UNCLASSIFIED

AD NUMBER
AD813574
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; Mar 1967. Other requests shall be referred to Rome Air Development Center, Air Force Systems Command, Griffiss AFB, NY.
AUTHORITY
RADC ltr, 21 Jul 1972

THIS PAGE IS UNCLASSIFIED



RADC-TR- 66-710 Final Report



RELIABILITY PREDICTION - MECHANICAL STRESS/STRENGTH INTERFERENCE

Charles Lipson Narendra J. Sheth Ralph L. Disney University of Michigan

TECHNICAL REPORT NO. RADC-TR- 66-710 March 1967



Rome Air Development Center Research and Technology Division Air Force Systems Command Griffiss Air Force Base, New York* When US Government drawings, specifications, or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded, by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacturer, use, or sell any patented invention that may in any way be related thereto.

Do not return this copy. Retain or destroy.

RELIABILITY PREDICTION - MECHANICAL STRESS/STRENGTH INTERFERENCE

Charles Lipson Narendra J. Sheth Ralph L. Disney

University of Michigan

\$\$ \$

C,

This document is subject to special export controls and each transmittal to foreign governments, foreign netiouals or representatives thereto may be made only with prior approval of RADC (EMLI), GAFB, N.Y. 13440

ŧ

FOREWORD

This final report was prepared by Charles Lipson, Narendra J. Sheth and Ralph L. Disney of the University of Michigan, Ann Arbor, Michigan, under Contract AF30(602)-3684, project number 5519, task number 551902.

This report outlines a nonelectronic reliability prediction technique subject to special export controls.

This report has been reviewed and is approved.

Approved DONALD W. FULTON

Reliability Engineering Section Reliability Branch

ADDIOV PICTHICE Envincering Division

FOR THE COMMANDER: GABELMAN Chief, Advanced Studies Group

ABSTRACT

This study addressed itself to the development of a stress-strength Interference Theory in the form of a practical engineering tool, to be used for designing and quantitatively predicting the reliability of mechanical parts and components subjected to mechanical loading.

Early practices in stress-strength relationship dealt almost entirely along the lines of factors of safety. Utilization of such factors is justified when they are based on considerable experience with parts not too different from the one under consideration. However, when substantial changes in the geometry, the processing, or the function of the part are contemplated, a major error may result if the old factors of safety are projected to the new set of conditions.

In the present investigation an approach was used which attempted to recognize the above limitations.Instead of an indiscriminate grouping of all the variables affecting stress and strength into one index (factor of safety) these variables were individually recognized. The principal variable is the scatter in the stresses imposed on the part and in the strength of the material resisting these stresses.

The prevailing practice is to use the mean values of the calculated stress and strength, ignoring the natural scatter that each may possess. However, the variability in these two factors results in a statistical distribution of stress and strength. When these two distributions interfere, that is when stress becomes higher than strength, failure results. Means of expressing these distributions, in a practical engineering sense, and means of calculating the resulting interferences, represent the heart of the present study.

The problem of strength distribution was approached with the aid of S-N curves. A great deal of fatigue data was gathered for various materials, heat treatments, surface conditions, etc. About 75% of these data were obtained from the Mechanical Properties Data Center, Traverse City, Michigan, which also provided some tensile and strength rupture information. The rest of the data came from literature and other sources.

The fatigue data thus obtained were then converted into strength data which portrayed the scatter of strength at a given life. Several methods of expressing the resultant distribution were studied and the Weibull distribution was decided on as the most effective means of expressing the strength distribution in the Interference Theory. For each material, heat treatment, surface condition, etc. studied Weibull parameters were calculated, and these are tabulated in Appendix 1. Pertinent information was then plotted and the graphs were incorporated in the body of the report (Section 6).

The problem of stress distribution (Section 7) turned out to be much more involved. When one speaks of "stress distribution" he usually refers to a spectrum of loading or stresses to which a part is subjected.

Indeed, most of the available data on the subject is expressed in this manner. In an engineering sense, this kind of a distribution means number of times that a given part is subjected to a given load or stress. In the Interference Theory, however, this is not what is wanted. For consistency with the strength distribution the number of parts subjected to a given stress is required instead.

In the present study the required stress distribution was obtained by converting the stress spectrum, which generally has some mean stress, into a spectrum with zero mean, with the aid of the Goodman diagram. This was done to facilitate the conversion of the resultant spectrum into an equivalent stress, based on zero mean stress. The conversion was accomplished by means of Miner's rule. The required stress distribution was then expressed in terms of the equivalent stress. This distribution was then compared with the strength distribution to determine the degree of interference.

From an extensive literature survey made in the course of this study, it was found that most investigations have assumed both the stress and strength distribution to be normal. In those cases when they were not normal a Monte-Carlo technique was employed. This involved a sophisticated means of randomly selecting a sample from one distribution and comparing it with a sample from a different distribution.

In view of serious limitations of the Monte-Carlo technique a method of Integrals was developed (Appendix 3 and Appendix 4) and used in the present study. This method involved developing an integral resulting from the interference of two distributions and calculating this complex integral with the IBM - 7090 computer using MAD language.

Although the interference of several distributions was considered the final tabulated interference values were restricted to the cases when the stress distribution was normal and strength distribution was Weibull, and when both distributions were Weibull (Appendix 2). This represents distributions most frequently encountered in actual engineering practice.

In order to show the application of the Interference Theory Technique, developed in the present study, an example was solved, as described in Section 9.

iv

TABLE OF CONTENTS

Section

۲

Ţ

÷

1.1

		Page 119.
1	. Introduction	1.
2	Interference Theory	4
•	2.1 Two Normal Distributions	4
	2.1 Normal pisticulius	7
	2.2 Nou Normal Distributions	
	2.5 Non-Normal Discributions	á
	2.4 The Integral Method	,
3	. Objectives of the Present Study	1.1
4	. Study Approach	12
	4.1 Literature Search	12
	4.2 Theoretical Analysis	12
	4.3 Empirical Data	1
	4.4 Factors Affecting the Statistical Distribution of Fatigue	• /
	Strength	14
	4.5 Factors Affecting the Statistical Distribution of Tensile,	
	Rupture Strength	10
	4.6 Analysis of Strength Data	16
5	. Analytical Expressions for the Interference	17
	5.1 Introduction	17
	5.1.1 Interference Probabilities	17
	5.1.2 Calculation of Probabilities of Failure	19
	5.1.3 Interforence Tables	2 3
	5.7 Use of (nterference Tables	24
	5.2.1 Parameters for the Weihull-Weihull Case	24
	5.2.2 Parameters for the Weibull Distributed Strength	
	Normal Natributed Strage Case	26
	5.2.3 Use of the Tables Evaluation of Missing Values and	20
	Thermalation	97
	5.2 Examples of New 45 the Mebles	28
	J.J Examples of USA C4 the tables	20
6	. Statistival Distribution of Strength	29
	0.1 Analysis of Strength Data	29
	6.1.1 Conversion of Life Data to Strength Data	29
	6.1.2 Strength Response Test	29
	6.2 Plot of Strength Data	31
	6.3 Determination of the Weibull Parameters	37
	6.4 Graphs of Weibull Parameters	45
7	. Statistical Distribution of Stress	158
	7.1 Stress Spectrum vs. Stress Distribution	158
	7.2 Conversion of Stress Spectrum to an Equivalent Stress (Secu) 158
	7.2.1 Miner's Rule	160
	7.2.2 Corten-Dolan's Rule	164

v

÷

١

.

Ţ

×

8. Interference of Stress Distribution with Strength Distribution							
 9. Application of Interference Theory to Design Problems 9.1 Weibull Parameters 9.2 The Equivalent Stress 9.3 Percent Interference 9.4 The Effect of Design Factors 							
Conclusions	182						
Recommendations	184						
References	185						
Bibliography	187						
Appendix 1 Tables of Weibull Parameters	194						
A-1.1 Weibull Parameters for Fatigue Strength	195						
Index to Weibull Parameters for Fatigue Strength of Various Materials Reference Data for Weibull Parameters Tables References for Fatigue Strength Data	196 198 206 241						
A-1.2 Weibull Parameters for Tensile Strength Index to Weibull Parameters for Tensile Strength	242						
of Various Materials Tables	243 244						
References for Tensile Strength Data	249						
A-1.3 Weibull Parameters for Rupture Strength Index to Weibull Parameters for Rupture Strength of Various Materials	250 251						
Tables	252						
References for Rupture Strength Data	257						
Appendix 2 Tables of Interference Values	258						
A-2.1 Stress Distribution - Normal, Strength Distribution - Weibull	259						
A-2.1.1 Stress Standard Deviation = 0	260						
A-2.1.2 Stress Standard Deviation ≠ 0	264						
A-2.2 Stress Distribution - Weibull, Strength Distri- bution - Weibull							
Appendix 3 Mathematical Theories of Analytical Expression							
A-3.1 Introduction	398						

vi ·

Downloaded from http://www.everyspec.com

1

۲,

4

ĩð

A

	A-3.1.1	The Concept of a Random Variable	398				
	A-3.1.2	Interference Theory and Random Variable	398				
A-3.2	Determination of Probability of Failure						
V	A-3.3.1 Normally Distributed Strength (X) and Normally Distributed Stress (Y)						
	A-3.3.2	Exponentially Distributed Strength (X) and Exponentially Distributed Stress (Y)	410				
	A-3.3.3	Gamma Distributed Strength (X) and Gamma Dis- tributed Stress (Y)	411				
	A-3.3.4	Weibull Distributed Strength (X) and Weibull Distributed Stress (Y)	418				
	A-3.3.5	Weibull Distributed Strength (X) and Normally Distributed Stress (Y)	422				
ppendix 4	Discuss and A	ion of the Evaluation of Integrals in A-3.3.4 -3.3.5	425				
A-4.1	Numerica	al Analysis	426				
	A-4.1.1	The Problem	426				
	A-4.1.2	Method of Solution	426				
	A-4.1.3	Properties of Simpson's Rule	427				
	A-4.1.4	Error Analysis-Weibull-Weibull Case	427				
	A-4.1.5	Conclusions Concerning Errors	440				
	A-4.1.6	A Note on Interpolation	441				
	A-4.1.7	Error Analysis-Weibull-Normal Case	441				
	A-4.1.8	Conclusions Concerning Errors	448				
	A-4.1.9	A Note on Interpolation	448				

vii

EVALUATION

This study was addressed to the development of a practical reliability engineering tool to be used in predicting the reliability of mechanical parts fabricated from ferrous metals and subjected to dynamic loading. The tool was to be based on the Stress-Strength Interference Theory and to be usable by design engineers with little or no statistical background.

The study has provided a prediction technique which is almost "cookbook" in nature and requires a minimum amount of computation. Once the values of the parameters of the interfering distributions have been determined, the probability of failure is obtained directly from tables contained in the report. Within the limitations that the material must be ferrous and the failure mechanism must be fatigue, the reliability of an almost unlimited number of parts can be predicted. For example, a few are gears, bolts, shafts, springs, torsion bars, vehicle frames and suspensions, landing gears, forged air frame members, etc. The engineering and statistical basis for the technique are such that there is every reason to believe that predictions based on this technique will be realistic. However, the precision will depend to a large extent on the accuracy of the stress distribution. If this distribution is based on measurements much greater precision will result than for the case where only the mean stress is known and the variability is estimated.

「「「「「「「「「「」」」

' **(}**al) and DONALD WA FULTON

Reliability Engineering Section Reliability Branch

SECTION 1 INTRODUCTION

A complete cycle of reliability is made up of four stages: 1. Specification of Reliability; 2. Prediction of Reliability; 3. Verification of Reliability: 4. Preservation of Reliability. The heart of the second stage, namely, the Prediction of Reliability, is the Interference Theory.

The basic idea behind reliability is that a given part has certain physical properties, which, if exceeded, will result in failure. The factor which may cause these properties to be exceeded is the stress imposed by the operating conditions. Thus, in prediction of reliability it is not the stress alone or the strength alone that are the determining factors but the combined effect of the two.

Early practices in stress-strength relationship dealt almost entirely along the lines of factors of safety. Once a part was designed and the ratio of strength to stress was in the range of approximately 5 to 10 it was considered to be safe for service. In certain industries and in certain applications factors of safety as high as 20:1 were employed.

The definition of the factors of safety varied from user to user, depending on the sophistication and the complexity of the problem.

Some of these definitions, found in literature, are listed below:

Fac	ctor	of	Safety		Ultimate Strength Nominal Stress
Fac	etor	of	Safety	=	Yield Strength Nominal Stress
Fac	ctor	of	Safety	82	Ultimate Strength Actual Working Stress
Fa	ctor	of	S af e⁺y	.3	Yield Strength Actual Working Stress
Fac	ctor	of	Safety	=	Maximum Safe Load Normal Load
Fa	ctor	of	Safety	=	Computed Strength Computed Load
Ma	rgin	of	Safety	=	Strength-Stress Stress
De	si gn	Fac	ctor =		Strength Design Stress
Fa	ctor	of	Utiliza	tio	n = <u>Stress</u> Strength

Downloaded from http://www.everyspec.com

17,

Functional Reserve Factor = Magnitude of Variable = <u>Producing Failure</u> Magnitude of Variable at Operating Conditions

> where the variable could be force, power, torque, material, surface finish, fillet radius, etc.

Apparently the factor of safety was meant to account for all the variables which were known to affect the stress and strength of the member. The utilization of a factor of safety of this kind has justification, only when its value is based on considerable experience, with parts not too different from the one under consideration. However, when substantial changes in the geometry, the processing, or the function of the part are contemplated, a major error may result if the old factor of safety is projected to the new set of conditions.

This is illustrated by the problem of automotive axle shafts which have been failing in service in large numbers. These shafts have been fabricated from a steel with a tensile strength of 240,000 psi, and yet, the operating stresses as measured in actual service were found to be only 13,000 psi. This produced an apparent factor of safety of 240,000/13,000 = 18.5. This is obviously a fictitious value, since the shafts were failing in service, and the true factor of safety was less than one. The explanation lies in the fact that axle strength to be compared with the 13,000 psi operating stress should not have been the ultimate strength of the material (240,000 psi) but the fatigue strength corresponding to the surface finish of the shafts, the mode of loading to which the shaft was subjected, etc. When the ultimate strength was reduced by these derating factors the resultant value was found to be 12,000 psi. This strength, when compared with the 13,000 psi stress produced the realistic factor of safety of 0.9.

Examples such as this lead to the next phase in the relationship between stress and strength, namely to the concepts of a significant stress and a significant strength. By significant stress is meant the actual stress imposed on the part and it may include the effect of stress raisers, magnification due to impact loading, residual stresses, etc. By significant strength is meant the actual strength of the part in its fabricated form, under actual operating conditions. A rational approach to significant strength still employs ultimate strength as the basis. However, instead of an indiscriminate grouping of all the factors affecting the ultimate strength into one index, it attempts to evaluate quantitatively the effect of each individual factor pertaining to the part and the conditions under consideration. The result is a value which is strictly applicable to the part under consideration and to the set of loading conditions to which the part is subjected in service. The principal factors affecting strength and which must be considered in determining the significant strength are: life expectancy, type of loading, (axial, bending, torsional, or a combination),

size effect, surface finish, surface treatment, notch effects, mode of loading (static, completely reversed dynamic, or a combination).

These concepts of significant stress and significant strength represent a major step toward a more realistic prediction of reliability and, as such, they have been included in the present investigation. By themselves, however, they are not sufficient. This is because the prevailing practice is to use the mean values of the calculated strength and stress, ignoring the natural scatter that stresses and strengths may have.

The variability in these two factors results in the existence of a statistical distribution function of stress and strength (See Figure 2.1) and is the heart of the Interference Theory. Thus, for proper prediction of reliability, an estimate must be made of both the mean value and the dispersion characteristics of both the strength and stress.

The strength of the part, as all properties of non-homogeneous materials, varies from specimen to specimen, in view of the variation in hardness, surface finish, degree of stress concentration, etc. The operating stress imposed on the part varies too. These stresses vary from time to time in a particular part, from part to part in a particular design, and from environment to environment. Therefore, both the mean value and the dispersion characteristics of stress and strength must be determined.

Once these parameters are found, percent interference and thus probability of failure can be determined from the interference area (shaded area in Figure 2.1). Means of computing these interferences represent one of the principal objectives of the present investigation.

Downloaded from http://www.everyspec.com

SECTION 2 INTERFERENCE THEORY

Suppose there are two barrels containing slips of paper, each having a number printed on it. The numbers in barrel Y are distributed according to distribution Y, as in Figure 2.1, and the numbers in barrel X are distributed according to distribution X. If, at random, elips of paper from each barrel are selected and paired, they may be classified into successes and failures. A success is constituted by a strength value exceeding a stress value, as for example, when $x_1 > y_1$. Failure will occur if $x_2 \leq y_2$ as shown. It will be noted that, although the shaded area is a measure of interference, it is not interference itself: a pair of points x_q and y_q , although in the shaded area, will not produce failure. By continued pairing of stresses and strengths, at random, pairs will be found where the stress will exceed the strength. By continued experimentation a good estimate of the probability of interference can be found.

2.1 Two Normal Distributions

From an exhaustive survey of literature made during this investigation it was found that most studies have assumed both the stress and the strength distribution to be normal. This is a natural assumption to make in order to solve a practical problem, as no work was found dealing with an analytical expression for two interference distributions when they are not normal.

When the stress and strength distributions are assumed to be normal the probability of interference can be determined from the equation:

where

 $\int_{\sigma_{x}^{2} + \sigma_{y}^{2}}^{r_{y} - x}$

(2.1)

 μ_v mean strength $\mu_{\mathbf{x}}$

σy²

σ<mark>x</mark>2

Z

stress variance

mean stress

- strength variance
- standardized normal variate determined from standard tables. (See Table 2.1)



÷ .

ţţ

j,

when it.

Downloaded from http://www.everyspec.com

Tabulation of the values of α versus K_{α} for the Standardized Normal Curve.

$$\alpha = P(z > K_{\alpha}) = \int_{K_{\alpha}}^{-} \frac{1}{\sqrt{2\pi}} e^{-\frac{z^{-1}/c_{dz}}{\sqrt{2\pi}}}$$

= Area under the Standardized Normal Curve from $z = K_{ij}$ to z = -

v

								/	\uparrow		- a
								Γ.			/ -
								7			×.
									0	K	
							-		z —		
Ka	.00	.01	.02	.03	.04	.05	.08	.07	30.	.00	
0.0	.5000	.4960	.4920	4880	.4840	.4801	.4761	.4721	.4661	.4641	
6.3	.4307	.4105	.4120	.4090	.4062	.4013	.3074	.30.36	3147	.2560	
0.3 0,4		.3400	.3173	,3834	.3300	,3364	,1226	.3192	3186	.3131	
0.5	.3085	.3080	.2015	.5881	.3046	.5012	.3877	.2013	.3810	3776	
0.7	.3430	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,3364	3157	.3396	3366	.3236	,3006	3177	.3146	
	.1841	.1814	.1786	.1762	.1736	.1711	.1965	.1993	.1 894 .1 636	.1611	
1.9	.1867	.1563	.1830	.1515	.1492	.1460	.1446	,1425	.1401	.1379	
li i	.1307	.1335	.1314	.1293	.1771	.1351	.1230	.1210	.1190	.1170	
1.4	.0008	.0961	.0854 .0778	.0918	.0901 .0749	.0045		.0063 .0706		.0001	
1.4	.0666	.0655	.0843	.0000	.0618	.0005	.0584	.0682	.0571	.0056	
	.0648	.0637	.0437	.0418	.0005	.0405	.0485	.0475	.0406	.8485 .8267	
13	.0359	.0351		.0136	,0329 ,0 31 9	.0223	.0314	.0307 .0344	.0301	.0204 .0823	
20		.0222	.0217	.0815	.0307	.0902	.0197	.0193	.0186	.0183	
21	.0179	.0174	.0170	.0106	.0163	.0156	.0154	.0150	.0146	0143 0110	
ឆ្ក	.0107	.0104	.0102	.00000	.00964	.00000	.00014		.00004	.00042	
<u> </u>				, 199, 199 , 199, 199							
<u>;</u>	.00406	.00458	,00440	.00427	.00118	.00402	.00901	A0579	.00300		
	.00947 .00956	.00000	,00000	.00323	.00206	.00319	.00213	.00706	.80199	.00198	
2.9	.00147	.80181	.00175	,00100	.00184	.00180	.00164	.00146	,00144		

Table 2.1 Normal Distribution¹

6

٩.

J

.

Downloaded from http://www.everyspec.com

Thus, if the average stress is 30 ksi, with a standard deviation of 3 ksi, and the average strength is 50 ksi with standard deviation of 10 ksi, z = 1.91 and from Table 2.1 °, which represents interference, is found to be .0281. Thus, percent interference, (probability of failure) is 2.81%.

In practical applications of the Interference Theory the following problem arises: both distributions under consideration extend to plus and minus infinity. It is apparent, therefore, that any two distributions will overlap and cause interference. This, of course, is erroneous because some distributions, such as strength, must have a finite lower bound of zero. In many situations the physical set-up and the sample size adjust for this lower bound. For example, suppose a part were designed so that the strength distribution is placed for away from the stress distribution, both distributions having standard deviation equal to σ . From equation 2.1 it is found:

$$z = \sqrt{\frac{6\sigma}{2\sigma^2}} = 4.24$$

and the probability of interference comes out to be .00001. This means that only one part will fail in 100,000 parts produced. If actually only 50,000 parts are made, the physical problem has effectively truncated the distributions. However, the probability of one part remains .00001. This means that due to sample size the extreme portions of these distributions are no longer important since the sample size is such that not even one failure can be expected.

For the case of application of the Interference Theory, a graph was constructed, as shown in Figure 2.2. The example solved previously through equation (2.1) now yields: $\frac{\mu_1 - \mu_2}{\sigma_{\min}} = \frac{50 \text{ksi} \cdot 30 \text{ksi}}{3 \text{ksi}}$

= 6.67 and $\frac{\sigma_{max}}{\sigma_{min}}$ = $\frac{10ksi}{3ksi}$ = 3.3

ł

and the probability of interference comes out approximately 0.03, as before.

2.2 Consistency of Two Distributions

In the application of the Interference Theory the following important point must be considered; the distribution of stress and the distribution of strength must be <u>consistent</u> with each other. In a fatigue test or in actual application in service, a single part has a single fatigue life for a given loading condition. Subsequent testing of additional parts under the same load will show a scatter in life, leading to a life distribution. Through more extensive testing a strength distribution for a given life can be obtained, such as the distribution in Figure 2.1 (the method



Probability of No Interference

 -1κ

8

Figure 2.2 Probability of Interference of Two Normal Distributions.

Ī

omin

. 1

Probability of Interference

Downloaded from http://www.everyspec.com

of obtaining a strength distribution from a life distribution is described in Section 6).

It follows then that for a consistent development, stress distribution must be of the same nature as strength distribution. That is, it should represent the plot of the frequency of occurrence versus the applied stress. This is not the same as stress distribution conventionally defived from the spectrum of loading acting on the part. The conversion of one to the other must be accomplished through the use of the equivalent stress (S_{equ}) and Miner's or Corten-Dolan's Rules. This is the method used in the present investigation, as described in Section 7.

2.3 Non-Normal Distributions

So far the discussion has been limited to the cases when both the stress and strength distributions can be assumed to be normal. In cases when either one or both are not normal the problem is much more involved. For example, the intersection of a normal and a log-normal distribution produces a distribution of an unknown origin.

In the past, problems such as this were solved largely through "brute force", by a method commonly referred to as the Monte-Carlo Technique. Essentially, the Monte-Carlo Technique consists of a Sophisticated means of randomly selecting a sample from one distribution and comparing it with a sample taken from a different distribution. This is accomplished with the aid of Tables of Random Numbers. The resultant paired data are plotted as a Comulative Density Function on a Probability, Weibull, etc. paper and percent interference is read from the graph.

2.4 The Integral Method

In the present investigation a Method of Integrals was used in preference to the Monte-Carlo Technique. This method involves determining the expression resulting from the interference of the two distributions under consideration and establishing percent interference from this integral.

The advantages of the Integral Method are:

- For some distributions the integrals have been already tabulated and percent interference can be read directly from the table.
- 2. In those cases where the integrals have not been already tabulated, they can be evaluated by Numerical Analysis as done in the present investigation.

3. The major shortcoming of the Monte-Carlo Technique is that it requires a very large sample size for any accuracy. This shortcoming is avoided when the Integrals are used.

Downloaded from http://www.everyspec.com

4. One of the objectives of the present study is to develop and avaluate an analytical expression for interfarence of any two distributions. Such an expression is possible when the Method of Integrals is used, but not when the Monte-Carlo Technique is employed.

ł

SECTION 3 OBJECTIVES OF THE PRESENT STUDY

The objectives of the study described in this report were:

i

- 1. To refine and to reduce to practice the stress/strength Interference Theory technique for designing for and predicting the quantitative reliability of mechanical parts and components under mechanical loading. Maximum use was to be made of empirical practical engineering values as well as a sound theory.
- 2. To study the effect of such factors as type of loading, surface finish, temperature, heat treatment, stress concentration, and surface treatment on the statistical distribution of fatigue strength.
- 3. To determine from the existing available empirical data the distribution of the fatigue strength under the effect of each of the above factors.
- 4. To develop the means of synthesizing the strength distribution function when such function is non-time variant, i.e., infinite life design (infinite fatigue strength), and when such function is time variant i.e. finite life design (inite fatigue strength).
- 5. To develop an analytical expression of the distribution of interference for the general case where the interfering distributions are different.

Downloaded from http://www.everyspec.com

SECTION 4 STUDY APPROACH

4.1 LITERATURE SEARCH

At the outset of the investigation an exhaustive literature search was made to determine the State of the Art in the field of Reliability Prediction-Mechanical Stress/Strength Interference. Some of the specific topics covered were: Interference Theory, Mathematical Tools as related to the Interference Theory, Monte-Carlo Technique, Reliability Prediction, Fatigue of Metals under different conditions, Statistical Analysis of Fatigue Data, Spectral Loading, Cumulative Damage due to Spectral Loading, etc. The sources where pertinent information was located are listed in the Bibliography. No references, however, were found dealing with the specific work objectives listed in Section 3, thus confirming the basic need for this type of information.

4.2 THEORETICAL ANALYSIS

One of the objectives of this investigation was to develop and evaluate an analytical expression for the interference of two distributions. When the two distributions are normal the interference can be simply expressed by a z-distribution, as described in Section 2. From an extensive survey of literature no work was found dealing with the analytical expression when the two interfering distributions are not normal. The purpose of this phase of the investigation, then, was to develop such an expression.

For reasons stated in Section 2, the Method of Integrals was chosen and an analytical expression was developed for the general case of two interfering distributions. This would include cases such as Weibull-Weibull, Weibull-Normal, Normal-Normal, Exponential-Exponential, etc. It was then necessary to find the way of solving the complex integrals expressing such interferences. Numerical analysis was carried out using an IBM 7090 Computer with MAD language to solve these integrals. Tables were then prepared for the interference as a function of the distribution parameters.

These tables included the combinations:

Stress Distribution Strength Distribution

Normal Weibull Weibull Weibull

because Normal and Weibull are the distributions most frequently found in actual engineering practice. The reason for choosing Weibull as the strength distribution for the two cases was that strength data, particularly

fatigue data, can be more conveniently expressed in terms of Weibull parameters (X, 0, b) than Normal parameters (u, σ) . It was felt that this restriction would not apply to the Stress Distribution.

4.3 EMPIRICAL DATA

The tables of interference are the heart of the Interference Theory as applied to the engineering practice. Once the stress distribution and strength distribution parameters are known, percent interference, and thus the probability of failure, can be read directly from these tables (for a procedure see Section 9 and for the tables see Appendix 2).

Over 250 articles from literature and other sources were examined and practically no data were found concerning the statistical distribution of stress. The only data located referred to <u>spectrum</u> of loads or stresses, which, as pointed out in Section 7, does not represent the Stress Distribution required for the Interference Theory. Interference Tables, therefore, were constructed so that for given dispersion characteristics of stresses a percent interference can be found. The range of these characteristics chosen here, and corresponding to engineering practice, are (if the stress distribution is Normal).

 $.01 \leq \frac{\sigma}{\mu} \leq .10$

As to the strength distribution it was found necessary to collect a great deal of data in order to arrive at a meaningful distribution. The search for these data turned out to be an involved task. To systematize the effort a format was prepared which included the factors which are known to affect the final distribution of strength. An attempt was made to collect data in different areas in order to determine the effect of such factors as type of loading, size, processes, surface conditions, heat treatment, surface environment, temperature, surface treatment, stress concentration etc.

An initial step was to gather scatter data from presently available published work. Many sources of information were examined, such as: RAND Reports, NASA Technical Notes, NACA Technical Notes, ASTM Transactions, ASM Transactions, SAE Transactions, ASME Transactions, etc.

Most of these data, however, were found to be in a graphical form, in many cases with test points not indicated, whereas statistical analysis requires data in a tabular form, for higher accuracy. The Mechanical Properties Data Center in Traverse City, Michigan was found to be a very useful scurce of information for tabular data. . They have been very cooperative in providing the necessary information. Although it was not possible to find data for every single factor affecting strength, stilla great deal of fatigue data was found and these data were systematized, evaluated in terms of Weibull parameters (Section 6), tabulated (Appendix 1) and plotted (Section 6).

While scanning through literature and other sources for possible fatigue data, some useful data for determining the statistical distribution of tensile strength and rupture strength of various ferrous materials was found. The effect of temperature and heat treatment on tensile strength and the effect of time and temperature on rupture strength were studied and the results were tabulated and plotted in the same manner. (see Appendix 1 and Section 6.4).

4.4 FACTORS AFFECTING THE STATISTICAL DISTRIBUTION OF FATIGUE STRENGTH

Since fatigue strength represents the major interest in the engineering applications of the Interference Theory, this problem was > studied in some detail. The statistical distribution of the fatigue strength of a mechanical component is a function of a number of factors, such as type of loading, surface finish, stress concentration, heat treatment, temperature, processes, and time. Each shows variability which is characterized by some form of a distribution. The effects of these factors on the statistical distribution of strength were studied in the present investigation.

Fatigue strength can be defined as the maximum stress that can be sustained for a specified number of cycles without failure, the stress being completely reversed within each cycle. In the case of steels a component is gaid to have finite fatigue strength if it fails between 10^3 and 10^5 or 10^7 cycles due to a given magnitude of cyclic load.

Type of Loading: The three major types of fluctuating load encountered in designing parts are axial, bending and torsion. Experimentally determined values of the ratio of average fatigue strength for axial loading, as compared to bending load were reported in literature as ranging generally from 0.75 to 1.0^2 , ³Although great deal of work has been done to obtain precise values for this ratio, no detailed study has ever been made as to the statistical aspects of these strengths. Investigations have been conducted to find statistical distributions (Normal, Exponential, Weihull, etc.) of fatigue strength tested under a given type of loading, such as bending. No work was done to determine the effect on the distribution if the loads were other than bending. In the present investigation an attempt was made to study the effect of different loads on the statistical distribution of the fatigue strength. The statistical parameters of the distribution for various materials under different loads were determined, tabulated according to materials (Appendix 1) and plotted (Section 6). Effect of Surface Finish: The surface finish of a part does affect its endurance strength. Hence, the condition of finish should be taken into account when the design is based on fatigue. Surfaces which have an effect on the significant strength can be classified into five broad categories: polished, ground, machined, hot-rolled, and as-forged. The worse the surface the lower will be the mean fatigue strength but the higher will be the scatter. As a result, the degree of interference is likely to be pronouncedly affected by the type of surface finish imparted to the member. Different surface effects were studied in the present investigation and the Weibull parameters were tabulated (Appendix 1) and plotted in Section 6.

Effect of Stress Concentration: A notch or a stress raiser in a part subjected to fatigue loading can be regarded as a factor causing a local increase in stress or as reduction in strength. For example, a notch with a stress concentration factor of 2 can be thought of as doubling the stress or as halving the strength. In the present investigation this factor was taken as a strength reduction factor.

If all parts were made of materials which are completely homogeneous and have perfectly polished surface finishes, the effect of a notch would be to increase the stress by the factor K_t . Since Actual materials are not perfectly homogeneous and actual surfaces are seldom perfectly polished, there exist internal and surface stress raisers. For this reason, the addition of a notch to a part, already having stress concentration due to geometry, generally produces a smaller effect than would be predicted from the theoretical stress concentration factor, K_t . The extent to which a notch reduces the endurance limit of a part is referred to as the fatigue stress concentration factor, or the fatigue strength reduction factor, and is designated by the symbol K_f . This is defined as:⁴

K_f = endurance limit of specimen without the notch endurance limit of specimen with the notch

In this study an attempt was made to determine the effect of stress concentration on the statistical scatter of the fatigue strength. More specifically, the objective was to find out whether this factor changes the mean strength only, whether it has an effect on the standard deviation or whether it completely changes the nature of the distribution itself. The data were collected for various materials at different temperatures, because, for example, the scatter of fatigue strength at 10⁴ life cycles with $K_{t} = 2.0$ for AISI 1040 steel tosted at 70°F may be different than at say 100°F, 200°F, or 500°F. Changes in the parameters of the statistical distribution of the strength due to the effect of stress concentration at various testing temperatures, for different materials are tabulated in Appendix 1 and plotted in Appendix 1 and plotted in Appendix 1

The effect of stress concentration was to decrease the values of X_0 and θ and in some cases of b, where X_0 is the lower bound of strength, θ is the characteristic strength, where 63.2% of the population have strengths less than or equal to this value, and b is the Weibull slope.

ł

Effect of Heat Treatment: Different heat treatments such as annealing, quenching, tempering, aging etc., can be imparted to materials to change their mechanical properties. Heat treatment may change the average fatigue strength but also the statistical scatter. Pertinent parameters are tabulated in Appendix 1 and plotted in Section 6.

The effect of heat treatment is to increase or to decrease Xand θ , depending on the design life. In most of the materials which were investigated the slope b increased with life for a given heat treatment.

Effect of Temperature: In a similar manner the effect of temperature on the statistical scatter is shown in Appendix 1 and Section 6.

With few exceptions the effect of temperature is to decrease X_{0} and θ and increase b with increased temperature.

4.5 FACTORS AFFECTING THE STATISTICAL DISTRIBUTION OF TENSILE, RUPTURE STRENGTH

In this phase of the study dispersion characteristics of the tensile strength and its statistical distribution were studied for several materials, heat treatments and operating temperatures. The scatter data were plotted in the same manner as the fatigue data, and the Weibull parameters were determined. These parameters were tabulated in Appendix 1. From these tables graphs were prepared with abscissa as temperature and ordinate as Weibull parameters (Section 6.)

Rupture strength can be defined in terms of that static stress which will result in a fracture within a specified time for a specified temperature. Data were collected to determine the statistical distribution of the rupture strength of various materials. The distribution parameters were computed for different operating temperature and for different times such as 100, 1,000 or 10,000 hours. These parameters were then tabulated according to the temperature and time (See Appendix 1).

4.6 ANALYSIS OF STRENGTH DATA

Data collected during this phase of the investigation were organized and systematized according to materials and conditions. In the case of fatigue, these data were plotted on S-N diagrams. Fatigue life data were subsequently converted to fatigue strength data for a given life. (Section 6.) The fatigue strength data thus obtained were plotted on the modified Weibull probability paper to determine Weibull parameters. The same procedure was repeated for different life cycles, for various materials and under different conditions. The Weibull parameters thus found were then tabulated in Appendix 1 and plotted in Section 6. SECTION 5 PRALITICAL EAPRESSIONS FOR THE INTERFERENCE

5.1 INTRODUCTION

5.1.1 Interference Probabilities

In interference theory one supposes that the strength of a manufactured part is not known with certainty prior to performing some test on it and that the stress induced by a load is not known wit'. certainty prior to actually loading the part. Thus, for example one does not know with certainty that the strength of a part is exactly 50 ksi. He may know that the part cannot have a strength greater than 58 ksi or less than 40 ksi. Or he may know that the average strength that has been obtained in previous tests on these parts is 49 ksi. He may have some measure of how dispersed the strength measures are around this average strength. The point, of course, is that this type of knowledge is quite different from knowing precisely what the strength is prior to testing. For a multiplicity of reasons strengths of seemingly identical parts are not exactly the same and precisely what strength a part will have cannot be known until some type of strength test is performed. In the theory of probability one says that the strength of a part is a random variable. Certainly the same type of reasoning applies to the stress. Thus for a mathematical theory of interference one starts with the idea that strength is a random variable, say X and stress is a random variable, Y.

In describing the properties of random variables, since their values are not known exactly, one supposes that associated with every set of values that the random variable can take there is a real number called the probability that the random variable takes values in the set. These probabilities are non-negative real numbers, they are all less than 1 and in the canse given below they "sum" to 1.

If x is any real number then there is a probability that the random variable takes some value less than or squal to x. Symbolically,

$\Pr(X \leq x)$

is a number such that $0 \le Pr(X \le x) \le 1$. Surely (i.e. with probability 1) $X \le \infty$ so that

 $Pr(X < \alpha) = 1$,

Downloaded from http://www.everyspec.com

and

$$\Pr(-\infty > X) = 0$$

Clearly $Pr(X \le x)$ depends on the real number x. Consequently one defines a probability distribution function F(x) by the relation

 $F(x) = Pr(X \le x)$.

One sees immediately that

$$0 \leq F(x) \leq 1,$$
$$F(-\infty) = 0$$
$$F(\infty) = 1$$

and that F(x) is a non-decreasing function.

In most engineering applications F(x) has a derivative for every value of x and one defines the probability density function, f(x), by

$$f(x) = \frac{dF(x)}{dx} .$$

One takes

$$f(x) dx = Pr(x < X < x + dx)$$

(i.e. the probability density function multiplied by dx is the probability that X takes values in the neighborhood of x). Since

$$f(x)dx = dF(x)$$

one has

$$\int_{-\infty}^{\infty} f(x) dx = \int_{-\infty}^{\infty} dF(x) = F(x) \Big|_{-\infty}^{\infty} = 1,$$

the probabilities given by f(x)dx "sum" to 1.

In the mathematical theory of interference one assumes that the probability density function for the random variables X (strength) and Y (stress) are known. Sections 5 and 6 following show how these functions can be found from engineering data. Thus the "givens" of the mathematical theory of interference use the random variables X and Y, the set of values that they each can take (usually the non-negative real line), and the probability density or distribution function F(x) (or f(x)) and G(y) (or g(y)).

Downloaded from http://www.everyspec.com

The problem to which interference theory addresses itself is that of finding the probability of failure. Failure is said to occur whenever the stress exceeds strength. Thus from the known probabilities for the X and Y random variables one wishes to find

$$\Pr(\mathbb{Y} \geq \mathbb{X})$$

which is the probability that stress exceeds strength or the probability of failure.

5.1.2 Calculation of Probabilities of Pailure

There are two useful ways of detwikining the probability of failure from the known properties of X and X :

(a) Since one wishes to find $Pr(Y \ge X)$ it is convenient in some cases (e.g. when stress and strength are normally distributed) to define a new random variable Z by the relation

Then if one can find the probability density function of Z, h(z), the probability of failure will be simply the probability that $z \leq 0$. In terms of h(z) this is found by

$$Pr(failure) = \int_{-\infty}^{0} h(z) dz .$$

The problem in general is then to find h(z) from the known probability density functions f(x), g(y). A complete discussion of this method and its applications is found in Section A-3.2*

* All references to Section A pertain to the Appendix. Thus, Section A-3.2 means Section 3.2 of Appendix 3.

Downloaded from http://www.everyspec.com

In the important special case in which both stress and strength are normally distributed random variables it is well known that Z is also normally distributed with parameters. An outline of the proof of these results is given in Section A-3.3.1.

 $\mu_{Z} = \mu_{X} - \mu_{Y}$ $\sigma_{Z}^{2} = \sigma_{X}^{2} + \sigma_{Y}^{2}$

and

Consequently the probability of failure can be found directly from tables of the normal curve areas. One wants the area from $-\infty$ to 0 from these tables. A complete discussion of how to do this is given.

A complete example of how this method can be used for nonnormally distributed random variables is given in section A-3.3.3 for the case in which stress and strength are each random variables with gamma density functions.

A comparison of this method of finding the probability of failure with the method of part b below is given in section A-3.3.2 for the case of negative exponential probability density functions.

(b) For most applications method (4) above is unnecessarily complex because one must first find the entire donsity function of the random variable Z before finding the probability of failure. Since the random variable Z is of no practical value for Z < 0 the approach in part (a) is unduly long. The methods described in this section are more direct and from our experience more useful in general.

One can derive the probability of failure as follows. Suppose we superimpose the stress and strength density function on the same graph as shown in Figure 5.1.

Although Y is a random variable let us fix attention on a particular, small interval that Y can take values in. Let us fix $y < Y \leq y + dy$. Then let us find the probability that the random variable X takes values less than this fixed Y. One can show that this probability is



$$\Pr(X \leq y \mid y < Y \leq y + dx) = \int_{0}^{y} f(x) dx.$$

The left hand side of this expression is called a <u>conditional probability</u>. It is the probability that the random variable X takes values less than the real number y when it is known ("given that") the random variable Y is "nearly" y. By the definition of f(x) this probability is obviously the same as the right hand side of the expression. If now we multiply this conditional probability by

$$\Pr(y < Y \le y + dy) = g(y)dy$$

we obtain the joint probability that $X \le y$ and $y < Y \le y + dy$ which symbolically is

$$\Pr(X \le y \mid y < Y \le y + dy) \ \Pr(y < Y \le y + dy)$$

= $Pr(X \leq y; y < I \leq y + dy)$.

This probability is given by the integral

$$\int_{0}^{\mathbf{y}} \mathbf{f}(\mathbf{x}) d\mathbf{x} \quad \mathbf{g}(\mathbf{y}) d\mathbf{y} \quad \mathbf{.}$$

From the joint probability one obtains the probability of failure by:

Pr (failure) =
$$\int_{0}^{\infty} \int_{0}^{y} f(x) g(y) dx dy$$
.

Thus this double integral gives the probability of failure directly.

If one recalls the relation between f(x) and F(x), it is clear that the double integral is easily reduced to the single integral

Pr (failure)
$$= \int_0^\infty F(y) g(y) dy$$
.

If F(x) is easily obtainable then this expression is easier to work with than the double integral. For example one knows, that for a strength with a Weibull probability density function the probability distribution

function F(x) is given by

$$F(x) = 1 - e^{-\left(\frac{x - x_0}{9x - x_0}\right)} b$$

In these cases the probability of failure is then given by

Pr(failure) =
$$\int_{0}^{\infty} (1 - e^{-\left(\frac{y - x_{0}}{\Theta_{x} - x_{0}}\right)^{b}x}) g(y) dy$$

= $1 - \int_{0}^{\infty} e^{-\left(\frac{y - x_{0}}{\Theta_{x} - x_{0}}\right)^{b}x} g(y) dy$.

The latter expression follows because

$$\int_0^\infty g(y) dy = 1$$

if the random variable Y takes only positive values which is the usual case in interference theory.

Similar expression to those above can be found as shown in Section A-3.3.4. In any event one is free to use whichever expression is easiest to work with.

Examples of the use of this method for non-normally distributed random variables is found in Section A-3.3.

5.1.3 Interference Tables, pages 258-396.

In Section 5.1.2 it was shown that the probability of failure could be expressed as an integral involving the known probability density or distribution functions. In certain cases this integral can be evaluated in closed form (e.g. when f(x) and g(y) are both exponential functions). In some cases this integral can be evaluated in terms of other well known and tabulated functions (e.g. when f(x) and g(y) are both gamma functions or when f(x) and g(y) are both normal functions). In general it is not to be expected that the integral for the probability of failure can be evaluated in closed form or in a form involving other well known functions. (e.g. when f(x) and g(y) are both Weibull functions or when f(x) is a Weibull function and g(y) is a normal function). In those cases one must resort to numerical evaluation of the integral.

From the discussion in Section 2 it is apparent that two cases are of importance to interference theory. They are

- (a) f(x) and g(y) are each Weibull functions
- (b) f(x) is a Weibull function and g(y) is a normal function.

Since the integrals giving the probability of failure cannot be expressed in terms of well known functions, in general, we have evaluated the integral numerically. Tables of the probability of failure are given in Section A-2. A full discussion of the numerical methods used and the errors of approximation appropriate to the tables are given in Section A-4.

5.2 USE OF INTERFERENCE TABLES, pages 258 - 396.

5.2.1 Parameters for the Weibull-Weibull Case

The form of the integral evaluated for finding the probability of failure when both the strength and stress are Weibull distributed random variables is given in Section A-3.3.4. Tables of this probability of failure are given in Section A-2.2. A discussion of the numerical analysis, errors and accuracy of the tables is given in Section A-4.

For each of the random variables X and Y the probability density function is of the form

$$\mathbf{f}(\mathbf{x}) = \frac{\mathbf{b}_{\mathbf{x}}}{\mathbf{o}_{\mathbf{x}}-\mathbf{x}_{\mathbf{0}}} \quad \left(\frac{\mathbf{x}-\mathbf{x}_{\mathbf{0}}}{\mathbf{o}_{\mathbf{x}}-\mathbf{x}_{\mathbf{0}}}\right)^{\mathbf{b}_{\mathbf{x}}-1} \quad e^{-\left(\frac{\mathbf{x}-\mathbf{x}_{\mathbf{0}}}{\mathbf{o}_{\mathbf{x}}-\mathbf{x}_{\mathbf{0}}}\right)^{\mathbf{b}_{\mathbf{x}}}}, \quad \mathbf{x}_{\mathbf{0}} \leq \mathbf{x} < \infty .$$

Each density function is completely characterized by three parameters $b_x(\text{ or } b_y)$, $\theta_x(\text{ or } \theta_y)$, $x_0(\text{ or } y_0)$. These parameters are called the slope, the characteristic value and the truncation parameter respectively. These names follow from the facts that

(1)
$$f(x) = 0$$
 if $x < x_0$,

Hence the strength (or stress) has zero probability of taking values less than $x_0 \sim$ the probability density function is "truncated" at x_0 .

(2) If one plots 1/(1-F(x)) vs $(x-x_0)$ on ln vs ln ln paper the graph will be a straight line with slope b_x .

(3) If $(x-x_0) = \Theta_x^{\prime}$, 63.2% of the area under f(x) falls below $(x-X_0)$. Hence Θ_x , the "characteristic" of x, is equal to $(\Theta_x^{\prime} + X_0)$.

It is to be noted that since f(x) is characterized by three parameters one expects the probability of failure to be characterized by six parameters (3 for strength and 3 for stress). Fortunately, this is not the case. As is shown in section, A-3.3.4 the integral for the probability of failure is determined by four parameters. These are used in the tables as:

(1) b_X - the slope of the strength distribution. In the tables this is called B_1 .

(2) b_x/b_y - the ratio of the slopes of the strength distribution (b_x) and the stress distribution (b_y) . In the tables this is called B_1/B_2 .

(3) $(x_0-y_0)/(\Theta_x-x_0)$ - the difference of the truncation parameters divided by the difference of characteristic value and the truncation parameter of the strength distribution. In all of the tables it is assumed that $x_0 \geq y_0$. This appears to be the most useful case for interference theory. In the tables this is called $(X_0-Y_0)/(\text{THETA } 1$.

(4) $\Theta_y - y_0 / \Theta_x - x_0$ - the ratio of the difference of the characteristic values and the truncation parameters. In the tables this is called Theta 2/Theta 1.

The following values of these parameters are used in the table. They are considered to be the most useful values for interference theory in mechanical problems.

> B_1 , $B_2 = 1$, 1.5, 2, ... 10. $B_1/B_2 = .1$, .2, ... 1 and 1, 2, ... 10. $(X_0-Y_0)/THETA 1 = .000$, .250, .500, .750, 1.000

> > 25 2.5
Ł

THETA2/THETA 1 = 1/1, 1/1.25, 1/1.50, 1/1.75, ..., 1/3. THETA2/THETA 1 = 1, .800, .667, .571,333.

or

į

The values in the bedy of each table are the probability of failure for the parameters given at the heading of the tables. From the discussion given in Section A-4.1.4 our estimate is that these tables are correct to $\pm 1 \times 10^{-4}$ and most of the values are correct to $\pm 5 \times 10^{-5}$.

5.2.2 Parameters for the Weibull Distributed Strength, Normal Distributed Stress Case

The form for the integral involved in finding the probability of failure when the strength is Weibull distributed and the stress is normally distributed is given in Section A-3.3.5. Tables of these probabilities are given in Section A-2.1. A discussion of the numerical analysis, error and accuracy of the tables is given in Section A-4.1.7.

The form of the distribution of the strength has been given in section 5.2.1. The parameters were discussed in that section. If the stress is normally distributed the probability density function is given by

$$g(y) = \frac{1}{\sqrt{2\pi^2}\sigma} \quad e^{-\frac{(y-\mu)^2}{2\sigma^2}}, \quad -\infty < y < \infty.$$

Each density function of this form is completely characterized by two parameters, μ and σ . These parameters are called the mean stress (average stress, expected stress are also used) and standard deviation of the stress (the square σ^2 is called the variance of the stress.) If one plots f(x) on rectangular coordinates μ is the value of xat which the peak of f(x) occurs. It is also the point of symmetry of f(x) and mathematically is the value of the integral

$$\mu = \int_{-\infty}^{\infty} \mathbf{x} \mathbf{f}(\mathbf{x}) \, \mathrm{d}\mathbf{x} \, .$$

 σ can be interpreted as the value for which the following probability statement is true.

$$Pr(\mu - \sigma < \Upsilon < \mu + \sigma) \approx .68$$
.

Since the strength distribution is characterized by three parameters (b_x, θ_x, x_0) and the stress distribution is characterized by two parameters μ , σ one expects that the integral for the probability of failure in this case is characterized by five parameters. Fortunately this is not the case. As shown in Section A-3.3.5 the integral for the probability of failure is characterized by three parameters. These three parameters as used in the tables are:

(1) $b_{\rm x}$ - the slope of the strength distribution. In the tables this is called $B({\rm x})$.

(2) $\theta_{x}-x_{o}/\sigma$ - the ratio of the difference of the characteristic strength and the truncation parameter to the standard deviation of the stress. In the table this is called <u>C</u> for typographical simplicity.

(3) $(x_0-\mu)/\sigma$ - the difference between the strength truncation parameter and the mean stress divided by the standard deviation of the stress. In the tables this is called <u>A</u> for typographical simplicity.

The following values of these parameters are used in the table. They are considered to be the most useful values for interference theory in mechanical problems.

B(x) = 1, 1.2, 1.3, ... 3.2
C = 10, 15, 20 ... 100
A = 0, 0.2, 0.4, ... 2.8, and from -0.2 to -10.0.

The values in the body of each table are the probabilities of failure for the parameters given at the heading of the tables. From the discussion given in Section A-4.1.7 these probabilities are correct to $\pm 5 \times 10^{-5}$.

5.2.3 Use of the Tables, Explanation of Missing Values and Interpolation

Numerical examples of the use of the tables are given in Section 5.3. In general the user will enter the table with known parameters (b_x , Θ_x , x_0 and the appropriate parameters for the stress distribution) and wish to find the probability of failure. This is a direct table look-up. In some design problems the user will have a given probability of failure to achieve and will know the general

shape of the distribution of stress and strength appropriate to the material that he is using. The table will then give him the relative parameters (there may be many of these) to design for. It would be expected that a cost analysis would give the acceptable parameter values for each distribution. As long as the relative values are as given in the table the probability of failure will be the same no matter what the values for each distribution are.

In the tables there are some values not tabulated. For example in the Tables A-2.2 for the Weibull strength and Weibull stress there is a row of non-tabulated values for B1/B2 = .1 and B1 > 1 for every value of $(X_O-Y_O)/THETA 1$ and THETA 2/THETA 1. These values were not tabulated because they require values of the parameters (i.e. Bl and B2) that are outside the limits considered useful for mechanical problems in interference theory. For example the value in the table $(X_O-Y_O)/THETA 1 = .000$, THETA 2/THETA 1 = .571 at B1 = 5, B1/B2 = .1 is missing. To include this value in the table would have required determining the probability of failure for the case B2 = 50. But B2 = 50 is a value seldom found in mechanical interference theory. Hence this probability of failure was not computed.

Some of the non-tabulated values are nearly zero and hence have not been tabulated. This occurs only in the Weibull Strength-Normal Stress tables. For example when A > 3.5 one knows that $(x_0-\mu)/\sigma > 3.5$. From the theory of the normal curve one knows that the area under the normal curve from 3.5 to ∞ is less than 3×10^{-4} and the probability of failure is less than 1×10^{-4} . We take these values to be too small to be significant for the mechanical interference theory.

