,582	1	2	2	2
49,433	0	4	0	0
		$N = 10$	$A = 10$	$B = 18$

d = stress increment = 2,149 psi

X_0 = lowest stress level = 49,433 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 49,433 + 2,149 \left[\frac{10}{10} + \frac{1}{2} \right]$$

$$\bar{X} = 52,656.5 \text{ psi} \approx 53,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d [(NB - A^2) / N^2 + 0.029] = 1.62 (2,149) \left[\frac{10 \times 18 - (10)^2}{(10)^2} + 0.029 \right]$$

$$s = 2,886.1 \text{ psi} \approx 2,900 \text{ psi}^{**}$$

This information supersedes the information reported in Table 4-2, p. 299 of [III].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-6 Reduced Data for Group 34, AISI 4130 Steel. Axial Fatigue Machine,

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 26

Specimen geometry: $b = 0.3750$ in.

$d = 0.0642$ in.

$r = 1.8700$ in.

Stress Ratio: $r_s = 0.4$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
74,463	3	1	3	9
72,468	2	3	6	12
70,473	1	5	5	5
68,478	0	3	0	0
		$N = 12$	$A = 14$	$B = 26$

d = stress increment = 1,995 psi

X_0 = lowest stress level = 68,478 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 68,478 + 1,995 \left[\frac{14}{12} + \frac{1}{2} \right]$$

$$\bar{X} = 71,803 \text{ psi} \approx 72,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (1,995) \left[\frac{12 \times 26 - (14)^2}{(12)^2} + 0.029 \right]$$

$$s = 2,697.2 \text{ psi} \approx 2,700 \text{ psi}^{**}$$

This information supersedes the information reported in Table 4-22, p. 300 of [III].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-7 Reduced Data for Group 62, AISI 4130 Steel Axial Fatigue Machine,

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 21

Specimen geometry: $D = 0.373$ in.

$d = 0.0628$ in.

$r = 1.87$ in.

Stress Ratio: $r_s = 0.1$

Stress Vector psi	i	n_i Failures	in_i	$i^2 n_i$
90,770	1	6	6	6
87,530	0	4	0	0
		N = 10	A = 6	B = 6

d = stress increment = 3,240 psi

X_0 = lowest stress level = 87,530 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N - 1/2] = 87,530 + 3,240 \left[\frac{6}{10} - \frac{1}{2} \right]$$

$$\bar{X} = 87,854 \text{ psi} \approx 88,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620d \left[\frac{(NB-A^2)}{N^2} + 0.029 \right] = 1.62 (3,240) \left[\frac{10 \times 6 - (6)^2}{(10)^2} + 0.029 \right]$$

$$s = 1,411.93 \text{ psi} \approx 1,400 \text{ psi}^{**}$$

This information supersedes the information reported in Table 15.3.3.1.1, p. 461 of [IV].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

*** Run to check the results of Group 35 reported in Table 4-23, p. 101 of [IV].

Table 9.3-8 Reduced Data for Group 63, AISI 4130 Steel. Axial Fatigue Machine, See Table

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 25

Specimen geometry: $D = 0.375$ in.

$d = 0.047$ in.

$r = 2.70$ in.

Stress Ratio = $r_s = 0.2$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
81,130	1	6	6	6
78,780	0	6	0	0
		$N = 12$	$A = 6$	$B = 6$

d = stress increment = 2,350 psi

X_0 = lowest stress level = 78,780 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 78,780 + 2,350 \left[\frac{6}{12} + \frac{1}{2} \right]$$

$$\bar{X} = 81,130 \text{ psi} \approx 81,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 \cdot d[(NB - A^2)/N^2 + 0.029] = 1.620(2,350) \left[\frac{12 \times 6 - (6)^2}{(12)^2} + 0.029 \right]$$