It can be seen that the tables are non-linear for almost all values of the parameters. This can cause inaccuracies when the tables are interpolated. The absolute value of the interpolation error depends on which tables are interpolated. For precise values the user should use a higher order interpolation formula rather than linear interpolation. We have not explored the relative errors of interpolation closely. In those cases checked, the relative errors are small.

5.3 EXAMPLES OF USE OF THE TABLES

For an example illustrating the use of these tables in an application of the Interference Theory see Section 9.

SECTION 6 STATISTICAL DISTRIBUTION OF STRENGTH

6.1 ANALYSIS OF STRENGTH DATA

Most fatigue testing involves subjecting a number of specimens or parts to the same stress and repeating this process at various stress levels. The data thus obtained, known as life data, are used to construct the conventional S-N diagram. In this case, the scatter obtained is the scatter in life at a given stress. In the present investigation the attention was focused on the nature of the scatter in the fatigue strength at a given life. To obtain such data it is necessary to fatigue test all the specimens with different stresses imposed on them in such a manner that all would fail at a predetermined life. Practically, this is impossible and, therefore, in the present investigation, two alternate methods, discribed below, were considered.

6.1.1 Conversion of Life Data to Strength Data

The fatigue life data were obtained for various materials under various conditions. These data were then plotted on the conventional S-N diagram. Here, it is assured that to each specimen of the population can be attributed an individual S-N curve, and that there exists for any pepulation of specimens (at fixed test conditions) a family of non-intersecting S-N curves, which can be determined with any desired accuracy, each curve corresponding to a given probability.

The average S-N curve is then fitted to all the test points on the S-N diagram using the least square method. Passing through each test point draw an S-N curve parallel to the average S-N curve. These will make a family of S-N curves. (see Figure 6.1). Now if the fatigue strength distribution at $N = N_1$ life is required, draw a vertical line at $N = N_1$ intersecting the family of S-N curves. These points of intersection S_1, S_2, \ldots , represent a sample from the strength distribution at a desired life? These data are then plotted on the probability paper as a cumulative distribution function to determine the strength distribution (see Figure 6.3).

6.1.2. Strength Response Test

As an alternative method, the strength response test was considered. The cumulative percentage point of fatigue strength distributions can be determined at any stress level S by testing a <u>large</u> number of specimens at this level and counting the fraction of specimens failing at the preassigned life N. If this procedure is repeated at different





. 46.

levels, several points of the strength distribution are obtained and can be used for the analysis of strength distribution.

For example, suppose, the fat gue strength distribution at life N₁ is desired. (See Figure 6.2). A large number of specimens, say 50, are tested at stress level S₁ and if only one out of these 50 fails before or at the preassigned life N₁ then it can be said that on an average only F₁ = 2% from the lot of specimens have fatigue strength less than or equal to S₁. The same procedure can be repeated for several other stress levels S₂, S₃, . . . S₁, and corresponding percentage points (F₂, F₃, . . . F₁) can be determined. These points represent the cumulative behavior of strength, and can be plotted on the several probability papers (such as Weibull, Normal, Logistic, Extreme value, etc.) with S as its abscissa and XF as its ordinates, (Figure 6.3).

The percentage points of the strength distribution measured by this method are independent of each other and accordingly the method of least squares can be applied.

As this mathod requires testing of a large number of specimens at any one stress level, very limited data of this type are available although recently a method was proposed for generating such data.⁵ Hence, in the present study the fatigue strength distributions ware analyzed by converting the directly observed scatter in fatigue life into a scatter in fatigue strength, as discussed in Section 6.1.1, rather than by evaluating the data from response tests.

6.2 PLOT OF STRENGTH DATA

In order to determine the distribution of strength at a given life, it was necessary first to obtain supirical data from literature and other sources (see Section 4.3) and then to plot these data so that the parameters of the distributions could be determined. The type of information desired is illustrated in Figure 6.4 where it is shown that the strength distribution may be different at the different lives.

The usual method, of determining this statistical distribution is to construct a histogram. This was tried in the present investigation for a number of cases, one of which is shown in Figure 6.5. This refers to strength data obtained from Machanical Properties Data Center for D_{6AC} Steel under conditions as follows:

Type of load - completely reversed; Surface finish - Mechanically Polished; Stress Concentration factor - $K_t = 1.0$; Test Temperature 80° F. Fatigue Strength distribution data at 10° cycles are: 55.3, 57.3, 59.2, 61.4, 62.5 ksi.





er Liter

h

. in

ţi,





رد ا:



R .





...

. .

In Figure 6.5 this data are plotted for 3, 4, and 5 ksi intervals. It can readily be seen that each interval suggests a different form of distribution. Furthermore, for the histogram method to be effective, a large amount of data, well in excess of the data available in the present investigation, is required.

For this reason, the histogram method was not used here, and, instead, the Weibull distribution was adopted.

The Weibull distribution is of great usefulness in the analysis of fatigue data. The utility and value of the Weibull distribution results from the fact that it covers a considerable variety of distribution patterns, and data which fit any of these patterns plots as a straight line on special graph paper, known as Weibull probability paper. (For explanation see page 44). Although the Weibull distribution provides a versatile means for describing the life characteristics, it can also be used for describing the mechanical properties, such as, fatigue, tensile and rupture strengths studied in the present investigation.

The Weibull equation is a three parametric mathematical function having x as a variable. The general expression for the Weibull density function is:

 $f(x) = \frac{b}{\theta - X_o} \left(\frac{x - X_o}{\theta - X_o} \right)^{b-1} e^{-\left(\frac{x - X_o}{\theta - X_o} \right)}, \quad (6.1)$

「「「「「「「「「「」」」」

 $X_{o} \leq x \leq \infty$

and the general expression for the cumulative distribution function is:

 $F(x) = 1 - e^{x - X_{o}}, \qquad (6.2)$

X₀ ≤ x ≤ ∞

where, as used in this study,

X₀ is the lower bound of strength

O is the characteristic strength, where 63.2% of the population have strengths less than or equal to this value.

b is the Weibull slope.

Versatility of the Weibull distribution is illustrated in Figure 6.6 and Figure 6.7 which show different forms of the distribution for various values of b. The Weibull slope b defines the shape of the curve, whereas θ , the characteristic strength, defines the scale of the curve (see definition on page 36). It is therefore possible to have several forms of a particular distribution depending on:

- 1. The value of b (where θ and X_0 are constant)
- 2. The value of θ (where b and X_o are constant)
- 3. The value of X_0 (where θ and b are constant).

As to special cases of Weibuil distribution, it reduces to the truncated normal distribution when b is approximately equal to 3.5 and to the truncated exponential distribution when b is equal to 1.0.

6.3 DETERMINATION OF THE WEIEULL PARAMETERS

In order to determine the Weibull parameters for the strength data the following steps are required:

1. The scatter of fatigue life at a given stress level, as obtained from the literature or other sources is converted to the scatter of fatigue strengths at a given life in the manner discussed in Section 6.1.1. 12

- 2. The fatigue screngths obtained from above are then arranged in the increasing order of value and median rank is assigned to each value as described in the example that follows.
- 3. The strengths are then plotted on the modified Weibull probability paper on the abscissa against the median ranks on the ordinate.
- A correction is then made to the resultant curve by determining the probable value of the lower bound of strength X₀.
- 5. From the corve thus modified the three parameters of Weibull are then determined.

This method is illustrated by the following example.

Material: D_{6AC} Steel, $S_u = 270$ Ksi

Conditions: Type of Load - Completely Reversed Rending

Surface Finish - Mechanically Polished







ş

Figure 6.7 Weibull Plots for Various Slopes on Weibull Probability Paper

39

ŧ

a construction of the second sec

Stress Concentration Pactus, Rr = 1.0

Test Temperature, 80°F

Fatigue Strength distribution data at 10^5 cycles are (in ksi):

57.3, 59.2, 62.5, 55.3, 61.4

In order to make the Weibull cumulative plot, it becomes necessary to decide what rank is to be assigned to each particular strength value. The lowest strength in a group tested will have a definite percentage of the total population having strengths lower than this, if the entire population were tested. If we knew exactly the percentage of the population having strengths lower than the lowest in the sample, that percentage would be the true rank of the lowest strength in the sample. However, since we do not know the true rank, we make an estimate of it. We use an estimate such that in the long run the positive and negative errors of the lowest strength a rank that is too high and the other half of the time a rank too low. A rank with this property is called median rank. A table of median ranks is given in Table 6.1. The test data are then arranged in an increasing order of value and the appropriate median ranks for sample size n = 5 are read from Table 6.1 as follows:

x, Ksi	Median Ranks, X
55.3	12.94
57.3	31.47
59,2	50.00
61.4	68,53
62.5	87.06

These data are then plotted on the modified Weibull probability paper as shown in Figure 6.8, curve A.

In plotting these data an assumption was made that the lowerbound of strength X_0 (i.e. the minimum strength that can be expected in the whole population) is zero. This is obviously not the case, as mechanical parts must have a strength greater than zero. Therefore the next step was to determine the probable value of X. This value should be somewhere between the lowest value of the sample (55.3 ksi) and zero. As the first trial therefore assume that X is 35 ksi.

By subtracting X from the original set of data, the following is obtained:

74.17 05.7 0.47 0.147 0.148 able 1 30.47 04.77 0.449 10.49 1.049 1 1 30.47 04.46 1.049 1.049 1 1 1 30.47 04.46 1.049 1.049 1 1 1 30.47 04.46 1.049 1.049 1 1 1 30.48 04.46 1.049 1.049 1 1 1 30.49 04.46 1.049 1.049 1 1 1 31.40 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 31.41 04.46 1.049 1.049 1 1 1 <
Solution Color Solution Solution Solution Solution Solution Solution Solution Solution Solution Solution

Table 6.1 Table of Median Ranks¹

j£

Downloaded from http://www.everyspec.com



Downloaded from http://www.everyspec.com

Figure 6.8 Modified Weibuil Plot for D Weibull Parameters for the Abov









(x - X ₀)	Ksi	Median Ranks, 7
20.3		12.94
22.3		31.47
24.2		50.00
26.4		68.53
27.5		87.06

When these are plotted (Figure 6.8, curve B) the resultant curve is not a straight line. Therefore, other values of X_0 are assumed,⁵ and the same procedure is repeated until, for a certain assumed X_0 , one can best linearize all the test points. In this case the best line nearest to a straight line is for $X_0 = 50$ Ksi, curve C. Through these points, then, a straight line is fitted using the Least Square Method.

The value of $(x - X_0)$ at 63.2% is read off to determine the characteristic strength θ :

x at 63.2%

A

 $(x-x_0)$ 63.27 $\theta = (x)_{63.27}$ $= \theta_1 + x_0 = 10.3 + 50$

= 60.3 Ksi

The Weibull slope b is determined by drawing a line parallel to the straight line of $X_0 = 50$ and passing it through the pivot point. The point where this line intersects the Weibull slope scale is the value of the Weibull slope. In this case, b = 3.0. Hence, the Weibull parameters for the given set of fatigue strength data are:

$$x_0 = 50$$
 ks1
 $\theta = 60.3$ Ks1
 $b = 3.0$

The analytical form for the corresponding Weibull equation is:

۰,



These parameters were tabulated for various materials under various conditions, (see TablesAppendix 1) on the basis of all the available test data obtained. The most representative parameters were then plotted, as shown in Figure 6.9 to Figure 6.115.

As stated on page 36, one of the advantages of the Weibull distribution is that it plots as a straight line on a Weibull probability paper. This is shown below:

Equation 6.2 gives:

$$F(x) = 1 - e^{-\frac{x - X_0}{9 - X_0}}$$

or $\frac{1}{1-F(x)}$

$$\ln \ln \left[\frac{1}{1-F(x)}\right] = b \ln (x-X_0) - b \ln (\theta - X_0)$$

This equation has a form Y = b(X) + C which represents a straight line with a slope b and intercept C on the Cartesian X, Y co-ordinates. Hence, a plot of lulu 1/1-F(x) against ln $(x - X_{0})$ will also be a straight line with a slope b.

6.4 GRAPHS OF WEIBULL PARAMETERS

Weibul 1 parameters 9, b and X_0 for fatigue strength determined, as shown in Section 6.3, were then plotted against life on log-log scale for various materials including the affect of heat treatment, stress concentration, comperature, type of loading surface finish, etc. Weibull parameters for tensile strength determined in the same manner were then plotted against temperature on Cartesian coordinates for various materials.

Downloaded from http://www.everyspec.com

For case of locating specific information the following Table of Contents is offered.

MEANING OF SYMBOLS

s _n S _y	Vield Strength of Specimen
0	Characteristic Strength, ksi
b b	Weibull Slope
T of L	Type of Loading
R	Rotary Bending
P	Plate Bending
A	Axial bending
Spec	Type of Specimen
V-N	Vee Notched, Flank Angle = 60°
H-N	Hole Notch
No-N	Unnotched
Sm	Mean Stress _a kai
K _t	Theoretical Stress Concentration Factor
Melt.	Type of Melt Practice
Sec. Op.	Secondary Operation Applied to Test Specimen
T.1.G.	Tungsten Inert Gas Welded
Surf.Cond	Test Surface Condition
S.P.	Shot Peened
C.P.	Chrome Plated
С. В .	Chromed and Baked
M.P.	Mechanical Polish
G.	Ground Gereteked Mechanderller
SCI. N D	Scietched Abonenically No Brenewation to Surface
N • E •	No resperation to Surmed
Н.Т.	Heat Treatment Applied to Specimen
W.Q.	Water Quenched
A.C.	Air Coeled
0.q.	011 Quenched
Sol.Tr.	Solution Treated
Temp.	Tempered
Aust.	
	Austinitized
Norm.	Austinitized Normalized

46

٦.

INDEX TO GRAVHS OF WEIBULL PARAMETERS

Fatigue Strength

Material:

.

ł

<u>Material</u>

Weibull Parameters can be found:

1	ATST 3140 Step1	Page No.	Figure No.
~ .	Effect of Stress Concentration, H.T. = Ko	51	6.9
	Effect of Stress Concentration, H.T. = K_{λ}	52	6.10
	Effect of Heat Treatment, Unnotched	53	6.11
	Effect of heat Treatment, V-Notched	54	6.12
2.	AISI 1045 Steel		
	Effect of Heat Treatment, V-Notched	55	6.13
	Effect of Stress Concentration, H.T. = K_1	56	6.14
3.	AISI 2340		
	Effect of Heat Treatment, V-Notched	57	6.15
•	Effect of Heat Treatment, Unnotched	58	6.16
	Effect of Stress Concentration, Oil Querch	59	6.17
	Effect of Stress Concentration, Air Blast Quench Te	mp, 60	6.18
	Effect of Stress Concentration, Air Blast Quench, no Te	61 mp.	6.19
4.	4140 Steel	• -	
	Effect of Stress Concentration	62	6.20
5.	-D _{ÉÁC} Steel		
	Effect of Temperature, Kt = 1.0	63	6.21
	Effect of Temperature, Kt = 3.0	64	6.22
	Effect of Temperature, $K_t = 3.0 \text{ Sm} = 30-50 \text{ ksi}$	65	6.23
	Effect of Temperature, Kt = 1.0 Sm = 70-80 ksi	66	6.24
	Effect of Stress Concentration, $T = 80^{\circ}F$	67	6.25
	Effect of Stress Concentration, $T = 450^{\circ}F$	68	6.26
	Effect of Stress Concentration, $T = 550^{\circ}F$	69	6.27
6.	H-11 Steel	70	< ab
	Bilect of Surface Treatment, N.P.	70	6.28
	Effect of Surface Treatment, N.P.	71	6.29
	Effect of Surface Treatment, Pretest Exposure at 3	/5°F/2	6.30
	Effect of Surface Treatment, Pretest Exposure at 5		6.31
	BIJECT OF SURFACE Treatment, Pretest Exposure at 7	シリッチ74 2028年74	6,32
	Effect of Surface Treatment, Pretest Exposure at 1		6,33
	Effect of Heat Treatment, N.P., M.P.	76	6,34

	Effect o	of Heat Treatment, S.P., M.P.	77	6.35
	Effect o	f Hest Treatment, C.P., C.B.	78	6.36
	Effect o	of Heat Treatment, S.P., C.B.	7 9	6.37
7.	4340 Steel	· · · · · · · · · · · · · · · · · · ·		
	Effect o	of Heat Treatment, V-Notched, Air Melt	80	6.38
	Effect c	of Heat Treatment, Unnotched, Air Melt	81	6,39
	Effect o	of Heat Treatment, V-Notched, Vac. Melt	82	6.40
	Effect o	of Heat Treatment, Unnotched, Vac. Melt	83	6.41
	Effect o	of Heat Treatment, V-Notched, Vac. Melt	84	6.42
	Effect o	of Melt Practice, V-Notched, H.T.A.	85	6.43
	Effect o	or Melt Practice, V-Notched, H.T.B.	86	6.44
	Effect o	of Melt Practice, Unnotched, H.T.A.	*8/	0.45
	Effect o	of Melt Practice, Unnotched, H.T.A.	88	0.40
	Effect o	of Stress Concentration, H.I.A. Air Melt	89	0.4/
	Effect o	of Stress Concentration, H.I.B. Air Melt	90	0.48
	Effect o	of Stress Concentration, 6A. Vac.Melt	91	0,49
	Effect o	of Stress Concentration, R.I.D. Vac.Melt	92	0,50
	Effect o	of Stress Concentration, T. B. Vac Malt	93	0,51
	Affect o	of Stress Concentration, 1.5, Vac. Meit	94	0,52
8.	AISI 4340	Steel	05	6 53
	Effect o	of Heat Treatment, Not Roused and Cround	95	6.54
	DITECT C	T heat iteatment, forged and ground	30	0.34
9.	Thermold J	I. If Stress Concentration	97	6 55
				0153
10.	Fe, 5.5%,	Mo, 2.5% Cr., 5% C		
	Effect o	of Stress Concentration	98	6.56
11	MIO Teol S	11001		• •
TT •	Effect o	of Heat Treatment	99	6.57
12.	321 Stainl	ess Steel	100	6 60
	LIIECU O	F Stress Concentration at 80°F	101	0,50
	Effect o	f Stress Concentration at -320°F	101	0.39
	Effect o	I Stress concentration at -423° F	102	6.60
	Effect o	of process at our, $K_{t} = 1.0$	103	6.01
	Effect o	F Process at -320° F, K = 1.0	105	0.04
	Effect o	f = 1.0	106	6.64
	Effect o	$M_{\text{Temperature, M.P., K_{\text{t}}} = 1.0$	107	5 65
	Effect o	I remperature, M.r., $K_{t} = 3.5$	108	6.66
	EILECL U	t remperatore, 1.1.6. werded, $\kappa_t = 1.0$	100	0.00
13.	A-286 Stain	less Steel		
	Dilect O	F Tumperature, M.F., Kt = 1.0	109	6.67
	ELLECU O	Temperature, M.F., Ke = 5.5 و Temperature, M.F. Ke = 5.5	110	6.68
	ELLECL D	f Strong Concentration of 2007	111	6.69
	FILECC 0	T STRESS CONCENTRATION BE OU.L.	112	6,70

and the second second

1. March & Ball & State & Soundary

Downloaded from http://www.everyspec.com

	Effect of Stress Concentration at -320°F	113	6.71
	Effect of Stress Concentration at -423°F	114	6.72
	Effect of Process at 80°F	115	6.73
	Effect of Process at -320°F	116	6.74
	Effect of Process at -423°F	117	6.75
L4.	Multiment N-155		
	Effect of Temperature, Axial Load	118	6.76
	Effect of Temperature, Rotary Bending	119	6.77
	Effect of Surface Treatment, Axial Load	120	6.78
	Effect of Type of Loading, 1200°F	121	6.79
	Effect of Type of Loading, 1350°F	122	6.80
	Effect of Type of Loading, 1500°F	123	6.81
15.	Multiment N1-155		
-	Effect of Surface Finish	124	6.82
	Effect of Surface Finish	125	6.83
	Effect of Surface Finish	126	6.84
16.	17-7 PH		
	Effect of Stress Concentration	127	6.85
17.	Duralumin		
	Effect of Salt Water Corresion	128	6,86
18.	T1-6A1-4V		
	Effect of Temperature, H.T.A.	129	6.87
	Effect of Temperature, H.T.B.	130	6.88
	Effect of Heat Treatment, 80°F	131	6,89
	Effect of Heat Treatment, 400°F	132	6,90
	Effect of Heat Treatment 600°F	133	6.91
	Effect of Heat Treatment 800°F	134	6,92
	Effect of Heat Treatment 80°F, Sm = 82-107 ks1	135	6.93
	Effect of Heat Treatment, 400°F, Sm = 30-42 ksi	136	6.94
	Effect of Heat Treatment, 400°F, Sm = 77-100 ksi	137	6,95
	Effect of Heat Treatment, 800°F, Sm = 40-64 ksi	138	6.96
	Miscellaneous-Effect of Mean Stress	139	6.97
	Miscellaneous-Effect of Mean Stress	140	6.98
	Miscellaneous-Effect of Mean Stress	141	6 ,9 9
	Miscellaneous-Effect of Mean Stress	142	6.100
	Miscellaneous-Effect of Mean Stress	143	6.101

7

State State States

	Tensile Strength	Page
1.	Low Carbon, Low Alloy Steel, (Killed)	144
2.	Low-Medium Carbon, Low Alloy Steel,	145
3.	Killed, Low Carbon, Low Alloy Steel,	146
4.	Low-Medium Carbon, Low Alloy Steel,	147
5.	Low Carbon, High Alloy Steel	148
6.	Low Carbon, High Alloy Steel,	149
7.	Stainless Steel (17% Cr., 12%)	1 50
8.	Low Carbon, High Alloy Steel	151
9.	Stainless Steel (25% Cr., 12% N1, 2% C)	152
10.	Stainless Steel (18% Cr., 8% Ni, .8%Ti, (.0409)%C)	153
11.	Stainless Steel (18% Cr., 8% Ni., .8% Cb.,.06%C)	154
12.	Stainless Steel (18% Cr., 8% Ni, (.0209)%C)	155
13.	Stainless Steel (18% Cr., 12% Ni, 2% Mo, .08%C)	156
14.	Stainless Steel (25% Cr., 20% Ni., 2% Mn, 2 Si,.25% C)	157

FATIQUE STRENUTH

AISI 3140



Rotary Beam Bending Room Temperature Composition: .45 C, .85 Mn, .35 S1, 1.2% N1, .65% Cr! Figure: 6.9

Hot Rolled, Lathe Turned, Hand Polished Mean Stress = 0 Heat Treatment: Ky:See Page 198, Item 1 (For Tabulated Data See Page 207)

FATINUE CIRCINIA

S_u = 109 ksi $S_{\rm w} = 75$ ksi




AISI 3140

 $S_{12} = 108, 109 \text{ ksi}$

 $S_y = 87, 75$ ksi



 Hot Rolled, Lathe Turned, Hand Polished Mean Stress = 0 Heat Treatment: K3 & K4: See Page 198, Item 1

.11 (For Tabulated Data See Page 207)



Su = 108, 109 kat

Sy = 57, 75 kai



Ľ



PATIOUE STREAME

Rotary Beam Bending V-Notched Composition: .4% C. .8% Mn, .3% S1 1.2% Ni, .65% Cr! Figure:6.12 Hot Rolled, Lathe Turned, Hand Polished Mean Stress = 0 Heat Treatment: K3 & K4: See Page 198, Item 1 (For Tabulated Data See Page 207)

FALLING CHIDENSING

AISI 1045 Steel

 $S_u: K_1 = 105 \text{ ksi}, K_2 = 120 \text{ ksi}$







FATIQUE STRENUTH

TO TO DOGET

 $S_u = 105$ kmi $B_y = 84$ kmi

「「「「「「「」」」」



Rotary Beam Bending Room Temperature Composition: .43-.50% C, .60-.90% Mn .040 max. P, .05% max. S Figure:6.14



.









_ a
FATIGUE STRENGTH

A1S1 2340 Steel

御湯

 $S_u \approx 122$ ksi, $S_y = 76$ ksi



Figure: 6.19 (For Tabulated Data See Page 210)

7





 $S_u = 135$ ksi, $S_y = 122$ ksi



= unknown for V-notched

Aust. 1550 F 1 hr, 00, Temp. 1230°F 1 hr.

Composition: Standard 4140

Figure: 6.20

Kt

(For Tabulated Data See Page 210)



FATIGUE STRENGTH

 $S_u = 270 \text{ ksi}, S_y = 237 \text{ ks}^4$



 Axial Load, Completely Reversed
 Hot Rolled, Polished

 Stress Conc. Factor Kt = 1.0
 Mean Stress = 0

 Composition), See Page 198, Limit i
 Heat. Treatment: See Page 198, Limit i

Figure: 6.21

(For Tabulated Data See Page 213:)



Stress Conc. Factor Kt = 3.0

not solled, formed

Mean Stress = 0

Compositions Ses Page 198, Item 6

Heat Treatment: See Page 198, Item 6

Figure: 6.22 (For Tabulated Data Sec Page 213.)

FATIGUE STRENGTH

 $S_u = 270$ kmi, $S_y = 237$ kmi



Arial Load

Stress Conc. Factor Kt = 3.0

Composition1 See Page 198, Item 6

Figure: 6.23

Hot Rolled, Polished

Mean Stress = 30-50 ksi

Heat Treatment: See Page 198, Item 6

۰.

(For Tabulated Data See Page 213)







Downloaded from http://www.everyspec.com



FATIGUE STRENGTH

 $g_u = 270$ ksi. $S_v = 237$ ksi



Hot Rolled, Polished Axial Load, Completely Reversed Mean Stress = 0 Temperature = 550°F Composition: See Page 198, Item 6 Heat Treatment: See Page 198, Itom 6

Figure: 6.27 (For Tabulated Data See Page 213)

69





Rotary Beam Bending Mean Stress = O Composition: 5% Cr, 1.5% Mo, .4% V, .35% C Hot Rolled, Lathe Turned Grain Direction is Transverse to Lengthwise Axic Surface Treatment Code: See Page 40, No (Pretest) Conditioning Initial Heat Treatment: see page 199, Item 7

Figure: 6 28 (For Tabulated Data See Page 214)

FATIGUE STRENGTS



S_u = 272 ksi

 $S_y = 228 \text{ ksi}$



Rotary Beam Bending Mean Stress = 0 Composition: 5% Cr, 1.50% Mo, .4% V, .35% C

Figure:6.29

Hot Rolled, Lathe Turned Grain Direction Transverse to Lengthwise Axis C Surface Treatment Code: See Page 46 No Pre-Test Conditioning Initial Heat Treatment: See Page 199, Ttam 7 (For Tabulated Data See Page 214)

FATIQUE STRENGTH

H-11 Steel

 $S_u = 272 \text{ ksi}$ $S_v = 228 \text{ ksi}$

Effect of Surface Treatment p_{1} I SP-CB 15 . 60 ł. No Prep umur derfahlen strenss Laur Semura Streenen Laur Semura Streenen 177) 40 40 40 40 40 40 40 SP -CE 20 'n No Prepi-SP-CB 7 8 9 107 1 1178, 4 5 6 Rotary Beam Bending Mean Stress = 0 Composition: to Lengthwise Axis

5% Cr, 1.5% Mo, .4% V, .35% C

Hot Rolled, Lathe Turned Grain Direction Transverse to Lengthwiss Axis Surface Treatment Code: See Page 46 Exposed 4 hr. at 375°F Initial Heat Treatment: See Page 199, Item 7

Figure: 6430 | (For Tabulated Data See Page 214)



 $S_{11} = 272$ ks1

FATIGUE STRENOTH

H-11 Steel



Mean Stress = 0 Composition; 35 Cr, 1.35 Mo., 45 V. Hot Rolled, Lathe Turned Grain Direction Transverse to Longthwise Axis Burface Treatment Code: See Page 44: Burgased 4 hr. at 700°F Enitial Heat Treatment: Spe Fage 199; Item 7.

 $S_y = 228$ ks1

¢

Figure 18. (For Tabulated Data See Page 214)

741

•

PATIGUE STRENOTH

B-11 Steel

8_v = 228 ksi

8₁₁ = 272 ksi



Rotary Beam Bending Mean Stress = 0 Composition: 75 Cr, 1.75 Mc, .45 V, .335 C

Hot Rolled, Lathe Turned Grain Direction Transverse to Lengthwise Axis C Burface Treatment Code: See Page 46 Exposed 4 hr. at 1000°F Initial Heat Treatment: See Page 199, Item 7? (For Tabulated Data See Page 215)

Figure: 6 (For











Rotary Beam Bending Mean Stress = 0 Composition: 5% Cr, 1.5% Mo, .4% V, .55% C

Pigure: 6,35

Hot Rollad, Lathe Turned Grain Direction Transverse to Lengthrise Axis Surface Treatment: Shot-Feened-Mechanical Polish Fratest Conditioning Code: See Page 46 Unitiel Book Treatment: See Page 139, Item 7'

 $S_y = 228$ ksi

8₁₁ = 272 ks1

(For Tabulated Data See Page 215).

77

· u

Downloaded from http://www.everyspec.com

Į



а,

.32





Downloaded from http://www.everyspec.com

8Ø ·

FATIGUE STRENGTH

4340 Steel

1.2

 $S_{u_A} = 246$ ksi $S_{uB}^{"A} = 222$ ksi



Figure: 6.39 (For Tabulated Data See Page 217)



Downloaded from http://www.everyspec.com

Downloaded from http://www.everyspec.com



4340 Steel

ŝ

 $c_{\rm N}$

S_{uA} = 264 ksi S_{uB} = 206 ksi

ł



83

ţ









Sug = 246 ksi, Sug = 268 ksi





Melt Practice: See Page 199, Item 8A Composition: $(.37 - .44) \neq C, (.55 - .90) \notin M_{1}$ (.20 - .359 $\# B_{1}, (1.55 - 2.0) \notin M_{1}$ (.65 - .95) $\# C_{27}, (.20 - .30) \# M_{5}$

Mechanically Polished Unnotched

Heat Treatment: A See Page 1199, Item 84

Figuret 6.46

(For Tabulated Data See Page 218)



ł

Downloaded from http://www.everyspec.com



FATIGUE STRENGTH



3



Rotary Heart Bending

Melt Practice: Air Melt, Vacuum Arc Remelt Composition: $(.37-.44) \leq C$, $(.55-.90) \leq M_{n}$ $(.20-.35) \leq B_{1}$, $(1.55-2.0) \leq M_{1}$ $(.65-.95) \leq C_{r}$, $(.20-.30) \leq M_{0}$

Lathe Turned Mechanically Polished Heat Treatment: H: | Normalize 1550°F, Quenched, Thuper. 775°F, AC

Figure: 6.48 . (For Tabulated Data See Page 218)





91',

. .

i

l

2



FATIGUE STRENGTH

 $S_{u} = 207 \text{ ksi}$

1



Figure: 6.50

(For Tabulated Data See Page 219)

. 92



. 93

S

2

. . .

Downloaded from http://www.everyspec.com

4340 Steel

FATTCHE STRENGTH

 $S_u = 205$ ksi



FATIGUE STRENOTH

AISI 4340 Steel

Su: B - 158 ksi, C - 171 ksi

Effect of Heat Treatment



FATIQUE STRENOTH

AISI 4340 Steel

Su: D - 275 kai, E - 290 kai

Effect of Heat Treatment



 Rotary Beam Bending
 For

 Stress Conc. Factor Kt = 1.0
 Mea

 Composition:
 Hea

 .37-.44% C, .55-.90% Mn,
 See Pag

 .20-.35% Si; 1.55-2.0% Ni,
 See Fag

 .65-.95% Crl, .20-.30% Mo
 Figure:6.54

Forged and Ground Mean Stress = 0 Heat Treatment: See Page 199, Item 8B
FATIQUE STRENOTH

Thermold J

2

 $S_u = 294$ ksi





Axial Load, Completely Reversed: Temperature = 30°F Competition: .37+.445 0, .35-.905 Mn, .20-.555 81

41

Moan Stress = 0 Hest Treatment: See Page 199, Item 9

1.55-2.0% N1, .65-.95% Cr. .20*.30% No Figure: 6.55 (For Tabulated Data See Page 221)

FATIGUE STRENGTH



FATTOUR SERENCIES

M-10 Tool Steel

Su = 330 k#1





Figure: 6.58 (For Tabulated Data See Page 224))

PATIOUS STRENGT

Downloaded from http://www.everyspec.com

521 Stainless Steel

Su = 86 ksi, 8_y = 33 ksi



Composition: 18% Cr 10% M1, 2% Mn, 1\$ 81, .081 C

Figure: 6.59

Heat Treatments See Page 200, Iten 12 Hot Rolled, Annauled

(For Tabulated Data See Page 274)

9



.





Composition: 186 Cr., 10% Wi, 25 Ma, 15 Si, .08% C

Heat Treatment: Sea Page200, Item 12 Not Rolled, Annealed

Figure: 6.61 (For Tabulated Data See Page 224)



FATIGUE STRENGTH





321 Stainless Steel



Axial Load, Completely Reversed

Stress Conc. Factor Kt = 1.0 Composition: 185 Cri, 105 Ri, 25 Mn, 15 Si, .085 C

TIG = Tungsten Inert Gas Welded Mechanically Polished MP

Mean Stress = 0

Heat Treatment: See Page 200, Item 12. Hot Rolled, Annealed

(For Tabulated Data Ses Page 224) Figure: 6.63

105

the part of the second

B. A. S. State Sec.

وها فعذار كرحت القلار



「「「「「「「」」」」

Downloaded from http://www.everyspec.com

FATIQUE STRENGTH

321 Stainless Steel

 $S_{11} = 86$ ks1; $S_v = 58$ ks1



107

1.



2

ì

Figure: 6.66 (For Tabulated Data Sec Page 225)

PATIGUE STRENUTE

A-286 Stainless Steel

$S_{11} = 90$ ksi $S_{12} = 46$ ksi



Axial Load, Completely Neversed Stress Conc. Factor $K_{t} = 1.0$ Composition: 155 Or, 265 H1, 1.295 No, 25 T1, .2% AL

¹ piera,

Mechanically Polished

an Streas + O

Mest Treatment Page 200, Item 13 Solution Treated, Not Holled

Figure: 6.67 | (For Tabulated Data See Page 286)

FATIGUE STRENGTH $S_u = 90 \text{ ksi}$ $S_v = 46 \text{ ksi}$ A-286 Stainless Steel Effect of Temperature 20 ,r 4 425' 320 80* θ Characterfect. Strength 4, Kal Lower Aund of Strength E., Kel Karal Chee N. 150 ħ. -320°F -320 ъ ٨ 2 -Mechanically Polished Axial Load, Completely Reversed Stress Conc. Factor $K_{\rm t} = 3.5$ Mean Stress = 0

Composition: 135 (Or, 265 N1, 1.25% No, 2% Ti, .25% Al

Figure: 6.68

Heat TreatmentsPage 200, Item 13 Solution Treated, Hot Rolled

110

(For Tabulated Data See Page 226)



TANTATTE CARACTER

A-286 Stainiess Steel

 $S_{u} = 90$ ksi $S_{y} = 46$ ksi.



FATIQUE STRENUTH

A-286 Stainless Steel

.

v 7

 $B_{ii} = 90$ ksi $B_{ij} = 46$ ksi



Axial Load, Completely Neversed

Membersture = -380"Y

A De al

1.19

Composition: 175 Cr, 265 ML, (1.275 MD, 25 TL, .875 Al Mechanically Polishei

Maen Stress = 0

Nest Traimatifues 200, Item 13 Solution Prested, Not Bolled

Ja Cast

Figure: 6.71 (For Tabulated Data See Page '226)

FATIOUS STRENGTH

A-256 Stainless Steel

Su - Sussi Sy - 46 151



Arial Lond, Completely Neversed

Mechanically Polished

Temperature - 423°F

Nean Stress = 0

Composition: 175 Cr) 265 Bi, 1.275 Mo, 25 T1, .295 Al Figure: 6.72 (For Reat Treatment Sage 200 Stem 23 Solution Treated, Bot Rolled

(For Tabulated Data See Page 226)



ī

1.



A-285 Stainless Steel

 $S_{u} = 90$ ksi $S_{y} = 46$ ksi



FATIQUE STRENGTH



 $S_u = 119$ ksi

PATTINE PIREMIN

Multiment N-155

ï, Ĩ

> λ. ٤,





Axial Load , Completely Reversed Composition: 21% Cri, 20% Ni, 20% Co, 5% S1, 3% Mo, 3% W, 1.5% Mn, 1% Cb, .15% C Figure: 6.76

Lathe Turned or Bored, Mechanically Polished Mean Stress 🖌 O Heat Treatment: See Page 200, Item 15A (For Tabulated Data See Page 228)

8_y = 60 ksi



-



۰. ·

FATIQUE STRENGTH



Axial LoadCompletely ReversedLathe TurnTemperature = 1350°FMean StreComposition:Mean Stre21% Cr., 20% Ni, 20% Co,Heat Trea5% Si, 3% Mo, 3% W,See Page1.5% Mn, 1% Cb, .15% CFigure: 6.78 (For Tabulated Data See Page .228)

Lathe Turned or Bored,

•

Mean Stress = 0 Heat Treatment: See Page 200, Item 15A

FATIGUE STRENGTH

Multiment N-155

 $S_u = 119 \text{ ksi}$ $S_y = 60 \text{ ksi}$

Effect of Type of Loading



Temperature = 1200°F Composition: 21% (Cr), 20% Mi, 20% Co 3% S1, 3% Mo, 3% W, 1.5% Mn, 1% Cb, .15% C Figure: 6.79 Lathe Turned or Bored, Mechanically Polished Mean Stress = 0 Heat Treatment: See Page 200, Item 15Å (For Tabulated Data See Page 228;)

121

بدر،

S.,



Multiment N-155

ź



よい 間内 目前に

ij





Temperature = 1350°F Composition: 21% Cr. 20% Ni, 20% Co, 5% Si, 3% Mo, 3% W, 1.5% Mn, 1% Cb. .15% C Figure:6.80



FATIQUE STRENOTH

Multiment N-195

 $S_{\rm u} = 119$ ksi $S_{\rm y} = 60$ ksi



Temperature = 1500°F Composition: 21% Crb 20% Ni, 20% Co 5% Si, 3% Mo, 3% W, 1.5% Mn, 1% Cb, .15% C Figure: 6.81 Lathe Turned or Bored, Mechanically Folished Mean Stress = 0 Heat Treatment: See Fage 200, Item 15A (For Tabulated Data See Page 228) E. S. B. S. S.

「「「「「「」」」」



124



Figure: 6.83 (For Tabulated Data See Page 229) 1

とうちょう しんしょう しょうしん いちょう

and server a server



and the second second

th

きょう

FATIGUE STRENGTH

17-7 PH

:

to N

S_y = 195 ksi

Su =|205 ksi

に言語の時間になる。

A REAL FOR THE REAL PROPERTY OF





Axial load, completely reverse Temperature = 80°7 ____ Composition: 17% Cr; 7% N1, 1.15% A1, .4% S1, .7% Mn, .07% C Figure:6.85 (Hand Polished-Longitudinal Mean Stress = 0 Beat Treatment: See Page 201, Item 17

(For Tababated Data See Page 232)

FATIQUE STRENGTH



Duralumín

Rotary Beam Bending Stress Conc. Factor Kt - Unknown Composition: Al, Cu, Mn, Mg

Specimen Condition: Unknown Mean Stress - Unknown Heat Treatment: Unknown

(For Tabulated Data See Page'236.) Figure:6.86



- 5

۲.

. . . .



Rotary Beam Bending

Composition: 6%Al, 4%V, max. 07%, N₁, max.10% C, max.015%H, max.40% F_e, max.30% 0 Hot Rolled Mean Stress = 0 Heat Treatmant: B: sol. treated 1675°F, 20 min. WQ, aged 900°F, 4 hrs air cooled 56.6

Figure:6.88

13Ó ·

130

(For Tabulated Data See Page 237')

FATIGUE STRENGTH

 $S_{u} = 177$ ksi, $3_{y} = 166$ ksi



151 131

î





 $S_u = 177 \text{ ksi}, S_y = 166 \text{ ksi}$

2




 $S_u = 177 \text{ ks}$, $S_y = 166 \text{ ks}$ i



T1-6A1-4V

FATIGUE STRENGTH

$S_{u} = 177$ ksi, $S_{y} = 166$ ksi



134

-95



ないましたい

1





Rotary Beam Beuding Temperature = 80°F Composition: 6%A1, 4%V, max .07%N1, max .10% C, max .015%H, max .40%Fe, max .30% 0

Mean Stress = 82-107 ksi Heat Treatment: HT-A and HT-B See Fage 202, Item 28

Figure: 6.93 (For Tabulated Data See Page 238:)

FATIGUE STRENGTH

5_u = 177 ksi, Sy - 166 ksi



.136

FATIQUE STRENGTH

T1-6A1-4V

 $S_u = 177 \text{ ksi}, S_y = 166 \text{ ksi}$



FATIGUE STRENGTH

T1-6A1-4V





Rotary Beam Bending Temperature = .800°F Composition: 6%Al 4%V, max .07%Ni, max .10% C, max .015%H, max .40%Fe, max .30% 0 Hot Rolled Mean Stress = 40-64 ksi Heat Treatment: HT-A and HT-B See Page

Figure: 6.96

(For "abulated Data See Page 238))



FATIGUE STRENGTH

T1-6A1-4V

 $S_u = 177 \text{ ksi}, S_y = 166 \text{ ksi}$

Miscellaneous Results (Effect of Mean Stress)





FATICUE STRENGTH

$S_{\rm u} = 177$ ksi, $S_{\rm y} = 166$ ksi



Rotary Beam Eending Temperature = 400°F Composition: 6%Al, 4%V, max .07%N₁, max .10% C, max' .015%H, max .40%F_e, max .30% O

Heat Treatment: A: sol. treated 1690°F, 12 min-WQ, aged 900°F, 4 hrs, air cooled

Figure: 6.98

(For Tabulated Data See Page 239 /)



141

• •

 $S_u = 177$ ksi, $S_y = 166$ ksi

T1-6A1-4V

FATIGUE STRENGTH



Rotary Beam Beading Temperature = 800°F Composition: 6%A1, 4%V, max .07%N1, max .10%C, max .015%H, max .40%Fe, max .30% 0

Hot Rolled Heat Treatment: A: sol. treated 1690°F, 12 min. WQ, aged 900°F, 4 hrs. sir cooled

١

Figure: 6.100 (For Tabulated Data See Page 239)



TENSILE ATRENOTH Low Carbon, Low Alloy Steel = 41 ksi s_u kş1 60 8, Iffect of Tea 60 C 50 Ĩ I Characteristic Strength 9, 1 Lower Bound of Strength X₀, 1 8 8 8 5 5.0 810 3.0 2.5 10 2.0

Downloaded from http://www.everyspec.com

(.12-.17)\$C, .5% Mn, 128\$ Si Figure: 6.102 (

300

0

Composition:



١

1900

1200



Temperature, *F

600



.



Downloaded from http://www.everyspec.com



TENSILE STRENOTH



ė





THENSTLE STRENGTH



TENSILE STRENGTH



 $S_u = 72 \text{ ksi}$ $S_y = 39 \text{ ksi}$



Downloaded from http://www.everyspec.com

TENSILE STRENGTI

Low Carbon, High Alloy Steel

$S_u = 110$ kmi $S_v = 75$ ksi



TENSILE STRENGTH



152

k

に渡り



Stainless Steel

S_u = -85 ksi S_y - 35 ksi



Downloaded from http://www.everyspec.com

TENELLE . STRENGTH

Stainless Steel

Su = 85 ksf > Sy = 38 ksi



Downloaded from http://www.everyspec.com





fbull Slope, b

1.5

∐1.0

1500

Hest Treatment:

Annealed 1950°T

TENSILE STRENGTH

Downloaded from http://www.everyspec.com

Steinless Steel

15

0

Composition:

300

.08%C, 18%Cr, 12%N1, 2%No Figure: 6.114 (For Tabulated Data See Page 247) 156

Temperature,

900

•7

1200

TRACIES STRENGTH

Stainless Steel





SECTION 7 STATISTICAL DISTRIBUTION OF STRESS

7.1 STRESS SPECTRUM VS STRESS DISTRIBUTION

The problem of stress distribution, in the Interference Theory, appears to be much more involved than the problem of strength distribution. Consider, for example, the problem of a connecting rod in a reciprocating engine. Because of the variation in hardness, surface finish, etc, the fatigue strength will vary from one rod to another. This will result in a distribution curve, in which the strength will be plotted on the abscissa and the number of rods having a given strength (i.e. frequency of occurrence) on the ordinate.

Consider now the stress distribution in the connecting rods. The stresses in the rod result from the combined effect of gas pressure loading and inertia loading. If the attention is now focused on a single rod, then the variation in the two types of loading will produce a distribution of stresses in this particular rod. The resultant curve will be a plot of the stresses in the rod on the abscisse and the number of times that this stress occurs in this particular rod on the ordinate (Figure 7.1 (a)).

This, however, is not what is wanted in the application of the Interference Theory, because this distribution of stresses cannot be matched with the distribution of strength. In the strength distribution the ordinate gives the number of rods having a given strength. Therefore in the stress distribution the ordinate must read number of rods having a given stress (and not the number of times a given stress occurs in a single rod). This can be obtained by considering the fact that different engines will be subjected in service to different operating conditions and, therefore, the distribution of gas pressure loading and inertia loading will vary from engine to engine. As pointed out in Section 7.2 a spectrum of stresses must be converted to an equivalent stress for the purpose of Interference Theory. Therefore, if a spectrum of loading due to different service conditions varies from engine to engine, in a population of connecting rods the equivalent stress will vary from rod to rod. Thus the statistical stress distribution desired for the Interference Theory may be obtained (Figure 7.1 (b)). In this distribution the equivalent stress will be plotted on the abscisse and the number of rods (frequency of occurrence) having that stress on the ordinate. This distribution then can be compared with the strength distribution to obtain the probability of interference.

7.2 CONVERSION OF STRESS SPECTRUM TO AN EQUIVALENT STRESS (Sequ)

By definition, equivalent stress is a completely reversed stress of constant amplitude which, when imposed on a part, should cause failure







1. N

at the same life as if the stress spectrum was imposed instead. Thus, the damage accumulated at any given life, due to this equivalent stress; will be the same as if due to the spectrum of stresses.

The first step towards converting the spectrum to a single stress (S_{equ}) is to convert the operating stresses, which may have some mean stress associated with them, to zero mean stress, that is, the completely reversed stress. (Figure 7.2). This can be done by means of the modified Goodman diagram. Draw the Goodman diagram as shown in Figure 7.3. From the spectrum of operating stresses plot each stress cycle on this diagram as shown, for example, line AB. Connect CA and CB and extend to the vertical line where mean stress is equal to zero. Hence, XY is the zero mean stress equivalent to AB. After reducing all such stress cycles to zero mean stress the stress spectrum will have all the stress cycles completely reversed. The magnitude XY will be different for different stress cycles. Therefore, the original operating stress spectrum (Figure 7.2 (a)), with various mean stress levels, is thus reduced to a stress spectrum with zero mean stress level, that is, a completely reversed stress (Figure 7.4).

This spectrum can then be reduced to a single equivalent stress of constant amplitude, by means of Miner's or Corten-Dolan's Rules.

7.2.1 Miner's Rule

Miner's rule assumes that the total life of a component can be estimated by simply adding the fraction of life consumed by each overstress cycle. Overstress can be defined as the stress above the endurance limit of the material which, if applied, will damage the part.

This rule is expressed as:

$$\frac{n_{1}}{N_{1}} + \frac{n_{2}}{N_{2}} + \frac{n_{3}}{N_{3}} + \cdots + \frac{n_{k}}{N_{k}} = 1$$

or

 $\sum_{i=1}^{1=k} \frac{n_i}{N_i} = 1$

(7.1)

where $n_1, n_2, n_3 \ldots n_k$ represent the number of cycles at specific overstress levels, and $N_1, N_2, N_3 \ldots N_k$ the life cycles to failure at these levels, as read from the S-N curve.

The equivalent life of a part (N_{equ}) under a spectrum of stresses may be found by rearranging the above equation:



â





$$N_{equ} = 1 \times \frac{\sum_{i=1}^{i=k} n_i}{\sum_{i=1}^{i=k} \frac{n_i}{N_i}}$$
 (7.2)

Suppose, for example, there are three stress levels, 90, 70, and 50 ksi, in a given spectrum. With the reference to the curve in Figure 7.5 $1/(6 \times 10^4)$ life is consumed by each 90 ksi stress cycle, $1/(5 \times 10^5)$ by each 70 ksi cycle, $1/(8 \times 10^5)$ by each 55 ksi cycle, etc. Using equation (7.2).

Nequ =
$$\frac{1+1+1}{\frac{1}{6 \times 10^4} + \frac{1}{5 \times 10^5} + \frac{1}{8 \times 10^5}} = 1.5 \times 10^5$$
 cycles

Thus, the life of the part under the above spectrum of stresses will be equivalent to a life of 1.5×10^{5} cycles. The stress equivalent to this life is (from Figure 7.5) 75 ksi. Hence, the damage that the part accumulates due to the above spectrum of varying stress amplitude will be the same as if stress cycles of constant amplitude equal to S_{equ} (in this case, 75 ksi) were imposed for N_{equ} (1.5 x 10^{5} cycles). Thus, the spectrum of stresses can be replaced by a single stress.

Miner's rule, as stated in equation (7.1), gives one (1.0) as the criterion for failure. Miner's original tests showed that the value for the summation in Equation 7.1 actually varied between 0.61 and 1.45. His more recent data gives a range of 0.7 to 2.2. Other sources quote a range as high as 0.18 to 23.0. In view of all this scatter it is generally agreed that the value of one (1.0), originally proposed by Miner, is probably the best overall estimate that can be made at this time.

7.2.2 Corten-Dolan's Rule

The application of this rule in converting the stress spectrum to a single equivalent stress (S_{equ}) is identical to that of Miner's rule, except that the S-N curve used to obtain the life values $N_1, N_2...N_K$ is modified. This modification is done, as shown in Figure 7.6, by changing the slope of the S-N curve. A line is drawn with an inverse slope d and passing through the point N_1 on the S-N curve, of maximum stress amplitude (in this case, S_1) occurring in the stress spectrum. This new line is known as the Corten-Dolau line.







166 '

From available data^{10,11} it appears that for structural steel specimens, having no stress concentration ($K_f = 1$), the value of d/d' = 0.8 is a reasonable satimate. A recent study by Harris and Lipson¹² indicates that when stress concentrations are present the following relationship can be used

$$d/d' = (0.73 + 0.07K_{f}) \qquad (7.3)$$

This can be graphically expressed as in Figure 7.7. It will be noted that if $K_c = 3.5$, $d/d^{4} \cong 1$ and this because equivalent to the criterion obtained from Minor's Rule.

Ì

上・内野



14.14

. .

1911 - 11 - 14 - M

÷,

Downloaded from http://www.everyspec.com
SECTION 8 INTERFERENCE OF STRESS DISTRIBUTION WITH STRENGTH DISTRIBUTION

After the strength distribution and the stress distribution are determined (Sections 6 and 7 respectively) the two are compared and the percent interference is determined, as discussed in Section 2, Section 5, and in detail, in Section 9. For a given strength distribution the percent interference will depend on the distribution of the equivalent stress Sequ. A search through literature and other sources produced considerable amount of data leading to strength distribution but very little information on stress distribution.

In some engineering applications there is very little scatter in stresses. This leads to a stress distribution with standard deviation equal to zero. This distribution can be represented by a straight liney as in Figure 8.1, and the interference can be determined as shown.

For a given S_{equ} , interference may increase or decrease, if the life to which the components are designed is changed. This is shown in Figure 8.2, and in terms of S-N diagram in Figure 8.3. The shape of the distribution curve in Figure 8.2 is different from those in Figure 8.3 because the former are plotted on a linear scale while the latter on a log-log scale.

In those engineering applications where the scatter in stresses is appreciable the above approach will obviously not apply. On the basis of past experience, in the present investigation the stress distribution (S_{equ}) was assumed to be normal and the range of standard deviations to be not less than .01 μ and not more than .10 μ where μ is equal to S_{equ} . The resulting interference is represented qualitatively in Figure 8.4.

Examples of a design problem employing this method are given in Section 9.









4



Life, cycles



WHERE SHE IS CONSTRUCTION AND INCOMENTS AND ADDRESS OF







SECTION 9 APPLICATION OF INTERFERENCE THEORY TO DESIGN PROBLEMS

Once the parameters of the strength distribution (X_0, b, θ) and stress distribution $(\mu = S_{equ} \text{ and } \sigma = k\mu$, where k represents a fraction of the average stress) are determined, as shown in Sections 6 and 7 respectively, the parcent interference can be computed with the aid of Tables on pages 258-396. Specific steps to be taken are illustrated by the following example.

A certain machine part was designed to withstand in service 10,000 overload cycles. The problem was to predict its reliability under the following conditions:

> Material: $T_1^{-6A1-4V}$, $S_u = 177$ ksi, $S_y = 166$ ksi Design Life: 10^4 cycles Type of Loading: Bending, completely reversed Size: 0.25 in. Surface Finish: Hot rolled

Theoretical Stress Concentration Factor: k_ = 1.0

Operating Temperature: 600°F

9.1 Weibull Parameters

The first step was to determine the strength distribution in terms of the Weibull parameters. From the graph on page 129 or Table on page 237. Weibull parameters corresponding to the above conditions were found to be:

х _о		50 ksi
Ъ	-	2,65
θ	-	77.1 kei.

9.2 The Equivalent Stress

As to the stress distribution, the part was instrumented and the stress spectrum was recorded as shown in columns 1 and 2 of Table 9.1.

Spectrum	of Stress	Miner's R	ule Data
Completely* reversed stress S, ksi 1	Occurrences n, cycles 2	Number of cycles to failure, N 3	<u>n</u> N 4
52.0	200	3.5 x 10 ⁵	5.710 x 10 ⁻⁴
54.1	80	2.4 x 10 ⁵	3.333×10^{-4}
56.5	50	1.6 x 10 ⁵	3.125 x 10 ⁻⁴
58.0	60	1.2 x 10 ⁵	5.000 × 10 ⁻⁴
59.3	20	1.0 2 10 ⁵	2.000×10^{-4}
62.0	10	6.6 x 10 ⁴	1.515×10^{-4}
64,.8	5	4.3×10^4	1.162 x 10 ⁻⁴
	∑n _i = 425		$\sum_{i=1}^{n_{i}} = 21.845 \times 10^{-4}$

Table 9.1 Stress and Life Data for Miner's Rule

*Actually, stress was not completely reversed. It was reduced with the aid of the Goodman diagram to a completely reversed stress using the procedure given in Section 6.1.1.

In order to determine the parameters of the stress distribution ($S_{equ} = \mu$, and σ) Miner's rule was used. From the S-N curve of the material (Figure 9.1), the number of cycles to failure, N, corresponding to stresses in Column 1, Table 9.1 were determined. This is shown in Column 3, Table 9.1. Using Miner's rule, as expressed in equation (7.2) and tabulated data in Table 9.1, N_{equ} was determined:

$$N_{equ} = 1 \times \frac{\sum n_1}{\sum \frac{n_1}{N_1}}$$

$$N_{equ} = 1 \times \frac{425}{21.845 \times 10^{-4}} = 1.945 \times 10^{5}$$
 cycles.

From the S-N curve (Figure 9.1), the stress corresponding to $N_{equ} = 1.945 \times 10^5$ cycles was found to be $S_{equ} = 55$ ksi. Hence, a completely reversed stress application of 55 ksi can be substituted for the recorded stress spectrum (Columns 1 and 2, Table 9.1).

9.3 Percent Interference

Once the strength and stress distribution parameters are established, percent interference can be determined.

In some engineering applications the scatter in the operating stresses is very small and, therefore, the standard deviation of the stress can be assumed to be zero. In those cases the percent interference can be determined as follows:

> $-\left(\frac{x-X_{o}}{\theta-X_{o}}\right)^{b}$ Interference = F(x) = 1 - e = shaded area under the curve shown in Figure 0.1 where x = S_{equ} = 55 ks1 X_o = 50 ks1 b = 2.65 θ = 77.1 ks1. 176



$$F(x) = 1 - e^{-\left(\frac{55}{77.1} - \frac{50}{50}\right)^{2.65}}$$

= 1 - e^{-.0114}
= .0113

Percent Interference = 1.132

This can also be read directly from the Table on page 262.

Find $X = \left(\frac{x - X_{o}}{\theta - X_{o}}\right)^{b} = .0114$

Corresponding to X = .0114 read interference F(x), = .0113, from the above table. Therefore, Percent Interference = 1.13%.

In those engineering applications where the scatter of stress is appreciable interference may be found as follows. As pointed out before, in actual engineering practice, the standard deviation lies in the range

$$0.01 \leq \frac{\sigma}{\mu} \leq 0.10$$

In the absence of any specific information, an average value of $\frac{\sigma}{\Psi}$ = 0.05 can probably be assumed. Using this value, percent interference is determined:

Strength				Stress			
Xo		50 k si	•	μ		Seque = 55 ksi	
b	-	2.65		σ	=	0.05µ	
9	-	77.1 kmi			-	0.05 x 55 ksi	
						2.75 ksi	

From the above data, parameters C, A and B(x), (for definition see page 27) to be used in the interference table, were computed:

$$C = \frac{\theta - x_0}{\sigma} = \frac{77.1 - 50}{2.75} \approx 10$$

$$A = \frac{x_0 - \mu}{\sigma} = \frac{50 - 55}{2.75} = -1.82$$

$$B(x) = b = 2.65$$

The interference value corresponding to these parameters was found by interpolation between Table on page 293 (for B(x) = 2.0) and Table on page 295 (for B(x) = 3.0). By interpolating between these two sets of data, the interference was found to be

Interference × .0245

or Percent Interference = 2.45%.

Thus, percent interferences, that is, probabilities of failure to be expected are:

In the event of no scatter in stresses - 1.137 Failures.

For the scatter of the order of 0.05μ (2.75 ksi) - 2.45% Failures.

9.4 The Effect of Design Factors

In this manner, the effect of various design factors on percent interference, can be determined. Table 9.2 shows the effect of temperature on interference for design conditions stated in the above example. Table 9.3 gives the effect of life on interference for a different set of conditions stated below:

> Material: M10 Tool Steel, $S_u = 330$ ksi Design Life: 10^5 cycles Type of loading: Bending, completely reversed Surface Finish: Machanically Polished Theoretical Stress Concentration Factor: $k_t = 1.0$ Heat Treatment: 2A shown on the Table ou page 223.

ì		Equivalent	Weibull Parameters of Strength			Percent Interference		
Material	Temperature of	Stress S _{equ} , ksi	X _o , ksi	b	0, ksi	σ = 0	σ = 0.05μ	
T ₁ -6 A1-4V	600	55.0	50	2.65	77.1	1.13	2.45	
	30	55.7	70	3.2	96.8	 	0.0	

Table 9.2 Effect of Temperature on Percent Interference

180

	·	Fautwalent	Weibull Parameters of Strength			Percent Interference	
Material	Life, cycles	Stress, Sequ, ksi	X _o , kei	b	0, ksi	σ = 0	σ = .02 8μ
M 10 Tool	10 ⁴		127	1.89	163.5	0.0	0.0
Steel	10 ⁵	122	119	1.95	153.2	0.865	2,04
	10 ⁶		111	2.0	143.5	10.80	12.03

Table 9.3 Effect of Life on Percent Interference

CONCLUSIONS

Downloaded from http://www.everyspec.com

- 1. A method was developed for employing stress-strength Interference Theory as a practical engineering tool to be used for designing and quantitatively predicting the reliability of mechanical parts and components subjected to mechanical loading.
- 2. This method is based on the considerable empirical data gathered (Appendix 1) and it also has sound theoretical basis (Appendix 3 and Appendix 4). This method eliminates the concept of a Factor of Safety and substitutes Percent Interference (Probability of Failure). Tables of interference values are given in Appendix 2 for a variety of stress and strength conditions.
- 3. Although a great deal of data were gathered and analyzed in the course of the present study, no data were found to permit the establishment of confidence intervals on the probability of interference.
- 4. This method can be used for three cases most commonly encountered in engineering practice:

Stress Distribution	Strength Distribution
Normal	Normal
Norma1	Weibull
Weibull	Weibull

- 5. The effect of type of loading, surface finish, surface treatment, temperature, stress concentration, heat treatment etc, on the statistical distribution was also studied. These effects were expressed in terms of Weibull parameters X_0 , 0, and b (see graphs in Section 5.4 of the body of the report and Tables pages 194-257.
- 6. For most of the materials studied, the lower bound of fatigue strength (X_0) and the characteristic strength (0) have a linearly decreasing relationship with life, on a log-log scale. In the case of the Weibull slope (b) it decreases or increases linearly with life, on a log-log scale, depending on the material and the loading, surface, etc. conditions.
- 7. In the case of the tensile strength data were obtained to study the effect of temperature. None of the Weibull parameters showed any recognizable relationship between tensile strength and temperature, on either Cartesian or log-log scale.
- 8. Although the relationship between the fatigue factors (listed under item 5 above) and the statistical distribution of strength was established on an individual basis (item 6 above), no data were found which could be used to determine their combined effect. It may be safely assumed that under this condition the fatigue strength will follow a normal

distribution (a special case of Weibull). As in the present study, this distribution will probably vary with the design life.

9. As to the problem of stress distribution, the data found in literature and other sources were in the spectral form. For use in the Interference Theory they had to be converted into a distribution of equivalent stresses.

183

Y .

5. - 5

.

RECOMMENDATIONS

- 1. In the present investigation the work involved the determination of Weibull parameters, mostly for ferrous materials. These parameters are essential for the prediction of interference. In the sircraft industry the materials are largely non-ferrous. It would be desirable, therefore, that the interference for these materials be determined too.
- It is proposed that a computer method, instead of the currently used (Section 6) graphical method, be used for the determination of the Weibull parameters. This method has the advantage of time saving, higher accuracy, and it may allow the establishment of confidence levels associated with interference.
- 3. An analytical expression for the general case of interference, as a function of time (life, cycles), should be developed. At the present time, Weibull parameters of strength (X_0, b, θ) have to be specifically determined for each particular life in order to calculate interference at that life. By establishing a general expression, once the interference at one life is known, the interference at any other life can be quickly calculated.
- 4. The problem of stress distribution demands further work. Means of conversion from stress spectrum to stress distribution should be refined and a more exact form of the statistical distribution of the equivalent stress should be established.
- 5. At present, in using the tables of interference it is necessary to extrapolate and interpolate interference values in a given table or between the tables. Because of the highly non-linear behavior of these values (as discussed in Appendix 4, Section 4.1.6 and Appendix 4, Section 4.1.9) it would be desirable to have tables calculated for a finer grade of values of the parameters.
- 6. In the case when both interfering distributions are Weibull, percent interference will depend on six parameters $(X_{01}, X_{02}, \theta_1, \theta_2, b_1, b_2)$. By appropriate grouping, these parameters can be reduced to four and percent interference calculated. In order to include a reasonable range of values for each parameter a large number of tables, cumbersome to handle, would be necessary. Hence, four or five dimensional nomographs should be prepared which would give percent interference as a function of a full range of values of the four parameters.
- 7. In order to verify the validity of the Interference Technique developed have it should be checked against an actual life situation. That is, percent interference should be computed for an actual engineering problem. These results then should be compared with actual service failures.

REFERENCES

- Lipson, C.; Kerawalla, J.; and Mitchell, L.; <u>Engineering</u> <u>Applications of Reliability</u>. Engineering Summer Conference, University of Michigan, Ann Arbor, Michigan, 1963.
- Grover, H. J.; Gordon, S. A.; and Jackson, L. R.; "Fatigue of Metals and Structures", Department of Navy, U. S. Government Printing Office, 1960.
- 3. deywood, R. B <u>Designing Against Fatigue</u>. London: Chapman and Hall, Ltd., 1962
- 4. Lipson, C.; and Juvinall, R. C.; <u>Handbook of Stress and Strength</u>, New York: The MacMillan Co., 1963.
- 5. Weibull, W. <u>Fatigue Testing and Analysis of Regults</u>. New York: The MacMillan Co., 1961.
- Little, R. E. <u>Multiple Specimen Testing and the Associated</u> <u>Fatigue Strength Response</u>. The University of Michigan, Ann Arbor, Michigan, 1966.

5

- Miner, M. A. "Cumulative Damage in Fatigue." <u>Journal of Applied</u> <u>Machan'28</u>, Vol. 12, 1945.
- Miner, M. A. "Estimation of Fatigue Life with Particular Emphasis on Cumulative Damage." Chapter 12 of <u>Metal Fatigue</u>, edited by Sines, George and J. L. Waisman, New York: McGraw Hill Book Co., 1959.
- Dolan, T. J.; Richart, F. E.; and Work, C. E. "Influence of Fluctuations in Stress Amplitude on the Fatigue of Matals." <u>ASTM Proceedings</u>, Vol. 49, 1949.
- 10. Richart, F. E.; and Newmark, N. M. "An Hypothesis for the Determination of Cumulative Damage in Fatigue," <u>ASTM</u> Proceedings, Vol. 48, 1948.
- 11. Grover, H. J.; Bishop, S. M.; and Jackson, L. R.; "Fatigue Strength of Aircraft Materials: Axial Load Fatigue Tests on Unnotched Sheet Specimens of 248-T3 and 758-T6 Aluminum Alloys and of SAE 4130 Steel." <u>NACA Tech. Note 2324</u>, 1951.
- Harris, J. P.; and Lipson, C. "Cumulative Damage Due to Spectral Loading." <u>Aerospace Reliability and Maintainability Conference</u>, SAE, ASNE, AIAA Conference Proceedings, July, 1964.

- Pearson, K.; Stouffer, S. A.; and David, F. N. "Further Applications in Statistics of the T (x) Bessel Function." <u>Biometrika</u>. Vol. XXIV, November, 1932, Parts III and IV, pages 293-350.
- 14. Kullback, S. "The Distribution Laws of the Differences and Quotient of Variables Distributed in Pearson Type III Laws". <u>The Annals of Mathematical Statistics</u>, Vol. VII, No. 1, March, 1963, pages 51-53.
- Abramowitz, M.; and Stegun, I. A.; (Editors), <u>Handbook of</u> <u>Mathematical Functions</u>, U. S. Department of Commerce, National Bureau of Standards, Applied Mathematics Series 55, December, 1965.
- Pearson, K. (Editor), <u>Tables of the Incomplete Beta Function</u>, Biometrika Office, Cambridge University Press, Cambridge, 1948.
- Thompson, C. M.; "Tables of the Percentage Points of the Incomplete Beta Function," <u>Biometrika</u>, Vol. 32, 1941, pages 151-181.

BIPLICOPA PHY

- 1. American Society of Testing and Materials. <u>A Guide for Fatigue</u> Testing and the Statistical Analysis of Fatigue Data. Special Technical Publication No. 91-A (Second Edition), 1963.
- Baur, E.H. <u>Skewed Load-Strength Distribution in Reliability</u>. Aero General Corporation, Report No. 9200 6 64, Sacramento, California, AD 434-414. February 10, 1964.

١t

- Bazovsky, I. <u>Reliability Theory and Practice</u>. Prentice Hall Inc., Space Technology Series, Chapter 15: "Component Failure Rates at System Stress Levels."
- 4. Bird, G.T. "On the Basic Concepts of Reliability Prediction." (Monte Carlo) p. 54, Seventh National Symposium on Reliability and Quality Control, 1961.
- 5. Bowker, A.H. and Lieberman, G.J. Engineering Statistics. Prentice-Hall, Inc., New Jersey: 1959.
- 6. Bratt, M.J., Reethof, G. and Weber, G.W. "A Model for Time Varying and Interfering Stress-Strength Probability Density Distributions with Consideration for Failure Incidence and Property Degradation." <u>Aerospace Reliability</u> and <u>Maintainability Conference</u>, Washington D.C.: July, 1964.
- 7. Breipohl, A.M. "Statistical Independence in Reliability Equations." (Failure Models), and (Causal Dependence) p. 2-3, Eigth National Symposium on Reliability and Quality Control, 1962.
- Bussiere, R. "Method for Critiquing Designs and Predicting Reliability in Advance of Hardware Availability." <u>SAE Paper, 343A</u>, 1961.
- Corten, H.T. "Application of Cumulative Fatigue Damage Theory to Farm and Construction Equipment." <u>SAE Paper, 735 A</u>, September, 1963.
- Corten, H.T. "Overstressing and Understressing in Fatigue, (Cumulative Fatigue Damage)." in ASME Handbook, <u>Metals Engineering</u>-Design, 2nd Edition, 1965.
- 11. Corten, H.T. and Dolan T.J. "Cumulative Fatigue Damage." The International Conference on Fatigue of Metals, I.M.E. and ASME, September 10-14, 1956.

ì

4

ų,

- Dieter, G.E. and Mehl, R.W. "Investigation of Statistical Nature of Fatigue of Metals." <u>NACA Technical Note No. 3019</u>, September, 1953.
- Dolan, T.J. and Corten H.T. "Progressive Damage Due to Repeated Loading." WADC Symposium, <u>Fatigue in Aircraft Structures</u>, August, 1959.
- 14. Dolan, T.J.; Richart, F.E. and Work, C.E. "Influence of Fluctuations in Stress Amplitude on the Fatigue of Metals." <u>ASTM Pro-</u> ceedings, Vol. 49, 1949.
- Eckert, L.A. "Design Reliability Prediction for Low Failure Rate Mechanical Parts." Engineering Application of Reliability. The University of Michigan, Engineering Summer Conference, 1962.
- 16. Epremian, E. and Mehl, R.F. "Investigation of Statistical Nature of Fatigue Properties, "NACA Technical Note 2719, June, 1952.
- 17. Faires, V.M. <u>Design of Machine Elements</u>. New York: The MacMillan Co., 4th Edition, 1965.
- 18. Forrest, P.G. Fatigue of Metals. New York: Pergamon Press, 1962.
- 19. Fralick, R.W. "Experimental Investigation of Effects of Random Loading on the Fatigue Life of Notched Cantilever Beam Specimens of 7075-T6 Aluminum Alloy," <u>NASA Mem. 4-12-59L</u>, 1959.
- 20. Freberg, D.D. and Spector, R.B. "Reliability Analysis and Prediction for Turbojet Engines - Results versus Needs." <u>Aerospace</u> <u>Reliability and Maintainability Conference</u>, Washington D.C.: 1964.
- 21. Freudenthal, A.M. Fatigue Sensitivity and Reliability of Mechanical Systems. SAE, Paper 459 A, January, 1962.
- 22. Freudenthal, A.M. "Fatigue Testing and Test Interpretation," <u>T6AM Technical Report No. 26</u> on "Behavior of Materials Under Repeated Stress," July 1951.
- Freudenthal, A.M. "Planning and Interpretation of Fatigue Tests," ASTM STP No. 121, 1951.
- 24. Freudenthal, A.M. and Gumbel, E.J. "Distribution Functions for the Prediction of Fatigue Life and Fatigue Strength," <u>The Inter-</u> national Conference on Fatigue of Metals. IME and ASME. 1956.

i

182

N.

¢,

25. Freudenthal, A.M. and Heller, R.A. "Cumulative Damage of Aircruft Structural Materials, Part 2:2024 and 7075 Aluminum Alloys Additional Data and Evaluation." <u>WADC Technical Note 55-273</u>, Part 2, October, 1956.

- 26. Freudenthal, A.M. and Heller, R.A. "On Stress Interaction in Fatigue and a Cumulative Damage Role, Part 1: 2024 Aluminum and SAE 4340 Steel Alloys," <u>WADC Technical Report 58-69</u>, June, 1958.
- 27. Gentle, E.J. and Chaple, C.E. <u>Aviation and Space Dictionary</u>. Los Angeles: Aero Publishars, Inc., 4th Edition, 1961.
- 28. Grey, E.F. "Statistical Methods as Design Tools." <u>Eighth National</u> Symposium on Reliability and Quality Control. pp. 70-71, 1962.
- 29. Grover, H.J.; Bishop, S.M. and Jackson, L.R. Fatigue Strength of Aircraft Materials. NACA Technical Note 2324 and 2389, March, 1951.
- 30. Grover, H.J.; Gordon, S.A. and Jackson, L.R. Fatigue of Metals and Structures. Superintendent of Documents, U.S. Government Frinting office, Washington D.C.: June, 1966.
- 31. Gumbel, E.J. and Freudenthal, A.M. "Minimum Life in Fatigue," <u>American Statistical Association Journal</u>, 49, No. 267, September, 1954, p. 575.
- 32. Hald, A. <u>Statistical Theory with Engineering Applications</u>. John Wiley and Sons, Inc., New York, New York: 1952.
- 33. Hanne, R.W. and Varnum, R.C. "Interference Risk When Normal Distributions Overlap." <u>Industrial Quality Control Journal</u>. September, 1950, pp. 26-27.
- 34. Harris, J.P. and Lipson, C. "Cumulative Damage Due to Spectral Loading." <u>Aerospace Reliability and Maintainability Conference</u>. SAE, ASME, AIAA Conference Proceedings, July, 1964.
- 35. Haugen, E.B. "Implementing a Structural Reliability Program." Eleventh National Symposium on Reliability and Quality Control, pp. 158-168, 1965.
- 36. Haugen, E.B. "Statistical Methods for Structural Reliability Analysis." Appendix p. 110-121, <u>Tenth Symposium on Reliability and Quality Control.</u> pp. 97-109, 1964.

- 37. Haviland, R.P. "Engineering Reliability and Long Life Design." Van Nostrand, 1964, p. 1-4, pp. 133-148.
- Haviland, R.P. "Introduction to Theory of Reliability." <u>SAE Paper</u> 343D, 1961.

- 39. Heywood, R.B. <u>Designing Against Fatigue</u>. London: Chapman and Hall, Ltd., 1962.
- 40. Horger, O.J. and Neifert, H.R. "Fatigue Properties of Large Size Specimens with Related Size and Statistical Effects." ASIM Special Technical Publication 137, 1953, pp. 70-89.
- 41. Howell, G.M. "Factors of Safety." <u>Machine Design</u>. pp. 76-81, July 12, 1956.
- Hsuan-Loh Su. "Design by Quantitative Factor of Safety." <u>ASME</u> <u>Transaction, Series B.</u> November 1960, pp.: 387-392.
- 43. Juvinall, R.C. Stress Considerations in Design. Department of Mechanical Engineering, University of Michigan, Ann Arbor; Michigan. Copyright, 1964.
- 44. Keechele, L.E. 'Designing to Prevent Fatigue Failures." <u>RAND</u> <u>Report F-3022</u>. February, 1965.
- 45. Kaechele, L.E. "Probability and Scatter in Cumulative Fatigue Damage." <u>RAND Report, RM-3668-PR</u>, December, 1963.
- 46. Kaechele, L.E. "Review and Analysis ? Cumulative Damage Theories." The RAND Report, RM-3650-PR. September, 1963.
- 47. Kao, J.H.K., "The Beta Distribution in Reliability and Quality Control." <u>Proceedings of the Seventh National Symposium on Re-</u> <u>liability and Quality Control.</u> pp. 496-511, 1961.
- 48. Kececioglu, D. and Cormier, D. "Designing a Specified Reliability Directly into a Component." <u>Aerospace Reliability and Maintain-</u> ability Conference. Washington D.C.: pp. 546-564, 1964.
- 49. Kullback, S. "The Distribution Laws of the Differences and Quotient of Vairiables Distributed in Pearson Type III Laws." <u>The Annals of Mathematical Statistics</u>. Volume VII, Number 1, March, 1936. pp. 51-53.

- Langer B.F. "Fatigue Failure from Stress Cycles of Varying Amplitude." Transactions, ASME. Volume 59, p. A-160, 1937.
- 51. Lazan, B.J.; Wu, T. "Damping, Fatigue and Dynamic Stress-Strain Properties of Mild Steel." <u>Proceedings ASTM, No. II</u>. pp. 649-678, 1951.
- 52. Leve, H.L. "Element Reliability for an Individual Life History." <u>Aerospace Reliability and Maintainability Conference</u>. Washington, D.C.: pp. 24-26, 1963.
- 53. Lipson, C.; Kerawalla, J. and Mitchell, L. "Interference Theory." Engineering Applications of Reliability. Chapter 12. The University of Michigan, Ann Arbor, Michigan; Summer, 1963.
- 54. Lipson, C. and Juvinall, R.C. <u>Handbook of Stress and Strength</u>. New York: The MaxMillan Company, 1963.
- 55. Lipson, C. and Noll, G.C. "Design Practice." In ASME Handbook Metals Engineering Design. 2nd Edition, 1965.
- 56. Lipson, C; Sheth, N.J.; and Sheldon, D.B. "Reliability and Maintainability in Industry and the Universities." Fifth Reliability and Maintainability Conference. Volume 5, 1966.
- 57. Little, R.E. <u>Multiple Specimen Testing and the Associated Fatigue</u> <u>Strength Response</u>. The University of Michigan, Ann Arbor, Michigan; January, 1966.
- Liu, H.W. and Corten, H.T. "Fatigue under Varying Stress Amplitude." <u>NASA Technical Note D-647</u>. November, 1960.
- 59. Miner, M.A. "Cumulative Damage in Fatigue." Journal of Applied Mechanics. Volume 12, No. 3, p. A-159, September, 1945.
- 60. Miner, M.A. "Estimation of Fatigue Life with Particular Emphasis on Cumulative Damage." Chapter 12 of <u>Metal Fatigue</u>. Edited by Sines, G. and Waisman, J.L., New York: <u>McGraw Hill Book</u> Co., 1959.
- 61. Mittenbergs, A.A. "Fundamental Aspects of Mechanical Reliability." <u>Mechanical Reliability Concepts.</u> ASME Design Engineering Conference, New York: May 17-20, 1965.
- 62. Myers, P.J. "Monte Carlo: Reliability Tool for Design Engineers." <u>Ninth National Symposium on Reliability and Quality Control.</u> pp. 487-492, 1963.

- 63. Palgren, A. "The Endurance of Ball Bearings." (in German), Z.V.D.I., Volume 68. p. 339, April 15, 1924.
- 64. Rearson, K.; Stouffer, S.A. and David, F.N. "Further Applications in Statistics of the $T_m(x)$ Bessel Function." <u>Biometrika</u>. Volume XXIV, Parts III, IV, pp. 293-350, November, 1932.
- Pearson, K. (Editor). Tables of the Incomplete Beta Function. Biometrika Office, Cambridge Office, Cambridge University Press, Cambridge: 1948.
- 66. Phelan, R.M. Fundamentals of Machine Design. New York: McGraw Hill Book Co., 2nd Edition, 1962.
- 67. Pieruschka, E. Principles of Reliability. Prentice Hall, Inc., pp. 99-115, 336-340, 1963.
- 68. Pope, J.A. "Cumulative Damage in Fatigue." <u>Metal Fatigue</u>. London: Chapman and Hall, Edited by Pope, J.A., 1959.
- 69. Popp, H.G. "Reliability Through Statistical Material Property Definition." <u>SAE Paper 580B</u>. October, 1962.
- Ransom, J.T. and Mehl, R.F. "The Statistical Nature of the Endurance Limit." <u>Transactions, AIME, Volume 185</u>. January, 1949.
- 71. Richart, Jr., F.E. and Newmark, N.M. "A Hypothesis for the Determination of Cumulative Damage in Fatigue." <u>Proceedings</u> ASTM, Volume 48. 1948.
- 72. Rothstein, A.A. "New Concepts in Prediction of Mechanical and Structural Reliability." <u>Aerospace Reliability and Maintainability</u> Conference, Washington D.C.: pp. 93-95, 1963.
- 73. Sinclair, G.M. and Dolan, F.J. "Effect of Stress Amplitude on Statistical Variability in Fatigue Life of 75S-T6 Aluminum Alloy." <u>Transactions, ASME, 75</u>. p. 807, July, 1953.
- 74. Sines, G. and Waisman, J.L. <u>Metal Fatigue</u>. New York: McGraw-Hill Book Co., 1959.
- 75. Smith, A.I. "Mechanical Properties of Materials at High Temperatures." <u>Chartered Mechanical Engineering</u>. pp. 278-285, May, 1961.
- 76. Stulen, F.B. "On the Statistical Nature of Fatigue" ASTM Special Technical Publication No. 121. 1951.

- 77. Stulen, F.B. and Cummings, H.N. "Statistical Analysis of Fatigue Data." <u>Proceedings for Short Course in Mechanical Properties of</u> <u>Metals.</u> (Marin, H.U. Editor). The Pennsylvania State University, Department of Engineering Mechanics, 1958.
- 78. Svensson, N.L. "Factor of Safety Based on Probability." Design Engineering. Volume 191, No. 4845, January 27, 1961. pp. 154-155.
 - 79. Thompson, C.M. "Tables of the Percentage Points of the Incomplete Beta Function." <u>Biometrika</u>. Volume 32, pp. 151-181, 1941.
 - 80. Weibull, W. Fatigue Testing and Analysis of Results. New York: Pergamon Press, 1961.
 - 81. Weibull, W. "Statistical Distribuiton Function of Wide Applicability." Journal of Applied Mechanics. p. 293, September 18, 1951.
 - 82. Weibull, W. "Statistical Representation of Fatigue Failures in Solids." <u>Royal Institute of Technology Transactions</u>. Stockholm: Volume 27, No, 49, 1949.
 - 83. Wilkine, E.W.C. <u>Cumulative Damage in Fatigue</u>. IUTAM Colloquium on Fatigue Springer, Stockholm: p. 321, 1956.

1.

APPENDIX 1

TABLES OF WEIBULL PARAMETERS

Ø



A-1.1 WEIBULL PARAMETERS OF FATIGUE STRENGTH



INDEX TO WEIGHTL PARAMETERS FOR FATIGUE STRENGTH OF VARIOUS MATERIALS

Material	Weibull Parameters can be found:
	Page No.

CARBON	and	ALLOY	STEELS
			the second s

1.	AISI 3140	20 7				
2.	AISI 1045	208				
3.	AMS 5727	209				
4.	AISI 2340	2 10				
5.	AISI 4140	21 2				
6.	D _{6AC} Steel (Ladish)	213				
7.	H-ll Steel	214				
8 ▲ .	4340 Steel	21.7				
8в.	4340 Steel	220				
9.	Thermold J	221				
10.	Fe - 5.5, Mo - 2.5, Cr5C	22 2				
11.	M 10 Tool Steel	223				
STAIN	STAINLESS STEELS					

15A.	Multiment N-155	228
14.	347 Stainless	227
13.	A - 286 Stainless	226
15.	221 Stainless	224

15B. Multiment N-155

	,	
1.6.	PH 15 - 7 Mo Stainless Steel	231
17.	17 - 7 PH Stainless Steel	323
MISCE	LIANEOUS BASE MATERIALS	
18.	Timkin 16-25-6 (AMS 5727)	233
19.	Stainless 403	233
20.	Lapelloy 311	234
21.	S-816 (AMS 5534)	234
22.	Inco SHS 260	234
23.	GMR - 235	234
24.	s - 816 (AMS 5765)	235
25.	Udimet 500	235
26.	' ri - 140	235
27.	Duralumin	236
28.	T1-6A1-4V	237
20	Theonel Y	240

229

ķ

REFURENCE DATA FOR WEIBULL PARAMETERS

(COMPOSITION, HEAT TREATMENT AND TENSILE STRENGTH)

À

CARBON AND ALLOY STEELS.

1.	AISI 3140 Steel	: $Su = 108 - 109$ Ksi.
	Composition:	.4% C, .8% Mn, .3% S1, 1.2% Ni, .65% Cr.
	Heat Treatment:	$K_3 = 0Q$ from 1520°F, Tempered at 1300°F,
		Su = 108 Ksi
		K 4 = Air blast quenched from 1520°F, Tempered
		at 1050 F, Su = 109 KB1.
2.	AISI 1045 Steel	: Su = 105 - 120 Ksi.
	Composition:	.435% C, .69% Mn, .040% P(max), .05% S(max)
	Heat Treatment:	K 1 - Water quenched from 1520°F, Tempered at
		3210° F, Su = 105 Ksi, Sy = 82 Ksi.
		K 2 = Oil quenched from 1520°F, Tempered at
		1050° F, Su = 120 Ks1, Sy = 84 Ks1.
3.	AMS 5727 Steel Composition:	<u>:</u> Su = 120 Ksi
	Heat Treatment:	Fleishmann hot cold-work, equalize at 1950°F,
		reduce crossection 18% from 1200°F, stress relieve
		at 1200°F for 8 hours.
հ	ATST 2300 Steel	-116 - 122 Kei
Te	Composition:	
	Heat Treatment:	A = Oil quenched from 1450°F, Tempered at 1200°F,
		Su = 116 Ksi.
	•	B = Air Blast quenched from 1450°F, Tempered
		at 700°F, Su = 119 Ks1.
		G = Air Blast quenched irom 1470 F, no temper;Su = 122 Vet
		Du = IEE RSI.
5.	AISI 4140 Steel	: Su = 135 Ks1.
	Composition:	C = .3744%, $Mn = .5590%$, $Si = .2035%$,
	.	Ni = 1.55 - 2.00%, $Cr = .6595%$, $Mo = .2030%$.
	Heat Treatment:	Aust 1550°F, 1 hour; OQ, Temperature 1230°F,
		l nour,
€.	D _{6AC} Steel - (Lad	ish): Su = 270 Ksi.
	Composition:	.4248% C. 69% Mm 015% 2 015% S
		.1513% S, $.47%$ N1, $.9 - 1.2%$ Gr.
		.9 - 1.1% Mo, .051% V.
	Heat Treatment:	Hold at 1500°F in oxidizing atmosphere, OQ Tem-
		perature 500°F, 2 hours.

198

II-11 Steel: 7. Su = 272 Ksi. Composition: 5% Cr, 1.5% Mo, .4% V, .35% C. Vacuum arc melt, pre heat 1400°F, 30 min., Aust. Heat Treatment: at 1850°F, 45 min., A.C., Temperature 2 plus 2 hours at 1050°F, A.C. + pre test exposure. 8**A**. 4340 Steel: Su = 206 - 280 Ksi. .37 - .44% C, .55 - .90% Mn, .20 - 35% S1, 1.55 - 2.00% N1, .65 - .95% Cr, .20 - .30 Mo, Composition: Heat Treatment: A = normalize at $1550^{\circ}F$, OQ, 440°F, Temper AC. = normalize at 1550°F, В Quench, Temper 775°F, AC. Melt Practice: •8 = Air melt, Vacuum arc remelt. - Vacuum Induction melt. 9 10 = Vacuum Induction melt, Vacuum arc remelt. 8B. 4340 Steel: - varied tensile strength. Su = 144 - 290 Ksi. Composition: same as 8A. Heat Treatment: Norm, 1600°F, 1.5 hours, AC; Aust. 1525°F, Α: 1.5 hours, OQ, Temper 1150°F, 4 hours. AC. **B**: Norm, 1600°F, 2 hours, AC, Aust. 1500°F, 2 hours, 0Q, Temper Norm, 1600°F, 1 hour. 1150°F, 4 hours, AC. C: D: Aust., 1550°F, Salt Bath 20 min., 0Q to 120°F to 150°F, Temper 400°F, 4 hours. Melt-400°F, 4 hours, Meltpractice - elect. Furnace Aust. 1550°F, Salt Bath 20 min., OQ to 120°F E : to 150°F, Temper 400°F, 4 hours, Meltpractice - Vacuum furnace. 9. Thermold J Su = 294 Ksi.Composition: .37 - .44% C, .55 - .90% Mn, .20 - .35% S1, 1.55 - 2.00% Ni, .65 - .95% Cr, .20 - .30% Mo. Sol Treated 1825°F, A.C., Tempered 1025%F, 2 hours . A.C. .Retempered 1025°F, 2 hours A.C. Heat Treatment: 10. Fe - 5.5 Mo - 2.5 Cr - .5 C: Su - 314 Ksi. Composition: designated in name Prehest 1400°F, 1/2 hours, harden 1950°F, 20 min. Heat Treatment; Temper 1050°F, 2 hours, Retemper A.C.

2 nours after finish machining.

Su = 330 Ksi. 11. M 10 Tool Steel: 4% Cr, 2% V, .85% C. Composition: Preheat 1450°F, 1/2 hour, harden 2150°F, Heat Treatment: A 5 min., 09 until black, A.C. Temper 1100°F 2 hours, A.C., Retemper 1100°F, 2 hours, A.C., after finishing operation, nitrided 975°F, 48 hours. Same as A but instead of nitriding, stress Б = relieve at 1000°F in protective atmosphere, Furnace cool.

STAINLESS STEELS

- 12. <u>321 Stainless Steel:</u> Su = 87 Ks1. Composition: 18% Cr, 10% Ni, 2% Mn, 1% Si, .08% C. Heat Treatment: Annealed
- 13. <u>A-286 Stainless Steel:</u> Su = 90 Ksi. Composition: 15% Cr, 26% Ni, 1.25% Mo, 2% Ti, .25% A Heat Treatment: Hot rolled, solution treated.
- 14. <u>347 Stainless Steel</u>: Su = 92 Ksi. Composition: 18% Cr, 11% Ni, 2% Mn, 1% Si, .08 C. Heat Treatment: Annealed.
- 15A. <u>Multiment N 155:</u> Su = 119 Ksi. Composition: 21% Cr, 20% Ni, 20% Co, 5% Si, 3% Mo, 3% W, 1.5% Mn, 1% Cb, .15% C. Heat Treatment: Sol. Treated 2200°F, 1 hour, W.Q., Aged 1440°F, 16 hours, A.C. .
- 15B. <u>Multiment N 155:</u> Su = 114 126 Ksi. Composition: Same as 15A. Heat Treatment: Same as 15A,

except

Some specimens were stress relieved after the Heat Treatment

16. <u>Ph 15 - 7 Mo</u> Stainless: Su = 201 Ksi Composition: 15% Cr, 7 % N1, 2.25% Mo, 1.15% Al. Heat Treatment: Condition at 1750°F, 10 hours, A.C. refrigerate at -100°F for 8 hours, age 950°F, for 1 hour, A.C. TH 105.

17. <u>17 - 7 PH Stainless Steel</u>:

Su = 205 Ksi. Composition: 17% Cr, 7 % Ni, 1.15% A1, .7% Mn, .4% Si, .07% C. Heat Treatment: Condition at 1750°F for 10 hours, A.C., Refrigerate at -100°F for 8 hours, Age 950°F for 1 hour A.C.

MISCELLANEOUS BASE MATERIALS.

- 18. <u>Timken 16-25-6</u>: Su = 120 Ksi. Composition: Not Available.
- 19. <u>Stainless 403</u>: Su = 141 Ksi (Axial test), 129 Ksi (Rotary test) Composition: .15% C(max), 1.0% Mn(max), .5% Si(max), 11.5% - 13.0% Cr.
- 20. Lapelloy 311: Su = 136 Ksi (Axial), 129 Ksi (Rotary) Composition: Not Available.
- 21. S = 816 (AMS 5534): Su = 147 Ksi. Composition: Not Available.
- 22. Inco SHS 260: Su = 260 Ksi (Axial), 129 132 (Rotary) Composition: Not Available.
- 23. <u>GMR 235:</u> Composition: 65% Ni, 15% Cr, 10% Fe, 5% Mo, 3% AI, 2% Ti.
- 24. <u>S-816 (AMS 5765):</u> Su = 147 Ksi. Composition: 42% Co, 20% Cr, 20% Ni, 4% Mo, 4% W, 4% Cb, 4% Fe.
- 25. Udimet 500: Composition: Ni base, .1% C, 19% Cr, 19% Co, 4% Mo, 3% Ti, 2.9% Al, 4% Fe.
- 26. <u>Ti 140 (AMS 4923)</u>: Su = 130 150 Ksi. Composition: 5.5 - 6.75% A1, 3.5 - 4.5% V, .07% Ni, .1% H(max), .4% Fe(max).
- 27. Duralumin: Su = unknown Composition: A1, Cu, Mn, Mg Heat Treatment: unknown

18

201

28. <u>Ti - 6Al - 4V:</u> Composition: Su 177 Ksi. <u>Ti base, 67 Al, 45 V, .075 Ni(max), .15 C(max),</u> .0155 H(max), .45 Fe(max), .35 O(max). A = Sol treated 1690°F, 12 min, W.Q., Aged 900°F, 4 hours, A.C. B = Sol Treated 1675°F, 20 min, W.Q., Aged 900°F, 4 hours, A.C.
29. <u>Inconel X:</u> Composition: Su = 225 Ksi. 735 Ni, 155 Cr, 75 Fe, 2.55 Ti, 15 Cb, .75 Mn, .045 C. Heat Treatment: Aged 1350°F, 16 hours, A.C.

202

Are a set

REFERENCE DATA FOR WEIBULL PARAMETERS

(SPECIMEN CONDITIONS)

CARBON AND ALLOY STEELS.

- 1. AISI 3140 Steel: Tested at Room Temperature.
- 2. AISI 1045 Steel: Hot rolled, lathed; tested at Room Temperature.
- 3. AMS 5727 Steel: Ground and lapped, 10 RMS.
- 4. AISI 2340 Steel: Hot rolled, lathe turned, hand polished, tested at Room Temperature.
- 5. AISI 4140 Steel: Hot rolled, longitudinal machining (mechanical), tested at Room Temperature.
- 6. D_{6AC} Steel (Ladish): Vacuum furnace melt, hot rolled, machine polished with 600 grit belt.
- 7. H-ll Steel: Hot rolled, lathed, grain direction is transverse to lengthwise axis.
- 8A. AISI 4340 Steel: Lathe turned, mechanical polish.
- 8B. AISI 4340 Steel: for specimens with Su = 144, 158, 171 Ksi, preparation = hot rolled and lathed.yor specimens with Su = 275, 290 Ksi, preparation = forged and ground. All tested at Room Temperature.
- 9. Thermold J: Tested at Room Temperature.
- 10. Fe 5.5 Mo 2.5 Cr. .5C Forged and Swaged - 5 RMS
- 11. M 10 Tool Steel: Forged and Swaged, lathe turned, 5 RMS, tested at Room Temperature.

STAINLESS STEELS.

- 12. 321 Stainless Steel: Hot rolled, mechanical polish. Some specimens T.I.G. (Tungston Inert Gas) welded.
- 13. A-286 Stainless Steel: Hot rolled, mechanical polish. Some specimens T.I.G. welded.
- 347 Stainless Steel: Hot rolled. 14.
- Multiment N-155: Hot rolled, lathed, mecha ical polish. 15A. Tested at Room Temperature.
- Multiment N-155: Hot rolled, lathed, mechanical polish. 15B. Tested at Room Temperature. Surface preparation code:
 - Stress relieved after surface finishing. A.
 - B. Surface finished, stress relieved, refinished.C. Heat treated after surface finishing.
- Ph 15-7Mo, Stainles Steel: Hot rolled, milled edges. 16.
- 17-7 PH. Stainless Steel: 17. Hot rolled, hand polished, ground edges.

MISCELLANEOUS BASE MATERIALS.

- 18. 16-25-6: Timkin Completely reversed test, unnotched spewimen.
- 19. 403 : Stainless Completely reversed test, unnotched specimen.
- 20. Lapelloy Completely reversed test, unnotched specimen.
- 21. S-816 (AMB 5534): Completely reversed test, unnotched specimen.
22. Inco SRS 200: Completely reversed test, unnotched specimen.

- 23. <u>GMR 235:</u> Completely reversed test, unnotched specimen.
- 24. <u>S-816 (AMS 5765):</u> Completely reversed test, unnotched specimen.
- 25. <u>Udimet 500:</u> Completely reversed test, unnotched specimen.
- 26. <u>Ti 140 (AMS 493):</u> Completely reversed test, unnotched specimen.
- 27. <u>Duralumin:</u> Non corroded and corroded in saltwater.
- 28. <u>Ti 6A1 4V:</u> Kot rolled.

29. Inconel X: Hot rolled.



.

ŝ

ų,

TABLES

, , , ,

· · ·

ŀ.

5

					AISI	3140	STERL.					
	Su = 10 Sy = 10	8 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	9 ksi ksi		ROTA	, BEA	DING		Compositic Heat Treat Specimen (Weaning of	on ^l tment ² Condition ? Symbols	برية م	: .
r. Spec fe, Cycles	103	Xoksi 0, ¹	Lo ⁵	106	103	10	ь 10 ⁵	106	• •	10 t B	si 10 ⁵	106
				Bffect	of Str	ess C	oncentr	etion				
N-V N	68		89	21 50	3.7	5.6	5 6.1	5.5 5.1	100.4	87.7 62.2	76.7	67.2 36
	85	50 50	6.5 6.5	59.0	2.2	5.2	2.4 3.2	3.5	87.9	77.87	69.08 14.25	61.07 29.53
				B r fe	ct of	Beat T	lreat m e	t				
11-01 11-01 11-01 11-01	88 ~ ~ ~ ~ ~ ~	A FO O	19.99.90 1. 1. 1.	C	3.7 2.2	5 1	501 2011 2011	7.5 7.5 7.1	100.4 87.9	87.7 77.87 62.2 70.2	76.7 69.08 47.3 44.25	67.2 61.07 36 29.53

.

AISI 1045 STEEL $S_u = 105$, 120 ksi Composition ROTARY BENDING Heat Treatment Specimen Conditions Meaning of Symbols H.T. Su Spec X_o ksi ъ 0 ksi 10⁴ 104 10⁵ 105 106 106 104 10⁵ 10⁶ Life, Cycles Effect of Heat Treatment κ₁ κ₂ 56.0 39.0 27.0 105 V-N 1.67 2.25 2.75 67.3 . 47.3 33.4 120 V-N 54.0 36.0 24.2 2.72 3.1 3.25 65.3 44.25 29.9 Effect of Stress Concentration κ₁ κ₁ 79.0 67.0 56.7 105 No-N 2.6 2.75 2.85 86.2 73.0 61.65 56.0 39.0 27.0 105 V-N 1.67 2.25 2.75

67.3 47.3

33.4

Downloaded from http://www.everyspec.com

1 For Composition - see page 198, Item 2 2 Heat Treatment A: K₁ WQ for 1520°F Tempered at 1210°F, Su = 1.05 ksi and S_v = 82 ksi B: K₂ Oil Quenched from 1520°F Tempered at 1050°F, Su=120 kai, Su=84 kai 3 For Specimen Condition - see page 203 4 For Meaning of Symbols - see page 46

AMS 5727 STEEL

	s _u	= 120 kai		AXIAL	load		(ompositio	ⁿ _2	
	Sy	= 30 ksi	C	ompletely	Rever	sed	1 5 1	lest Treat: Specimen Co Seaning of	ment ondit Symb	10ns ³ 01s ⁴
T , F	к _t)	Х _о ,	ksi		ъ		6), ksi	Ĺ
Life,	cycles	10 ⁴	10 ⁵	10 ⁶	10 ⁴	10 ⁵	10 ⁶	10 ⁴	10 ⁵	10 ⁶
	•		Ef:	fect of T	empera	ture				
80 1200	1.0 1.0	68 51	61 47	55 44	2.5 2.85	2.75 2.85	2.8 3.0	74 58	67 54	61 50
80 1200	2.4 2.4	59 29	42 24	30 20	2.75 2.21	2.95 2.3	2.98 2.32	66 36	47 31	34 26
80 1200	3.4 3.4	48 27	31 20	19 15	2.15 2.62	2.15 2.75	2.33 3.02	61 33	38 25	25 19
		E	ffect	of Stress	Conce	ntrati	on			
80 80 80	1.0 2.4 3.4	68 59 48	61 42 31	55 30 19	2.5 2.75 2.15	2.75 2.95 2.15	2.8 2.98 2.33	74 66 61	67 47 38	61 34 25
1200 1200 1200	1.0 2.4 3.4	51 29 27	47 24 20	44 20 15	2.85 2.21 2.62	2.85 2.3 2.75	3.0 2.32 3.02	58 36 33	54 31 25	50 26 19

For Composition - see page 198 It m 3
 For Heat Treatment - see page 198 Item 3
 For Specimen Conditions - see page 203 Item 3
 For Meaning of Symbols - see page 46

	ſ	
-		
	ſ,	ļ

なる事実がないます。 こうしん しんてき たんな事実の 気気の うまっ しょうせい おうせい シー・ション・シー・エント しゅうせい しゅうせい マン・・・・

			$s_u = 116$ $s_y = 76$	5-122 ksi 5-96 ksi	-	ROTARY	BENDING	· ·	Compos Heat 1 Specin Meanir	sition ¹ freatment ien Condi ig of Sym	2 tion ³ bols ⁴		
	H.T. ²	Spec	Sy	ນ ສ	n	Ko ksi			ų			0 ksi	
	(Code) Life,	cycles			10 ⁴	105	10 ⁶	то _†	105	106	το ^μ οτ	IQ	106
					Effect	t of He	at Treat	ent.					
	A	N-ON	8	911	0 . 48	0" 112	61.0	6. 4	3. 4	4.J	101.5	85 .4	72.0
21	B	N-ON	62	611	81.0	71.0	62.0	2.8	2.8	2.8	88.7	77.6	67.8
0	ບ	N	76	122	87.0	75.0	64.0	h. 4	4.4	, • •	4° 1 6	81.55). 2
	¥	NV	8	911	1 ₄ 8.0	36.0	27.5	2.7	2.6	2.3	59.1	44.8	<u>3</u> 2.3
	8	V-R	61	611	57.0	37.0	24.0	2.2	2.4	2.6	66.5	10.36	26.26
	U	Ν- Ν	40	122	47.0	30.0	20.0	5.3	5.3	5,2	†∙0 L	4 6. 2	30.6
				-			,						
	,				Effect of	f Stres	s Concent	ration					
	A	N-on	8	116	0.48	74.0	61.0	t.3	3.4	4.1	101.5	85.4	72.0
	V	N-V	8	9TT	48.0	36.0	21.5	2.7	2.6	2.3	59.1	<u>44.8</u>	32.3
	д	No-N	61	, 611	81.0	71.0	62.0	2.8	2.8	2.8	86.7	77.6	67.8
	щ	N-V	P2	119	57.0	37.0	24.0	2.2	5. ⁴	2.6	62,5	₹. X	26.26
	ť	NO-N	76		87.0	75.0	0.43	4.4	4.4	4.9	4.40	81.55	70.5
) ບ	Δ-N	292	ន្ត	47.0	30.0	20.0	5.3	5.3	5.2	70.4	46.2	30.6

į

•.

ï

e.

, ,

ş

For Composition - see page 198, Item 4
 Heat Treatment Code

|.