$$s = 1062.15 \text{ psi} \approx 1,100 \text{ psi}^{**}$$

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

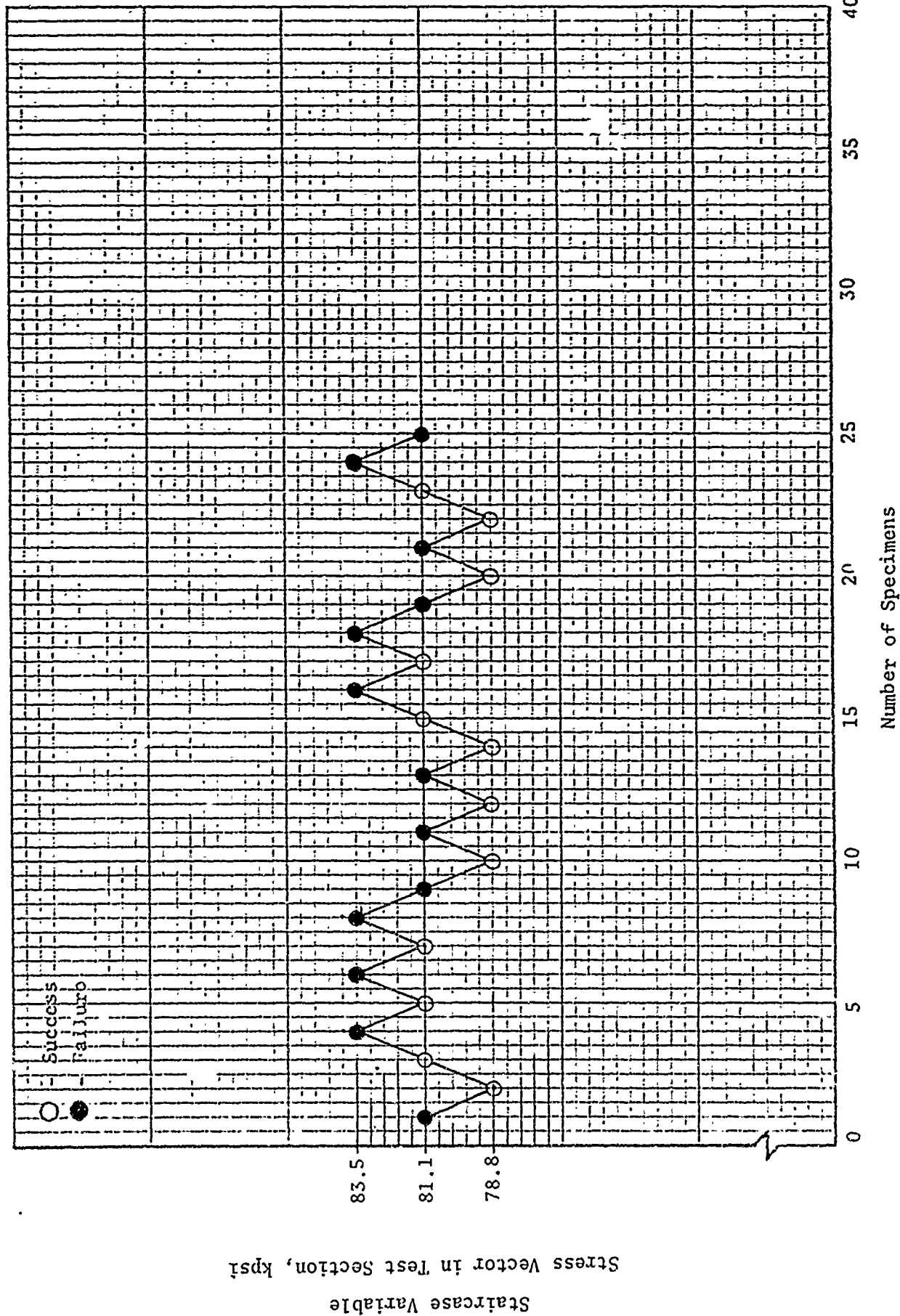


Fig. 9.3-4 Staircase plot of endurance strength data for Group 63, AISI 4130 steel specimens, $d = 0.048$ in., groove radius = 2.70 in., tested at stress ratio $r_s = 0.2$.

Table 9.3-9 Reduced Data for Group 64, AISI 4130 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 23

Specimen geometry: $D = 0.375$ in. $d = 0.0664$ in. $r = 1.87$ in.Stress Ratio: $r_s = \infty$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
40,310	1	3	3	3
37,431	0	8	0	0
		N = 11	A = 3	B = 3

 d = stress increment = 2,879 psi X_0 = lowest stress level = 37,431 psi $\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 37,431 + 2,879 \left[\frac{3}{11} + \frac{1}{2} \right]$$

$$\bar{X} = 39,655 \text{ psi} \approx 40,000 \text{ psi}^*$$

 s = standard deviation (estimate)

$$s = 1.620d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (2,879) \left[\frac{11 \times 3 - (3)^2}{(11)^2} + 0.029 \right]$$

$$s = 1,060.3 \text{ psi} \approx 1,100 \text{ psi}^{**}$$

This information supersedes the information reported in Table 15.3.3.1.3, p. 465 of [IV]

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

*** Run to check the results of Group 31 reported in Table 4-19, p. 297 of [III]

Table 9.3-10 Reduced Data for Group III, AISI 1038 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in. $d = 0.065$ in. $r = 2.70$ in.Stress Ratio: $r_s = 0.1$

Stress Vector psi	i	n_i Failures	in_i	$i^2 n_i$
59,320	2	6	12	24
57,800	1	6	6	6
56,280	0	5	0	0
		N = 17	A = 18	B = 30

 d = stress increment = 1,520 psi X_0 = lowest stress level = 56,280 psi $\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N - 1/2] = 56,280 + 1,520 \left[\frac{18}{17} - \frac{1}{2} \right]$$

$$\bar{X} = 57,129.4 \text{ psi} \approx 57,000 \text{ psi}^*$$

 s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (1,520) \left[\frac{17 \times 30 - (18)^2}{(17)^2} + 0.029 \right]$$

$$s = 1,656.2 \text{ psi} \approx 1,700 \text{ psi}^{**}$$

This information supersedes the information reported in Table 15.3.3.2.1, p. 478 of [IV].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-11 Reduced Data for Group 112, AISI 1038 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $b = 0.375$ in.