0il Quenched from 1450°F, Tempered at 1200°F Å:

Air Biast Quenched from 1450°F, Tempered at 703°F ä

Air Blast Quenched from 1450°F, no Temper Ü

 \mathbf{f}_{i}

Ŷ

記録

For Specimen Conditions - see page 203, Item 4 46 m

For Meaning of Symbols - see page

				·	S OfTh	<u>TREL</u>							
	S _u = 135 k S _y = 122 k	161 181		æ	OTARY		<u>u</u>	Com Heat Spec	positio t Treat timen C ting of	anl ment ² conditic 'Symbol			
Type of Specimen			x°,	te î				Ą			Φ	ksi	
Life, cycles	Ħ	* 0	ЪС ⁵	90T	TOL	104	Į0	106	Tot.	⁴ OL	<u>Jo</u>	106	107
			ffect	t Of	Stress	Conce	ntrati	uo					
unnotcheă	4L	_++	88	63	8	2 . 4	2.5	2.7	2.8	90.8	83.5	76.8	70.4
V-notched Flank Angle	• 0 9	6.0	28	23	18	3.2	3.45	3.6	3.8	ጽ	4 - 94	37.6	31.8

212

For Composition - see page 198, Item 5 ----

For Heat Treatment - see page 198, Item 2

Ë For Specimen Condition - see page 203, M .#

For Meaning of Symbols - see page 46

DGAC STEEL

		$S_u = 27$ $S_y = 27$	70 ksi 77 ksi	Con	AXIAI aple:.!	LOAD	sed	Col 11_ Sp Me	mpositi at Tros ecimen aning (ton ² tment ² Condit of Symb	ions ³ 1018 ⁴
T	s _m	Kt		Xo			ъ			•	9
Lif	e, cyc	les	10 ⁴	10 ⁵	10 ⁶	10 ⁴	10 ⁵	10 ⁶	104	10 ⁵	10 ⁶
		,		eff	ect of	Tempera	ature				
20	000	1.0	160	90	50	2.8	2.9	3.0	191	106	60
50	000	1.0	145	115	90	3.15	3.3	4.6	162	129	102
550	000	1.0	125	100	78	3.7	3.8	4.0	161	125	98
				40	20	2 2	34	38	82	66	53
BO	000	3.0	52	40	26	2,2	2.4	1.4	81	46	40
450	000	3.0	/3	41	34	5 1 L D D D D D D D D D D D D D D D D D D	3.0	3.4	70	51	40
550	000	3.0	03	44	, se	£.(J	5.0	314			• -
80	30-50	3.0	55	38	26	2.7	3.1	3.25	66	46	32
450	30-50	3.0	39	34	29	3.8	4.1	4.7	48	42	37
550	30-50	3.0	43	35	29	4.0	4.5	4.7	51	42	34
• 、											
			E	ffect	of Str	ess Conc	entrat	:ion			
۵۸	000	1.0	160	90	50	2.8	2.9	3.0	191	106	60
90 90	000	3.0	52	40	30	3.3	3.4	3.8	82	66	53
00		0.0			• -						
450	000	1.0	145	115	90	3.15	3.3	4.6	162	129	102
450	000	3.0	73	41	34	2.1	2.45	3.4	81	46	.40
			195	100	78	37	3.8	4.0	1 61	125	98
530	000	3.0	63	44	35	2.75	3.0	3.4	70	51	40
220	000	3.0									
				M	scella.	neous R	esults			,	
••	100 1	98 1 0	0.9	81	65	3.6	4.0	4.2	1 19	96	78
80	100-1	33 I.V 37 I.V	70	60	48	3.8	4.0	4.2	115	91	72
470	07-1	22 I.U	110	91	82	2.6	3.25	4.0	122	101	90
220	70-1	I.V		<i>.</i>	~-	2	_				
1	For Co	mpositi	.on - ##		198.	Item 6					
2	For He	at Tres	tment -		aga 19	8, Item	G				
3	For Sp	ecimen	Conditi	Lons -	800 p4	ige 203,	It.en	6			
4	For Me	ening o	f Symbo)1s - (sec pag	10 46					

1-1	

「日本市の泉村」には日本市で加い

ROTARY BEIDING

S₁₁ = 272 kei S_y = 228 kei

Specimen Condition Meaning of Symbols

Reat Treatment²

Composition¹

Sec Remarks

P° 0 ket ₽¢ 707 P Effect of Surface Treatment Ŗ *****9 Lai 90 190 Xo kei ĥ ື່ ຊ े Life, cycles 8 Surf Cond

214

۲_,

92.8 96.8 95.8 93.8 95.2 51.2 55.5 89.5 91.6 93 93 100.2 100.2 97.9 112.7 108.45 8.801 4.401 211 113.6 102.6 109.6 113.5 102.1 122.8 136 131.2 1**.**70.4 135.6 1.811 1.32.9 4.771 4.121 14.121 126.5 131.4 131.4 156.5 173.65 166.1 163 555 555 555 <u>8</u>2 3.8 3.15 3.7 2.1 2.22 2.05 3.2 3.8 у. У. Г. 1.99 2.2 1.9 ~ ~ ~ ~ ~ 0.K 7.0 0 % N 0 % 0 у.8 4.6 4. K 4. K 1. K 1.9 2.1 3.6 3.5 2.8 3.5 2.9 7.4 8.8 3.4 2.95 1.75 2.8 3.1 2.7 2.4 8-78 8-78 *** 8** 588 ×84 57 86.5 189 182.6 88 888 \$5 \$6 \$8 88 % 100 100 100 8 8 8 88 <u>8</u> 7 8 H S 128 155.5 <u>19</u> 222 អ្នះ 87.78 888 S S 88 222 **4 4 4** ê S ы 1 1 보문문 Я С 불 불 문 副防防 S ບ

Effect of Surface Treatment

55.7

1.4LL 0.9EL

161.2

2.18

						215		
8	5 9 1		닅		h in s	. អ្នំអ្ន	ច ច ច ច ច	ថ ស ស ស ស
ê, ê	8 		· 👷	<u>e</u> 9	<u>1</u>			
8 8	K 84		8	\$ \$	የ አ የ		8 8 A 8	838888
148	747		811	<u>8</u> 1	19 19 19 19	151 151 151	8 <u>8</u> 4 6	32335
124.3 155	ĥ		100	51 8	× 5 3	3335	85 83 88 5.58	100 100 100 130.7
104.5	ま	Effe	ß	88	104.5 104.5	888 1133	<u> 8</u> 8 6 8	888854 2
88 fg	46	et of 1	22	61	88	8878	<u>84</u> 83	4 7 1 3 8 9 8 . 8
2.03	1.9	lieat Tr	2.8	4 K	1.75	3.1 2.95 2.03	2.4 2.7 1.98 2.0	2:4 2:4 1.8 1.9
2.03	2.06	eataen	2.9	ю. • •	2.03 2.03	4. L. C.	2.3 5.9 5.1	8.57.5.8 5.66.7 5.67.5 5.67.5 5.67.5 5.67.5 5.66.7 5.67.5 5.75.5
2.1 2.05	2.12	دب	0°£		2.1.99	3.6 2.3 2.0	2.5 2.5 2.5	2.12 2.12 2.12 2.12
2. <u>3</u> 5	2.23		3.1	, 4 . 8. 8.	2.1 2.18	3.8 3.45 2.35 2.35	7.1 3.4 2.18 2.12	3.2 3.5 2.05 2.23
161.2	176.5		147.1	1.001	143 161.2	160 175.5 156.5	121.8 166.5 151.7 162	178 159 173.65 173.65
136.0 166.7	143		1.26.5 1.10	+.0CT	118.4 136.0	131.4 136.1 138.9 166.7	6.9 4.5 7.011 7.011	131.4 135.6 131.2 131.2 137.4 147.4
1.4U	115.5		- 601 - 601	108.8	97.9 114.4	9.901 4.401 7.211 9.121	61.2 65.4 88:15	113.6 112.2 112 108.45 115.5
<u>8</u> 8	52. 5		9°25	<u> </u>	91.2 95.1	1.98	K 4 2 8	888888

For Composition - see page 199, Item 7 2

A.

for Heat Treatment - see page 199, Item 7

For Specimen Condition - see page 203, Its for Meaning of Symbols - see page 46

00 - No preparation

49 - exposed 4 hr at 375°F before test

hr at 500% before test

hr at 7507 haftere teat

hr at 10007, before test

it 1250 M before test 70 - crypoed 71 - crypoed 72 - crypoed

			2 <u>0</u>			2	1.2	9.0	3.6
			a.		22	8.8	21 R	36	X X
		4	106		18.5 23	2.101 1.67	29.8 37.4	91 31,5	39.5 45.8
	ton ³ de la	e ke	IO		40.1 42.8	11 ^b 94.5	46.8 41.2	88	¥ 72.00
	tion ^l n Condit of Symb	•	Ъ¢		90.8 71.5	128.5 113.5	73-5 49-2	801 sq	67 64.5
	omposi pecime eaning		Tol		3.5	3.8 3.2	و، د د	3.5 5.5	3.1 3.1
	303	م	301		3.6 3.05	3.0	3.3 2.75	3.3 3.1	5.4 2.95
	č 5		Ър.	estment	3.4 2.6	3.3 2.85	2•5 2•5	2.9 2.9	3.0 2.8
STEEL	RENDIN		[†]	st Ir	2.4 2.4	3.05 2.75	2.5 2.2	2.7	2.7 2.1
1-340	OTART		107	of He	13 6.0	đ 7	9 81	83	ឌ ន
	24	ksi	106	Effect	ង	2	25 FC	55 16.0	88
		xo	in in		ት ይ	\$ \$	27	S R	ጽጽ
	io ksi		⁴ ot		82 J	65	ЭR	አሪ	3 K
	206-28	រុក ព			34C 55	88 88	80 80 80	ත් ති	තී ශී
	ຍ ເ	Spec	les		Щ-А Щ-А		8-A 8-A	No-N	第-7 第-7
		Melt ⁵	Life, cyc		හ හ	ထဆ	0 0	99	99
		н.т. ²			A B	4 A	. 4 Ø	< ₽	₹ Ø
						217			

à

÷.

jî.

ľ

4

.

Effect of Melt Practice

~ ~ ~	Ⅱ-A 1-A 1-A	******	6	***	おお ぬ	ដង	2.t 2.75	4.0 4.0 4.0	3.6 3.4 3.4	њ. 7.9 7.7	90-8	1.04 04 04 04 04 04 04 04 04 04 04 04 04 0	-18.5 33.6 39.5	17.4 28 32.6
		88 88	358	หลิน	814	°98	2.5 2.8 7.2	2.6 2.8 2.8	3.05 3.5 2.95	<u>к</u> к К К С	5.5 9 9	अ.स.म. ९.९.म.	ት ት ት	12.7 29.2 38.6
	11 - 02 11 - 03	568 246	12 8 0 17 8 0	\$ 8	72 26	64 63	3.05	н, 9 8-9 8-9	3. 5 2.9	3.8 3.8	128.5 144	111	101.5 100	90 83.2
F 1		82	44	\$8	5 3	58	2.75 3.0	3.1 3.1	3.0	3.2 3.4	113.5 112.5	94.5 102.5		8 .5
				. 20	lect o	f Stre	is Conc	entrat	ion					
	■- 0 第- 0 第- A	540 540	85	ちた	36	57 SP	2.4 3.05	4. K. K. K.	3.6 3.5	4.4 3.8	90.8 1286.5	1.04 11	18.5 101.5	5 8
	<u>я</u> -оя	***	35	<i>Ƙ &</i>	R 12	6.0 45	2.4 2.75	2.6 2.85	3.05 3.0	3.5	11.5 113.5	5-8 5-5	23 79.4	લે (8
	й-ой 1-7	% %	901 801	ଶ ଛ	ちて	ମ ତ	2.7	2.8 2.8	2.9	2.9 3.2	144	0 1	33.2 100	83.£9

Downloaded from http://www.everyspec.com

, `

2**9.**2 85.5

まま

42.5 102.5

55.5 112.5

д. 6 4. 6

3.0

2.8 3.0

9 K

15

ନ୍ଧ ଷ୍ଡ

5

207

N--N

9 9

a a

Ń

.*

. . .

19.1 82.6	30.2 75.0
8.6	7.F
8.9	ю ю с
38	77 88
73.5 108	4 9. 2 9 4
3.5	ы. К. К.
ν. Γ. Γ.	2.75 3.1
2.8 2.9	2.5
2.6	2.2
er B	81 [4]
38	24 146.0
21 60 35	27 24 20 146.0
5 5 5 7 7 7	33 21 24 54 50 46.0
264 55 21 16 264 65 68 33	206 33 21 24 206 34 50 46.0
7-1 264 45 27 16 16-1 264 65 60 55	V-N 206 33 27 24 No-E 206 34 50 46.0
9 36-11 264 45 27 16 9 360-11 264 65 60 55	9 V-II 206 33 27 24 9 Bo-II 206 34 50 46.0

1

Ц.

1 For Composition - see page 199, Item 38

219

2 For Heat Treatment code

A: normalize 1550°P, 00, Temper 400.°P MC

B: normalize 1550'F, Quench, Temper at 775'F MC

For Specimen Condition - see page 203, Item 8A

ŝ

4 For Meaning of Symbols - see page 46

5 Melt Practice code

8 Air Melt, Yacuma are remelt

9 Vacues Induction Helt

10 Pacume Induction Meit, Facume arc Remeit

						13 0161							
		<i>и</i> ј ,	1 = 1 11- 21	90 ket		ROTARY	BENDING	S H N N	mpositio st Treat ecimen C san of Sy	n ¹ ment ² sudition ³ mbols ⁴			
	в.т. ²	K t	^{تو} ري		X ₀ ksi			م			0 ksi		
	Code Life,	, cycles		*o	IG	306	⁴ ot	το ^Σ	106	₽	ئەت	л ^{,6}	
	ı				Bilec	t of Heat	Treatme	nt		-			
	A	2.6	The	0-14	C ¥	8	2.1	2.4	2.95	84.0	4.94	21.76	
220	a د	1.0	81	8 8 8	6 8	ß	2.55 2.4	2.8 2.7	3.0	124.8 140.3	93.1 17.2	61.9 99.2	
	Д M	0.1	275 2 90	133 153	<u>6</u>	75 113	2.2	2.35	3.1	138.9 165.9	119.5 15 3. 5	102 1429	
	I For C	ompos1+10	n - see I	ag e 195 ∑1	en 83								
	2 Heat A: B:	Treatment Norm, 16 Norm, 16	code 00°F,1.52 00°F,2hr,	ur, AC; Au , AC; Aust	st 1525 1500 °F ,	г , 1.5 hr 2 hr, 00,	, 00, Tem Temp 1150	1501 1,2,4 hr	, th br, A	ų			
	ü ä	Norm, 10 Aust 155	00°F, Salt 0°F, Salt	t Bath 20)	min, 00	to 120T	to 150°F	, Temp	ц 1, 2 001	ŝ			
	ŝ	Aust 155	ctice - 1 O'F, Sali rtice - V	t Bath 20 1 Recum Fur	uruace min, 00 nace	to 120°F	to 150°F	Tenp 4	30°F, 4 h	81			
	J For S 4 For M	pecimen C	ondition Symbols	- see pag	e 203, I e 46	tem 8B						,	

. .

123

'n

1



Fe -5.5 Mu -2.5 Cr -.5C

					•	
		107		156.5	<u></u> 27	
		10 ₆		169.1	75.6	
nt ² ditions ³ ymbols ⁴	6 ksi	105		381	6.61	
osition- Treatme: tmen Con ting of S		10 ⁴	• .	195.8	82.9	
Com Heat Upec Mear		101	g	3.6	4.8	
		90T	tratio	3.6	4.8	
NDING	Q	105	Concen	3.6	4 4	
LARY BE		104	Stress	3.8	5.0	
ю́н И		Tot	fect of 5	130	63.0	
ksi	ksi	JŪę		140	66.0	
s _u = 314 s _y = 267	×°	105		150	69.0	
		10 ⁴		160	72.0	
	Spec	cycles		N-oN	N-V	
		Life,		1.0	2.6	
				22	2	

For Composition - see page 19^{n} , Item 10 н

. . .

\$

For Heat Treatment - see page 199, Item 10 For Specimen Conditions - see page 203, Item 10 3

M

For Meaning of Symbols - see page 46 4

MIO TOOL STEEL

	^S u •	= 330 ks	1		ROTAR	Y BEND	ING	Com Spec Mean	cosition imen Co ning of	l ndition Symbols	3
н.т. ²	κ _t	Spec		X _o ka	31		Ъ			0 ksi	
Life	e, cyc	les	104	10 ⁵	10 ⁶	10 ⁴	3.0 ⁵	10 ⁶	10'+	105	10 ⁶
				Effe	ct of 1	leat Tr	eatmen	it			
A	1.0	No-N	152	133	117	2.67	2.7	2.73	185.7	163.7	144
В	1.0	No-N.	1.27	119	111	1.89	1.95	2.0	163.5	153.2	143.5
		-		Mia	cellan	sous Re	sults				
в	2.6	V-N	71	65	59.5	3.37	3.5	3.62	94.4	86.8	79.8

- 1. For Composition see page 200, Item 11
- 2 Heat Treatment
 - A: Preheat 1450°F 1/2 hr, harden 2150°F 5 min, OQ until black, AC, Temp. 1100°F 2 hrs, A.C. Retemp 1100°F 2 hrs, AC, after finishing op. Nitrided 975°F 48 hrs.
 - B: Same as A but instead of nitriding stress relieve at 1000°F in protective atmosphere F.C.
- 3 For Specimen Condition see page 203, Item 11
- 4 For Meaning of Symbols see page 46

						321 S	TAINLES	S STEEL							
			ب مړي س	= 86 ksi = 38 ksi		AX Comple	IAL LOA tely Re	D versed	ŬĔØX	omposit: eat Trea pecimen eaning (ion 2 atment Condit of Symb	ione ols			
	K,	T, OF	spec.		į	cs1			م				0 ksi		
	1	1	I	10 ³	104	105	10 ⁶	10 ³	104	105	10 ⁶	10 ³	104	10 ⁵	10 ⁶
					Effe	sct of 5	Stress (Concentra	ttion						
	1.0	80	¥	44.0 28.0	39.6 20.0	32.4 21 6	27.9 16 0	1.5 8	1.4	1.4	1.4	47.15 45.2	42.5 34.8	34.8 26.3	29.9 19.85
	3.5 1.0	88	ဆုပ	20.0	39.0	29.5	22.2		2.56	2.74	2.85		46.85	35.5	26.95
22	-		•		87.0	58.3	40.3		2.5	3.42	3.6		91.35	61.32	42.33
24	3.5	-320	< m U		53.3 41.0	31.0 27.0	17.5 18.0		1.48 2.33	1.60 2.38	2.15		58.4 70.6	34.45 46.3	29.62
	1.0	-423	V		93.0	62.0	41.0		2.92	2.94	3.0		115.3 67.8	78.9 40.2	53.6 24.0
	3.5 1.0	-423 -423	а С	120.0	39.0 64.0	35.0	0.81	2,6	2.8	3.4	4.3	161.5	92.4	53.6	30.8
					:	. Effec	it of Te	mpera tur	نو						
	1.0	-30 -30 -753	~ ~ ~	0.44	30.0 33.0	32.4 58.3 62.0	27.9 40.3 41.0	1.5	1.4 2.5 2.92	1.4 3.42 2.94	1.4 3.6 3.0	47.15	42.5 91.35 115.3	34.8 61.32 78.9	29.9 42.33 53.6
		-320	29 29 29	38.0	29.0 53.3 39.0	21.6 31.0 23.0	16.0 17.5 12.5	1.8	2.0 1.48 2.35	2.2 1.6 2.37	2.5 2.15 2.4	45.2	34.8 58.4 67.8	26.3 34.45 40.2	19.85 20.25 24.0

۵)
H
5
4
1
Ĥ.
ų.
•
н.
썦.
0
**
X
<u>ت</u>
11
23
-

35.5 46.3 53.6
46.85 70.6 92.4
161.5
2.85 2.45 4.3
2.74 2.38 3.4
2.56 2.33 2.8
2.6
22.2 18.0 18.0
29.5 27.0 35.0
39.0 41.0 64.0
120.0
000
-320 -320 -320
000

26.95 29.6 **30.**8

12
ten t
page 200, Item 12 ee page 200, Item 12 a - see page 204, Ite - see page 46
Composition - see Heat Treatment - st Spectmen Condition Meaning of Symbols

	Quan	- Second
-	ŧ	۱
Spect	4	į۵
*		

	- unnotched	- edge notch	- TIG velded
2	4	(ii)	U

(). |

100 ù,

(and

÷.,

A-786 STAINLESS STREL

۰.

٠ ٠

.

8, •	• 90 ksi		AX1/	L LOAD		Cou	positi	^{DR} 2	
8 <u>'</u> -	46 ksi	C	ompletel	y Reverse	ad	Hea Spe Mea	t Tres cimen (ning of	tment Condit: E Symbo	ions ³
K,		Xo	ksi.		ъ.		6) ksi	
•	10 ⁴	3 10	10 ⁶	104	10 ⁵	106	104	10 ⁵	10
		1	ffect of	[Temperat	ture				
1.0 +	40	31	24	1.84	2.1	2.7	54	43	34
1.0 *	61 73	58 67	54 62	2.3 2.12	2.34	2.45	78 84	74 78	70 72
• e#	90	99		9.7	9 Q		16	97	
3.5*	35	25	17	1.58	1.58	1.8	56	39	27
3.5*	30	12	5	2.15	2.25	2. 37	56	36	15
1.0**	29	18	12	2.27	2.49	2.56	40	25	16
1.0**	27 41	15	8 19	3.05	3.12	3.25	66 70	37 ▲7	21 32
, .			.,	<i>2</i> ,. 4	8 I # M	.		- * *	
•	1	ffeci	t of Str	ess Conce	ntrati	on			
1.0*	40	31	24	1.84	2.1	2.2	54	43	34
3.5"	30	22		2.7	2.9		36	27	
1.0*	61	58	54	2.3	2.34	2.45	78	74	70
3.5*	35	25	17	1.58	1.58	1.8	56	39	27
1.0*	73	67	67	2.12	2.3	2.33	64	78	72
3.5*	30	12	5	2.15	2,25	2.37	86	36	15
			Effect	of Proce					
1.0	40	31	24	1.84	2.1	2.2	54	43	34
1.0**	29	18	12	2. 27	2.49	2.56	40	25	16
1.0	61	58	54	2.3	2.34	2.45	78	74	70
1.0**	27	15	8	3.05	3.12	3.25	66	37	21
1.0	73	67	62	2,12	2.3	2.33	84	78	72
1.0	41	28	19	2:48	2.51	7. 52	70	47	37.
Compositi	on	e pag	e 200, 1	Etem 13		le chanic	ally Po	lishe	d
	Su * Sy * Sy * 1.0 * 1.0 * 1.0 * 3.5 * 3.5 * 1.0 ** 1.0 * 3.5 * 1.0 * 3.5 * 1.0 * 3.5 * 1.0 * 3.5 * 1.0 *	$S_{u} = 90 \text{ ksl}$ $S_{y} = 46 \text{ ksl}$ I_{0}^{4} $I_{0}^{*} = 40$ $I_{0}^{*} = 40$ $I_{0}^{*} = 61$ $I_{0}^{*} = 30$ $I_{0}^{*} = 40$ $I_{0}^{*} = 30$ $I_{0}^{*} = 30$ $I_{0}^{*} = 40$ $I_{0}^{*} = 61$ $I_{0}^{*} = 61$ $I_{0}^{*} = 73$ I	$S_{u} = 90 \text{ ks1}$ $S_{y} = 46 \text{ ks1}$ $I_{u} = 40 \text{ s1}$ $I_{u} = 41 \text{ s2}$ $I_{u} = 41 \text{ s2}$ $I_{u} = 41 \text{ s2}$ $I_{u} = 40 \text{ s1}$	$S_{y} = 90 \text{ ksi} \qquad \text{Axid} \\ S_{y} = 46 \text{ ksi} \qquad \text{Completel} \\ \text{Completel} \\ \text{K}_{t} \qquad X_{o} \text{ ksi} \\ 10^{4} 10 \qquad 10 \qquad \text{Effect of} \\ 1.0 & 40 31 24 \\ 1.0 & 61 58 54 \\ 1.0 & 73 67 62 \\ 3.5 & 35 25 17 \\ 3.5 & 30 12 5 \\ 1.0 & 73 67 62 \\ 3.5 & 30 12 5 \\ 1.0 & 73 5 25 17 \\ 3.5 & 30 12 5 \\ 1.0 & 73 67 62 \\ 1.0 & 41 28 19 \\ \text{Effect of Str} \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 3.5 & 35 25 17 \\ 1.0 & 61 58 54 \\ 1.0 & 12 5 \\ \text{Effect} \\ 1.0 & 12 5 \\ 1.0$	$S_{y} = 46 \text{ ksi}$ Completely Reverse K_{L} K_{L} $X_{0} \text{ ksi}$ $10^{4} 10^{5} 10^{6} 10^{4}$ Effect of Temperat $1.0^{4} 40 31 24 1.84$ $1.0^{4} 61 58 54 2.3$ $1.0^{4} 73 67 62 2.12$ $3.5^{4} 30 22 7.7$ $3.5^{*} 35 25 17 1.58$ $3.5^{*} 30 12 5 2.15$ $1.0^{4*} 29 18 12 2.27$ $1.0^{4*} 29 18 12 2.27$ $1.0^{4*} 29 18 12 2.27$ $1.0^{4*} 40 31 24 1.84$ $5ffect of Stress Conce$ $1.0^{4} 40 31 24 1.84$ $3.5^{*} 30 22 2.77$ $1.0^{4} 61 58 54 2.3$ $1.0^{4} 73 67 67 2.12$ $3.5^{*} 30 12 5 2.15$ $Effect of Proce$ $1.0^{4} 40 31 24 1.84$ $2.77 15 8 3.05$ $1.0^{4} 73 67 67 2.12$ $S.5^{*} 30 12 5 2.15$ $Effect of Proce$ $1.0^{4} 40 31 24 1.84$ $2.77 15 8 3.05$ $1.0^{4} 73 67 67 2.12$ $3.5^{*} 30 12 5 2.15$ $Effect of Proce$ $1.0^{4} 40 31 24 1.84$ $1.0^{4} 73 67 62 2.12$ $3.5^{4} 30 12 5 2.15$ $Effect of Proce$ $1.0^{4} 40 31 24 1.84$ $1.0^{4} 29 18 12 2.27$ $1.0^{4} 61 58 54 2.3$ $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05 $1.0^{4} 73 67 62 2.12$ 3.05	$S_{y} = 90 \text{ ksi} $ $S_{y} = 46 \text{ ksi} $ Completely Reversed $K_{t} $		$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$

For Meaning of Symbols - see page 46 3

*

Ne

347 STATULESS STEEL

	S _u = 92 S _y = 46	ksi ksi				ATTAI LOAD	4	ı	Compos Heat 1 Specim Meanin	reatma reatma len Com le of S	nt ² ditic ymbol	as ³	
	-		v	- kat	Ł			Ь		•	0 K	81	
^K t	8 _m	۰ ³	م 10 ⁴	10 ⁵	- 10 6	10 ³	104	10 ⁵	106	10 ³	104	10 ⁵	10
L110	s, cycres	10	20	Effec	t of f	tress (Conce	ntrati	Lon				
1.0	25- 3 5 25-35	54	35	28 23	26	3.9 2.9	5.2 2.7	1.47 5.6 2.25	1.55	58 36	38 25	52 90 17	30
4.0 1.0 2.0	25-35 38-45 38-45	32 38 42	36 34	35 28		4.3 4.9	4.7 5.5	4.3		43 47	41 39	39 32	
					Misco	lianeou	us Rai	sults					
1.0 2.0 4.0	32-37 18-22 10-15		39	31 18 9	24 17 8		3.9	4.0 3.6 3.0	4.8 3.9 3.8		44	35 22 10	28 21 14

1 For Corposition - see page 200, Item 14 2 For Heat Treatment - see page 200, Item 14 3 For Specimen Conditions - see page 204, Item 14 4 For Meaning of Symbols - see page 46

1. 1. 1.

. Silin

10122

 $\mathcal{T}_{\mathcal{T}}$

٦

۰,

.

.

MULTIMENT N-155

S	u = 119 y = 60	ksi ksî		RO AND Comple	PARY, P AXIAL L etely R	LATE OADING Leverse	, d	Com Hea Spe Mea	position t Treatu cimen Co ning of	nt ment ² ondition Symbols
T of L	Ţ,°F	· .	X _o ks	i		ъ			0 ks	1
Life, Cy	cles	104	10 ⁵	10 ⁶	104	10 ⁵	10 ⁶	10 ^{4.}	10 ⁵	10 ⁶
	-		eff	ect of	Test T	empera	ture		†	
Axial	1200	48.0	45.0	42.5	2.25	2.4	2.52	54.7	51.95	49.0
Axial	1350	43.0	40.5	38. 0	2.55	2.73	2.85	49.85	46.8	43.95
Axial	1500	27.0	24.3	22.0	2.83	2.91	3.0	41.6	37.1	33.1
Rotary	1200	44.5	43.0	41.6	2.77	2.9	3.0	51.85	49.85	47.95
Rotary	1350	41.0	35.0	32.5	2.28	2.28	2.35	55.5	47.3	44.1
Rotary	1360	39.5	38.0	36.7	2.77	2.8	2.9	44.05	42.53	41.1
Rotary	1500	39. 0	33.7	29.3	2.27	2.37	2.45	48.5	42.0	36.15
			eff	ect of	Surfac	e Tres	itment	·	1.	
Axial A	1350	43.0	40.5	3e.o	2.55	2.73	2.85	49.85	46.8	43.95
Axial B	1350	35.0	34.0	33.0	2.23	2.27	2.32	43.2	42.1	40.9
			· Ef	fect o	f Type	of Lo	ading			
Rotary	1200	44.5	43.0	41.6	2.77	2.9	3.0	51.85	49.85	47.95
Axial	1200	48.0	45.0	42.5	2.25	2.4	2.52	54.7	51 .95	49.0
Rotary	1350	41.0	35.0	32.5	. 2.28	2.28	2.35	55.5	47.3	44.1
Axial	1350	43.0	40.5	38.0	2.55	2.73	2.85	49.85	46.8	43.95
Rotary	1500	39.0	33.7	29.3	2.27	2.37	2.45	48.5	42.0	36.15
Axial	1500	27.0	24.3	22.0	2.83	2.91	3.0	41.6	37.1	33.1
1 For C 2 For F 3 For S 4 For M A Lathe B Mille	Composit leat Tre Specimen Meaning ad	ion - 1 atment Condi of Sym	see pag - see tion - bols -	ge 200, page 2 see pa see pa	Item] 200, It Age 204, Age: 46	13A em 15A , Item	154			

					-132	SELUTIES	STEEL	, _ 1				
	^∾ "∿	- 114-126 ket - 60-73 ket		BOTARY AND Comple	, FLA MUAL MULAL	IE HERDIN LOADING Reversed			Compositi Heat Trea Specimen Mesning o	ten ^l tment ² Conditi f Symbo		
Surf Puntah (HZB)	T of L	Surf. Frep.	N N		اللہ م_			م		۰ ۴	0 kai	
	सिं, ९	gries		Sol.	305	ίστ	το	901	Lot	Ъ.	302	701
			jaq	Meet of	C Sur	face Plat	मु					
,st	4	M.P.	6 T	8	8	ţ	4	4.2	8.4	61.9	57.8	23
8	4	M.P.	ભા	8	9	14	2.6	2.8	6	60.5	5.2	8
£	¥	N.P.	ส	8	55	R	2.8	2-95	3.2	6-19	60.8	5
5	Pi	Ground	921	්	\$	8	5	4.8	5.0	78.6	53.2	Ŕ
3	A i	Scratehed -	ष्ट्र	ଷ	8	2	2.8	2.9	3.1	61.3	6.09	8
ŝ	P 4	M.P.	â	ઝ	8	T	2.7	0.K	3.2	2	60.6	8
P.	P 4	Scratched	6 7	51	R	R	3.6	3.8	0.4	63.9	60. 2	8
			X	iscella	peous	Realts						
ŝ	F	M.P.	61	8	ا لخ	47	10 10	5.5	3.7	88 (88 (4.99 1	đ,
ŝ	Pi Pi 1	Ground" -	a a i	ନତୀ	R	8.	5 Q .	କ ର କାର୍ଯ୍ୟ	5	19.98 / 19.98 /	5.9 5.9	Ŕ
ŝ	₽4 	N.P	021	ጸ	1	2	T C	<u>5</u> N	0.0	6 8	27.1	2

229

- Que
- 14
-
- 44
18
-
-
- 25
-
- 14
- 9
- 63

1.9.1 53.6 13.6	
53-9 61-8 58-8	
838	
4.9 4.9	
CI 99 60 4 4 4	
К. 4 Г. 4 4	
5.8 8.9	
52.55 F	
<u> </u>	
91 fi	
Ground ^C M.P. C M.P.	

ŝ

East Treatment - see page 260, Item 153 For Composition - see page 200, Item 158 12 M

:'

230

Specimen Condition - see page 204, Item 158

eaning of Symbols - see page 46

Jog I

N 10 -

m

Surface Preparation Res

- Stress relieved after surface finishing 4
- Burface Minished, stress relieved, refinished
 - Seat Prested after surface finishing äü

g

а. Ч

÷

i.

.

•

PH 15-7 MO STAINLESS STEEL

	su sy	201 196	ksi ksi	AX1 Complet	IAL LOAD ely Revo	rsed	C H S M	ompositi est Tref pecimen esning d	itment ² Condit of Symb	:ions ³ 001s ⁴
T, OF	K _t		X _o ke	1		ъ			0 ks:	Ĺ
Life,	cycles	10 ⁴	5 10 ،	106	10 ⁴	10 ⁵	10 ⁶	10 ⁴	10 ⁵	10 ⁶
				Effect	of Ten;	eratu				
80 500	1.0 1.0	145 120	104 73	75	1,68 2,8	1.73 2.85	1.78	169 129	119 79	86
80 500	4.0 4.0	42 36	31 32	23 29	2.35 2.55	2,4 2.58	2.43 2.7	56 - 41	41 37	30 32
			Effect	t of St	rese Con	centre	ition			
80 80	1.0 4.0	145 42	104 31	75 23	1.68 2.35	1.73 2.4	1.78 2.43	169 56	119 41	86 30
500 500	1.0 4.0	120 36	73 32	29	2.8 2.55	2.85 2.58	2.7	129 41	79 37	32

1 For Composition - see page 200, Item 16 2 For Hest Treatment - see page 200, Item 16 3 For Specimen Conditions - see page 204, Item 16 4 For Meening of Symbols - see page 46

:

å

17-7PH

	8 _u = 205 Sy = 195	i ksi i ks <u>i</u>		A Compl	XIAL L etely	OAD Rever	sed	Loi He Sp Mei	mpositio at Treat ecimen (aning of	on ¹ tment ² Condition ³ f Symbols ⁴
ĸt	Spec	Х	o kai			Ъ		θ	ksi	
Life,	cycles	10 ⁴	105	10 ⁶	10 ⁴	10 ⁵	106	μοτ	105	10 ⁶
1	No-N	90.0	82.0	63.0	8.3	6.0	6.0	153.6	126.6	88.6
2.3	H-N	76.0	56.0	40.5	3.5	3.9	4.2	80.24	58.82	43.15
4.0	H-N	44.2	31.0	21.7	4.8	4.4	4.3	47.4	33.0	23.4
5.0	H-N.	39. 2	28.5	20.8	3.8	3.4	3.1	41.59	30.43	21.74

1 For Composition - see page 201, Item 1. 2 For Heat Treatment - see page 201, Item 17 3 For Specimen Condition - see page 204, Item 17 4 For Meaning of Symbols - see page 46

		2	(_o , ksi			Ъ		6), KS1	
Type of Loading	Temp. °F	10 ⁴	10 ⁵	106	10 ⁴	10 ⁵	106	10 ⁴	105	106
				TIMKEN	16-25-	6				
			Co	AXIA	L LOAD y Rever	sed		Composi Heat Tr Meaning	tion ¹ catment of Sym	2 ibols ³
			Efi	ect of !	Fempera	ture				
Axial Axial	Room 1200	63.0 47.0	58.0 43.0	53.0 40.0	4.8 4.4	5.0 5.0	5.2 5.2	71.1 56.9	65.4 53.3	60.1 50.0
		t kan		STAINL	ess 403					
			4 Y T	Δ. Δ. ΝΤ) 121	LATE 10	ADTING		Compost	ltion ¹	
			Co	ompletel;	y Rever	sed		Heat Tr Meaning	reatment s of Syr	,2 abols ³
			Ef:	feat of !	Tempera	ture		•	-	
Axial Axial Axial Axial	Room 500 700 900	75.0 59.0 58.0 50.0	69.0 54.0 53.0 45.5	65.0 50.0 49.0 41.6	1.9 3.0 4.7 3.2	2,5 4.3 4.82 3.8	2.65 4.8 5.1 4.1	78.4 65.6 62.2 57.2	73.1 61.7 59.4 46.6	68.0 58.2 53.0 42.68
Rotary Rotary Rotary	Room 700 900	95.0 80.0 71.0	76.0 62.0 58.0	60.0 49.0 47.5	3.2 3.8 3.45	3.5 5.1 3.55	3.7 5.9 4.8	106.0 86.3 74.2	85.4 67.2 60.5	69.9 52.6 49.7
			Effe	et of Ty	pe of I	oading	5			
Axial Rotary	Room Room	75.0 95.0	69.0 76.0	65.0 60.0	1.9 3.2	2.5 3.5	2.65 3.7	78.4 106.0	73.1 85.4	68.0 69.9
Axial Rotary	700 700	58.0 80.0	53.0 62.0	49.0 49.0	4.7 3.8	4.82 5.1	5.1 5.9	62.2 86.5	59.4 67.2	53.0 52.6
Axial Rotary	900 900	50.0 71.0	45.5 58.0	41.6 47.5	3.2 3.45	3.8 3.55	4.1 4.8	57.2 74.2	46.6 60.5	42,68 49.7

1 For Composition - see page 201, Items 13, 19

2 Heat Treatment Unknown

3 For Meaning of Symbols - see page 46

t

			x ₀ ,	ksi			ъ		θ,	kei	
;	Type of Loading	Тетр. °F	10 ⁴ 10	5 l	0 ⁶	104	10 ⁵	106	10 ⁴	10 ⁵	10 ⁶
			:	L	APELLO	Y 311				-	
:				-	AXIAL	LOAD			Composi	$ition^{\perp}$.2
				Compl	etely	Revers	ed		Heat T: Meanin	reatmen g of Sy	t- mbols ³
	•			Miscel	laneou	is Resu	lts				
	Axial	1100	35.0 33	.0 31	1.0	4.5	4.8	5.0	42.2	39.9	37.7
				S	-816 (1	AMS 553	<u>54)</u>			1	
	en e			R	OTARY 1 Letely	BENDING Revers	} sed		Compos Heat T Meanir	ition ⁺ reatmenng of S	mt ² ymbols ³
	5			Effec	t of T	empera	ture				
	Rotary	Room 1350	100.0 81 58.0 50	.0 6 .0 4	5.0 4.0	2.8 3.5	2.9 4.1	3.2 4.6	122.5 70.2	99.5 61.8	82.1 51.4 36.6
	Rotary	1650	15.0 13	.0 1	2.0	3.3	3.4	2.2	42.0	<i>))</i>	
					INCO S	SHS 260				٦	
				Com	AXIAI pletely	L LOAD y Rever	Beđ		Compo Heat Meani	sition Treatme ng of É	ent ² Symbols ³
				Eff	ect of	Temper	ature				
	Axial Axial	525 800	110.0 8 100.0 7	5.0	60.0 55.0	-3.8 5.8	4.1 6.0	4.3 6.5	190.0 160.0	136.0 119.0	102.0 89.0
					GMR	-232			Comp	aition	1.
÷				Com	AXIA pletel	L LOAD y Reve	rsed		Heat Mean	Treatm ing of	ent ² Symbols ³
۰،	• • •			Effe	ct of	Temper	ature			'	
•	Axial Axial	Room - 1200	74.0 5 43.0 3	6.0 59.0	42.0 35.5	2.4 3.9	2.7	2.8 4.1	79.9 53.4	60.8 48.4 5 29.2	46.05 3 44.18 2 27.53
	Axial	1650	26.5	24.5	23.0	2.43	2.1	<i>4</i> .0	J	//!	· · · · · · ·

1 For Composition - see page 201, Items 20, 21, 22, 23

2 Heat Treatment Unknown

Axial

3 For Meaning of Symbols - see page 46

234

1 1.

10 ⁴ 55.0 39.0 37.0 75.0 76.6 76.6 62.0	10 ⁵ AXIAL, Co 54.0 37.0 32.0 60.0 72.4 Effe 72.4 57.0	10 ⁶ <u>s-816 (1</u> FLATE, 1 mmpletel; 52.0 36.0 28.0 50.0 68.8 ect of T	10 ⁴ AMS 576 AND ROTA Y Rever Tempera 3.7 3.1 4.6 4.5 2.05	10 ⁵ ARY BE sed ture 4.1 5.2 5.0 2.48	10 ⁶ NDING 4.6 4.8 5.6 5.3 2.95	10 ⁴ Compos Heat T Meanin 69.2 42.8 44.0 110.0	10 ⁵ ition ¹ reatmen g of Sy 67.1 41.2 38.6	10 ⁶ t ² 65.2 39.6 33.9
55.0 39.0 37.0 75.0 76.6 76.6 62.0	AXIAL, Co 54.0 37.0 32.0 60.0 72.4 Effe 72.4 57.0	<u>S-816 (/</u> PLATE, / mmpletel; ect of f 52.0 36.0 28.0 50.0 68.8 ect of T	AMS 576 AND ROTA Y Rever 3.7 3.1 4.6 4.5 2.05	5) ARY BE sed ture 4.1 5.2 5.0 2.48	4.6 4.8 5.6 5.3 2.95	Compos Heat T Meanin 69.2 42.8 44.0 110.0	ftion ¹ reatmen g of Sy 67.1 41.2 38.6	t ² mbols ³ 65.2 39.6 33.9
55.0 39.0 37.0 75.0 76.6 76.6 62.0	AXIAL, Co Eff 54.0 37.0 32.0 60.0 72.4 Effe 72.4 57.0	PLATE, A mmpletel; 52.0 36.0 28.0 50.0 68.8 ect of T	AND ROT. y Rever Tempera 3.7 3.1 4.6 4.5 2.05	ARY BE sed ture 4.1 5.2 5.0 2.48	4.6 4.8 5.6 5.3 2.95	Compos Heat T Meanin 69.2 42.8 44.0 110.0	ition ¹ reatmen g of Sy 67.1 41.2 38.6	t ² mbols ³ 65.2 39.6 33.9
55.0 39.0 37.0 75.0 76.6 76.6 62.0	Eff 54.0 37.0 32.0 60.0 72.4 Effe 72.4 57.0	ect of 3 52.0 36.0 28.0 50.0 68.8 ect of T	Tempera 3.7 3.1 4.6 4.5 2.05	ture 4.1 5.2 5.0 2.48	4.6 4.8 5.6 5.3 2.95	69.2 42.8 44.0 110.0	67.1 41.2 38.6	65.2 39.6 33.9
55.0 39.0 37.0 75.0 76.6 76.6 62.0	54.0 37.0 32.0 60.0 72.4 Effe 72.4 57.0	52.0 36.0 28.0 50.0 68.8 ect of T	3.7 3.1 4.6 4.5 2.05	4.1 4.1 5.2 5.0 2.48	4.6 4.8 5.6 5.3 2.95	69.2 42.8 44.0	67.1 41.2 38.6	65.2 39.6 33.9
75.0 76.6 76.6 62.0	60.0 72.4 Effe 72.4 57.0	50.0 68.8	4.5 2.05	5.0 2.48	5.3 2.95	110.0	07.1	
76.6 62.0	Effe 72.4 57.0	ect of T	vne of			78.88	95.1 75.04	79.2 71.22
76 .6 62.0	72.4 57.0	<i>.</i>	A PACE	Loadin	æ			
	21.0	68.8 54.0	2.05 2.42	2.48 3.0	2.95 3.4	78.88 79.2	75.04 76.8	71.22 75.3
		UDIM	ET <u>500</u>				۹.	
	(AXIA Complete	L LOAD ly Reve	rsed		Compos Heat 1 Meanin	ition ¹ reatmend ng of Sy	nt ² /mbols
	Ef	fect of	Tempers	ture			- •	
116.0 84.0	92.0 78.0	76.0 71.0	2.35 3.1	2.5 3.13	2.7 3.25	136.5 96.4	112.7 87.65	92.4 80.4
		<u>T1-14(</u>	(AMS L	<u>193)</u>				
	1	ROTAF Complete	r y Bendi Bly Reve	ING ersed		Compo Heat Meani	sition⊥ Freatmen ng of S;	nt ² ymbols
	E	ffect of	Temper	rature				
83.0	62.0 61.5	45.0 45.0	2.4 2.35	3.22 2.6	3.5 2.85	113.9 92.1	87.3 67.8	67.2 50.2
	83.0 85.0	E 83.0 62.0 85.0 61.5	<u>Ti-140</u> ROTAN Complete Effect of 83.0 62.0 45.0 85.0 61.5 45.0	<u>T1-140 (AMS 1</u> ROTARY BEND) Completely Reve Effect of Temper 83.0 62.0 45.0 2.4 85.0 61.5 45.0 2.35	<u>T1-140 (AMS 493)</u> ROTARY BENDING Completely Reversed Effect of Temperature 83.0 62.0 45.0 2.4 3.22 85.0 61.5 45.0 2.35 2.6	<u>Ti-140 (AMS 493)</u> ROTARY BENDINC Completely Reversed Effect of Temperature 83.0 62.0 45.0 2.4 3.22 3.5 85.0 61.5 45.0 2.35 2.6 2.85	Ti-140 (AMS 493) ROTARY BENDING Composition Completely Reversed Heat 1 Meaning Meaning Effect of Temperature 113.9 85.0 61.5 45.0 2.35 2.6 2.85 92.1	Ti-140 (AMS 493) Composition ROTARY BENDINC Composition Completely Reversed Heat Treatment Effect of Temperature Meaning of State 83.0 62.0 45.0 2.4 3.22 3.5 113.9 87.3 85.0 61.5 45.0 2.35 2.6 2.85 92.1 67.8

1 For Composition - see page 201, Items 24, 25, 20

2 Heat Treatment Unknown

 $\cdots ^{it} X^{i}$

ķ

3 For Meaning of Symbols - see page 46

í.	
E	
Ł	
L	
Ł	
1	
s.	
L	'
Ł	
£	
U	

抗药

in alore

ų

. 6

	ด้ ด้า	unkno	Ę		otary be			ชีส์	position Cu, Mn,	×				
Specimen Condition			×°	ks t				م			4 6	18		
Life, cycles		ξġ	106	101	gor	102	106	701	ы ⁸ 01	lo ⁵	106	7οτ	10 ⁸	
non-corroded		22.0	17.0	13.0	0.01	4.4	4.5	5.2	5.6	30.9	24 . 8	20.2	16.4	
corroded in salt wate.	54	12.0	0-7	4 -0	2.0	2.8	3.2	3.75	4.7'	25.0	16.4	10.8	7.2	

	°¢		0 m 0 0 0		¢	2. T
		;	88748	833 <i>¥</i>	ı	
			78.0 7.27 60.5 7.09 7.04	80.2 57.5 59.9 50.4		80.2
tion ³ talat	*o1		89.2 96.1 77.1 65.0	97.7 18.8 19.2 17.1		118.6 97.7
n Condit of Symb	106		3.35 3.1 3.0 4.1	3.48 2.7 3.6 4.1		4.1 3.48
Composi Specime Meaning	ه ۱۵۶		2.95 2.95 3.1 4.0	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5		3.8 3.35
•	, 1 4	bure	2.8 2.75 2.65 3.5	3.05 3.15 3.25	atment	2.9 3.05
ART BENDING	10 ⁶	of Temperat	20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0	8.0 8.0 8.0	of Reat Tre	26.0 46.0
TOH	6 kai	Effect	27.0 26.0 4.0	5.05 0.05 0.05 0.05	Effect	40.0 55.0
ksi ksi	Jo t		67.0 75.0 75.0	10.04 0.04 0.04		0.07
s _u = 177 s _y = 166	S. Ini		0000	0 0000		00
	R.T. ² cycles		< < < <	≪ 82 82 82 A2		× ¤
	T *F Life,		ନ୍ଦୁ ପୁ ସୁ	38 8 <u>9</u> 8 8		සි සි
			237			

5 M.

, Pol

 $\sim 0^{p}$

T1-6A1-4V

Treatment	
Heat	
Ы	
Effect	

2.3 47.4 7.5 44.0	0.5 47.3 9.9 44.5	5.0 44.0 0.4 76.6 4.2 23.55 24.25 24.25	4.5 29.7 3.4 37.5	8.96 25.92 3.2 26.35	3.75 40.8) L.25		3.9 49.2 3.9 49.2 1.5 41.2	1.6 27.4
81.5 78.8 5	77.1 79.2 75	0.1-1	66.8 44 30.64	72.24 72.3 72.3	58.5 54.45 54.45		5.55 7.0 7.6 7.6 7.6	80 87 87
2.49 2.7	3.6 .6	3.25 4.1 3.3 3.3	3.9 3.8	3.97 3.8	3.7		4 5 4 5 5 5 5	4°2
1.9 2.2	2. 7 3. 2	ы. 5. 9. 9. 9. 9. 9. 9. 9. 9. 9. 9. 9. 9. 9.	3.73 3.4	3.7	3.5 2.75		0 1 0 4 5 4	0.4
1.9	2.65 3.15	3.29 3.29 2.89 2.99 2.99	. 3. 4 2.95	ν. Γ.τ.	3.35	sults	у. 5.0 3.65	5-2
36.0 25.0	0.55 20.05	88.0 80.0 17.5	19.0 18.0	23.6 18.0	36.0	ancous Re	20.0 20.0 0.0	23.0
48.0 35.0	0.04 0.05	5.5. 5.5. 5.5. 5.5.	28.0 20.0	26.5 20.0	43.0 29.7	Miscell	15.0 10.0	2
64.0 45.0	0.0 <u>7</u> 0.0 <u>7</u>	5.04 5.04 7.05 7.00	50.0 52.0	0.05	8 8 9 9		5.98 5.09 6.09 7.09 7.09 7.09 7.09 7.09 7.09 7.09 7	27.0
00	00	0 82-107 82-107	30-45 30-45	00T-11 00T-11	40-04 15-01		-0- -0- -0- -0- -0- -0- -0- -0- -0- -0-	85-100
4 8	< A	4 19 4 19	a b	< ¤	¥ £		< < < .	<
99 99 14	88 85 8	සිහි සිහි	00 yr	00 14 14	8 8 8		සි සි සි සි	£
			238					

w.
.
-
<
99
65
-
-
۳.
2
Χ.
×.
•
α.
3
99
_
_
•
6
Ξ.
ч.
-

And a star 动物的

e,

							2 8	202, Ite	- see page	Composition	1. You
	ł					~		0.00	×	ф	80
33.8	0.66		3.45	3.2		5 5		式 (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	R-12	A	8
r, R	38.17	18.2	5 1 1	3.05	2.95			?? ?		A	8
ì	N.	<u>6</u>		<u>,</u>	Z.	0.05	0-92-	51.0	17 - 22		2
6		F	, H				0.0	35.0	25-33 25-33	Y	8
33.5	k0.5	14 B	3.6	C	50 K	i	i				
		.	N I			0.01	20.0	80.8	66-95	¥	80
21.4	23.6		2.5	0,18			? ま、	0.74	8-9-9-	×	8
3 6	42.24		2.6	5.5	, IC	; ; ; ;	2 (2 (œ٩	8
41.01	21.44	23,95	3.75	3.5	۲.۴ ۲	7 45	7 00				
				,		57.5	2 2 2	った	311-38	8	8
	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	00 	n ac	- 4	r 0 1	19.0	5 8 .0	0-04	30-65	Ŕ	ŝ
بر ۲			(1						4	\$
5	8.16	51°6£	3.25	2 • 3	2.6	19.5	26.0	ς Έ	Be-115	< •	<u>ş</u>
n R	6.0	61.3	5.0	4°9	5.4	20-0	27.0	2		¢ •	<u></u>
1.62	40 . 6	71.34	ŝ	ۍ. رئي	2.9	33.0	24°0	26.0	zscho	•	

2 For Rest Treatment code

239

Sol Freated 1690'F, 12 min, WQ, Aged 900'F, 4 hrs, Air Cooled. Sol Freated 1675'F, 20 min, WQ, Aged 900'F, 4 hrs, Air Cooled.

ä

205, Item 28 For Specimen Condition - see page

9 For Meaning of Symbols - see page n .4

3

्यते

97 - 1

i

se)

and the second secon

¢

1 ø

19 19 19

INCOMEL X

8 ₄ = 225 km 8 _y = 194 km 194 km		AXIAL AND BOTARY LOAD					Composition ¹ 2 Next Treatment Specimen Conditions ³ Neaning of Symbols ⁴			
T,91	Type of		X _o ka	ite.		ն			0 ke	1
Life,	Lund cycles	10 ³	104	10 ⁵	10 ³	10	10 ⁵	103	104	105
		1	:	Iffect	of Tem	peratu				
200 400 600 1300 1500	Ariel Ariel Ariel Ariel Ariel	50 54 59 29 17	40 44 27 14	30 35 42 24 12	2.6 4.1 1.5 2.2 3.4	2.75 4.6 2.3 3.05 3.7	3.2 6.1 2.4 3.15 4.0	73 59 65 31 23	57 48 56 29 20	47 39 47 27 17
			·.	Miscel:	laneous	Result			•	
80	Rotery	69	50	38	1.0	1.12	1.54	71	53 -	39

 ι

1 For Composition - see page 202, Item 29 2 For Heat Treatment - see page 202, Item 29 3 For Specimen Conditions - see page 204, Item 29 4 For Meaning of Symbols - see page 40

The subscription of the second state of the second states of the second

S. hus

Concerne Alter

240

. And

.**.** .

A MAR THE MARK

م مرکزین دور کار

Station States and States
REFERENCES FOR FATIGUE STRENGTH DATA

Source :

l through 7	Mechanical Properties Data Center (MPDC) Traverse City, Minhigan.
86	Asronautical Systems Division (ASD), Tech. note 61-117, Part III, Machanical Properties Information Processing System. "Patigue of Matals, Low Alloy Steels" Sec. 1, Feb. 1962, Belfour Eng. Co., Suttons Bay, Michigan.
8B through 17	MPDC (See Above)
18 through 26	ASD Tech. Note 61-117 Part II, "Fatigue of Metals - Corrosion and Heat Resistant Metals," Nov. 1961. Belfour Eng. Co., Suttons Bay, Michigan.
27	L. R. Jackson, H. J. Groover, R. C. McMaster, Advisory Report on the "Fatigue Properties of Aircraft Materials and Structures " OSPD Rep. 46600

28 and 29

Materials:

i.

ę

-

Ŷ

3 3

. 1

.*

MPDC (See Above)

A-1.2 WEIBULL PARAMETERS FOR TENSILE STRENGTH

tč ∙r

.

a È

198.5.

1

INDEX TO WEIBULL FARAMETERS FOR TENSILE STRENGTH OF VARIOUS MATERIALS

Page Number where Material Weibull Parameters for a given Material can be located (.12 - .17)% C Steel. 245 1. (.08 - .30)% C Steel. 245 2. (.18 - .24)% C Steel. 245 3. (.08 - .35)% C Steel. 245 4. 5% Or, .5% Mn, .5% Ti, .12% C Steel. 246 5. 246 5% Cr, .5% Mo, .2% C Steel. 6. 17% Cr, .12% C Stainless Steel. 246 7. 2.25% Cr, 1% Mo, .15% C Steel. 246 8. 1.25% Cr, .5% Mo, (.07 - .15)% C Steel. 246 9. 25% Cr, 12% Ni Stainless Steel. 246 10. 18% Cr, 8% Ni + Ti Stainless Steel. 247 11. 12. 18% Cr, 8% Ni + Cb Staipless Steel. 247 18% Cr, 8% Ni Stainless Steel. 247 13. 18% Cr, 12% Ni, 2% Mo Stainless Steel. 247 14. 25% Cr, 20% Ni Stainless Steel. 247 15. 247 16. SAE 4340 Steel. 4140 Steel. 248 17. SAE 248 18. 1.25% Cr, .5% Mo, .25% V, .4% C Steel. 248 1% Cr, .35% Mo, .25% V, .4% C Steel. 19. D_{6AC} Steel. (Ladish). 248 20.

٦

Ċ,

TABLES

Effect of Temperature on Tensile Strength of Various Commercially Available Materiels

Material	Heat Treatment	Tamp. °F	S y	Su	X _o	Ъ	0 kai
			ksi.	ksi	K81		VBT
Killed Carbon Steel	Normalized	70	41.0	60.0	52.0	1.42	61.8
1. (.1217)% C	at 1725°F	1900	17.0	31.0	23.0	1.,90	35.4
.55% (max) Mn	Drawn at						
.09% (max) P	1200°F for						•
.06% (max) S	<u>1 hr</u>				دارد دو بر اک برد		
.28% (max) Si		70	41.0	60.0	54.5	1.55	62.2
	Annealed	900	20.0	41.0	33.0	1.70	44.0
Low Carbon	at 1550°F	1000	17.0	31.0	20.0	2.05	36.0
Low Alloy Steel	for 1 hr	1100	14.0	23.0	11.0	2.40	25.4
		1200	10.0	10.0	/.5	2,49	17.4
2. (.0830)% C		70	42.0	62.0	36.0	2,90	65.0
1.0% (max) Mn		300	37.0	66.0	48.0	1,70	71.2
.050% (max) P		400	35.0	67.0	52.0	1.40	72.5
.060% (max) S		500	32.0	66.0	57.0	1.07	72.5
.2 5% (max) Si		600	29.0	63.0	61.0	1.12	65.2
Low Carbon	None	700	27.0	55.0	53.0	1.23	60.9
Low Allov Steel	Specified	800	23.0	45.0	28.0	1.65	51.5
	•	900	20.0	35,0	27.0	2.30	41.0
		1000	17.0	27.0	14.0	2.60	32.0
		1100	13.0	20.0	10.0	2.80	24.5
		1200	10.0	14.0	4.0	3,00	15.5
		1400	4.0	7.5	2.0	3,20	7.6
3. Killed Carbon Steel	,	70	37.0	63.0	59.0	1,70	64.8
(.1824)% C		200	35.0	59.0	57.0	1.90	60.0
.86% (max) P	Stress	400	32.0	66.0	55.0	1.14	67.3
.032% (max) Mn	Relieved	600	28.0	63.0	57.0	1.05	64.8
.043% (max) S		800	25.0	52.0	49.0	1.80	53.7
.24% (max) Si		1000	20.0	34.0	26.5	2.40	35.3
Low Carbon							
LOW Alloy Steel							
4. (.0835)% C		70	40.0	63.0	54.0	1.45	65.5
(.3080)% Mn		750	30.0	62.5	53.0	1.50	64.5
(.1050)% Si	None	900	26.5	54.0	44.0	1.55	53.0
.04% (max) P	Specified	1000	23.0	46.0	37.0	1.80	51.8
.05% (max) S	_	1100	19.0	38.0	34.0	2.00	40.2
(.4065) Mo			-	-			
Low-Medium Carb	on						
Low Alloy Steel	•						

.

14

5. Material	Heat Treatment	Temp.	s y	S u	×o	D .	÷
5.0% Cr 0.5% Mo (15)% T .12% C Low Carion High Alloy Steel	i Annealed at 1550°F	900 1000 1100 1200 1300 1400	20.0 17.5 15.0 13.0 10.0 7.5	50.0 44.0 37.0 28.0 19.0 13.0	44.0 38.0 31.0 21.0 10.0 5.0	1.36 1.43 1.50 1.90 2.35 2.70	50.9 44.8 36.1 28.4 19.0 12.6
6. 5.0% Cr 0.5% Mo 0.2% C Low Carbon High Alloy Steel	None Specified	70 400 600 900 1000 1100 1200 1300 1400	30.0 26.0 24.0 20.0 18.0 16.0 14.0 10.0 8.0	71.0 68.0 58.0 51.0 43.0 34.0 25.0 17.5 12.0	57.0 55.0 53.0 42.0 32.0 28.0 16.0 9.0 6.0	1.42 1.55 2.00 3.00 3.40 3.60 4.20 4.70 4.80	73.0 61.5 59.9 52.3 44.0 34.2 26.1 18.9 12.1
7. Stainless Steel 17% Cr .12% (max) C	Annesled at 1950 ⁰ F	70 1300 1400 1500	39.0 8.0 6.0 4.0	72.0 15.0 10.0 6.0	68.0 7.0 5.0 3.0	1.50 2.10 2.50 2.60	74.0 16.2 11.5 6.95
8. 2.25% Cr 1.0% Mo 0.15% C Low Carbon Low. Alloy Steel	Annealed at 1550°F Cast Normalized at 1650°F	70 1100 70 1000 70 800	41.0 30.0 65.0 40.0 75.0 75.0	74.0 54.0 92.0 58.0 110.0 110.0	65.0 36.0 65.0 46.0 54.0 53.0	1.35 1.50 1.80 1.90 1.15 1.90	71.9 43.5 93.5 60.1 126.0 126.0
^{9.} 1.25% Cr-0.5% Mo 0.0715)% C Low Carbon	Normalized at 1700°F	900 1000 70	70.0 60.0 55.0	95.0 75.0	52.0 51.0 64.0	2.40 2.45	78.8
Low Alloy Steel 10. Stainless Steel 25% Cr-12% Ni .20% (max) C	Annealed at 2000°F	70 800 1200 1300 1400 1500	57.0 41.0 31.0 28.0 26.0 25.0	80.0 69.0 52.0 44.0 36.0 27.0	63.0 62.0 37.5 36.0 21.0 17.0	1.15 1.19 1.17 1.80 2.00 2.10	91.0 74.5 56.9 49.3 38.9 28.2
		1600 2	20.0	20.0	11.0	2.20	21.5

Material 11.	Heat Treatment	Temp.	s _y	ร _{ับ}	×°	Ъ	0
Stainless Steel 18% Cr-8% Ni .8% (.0409`% C	Ti Annealed at 1950 ⁰ F	70 1000 1200 1300 1500	35.0 30.0 28.0 25.0 18.0	85.0 55.0 45.0 41.0 22.0	71.0 46.0 35.0 21.0 11.0	1.80 2.00 2.30 2.50 2.75	87.0 60.4 49.2 43.0 24.5
12. Stainless Steel 18% Cr-8% Ni +.8% .06% C	Cb Annealed at 1900 [°] F	70 1000 1100 1200 1300 1500	38.0 29.0 27.0 25.0 22.0 18.0	85.0 60.0 58.0 47.0 44.0 25.0	75.0 52.0 51.0 40.0 40.0 13.0	1.50 1.55 1.60 1.70 1.70 3.00	87.5 63.3 60.0 48.7 45.2 26.7
13. Stainless Steel 18% Cr-8% Ni (.0209)% C	Annealed at 1950°F	70 800 1000 1200 1400	45.0 25.0 20.0 18.0 14.0	85.0 60.0 54.0 45.0 31.0	73.0 51.0 45.0 36.0 20.0	2.40 2.60 2.80 2.95 3.10	86.9 63.5 55.6 47.8 32.2
14. Stainless Steel 18% Cr-12% Ni-2% .08% C	Mo Annealed at 1950 F	70 600 800 1000 1200 1300 1400 1600	41.0 31.0 27.0 24.0 21.0 19.0 18.0 17.0	88.0 73.0 72.0 69.0 55.0 47.0 35.0 21.0	79.0 66.0 65.0 60.0 44.0 35.0 24.0 13.0	1.08 1.12 1.23 1.39 1.50 1.55 1.75 2.00	89.0 75.8 74.6 70.3 56.8 52.3 38.2 22.8
15. Stainless Steel 25% Cr-20% Ni .25% (max) C	Annealed at 2000 F	70 1000 1300 1400 1500	32.0 24.0 20.0 19.0 17.0	88.0 70.0 47.0 37.0 34.0	80.0 65.5 40.0 30.0 17.0	1.17 1.20 1.33 1.38 1.40	89.2 73.2 48.5 38.8 36.0
16 SAE 4340 Steel .4% Cr4% N1- .4% Mo (.3550)% C Madium Carbon Low Alloy Steel	Normalized at 1600°F Tempared at 1200°F	70 850 950 1000	90.0 65.0 50.0 50.0	120.0 90.0 78.0 70.0	101.0 72.0 55.0 53.0	1.09 1.13 1.59 1.90	124.5 100.5 92.5 79.8

Ĵ.

Material 17.	Heat Treatment	Temp. F	s y	s _u	xo	Ъ	•
SAE 4140 Steel .92% Cr6% Mn- .25% Si .4% C Medium Carbon Low Alloy Steel	Quenched and Tempered at 1200 F	70 1000	115.0 56.0	125.0 75.0	113.0 50.0	3.20 4.00	130.5 81.5
10. 1.25% Cr5% Mo 5% Mn6% Si- .25% V Medium Carbon Low Alloy Steel	Normalized at 1725 P Drawn _O at 1200 P	70 1000	122.0 75.0	145.0 95.0	115.0 70.0	1.65 2.05	149.5 99.5
19. 1.0% Cr35% Mo 25% V .4% C Medium Carbon Lów Alloy Steel	Normalized at 1700°F Tempered at 1200°F	70 900	125.0 90.0	146.0 109.0	133.0 88.0	1.80 2.40	150.5 117.5
20. D6AC Unnctched Steel	Tempered at 1150 F 1200 F 1250 F	70 70 70			119.0 139.0 101.0	2.00 2.30 3.30	194.0 145.4 124,5

2. .

REFERENCES FOR TENSILE STRENGTH DATA

Materials	Source:
1.	ASTM STP # 180 (1955)
2.	ASTM STP # 100 (1950)
3.	ASTM STP # 180 (1955)
4.	ASTM STP # 100 (1950)
5.	ASTM STP # 100 (1950)
6.	ASTM STP # 100 (1950)
7.	Stainless Steel ASTM STP # 100 (1950)
8.	ASTM STP # 151 (1953)
9.	ASTM STP # 151 (1953)
10.	Stainless Steel ASTM STP # 100 (1950)
11.	Stainless Steel ASTM STP # 124 (1952)
12.	Stainless Steel ASTM STP # 124 (1952)
13.	Stainless Steel ASTM STP # 124 (1952)
14.	Stainless Steel ASTM STP # 100 (1950)
15.	ASTN: STH # 100 (1950)
16.	ASTM STP # 199 (1957)
18.	ASTM STP # 151 (1953)
19.	ASTM STP # 199 (1957)
20.	Mechanical Properties Data Center Search # 1333

G. 20 - 44

P

计比

A-1.3 WEIBULL PARAMETERS FOR RUPTURE STRENGTH

7. . .

ŝ

INDEX TO WEIBULL PARAMETERS FOR RUPTURE STRENGT: OF VARIOUS MATERIALS

Mate	erial	Page Number where Weibull Parameters for a given Material can be located
1.	12 Cr - 2.75 Mo-V	253
5.	12 Or Steel	253
3.	12 Cr - Cb Steel	253
4.	12 Cr - 2.5 W-V	253
5.	12 Cr - 5 Co - 3 W-V	253
6.	13 Cr - W - Mo - V	254
7.	17 - 22 - A - "S" Steel	254
8.	.1217 C Steel	254
9.	.1824 C Steel	254
10.	ASTM A - 201 - B Steel	2.54
11.	17 - 22 A-5	254
12.	.5 Cr5 Mo Steel	254
13.	.5 No Steel	254
14.	5.0 Cr = .5 Mo = Ti	255
15.	18 Cr - 8 11 + No + Cb	255
16.	18 Cr - 8 Ni + Cb	255
17.	18 Cr - 8 Ni	255
18.	4340 Steel	253
19.	C5% No Steel.	253
20.	5% Cr -/.5% Mo - 21	255
. 21.	185 Cr - 8 5 H1.	256



T CON

いの説真の問

500 - 10 V

NUPTORE STRENGTH OF HIGH ALLOY STRENS

S.

Effect of Temperature, Time, and Heat Treatment on the Weibull Parameters

	105		33.4	18.3 28.9		56.2		29.1 10.9 52.8		44 .7 13.9 65.5
ų	1 0		47.0 24.9	24.65 34.3		43.9 62.1		42.4 17.5 55.45		55.6 25.5 72.4
	103		59.0 36.3	29.3 43.5		55.6 68 .9		52.8 31.0		67.4 41.8 29.5
	102									
	105	••	2.8	3.25		2.95	:	2.9 2.55 2.53	-	2.85
	104	2 10-1	2.72 3.05	2.98 2.48	Steel	2.3	<u>7-8 S.</u>	2.7	Co-3. H-1	2.6
A	103	12 Cr-2.7	2.5 2.7 12 Cr 3	2.7 2.05	12 Cr-C	2.9	12 Cr-2	2.85	12 Cr-5	2.45 1.75
	102	3	. 2		6		•		(2)	
	105	-	13.0	5.0 20.0		33.0		16.0 7.0 33 .0		16.0 7.5 36.0
. 4	104		15.0 14.0	19.0 29.5		25.0 48 .0		23.0 8.0 46.0		30.0 13.0 10.0
N N N	10		30.0	18.0 37.0		37.0		34.0 17.0		39.0 18.0 7.0
iji de la constante La constante de la constante de La constante de la constante de	LT.* 10 ²				•.	U U		A A A		
Plan to M is No.	יא א ן		1000	905 905		80 80 80 80 80 80 80 80 80 80 80 80 80 8				
	-			253						

₩.

đ

105		10.05									5.14							
4 91		22.1					15.4		6.68		7.2					4.31		14.38
٩٩ م		57.4 36.1		52.1 18.65	7.15		20.1		10.29		9.96		33.6			6.88		19.35
102		68.8 59.0		68.5 37 .4	15.5		27.4		14.08		1ê.17				30.2	10.0		
102		3.55				-416		না			3.1							
1	T	3.25	"S" Sta				2.62	4 C Ste	3.3	1	2.9	%]		5.60		2.8	10	2.75
103	755	3.1 2.85		5.6	5 5 5 7		2.5	10.2	3.2	STM A-2	2.6	17-22 A	2.6	-5 Cr-		2.55	· 5 16 8	2.75
102		2.85	5	2.12	2.32	2	2.12	•	2.7	7	2.35	1		3)	2.9	X :7	6	
201	J	22.0	C					S		5	4.4	e		2			9	
* <u>*</u>		32.0	•			· (0.0		5.7					2.7		0.11
3		90.0 10.0		0.0.0 2 9.0	0.2		13.5		7.5		6.6		22.0			5.0		16.5
107		17.0		28.0 16.0			19.0		12.0		12.2				21.0			
		44	•		٩		Killet				tr.ml.		M		ti ti	j		IJ
					R													1090

254

		102	10 ⁻¹	10	105	102	103	104	5 0 1	10 ²	10 ³	104	105
						(1 5)	.0 Cr1	11-01 2					
1200 1200 1200	ast and 1-1	3 5 5 5 6 7 5 7 5 7 6 7 5 7 5 7 5 7 5 7 5	18.0 3.7 7.0	11.5	3.5 1.1	2.1 2.15 2.66	2.35 2.35 2.15	2.55	2.85 2.87	32.55 8.3 9.23	22.25 5.82 8.76	13.95 3.7	8.46 2.67
						(15)	8 CT-8 1	91 + 11	ප +				
801 800 800 800 800 800 800 800 800 800	333	22.0	21.0 19.5 1.2	19.0 34.2	19.0 5.5	2.06 2.35 2.25	2.5 2.62 2.3	2.6 3.33	3.25 3.12	35.6 33.2 9.87	28.9 24.41 7.15	23.33 17.75	20.41 14.4
						(16)	8 Cr-8]	11 + Cb					
	Sant and just	9.0 9.0 9.0	23.0 11.0	13.0 7.6 .5		2.55	2.65 3.1 3.1	1.92 2.12 2.19		44.2 31.7 23.4	36.9 25.8 17.8	29.7 19.5 11.8	
						(12) T	8 CT-8 1	湖					
1200	1 11	13.0	0.8	6.0	1.0	2.05	2.2	2.86	2.53	26.7	17.35	13.3	7.9
						(31)	4240	it and					
	Ħ	14.0	6.0	8.0		2.04	2.23	3.2		42.0	20.3	15.8	
						~ (fI)	<u>C57</u>	6 Steel	_1				
<u>8</u>	• •		32.5 15.5	21.0 6.5			2.1k 2.38	2.5			46.7 30.1	38. 6 18.4	
•					F		51 Cr	77 No-TI	ا م				
	• •		18.0 4.4	6.0 2.0		•	2.5 2.78	2.87 3.25			21.98 5.52	15.6 4.05	

	102	60 1	10 *	10 ⁵	105	103 10	1 SG ⁵	2 0 2	. 103	104	105	
	•	7.7			(iii)	187. CE-67. M	-1			•••		•
		ł				•	·			¢		
Ĭ	Treatment Cade A - Aust B - finish C - Netu	יישיא קייי קייי	L INGT	20 6 20 6	ŕ							
,- -				ъ.,	5. I							
~~			n tack stark	3 9 1	ŕ	•		. 1				
						X . 1						
						•		·				. ₁₁
					×.	• •						
ł					· .							Heft Affreige af ten una nege
					۰.	х.;					• .	Shariba tanis awake <i>s</i> e navo
											•	alle angere fer an organis
	۰. ،			. •	.• ¥	•				٠		
						1 S						` `
				-	 	'. ∢						

REFERENCES FOR RUPTURE STRENGTH DATA

Materials:		Source:
1 through 6	ASTH STP # 228	(1958)
7	ASTM STP # 199	(1957)
8 through 10	ASTM STP # 180	(1955)
11 through 14	ASTM 3TP # 151	<u>(</u> 1953)
15 through 17	ASTM STP # 124	(1952)
18	ASTM STP # 199	(1957)
19 through 21	ASTM STP # 100	(1950)

۰.

ť

APPENDIX 2 TABLES OF INTERFERENCE VALUES

A-2.1 STRESS DISTRIBUTION - NORMAL

STRENGTH DISTRIBUTION - WEIBULL

,

èн.,

A-2.1.1 STRESS STANDARD DEVIATION = 0

THE LEASING SUCCESSION AND IN A



8		010.	9820 .			.0572	.0665	.0759	00.50		6.0		WE/1 -	.251	.322	.3874	54.	.49 84	. 546	. 589	. 623
80,	.00796	.0178	.0276	2760.	.0468	.0562	.0656	.0749	.0641	.0932	0.08		.1647	.2442	.3161	.3812	1044.	469 4	.5416	. 5852	.6247
.007	,00697	.0168	.0266	.0363	.0458	.0553	.0646	.0740	.0832	.0923	0.07		.1563	.2366	.3093	.3750	.4345	.4883	. 5370	.5810	. 6209
.006	.00598	.0158	.0256	.0353	.0449	.0544	.0637	.0730	.0823	.0914	90°0		.1479	.2289	.3023	.3687	.4288	.4831	.5323	.5768	.6171
.005	.00498	.0149	.0246	.0344	.0440	.0535	.0628	.0721	.0814	.0905	0,05		. 1393	.2212	.2953	.3624	.4231	.4780	.5276	.5726	.6133
400 .	66E00.	0139	.0237	0334	0430	0525	6190	.0712	.0805	.0896	90 O		. 1306	.2134	.2882	.3560	.4173	.4727	.5229	. 5683	• 609
.003	003	.0129	.0227	0326	0420	0515	0610	0703	0795	.0887	50 0	22.22	.1219	.2055	.2811	.3494	4114.	4674	.5181	. 5640	.6054
.002	600	0119	0217	4150		0506	0000.	4640	0786	.0878	60 U		.1131	.1975	.2739	.3430	.4055	.4621	.5132	. 5596	.6015
.001		010	8060	9020-	1070	9090	0501	1600-	0776	.0869		17.7	. 1042	.1894	.2666	. 3363	.3995	.4566	. 5084	.5551	.5975
000	-	00005	0108	2000	C20.	1000	1950	1000.	0768	0980.	c		.0952	. 1813	.2592	.3297	.3935	.4512	3036	. 5507	45934
×	5	3 5	5.0		52					8°.0	,	 	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

۰.

N

F(X)

	0.90	0.95	.8504	.8577	95.96	1146.	96 26.	, 9926	.99726	66866	.99962	98666°	166 56 °
	0.80	0.85	. 8341	.8428	.9392	.9422	.9776	8166.	. 99697	. 99889	065666.	678666.	7 76666°
	0.70	0.75	.8173	.8262	, 9 328	.9361	.9753	6066°	.99665	.99877	.999547	. 999833	6£666ő°
	0.60	0.65	. 7981	.8080	.9257	.9293	.9727	6686.	.99630	,99864	667666.	.999816	. 999932
:	0.50	0.55	.7769	. 7878	6/16.	.9219	.9698	.9889	.99592	. 99650	7449947	96/666.	. 999925
	07.0	0.45	. 7534	.7654	.9093	. 9137	.9666	.9877	64566.	. 99836	. 999389	.999775	716666.
•	0.30	0.35	. 7275	. 7408	1668.	9046	.9631	,9864	.99501	.99816	42699324	. 999751	606666°
	0.20	0.25	. 6988	.7135	.8892	9468.	.9592	.9850	84466.	76766.	. 999253	. 999725	668666.
	0.10	15	.6671	.6834	.8775	.8835	.9550	4 689.	16£66,	.99776	.999175	, 999696	, 999888
	o	0.05	6321	.6501	.8647	6178.	.9302	.9817	, 99326	. 99752	\$806 0 6°	.999665	718999.
,	м	ł		•	2.0) 1:	3.6	4.0	5.0	6.0	7.0	8.0	0.6

F(X)

263

١.,

Downloaded from http://www.everyspec.com

0

356666.

10.0

ì

A REAL RAIL

٠.

2004年1月1日1月1日

.

A-2:1.2 STRESS STANDARD DEVIATION # 0

· ·

TABLES OF INTERFERENCE



Ø

「「ない」の「「「」」

10 13 20 35 30 35 5021 5013 5021 5014 5001 <th>1.0 1.5 20 25 39 35 40 59 1.0 .0060 .0054 .0041 .0023 .0721 .0018 .0011 1.1 .0054 .0071 .0031 .0021 .0018 .0014 .0018 .0011 1.1 .0054 .0024 .0024 .0021 .0018 .0014 .0018 .0011 1.1 .0035 .0021 .0014 .0031 .0024 .0023 .0024 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0013 .0013 .0013 .0011 .0013 .0013 .0013 .0013 .0013 .0011</th> <th>B(X) =</th> <th>1.00</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>Ľ</th> <th></th> <th>-</th> <th>7</th>	1.0 1.5 20 25 39 35 40 59 1.0 .0060 .0054 .0041 .0023 .0721 .0018 .0011 1.1 .0054 .0071 .0031 .0021 .0018 .0014 .0018 .0011 1.1 .0054 .0024 .0024 .0021 .0018 .0014 .0018 .0011 1.1 .0035 .0021 .0014 .0031 .0024 .0023 .0024 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0011 .0013 .0013 .0013 .0013 .0011 .0013 .0013 .0013 .0013 .0013 .0011	B(X) =	1.00						Ľ		-	7
10 12 20 30 35 40 45 50 1.20 00954 (0054 0013 0013 0023 0021 0019 0017 00 1.2 00954 (0034 0013 0014 0013 0012 0011 000 1.2 00954 (0034 0013 0012 0014 0013 0014 0013 0014 0011 0005 0001 0005 0001 0005 0001	10 10 20 20 20 30 35 40 5018 5011 1.2 .0054 .0054 .0054 .0054 .0013 .0023 .0024 .0016 .0013 1.2 .0054 .0035 .0024 .0036 .0014 .0012 .0013 1.5 .0054 .0036 .0027 .0013 .0122 .0014 .0012 .0013 .0014 .0013 .0014 .0012 .0011 .0013 .0014 .0013 .0014 .0013 .0014 .0013 .0014 .0013 .0014 .0013 .0014 .0013 .0014 .0013 .0013 .0014 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0011 .0011 .0011 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013	: ; •		-	i 1 1	-		:	, ,		۱ ۹ ۱	
1.0 .0090 .0054 .0011 .0013 .0013 .0014 .0014 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0014 .0011 .0014 .0011 .0014 .0014 .0014 .0011 .0014 .0011 .0014 .0011 .0014 .0014 .0011 .0014 .0014 .0011 .0014 .0014 .0011 .	1.0 .0060 .6054 .0041 .0033 .0023 .0014 .0018 .0014 .0012 .0011 1.1 .0034 .6034 .6034 .6033 .0014 .0014 .0012 .0011 1.4 .0035 .0034 .0018 .0014 .0014 .0012 .0014 .0012 .0014 1.6 .0035 .0018 .0014 .0017 .0006 .0009 .0009 .0009 .0009 .0011 .0014 .0012 .0011 .0014 .0012 .0011 .0014 .0012 .0011 .0017 .0017 .0006 .0009 .0009 .0009 .0001 .0011	•	· 01	1	20	52	ЭÛ ЭÛ	32	4	45	50	5
1.2 0054 0024 0022 0014 0015 0014 0015 0011 0009 0001 0011 0009 0001	1.2 0034 .0034 .0034 .0034 .0014 .0015 .0013 .0012 .0013 .0012 .0013 .0012 .0013 .0012 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0014 .0014 .0013 .0011 .0013 .0013 .0011 .0013 .0013 .0013 .0011 .0013 .0013 .0011 .0013 .0013 .0013 .0011 .0											
1.4 .0935 .0024 .0014 .0014 .0005 .0009 .0009 .0004 .0009 .0004 .	1.4 .0335 .0024 .3018 .0714 .5035 .0008 .0008 .0008 .0008 .0008 .0008 .0008 .0008 .0003 .0004 .0003 .0004 .0003 .0004 .0003 .0001 .0003 .0001 .0003 .0001 .0003 .0001 .0003 .0001 .0003 .0001 .0003 .0001 .		******			6600+		4100 ⁻	7100-	6100°		
1.6 • .0012 .0011 .0009 .6008 .0001 .0005 <td< td=""><td>1.6 . 6015 .0011 .0009 .6036 .0005 .0001</td><td></td><td>• •035</td><td>0024</td><td>0018</td><td>100</td><td>-9012</td><td>0103</td><td>6000-</td><td>0009</td><td>1000-</td><td></td></td<>	1.6 . 6015 .0011 .0009 .6036 .0005 .0001		• •035	0024	0018	100	-9012	0103	6000-	0009	1000-	
1.8 • 0014 • C003 • C005 • C005 • C003	1.8 • 0014 • C003 • 6007 • 0006 • 0003 • 0002 • 0002 • 0002 • 0002 • 0003 • 0002 • 0003 • 0001 • 0011 • 0011	3.6	* .6022	.0015	1100.	•000	.0008	.000	•000•	.0005	•0005	. 00.
2.0 .0006 .0005 .0005 .0002 .0002 .0002 .0002 .0002 .0002 .0002 .0001 .001 .0001 .001 .0001 .001 .0001 .001<	2.0 .0006 .0005 .0003 .0002 .0002 .0002 .0002 .0001 .	1.8	* .0014	•003*	.6007	•000	10605	+000+	•000•	£000*	-003	• [0]
2.2 .0°C5 .0°C3 .0°C1 .	2.2 .0°C5 .0°C3 .0°C1 .0°C0 .	ວ ເ 24	* .0008	9000°	*00J*	• 0003	• 0003	-0002	-0002	-000-	-0002	(2 0•
2.4 • • • • • • • • • • • • • • • • • • •	2.4 • • • • • • • • • • • • • • • • • • •	2.2	* •0-05	5000 °	•0002	* 000S	.0002	1000.	1000-	1000*	1000-	5-52-
2.6 . CCC1 .CC01 .0C01 .0C00 .0000 .CC 2.8 . C001 .CC01 .CC01 .CC00 .0000 .CC 2.8 . C001 .CC01 .CC01 .CC01 .CC01 .0000 .CC 2.8 . C001 .CC01 .CC01 .CC01 .CC01 .0000 .CC 2.8 . C001 .CC01 .CC01 .CC01 .C000 .CC01 .C000 .CC 2.8 . C001 .CC01 .CC0	2.6 •	2.4	*	-003	1000.	"cjel	1000-	1000.	.000.	1000-	1000-	C00+
Z.8 •	Z.8 . 296 . 6060 . 506 . 0000 . 0000 . 0000 . 0000	2.6	1000° +	1003-	1000*	1000*	0000*	.0000	• 0000	6000*	•0000	5 U U V
STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Wetbuil	STRENGTH DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil	2.8	* *000;	•0000	, 500 1	.000		0300*	0000 *	0000.	• 0000	- 0- ⁻
STRESS DISTRIBUTION - Normal STRESS DISTRIBUTION - Werbuilt	STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil		Υ. Υ									
STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil	STRESS DISTRIBUTION - Norgal STRENGTH DISTRIBUTION - Weibuil	·	ja ĝis								-	
			`₩ `	6. . .	STR STR	ESS DISTRI Ength DIST	CRIBUTION	Normal - Weibuil				
			• W ¹⁰⁵	·								
			••			•						

*,*8

Real to the second

STRESS DISTRIBUTION -- Normal STRENGTH LISTRIBUTION - Weibull

+	U I					•				
	÷ + + + + +	م مججم ون	65 ******	دې. دې. ۲:	75 :******	9ر: ب د د د د د د د د	95 :*******	9C :******	95 :******	100
¢.	* *	7160	• 1 3	-1v12	1100.	101	\$ 1 03*	6000*	6302.	9CC3•
<•1	•	6360	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ين ر	7000.	1.30.	1:00.	.9036	\$ DE 6	96as•
4.	•	9000	¢jCJ•	• 0712	• 0002	5-7-*	•000•	• 300 •	• 2004	• 1034
l•6	•	4 Jue	• 000 •	• 2373	50L0"	€010°	.0003	£000°	2 000.	.000
L . 8	• *	7 300		. 312	2000*	. 3002	• C D'J 5	2000*	1900.	1000.
0-0	• *	1000	• زيانا	100	1-60*	15	1.03.	•0001	1000.	1000.
2.2	• 4 4	1 10	1 000•	EJÚL •	1:00*	1	1000-	.000	1366.	0000.
4.5	• •	- 16 -	0000-	000	0000-			ecce.		6600.
5.6	* *			· · · ·		در ۱	ر دار ب • ۰	1.000 •	- 000-	5.5°C.+
2 • 8	* *	e e	₹ 6. 8. 8.	(UD) (*	いいいで、	• • • •	с С. •	0000-		0000.

Downloaded from http://www.everyspec.com

8(X) = 1.^^

.

÷

וו כס

п_0х

I

4

0-x-0

ь

Marthan Ali Ali

A Lines

ζţ.

.

.0000 •0000 •CC 34 .0003 •2002• •0000 а х х 3103. -C/07-.000 .()). 5 !! •0000 IIJc. 2635-.0003 •C002 .0001 .0000 .0000 .000. -0005ŝ <₹, а 10 10 10 . 3008 • 2005 €000--0002 -0000 0000* -000C 1000. 1000. .2012 45 H 6000. 000C. • 000 • .0054 .0000 0000. ပ .0001 1000* .0002 •100• 4 1000. 400J. •0003 1303. 1000. 0000* 0000-1166. •0016 E000-5 Zuuc-•00**13** •0008 • 0000 000C* 61.... 5003 · 000C. 1000. 1000ŝ 010J* •000 0 • .0000 .023 .0002 .0001 1200. 0000. .0009 51U. 25 . 03CB 0000 000 00 •2029 .0013 • 30C 5 •03150. .00r5 .0073 1:00. .0320 2 . 240 .6227 .0318 1100. .0332 1200. •000**4** .0003 1:00. 1000° 5 • 0042 .0017 0100* **•**0000• \$JC0. •0002 1000-1060. • 0062 .0027 ¢. 1.17 R(X) = 1.6 1.8 2.0 2.4 2.6 2.8 ر.: • 1.2 1.4 2°2

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull *.*

¢

• ;

= (λ)ġ *	1.10 C					U	θ-x ⁰ =	" ~ .	1-0x
	* *********	65 4444444	70 Jū	75 ~. F########	80 14444444	85 r*****	90 802	95	100
1.0	6000° · +	6008	• 00 0 8	-000	-000	.0006	•000	-0005	•0005
1.2	* .0056	\$000°	•0005	• 0005	\$ 000 *	•000	* 000*	+00C+	•0003
1.4	÷ •0004	•0004	.0003	• 0003	-3033	£000*	-000	-0002	-002
1.6	* •C0C2	• 0002	2000-	6002	1005	-0002	• 0002	1000-	1000-
1.8	1000" +	1000-	1000-	1000*	1000*	•000	1000-	1000-	1000-
2•0	1000" #	1000-	1000°	1000-	• 0001	1000*	1000-	1000.	1000.
2.2	1000 *	.070	1000 .	•0000*	-3006	0000-	0000*	3000-	0000*
2.4	• • • • •	•000	9000*	0000*	0000-	•000-	•0000	0000-	•0000
2.6	€000° * * *	0000	• 2060	, • 0462	35000	0060*	3300.*	• 0000	•0000
2.8	* *0000	C0C0*	-00Ce	0000-	.3000	-000-	• 0000	.0000	•0000

27

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Wetbull

.

Downloaded from http://www.everyspec.com

104×14

しちてきてきてんしい

• .

٠,

	B(X) = *	1•2 ⁰						U	0 0 1 1	= ¥ ,	α X
	**	ں ب									
	•	* ******	15	25	. 25 ::::::::::::::::::::::::::::::::::::	30 30	35 :*******	++++++++++++++++++++++++++++++++++++++	45 *******	50	55 1441444
	I.0	* •048	.603.	•0021	.3016	•cc13	1100*	6000*	•0008	.000	•000*
	1.2	* * •0032	.0020	*10 5 *	1100*	5 006*	• 0 001	•0000•	•0002	\$600.	•0004
	1.4	* * .6021	. CO.	6000*	-0907	9000°	•0065	• 000 •	+000+	-0003	ECU1-
۰.	1.6	* * .0013	•003	•0000•	•000•	•000•	•0003	£000°	2000*	•0005	-0002
	1.8	* * 6008	.0005	£000	£003.	2556*	.0002	*0005	1000°	1000-	1000.
2	2.0	* `*0%C5	•0003	- 3002	•000 -	1000*	.000.	.000	1000-	1000*	1670.
70	2.2	* •0053	-000	1000*	• 0001	1000*	1000*	1000.	• 0000	•0000	0000.
	2.4	* •0001	1000-	1000*	0000*	0000*	0000	0000*	•0000	•0000	0000-
275	2.6	1000°. +	C300*	•000	000g•	• 3000	• 0000	• 0000	•0000	•0000	• 3036

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

. •

.

۰.

٠.

B(X) =	1.20 C				•	ני	0 	" "	
•	* 60	65 ********		75	80 14444444	85 144 4444	- 06 1740000	95 14444444	100
1.0	* .0006	•0005	0005	•000	•000*	-000	•000•	•0003	• 0003
1.2	÷ 0004	+000+	£000-	•0003	•000 3	• 0003	•0002	-2002	*000 [×]
1.4	* - 0002	•0005	-0002	-0002	-3002	•0002	-0002	1000*	1000*
1.6	• 0002	1000	1000-	1000*	1000.	1000-	1000-	1000.	.0001
1.8	1000* *	1000-	1000.	1000-	1000*	1000*	1000-	1000*	-000
2-0	1000* *	1003-	- 000	0000-	0000	0 00 0-	.0000	.0000	.0000
2.2	0000 *	0000-	.0000	• 0000	•0000	-000	.0000	• 0000	cooo •
2.4	• • • • • • • • • • • • • • • • • • • •	-0000	- 0000	• 0000	-0000	0000-	-0000	-0000	•000
2.6	• • • • • •	• 0000	• 0000	•000•	•0000	•0003	•0000	0000*	-000

e. Ref

271

. 11

.

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Wetbull

BC .	<						27	2
* * 2	₩	1.0	1.2	1.4	1.6	1.8	2•0	2.2
C 1.3	*	**	* * *	**	* * *	**	**	* *
	16 ######1	•CC38	52JÚ-	•0216	0 1 00•	• 1016	• 30r 4	6-00-
	15 1444444	•5023	• C 11 5	0109*	•0009	+003+	.6692	1000-
	2' #******	916 .		1000.	•300•	5 962	1360*	1.87.
	25 *******	-0112	80003	•0015	•0003	-003	1000-	-000 -
	30 \$\$\$\$\$	6000	9000-	*000 *	-010 -	1000 ⁺	1000-	0000-
	35 -	• COCB	-0005	.6003	-0002	1000-	1060.	-0 00 0
C	40 40	•0000	.0004	£300*	2000-	1303*	1000-	.0000
а <mark>0</mark> -х а 0	45 *******	•0002	+000.	-0002	1000.	1000*	1000-	-000-
<	50	•0002	£000*	-002	.000	.000	0000-	0000-
рі р	5.5 *****	00)*	0	00 J.•	•	(°))•	00)•	0010

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibul

Downloaded from http://www.everyspec.com

-(re)-

•0000

-3060

•0000

0000*

1000.

0000.

0000

-0003°

- 1000-

2.6 2.4

14

•0000

•0000

0000-

0000-

.......

3000.

0000*

00€€

1000-

1000*

**	Ċ	4 8 1	!	•	• •	1		1	Ø
*	*******	65 *******	70	75 ********	80 *******	85 *******	96 36	95 :*******	100
L•0	* .0004	£303-	• 6003	•000 •	• 00:03	•0003	•0002	•0002	-0002
1.2	* °6062	°CÚ65	3 362*	•0002	2005-	2000*	1000-	1000-	.000
1.4	* •002	1009.	-0001	1003*	1000*	1000*	1000*	1000.	1000*
1.6	+ •0001 +	1000.	.0301	1000-	1000-	1000-	.0061	.0001	.000
1.8	* -0001	1000-	•0000	0000*	.2000	-0000	• 0000	•000	•0000
2.0	*	.0000	2000*	•0000	0000-	0000-	-0000	• 0000	•coo
2.2	• • • • • • • • • • • • • • • • • • • •	• COCO •	0000*	0000*	-0000	9 00 0*	•0000	0000*	-000
2.4	• - 2000 *	000 °	- 0200-	0000*	;000°;	0 00 0-	0000*	0000*	•0600
2.6	÷ .000°	-£263*	0000*	0000-	-0000	2000*	0300-	0000*	0000

ų,

.

2.13

273

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

4
8 (X

 $C = \frac{\theta - x_0}{\sigma} , A = \frac{x_c - \mu}{\tau^2}.$

		*****	****	****	*****	******	*****	****	******	******	****	****
	1.0	÷+	103 U	11007	1169.	9000 *	•00:00	• 0005	•000•	+000-	.0003	00 0*
	1.2	دن • • •	020	1180.	1000 °	\$003 *	4 060.	£000-	c003.	2000-	2000-	•00
	1.4	¢.	212	.603	\$006*	£00u*	•0C03	°0902	-0002	-0002	1000.	•003
	1.6	¢,	800	\$C0J*	• 0003	-0002	2000-	1000*	.000	1000*	1000-	-00 •
	1.8	ن • • •	500	•0003	-0002	1060.	1050*	1000*	1000*	1000*	•0000	CC)•
2	2.0	÷++	003	- 0002	1303*	1000.	1000-	0000-	.0000	0000-	• 0000	:00*
74	2•2	• • •	002	1060*	1000-	2001*	0000	• 0000	•0000	0000*	•0000	- 00
1	2.4	•• • •	100	•coou	0000*	000°	•0000	-000	.0000	0000*	•0000	- 60

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

1.40					•	U	0 	V	H H
u **	- 39	65 ******	76	75.	80 :*******	85 *******	96 96	95 *******	100
**	0002	.002	2000.	• 000 S	-000	•0003	.000	1000-	000-
+ +	2000	. 6001	1000.	100Ĵ.	1000*	1000-	1000*	1000-	000.
- 44 - 48	1000-	1000.	1000-	.6001	1005*	• 000 F	1000-	1000.	00
+ + * H	1000	.001	.0001	0000-	-0000	•0000	0000	0000*	• 000
**	0000	000ū*	0000-	.0000	0,00.	•0000	0000-	0000-	000-
* *	C000-	- C000-	0000-	-6000°	•0000	0000*	0000	•0000	000*
* *	0000	.0000	0000*	• 0000	-000	0000	• 0000	0003*	00.
* *	.0360 .	0000-	0000	•0000	0000*	C000*	• 0000	•0000	00.

75

6(X)

4

STRE3S DISTRIBUTION - Normal STRENGTE DISTRIBUTION - Weibull

8,

T- OX 0000-***** IC JU. 00003* .0030 0000-00000 **2C**00-ICU Y 5 .0000 -CC00 .0000 .0000 -0002 .0001 .0001 1000ŝ ê-- x₀ •0000 .0000 0005* •0000 .0003 -0062 1000. 1000. 5 ບ .0000 •0000 E000. -2002 0060-°0000 .000 .0001 Ŷ 0000-•(304 .0000 +0000 2000. .0002 1000-.000. ន្ត .0000° -0002 0000* 00000 •0003 1000. .0001 **5000**. (:) (*) .0000 10000 9JČJ* •000¢• 5000. +0002 1003. 1000. 5 8300. \$363° £300. .0000 2000 -.0001 1003-.202. ä .6013 8000. -0005 £003* **5003** .0001 0053. 10éJ. 5 -0010 • **3**00 • 1000-1000* .0523 5100. \$100. .0052 2 1.53 B(X) = 2.0 2.2 2-4 0 1.2 1.8 1 . F 9 275

1

STRESS DISTABUTION - Normal STRENGTH DISTRIBUTION - Weibull

Ş

S. N. Leanne

:16
**	, , U			1	•		а Р 	# K	ð
•	* 50 ********	65 111111111111111111111111111111111111	70 *******	75 10444444	80 111111111111111111111111111111111111	85 ********	06	95	160
1.0	* *0002	1000-	.000	.000	.0001	1000-	1000.	1000-	10001
1.2	1000°, •	1000.	1060-	1000*	1000*	1000-	-000	1000-	.0000
1.4	* •000	.0601	1000-	.0006	•0000	•0000	•0000	.0006	• 0000
1.5	•••••	000°	0000	.0000	0000*	-0000	• 0000	.0000	.0000
l.8	0000° +	C500*	0000	0000*	•0000	.0000	• 0000	• 0000	0000*
2.0	• • •	-000-	-0000	0000*	0000*	0000	.0000	•0000	0000-
2.2	• • • • • •	. cõoc	• 0000	0000	-0000	0000	.0000	.0000	•0000
2.4	• • • • • • • •	0000-	.0000	•0000	• 0000	•0000	.0000	• 0000	• 0000

277

 $1 L^{\circ}$

⊖-x°

1.50

8(X) *

. , Гр.

ų

1

b 1

ģ

STRENGTH DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

ļ

Downloaded from http://www.everyspec.com

÷

0 8(X) =

 $C = \frac{e^{-x_0}}{\sigma}, A = \frac{x_0^{-\mu}}{\sigma}$

25 •0002 •0001 •0001 •0000	25 30 .0002 .0003 .0002 .0001 .0001 .0001 .0000 .0000	25 30 35 35 35 	25 30 35 40 .0003 .0003 .0002 .0001 .0002 .001 .0001 .0001 .001 .0001 .0001 .0001 .0000 .0000 .0000 .0000	25 30 35 40 40 45 .0002 .0003 .0002 .0002 .0002 .001 .0001 .0001 .0002 .001 .0001 .0001 .0001 .0001 .0001 .0000 .0001 .0000 .0000 .0000 .0000 .0000 .0000 .0000	25 30 35 40 45 50 0003 .0003 .0002 .0001 .0001 .0003 .0002 .0001 .0001 .0001 .0003 .0002 .0001 .0001 .0001 .0002 .0002 .0001 .0001 .0001 .0001 .0001 .0001 .0000 .0003 .0001 .0001 .0000 .0000 .0003 .0001 .0001 .0000 .0003 .0033
	30 • • 0903 • • 9901 • • 9901 • • 9000	30 35 - 0003 0003 - 0002 - 0001 0001 - 0001 0001 - 0001 0001	30 35 35 40 -0003 0002 0002 -0002 0002 -0001 0001 -0001 0001 -0000 0000 -0000 0000	35 35 40 45 45 • 0002 • 0002 • 0002 • 0002 • 0002 • 0002 • 0001 • 0001 • 0001 • 0001 • 0000 • 0000 • 0000 • 0000 • 0000 • 0000 • 0000 • 0000	30 35 40 45 50 .0303 .0003 .0062 .0001 .0001 .6702 .0001 .0001 .0001 .0001 .6702 .0001 .0001 .0001 .0001 .6702 .0001 .0001 .0001 .0001 .6701 .6001 .0001 .0003 .0003 .6701 .0001 .0000 .0003 .0003 .0690 .0000 .0000 .0003 .0003 .0003 .0005 .0003 .0003 .0033

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

09-	
~	
Ħ	
X	
2	

 $= \frac{\Theta - x_0}{\sigma}, \quad A = \frac{x_0 - \mu}{\sigma}$

υ

60 :********	65 k*******	*******	7.7 14******	******	******	*****	******	*****
•0061	1600.	1000-	100J.	1000-	-000	1000-	1000*	.000
0001	1000.	1000*	0000*	•)660	• 0000	0000 *	0000-	•0000
	•0030	0000°	0000*	0000-	• 0000	0000.	0000-	•0000
-000-	ບັນດິນ*	9 00 0	•0000	0000-	0 40 0*	• • • • • •	.0000	0000-
* `°0060	·683*	.2300	0067*	-0000	.000	•0000	0000.	1020*
	000 0 "	• 2060	900c*	0000*	6000-	.000	-000	-000
* • ¢003	.000	1000.	.0000	.0000	0000°	.0000	0000-	•000

.

STRENGTH DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Welbuill

1

ļ

日、「日本町」で、「日本」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の「日本町」の

* O N 4 9	د	10 • 0005 • 3006	15 - 2007 - 2003 - 2003	20 • • • • • • • • • • • • • • • • • • •	25 • 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	30 •900 2 •000 1 •0001	35 •0002 •0001 •0001	40 1000 1000 1000	45 • 1001 • 3000 • 3000	50 • 0000 • 0000	0000 • 0000 • 0000
	* *		.0001	.0001	0000*	0000*	0000-	-0000	0000-	0000.	0000
1.6	* *	400¢*	•003	1000-	1000.	1000.	0000*	0000*	.0000	•0000	0000*
	* •			0000		, 1000 ,	-000û	0000-	0000.	• 0000	0000-

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

.*

٠,

Downloaded from http://www.everyspec.com

Ĵ

3(X) * *	L - 1	ţ.					Ð	а <mark>1</mark> 1	ح	X A V A V
*	, #	6C ******	65 *******	7C 1++++++++	75 *******	80 80	85 r##\$#####	06 06	95 *******	100
1.0	**	1000*	1303.	1000*	0500*	0000*	• 0000	0000-	0000-	• 0000
1.2	* * *	3903 °	• 0000	•0000	0060.	5056	0000-	0000-	• 0000	•0000
1 . 4	* * ·	• 3960	8009°	U000 -	0000-	0000	•000•	0020*	0000°	6000-
1.6	* * *	0000*	0000°	0530°	-0000	000C*	•0000	0000÷	0000	-0000
1.8	* * '	- 306	• 6003	3000-	0600*	0000-	0000-	0000*	0000-	• 0003
2.0	* * 4	0000°	-00 -	• 0000	• 0000	0000-	0000	• 0000	• 3000	-00JO
2•2	* *	0000	ecco.	0000	0000*	0000*	•000	0000-	•0000	•0000•

,

 :

. .

281

21

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

ţ,

Downloaded from http://www.everyspec.com

- 1. 80	υ	
B(X) =	***	

1.4

7 7 8

11

о<mark>-х</mark>о

ł

υ

	*									
<	********	0 15 +++++++	2C *********	25 ********	30 50	35 ########	، بە خە خە خە خە خە تە مە تە خە تە ھە تە	45 4444444	50 ******	55 ******
1-0	190° *	12 *001	• • 0 0 C3	-002	2000.	1000-	1000.	1000.	1000.	1600*
1.2	÷ , • 000	130 °COC	4 .0002	.000.	1000*	1000-	1000-	1000-	•0000	1000.
1.4	-00 +	-000 * 000	2 .0301	1000*	1000*	0000*	• • • • • •	0000*	•0000	-0000
1.6	• • • •	C3 * 600)	1000.	1000*	• 0000	•000	0000*	6000*	•0000	-0000
1.8	+ • •	22 +000)	19056	•0000	-0000	0000-	• 0000	0000-	•0000	•0606•
ű•2	• • • • •	1 •000	0.000° C	0003*	-0000	0000*	.000	•000	•0000	•0000
2.2	• 000	000- 10	0000* 0	0000-	0000-	0000-	.000	0000-	-000	0000-

282

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

₹ × ×		55	•0000	0000*	•0000	-0000	0000*	•0003
×	4	50 ******	•0000	•000	•0000	• 0000	•0000	•0000
×° t o		45 ********	1000*	0000*	• 0000	0000*	0000*	0000-
S	1 1 1	40 *******	.000	0000*	• 0000	0000-	0000	0000*
	; ,	35	1000*	1005*	0000*	0000*.	0000-	0000-
		30 30	1000.	.0001	0000*	- 1000	-0000	-0000
		25	-000	1000*	1003*	• 0000	0000*	•0000
		20	-0002	•0005	1000.	1000*	-0000	2000*
		15	•000	£00J*	• C 0 C 2	1000*	1000*	•000-
• •		10	• 000 •	°000°	+000-	-002	1000*	1000-
5• 1	ں ب	, * [‡]	* *	* *	* * *	* * •	**	* *
	•	<.	1.0	1.2	l.4	1.6	î • 8	2 "ت

283

s- 50

. У Ж.

N_KA

۰,	
ŧ,	
	4
'e	•
1	4
2	2
2	
٩	1
	ć

c = 0-x0, A

구 있

6

,

0000-.0300 JC0J* -0000 0000. -000° 5 .0000 0000-.6000 .0000 0000. 0000-50 C000* 0000-.300C. 0000 -0000 0000-45 • 00C 0 •0000 .6000 0000° •0000 .0000 Ŷ -0003* 0000-0000-• C 00 E -0000 -0000 ŝ 00000 0000° .0000 1000. 00000* 1000. ŝ - COOD 00000. 0000-1000. •000° 1000. 25 3000. **2030*** 1000-1000° **3006*** -0000-22 £003* 0000--0062 1000. 0000° 1000. 5 5000° E000* .0962 .0001 1000. 1006* 5 ř. 2.2 1 • A 1.6 1.8 **Z**•2

264

1.

 STRENGER DISTRIBUTION - MOINNEL

S. LIEVAL

¥ 13

. . . •**1**

پ*

•

٠

.

J.