$d = 0.068$ in.

$r = 2.70$ in.

Stress Ratio: $r_s = 0.4$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
50,800	2	5	10	20
48,800	1	10	10	10
46,800	0	2	0	0
		N = 17	A = 20	B = 30

d = stress increment = 2,000 psi

X_0 = lowest stress level = 46,800 psi

$\bar{X}$ = mean (estimate)

$\bar{X} = X_0 + d[A/N + 1/2] = 46,800 + 2,000 \left[\frac{20}{17} + \frac{1}{2} \right]$

$\bar{X} = 50,153$ psi $\approx 50,000$ psi*

s = standard deviation (estimate)

$s = 1.620 d [(NB - A^2)/N^2 + 0.029] = 1.62 (2,000) \left[\frac{17 \times 30 - (20)^2}{(17)^2} + 0.029 \right]$

$s = 1,327.2$ psi $\approx 1,300$ psi**

This information supersedes the information reported in Table 15.3.3.2.2, p. 480 of [IV].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-12 Reduced Data for Group 113, AISI 1038 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in.

$d = 0.075$ in.

$r = 2.70$ in.

Stress Ratio: $r_s = 1.0$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
41,300	4	1	4	16
40,400	3	4	12	36
39,400	2	6	12	24
38,500	1	4	4	4
37,500	0	2	0	0
		$N = 17$	$A = 32$	$B = 80$

d = stress increment = 950 psi

X_0 = lowest stress level = 37,500 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 37,500 + 950 \left[\frac{32}{17} + \frac{1}{2} \right]$$

$$\bar{X} = 39,763.2 \text{ psi} \approx 40,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (950) \left[\frac{17 \times 80 - (32)^2}{(17)^2} + 0.029 \right]$$

$$s = 1,833.9 \text{ psi} \approx 1,800 \text{ psi}^{**}$$

This information supersedes the information reported in Table 15.3.3.2.3, p. 482 of [IV].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-13 Reduced Data for Group 114, AISI 1038 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $D = 0.375$ in. $d = 0.075$ in. $r = 2.70$ in.Stress Ratio: $r_s = 2.0$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
34,500	4	1	4	16
33,500	3	6	18	54
32,500	2	3	6	12
31,500	1	5	5	5
30,500	0	2	0	0
		$N = 17$	$A = 33$	$B = 87$

 d = stress increment = 1,000 psi X_0 = lowest stress level = 30,500 psi $\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 30,500 + (1,000) \left[\frac{33}{17} + \frac{1}{2} \right]$$

$$\bar{X} = 32,941 \text{ psi} \approx 33,000 \text{ psi}^*$$

 s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (1,000) \left[\frac{17 \times 87 - (33)^2}{(17)^2} + 0.029 \right]$$

$$s = 2,233.1 \text{ psi} \approx 2,200 \text{ psi}^{**}$$

This information supersedes the information reported in
Table 15.3.3.2.4, p. 484 of [IV].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi

Table 9.3-14 Reduced Data for Group 115, AISI 1038 Steel. Axial Fatigue Machine.

Staircase method at 2×10^6 cycles

Number of Useful Specimens: 35

Specimen geometry: $\bar{d} = 0.375$ in.

$d = 0.075$ in.

$r = 2.70$ in.

Stress Ratio: $r_s = \infty$

Stress Vector psi	i	n_i Successes	in_i	$i^2 n_i$
31,674	3	5	15	45
30,543	2	6	12	24
29,412	1	5	5	5
28,281	0	1	0	0
		N = 17	A = 32	B = 74

d = stress increment = 1,131 psi

X_0 = lowest stress level = 28,281 psi

$\bar{X}$ = mean (estimate)

$$\bar{X} = X_0 + d[A/N + 1/2] = 28,281 + (1,131) \left[\frac{32}{17} + \frac{1}{2} \right]$$

$$\bar{X} = 30,975.5 \text{ psi} \approx 31,000 \text{ psi}^*$$

s = standard deviation (estimate)

$$s = 1.620 d \left[(NB - A^2)/N^2 + 0.029 \right] = 1.62 (1,131) \left[\frac{17 \times 74 - (32)^2}{(17)^2} + 0.029 \right]$$

$$s = 1,536.7 \text{ psi} \approx 1,500 \text{ psi}^{**}$$

This information supersedes the information reported in Table 15.3.3.2.5, p. 486 of [IV].

* Rounded off to nearest 1,000 psi

** Rounded off to nearest 100 psi