Downloaded from http://www.everyspec.com

.0000 -000 Ci000-0000* 0000 ₽ ₩ 6 .0000 .0000 .0000 .0000 -0000 ×-0 -0000 0000* 0000. 0000-•0000 • 0000 .0000 0000-.0000 .0000 0000 .0000 0000--000 0000-.0000 0000- 0000-1000*. •0000 •0000 8 •0000 1000. -0000 25 .0001 1000* .0000 0000. 1000. 1000. 0000 .0003 1000-1000. 10007 1000. .0001 .000 .0002 1000. B{X} = 2.10 R.A. 1.0 2.1

STRUESS DISTRIBUTION - Merimal STRUESCE DISTRIBUTION - Verball

• (X) •	ļ									
4 6 14	c c						U	×° °	¥ ,	
**	17 25	15 ********	20 1444444	25	30 1000000	1999 1995 1995 1995 1995 1995 1995 1995	40	45 14444444	50	55
1•0	* .coc5	2003*	1000*	1000*	0000*	- COCC	-000	000.	0000-	0000
1.2	÷ .6303	1003**	3005 *	.000	9000*	-000	0000-	0000-	.0000	00.00-
•	• •0002	1000*	• 000 •	•000	0000*	0000*	0000*	.0000	0000-	00:00*
1.6	1000* 4	-0003	0000	•0000	- 0000	• • • • • •	0000	0000	0000-	0000*
80 •	1049. 4	0 0 -00	0000	.coo3.	0000*	- 0000-	0000-	0000-	•0000	0000-
B(X) =	2•3]			•	•		" دع		" •	Ť ×
• * '	J		•••	•	ı			Þ	1 1	۵
•	10	15 h###0###44	2C 3C	25	. 30 1444444	1	04	· · 45	50	52 25
0	CCO+	1000÷	1000-	-0003	0000-	• 000 •	•0000	-000	-000 -	. 0000
1.2	2.50° *	1000*	•0000	0000	0000*	0000-	0000	-0000	0000*	0000*
₩ ₩ • •	1000- 4	1000*	v302*	.5303	0000*	-000	0000-	•000	• 0000	00:00
1.6	1.000 - 1	0000-	0000	6000-	0000*	-000	0000-	0000-	-0000	0000-

. •

: ; ; ;

17. 19.

vel.

4 ١Ì

.....

ż

ŕ·

4.00

and The second

Downloaded from http://www.everyspec.com

1

Ų.

	0000 0 0000 0 0000 0	K	50 5000	0000-	0000.	
x-] - ' \$	0000°	0-x 0-	45	.0000	• 3 0 05	
n 2	.0000 .0000	ບຸ	0	0000-	0000	
35	0000		35	0000.	0003 •	- Normal
30	- 0000 - 0000 - 0000		30	0000-	0000°	NO1 LINET
2	0000 0000 0000		25 14488444	0000*	0003" "6000	UESS DISTR
Ş	0000 0000		20 20	5005*	3300°	ST
5	6601 690 690 600		15	1000.	. 0003. . 0003.	
. 1	000 I 000 I	C	01	.000.3	1 000° 1 000°	
	*******	= 2.5	ں **	* *	*****	

 $\{ T_{j_1} \}_{j_2} \in \mathcal{T}_{j_1}$

÷ •,

21.11

1.1.

and the second second

1000

54 S

*							• ·	Ċ		•
• • • ت ان∢<	C 1C	15 *******	20 20	25	30	35	- J4	45	50	55
3,	* • 000-2	1303-	JOJ0.	COCU	0500*	000°	0000-	0000	0000	0000
1.2	1000* *	•0001	•000	000°	• 1000	•0000	-0000	-0000	-0090	0000*
1.4	1302* .*	0060.	0000-	0000-	.0000	0000	-0000	0000-	• 0000	• 2000
**	1 * C	15	20	25	30	35	0 +	45	ĐĔ	ζ.
1.0	*********	•••••••	1969-	0000	.0000	0.000	.0000		.0000	
1.2	1005° ÷	6000*	0000-	-0000	0000*	• 000 0	0000*	0000-	•0000	3690.
1.4	1000* *	-000	• 000 •	0000-	0000*	• 000	•0000	0000*	•0000	.0030

1.110





in wije staar

8(X) = *	с о 		{	м Т	÷	:	:	" 5 1	0-x-0	" 4 .	л- о <u>х</u>
	, + , +	10	15	20	25	30	35	40	45 kēttē tā	50	55
. 	*								-		
00 v •	* *	-0115	.0078	0059	.0047	.0039	4600.	-0030	•0026	•200•	
•	•	.0218	0148	.0112	0600.	.0075	0065	.0057	.0051	0040	00
2	¥	.0290	.0197	0149	.0120	.0100	.0086	.0076	-0067	.0061	.00
0	•	.0375	.0255	-0193	.0156	0610-	-0112	•0098	.0087	.0079	00-
2.1	+	-0475	.0323	.0245	1610.	•0165	-0142	•0125	-0111	.0100	ð.
4 s 1	# +	.0588	1040.	10304 1370	• 0245 020e	.0205	.0176	2210°	STIC.	47T0.	5
	• •	0849	0581	10447	.0356	.0298	.0257	.0225	-0201	.0181	-01
-1-0	¥	4660.	.0681	20518	.0418	.0351	-0302	.0265	.0236	.0213	010
-1.4	*	1061.	.0896		.0552	.0463	.0399	.0350.	.0312	.0282	.02
-1-8	*	.1620	.1121	-0857	•0693	.0582	•0502	-0441	6960.	-0355	, 03
-2.2	*	.1940	.1348	.1033	.0837	+010.	-0607	.0533	•0476	•0430	E0
-2.6	*	.2252	.1574	.1209	.0981	.0826	.0713	.0627	•050•	-0505	•0
-3.0	¥	.2555	.1795	.1382	.1124	1460	.0818	.0720	•0643	.0581	50
-3.4	*	.2847	.2010	.1553	.1265	.1067	.0922	-0812	.0725	.0656	-02
-3.8	*	.3127	.2221	.1720	• 1403	-1185	.1025	•060	-0808	•0730	-06 -
	₩ 14 1	1935.	2425		1540	1302	-1121	+660.	6880.	0022	
	• •	0000 ·	6797.	- 2000	-101-	11510	0771+	11172	1040	0990	
			3054	2395	1968	-1670	.1451	.)282	1148	.1040	60
0-9-	*	- 4484	.3282	.2583	-2127	.1808	.1572	.1390	.1246	.1129	.10
	•	.4753	.3502	.2766	.2283	•1944	.1692	.1497	.1343	.1217	.11
-7.0	#	.5009	.3715	•2944	•2436	.2077	.1809	E091.		-1305	11.
-8•C	#	-5484	.4120	.3288	2733	.2336	.2040	.1810	.1627	.1477	•13
-9 .6	¥	+5914	.4500	.3616	.3018	.2588	•2264	.2012	.1811	.1646	•15
10.01	*	-6303	4854	1927	1975.	.2831	-2482	.2210	1991.	1811	- 16

STRESS DISTRIBUTION - NOTWAL STRENGTH DISTRIBUTION - Weibuil

÷

,

The second se

p	
H.	
ش	
×	
-	
CC ا	

C.

л-^сх

R 35 < <u>ө-х</u>о 95 n C 35 с 8 75

ř

ŝ

ċ

~

100

	¥									
8	*	.0020	• 0118 •	.0017	•016	5IC0*	.0014	.0013	.0013	.0013
•	#	• 0028	.0026	.0024	.032	.0021	.020	.0019	. 8100.	
4.	*	.0038	.0035	.(533	1600.	•0029	.0327	•0025	.0924	°5053
-2	#	.0051	• 0047	.0043	.04I	•0038	.036	.0034	.0332	• (C 3 3
	*	•	.0061	.0050	.0053	•00•	10047	.0044	.0042	۰. در در
2.	*	• 0.084		.0072	.0067	.0063	.0059	•5056	.3053	0020
4	#	•C164	•0096	-0089	.3083	.3078	•0014	•0000	.2366	.9.
6	¥	• 126	• r117	•010•	.010.	.0095	•0600	•0085	.0680	001
* •	*	.0151	.0140	•0EI0•	.3121	•J114	.01C7	.0161	•0056	(600°
0.1-	#	. 178	•C164	.0153	.0143	.0134	•0126	<u>.0119</u>	•0113	
-1.4	ŧ	• 235	.0718	.0202	.0189	-0177	.0167	•6158	.0150	(* [,
-1.8	#	192 .	.1274	., 255	.0238	• 1224	.0211	66107	•0189	1.1.1
-2.2	#	.7360	•0332	•.309	•0289	•0271	•0255	•0241	•0229	.023.8
-2.6	*	.0423	•0391	.0364	/*0340	•0319	.0301	.0284	.0270	• 25.56
ن • • •	Ħ	. 486	-:450	• 4 19	.0391	.0367	.0346	.0327	.0310	.029
-3.4	*	.1550	•(509	. 6473	•0442	.0415	.0391	.0370	.0351	10 E U *
-3.8	*	.0612	.0567	. 2527	.0493	•0463	.0437	.0413	.0392	7.50°
- 4 - 7	*	.0675	•0625	.0581	.0544	1150.	•0481	•0455	,0432	.041
-4-6	#	. 5737	. 682	.3635	.0594	.0558	.0526	•€498	.0472	オオン・
-5-0	*	. 798	•C739	.0688	• 0644	.)605	1230 .	• 2540	.0512	• 5 8
-5 • 5	*	.0875	.0180.	.0755	.0706	•0664	•C626	.0592	•0562	.053
0-9-	*	1996	.(88]	.0821	. J768	.0722	.3681	•1644	.0612	80
	#	.1025	•0951	. 1835	.0829	•0780	°€736	•000	.3661	• 5 6 2
-7-5	#	.1105	.1020	1560*	3680*	.0837	.0790	8420.	0110*	•CE7(
-8-0	#	.1247	.1157	.1079	1101.	•0951	• 0898	.C85C	.0801	" 16
0.6-	ŧ	2621.	.1292	.1206	.1130	•1063	• 100 4	.0951	•093 •	•056
0-01-	#	.1534	.1425	•1330	1 247	.1174	•1109	.1051	6660.	•0.15

292

Downloaded from http://www.everyspec.com

STRENGTH DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

N...

" * *	5.0	0	1	i	······································			ບ	4-X.0	4 	H-ON
	*	10 10	15 1*******	20 ******	25 844444	30 *******	35 195	40		50 50	55
. 00	* *	1100-	-005	0003	.0002	1000-	1000-	-0001	1000	0000-	0000
<u>م</u>	*	100.	.0008	.0004	E000.	-0003	1000-	-0001	1000-	1000.	.000
	*	.0025	.0011	.0006	+0000*	.0003	.0002	.0002	.000.	1000.	1000.
Ņ	¥	-0035	.0016	6000-	9000°	+0000-	£000°	•0002	2000*	-0001	1005
0	*	•0049	.0022	.0012	• 0008	-0006	+000-	.0003	.0002	.0002	.0002
2	*	1900.	.0030	.100.	1100-	.0008	•0009	+0004	.0003	-0003	-0002
4.	* (• 0089	-0040 	• 0023	-0014	-0010	1000.	3000*	+000+	•0004 •	-0003
a 0	•	9110.	-0052	0030	0019		0100.	×000.		<000-	+000.
	• •		-009-	0000°	1200.	12001	7100-	0100.	0000 °	-0008	9000°
	*	.0284	.0128	.0073	1400.	.0032	0024	.6018	.0014	.0012	.0010
œ	#	-0407	-0185	.0105	.0067	-0047	- ÚG34	.0025	.0021	-100.	-0014
2	*	.0557	.0254	.0145	.0093	. 0065	-0047	.0036	.0029	.0023	-0019
Ş	#	.0733	.0336	1610.	-0123	.0086	.0063	•0048	•0039	.0031	.0026
0	*	.0935	.0431	.0246	.0158	.0110	1.00-	• J062	• 00 • 9	0400-	.0033
4	#	.1159	.0538	• 0308	.0198	.0138	-0102	.0078	<u>0062</u>	.0050	1400.
80	*	.1406	0658	175C.	.0243	.0170	.0125	9600.	±0076	.0062	.0051
2	#	.1671	.0789	• 0453	.0293	.0205	.0151	•0116	•0092	•0014	.0061
0	#	-1954	.0530	.0536	.0347	.0243	-6119-	-0137	-010 -	.0088	.0073
0	*	.2251	.1082	•0626	-0406	.0284	.0210	.0161	.0127	E010.	.0086
Ś	+	.2640	.1286	•0748	-0486	-0341	•025L	.0193	.0153	-0124	-0103
0	*	.3043	.1504	.0879	£230*	.0432	.0297	.0228	.0181	-0147	-0121
5	*	.3457	.1735	.1020	.0667	.0468	•0346	•0266	.0211	1110.	0142
0	#	, 3876	.1977	.1176	1676.	.0539	.0399	-0307	•0244	.0198	•0164
i ica	#	.4713	. 2490	.1493	.0985	• 3695	.0516	•C398	.0316	.0256	.0212
0	*	. 5525	.3032	.1845	。1226	•0869	-0646	•0499	.0396	•0322	.0267
į	1			1						j	- 1

;

 $\langle \cdot, \cdot \rangle$

.

2 • ·

 $\theta(x) =$

19

294

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

тх

ļ

о́ х-ө

11

C

ъ

С

g
3.0
H
EX)
3(X) =

I,

۱

2

i

0-X,

;

I .

i

:

ļ

7 %

D

11	
A	
P	
R	
ບຸ	

Downloaded from http://www.everyspec.com

* 0001 00000 0000 0000 0		*	10 *******	15 14444444	20	25 	30 14 4 4 4 4 1	35 1000000000000000000000000000000000000	40 0 4	45 64445660	50 50	55 1444444
* 0002 0000 00	1	*	1000					VEV		ũũũũ		0000
* .0005 .0001 .0000 .00	5.50	- 41										
* .0005 .0002 .0001 .0000 .00		•	0004	1000	0000	0000	0000	0000	0000	0000	0000	0000
0 0	- CI	#	.0005	-0002	-0091	-0000	0000	.0000	0000-	.0000	.0000	0000
• 0011 0003 0001 0001 0000 00	lo	•	.0008	.0002	.0001	1000-	-000	.0000	.0000	0000.	.0000	0000.
6 .0016 .0007 .0001 .0001 .0000 .00	~	#	-0011	-0003	.0001	-0001	-0000	0000-	.0000	-0000	0000*	0000-
6 0022 0007 0001 0001 0001 0000	: 1 • *	•	.0016	.0005	.0002	-0001	1000-	0000.	-0000	.0000	.0000	0000.
8 • 0030 • 0007 • 0002 • 0001 • 0000	9	#	.0022	.0007	.0003	1000.	1000-	.0001	0000-	.0000	.0000	-0000
0 .0012 .0003 .0002 .0001 .00		*	.0030	6000°	.0004	.0002	1000.	.0001	0000-	0000.	.0000	.0000
4 * .0069 .0071 .0004 .0001 .0011 </td <td>0</td> <td>#</td> <td>. CO41</td> <td>-0012</td> <td>-0005</td> <td>-0003</td> <td>-0002</td> <td>-000</td> <td>1000.</td> <td>0000-</td> <td>-0000-</td> <td>6000-</td>	0	#	. CO41	-0012	-0005	-0003	-0002	-000	1000.	0000-	-0000-	6000-
6 •		•	-0069	.0021	.0009	•000e	.0003	.0002	.0001	1000-	1000.	0000-
2 * .0169 .0051 .0022 .0011 .0006 .0004 .0003 .0002 .0002 .0003 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 .0013 </td <td>-</td> <td>#</td> <td>1110.</td> <td>-0033</td> <td>+100.</td> <td>.0001</td> <td>+000-</td> <td>.0003</td> <td>-0002</td> <td>1000*</td> <td>1000-</td> <td>-0001</td>	-	#	1110.	-0033	+100.	.0001	+000-	.0003	-0002	1000*	1000-	-0001
6 * .0247 .0075 .0032 .0016 .0009 .0006 .0004 .0003 .00 6 * .0349 .0106 .0045 .0023 .0013 .0006 .0006 .0005 .000 .0005 .0005 .0005 .0007 .00 8 * .0630 .0193 .00682 .0042 .0012 .0008 .0007 .00 2 * .0815 .0193 .0082 .0041 .0012 .0001 .0007 .00 2 * .0815 .01522 .01168 .0055 .0021 .0001 .0010 .0001 .0010 .0007 .00 2 * .1031 .03222 .01168 .0057 .0020 .0011 .0012 .001<	2	+	.0169	.0051	.0022	.0011	-0006	+000-	.0003	-0002	.0001	1000.
0 * .0349 .0106 .0045 .0023 .0013 .0008 .0006 .0005 .00 4 * .0475 .0145 .00622 .0032 .0016 .0012 .0008 .0007 .00 8 * .0630 .0193 .00622 .0032 .0016 .0012 .0008 .0007 .00 2 * .0815 .0252 .0158 .0055 .0032 .0012 .0017 .0017 .0012 .00 2 * .1031 .03222 .01168 .0057 .0026 .0017 .0012 .00 6 * .1279 .0404 .0173 .0089 .0057 .0026 .0012 .00 6 * .1634 .0178 .01667 .0026 .0017 .0012 .00 6 * .1634 .0178 .00167 .0026 .0012 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 <td>ş</td> <td>#</td> <td>.0247</td> <td>-0075</td> <td>-0032</td> <td>.0016</td> <td>•000•</td> <td>-0006</td> <td>+000-</td> <td>•0003</td> <td>-0002</td> <td>-0002</td>	ş	#	.0247	-0075	-0032	.0016	•000•	-0006	+000-	•0003	-0002	-0002
4 * .0475 .0145 .0062 .0032 .0016 .0012 .0008 .0005 .00 2 * .0630 .0193 .0082 .0042 .0024 .0015 .0016 .0007 .00 2 * .0815 .0252 .0168 .0055 .00312 .0016 .0017 .00 6 * .1031 .0322 .0118 .0055 .0026 .0017 .0012 .00 6 * .1031 .0322 .0116 .0067 .0026 .0017 .0012 .00 6 * .1279 .0404 .0173 .0089 .0052 .0017 .0012 .00 7 * .1634 .0725 .0116 .0067 .0026 .001 .00 7 * .2037 .0665 .0287 .0186 .00566 .0026 .00 6 * .2783 .0186 .0186 .0056 .0012 .002 .00 7 .2033 .0196 .0186 .00667 .00666 .0026 .00 .00 .00 <td>0</td> <td>*</td> <td>.0349</td> <td>40106</td> <td>•0045</td> <td>•0023</td> <td>•0013</td> <td>.0008</td> <td>•0000</td> <td>+000.</td> <td>•0003</td> <td>.0002</td>	0	*	.0349	4010 6	•0045	•0023	•0013	.0008	•0000	+000.	•0003	.0002
8 * .0630 .0193 .0082 .0042 .0024 .0015 .0010 .0007 .00 2 * .0815 .0252 .0168 .0055 .0024 .0017 .0010 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0011 .0012 </td <td>4</td> <td>#</td> <td>.0475</td> <td>.0145</td> <td>• 0062</td> <td>•0032</td> <td>.0018</td> <td>.0012</td> <td>.0008</td> <td>-0005</td> <td>-0004</td> <td>•00C3</td>	4	#	.0475	.0145	• 0062	•0032	.0018	.0012	.0008	-0005	-0004	•00C3
2 * .0815 .0252 .0168 .0055 .0032 .0014 .0010 .001 6 * .1031 .0322 .0138 .0071 .0041 .0026 .0017 .0012 .00 6 * .1279 .0404 .0173 .0089 .0052 .0033 .0022 .0015 .00 7 * .1634 .0524 .0225 .0116 .0067 .0043 .0029 .0026 .001 .002 .002 .002 .001 .002 .002 .0015 .00 .002 .0015 .00 .001 .001 .00 .00 .0015 .00 .001	8	*	.0630	E610.	-0082	•0042	.0024	.0015	0100.	-0007	.0005	+000-
6 * .1031 .0322 .0138 .0071 .0041 .0026 .0017 .0012 .70 7 * .1279 .0404 .0173 .0089 .0052 .0033 .0022 .0015 .0015 .00 7 * .1634 .0752 .0167 .0067 .0043 .0029 .0020 .00 6 * .1634 .0725 .0116 .0067 .0043 .0029 .0020 .00 6 * .2037 .0665 .0287 .0148 .0066 .0024 .0026 .00 6 * .2485 .0826 .0284 .0128 .0026 .00 7 .2743 .0126 .0138 .0058 .0046 .0032 .00 6 * .2743 .0136 .0136 .0126 .00 .00 6 * .0545 .0336 .0136 .0126 .00 .012 .00 .01 7 .1454 .0645 .0336 .0136 .0126 <td>N</td> <td>#</td> <td>.0815</td> <td>.0252</td> <td>.0108</td> <td>-0055</td> <td>.0032</td> <td>.0020</td> <td>+100.</td> <td>0100.</td> <td>5000[°]</td> <td>-0005</td>	N	#	.0815	.0252	.0108	-0055	. 0032	.0020	+100.	0100.	5000 [°]	-0005
0 * .1279 .04.04 .0173 .0089 .0052 .0033 .0022 .0015 .00 5 * .1634 .0525 .0116 .0067 .0043 .0029 .0020 .00 6 * .2037 .0665 .0287 .0148 .0066 .0024 .0029 .0020 .00 7 * .2687 .0148 .0066 .0054 .0026 .00 6 * .2748 .07260 .0148 .0068 .0026 .00 0 * .27973 .1013 .01443 .0230 .0134 .0064 .0032 .00 0 * .4039 .1454 .05455 .0336 .0134 .0064 .0057 .00 0 * .5165 .1985 .0897 .0471 .0276 .0127 .0183 .00 0 * .0176 .0117 .0083 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00	9	#	.1031	.0322	.0138	.0071	-0041	•0026	-100.	.0012	600C.	.0001
5 * 1634 .0524 .0225 .0116 .0067 .0043 .0029 .0020 .00 0 * .2037 .0665 .0287 .0148 .0066 .0024 .0026 .002 .000 .002 .002 .002 .002 .002 .002 .002 .001 .002	0	•	.1279	+0+0+	.0173	.0089	.0052	•0033	-0022	-0015	-0011	8000*
0 * -2037 .0665 .0287 .0148 .0066 .0054 .0036 .0026 .00 5 * .2485 .0828 .0360 .0186 .0108 .0068 .0046 .0032 .60 0 * .2973 .1013 .0443 .0230 .0134 .0084 .0057 .0040 .00 0 * .4039 .1454 .0645 .0336 .0196 .0124 .0083 .0059 .00 0 * .5165 .1985 .0897 .0471 .0276 .0175 .0117 .0083 .00	In		.1634	.0524	.0225	-0116	.0067	.0043	.0029	.0020	•0015	1100.
5 * 2485 .0828 .0360 .0186 .0108 .0068 .0046 .0032 .00 0 * .2973 .1013 .0443 .0230 .0134 .0084 .0057 .0040 .00 0 * .2973 .1013 .0445 .0230 .0134 .0084 .0057 .0040 .00 0 * .4039 .1454 .0645 .0336 .0196 .0124 .0083 .00 0 * .5165 .1985 .0897 .0471 .0276 .0125 .0117 .0083 .00 0 * .01276 .0117 .0083 .01 .0117 .0083 .01	0	*	.2037	.0665	.0287	-0148	.0086	.0054	•0036	.0026	•100.	+100"
0 * .2973 .1013 .0443 .0230 .0134 .0084 .0057 .0040 .00 0 * .4039 .1454 .0645 .0336 .0196 .0124 .0083 .0059 .00 0 * .5165 .1985 .0897 .0471 .0276 .0117 .0083 .00	 m	*	.2485	.0828	.0360	.0186	801C.	.0068	•0046	•0032	.0023	.0018
0 * .4039 .1454 .0645 .0336 .0196 .0124 .0083 .0059 .00 0 * .5165 .1985 .0897 .0471 .0276 .0175 .0117 .0083 .00	0	#	.2973	.1013	. 0443	.0230	-0134	-0084	-0.057	.0940	.0029	-0022
0 * .5165 .1985 .0897 .0471 .0276 .0175 .0117 .0083 .00	¦0		4039	.1454.	• 0645	.0336	•0196	.0124	.0083	•0059	•0043	2600.
A A AA 3100 1300 A434 A374 A337 A14A A113 AA	0	#	.5165	.1985	-0897	.0471	.0276	•0175	1110.	.0083	.0060	-0045
$\mathbf{n} \mathbf{n} \mathbf{n} \mathbf{n} \mathbf{n} \mathbf{n} \mathbf{n} \mathbf{n} $	C	• #	.6269	• 2600	.1202	.0636	.0374	.0237	.0160	.0112	-0082	.0062

STRENGTH DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibwill

. 1

60 65 70 75 80 85 90<	Ť						>		4 4	, -
0000 0000 <th< th=""><th>**[,]#`</th><th>60</th><th>65 *******</th><th>ÚL</th><th>75</th><th>80 80</th><th>85 14 44 44 44</th><th>06</th><th>\$6 \$6</th><th>100</th></th<>	** [,] #`	60	65 *******	ÚL	75	80 80	85 14 44 44 44	06	\$6 \$6	100
9700 0000 <th< td=""><td># #</td><td></td><td></td><td></td><td>0000</td><td></td><td></td><td></td><td>-</td><td></td></th<>	# #				0000				-	
COCC COCC <th< td=""><td>- 4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0000</td><td>0000</td></th<>	- 4								0000	0000
 0000 0000 0000 0000 0000 0000 0000 00	#	0000				0000		0000		0000
•0000 •0000 <th< td=""><td>#</td><td>.0000</td><td>0000-</td><td>-0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000-</td></th<>	#	.0000	0000-	-0000	0000	0000	0000	0000	0000	0000-
• 0000	#	-0000	-000C	.0000	0000	0000.	0000	0600-	0000	0000
 0000 6000 0000 0000 0000 0000 0000 000	#	.0000	•0000	0000-	0000-	0000	-0000	0000	.000.	-000°
• 0000 • 0000<	#	.0000	-0000	0000.	0000.	- 0000-	-0000	.000	.0000	.0000
 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0001 -0001 -0001 -0001 -0000 -0000 -0000 -0000 -0001 -0001 -0001 -0001 -0000 -0000 -0000 -0000 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0000 -0002 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0002 -0002 -0001 -0001 -0001 -0001 -0001 -0001 -0001 -0002 -0002 -0002 -0001 -0001 -0001 -0001 -0001 -0001 -0003 -0002 -0002 -0002 -0002 -0001 -0001 -0001 -0003 -0003 -0002 -0002 -0002 -0001 -0001 -0001 -0003 -0003 -0002 -0002 -0002 -0002 -0001 -0001 -0003 -0003 -0003 -0002 -0002 -0003 -0003 -0003 -0003 -0003 -0003 -0003 -0003 -0003 -0002 -0002 -0003 -0	₩ İ	0000-	-0000	0000.	.0000	0000.	-0000	.000.	.0000	0000.
 • 0000 6300 6300 0000 0000 0000 0000 000	*	-0000	-0000	-0000	0000-	•0000	-0000-	.0000	0050-	0000.
 .9000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0001 .0001 .0000 .0000 .0000 .0000 .0000 .0000 .0001 .0001 .0001 .0001 .0000 .0000 .0000 .0000 .0000 .0001 .0001 .0001 .0001 .0001 .0001 .0001 .0001 .0001 .0000 .0001 .00001 .0001 .0001 .0001 .0001 .0001 .0001 .0001 .0001 .0001 .0001	# '	-0000	.0000	-0000	•0000	0000-	0000*	.000.	0000	0000-
 -7601 -6000 -0000 -0001 	#	0006.	-0000	• 0000	0000-	0000.	.0000	0000-	.0000	.0000
<pre>* 5601 •0001 •0001 •0000 •0000 •0000 •0000 •0000 * 0001 •001 •0001 •0001 •0001 •0000 •0000 •0000 * 0002 •001 •0001 •0001 •0001 •0001 •0001 •000 * 0005 •0002 •0002 •0001 •0001 •0001 •0001 •000 * 0005 •0004 •0003 •0002 •0002 •0001 •0001 •000 * 0005 •0004 •0003 •0003 •0003 •0003 •0003 * 0001 •0004 •0004 •0004 •0003 •0003 •0003 •0003 * 0011 •0009 •0004 •0004 •0003 •0003 •0003 •0003 * 0011 •0009 •0007 •0004 •0003 •0003 •0003 •0003 * 0017 •0013 •0017 •0006 •0005 •0004 •0003 •0003 * 0017 •0013 •0017 •0006 •0005 •0004 •0003 •0003 * 0017 •0013 •0017 •0006 •0005 •0004 •0003 •0003 •0003 * 0017 •0013 •0017 •0006 •0005 •0004 •0003 •0003 •0003 * 0017 •0013 •0017 •0005 •0004 •0003 •0003 •0003 •0003 * 0005 •0006 •0005 •0004 •0003 •00</pre>	# ·	1090-	.0000	0000-	0000	•0000	0000-	0000	- COCO-	0000.
• 0001 0001 0001 0001 0001 0001 0001 00	#	.000.	.0061	1000.	• 0000	•000C*	-0000-	.0000	.0000	0000°
<pre>* .C302 .6631 .0001 .0001 .0001 .0001 .0030 .3086 .0066 * .0063 .0002 .0601 .0001 .0001 .0001 .0001 .0001 * .0065 .0004 .0003 .0002 .0061 .0001 .0001 .0001 * .0006 .0005 .0004 .0003 .0002 .0001 .0001 .0001 * .0008 .0007 .0004 .0003 .0003 .0003 .0003 .0003 * .0008 .0007 .0006 .0006 .0003 .0003 .0003 * .0011 .0009 .0006 .0006 .0003 .0003 .0003 * .0011 .0009 .0007 .0006 .0003 .0003 .0003 * .0011 .0009 .0001 .0009 .0003 .0003 .0003 * .0013 .0013 .0006 .0006 .0006 .0003 .0003 * .0013 .0013 .0011 .0009 .0001 .0003 .0003 * .0013 .0013 .0011 .0009 .0007 .0003 .0003 .0003 .0003 * .0013 .0011 .0009 .0007 .0003 .00</pre>	٠	lideo.	.C001	1000-	1000-	-0000	.000	-0000	°0000°	.0000
CUCZ CO2 C002 0001 0001 0001 0001 0001 0001 000	#	.002	.0001	-0001	1000-	1000*	1000-	0000-	- 2000	.0000
* 0663 .0002 .0002 .0002 .0001 .0001 .0001 .0001 .0001 .0005 .0004 .0003 .0003 .0002 .0002 .0001 .0001 .0001 .0006 .0005 .0004 .0003 .0002 .0002 .0001 .0001 .0008 .0007 .0004 .0003 .0	₩.	.0002	-000 2	1090-	1000-	1000-	.0001	1000.	1000-	-0000
<pre>* .0004 .0003 .0003 .0002 .0001 .0001 .0001 .0001 * .0005 .0004 .0003 .0003 .0002 .0002 .0001 .0001 * .0006 .0005 .0004 .0003 .0003 .0003 .0003 .0003 * .0011 .0009 .0004 .0006 .0003 .0003 .0003 .0003 * .0011 .0009 .0004 .0006 .0003 .0003 .0003 .0003 * .0011 .0009 .0007 .0006 .0003 .0003 .0003 .0003 * .0011 .0009 .0007 .0006 .0003 .0003 .0003 * .0013 .0013 .0013 .0017 .0009 .0003 .0003 * .0013 .0013 .0013 .0011 .0009 .0003 .0003 .0003 * .0013 .0013 .0013 .0011 .0009 .0003 .0003 .0003 * .0013 .0013 .00113 .0011 .0009 .0003 .0003 .0003 * .0013 .0013 .0013 .0011 .0009 .0003 .0003 .0003 * .0013 .0013 .0013 .0011 .0009 .0003 .0003 .0003 * .0013 .0013 .0011 .0009 .0001 .0003 .0003 .0003 * .0013 .0013 .0011 .0009 .0001 .0003 .0003 .0003 * .0003 .0003 .0003 .0003 .0003 .0003 .0003</pre>	#	.0603	.0002	.0002	• UČOZ	1000-	1000.	.0001	10001	1000.
• .0005 .0004 .0003 .0003 .0002 .0002 .0002 .0001 .0001 • .0006 .0005 .0004 .0003 .0003 .0003 .0003 .0003 • .0011 .0009 .0004 .0006 .0003 .0003 .0003 .0003 • .0011 .0009 .0007 .0006 .0005 .0003 .0003 .0003 • .0011 .0009 .0007 .0006 .0005 .0003 .0003 • .0017 .0013 .0017 .0006 .0005 .0004 .0003 .0003 • .0017 .0013 .0013 .0011 .0009 .0005 .0004 .0003 • .0017 .0013 .0013 .0011 .0009 .0005 .0006 .0003 • .0015 .0012 .0010 .0009 .0001 .0003 .0003 • .0015 .0017 .0009 .0001 .0009 .0001 .0003	# :	+000+	-0003	.0003	- 0002	-0002	-000°	.0001	.0001	1000-
* .0006 .0005 .0004 .0003 .0003 .0002 .0002 .0002 .0001 * .0008 .0007 .0005 .0004 .0003 .0003 .0003 .0003 .0002 * .0011 .0009 .0007 .0006 .0005 .0003 .0003 .0003 .0003 * .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 .0003 * .0017 .0013 .0017 .0006 .0005 .0004 .0003 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0006 .0004 .0003 .0003 * .0017 .0013 .0013 .0011 .0009 .0007 .0006 .0005 .0004 .0003 * .0017 .0013 .0013 .0011 .0009 .0007 .0005 .0006 .0003 .0003 * .0017 .0013 .0013 .0011 .0009 .0005 .0006 .0003 .0003 * .0017 .0013 .0013 .0011 .0009 .0005 .0006 .0005 .0006 .0003 * .0013 .0013 .0013 .0011 .0009 .0005 .0005 .0006 .0003 .0003	#	.0005	+000+	-0003	.0003	-0002	.0002	.0002	.0001	.000°.
* .0008 .0007 .0005 .0004 .0004 .0003 .0003 .0003 .0003 * .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 .0003 * .0014 .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0005 .0004 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0005 .0004 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0009 .0005 .0004 .0003 * .0016 .0013 .0011 .0009 .0007 .0009 .0005 .0004 .0003 * .0010 .0009 .00015 .0010 .0003 .0003 * .0035 .0013 .0011 .00019 .00010 .0003	ŧ	• 0006	-0005	+006*	•0003	.0063	±0002	-0002	2000-	1000*
* .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 .0003 * .0017 .0013 .0007 .0006 .0006 .0004 .0003 .0003 * .0017 .0013 .0011 .0009 .0007 .0006 .0005 .0004 .0003 * .0025 .0013 .0011 .0009 .0007 .0009 .0005 .0004 .0004 * .0025 .0013 .0013 .0011 .0009 .0005 .0005 .0004 .0003 * .0025 .0019 .0013 .0011 .0009 .0005 .0005 .0004 .0004 * .0025 .0019 .0013 .0011 .0009 .0005 .0005 .0004 .0003 * .0025 .0019 .0013 .0011 .0009 .0005 .0004 .0004 * .0025 .0019 .0013 .0011 .0009 .0005 .0004 .0005 * .0025 .0018 .0015 .0011 .0010 .0003 .0035 .0005	#	.000.8	.0001	•0005	+000-	+000+	0003	.0003	.0002	.0002
* .0014 .0011 .0009 .0007 .0006 .0005 .0004 .0003 .0003 * .0017 .0013 .9611 .0009 .0007 .0005 .0004 .0004 * .0025 .0019 .0016 .0013 .0010 .0009 .0007 .0006 * .0035 .0027 .0022 .0018 .0015 .0012 .0010 .0039 .0038 * .0048 .0037 .0030 .0024 .0015 .0014 .0012 .0010	¥	1100.	. 6000 .	.0001	-0006	-00055	• COO +	.0003	.0003	-0022
* .0017 .0013 .0011 .0009 .0007 .0006 .0005 .0004 .0004 * .0025 .0019 .0016 .0013 .0010 .0009 .0007 .0006 .0005 * .0035 .0027 .0022 .0018 .0015 .0010 .0039 .0033 * .0048 .0037 .0030 .0024 .0015 .0014 .0012 .0010	¥	+100-	.0011	6000.	-000-	-0006	·0005	4000*	E000.	.0003
* .0025 .0019 .0016 .0013 .0010 .0009 .0007 .0006 .0005 * .0035 .0027 .0022 .0018 .0015 .0010 .0039 .0038 * .0048 .0037 .0030 .0024 .0015 .0014 .0012 .0010	# `	-0017	.0013	1196.	6000-	.0007	•000e	-0005	+000-	+0003
* .0035 .0027 .0022 .0018 .0015 .0012 .0010 .0039 .0038 * .0048 .0037 .0030 .0024 .0020 .0017 .0014 .0012 .0010	•	.0025	•C019	910 C•	-0013	-0010	-0003	1000.	.0006	.0005
* .0648 .0037 .0030 .3024 .3020 .0017 .0014 .0012 .0010	#	-0035	.0027	-0022	.0018	-0015	-001 ž	.0010	\$00C*	-0093
	#	• 0048	.0037	.030	+200.	0200	1100.	-0014	2100"	0100.

7.

Downloaded from http://www.everyspec.com

No. 1. Albert Chan Internet

۰,

4

. *

"*

.

..

٠.

00
4
44
-
×
ž.

4

	ļ
, , ,	İ
•	
۲.	1
	- 1

70

0-X0 b

1

. بار

A TOTO TO	•		10	15	20	25	30	35	05	45	05	55
<th></th> <th>•</th> <th></th>		•										
6 0.000 <th0.000< th=""> 0.000 0.00</th0.000<>		*	-00C	.0000	•0000	-0000	.0000	.0000-	0000	- 0000	0000-	0000
	••	*	-0000	.0000	.0000	0000-	-0000	0000	0000-	0000	0000-	0000-
	4.	₩	.0001	.0000	- 0 <u>0</u> C0	<u>0000</u>	0000.	0000.	0000-	-0000	.0000	0000.
0001 0000 <th< th=""><th>2</th><th>*</th><th>.1000.</th><th>•C000</th><th>•0000</th><th>0000*</th><th>0000-</th><th>0000</th><th>0000-</th><th>0000-</th><th>0000-</th><th>0000-</th></th<>	2	*	.1000.	•C000	•0000	0000*	0000-	0000	0000-	0000-	0000-	0000-
	0.	: ₩ - ¹	1000.	.0000	.0000	.0000	0000.	.0000	.0000	0000	.0000	0000.
	2	*	-0002	.0000	0000-	0000-	0000-	0000-	-0000	.0000	-0000-	-0000
0005 0001 0000	4.1	•	.0003	1000.	.0000	.0000	0000-	•0000•	-0000	.0000	0000-	00001
-1.4 • .0007 .0001 .0000 <t< th=""><th>6</th><th>*</th><th>-0005</th><th>1000.</th><th>•0000</th><th>0000</th><th>-0000</th><th>0000-</th><th>-0000</th><th>0000-</th><th>0000.</th><th>0000</th></t<>	6	*	-0005	1000.	•0000	0000	-0000	0000-	-0000	0000-	0000.	0000
-1.0 • 0010 0000		 	2000.	-0001	.0000	0000-	-0000	.000.	-0000-	0000-	0000	.0000
-1.4 •0015 .0001 .0000	-1-0	#	-0010	•0002	.0001	.0000	-0000	0000-	0000-	- 3000	.0000	.0000
16 -1.4 • .0033 .0006 .0001 .0000 <td< th=""><th>*•I - 7</th><th></th><th>.0018</th><th>.6004</th><th>1000</th><th>.0000</th><th>-00C0</th><th>.0000</th><th>-0000-</th><th>-0000</th><th>.0000</th><th>0000.</th></td<>	*•I - 7		.0018	.6004	1000	.0000	-00C0	.0000	-0000-	-0000	.0000	0000.
-2.2 • 0055 .0011 .0003 .0001 .0000 <td< th=""><th>97</th><th>*</th><th>.0033</th><th>-0006</th><th>2000°</th><th>.0001</th><th>-0000</th><th>-0000</th><th>-0000</th><th>.0000</th><th>.0000</th><th>-0000</th></td<>	9 7	*	.0033	-0006	2000°	.0001	-0000	-0000	-0000	.0000	.0000	-0000
-2.6 * 0088 0018 0000	-2.2	•	.0055	1100.	.0003	-0001	.0001	0000	.0000	.0000	0000	0000
-3.0 + 0136 -0027 -0009 -0005 -0001 -0001 -0001 -0000	-2.6	*	.0088	-0018	.0006	.0002	1000-	1000-	-0000	0000-	0000-	0000-
27 -3.4 * .0201 .0041 .9013 .9005 .0001 .0001 .0000 .	-3.0	*	.0136	-0027	.0009	+000 ·	-0002	1000.	1000-	.0000	.0000	0000
✓ -3.8 * 0289 0019 0008 0004 0002 0001 0000	4.E1 2'	٠	.0201	-0041	-0013	5000 °	E000-	.0001	1000.	.0001	0000	.0000
-4.2 * .0404 .0082 .0026 .0011 .0003 .0002 .0001 .0030 -4.6 * .0551 .0113 .0036 .0015 .0007 .0001 .0001 .0030 -5.0 * .0732 .0152 .0048 .0020 .0010 .0001 .0001 .0030 -5.0 * .0732 .0152 .0048 .0020 .0010 .0002 .0001 .0030 -5.0 * .1015 .214 .0068 .7726 .0019 .0005 .0002 .0001 .0002 -5.5 * .1768 .0726 .0019 .0016 .0706 .0007 .0001 .0002 -6.5 * .1768 .0726 .0018 .0011 .0007 .0007 .0007 .0003 -7.0 * .22822 .0539 .0126 .0018 .0011 .0007 .0007 .0007 -6.0 * .04438 .1284 .0267 .0114 .0056 .0017 .0017 .0013 .0007 .0007 .0003 -9.0 * .04838 .1284	8°E-	i#	.0289	.0059	.0019	.0008	+000+	-0002	1000.	1000-	.0000	-0000
-4.6 * .0551 .0113 .0036 .0015 .0007 .0004 .0002 .0001 .000	-4-2	#	+0+0+	.0082		1100*	-0005	•0003	-0002	.000.	1000-	-0000
-5.0 * .0732 .0152 .0048 .0020 .0005 .0001 .001 -5.5 * .1015 .0214 .0068 .0726 .0014 .0007 .0002 .0001 .0011 -6.0 * .1765 .0214 .0068 .0726 .0014 .0604 .0023 .0002 .0001 .0012 .0001 -6.0 * .1765 .0215 .0126 .0052 .0016 .0016 .0007 .0002 .0001 .0002 .0001 .0	-4.6	' ↔ }	.0551	.0113	.0036	.0015	100C.	1000-	-0002	1000-	1000-	1000-
-5.5 * 1015 .2214 .0068 .0326 .0014 .0007 .0004 .0002 .0001 -6.0 * 1366 .2293 .0094 .0039 .0019 .6010 .0004 .0002 .	-5-0	#	-0732	.0152	-0048	•0020	.0010	-0005	.0003	•0005	-0001	1000-
-6.0 * .1366 .0294 .0039 .0019 .6010 .0004 .0002 .0002 -6.5 * .1768 .0392 .0052 .0025 .0016 .0005 .0003 <td< th=""><th>-5.5</th><th>•</th><th>.1015</th><th>.0214</th><th>.0068</th><th>92Cū*</th><th>+100-</th><th>1000.</th><th>+000·</th><th>-0003</th><th>-0002</th><th>1000.</th></td<>	-5.5	•	.1015	.0214	.0068	92Cū*	+100-	1000.	+000·	-0003	-0002	1000.
-6.5 * .1765 .0325 .0014 .0006 .3003 .0003 .0003 .0003 .0003 .0003 .0003 .0003 .0003 .0003 .0003 .0003 .0004 .0003 <t< th=""><th>-9-0</th><th>#</th><th>•1366</th><th>• 0293</th><th>+600*</th><th>6600"</th><th>-0019</th><th>-6010</th><th>-0006</th><th>.0004</th><th>.0002</th><th>•0005</th></t<>	-9-0	#	•1366	• 0293	+600*	6600"	-0019	-6010	-0006	.0004	.0002	•0005
-7.0 * .2282 .0515 .01t .0069 .0033 .0011 .0007 .003 -8.0 * .3466 .0839 .0275 .11t4 .0055 .0030 .0017 .0017 .0007 .0003 -9.0 * .4838 .1284 .7429 .0179 .00677 .0047 .0027 .0011 .0008 -9.0 * .4838 .1284 .7429 .0179 .0047 .0027 .0011 .0008 -9.0 * .6252 .1862 .0638 .0267 .0136 .0011 .0001 .0001 .0001 -10.0 * .6252 .1862 .0638 .0267 .0136 .0047 .0026 .0017 .0012 STRENCT bistrention .0040 .0041 .0026 .0017 .0012 .0012 * .6252 .1862 .02567 .0136 .0041 .0026 .0017 .0012 * * .0120 .0136 .0170 .0041 .0026 .0017 .0012	-6.5	*	.1768	.0392	.0126	.0052	.0025	4100.	•0008	• 3005	.0003	.0002
-8.0 + -3466 -0839 -0275 -114 -0036 -6017 -0011 -0007 -0035 -9.0 + -4838 -1284 -7429 -0179 -00677 -0027 -0017 -0011 -0008 -9.0 + -4838 -1284 -7429 -0179 -06677 -0027 -0017 -0011 -0008 -10.0 + -6252 -1862 -0638 -0267 -0130 -0041 -0026 -0017 -0012 -10.0 + -6291 -0136 -0136 -0070 -0041 -0026 -0017 -0012 -10.1 - - - -0136 -0136 -0170 -0012 -0012 -10.0 + -	-7-0	#	.2282	. 0515	.0167	•0069	EE00*	.0018	1100-	-0007	+000+	e000.
-9.0 * .4838 .1284 .7429 .7179 .0087 .0047 .0027 .3017 .0011 .0008 -10.0 * .6252 .1862 .0638 .0267 .013C .0070 .0041 .0026 .0017 .0012 STEES DISTRIBUTION - Normal STEES DISTRIBUTION - Mortal	6.8-	; ↔ ; }	.3466	.0839	.0275	+115+	.2055	0600-	- 6017	1100.	-0001	.0035
-10.0 * .6252 .1862 .0638 .0267 .013C .0070 .0041 .0026 .0017 .0012 STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull	0-6-	*	•4838	.1284	• 242 4	eric.	- 5087	-0047	-0027	-3017	11007	9000
STRESS DISTRIBUTION - Normel STRENGTH DISTRIBUTION - Veibull	-10.0	•₩	.6252	.1862	0638	.ů267 [–]	.013C	-0070	1400-	.0026	.0017	.0012
STREES DISTRIBUTION - MOTMMA. STRENGTH DISTRIBUTION - Welbull	•	•						•				
STRENGTH DISTRIBUTION - METADAL					STREE	SS DISTRIB	UTION -	Normel.				
					STREET	CTH DISTR		Netbull	١			

ł

. . .

H

0(X)

n in the second se

7 N N

lt

ž b

H

ບ

00000 .0000 --0000 001 000 5 26 0000°• •0000 .0000 -000C .000. 1000-005 000 000 83 0000 0000 0000. 0620 0000 000 000 000 000 000 000 000 000 0000---0000 ---0000 0000 -0300 -0300 .0000 --0000 1000-2000 0003 1000 15 0000°* -0000-- 3000 - 2000 - 2000 0000 0000 1.00. .0000 0520 1000 1000 1000 2000 6000 202 Ť 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000. 1000. 0000 1000 00000 1000 0000 1000 5555 100 5 - 2000 - 2000 - 0000 .001. .002. .000 395. 255 5 -5.5 -6.5 0.01 -2.6 **6.0**--1-8 -3.0 -3-8 -5-0 -7.÷

298

-2-2

-1-0

-1-

ī

9. +

-m -

4.1

1

al King Caraca

1

٠.

٤

, ,

STRENGTH DISTRIBUTION - Weibull

NOLIDBILLSIG SSAUS

- Normal

۴.,

00
ŝ
#
m
×
-
-

2		
2		
١		
)		
2		

- 14

١

١Ì

i b

1

7

0-x₀

		91	5	20	52	30	35	04	45	50	55
		***	****								
	*	000	.0000	0000	.0000	0000	.0000	0000*	.0000	.0000	0000-
	*	000	0000	0000-	-0000	0000-	-0000	0000*	-0000	0000-	0000-
4		000	0000	0000	0000	-0000	0000.	.0000	.0000	0000	0000-
		000	0000-	0000	0000-	0000	.0000	.0000	0000	0000-	°0000
0		000	0000	.0000	.000	0000	0000-	.0000	0000.	5000.	0000.
	*		.0000	-0000	0000-	-0000	0000-	0000	0000	0000 -	0000
			.0000	.0000	.0000	.0000	0000	0000	0000	0000	0000
			0000-	-0000	0000"	0000-	0000	0000	0000	6600	0000
	4	002	0000	0000	0000.	-0000	0000.	0000	0000	0000	0000 -
		600	0000	-0000	-0000	.0000	0000*	0000-	0000	0000	0000
		200	1000	-0000	-0000	00000	-0000	-0000	.0000	0000	0000.
			1003	0000-	0000-	0000-	.0000	0000-	0000*	0000.	-0000
		610	0003	1000	0000	-0000	-0000-	.0000	.0000	0000	.0000
		EEDI	+000-	.0001	- 0000	0000-	0000-	.0000	0000-	-0000	-0000
		550	·.0007	.0002	1000-	.0000	0000-	•0000	0000.	.0000	.0000
			-0012	0003	1000-	0000-	0000-	0000-	0000-	-0000	0000
		137	-0018	+000-	.0001	1000.	0000	-0000	-0000	.0000	0000-
		1206	.6028	-0007	-0002	1000.	-0000	0000-	.0000	0000	0000.
		0.060	1400	0100.	E000.	-0051	.0001	0000	0000-	0000-	0000-
		1426	.0058	+100.	.0005	-0002	1000-	0000	0000-	-0000	•0000
		1639	0089	-0021	1000.	-0003	1000.	-0001	0000-	0000-	.0000
		100	IELO-	1600-	0100-	+000*	-0002	-000	.000.	.000.	0000
		205	-0187	-0045		9000-	E000-	1000-	.000.	C000.	.0000
		1261	20263	-0063	. 3021	.2008	.000.	-0002	1000.	1000-	. 0000
	•	998		.0118	.0039	•0016	.0001	.0004	-0002	-0001	.0001
0-6-	*	546	. (.828	.0205	.3068	7200.	-0013	-0006	+000+	-0002	1000.
-10.0		5535	1328	.0337	2116.	.0045	•0021	1100.	•0000	•000+	-0002

STREAST DISTRIBUTION - Normal STREASTRY DISTRIBUTION - Weibmilt

'n,



STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull . .

۶,

1.1

÷

9° 60
N
—
×
ă

, K	i
A	1
.*	
	1
Ϋ́,	o i
001	
ŧ	(ب) ۸
ບ	1.1
:	
	4
	•
	Х
	 ₽
	. ផ្ល
;	- ŠI
	- 1
	°,
	H

년 오

5

	# 1	ko Li	15	20	25	30	35	-tc	5	50
	*									*
60	*	0000-	.0000	-0000	-0000	-0000	.0000	.0000	-0000	0000-
9.	#	-0006	.0000	.0000	.0000	-0000	0000-	-0000	0000-	0000
	# 1	-0000-	-5000	0000-	-0000-	-0000		.0000	0000	-0000
-	#	.0000	.0000	.0000	0000-	0000-	0000	.0000	.0000	•0000
0.	i ⁺₩ i	_0000 °	.0000	-0000	0000	0000		•0000	0000-	• 0000
2	*	. 3606	0000-	.0000	0000-	-0000	-0000	0000	0000	0000
	, ₩ 	0000.	.coor	-0000	•0000	-0000	-0000	0050	0000	0000
••	۰	- 300 C	.0000	0000	-0000	-000C	0000	0000	0000	0000
9.1	*	.0000	.0000	.0000	- 2000	0000-	-•0000	0000	0000	0000
-1.0	*	.000	0000-	-0000	9000*	-0000	6000	0000	0000	0000
-1.4	+	.0002	0000	.0 <u>00</u> 0	0000.	-0000	.0000	.0000	0000	- 0000
-1-8	*	+000-	-0000	-0000	.0000	-0000	.0000	0000	0000	0000-
-2.2		.0007	.000	•0000	.0000	0000	0000-	0000	•0000	-0000
-2.6	#	.0013	.000	.0000	0000.	-0000	.0000	-0000	-0000	.0000
-3.0		-C023	. 6002	0000	-0000	0000-	-0000	0000.	.0000	-0000
4.0	#	0400-	+000-	.0001	-0000	•0000	0000-	•0000	0000-	0000-
-3.8	•	.0067	.000	-0001	0000.	.0000	.0000	0000	0000.	0000.
-4.2	#	.0108	0100.	+CCC2	0000-	•0000	-0000	0000-	-0000	0000-
-4.6	#	.0168	.0015	-0003	1000.	00000	.0000	•0000•	0000	0000-
-5.0	*	.0253	.0023	+000+	-000-	0000*	0000-	0000-	0000-	-0000
-5.5	*	0408	.(037	1000.	.0002	-0001	•0000	.0030	0000	-0000
-6.0	#	•0634	.0059	1100-	.0003	10001	.0000	.0000	-0000-	0000-
-6.5	*	0940	.0091		. 0004	1000.	1000*	.0000	-0000	-0000
-7.0	#	1371.	• CI35	.0024	• CO36	2000-	.0001	0000	0000.	0000
-8.0	*	.2591	.0280	.0051	£100.	+000*	-0002	.6001	COOO-	.0000
Ú•6-	#	•4286	•6534	• 0C98	• 3026	6000	•0003	2000°	1000-	0000
-10.0	*	.6215	1960-	#0178	1400-	• 0016	.0006	.0003	1000-	1000-

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

Downloaded from http://www.everyspec.com

. 301 301

B(X) = 7.00

9.5 1

:::::

L

1.

¥.

14. 19

35 b ŝ υ 22 when c > 101 ŝ $\mathbf{F}(\mathbf{x}) = \mathbf{0}$ 5

и Хо-ц

u

0x-0

11

ن چ

> 2. •

8 ٩ 4 -.6

--2 4.-

įΫ

Downloaded from http://www.everyspec.com

•* 5

\$

. .

ł

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibuil

8(X)	≭ 19•6	00		i C		⊆, A	×0-+
4	* C	андиница на _н осос с с ало	F(x) =	0 when	o ∾ > 35 ∞ ∾	/ > 35	σ
A	्म * *	10	15 *******	20	25	30	35 ******
	*						
.8	1 🛊 1	.0000	.0000	.0000	.0000	.0000	.0000
•6	*	.0000	.0000	.0000	.0000	.0000	.0000
•4	+	.0000	.0000	•0000	.0000	.0000	.0000
•2	*	0000 ه	.0000	.0000	•0000	.0000	.0000
•0	*	.0000	.0000	•0000	•0000	.0000	•0000
2	*	•0000	.0000	.0000	•0000	•0000	•0000
4	٠	•0000	•0000	.0000	•0000	•000C	0000
6	*	.0000	•0000	.0000	.0000	.0000	0000
8	*	•0000	.0000	•0000	•0000	.0000	0000
-1.0	*	•0000	.0000	•0000	0000	0000	-0000-
-1.4	*	•0000	.0000	•0000	•0000	•0000	0000
1.8	*	0000	•0000	•0000	.0000	.0000	•0020
-Z.2	*	.0001	.0000	.0000	•0000	.0000	.0000
-2.0	· •	.0002	.0000		•0000	.0000	.0000
-3.0		•0005	.0000	•0000	.0000	.0000	.0000
- 3.4	.				0000	.0000	•0000
		.0018	• (UU1	.0000	•0000	.0000	.0000
	·		.0001		-0000		•0000
		•0050	.0002	-0000	.0000	.0000	.0000
-2.0		60095 6174	-0004	-0000	0000	0000	•0000
		-0212	.0013	+0001	-0000	0000	.0000
	· 🚡 -	.0522	10013	-0062		10000	-0000
	Ť	.0950	-0022	.0002	.0001	-0000	-0000
-8.0	· · · · · · · · ·	1980	.0097		.0002	-0000	
-9.0	*	.3851	.0227	-0023	.0004	-0001	.0000
-10-0	• • • • • • • • • • • • • • • • • • •	6168	.0487	-0051	.0009		10000

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

303

B(X) =	9.0	0	Ċ	= 0 -x	<u>o</u> , A	$=\frac{x_0-\mu}{\sigma}$
*	c	F(x) = 0 v	when $c > 3$	10: 2 - 21	2
A	¥ *	10	15	20	25	30
	 				******	*******
.8	*		.0000	.0000	.0000	.000e
.6	*	. 0000	.0000	.0000	.0000	.0000
.4	*	.0000	.0000	.0000	.0000	0000
•2	\$ 1	.0000	.0000	.0000	.0000	.0000
•0	*	.0000	.0000	.0000	.0000	.0000
2	*	-0000 e	.0000	.0000	.0000	•0000
4	*	.0000	.0000	• 0000	.0000	•0000
6	*	.0000	.0000	.000ú	-0000	-000C
- 8	. *	.0000	.0000	.0000	.0000	.0000
-1+0	*	.2000	•0000	.0000	0000	0000
-1.4	*	.0000	•000 0	.0000	.0000	.0000
-1.8	*	.0000	•0000	.0000	.0000	.0000
-2.2	*	•0000	.0000	•0000	.0000	•0000
-2.6	*	. 00∪1	.0000	•0000	•0000	.0000
-3.0	*	.0002	•0000	 0000 	.0000	.0000
-3.4	*	.0005	•0000	.0000	.00 00	•0000
-3.8	*	•0009	•0000	• 0000	.0000	.0000
-4.2	*	.0018	.0000	.0000	•0000	.0000
-4.6	*	•0034	.0001	• 2000	•0000	.0000
-5.0	*	•0060	•000 2 ·	0000	•0000	.0000
-5.5	*	.0119	.0003	• 2000	.0000	•0000
-6.0	*	• 0223	-0006	.0000	•0000	•0000
-6.5	*	• 0402	•0011	.0001	•0000	.0000
-7.0	\$	•0690	.020	.0002	£0000	.0000
-8.0	*	. 1762	.0058	• COO4	.0001	.0000
-9.0	. * .	.3671	•0149	.0011	.0002	.0000
-10.0	*	.6172	. (*352	.0027	-0004	-0001

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

304

B(X) =	10.00 c	= 0-xc	Α	x₀-μ σ
*	$C \mathbf{f}(\mathbf{x}) = 0$	when c >	• 25 [*] > ?	
. A	* 10	15	20	25
	*******	*****	r sár sár sár sár sár sár sár sár sár	*****
•8	* .0000	.0000	.0000	.0000
• 6	* .0000	.0000	.0000	.0000
•4	• • • • • • •	•0000	.0000	.0000
•2	* .0000	.0000	.0000	.0000
•0	* .0000	•0000	.0000	0000
2	* .0000	•0000	.0000	.0000
4	+ .0000	•0000	•0000	.0000
6	* .0000	.0000	.0000	.0000
- • 8	↓ 0000	•0000	•0000	.0000
-1.0	* .00 00	0000	•0000	0000
-1.4	+ .0000	•0000	•0000	.0000
-1.8	* • 0000	•0000	0000	.0000
-2.2	* .0000	.0000	.0000	.0000
-2.6	* .0000	•0000	•0000	.0000
-3.0	* .0001	•0000	•0000	•0000
-3.4	* .0002	•0000	•0000	• 0000
-3.8	* .0005	•0000	•0000	•0000
-4.2	* .0011	.0000	•0000	•0000
~4.6	* .0021	.0000	•0000	.0000
-5.0	* • 0039	•0001	.0000	0000
-5.5	* •0081	.0001	•0000	•0000
-6.0	* •0163	.0003	•0000	•0000
-6.5	* .031 0	••0006	.0000	.0000
-7.0	• 0561	.0011	.0001	•0000
-8.0	₹ .1573	.0035	.0002	•0000
-9.0	<u>₹ •3511</u>	.0099	.0006	.0001
-10.0	₹ . 6114	•0256	.0015	•0002

San

STRESS DISTRIBUTION - Normal STRENGTH DISTRIBUTION - Weibull

305

ł





TAZI	YULTING IAL = /IHETAL =	1-600		ı	1				 • • •	
. •			•	· •	1	•			Å	
<u>82</u> +	• • • • • • • • • • • • • • • • • • •	1.5	Ž•Ô	2.5	3.0	3.5	0	4.5	5.0	5.5
	* .5917 *	2165 ·	.5917	I .	!	•	т 6		-	
- m	* .5742	.5742	.5742	.5742	.5742					i n
•	* .5589	•55.89		5855*	• 5589	585	•5589	!		
5	* .5450	• 5456	•5456	• 5456	•5456	•5456	.5456	- 5456	.5456	
	* •5341	.5341	.5341	.5341	:5341	.5341	1465.	.5341	.5341	•5341
	* •5240	.5240	-5240	.5240	• 5240	•5240	•5240	• 5240	•5240	.5240
	* .5150		-5150	.5150	-5150	•5150	•5150	-5150	•5150	.5150
6	* • 5071	.5071	.5071	.5071	1205.	.5071	.5071	.5071	-5071	.5071
ø	* • 5000	.5000	2005-	•5600	-5000	.5600	-5000	• 5000	.5000	. 5000
0	**		• 4544	+24+	+154+	4544	• • 5 • •	*+24+	· 4544	+15++
• •	* *			• •	1164.	.4311	•4311	.4311	.4311	.4311
.0	* *			:	. •	1	.4173	.4173	.4173	.4173
	: 	•	: : 1	•					.4083	+0 83

ŝ

Ē

.

1

nov P

1.7 4 4 7.1

. e

2

いの変

Downloaded from http://www.everyspec.com

THETA2	YO)/THETAL THETAL	= .000 = 1.000					ETA 1 =		
**`	18				•		ł		
B1/82	+ 6.C	6•5	7.C 5444444	1.5	8°C	`8≈5. ⊧₽₽₽₽₽₽₽	9.0		10.0
\$	4 €5. 4		1 . 1 4	i .			 		•
	+ • 524	v .5240	.5240			•			
8	+ .515	0 +5150	.5150	•5150	•5150				
6•	105. +	15071	1235.	1792.	-5671	.507J	.5071		• •
1-0	• • • 2CU	g .5000	•5000	•5003	• 500 8	•5000	j004•	:2005	°005*
<u>2</u> •0	* * * * * * * * * * * * * * * * * * *	4 .4544	• 4544	.4544	• 4544	•4544	*454*	+244	4544
3•0	43L	1 •+31J	.4311	.4311	.431L	.4311	.4311	116+.	1,164.
6 •0	215" #	£217• €	.4173	•4173	£214°	.4173	.4173	.4173	.4173
0• 5	* .4C8	J .4083	.40t3	.4043	.4683	•4083	•4083	• 4083	•4383
0 •9	+ +02	Q .4020	•4C20	.4020	.4020	.4020	-4C2r	•4.320	•4020
2.0	• • •		• 3974	+252.	÷19E.	+196.	.3974	.3974	•3974
8•0	F 46 4				£66E.	. 6262.	•3939	• 3939	5£6E*
0-6	· + ' 4					·	1166.	1166.	1165.
10.0	•					•		·	•388¢
				S DISTRIC	UTION -	Weibull Weibull			

...

u.

:

STATES IN CONTRACTOR OF A DESCRIPTION

.,

Ç

÷,

, *

...

• • •

.

) 4

٩,

-171

. /k ***

	Me Ho	0 5.5 666388888				36	22 . 2208	20 . 2209	28 .2221	45 .2240	68 .2267	04 . 2643	46 - 2926	360E • 368	88 • 3299	
	d ^H oh .	100 - 200 100 - 200 100 - 200				•3•	-24	• 2 •	•24	•24	•2•	•28	ŐE.	.31	•32	
	1 VIII 1 VIII 1 VIII	4.5	4".ph	N 1	b, . ^{. 4}	2671	.2652	.2646	.2630	.2662	.2681	.2969	.3172	.3291		
		, D.4			1100	.2923	•2898	.2686	.2885	.2892	•2906	-3136	-3297	•3389		1
		3.5		· .	0762	1616.	.3159	.3140	EE1E.	1616.	1416.	1966.	.3422	i		
		3.0			. 3611	3475	.3435	• 3409	.3393	1966.	.3386	.3480	.3548	, • , • ,		
J		2.5	1		1696.	.3775	.3726	.3690	.3666	.3650	.3640	-3655		1	·	
1.1		2.0		.4392	. 4268 . 4148	050+	.4029	.3983	8466.	.3922	209E.	-3832				
· ·	000	1.5		.4756	- 4619	1144.	.4345	.4287	.4240	.4202	1714.	1			•	
	0)/THETAL = INSTAL =	10 *******	#062. +	+ .5134	+ -4904 +	+ .4756	* .4676	• • • • • • • • • • • • • • • • • • •	+ +539	+	•	• • •	• •	• • •	• •	
	X0 - V	1/82		2•	6. 4	v	9 .	1.		6.	1.0	2.0	3_0	4 ° 0	5.0	

.». **م**لية

. . 4.

 $_{\rm H}$?

410

inisist.

THETA2.

- 0X)

THETA 1 THETA 2

> ي ه +

*

0-01 9**-**5 ***** 4.0 ***** **8**.5 8°C ******** 7.5 **** ن ۲ • ۲ ********** **6.**5 .205. و• ز **B1/82** •

+ .2013 .1631 .1e63

3160* .1416 .2516 2697 .283C .2267 1592. .1906 .1530 -2012 .2356 5721. •2592 • 2761 .2885 1967 . -1151 .1163 .1659 .2118 •2445 .2825 .2668 .2942 .3031 .1275 **.1**305 .1776 •2536 .2890 •2223 •2744 .2998 -3785 •2339 .1363 -1407 .1437 .1507 .2820 .2955 .3055 .2521 •3130 .1549 .1579 -2644 -2453 .2720 .3021 .1525 -2857 .3111 .1703 +671. .2813 .3686 •2568 .3168 .2187 .1679 -2974 •1846 .1670 •1499 +652. • 2968 .3052 .2086 . 3152 .2049 .2021 .2487 .2805 CELE. .3218 .2077 .3003 5.0 8.0 1.0 2.0 3.0 4.0 **6.**0 7.0 9

STIMUS DISTRIBUTION - Weibell STMMUTH BUSTLIDUTION - Weibell

Y

• ¥

YTOE.

.3012

95iE.

lule.

0.6

10.01

THETA1 = .CC3 1.0 1.5 2.0 3.0 3.1 TA1_		THETA I = $\begin{pmatrix} 0 \\ x \\ z \\ z \\ z \\ z \\ z \\ z \\ z \\ z \\ z$		5 4.0 4.5 5.0 1		· · · · · · · · · · · · · · · · · · ·	-	198 . 1504	180 .1571 .1308 .1085	175 .1570 .1309 .1087 .(181 .1578 .1318 .1097 .(96 .1595 .1335 .1113 .(19 .1619 .1359 .1136 .(148 .1649 .1389 .1164 .(177 .2110 .1960 .1629 .1	19 .2536 .2299 .2100 .1	•2763 •2595 •2430 •i	• 2655	Weithwill Meitheill	•
Theraal = .cco Tal = .cco Adal = .cco .4681 .4524 .3893 .3321 .4524 .3893 .3321 .4524 .3638 .3117 .4291 .3761 .3154 .4293 .3562 .3071 .4093 .3562 .3071 .4054 .3542 .3065 .4093 .3525 .3071 .4054 .3542 .3065 .4054 .3542 .3065 .4054 .3542 .3065 .4054 .3542 .3065 .3261 .				2.5 3.0 3.			2738 .2305	2685 .2264 .10	2651 .2239 .10	2632 .2228 .18	2626 .2229 .10	2630 .2240 .18	2643 .2260 .19	2663 .2286 .19	2955 .2659 .23	.2938 .21			ands plotaliseries -	
The Tal = .000 Tal = .000 .4395 .339 .4395 .339 .4291 .359 .4093 .356 .4093 .355 .4093 .355 .4093 .355		•		2. C		3321	3231	1 .3154 .	• 2112 • 9	19 .3087 .	3071 .	2 .3065 .	3068	• 2105. 3	.3261 .	•	,	•		
	·	/TFETAL = .000 ETAL = .667	, , ,	1.0 1.5	.4681	.4524 .389	.4395 .378	01E. 1924.	.4208 .363	.4143 .359	.4093 .356	+ <u>5</u> £;0;+-	.4024 .353	.400 .352	1					

Downloaded from http://www.everyspec.com

. . . <u>.</u> . . .

•

L. M. Martin Martin Martin State

× .

.

201.00

	HETAL =	•667			. 1			ч° м° • • •	
• • •	81						Ì		•
, 182 ,	- C*9	6=5 14=44441	7.5 :*******	7 * 5 5#######	8.C ••••••••	8.5 *******	9.7 •******	9 . 5 *******	10.0
م	* •0744	· ·	:	,			•		
	* .0752	1290-	• 3511						•
50	* .07 <u>6</u> 6	• 0633	.0522	-0429	•0353				
¢.	+ .0784	- 0049	• 3536	1440*	•0363	-029 <u>8</u>		i	.
0	0807	• 0669	.0553	.0456	•0376	•0369	+321.	• 0208	1710.
0	• • •1225	.1052	.0899	•0764	-0645	• 0543	•0455	- 3 8 60	¢160-
Ģ	1727	-1554	•1352	.1240	COIT.	5720-	.0851	2410.	°C645
9	.2112	•1959	.1812	1671.	.1535	5051.	.1281	.1164	1 254
0	+ .2385	.2254	.2125	• 1999	.1877	.1758	.1642	.1531	• 142 3
0	• -2582	• 2468	.2356	•2245	•2136	-2030	•1925	.1823	.1723
Q			.2530	.2432	.2335	•2240	•2146	-2054	1961
ġ				•	.2491	•2406	.2321	.2237	•215•
0	6°46. 4						•2461	-2385	.2304
ņ	• •								.2431
h.,

1.12

ų.

÷,

Downloaded from http://www.everyspec.com

•

B1 6.0 6.5 7.0 7.5 8.0 3.5 9.0 9.5 9.5 9.5 10.0 7.309 6.235 6.174 6.309 6.235 6.174 6.309 6.235 0.182 0.143 0.108 0.063 0.325 0.247 0.188 0.144 0.113 0.065 0.0049 0.037 0.336 0.256 0.195 0.146 0.113 0.065 0.0049 0.037 0.336 0.460 0.358 0.0277 0.213 0.164 0.125 0.0966 0.073 0.358 0.460 0.358 0.0277 0.213 0.164 0.125 0.0966 0.073 0.358 0.473 0.213 0.164 0.125 0.0966 0.073 1.161 1.1286 1.128 0.9990 0.7846 0.724 0.615 0.518 0.443 1.161 1.1286 1.128 0.9990 0.7846 0.724 0.615 0.518 0.433 1.161 1.1286 1.128 0.9990 0.1212 1.083 0.962 0.3850 0.747 1.160 1.1281 0.179 0.1651 0.1212 1.083 0.962 0.3850 0.747 2.076 1.931 0.1791 0.1652 0.1779 0.1661 0.1561 0.1355 2.076 1.931 0.1791 0.1652 0.1524 0.1661 0.1567 0.1565 1.1956 0.1932 0.179 0.1661 0.1561 0.1565 1.1956 0.1952 0.1955 0.1779 0.1667 0.1565 1.1932 0.1952 0.1952 0.1793 0.1657 0.1657 0.1565 1.1956 0.1952 0.1952 0.1793 0.1795 0.1956 0.1765 1.1956 0.1952 0.1952 0.1955 0.1793 0.1657 0.1565 0.1952	/THETAL			•		JHL ·	TA 2 = 0	y - To	
 .7304 .7304 .6379 .6247 .0182 .6143 .0108 .0256 .0195 .0143 .0108 .0685 .0069 .0049 .0037 .0336 .0256 .0195 .0148 .0113 .0085 .0663 .0049 .0037 .0336 .0256 .0195 .0148 .0113 .0085 .0663 .0049 .0037 .0037 .0213 .0164 .0125 .0096 .0073 .0049 .0113 .0164 .0125 .0193 .0164 .0125 .0096 .0073 .0095 .0073 .0095 .0096 .0037 .0095 .0095 .0095 .0095 .0095 .0095 .0096 .0095 .0095 .0095 .0095 .0096 .0095 .0095 .0095 .0095 .0095 .0095 .0095 .0096 .0095 .0096 .0095 .0095 .0095 .0095 .0096 .0095 .0096 .0095 .0096 .0095 .0096 .0096 .0096 .0096 .0095 .0096 .0095 .0096 .0013 .0105 .0196 .1095 .1095 .1095 .1096 .1096 .1095 .1095 .1095 .1096 .1096 .1096 .1095 .1095 .1096 .1096 .1096 .1096 .1096 .1096 .1096 .1096 .1096 .1095 .1095 .1095 <	* * * 6_0	ند م ب	7.0	7.5	ي. 8	a.5	C*6	9.5	10°0 10°0
 .7304 .6309 .6235 .617a .0316 .6247 .0182 .6138 .0105 .0325 .0247 .0188 .0143 .0108 .0063 .0063 .0225 .0247 .0188 .0143 .0108 .0085 .0063 .0049 .0037 .0336 .0256 .0195 .0146 .0113 .0085 .0065 .0049 .0037 .0336 .0460 .0358 .0277 .0213 .0164 .0125 .0096 .0073 .0358 .0710 .0582 .0473 .0381 .0304 .0251 .0189 .1025 .6857 .0710 .0582 .0473 .0381 .0304 .0251 .0189 .1025 .6857 .0710 .0582 .0473 .0381 .0304 .0251 .0189 .1025 .6857 .0710 .0582 .0473 .0381 .0304 .0254 .0189 .1025 .6857 .0710 .0582 .0473 .0381 .0304 .0254 .0189 .1025 .6857 .0710 .0582 .0473 .0381 .0305 .0741 .0189 .1025 .6857 .0710 .0582 .0473 .0381 .0305 .0741 .0189 .1025 .1931 .1791 .1655 .1524 .1399 .1279 .1165 .1357 .1037 .1935 .1339 .1279 .1165 .1356 .1056 .1931 .1791 .1655 .1524 .1399 .1279 .1165 .1357 .2076 .1931 .1791 .1655 .1524 .1399 .1279 .11657 .1358 .2076 .1931 .1791 .1655 .1524 .1399 .1279 .11657 .1356 .1935 .1956 .1877 .1770 .1667 .1566 .1932 .1956 .1877 .1770 .1667 .1566 .1932 .1956 .1877 .1770 .1667 .1566 		******	******	****					
.6309 .6235 .617a .0316 .6246 .0182 .0138 .0165 .0063 .0325 .0247 .0188 .0143 .0108 .0065 .0063 .0326 .0256 .0195 .0148 .0113 .0085 .0069 .0037 .0336 .0256 .0195 .0148 .0113 .0085 .0069 .0037 .0336 .0256 .0195 .0148 .0113 .0085 .0069 .0037 .0336 .0256 .0195 .0188 .0211 .0281 .0136 .0138 .1025 .6857 .0710 .0582 .0473 .0381 .0365 .049 .0037 .1461 .1286 .1128 .0582 .0724 .0163 .747 .1809 .1456 .1212 .1683 .0452 .0350 .747 .1809 .1649 .1751 .1683 .0462 .0350 .747 .1809 .1791 .1793 .1399 .1279 .1438 .1332 .2076<	+0EC • +	·		•					•
 .0316 .C24C .0182 .C138 .C105 .0225 .0247 .0188 .0143 .0108 .0C82 .0063 .0336 .0256 .0195 .0148 .0113 .0085 .0069 .0037 .0336 .0256 .0195 .0148 .0113 .0085 .0069 .0034 .0358 .0271 .0213 .0164 .0125 .0096 .0073 .3586 .6460 .0358 .0277 .0213 .0164 .0125 .0096 .0073 .1025 .C657 .0710 .0582 .0473 .0381 .0364 .0241 .0189 .1025 .C657 .0710 .0582 .0473 .0381 .0364 .0241 .0189 .1025 .C657 .0710 .0582 .0473 .0381 .0364 .0241 .0189 .1025 .C657 .0710 .0582 .0473 .0381 .0364 .0241 .0189 .1461 .1286 .1128 .0580 .C846 .C724 .C615 .0518 .0443 .1461 .1286 .1128 .0580 .C846 .0724 .1399 .1279 .1165 .1057 .2076 .1931 .1751 .1655 .1524 .1399 .1279 .1165 .1057 .2076 .1931 .1751 .1655 .1524 .1399 .1279 .1165 .1058 .2076 .1931 .1751 .1655 .1524 .1399 .1279 .1165 .1356 .2076 .1931 .1751 .1655 .1524 .1399 .1279 .1165 .1356 .2076 .1931 .1751 .1655 .1524 .1399 .1279 .1165 .1356 .2076 .1931 .1751 .1655 .1524 .1399 .1279 .1165 .1356 .1945 .1356 .1356 .1356 .1356 .1356 .1356 	* * •0309	.0235	•0176					:	
.0325 .0247 .0188 .0144 .0108 .0063 .0063 .0049 .0037 .0336 .0256 .0146 .0113 .0085 .0065 .0049 .0037 .0336 .0256 .0146 .0113 .0085 .0045 .0049 .0037 .0336 .0271 .0213 .0164 .0125 .0996 .0073 .0586 .0710 .9582 .0473 .0381 .0304 .0213 .1025 .0857 .0710 .9582 .0473 .0381 .0304 .0189 .1461 .1286 .1128 .0930 .0724 .0513 .0465 .0473 .1461 .1286 .1128 .0930 .0724 .0962 .0950 .0747 .1809 .1649 .1350 .1212 .1083 .0962 .0850 .0747 .1809 .1791 .1264 .1399 .1279 .1165 .1057 .2076 .1910 .1779 .1661 .1547 .1466 .1932 .2076	* + .0316	C240	.0182	• CI 38	•0105				
• 0336 • 0256 • 0195 • 0113 • 0085 • 0049 • 0031 • 0336 • 0460 • 0358 • 0277 • 0213 • 0164 • 0125 • 0996 • 0073 • 1025 • 0460 • 0358 • 0277 • 0213 • 0164 • 0125 • 0996 • 0073 • 1025 • 0460 • 0358 • 0710 • 0582 • 0473 • 0381 • 0394 • 0189 • 1025 • 0760 • 1128 • 0940 • 0724 • 0391 • 01653 • 0463 • 1461 • 1286 • 1128 • 0940 • 0962 • 0350 • 0747 • 1809 • 1649 • 1350 • 1212 • 1083 • 0962 • 0350 • 0747 • 1809 • 1791 • 1655 • 1524 • 1399 • 1279 • 1165 • 1332 • 2076 • 1931 • 1779 • 1661 • 1547 • 1438 • 1332 • 2024 • 1905 • 1779 • 1661 • 1546 • 1945 • 1656 • 1566 • 1945 • 1945 • 1945 <t< td=""><td>* * .0325</td><td>.0247</td><td>• 0188</td><td>.0143</td><td>•0108</td><td>.0082</td><td>•0063</td><td></td><td></td></t<>	* * .0325	.0247	• 0188	.0143	•0108	.0082	•0063		
* .3586 .07460 .0358 .0217 .0213 .0164 .0125 .0096 .0016 * .1025 .0857 .0710 .3582 .0473 .0381 .0304 .0189 * .1025 .0857 .0710 .3582 .0473 .0381 .0304 .0741 .0189 * .1025 .0857 .0710 .3582 .0473 .0381 .0304 .0189 .0189 * .1461 .1288 .1128 .3990 .07615 .3518 .0433 * .1809 .1649 .1350 .1212 .1083 .0962 .3850 .0747 * .2076 .1931 .1751 .1683 .1263 .1263 .1263 .1263 .1263 .1263 .1263 .1263 .1661 .1165 .1357 * .2076 .1931 .1799 .1163 .1165 .1365 .1566 * .2024 .1900 .1779 .1651 .1779 .1667 .1556 * .2024	* .0336	• 0256	•0195	•0148	e110.	.0085	•0065	•00*9	•0037
* .1025 .0710 .0582 .0473 .0381 .0304 .0241 .0189 * .1661 .1285 .1128 .0960 .0583 .0473 .0381 .0304 .0433 * .1461 .1285 .1128 .0960 .0747 .0433 .0462 .0350 .0747 * .1809 .1649 .1496 .1350 .1212 .1083 .0962 .0850 .0747 * .1809 .1649 .1791 .1655 .1524 .1399 .1279 .1165 .1057 * .2076 .1931 .1751 .1661 .1547 .1438 .1332 * .2076 .1931 .1790 .1661 .1547 .1438 .1332 * .2024 .1900 .1779 .1661 .1566 .1566 * .2024 .1905 .1877 .1770 .1667 .1566 * .1945 .1877 .1770 .1667 .1765 .1765 .1765	* .3586	.0460	.0358	.0277	.0213	•0164	•0125	•0036	.0073
* .1461 .1285 .1128 .0980 .C846 .C724 .C615 .7518 .C433 * .1809 .1649 .1496 .1350 .1212 .1083 .0962 .3850 .C747 * .1809 .1649 .1496 .1350 .1212 .1083 .0962 .3850 .C747 * .2076 .1931 .1791 .1655 .1524 .1399 .1279 .1165 .1357 * .2076 .1931 .1799 .1661 .1547 .1438 .1332 * .2024 .1900 .1779 .1661 .1770 .1667 .1566 * .2024 .1900 .1779 .1667 .1566 .1566 * .2024 .1905 .1877 .1770 .1667 .1566 * .1945 .1877 .1770 .1667 .1566 .1932 * .1945 .1877 .1770 .1656 .1932 .1932 .1932 .1932		. C857	.0710	• 0582	.0473	•0381	•0304	- 3241	6810.
	* 1461	.1285	.1128	0890.	•CB46	•0724	•0.615	.7518	•0433
· 2076 · 1931 · 1791 · 1655 · 1524 · 1399 · 1279 · 1165 · 1957 · 2076 · 1931 · 1790 · 1779 · 1661 · 1547 · 1438 · 1332 · 1945 · 1945 · 1877 · 1770 · 1667 · 1566 · 1956 · 1859 · 1765	* *	1649	.1496	.1350	.1212	.1083	•0962	• 3850	L+L3*
*	* 2074	1691	1621.	•1655	.1524	•1399	.1279	•1165	.1057
* * * * * * 1935 • 1877 • 1770 • 1667 • 1566 * * * * * * 1936 • 1859 • 1765 * * * * * * * * * * * * * * * * * * *			.2024	0061*	.1779	.1661	.1547	.1438	.1332
• 1956 • 1765 • • 1932			• •		•1945	.1877	0171.	.1667	.1566
* * * 1932	6 46' 4		۱'				.1956	.1859	.1765
	• •		,		ĩ				.1932

1 (è

ę,

Downloaded from http://www.everyspec.com

.

(xo - 40))/IHETAL =	•					THETA	ا ۹ ٦	× I	
THETA2/	IHETA1 =	• 500					THETA		0 0 1 H	•
**	Bl		,							
B1/B2	* 1.0 ********	L.5 F#######	2.ŭ r******	2.5 :******	3.0	3•5 :*******	4 • 0	4•5 ******	5.0	5.5 :++++*
••	* .3775								•	
•2	* * ,3645	.2752	.2640						-	
•	• 3545 • 3545	.2675	• 1988	• 1455	•1055	•	;	. 7		•
₩ .	* .3469	. 2628	1954	•1433 [°]	.1040	•0749	•0537		Í	
5	* • 3414	• 2595	.1935	. 1422	• 1034	•0746	•0535	• 0382	.0272	!
9 •	*	.2517	.1929	.1422	•1036	•0749	•0538	•0384	• 0274	•0195
۰٦	* .3351	.2572	1934	.1431	• 1045	.0757	-0544	0330	.0278	•0198
ຍ •	* * .3337	.2578	1948	. 1448	• EC02	1270.	•0555	•0398	.0284	•0202
6,	* .3332	.2552	1791.	.1472	.1084	.0789	-0570	60 1 0	•0293	.0209.
1.0	* • 3333	.2612	*2000	•1502	.1111	•0812	•0588	.0423	-0303	•0216
2.0	• •		.2421	.1971	.1573	.1231	1960*	•0716	•0534	•0393
3.0	₩ ₩ 1	•			•2050	.1733	•1443	.1185	• 0.958	.0763
0	* *		•. •				•1855	.1518	•1393	.1187
	*	1							1761	1557

į

2

đ

.

二二 五二 五二 五二

::

LXJ - YJ ThETA2/T)/[HETA] = HETA1 =	• • • • • • • • • • • • • • • • • • •	·		Ţ	HT HT	ETA 1 = ETA 2 =	о о - т - т - т	:
* *	ы 1								
# B1/B2 · #	0 • C ******	0 • 5 ******	7 • (********	7 • 5 ¢\$****	8°C ******	8 • 5 ******	0°0 0*****	9 • 5 ******	10+0 ******
· •	• 0138				•	, ,			
۲.	≠ +CL4⊍	• כדטכ	1100.						
1 00	•	•0102	.0073	0052	1600.				
0	•0143	• 1105	.9015	• 3053	.0038	-0027	6100*		ť
1.0	* •C154	•010•	•0C78	.0055	•0039	- 6202 •	• 5 5 5 •	•00 1 4	.0010
2.0	* • • 0267	•C208	•0156	1010.	.0076	•GU24	•0039	• 1228	•03C
0 • 0	• 0.598	- • 6463	•0353	•0266	• 0198	•0146	.0107	.2077	•0350
0.4	• • 1úC ·]	• 5833	• 0685	.3557	•Č44B	.0355	•C278	.0216	•C165
0	• • 1369	•1199	• 1041	•0830	•0765	.0647	• 7542	• 2450	0160.
ن •	• 1673	.1511	,1357	.1212	•1076	•046	•0832	•0724	.0626
0.7	* * 4	•	.1622	.1483	.1351	.1225	.1105	• 0,993	•C 887
6•Û	• •	. .			.1564	.1403	•1347	•1235	.11.29

1

STRESS DISTRIBUTION - Veibull STRENGTH DISTRIBUTION - Weibull

.1345

.1448

.155u

Ŋ

9.0 10.0

.1533

ţ

じん ちょうかい

٢ •

...

: ¥

316

Downloaded from http://www.everyspec.com

ì

. . . ,

					!		LIHL -	A 2 = 9	А - А	
•					:			- 1		- - -
81/82	÷ 1 0	1.5	2•Ç	2.5	3.0	3.5	0.4	4 • 5	5.0	5.5
1 •	* 3439									
•2	* * .3321	.2367	.1651		•	· ·				
÷.	+	- 2305	-1610	• 110d	•0755	; 			!	:
•	* 	- 2264	-1584	•1092	• • • 2 • •	•0504	•0339	:		-
1 0	111E"	.2239	.1571	.1285	.0741	•0502	•0338	• 0227	•0152	
0	≠ ≠ ,3 <u>0</u> 8 <u>7</u>	. 2228	.1570	1987.	•0744		•0340	•0229	•0153	£010-
	* .3071	.2229	.1578	.1097	.0752	1150-	•0345	• 0232	•0156	•010+
8	* • 3065	• 2240	•1595	.1113	• C 766	•0522	•0353	.0237	•0159	1010.
6.	≠ + .3068	.2260	.1619	.1136	。0784	•0536	•0363	.0245	• C164	J112.
1•0	* .3077	. 2286	.1649	.1164	1080.	•0553	9160*	.0254	1210.	•0114
2.0	₩ ₩ 1		.2110	•1629	.1225	•0899	•0645	.0455	.0316	1120.
3.0	₩ 4 1				.1727	.1392	0011-	158c.	• 1645	• 9479
4•0	₩ 44 (•1535	.1281	•1054	•0853
5 •0	8 8	•					,		.1423	.1220

KG - YO)/ HETA2/THE * "BI 1/B2 *	ThETAL =	. 1	•						
1/82 *		0 4 0 4 • •	•		• •		5TA 1 =	exe v v v	•
** ** · 5. • • • •	6.0 *******	6.5 *****	7.0	7.5	0 8-	8.5	0.6	9•5	10.0
•	C100.					*		* * *	**********
• • •	.007.0	.6047	1500.		• 1				
• • • • •	.3072	.0048	•0032	1200-	•0014				
6	+200-	0500-	• 0033	.0022	•0615	-0010	1000*		•
	1100-	. 3052	. 9034	.0023	• 001 5	00100*	1000°	• 0005	•0003
0	•0148	-0010-	.0067	•0545	-0030	• 3020	•3014	-000¢-	•0000
0	.0349	.0250	•0176	.0123	• 0085	-3058	.0039	.0027	÷0318
• • •	.968 <u>c</u>	.6533	.6411	1160.	. 5232	-0110	.0123	. 3086	•0062
0.0	.1035	. (368	611.0*	•0588	•0475	.0378	.0297	0230	•0175
• •	1351.	.1183	-1027	.0884	.0754	.0637	-0532	1440.	.0361
**			•1302	.1158	.1024	•0899	.0783	.0678	°0582
**					•1200	.1141	.1522	2160*	•0826
**	•		•	i			.1239	•11.28	.1023
* 0*									• 1218
			STATE STATE	A DISTRIBU	- NOLTH	detbull K .bull			

. •

...

318

я Т.

24. 4.

					,		. ,			
· .		·				· · · · · · · · · · · · · · · · · · ·				-
- Y3)/TEEF A2/THETA1 * R1	# 4) 	000 000 000		ų			ÎHETA THETA	2 = +	м° м° - 1	
* 2 * 1	0.4	1.5	2.C	2.5 644444	3 • C	3.5 *******	4.0 	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	5.0	5.5
* *	150									1
m. •	643	.2061	.1361	•		•	·	i		,
* * *	196	• 2009	•1326	• 3864	1550-	•				,
	90.6	+191.	.1306	.0852	•0543	.0352	•0224	1	•	 !
• •	968	.1955	•1299	.0844	-0547	1560-	•0223	-0142	1600.	•
		.1548	•1295	.3851	0220	.0353	.0225		1600-	•0029
• •	, š 1	•1953	•1309	•0859	•0557	.0358	•0229	-0145	•0033	•0059
•		.1968	•1326	.0874	• 0568	•0366	- C234	•0149	•0095	•0061
	245	. 1940	.1349	•6894	.0583	.0376	• 0241	.0154	8600	•0062
	853	6102 11	.1379	616C°.	.0602	.0389	•0250	•0159	.0102	•000
	· • •		.1851	.1358	•0966	•0666	6443*	1920.	.0193	• 0125
	.				.1462	.1124	•0842	• 3614		.0303
• •	, 4 -						.1272	.1018	6510.	• 190 •
••				٠	•				-1163	1693.

. .

Ħ

2

7

e^ë

1	:			· •	:			o	
									•••
* *	6.Ĵ 44444 8	6.5 244444	7.0	7.5	8.C	.8.5 .*******	0°6	9.5	10.0
•	.0037								
* * (860 <u>0</u> .	• 6024	•0015	-	•				
• • •	.0039	• 0024	- 0015	0100*	•0006	·			
• • •	• 00+0	• 6025	•0016	c100*	•0000	•000•	•0003		
• • •	1+00-	• 0026	•0016	•0010	.000	-0004	÷0003	2002	Toco*
• • •	•0080	1500-	• 0033	• 0021	£100+	•0008	5000-	• 0003	-0002
• • •	• 0 20 0	* 0138	1600.	• 0059	• 0038	•0054	•0016	-0010	9000*
• • • •	•0462	0460-	• 02 45	•C173	.0120	-0082	.0055	9600.	+200*
e pele	.0782	.0627	• 0454	•0383	•0291	•0218	•0160	-0115	-0282
	• 1094	.7290.	.0776	• 0642	.0525	•0423	•0336	.0264	.0204
,	•		• 1047	• 0905	•0175	-0657	.0552	• 3459	17E0.
) 4) a	:				.1013	.0889	£110.	.0670	• 0575
•	•		•	 :		•	• 0988	.0878	• 0176
• ••									.0968

. -

1.4

<u>ر با</u>

- 4

Bur

320

141

1.5

KD - 74 HETA2/1	DÌ/THETAL = [HEIAL =	• 000	• • .		: • •	1	THET	• ● × • • • • • • • • • • • • • • • • • • •	H ^o H ^o	
**		1 1	₹.	• • •	• • •		· •	• • •		. •
	* 1.0	1.5 	2.C	2.5 *******	3.0	3.5 :******	6.4 0.4	4.5	5.0	5.5
	* <u>*</u> 2518							•		-
~.	* .2817	.1815	.1140				•			
ť.	* + 2742	•1769	• 1112	.• 96,88	•0421		• • 1	:	1	
4	* * •2683	•1740	•1050	•0679	•0416	•0253	.0152			-
Ĵ.	* .2655	• 1-724	.1Cx9	.3676	51 70°	.0253	•0153	• 0093	1960*	
Ŷ.	* *	.1721	1501.	•0679	1140*	•0254	•0154	•9064	•0058	.0034
٠٦	* * .2630	.1728	1011.	. 3687	.0423	.0258	-2157	560C°.	•0758	•0035
10 •	* .2634	.1744	7111.	.0700	.0432	.0264	.0161	86r0.	59CJ*	•036
·,	* * .2547	.1764	.1140	LILC.	* 9440	.0272	-3160	1010.	-0061	-037
0-1	* * •26c7	.1798	.1168	.0738	•0459	°0282	.7172	.0105	•0064	.0039
· • 1	₩ ₩ 1		.1633	1911.*	.0767	• 0500	°C318	661 0°	•0123	.0075
6. 0	* * '				.1245	•0913	• 6648	.0446	6620°	•0195
0	* *						, 105B	.0812	-0607	•0442
¢	* •			•	•				. 0053	.0758

ć

and the classifier of the

4 2

ι,

111111

""

20

۷.

4.

ł,

ł

•									•
*	21								
/82 *	5 • C	6.5 1444444	7.0	7.5 	8.0		6.7 5.4	9*5 ******	10.0
~ ~ •	.0021	; ;				•			
· * *	1206.	e100.	.0008		:				
- -	.3022	-C013	• 0008	•0005	• 0003				
	.0022	- J013	• 0008	•0095	•0003	±0002	1000°	:	
• • • Q	. 0023	-0014	. 0008	• 0035	E000 -	• 2002	1000.	1000*	•0000
0	•0046	.0028	-0017	.0010	• 0000	•0004	•0005	1000-	1000-
• • 1 0	•0124		• 0046	. 2030	•0018	1100*	1000.	+000-	•0003
• • •	+IE3.	.0217	·0147	2500*	• 0063	3430-	•0025	•0016	.0010
~ # '1 Cj	. 0592	• 0452	.0339	• 0248	•0178	•0125	• 2085	-2051	BE00.
• • •	•0888	.0727	.0587	•0466	•0364	•0279	.0211	•1156	·0113
, .	. <u>.</u>		.0844	.070	.0586	5250*	.0387	-0308	•0242
• * • Q					.0812	*690*	.0587	1640.	.040.
0					• ,		•0789	• 3684	- 685ú*
, t									1220.

۰.

322 (

1

i.

							1.			
IXO - 1 INEEA24	101/THETAL = 11METAL =	• 60. • 333			ц. 1. 1.		THET.	A A 2	норо 1 1	•
	81	1 = 5 + + + + + + + + + + + + + + + + + + +	2•C ••• • ••	2•5 144444444	3.0 1	3.5	4 • 0	4 • 5 ******	5.0 *******	5.5 \$\$\$\$
	* •2712	•	: .			-				
•2	* * .2518	• Lc13	.0967		·	•				
÷	* *2543	.1573	•0.944		•032¢		•			
*	+ .2501	1241.	-033L	. 3550	•0322	1810*	.0138			
ŝ	* * .247L	· 1535	. 1926	*****	.0321	1810-	-0108°	\$966.	•236	
Ģ.	****	+ 1034	10 10 10 10 10 10	.:561	.325	481r.	\$115 •	•)365	785J.	120.0
٠٦	*	.1342	-: 53c	•6590	5200	1612*	111.	• 2065	•ÇJ38	N 2 00 •
8.	* * •2401	.1555	• - 453	• 150.	•0335	051C.	.114	.3367	SELS.	
* •	* .247 <i>f</i>	• 14 83	• 2 5 7 4	÷aço•.	. 345	°32C2	• î lio	• JC68	.0403	• 95.2 S
1-0	★ ★ •2552	.1614	1966	-0603	1650.	•020•	• 5122	1100.	. 04 1	+202+
2=0	* *		.1450	• 0960	•0618	.0382	.0231	.0137	.09080	1400.
3.0	* *				.1365	9410-	£050°	328 ر.	1020*	-7121
0*4	•						• Ĵ 884	• 3650	•7403	.0320.
			•						.0784	0630.

() •

ì,

t

i

		• • •	,		•		D = 7		
• *	IA					ı	P1	o	
/u2 +	0°0	6.5	7.G	7.5	8°C 8eeeeee	8.5 *******	9 °C	9.5 	10.0
	* • •0012	1 - - - - -	1	1					
۲.	• • 0012	-0001	*000 *	•				·	
•	£100* +	1000	• 000+	.6002	1000-	i	• .		-
0,	• • • • • •	.008	• 0004	• 0003	1000*	1000-	1000-		: t
6.	• • 0014	• 0008	• 0002	• 0003	•0002	.0601	1000*	000C*	0000*
0.	• • 0027	.016	•0008	•0005	.0003	*0CG2	1031.	1000*	1003.
0.	1100.	•00+9	.0027	910ó***	6000-	• 0005	£000-	-0002	1600°
	• -0215	•0140	•0089	• 0055	.0033	•0020	2100-	1000.	•000•
0	* • • 0448	1322	.0232	.0161	9010	1200.	• 0044	. 3029	9100
0	* • 0722	.0571	- <u>0443</u>	•0338	• 6252	+916+	.0131	- 00 <u>-</u> 25	2900*
0	* *		.0681	•0553	. •0443	69E0*	.0276	-0206	•0154
0	♦ نې			.'	.0652	1960.	•0444	• 2367	.0287
0	• •	,					1631.	•0533	•6446
0	* *		r t		•	:		•	.0614

. . .

The state of the second of the

5 - 1 1 Downloaded from http://www.everyspec.com

, •

....

4

iyan La shi yi.

÷ś

	5.5		:		.1		.1634	•1654	•1774	.1752	1081.	.2385	.2753	1962	£01c -	
	5.0					.1832	.1846	.1873	.1912	. 1959	1162.	-2547	.2874	.3.362	0816.	
	5.4		·			•2368	.2078	.2103	.2138	.2131	.2230	.2713	•2996	.3156		
	. 0.4			•	•2343	.2328	.2332	1351.	•2382	.2420	•2463	• 2880 ···	.3117	.3250		
	3.5		•	•	.2635	-2611	-2607	• 26195 •	•264i	.2672	•27C7	-3049	.3238	ı		
• • • • • • • • • • • • • • • • • • •	3. 0			-3015	• 2952	•251ó	• 2901	•2903	<152 *	•2536	1962 •	.3217	12565.			- WO <u>LTON</u>
•	2.5		•	£766.	-2292	.3241	21.5c.	•32C3	.32()	.3234	.3221	.3362	t			as public
	2,0		.3853	.3754	. 365 2	1636.	÷556.	.3554	• 34 to	.3460	8146.	9539-	t i	, 1		E
. 250 1. 000			.+321	1414.	1224.	. 3522	. 305°.	65200	.3/62	• 3736	.3718		•	:	·	
	1.0	.5007	.4757	555++	(°564°	.4240	• 4 4 1 4	÷ 00¢ •	• 3474	6268.	469C.			. 1	·	

.

1

٠

•

44

÷.,

۰. ٤,

10 - Y 161A2/1))/T+±TAl = IntTAl =	.255 1.000	ʻ		Nr.	THETA THETA	арка 19 7 - 19 7 - 19	×° × °	
162	61 * · 6.0	¢•9	7.0	1.5	ບ • ຫ	8 . 5	ς • β	9*5	10°0
	*********							***	
	* * .1473	1051.	.1146	ı					
80	+	1961.	.1184	• 1044 ·	•0913				
ୢୣୄୣୄୄ	* .1562	.1388	.1231	.1088	e220.	4480 •	•0742		
0	* .1617	.1443	.1283	• 11 30	1001.	•0889	• 6783	-3688	+090 +
0.	* .2227	.2073	•1925	.1742	•1644	e151.	•1389	.1271	.1159
0.	. * .26 <u>32</u>	.2513	•2356	.2280	.2167	•2055	•1946	-1840	.1736
0	* .2872	.2778	•2685	• 2552	.2503	60 4 2°	.2318	•2229	°2141
0•1	* • 3026	•2949	.2472	.2795	.2719	•2643	.2567	• 2493	.2418
0.	* * .3131	-300E	.3001	• 2930	.2871	-2807	.2742	• 2678	.2614
0-1	* *		•3055	•3039	• 2983	. 292	.2871	.2315	•2759
0•1	, * *			,	.3067	813E.	•2469	•192.	.2870
0.	* *						•3:46	-3062	.2958
¢	* •		•						.3726

. 4

٠.

s

ł,

326

•195t •0428 .0933 •C339 •22oC •0355 .1375 .0349 •155° ***** 5.5 .0452 .0471 .0503 .1132 .1716 .2126 964J. .2405 .0527 .0438 5.0 .1358 .0600 .1923 .2350 . 7624 .3655 .0735 .0583 2590-4.5 CHETA 1 2 .1609 2:63* .c173. .0792 .5856 .0952 •214C .2474 .0764 .0821 THETA ¢.4 .2365 . .1883 •1003 .1C18 .1114 •1164 .122C .1C4C .1272 3.5 •2178 .2556 •1432 •1332 .1353 .1484 .1543 .1325 .1367 .1337 ن ۳ .1816 .1724 .1724 .1742 •1773 .1923 .2467 .1867 .1747 2.5 •2209 .2258 .2217 .2202 • 237c £655. .2231 .22.65 .2803 .2333 2.0 · 2785 .2675 • 2802 1912. .2744 •2746 . 2014 · 2468 .2761 1.5 .259 **ču**22• 1475. 5626. .3652 5566. .3351 3245 .3440 6475. .3970 (X0 - 701/1HETAL • THETA2/THETA1 2 81/82 2.0 0.0 4 • Ú 5°.3 1.3 N 30 ? **ا**ا---327

Downloaded from http://www.everyspec.com

Weibull - Yeibull I STREETH DISTRIBUTION STRESS DISTRIBUTION

(x0 - Y0 Theta2/T))/ThETAl = [HETAL =	= •250		•	· · ·	THET .	× 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	y - X.	
**	81	:	i	•		ļ			•
B1/82	6=0 ********	6.5 *********	7 • 0	7.5	*** い。の *******	8 • 5 *****	*######## ℃*6	. 9 . 5 :******	I0.0
-0 •	* •0254	1		:		•		:	
۲.	• • •0266	•C199	.0148						
£9.	* .0282	.0211	.0158	-0118	-0088				-
6•	* • 0301	. 0226	.0169	.0127	•0094	0130.	•0053	; }	
1-0	* * •0324	• C244	-0183	7610.	• C103	. 5706.	.0057	-0243	.0032
2.0	* °0350	•0612	• 0488	• 0385	1050.	•0234	•0810-	•0138	.0105
3.0	* .1336	.1165	• 1008	÷0865	<u>, 0736</u>	- 062C	•0219		•C354
0.4	* • 1791	.1633	.1482	.1338	.1202	+101+	•0955	•0844	-0742
5.0	* •2118	.1979	•1843	.1712	.1585	.1463	•1545	.1233	.1126
6.0	* * * 2 355	•2233	•2113	•1556	.1881	•1769	•1660	.1554	.1451
1.0	• •• •		.2318	.2213	.2119	.2009	•1909	.1811	.1716
0 • 9	16 - 46 - 1				.2290	.2198	.2108	.2018	1691.
0•6	i n (•2269	.2187	•2106
10-0							·	·	.2251
			STRENGT	DISTRIBUTI H DISTRIBU	TILON - We	11nd1 11nd1			

328°

Downloaded from http://www.everyspec.com

THET A2/	THETAL	.667		:				THETA 2	1 1 1 1	P NO.
•	81	ι.	۰ ۱		, 1 1		•			 ;
Bi/B2		1 • 5 *******		2.5 *******	3°C 6******	3.5 :******	·		5 • 0 *******	5+5, ******
, L	* .3170				•	• 1	•	 -	 	
•2	* .2742. *	1102.	•1409			•				
.	* * .2825		.1370	•0918	1000-		•			
* •	* * .2732 *	.1966	1357	•0915	• 0603	•0460	.0261			
S •	* * .2683 *	.1558	.1360	.0928	•06190	6340*	•0268	.0175	•0114	
9 329	* * .2665	.1972	1561.	÷350•	• 0640	.0425	÷123*	• 3183	611 0 -	.Jr 76
£.	* * .2669 *	.2003	.1430	• 3989	-0673	1440*	•0295	• 193	•C126	.7032
8.	+ + .2c88	• 2345	•1479	.1034	•010 •	•0474	.0315	- 020 7	•0136	6802*
6	* * .2716 *	• 2095	.1536	• 1088	0410.	.0508	•0339	• 1224	141°	•0196
1-0	*	.2150	.1599	.1147	•0803	.0546	- 1367	* j244	°0161	-0136
2.0	/ * * *		• 2241	.1833	.1462	.1137	•0863	• 3640	•C^64	.0330
3=0	• • •				• 3619	.1726	•1454	.1205	•0984	C620.
9•4	• + •						•1399	.1673	• 1461	.1262
5.0	• •	·						!	.1325	.1642
			STR	IST DISTRI	BUTTON -	Weibull Weibull				

*							<u>ч</u>	, 	
, #	81			•					
1/82	· · · · · · · · · · · · · · · · · · ·	c • 5 ########	7•5 *******	1.5 +++++++	8 • () \$ ******	0.5 *******	9 •) *******	9.5 *******	***********************************
¢.	* .3051			1			i	⁻ •	
۰٦	* * •J054	• 0035	£20¢*					·	
20 •		•C038	•0024	•0016	•00 1 0				
6•	• 0063	.0041	• 0027	•0017	1100-	1000.	\$000°		
1-0	+ + •0000+ +	.0045	•0029	610C.	-2100	•0008	•0002	• 1003	1000
2.0	* •0230 •	.8510.	.0108	• 3672	•0048	•0032	•0021	• JJ14	5 050.
3.0	* .0623	• 6483	• 0368	.0276	.0203	-0147	-0105	+7074	1500.
4•0	* .1080 *	£160°	•J164	.0632	.0516	•0416	•0330	.0259	10201
5•0	* .1469 *	.1304	.1151	.1007	528ĉ*	.0754	•0644	• 7546	• : 4 58
0-9	* .1775 . *	. 1622	.1476	.1336	.1203	.1076	1063.	.3851	. 15 .
0.7			.1739	.1608	.1481	.1360	.1244	.1133	.1~28
6.0	- 44 +				.1712	1961.	.1485	.1.579	.1276
0°6	F 46 4		·				•1692	.159C	•1490
0-0	· •								1476

330

ł

(x0 - Thefa:	Y0)/THETAL Z/THETAL			•			THET	A 1 A 1 A 1	× ×	
* *	• •			•				•		
B1/32	+ + + + + + + + + +	1。5 \$*******	2 • C +++++++	2.5	3.6 *******	3.5	4.0 ******	4 • 5 r******	5.0 ******	5 • 5 + + + + + + + + + + + + + + + + + + +
.1	* * .2528	• "								
•2	* * * 2353	• 1448	• 0855							
÷.	* * 2238	• 1402	9 <u>6</u> 80.	1649.	.0284					
•	* •2179	.1348	.0840	• 04 55	.0287	-0165	•0064			
j L	* * .2162 *	.1400	.3857	+0509	•0296.	1710.	•0098	• 0056	.032	
• 331	* • 2173	• 143C	.0887	.0531	.0312	•0181	•C104	- 0060	≁€ 00 [°]	6100*
2 -	* * .2203	.1475	.0928	•0552	•0332	•0163	•0112	.0364	.037	1200*
80 •	* °2245	.1530	1120.	6650.	.0357	•0209		JC0 *	.0940	°تن 2ع
6	* *2254	.1552	.1435	• 3643	• C388	-0229	•0133	1100.	•0.045	•0056
1	* .2348 *	.1660	50T.	• 0653	•0423	.0252	.0148	•0086	•0360	•0059
2-0	€ # 4		.1607	.1358	1860*	• 0682	•0457	.7297	°C187	.0115
3•0	* ** *				.1580	.1261	•0982	• 7745	•0550	*0395
4.0	► 42 ₩						• 1 460	.1210	1997.	£082.
•	• 4								.1368	
			STRES	S DISTRIBU GTH DISTRI	BUTION - NOIT	Weibull Weibull				

.

M

Contraction of the second

THETA2	Trelal Trelal	н н 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					THETA 1	н 6 Х - <u>6</u>	
* *	1						THETA 2	* ⁶	0 0
81/ð2	· · · · · · · · · · · · · · · · · · ·	なながなない。このであるというです。	1. 	7.5 ********	0 4 0 4 10 1	2 • •	• • ?	بر ۱۰	
. 6	1105•		!			*****	***	***	· *
۲.	2102• *##	1000-	\$200. •				4	. '	
ۍ •	* *05L3	1000	• 3006 •	-2222	1000-			• .	
6	\$10?• *	CČĢġ	• 3005	•0003	700 0 -	1.1.267	ć		
1 .0	* •35 1 0	6000.	6 366.	ດ) ເມ ເງ					
2.0	* •3C73	• 1342	.0525	6190.		•• 1 .1 (. 			
0-E	* •C27a	• . 100	•0124	18000				2002 •	•
4.0	* * •0635	694 <u>9</u> .	1020		10	••032	•005£	• 00 12	С с, г,
6. ¢	• • • • • • • • • • • • • • • • • • •			8/20*	•0203	•0145	1010.	4900°	*(. • .
	7707•	•	.0702	.0574	.0462	1350.	•°286	0220.	160
	- 055j • *	• 1170	•1024	5850	čd7.	•364°	- 5 3 8 P		•
	* **		.1307	•1160	•1034	1160.	1613.	.1693	• . 36
5 C) 5 C) 6 J)	بر <u>ا</u> فرید				•1282	.1155	.1943	• 1933	• 19 19 19
* * 9							.1203	•1154	•1250
									.1248

....

STRENGTH DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

> ---

Downloaded from http://www.everyspec.com

•										
• • •	. 18							: :	:	
B1/B2 4		1.5 *******	2.5	2 • 5 *******	3 = 0 *******	3.5 :*******		4 • 5 :******	5 • 0 * * * * * * *	5.5
•1	* .2007		•							
•2	≠ čd8[• ≠	•108	•0525				l			
۳ .	* .1770	1850.	• C516	• 0265	•0134		. 1	:		
4.	1741	• 6983	•0523	.6271	•C138	.0070	•0036	7		•
ŝ.	* •1749	• 1005	.0542	•0283	•0145	+200 -	•0038	6100-	6000-	
•	* * .1782	.1044	•0571	.050	.0155	• 00 <u>7</u> 5	•0040	0020	0100-	5009°
.7	* * .1831	•1095	-0609	•0324	.0169	-0687	•C044	• 0022	1100*	•000•
8	+ • • 1889	.1155	• 3654	•0353	.0185	•0036	6400*	52üt.•	•0013	• 000 •
с ,	* * 1954	.1222	.07C5	•03 8 7	•0205	1010.	- 5500-	•0028	• 001 +	.000.
1.0	≠ ★ •2022	.1294	.0763	. 2425	• 0229	.012C	•00 0 5	2Eċl.	•[7]6	860 ~ *
2.0	* * •	·	.1469	.101.	.0661	.0411	•0244	•6139	FT00.	•9042
3+0	* * •				.1243	• 0924	•0662	•0457	.0303	* 610 *
C•4	H- 4+ -						.1128	• C 885	•0678	5÷50*
ר יי עז	₩ #	•							•1059	593u"

ø

1.421.1.1

Č

.

ļ

ļ

(XG - Y(.THETA2/1)/THETAL = Thetal =	. 250					[A] = 0	м м	
**	18							2 - Z	·
B1/82 ⊣	r 6.9 ********	6.5 \$*******	_7.€ \$ \$\$\$\$ \$	7.5	8 °C 8 ¢¢	8 • 5 ******	****** ن*6	9.5 :*****	-0=0] -0=01
•	* •¢033			4		؛ •	:	· :	
.7	+ .0603	1000*	1000.						
89. •	* • 0003	-000	1000*	1000-	.000				
6.	+ + 0004	• 0002	1000-	•0001	0000-	-0000	0000-	;	† i
1•0	+ 0004	•0005	1000.	•0001	•0000	•0000	•0000	0000-	00601
2.0	* .0022	2100	.3036	-0003	0005	1000-	1000-	•0000	00001
3.0	+ 0120	1200-	• 004L	• 0023	• 0013	1000	+000+	2000.	10001
4.0	* • 0367	.0258	-117	1110.	.0076	.0047	•0029	.0017	0100.
5.0	* .0693 *	• 0546	.0421	• 0319	•0235	•0170	•0120	• 0083	.0756
Q*9	* .1015	.0853	1070.	÷150-	-0407	1750-	• C 2 9 0	• 0223	JIÉB
7.0	• • •		• 0 9 8 4	• 3845	6110.	•0605	•0504	•0415	,0338
8.0	• +• +				.0561	•0840	.0728	• 0627	°0535
0*6	• •• ••	:					• 0944	• 0836	.0736
10.01	• •		:						,0930

ų

STRESS DISTRIBUTION - Weibuil STRENGTH DISTRIBUTION - Weibuil

.

1

î, 1

. •

1

ł

X0 - Y9Ĭ/ HETAZ/THE	(THETAL = ETAL =	• 250	i ł					· ; ; ;		!
8] * *	۰. سر	• • •		۱	:	•				
* 1/62 *] •:] }-: }+++++++++	1 • 5 ** ******	2 • 5	2.5	3.0	3.5	0*4	4.5 ******	5 « 0 * * * * * * *	5.5 ****
***	.1511									
* * * ~	• 1448	• 0695	.0318	•		;	•	:		
* * * m	•1394	• 6683	°0316	•0143	• 0065		-			
* * *	. 1393	-0695	•0326	.0148	.0067	•0030	.0013			
* * US	.1419	•0724	•0344	.0158	-0072	-003Z	•100.	•0000	• CCC3	
• • • •	. 1468	• 5766	.0370	•0172	.0078	•0035	•0016	2000.	•0003	1000.
* * ~	. 1530	• 0818	.0403	0610*	.0087	•0640	•0018	•00CA	-000-	-2002
* * 00	.1601	•6878	1940.	.0211	8600 *	-0045	•0 02 0	•000	*C004	-000
* * ·	.1670	-0945	- 0486	•0236	1110-	•0051	.0323	1100.	•0005	000
1•0 *	£17.	.1016	.0536	.0265	•0126	-0059	-0027	ZEUU.	•000	C 0 C •
* * 5*2			.1202	1910.	• 0449	.0250	-0132	1900*	•0033	100.
* * • • •				۰	.0984	.0679	2744	.0280	1910.	600.
4°0 *							.0874	• 2645	.0460	. 031 (
+ 4 c v									1180	1042

• 250	.444
ู้พ	ų
(XC - YO)/14ETAL	THETA2/THETA1

 \sim THETA -

×° a I THETA 1

10.0 **6°2 0**•6 8•5 с**.**8 ć• j 7.0 ć. 5 . 0 **B1/B2**

. GCOL 0

-000C 1000. ~ ~

30

\$

0000.

.0000 0000 .0000 0000* .0001 .0001 .0001 • 000 I

-0008 0000. 16ນນີ້ •0049 00000-.0015 .0002 1100. • C⁵28 •0004 .0001 .0117 • 00 48 1000. ,0174 1000. ÷0014 .0002 .0082 .0250 .0349 .0004 .0027 .0133 . 2052 .0008 .0209 .0474 .0694

0460.

.0418

•0507

.0608

•0722

.515

•:9:9:•

9-20.

Weibull STRENGTH DISTRIBUTION - Weibull I STRESS DISTRIBUTION

336

2.0

3.0

6.0

5.0

0000.

1000.

0000

.0000

0000-

.0000

.0000

0000.

.0000

. J000

.0000

1000-

1000.

?

ļ

00000-

0000

-000°

0000-

-0362

+JCC.

.0718

0E00.

.075

• 1108

•0153

.0211

.0285

.0376

.0487

. .0618

0220.

6•0

0-1

8.0

0.0

IC.0

٨

-0187

.0245

•C315

•0399

.0453

.0612

.0742

·····

- ことのなどの時間にない

B1 1.0 1.5 2.6 2.5 3.0 3.5 4.5 5.5 .1211 .0479 .0189 .0630 .0613 .209 .0914 .0902 .0901 .1115 .0479 .0191 .9014 .0613 .205 .9902 .0901 .1116 .0476 .0191 .9014 .0013 .205 .9902 .0901 .11168 .9488 .02201 .9024 .0013 .2075 .9902 .0901 .11153 .0521 .9218 .9044 .0035 .9014 .0705 .0911 .11168 .9249 .0545 .0714 .0703 .0914 .0703 .0911 .1123 .0521 .9014 .0704 .0703 .0713 .7021 .7021 .11263 .0512 .0124 .0752 .0121 .7025 .7021 .7021 .7021 .1264 .0723 .0124 .712 .712 .7025 .7021 .7025 .7021 .7021 .7021 .7025 .7021 .7021	NTHETAL =	250						THETA 1 -	
1.0 1.5 2.6 2.5 3.0 3.5 4.2 4.2 4.5 .121(.1115 .6476 .0189 .0613 .6739 .6739 .6902 .6901 .1108 .0498 .0211 .9014 .0735 .9014 .0735 .6901 .11153 .0521 .9218 .9061 .9035 .9014 .0735 .6901 .11153 .0521 .9218 .9064 .0632 .9014 .0735 .6901 .11153 .0521 .9218 .9035 .9014 .0735 .6901 .112163 .0521 .9014 .0735 .9014 .0736 .6901 .112153 .0521 .9014 .0736 .0737 .0733 .0911 .12163 .0514 .0234 .0146 .0746 .0738 .0731 .7031 .12185 .0614 .0726 .9124 .712 .771 .771 .1244 .0744 .0728 .9124 .772 .7925 .710 .775 .1344			•		1				} } }
 .1211 .1216 .0476 .0185 .0191 .0194 .0032 .0035 .0013 .0035 .0013 .0035 .0014 .00302 .001 .0014 .0025 .0014 .0021 .0012 .0014 .0021 .0011 .0045 .0014 .0025 .0014 .0025 .0012 .0012 .0013 .0014 .0025 .0011 .0014 .0025 .0014 .0025 .0012 .0012 .0012 .0014 .0025 .0014 .0025 .0014 .0025 .0012 .0012 .0012 .0012 .0012 .0012 .0012 .0012 .0012 .0013 .0014 .0112 .0114 .0114 <		1.5 **********	2•6 ********	2.5 :++++++++	3 ° C 44444444	3•5 *******	******* *****	4 • 5 *****	新
 1115 .0470 .0181 .1049 .0470 .0191 .0016 .0032 .0013 .0003 .0005 .1069 .0440 .0221 .0035 .0014 .0705 .0001 .1153 .0521 .0218 .0040 .0014 .0705 .001 .1154 .0523 .0214 .0045 .0040 .0516 .0006 .0002 .001 .1245 .0514 .0204 .0112 .0045 .0014 .0006 .0003 .0001 .1245 .0514 .0204 .0112 .0045 .0014 .0003 .0001 .0001 .1245 .0514 .0204 .0112 .0045 .0014 .0006 .0003 .0001 .1245 .0514 .0204 .0112 .0045 .0014 .0003 .0001 .0001 .1245 .0514 .0204 .0112 .0045 .0010 .0104 .0003 .0001 .1245 .0012 .0024 .0112 .0025 .0110 .0104 .0003 .0001 .1364 .0012 .0012 .0112 .0014 .0003 .0003 .0001 .1364 .0012 .0014 .0114 .0010 .0104 .0003 .0001 .1029 .0014 .0013 .0013 .0003 .0001 .1029 .0014 .0013 .0013 .0013 .0003 .1020 .0014 .0013 .0013 .0013 .0013 .0014 .0015 .0112 .0112 .0112 .0001 .0014 .0013 .0114 .0112 .0112 .0112 .0001 	* .1211		:						
 1049 . 2476 . 0191 . 7076 . 0032 . 0013 . 6665 .1108 . 9488 . 4201 . 4081 . 4035 . 0013 . 6675 .1153 . 0521 . 40218 . 4086 . 4035 . 4014 . 6676 . 6902 . 6011 .1154 . 6563 . 5241 . 6695 . 0649 . 7616 . 6376 . 6932 . 6011 .1265 . 6614 . 6236 . 0127 . 5645 . 7618 . 6076 . 7003 . 6911 .1264 . 0072 . 5336 . 0121 . 6761 . 5625 . 6710 . 7703 . 6911 .1364 . 0122 . 5336 . 0151 . 6761 . 5625 . 6710 . 7034 . 6752 .1249 . 3834 . 9146 . 6761 . 5625 . 6710 . 7034 . 6752 .1249 . 3834 . 9146 . 6761 . 5625 . 6710 . 7034 . 6752 .1249 . 2834 . 1340 . 0515 . 7304 . 0154 . 0073 . 7965 . 6002 .1529 . 2834 . 1340 . 0515 . 7304 . 0154 . 0013 . 7034 . 6314 .1529 . 2834 . 0151 . 0515 . 7304 . 0154 . 0112 . 7631 . 6314 . 6112 . 5765 . 6013 . 0134 . 6314 . 6341 . 5614 . 5614 . 5765 . 6112 . 5765 . 6013 . 5033 . 6315 . 5741 . 5441 . 5741 . 5441 . 5741 . 5441 . 5741 . 5441 . 5741 . 5441 . 5744 . 5614 . 5625 . 5716 . 5716 . 5716 . 5716 . 5765 . 5716 . 5716 . 5765 . 5716 . 5716 . 5716 . 5765 . 5716 . 5716 . 5765 . 5716 . 5716 . 5716 . 5765 . 5716 . 5716 . 5765 . 5716 . 57	* .ill5	.0473	.0185						
.1108 .0488 .6201 .0032 .0013 .0032 .0013 .1153 .0521 .0218 .3086 .0035 .0014 .0706 .0302 .001 .1153 .0521 .0218 .3086 .0035 .0014 .0706 .0302 .001 .1214 .0523 .3241 .0045 .0045 .0045 .0045 .0014 .0706 .0302 .0301 .1214 .0523 .3241 .0045 .0145 .5713 .0703 .0312 .0301 .1285 .5014 .0236 .0121 .5752 .5713 .7033 .0331 .1285 .514 .0245 .5713 .7034 .7031 .1384 .0723 .5146 .0712 .7035 .7033 .1440 .0154 .0525 .0124 .0333 .0334 .0334 .1529 .3834 .0154 .0724 .0724 .0724 .0712 .7055 .1299 .0515 .0734 .0733 .0734 .0744 .0744	0701 + +	- 2470	1510.	. 7076	0:30		3		
 1153 .0521 .0218 .0686 .0035 .0014 .0709 .0902 .0011 1153 .0521 .0216 .0649 .0049 .0516 .0906 .0902 .0011 11245 .0514 .0234 .0112 .0049 .0014 .0007 .0003 .0001 11264 .0072 .0320 .0127 .0052 .0521 .0008 .0073 .0003 .0011 11364 .0072 .0320 .0157 .017 .0073 .0033 .0016 1145 .1129 .0515 .03167 .0154 .0154 .0073 .0033 .0016 11529 .0514 .0515 .0308 .0154 .0073 .0033 .0164 .018 .0091 .0515 .0380 .0154 .0172 .0172 .0096 .0018 .0502 .0154 .0172 .0172 .0112 .0096 		88.70	10201	.0061	.0032	.0013			
 1153 .0521 .0521 .0525 .0040 .0516 .7006 .0002 .001 .1285 .0514 .0563 .3241 .0645 .0045 .012 .007 .0003 .0001 .1285 .0514 .0204 .0112 .0045 .012 .0003 .0001 .1285 .0514 .0204 .0112 .0025 .010 .0024 .0072 .1364 .0072 .0336 .0146 .0073 .0033 .0016 .1529 .0804 .0515 .0368 .0154 .0073 .0033 .0016 .0521 .0304 .0172 .0003 .0783 .0502 .0304 .0172 .0091 .0515 .0783 .0502 .0172 .0093 .0783 .0502 .0304 .0172 .0093 .0513 .0502 .0304 .0172 .0094 .0513 .0502 .0304 .0172 .0094 .0621 .0514 .0510 .0515 .0314 .0512 .0172 .0094 .0513 .0502 .0304 .0172 .0094 .0112 .0013 .0013 .0014 .0112 .0094 	* * *108			. 0088	.0035	+100.	GC00.	2000.	•co01
 1/2/4 - (5/63 - 5/2/4) - (0/2) 1/2/85 - (6/14 - (0/2)) 1/2/85 - (6/14 - (0/2)) 1/2/85 - (0/12 - (0/2)) 1/2/8 - (0/12 - (0/2)) 1/2/9 - (1/2) - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1/2/9 - (0/2) 1	* •1153	0521			0040	. 9616	9000.	2000 *	ILCO.
- 1285 - 5614 - 0204 - 0114 - 000 - 0121 - 5021 - 6008 - 7003 - 7001 - 1364 - 3072 - 5336 - 3127 - 5552 - 5516 - 5025 - 5716 - 5705 - 5002 - 1445 - 3735 - 5334 - 5146 - 5661 - 5525 - 5716 - 5705 - 5003 - 1502 - 3804 - 1567 - 5073 - 5033 - 6015 - 5991 - 0515 - 0368 - 0154 - 0073 - 5033 - 6315 - 0783 - 0562 - 6304 - 0154 - 0172 - 0095 - 1741 - 541 - 541 - 562 - 0783 - 0562 - 0364 - 0172 - 0172 - 0095	* .Lčl4 *	4 .C5e3	. 241			613C-	-C 307	• 90.03	.003.
- 1364 .0072 .0300 1014 .0012 .0025 .010 .0070 .0072 .002 1140 .0134 .0014 .0015 .0012 .010 .0105 .0072 .012 .0003 .1209 .0091 .0515 .0308 .0154 .0013 .0033 .0015 .0183 .0502 .030 <u>4 .0112 .0112 .009</u> .1141 .0112 .009	* .128	5 .Ccl4	.02od	-		1621	8000.	Eiuc.	1000.
- 146 . 1765 . 23167 . 2017 . 2016 . 2016 . 2016 . 2015 . 2012 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2015 . 2016 . 2012 . 2016	* * •130	4 .0072	a (330	1710.			0100-	400%	.0072
	* •144	4£76 . c	ی از م را م	, <u>9146</u>		3000	.012	•0102	. C222
	* 2dl• *	4C30 • 6	.1400	.0167		23 IV	.0073	550C.	5100*
	• • •		1669*	-05 IS	80fu"	.0502	6060	.0172	•0063
•062	• 4• 4				•	- - -	1892.	.)471	°C 91
	• + •								•062

.

STRESS DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - We built See

Downloaded from http://www.everyspec.com

۰.

• •

.

(¥ů + Y Theia2/	2)/fretal = Tretal =	、 () 、 () ・ () ・ ()				£. <u></u> .	THETA 1 =	е ^х е ^х е	
+ +	Н								
81/62	· 本本本本本本本本本本	1.444444	******** :-: :-:	7.5 5******	d.e.C ******	ö =5 ¢ ≠ ‡ ‡ ‡ ‡:	6 ° C 6 ° C	9.5 *******	
• •	(* *			•	! :	•			•
r	5000° *	0000.	0205*						
80	+ °0000	0050.	0000*	0000.*	0010°				
6•	00001 *	•200.	500ē•	- 000C	0000*	3000	0000-		
Ĩ.0	CC	500C •	.0000	C000.	(333*	3630.	0000.	. 3350	07601
2•3	* •0003	1000.	1000*	0005-	00.5.	0622.	0000-	UDLE *	0000'
3.0	* .0023	1100-	• 9006	• 00:02	1960*	1000-	0000.	0000-	,0000
6.4	* •0119	•0000	• 0038	•00500*	C1.0.	•00 c 2	£003°	leet.	1062.
2 •0	* * •0323	• 3222	.0147	,0094	12001	46034	610.*	1100	9000*
6.3	* * "ĴŠČĆ	\$\$\$C	•0334	°0243	•0172	5110*	6Lu3*	1900.	.032
0-1	* *		.0501	£44C.	•0344	.0262	.0195	-0142	-:Č101
8•0	ž n				•0542	0440°	•5352	126.	• 215
0.6							• .526	• 1438	• (359
10.0									.2518
			STREN	S DISTRIBU	- NOLTUA	Weibull Weibull			

たちの間になっていたのでいたちのである

1 0.512 3.0 3.5 4.0 4.5 5.0 3.5 2 0841 0310 0108 0040 0013 0040 0013 0000 <th>• 1.0 1.5 2.0 3.5 4.0 •1 •.0512 0.041 0.0108 9.0 3.5 4.0 •1 •.0512 0.041 0.0108 9.0017 9.005 9.0023 •2 •0841 •0310 •0113 •0040 •0015 •0005 •0002 •3 •0842 •0345 •0137 •0143 •0015 •0005 •0002 •4 •0346 •0137 •0143 •0017 •0017 •0006 •0002 •5 •0936 •0137 •0156 •0156 •0020 •0006 •0007 •0020 •7 •1066 •0156 •0156 •0056 •0020 •0008 •0054 •7 •1066 •0176 •0020 •0016 •0004 •0016 •0054 •8 •1167 •0256 •0236 •0031 •0024 •0016 •0054 •0054 2.0 •1341 •0276 •0236 •0031 •0016 •0054 •0054 •0056 •0056 2</th> <th>THEFT</th> <th></th> <th></th>	• 1.0 1.5 2.0 3.5 4.0 •1 •.0512 0.041 0.0108 9.0 3.5 4.0 •1 •.0512 0.041 0.0108 9.0017 9.005 9.0023 •2 •0841 •0310 •0113 •0040 •0015 •0005 •0002 •3 •0842 •0345 •0137 •0143 •0015 •0005 •0002 •4 •0346 •0137 •0143 •0017 •0017 •0006 •0002 •5 •0936 •0137 •0156 •0156 •0020 •0006 •0007 •0020 •7 •1066 •0156 •0156 •0056 •0020 •0008 •0054 •7 •1066 •0176 •0020 •0016 •0004 •0016 •0054 •8 •1167 •0256 •0236 •0031 •0024 •0016 •0054 •0054 2.0 •1341 •0276 •0236 •0031 •0016 •0054 •0054 •0056 •0056 2	THEFT		
1.1	1/82 1.0 1.5 2.C 2.5 3.0 3.5 4.0 .1 .0512 .0310 .0108 .0040 .0013 .0005 .0005 .2 .0841 .0310 .0113 .0040 .0015 .0005 .0002 .3 .0842 .0317 .0113 .0040 .0015 .0005 .0002 .4 .0374 .0137 .0043 .0017 .0006 .0002 .5 .0936 .0137 .0049 .0017 .0006 .0002 .6 .1006 .0137 .0049 .0017 .0006 .0002 .6 .1006 .0137 .0049 .0017 .0008 .0003 .7 .1006 .0179 .0056 .0002 .0004 .0003 .7 .1006 .0215 .0024 .0010 .0004 .8 .1167 .0517 .0225 .0012 .0004 .9 .11553 .0576 .0236 .0012 .0012 .0 .11341 .0641 .0121 .0012 .0012 .0 .1341 .0641 .0121 .0024 .0012 .0 .1341			
.1 .0512 .0310 .0108 .0042 .0310 .0108 .3 .0841 .0310 .0113 .0042 .0015 .0005 .0002 .0000 .4 .0842 .0317 .0131 .0043 .0015 .0005 .0002 .0001 .0000 .5 .0842 .0137 .0043 .0017 .0005 .0002 .0001 .0000 .6 .0016 .0005 .00017 .0006 .0002 .0001 .0000 .6 .1006 .0171 .0028 .0012 .0003 .0000 .0003 .7 .1064 .0512 .0028 .0012 .0004 .0001 .0003 .8 .1167 .0517 .0028 .0012 .0004 .0001 .0003 .9 .1253 .0576 .0236 .0034 .0012 .0002 .0001 .0002 .9 .1341 .0571 .0107 .0026 .0012 .0012 .0001 .0002 .9 .1251 .0571 .0107 <th>.1 .0512 .0310 .0108 .0212 .2 .0841 .0310 .0108 .0064 .0310 .0108 .3 .0842 .0317 .0113 .0046 .0015 .0005 .0002 .4 .0874 .0345 .0137 .0137 .0049 .0017 .0005 .0002 .4 .0936 .0373 .0137 .0049 .0017 .0005 .0005 .5 .0936 .0373 .0137 .0049 .0017 .0005 .0005 .7 .1006 .0517 .0179 .0026 .00017 .0004 .7 .1064 .0517 .0205 .0012 .0001 .0013 .8 .1167 .0517 .0205 .0016 .0004 .0016 .0004 .9 .1253 .0576 .0236 .0017 .0012 .0016 .0016 .9 .1141 .0641 .0234 .0012 .0012 .0016 .0016 .9 .1141 .0641 .0121 .0021</th> <th>3.5 4.0 4.5</th> <th>5.0</th> <th>10 ° 10 10 ° 10 10 ° 10</th>	.1 .0512 .0310 .0108 .0212 .2 .0841 .0310 .0108 .0064 .0310 .0108 .3 .0842 .0317 .0113 .0046 .0015 .0005 .0002 .4 .0874 .0345 .0137 .0137 .0049 .0017 .0005 .0002 .4 .0936 .0373 .0137 .0049 .0017 .0005 .0005 .5 .0936 .0373 .0137 .0049 .0017 .0005 .0005 .7 .1006 .0517 .0179 .0026 .00017 .0004 .7 .1064 .0517 .0205 .0012 .0001 .0013 .8 .1167 .0517 .0205 .0016 .0004 .0016 .0004 .9 .1253 .0576 .0236 .0017 .0012 .0016 .0016 .9 .1141 .0641 .0234 .0012 .0012 .0016 .0016 .9 .1141 .0641 .0121 .0021	3.5 4.0 4.5	5.0	10 ° 10 10 ° 10 10 ° 10
.2 .0841 .0310 .0108 .0108 .0108 .0113 .0040 .0013 .0005 .0002 .0006 .0	.2 .0841 .0310 .0108 .3 .0842 .0317 .0113 .0040 .0015 .0005 .4 .0874 .0340 .0137 .0043 .0017 .0005 .0005 .5 .0936 .0373 .0137 .0049 .0017 .0005 .0005 .5 .0936 .0373 .0137 .0056 .0017 .0005 .0002 .6 .1006 .0346 .0137 .0056 .0020 .0007 .0602 .7 . .1064 .0517 .0129 .0028 .0010 .0603 .7 . .1064 .0517 .0056 .0028 .0012 .0603 .8 .1167 .0517 .0236 .0031 .0034 .0012 .0044 .9 .1253 .0576 .0234 .0034 .0012 .0024 .0012 .0024 .9 .1341 .0641 .0274 .0028 .0012 .0024 .0012 .0024 .9 .1341 .0511 .0			i 1
.3 .0842 .0317 .0113 .0046 .0015 .0005 .0005 .0002 .0000 .0000 .5 .0936 .0373 .0137 .0049 .0017 .0005 .0007 .0000 .0000 .0000 .6 .1006 .0414 .0156 .0056 .00217 .0001 .0001 .0000 .0000 .7 .1064 .0462 .0179 .0056 .0024 .0001 .0001 .0000 .0001 .8 .1167 .0517 .0205 .0017 .0024 .0012 .0001 .0000 .9 .1253 .0576 .0236 .0091 .0034 .0012 .0001 .0002 .0 .1341 .0641 .0107 .0026 .0026 .0026 .0002 .0011 .000 .0 .1253 .0576 .0234 .0040 .0215 .0001 .0002 .0001 .000 .0 .1253 .0521 .0107 .0024 .0017 .002 .001 .000 .0 <td>.3 .0842 .6317 .0113 .0040 .0015 .0005 .0005 .4 . .0874 .0340 .0137 .0043 .0015 .0005 .0005 .5 . .0936 .0373 .0137 .0049 .0017 .0006 .0005 .6 . .0936 .0373 .0137 .0049 .0017 .0006 .0002 .6 . .1006 .0414 .0156 .0056 .0020 .0001 .0003 .7 . .1064 .0517 .0056 .0024 .0008 .0034 .8 .1167 .0517 .0205 .0077 .0028 .0010 .0054 .9 .1253 .0576 .0236 .0091 .0034 .0012 .0024 .0 .1341 .0641 .0271 .0107 .0040 .0012 .0024 .0 .1341 .0641 .0271 .0107 .0040 .0215 .0205 .0 . .0 .0107 .0021 .0024</td> <td></td> <td></td> <td> </td>	.3 .0842 .6317 .0113 .0040 .0015 .0005 .0005 .4 . .0874 .0340 .0137 .0043 .0015 .0005 .0005 .5 . .0936 .0373 .0137 .0049 .0017 .0006 .0005 .6 . .0936 .0373 .0137 .0049 .0017 .0006 .0002 .6 . .1006 .0414 .0156 .0056 .0020 .0001 .0003 .7 . .1064 .0517 .0056 .0024 .0008 .0034 .8 .1167 .0517 .0205 .0077 .0028 .0010 .0054 .9 .1253 .0576 .0236 .0091 .0034 .0012 .0024 .0 .1341 .0641 .0271 .0107 .0040 .0012 .0024 .0 .1341 .0641 .0271 .0107 .0040 .0215 .0205 .0 . .0 .0107 .0021 .0024			
	.4 .0874 .0123 .0043 .0015 .0005 .0005 .5 .0936 .0345 .0137 .0049 .0017 .0006 .0002 .6 .1006 .0156 .0156 .0020 .0007 .0003 .0002 .7 . .1006 .0414 .0156 .0056 .0027 .0008 .0503 .7 . .1064 .0452 .0179 .0056 .0024 .0008 .0503 .8 . .1167 .0517 .0236 .0091 .0028 .0010 .0064 .9 .1253 .0576 .0236 .0091 .0034 .0012 .0094 .9 .1253 .0576 .0236 .0091 .0034 .0016 .0094 .9 .1341 .0641 .0271 .0034 .0016 .0096 .0096 2.0 . .0321 .0107 .00934 .0016 .0096 .0096 .0 .1341 .0641 .0127 .0034 .0016 .0096 .0096 2.0 . .0 .0 .0 .0 .0 .0 .0 .0 .0 .0			
.6 .0373 .0137 .0049 .0017 .0006 .0002 .0001 .0000 .0	•5 • 0936 •0137 •0049 •0017 •006 •0020 •6 • 1006 • C414 •0156 • 0020 • 0007 • 0008 •7 • • 1064 • C462 • 0179 • 0056 • 0024 • 0008 • 0603 •8 • 1167 • 0517 • 0205 • 0077 • 0028 • 0010 • 0064 •9 • • 1253 • 0576 • 0236 • 0034 • 0012 • 0026 •9 • • 1253 • 0576 • 0236 • 0034 • 0012 • 0026 2.0 • • 1253 • 0576 • 0236 • 0031 • 0034 • 0016 • 0026 2.0 • • 1341 • 0641 • 0271 • 0107 • 0040 • 0016 • 0026 2.0 • • 0821 • 0107 • 0026 • 00215 • 0095 • 0095 3.0 • • 0127 • 0107 • 0026 • 0214 • 0096 • 0095 2.0 • • 0821 • 0107 • 00926 • 0215	-0005 -0002		i
	.6 . .1006 .0414 .0156 .0056 .0020 .0007 .0503 .7 . .1064 .0542 .0179 .0056 .0024 .0008 .0503 .8 .1167 .0517 .0205 .0077 .0028 .0010 .0054 .9 .1157 .0517 .0205 .0071 .0028 .0010 .0054 .9 .1253 .0576 .0236 .0091 .0034 .0012 .0054 .9 .1253 .0576 .0236 .0091 .0034 .0015 .0055 .0 . .0314 .0641 .0271 .0107 .0040 .0015 .0005 2.0 . .1341 .0641 .0271 .0107 .0040 .0015 .0205 2.0 . .0107 .0626 .0514 .0094 .0015 .0205 2.0 . .0626 .0526 .0514 .0094 .0215 .0205 3.0 . .0626 .05214 .0994 .0215	.0006 .0002 .000	1 .0000	
.1 .1064 .6462 .0179 .0056 .0024 .0008 .0603 .0001 .0000 .000 .8 .1167 .0517 .0205 .0071 .0028 .0016 .0064 .0701 .000 .000 .9 .1167 .0517 .0205 .0071 .0028 .0016 .0064 .0701 .000 .000 .9 .1153 .0576 .0236 .0091 .0034 .0012 .0002 .0001 .000 .10 .1341 .0641 .0271 .0107 .0034 .0015 .0005 .0001 .000 2.0 .1341 .0641 .0271 .0107 .0035 .0001 .000 2.0 .1341 .0641 .0271 .0107 .002 .001 .000 2.0 .0 .0 .0 .0 .0 .001 .000 .001 .000 2.0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .	.7 * .1064 .0462 .0179 .0056 .0024 .0008 .0603 .8 * .1167 .0517 .0205 .0077 .0028 .0010 .0054 .9 * .1253 .0576 .0236 .0091 .0034 .0012 .0054 .9 * .1253 .0576 .0236 .0091 .0034 .0012 .0054 .0 * .1253 .0576 .0236 .0091 .0034 .0012 .0026 1.0 * .1341 .0641 .0271 .0107 .0040 .0015 0055 2.0 * .1341 .0641 .0271 .0107 .0040 .0015 0205 2.0 * .0821 .0107 .0626 .0075 .0204 .0204 3.0 * .0526 .0526 .0374 .0094 .0204 .0204	•0001 •0002 •000	000	000
.8 .1167 .0517 .0205 .0016 .0004 .0001 .0	.8 .1167 .0517 .0205 .0077 .0028 .0010 .0004 .9 * .1253 .0576 .0236 .0091 .0034 .0012 .0004 1.0 * .1253 .0576 .0236 .0091 .0034 .0012 .0004 2.0 * .1341 .0641 .0271 .0107 .0040 .0015 .0005 2.0 * .1341 .0641 .0271 .0107 .0040 .0015 .0205 2.0 * .0821 .0139 .0615 .0096 .0096 .0095 2.0 * .0621 .0621 .00926 .0095 .0206 .0206 3.0 * .06226 .0373 .0206 .0206 .0206 .0206	-0008 -0603 -000	• 0000	• 000
.9 .1253 .0576 .0236 .0091 .0034 .6012 .6004 .0002 .0001 .000 1.0 .1341 .0641 .0271 .0107 .0040 .0015 .6002 .0001 .000 2.0 . .1341 .0641 .0271 .0107 .0040 .0015 .0002 .0001 .000 2.0 . . .0107 .0026 .0214 .0026 .0017 .000 3.0 . . .0626 .0373 .0216 .0022 .002 4.0 . .0532 .0345 .0212 .012 .012 .012 4.0 . . .0532 .0345 .0212 .012 .012 .012 .012 .012 .012 .012 .012 .012 .0419 .033 .0345 .0212 .012 .0345 .0212 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 .012 <td>•9 •1253 •0576 •0236 •0091 •0034 •0012 •0096 1.0 • •1341 •0641 •0271 •0107 •0040 •0015 •005 2.0 • •1341 •0641 •0271 •0107 •0040 •0015 •005 2.0 • •0321 •0439 •0214 •0096 •0041 •0094 2.0 • •0521 •0439 •0214 •0096 •0041 •0206 3.0 • •0622 •0373 •0526 •0373 •0206</td> <td>•0010 •0004 •000</td> <td>1000- 1</td> <td>000-</td>	•9 •1253 •0576 •0236 •0091 •0034 •0012 •0096 1.0 • •1341 •0641 •0271 •0107 •0040 •0015 •005 2.0 • •1341 •0641 •0271 •0107 •0040 •0015 •005 2.0 • •0321 •0439 •0214 •0096 •0041 •0094 2.0 • •0521 •0439 •0214 •0096 •0041 •0206 3.0 • •0622 •0373 •0526 •0373 •0206	•0010 •0004 •000	1000- 1	000-
1.0 • .1341 .0641 .0271 .0107 .0040 .0015 .0002 .0001 .000 2.0 • 0.821 .0439 .0214 .0096 .0017 .0007 .000 3.0 • 0.371 .0439 .0214 .0096 .0017 .0007 .000 3.0 • 0.373 .0276 .0107 .0052 .002 4.0 • • 0532 .0345 .0212 .012 4.0 • • 0532 .0345 .0212 .012 5.0 • • • .0532 .0345 .0212 .012 5.0 • • • • .0532 .0345 .0212 .012 5.0 • • • • • .0532 .0345 .0212 .012 5.0 • • • • .0532 .0345 .0212 .012	1.0 * .1341 .0641 .0271 .0107 .0040 .0015 .005 2.0 * .0321 .0439 .0214 .0096 .0041 .0041 2.0 * .0821 .0439 .0214 .0096 .0041 .0041 2.0 * .0621 .0036 .0204 .0204 .0204	000 9500 2100	- 1000- 2	• 000
2.0 • -0821 •0439 •0214 •0096 •0017 •0007 •0012 •0012 •0012 •0012 •0012 •0012 •012 <t< td=""><td>2.0 • 0096 -0041 2.0 • 00526 -0096 -0041 3.0 • 0526 -0373 -0206</td><td>•0015005000</td><td>2 .0001</td><td>000</td></t<>	2.0 • 0096 -0041 2.0 • 00526 -0096 -0041 3.0 • 0526 -0373 -0206	•0015005000	2 .0001	000
3.0 * 0206 .0107 .0052 .002 4.0 * .0532 .0345 .0212 .012 5.0 * .0532 .0345 .0212 .012	3.0 * .0206 .0373 .0206	100* 1400* 9600*	1000. 1	000
4.0	•	.0373 .0206 .010	7 .0052	-200-
5.0 * .C479 .033	4•0 + 0532	•0532 •034	5 .0212	.012
	5.0 *		• 6479	•033

۰.

シャー・ション かんかいます うまい シャー・ロード・レスタインの特定 けるいちょう ひませんきん 大切をとい

ţ

((°)/TrEIAL = /ThCTAl = BI	• 250 • 364					THETA	1 * 0 × 0
81/82	0•0 0•0 ±	. 6 .5 *****	7+5 2+5	7.5 ******	0 * 8 * 0	8.5 #######	9•°2	9 •5 ******
°,	* * 5023	1						11
~	CUDC. +	.2000	0000*					
8.	0000* *	• 0000	0000.	r ope*	• 0000			
6.	• • • • • • •	0000.	•000	0000.	0000-	-0000-	0000*	¢
1-0	5030° +	.0000	0000*	0000*	• 0000	0000*	10000	0000*
2.0	* *0001	1000*	- 0000	• 0000		-0000	0000-	0000.
3°0	+ .0CII	• 600 <u>5</u>	2020.	Ĩ£00* -	0000-	0000-	0000-	• 0000

I

ę

STRENSS DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

• •

•,

.2250

1162.

.0397

0°6

1C-0

.3388

.0002

•0004

.0008

.9015

.0028

.0050

.0036

.0141

.0221

5.0

+100+

• 0024

.0041

•0066

•0104

.0157 .0321

•0229

• C325

0440+

6.0

.0424

7.0

8.0

+300-

•0382

•0120

.0171

.0237

.0135

.01e3

•0244

•0319

•040P

. 3000

-0000

1000-

•0002

•0004

•0608

.0017

.0035

.0068

4.0

0000-

Downloaded from http://www.everyspec.com

-0000

.0000

10 1.5 2.6 3.0 3.5 4.0 4.5 5.0 5.0 1 . (655 . . (055 . . (055 . (055 . (057 . (056 . (057 . (056 . (057 . (056 . (057 . (057 . (050	11	(X0 - Y0)/THETAL =	•250	· ·					ETA 1 =	6 ^M 6 ^M	
1 • 0655 2 • 061B • 0196 • 0009 • 0005 • 0001 • 0002 • 0001 • 0002 • 0001 • 00000 • 0000 • 0000 • 0	1 • (655 2 • 0648 • 0059 • 0006 • 0002 • 0002 • 0001 4 • 0669 • 0234 • 0019 • 0002 • 0001 • 0002 • 0001 5 • 0694 • 0234 • 0012 • 0002 • 0001 • 0000 • 0000 • 0000 6 • 0693 • 0101 • 0032 • 0012 • 0004 • 0000	* B1 B1/B2 * 1.0		2, 0		3.0 *******	3.5 844444	0°4	4.5 *****	5.0	5 ÷ 5
2 . 0618 .C196 .0019 .002 .002 .0019 .0022 .0002 .001 .0002 .001 .0002 .0010 .0000 .0010<	2 0618 02196 0002 00019 0006 0002 0001 0000	• • • • • • • • • • • • • • • • • • •				1 , . !	•			·	·
3 0642 0209 0004 0002 0001 0002 0001 0000 <t< td=""><td>3 0642 0209 0004 0019 0002 0001 0002 0001 0002 0001 0000 <t< td=""><td>* •2 * • 0618</td><td>• 1096</td><td>•0059</td><td>·</td><td></td><td></td><td></td><td></td><td></td><td></td></t<></td></t<>	3 0642 0209 0004 0019 0002 0001 0002 0001 0002 0001 0000 <t< td=""><td>* •2 * • 0618</td><td>• 1096</td><td>•0059</td><td>·</td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	* •2 * • 0618	• 1096	•0059	·						
• • 0694 0234 • 0072 • 0002 • 0002 • 0002 • 0000 <t< td=""><td>• 0694 0234 -001 -0002 -001 -0002 -001 • - 0760 -0245 -0021 -0002 -001 -0000 -000 • - 0835 -021 -0032 -0012 -001 -0000 -000 • - 0835 -021 -0032 -0012 -0004 -0010 -0000 -00 • - - - - - - - -0001 -0000 -00 -00 • -</td><td>* .3 * .0642</td><td>.0209</td><td>.0064</td><td>.0019</td><td>•0000</td><td></td><td></td><td>1</td><td>) {</td><td>ţ</td></t<>	• 0694 0234 -001 -0002 -001 -0002 -001 • - 0760 -0245 -0021 -0002 -001 -0000 -000 • - 0835 -021 -0032 -0012 -001 -0000 -000 • - 0835 -021 -0032 -0012 -0004 -0010 -0000 -00 • - - - - - - - -0001 -0000 -00 -00 • -	* .3 * .0642	.0209	.0064	.0019	•0000			1) {	ţ
• •	• 0760 .0246 .0045 .0010 .0002 .0001 .0000 .000	• • • • • • • • • • • • • • • • • • •	•0234	.0073	.0022	-0007	•0005	.6001			
• •	- 0835 .6304 0101 .0032 .0011 .0020 .0000 .000 -1 - .0917 .C349 .0119 .0039 .0004 .0011 .0050 .0000 .000 -8 - .0917 .C349 .0141 .0547 .0012 .0004 .0001 .0050 .000 .000 -8 - .1002 .C399 .0141 .0547 .0015 .0005 .0001 .0030 .001 .0030 .001 -8 - .1001 .0554 .0155 .0019 .0072 .0001 .0303 .00 -9 - .1161 .0513 .0155 .0058 .0058 .0052 .0001 .0309 .0303 .00 2.0 - .0155 .0150 .0150 .0251 .0251 .0254 .02 2.0 - .0150 .0150 .0150 .0152 .0142 .0251 .0251 .0251 .0254 .0145 .0561 .0254 .0145 .05 .0551		.0266	.0085	.0027	• 0008	•0002	TCCO*	00úá*	0000-	
 .0917 .0349 .0119 .0039 .0012 .0004 .0001 .0050 .000 .000 .0917 .0349 .0119 .0057 .0015 .0005 .0002 .0001 .0000 .000 .100			6304	-0101	•0032	•0010	-0003	.000	.0000	0000-	000*
 8 1002 .0399 .0141 .0047 .0015 .0005 .0002 .0001 .0000 .000 9 100 100 1161 .0513 .0155 .0068 .0028 .0001 .0009 .000 000 /ul>			C349	6110-	•0039	• 0012	•000•	1600-	•0000	•0000	• 000
 9 1091 0454 0166 0057 0006 0058 0058 0058 0058 0058 0058 0058 0059 00	 1091 0454 0166 0057 0019 0006 0002 6001 0000 000 100 1001 0000 0008 0002 0001 0000 000 100 1161 0513 0155 0068 0023 0008 0002 0001 0009 0003 00 2.0 1161 0513 0155 00337 0150 0001 0024 0009 0003 00 2.0 1161 0513 0155 00337 0150 0001 0024 0000 000 2.0 1161 0513 0155 00337 0150 0001 0024 0000 000 2.0 1161 0513 0155 00337 0058 0051 0024 0000 000 2.0 1161 0513 0155 00337 0058 0051 0024 0000 2.0 1161 0513 0155 0033 000 2.0 1161 0513 0155 0058 0058 0059 0000 2.0 1161 0513 0155 0058 0058 0058 0058 0000 2.0 1161 0513 0155 0058 0058 0058 0000 2.0 1161 0513 0159 0058 0058 0058 0000 2.0 1161 0024 0000 2.0 1161 0024 0000 2.0 1161 0024 0000 2.0 1162 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 145 0000 2.0 1400 <		C399	.0141	.0047	.0015	.0005	2000*	1000.	0000.	•000
1.0 • 1161 .0513 .0155 .0008 .0028 .0302 .0001 .0000 .00 2.0 • • .0155 .0150 .0061 .0024 .0009 .0003 .00 2.0 • • .0150 .0061 .0024 .0009 .0003 .00 2.0 • • 0150 .0061 .0024 .0009 .0003 .00 2.0 • • 0150 .0150 .0061 .0024 .0033 .00 2.0 • • • 0150 .0150 .0261 .0267 .0229 .00 3.0 • • • .0563 .02778 .0142 .0264 .0145 .07 4.0 • • • .0563 .0278 .0254 .0145 .07 4.0 • • • .0563 .0278 .0244 .0145 .07 4.0 • • • .0563 .02563 .0244 .0145 .07	1.0 .1161 .0513 .0155 .0008 .0028 .0001 .0000 .00 2.0 .1161 .0513 .0150 .0061 .0024 .0009 .0003 .00 2.0 .0 .0150 .0150 .0061 .0024 .0009 .0003 .00 2.0 .0 .0150 .0150 .0061 .0024 .0009 .0003 .00 2.0 .0 .0150 .0150 .0263 .0278 .0142 .0267 .0229 .0145 .0145 3.0 . .0 .0563 .0278 .0142 .0264 .0145 .0274 .0145 .01		0454	.0166	1200-	6Ì00°	•0006	•0005	.6901	-000C	• • • •
2.0 * .0009 .0003 .003 .000 * 0150 .0024 .0009 .0003 .00 3.0 * .0142 .0067 .0229 .07 3.0 * .0145 .0145 .0145 .0145 .0145 .01	2.0 * .009 .0003 .000 .00150 .0278 .0142 .0009 .0003 .00 3.0 * .0142 .0067 .0229 .00 4.6 * .0145 .0145 .0145 .01 5.0 * .0250 * .0278 .0145 .0145 .00 4.6 * .0250 * .0278 .0145 .00 .0250 * .0278 .0278 .0145 .00	+ v + v + 1161	.0513	•0155	• 0068	•0023	.0008	•0302	1000.	0000*	• 000
	 2.0 * 3.0 * 3.0 * 3.0 * 5.0 *)	•0685	TEE0.	•0150	.0061	+200*	6000.	•0003	00
3.0	3.0	• • •				•0503	.0278	°C142	•0067	•0024	ບ ເມື
4•6 * * (37C • ³ 2	4.6 * * 5.0 * 	3.0°E						•〔4]8	.0254	.0145	ùō•
	5.0 * Veibull	()• *								.(370	20.

)

i.

. . . .

. .

?

ì

!

THETA2/To	/ITEIAL = 167Al =	- 255 - 333 - 333					2 VIAETA 1	1 1 5 ⁴ 05	× ~
B1/82 *	0 • 0	6.5 *****	5°1	7.5	8.C ******	8.5 :*******	9.9 5.0	9.5 :******	10°C
وب	0000					1 - 1 -		- - 	-
	• • 6030	-000C	0000-						
ар •	-0000	•0000	•0000	• 0060	• 0000				
- т С	-0000°	0000*	0000	0000*	• • • • • •	0000-	•0000	-	
1. 0	- 0COG	• 0000	0000*	500°*	6009.	0000*	2000-	•0000	000.
0	• • • COO1 •	,0000-	• 0000	0000*		. D F00	.0000	0000	000
0	* * .0005	-00C2	1000-	• 0000	.0000	0000	0000	0000-	000
	* * .0039	• 0018	8000*	• 000 •	.0002	1000.	0000*	00co.	• 300
2.0 2.5	* •0151	•0089	• 0650	.0027	e170*	1000	•0003	1000.	-000
6 •0	* * .0341 ·	.0236	.0157	1010*	.0062	.0036	1200*	1100.	000-
C*2	* =		.0322	.0233	.0163	-0111	.0073	1406.	•0.32
8°0					80EC.	1 620 *	.0169	1210.	800.
0•6	* * '						•0298	• 3230	.617
	* *								630 -

٤

342

• #

٠.

Ŀ

ł

(X0 - V 3 Theta2/1)/THEIAL = HETAL =	.500 1.640	•				. '	THETA	'co ^H co ¹	× ×
**	19									0
B1/82 4	1.0	1.5	2 + C -	2.5	3.0	3.5 ********	¢*******	4 • 5 * * * * * * *	5 • 0 * * * * * * *	5 • 5 ** ***
Į.	C65E* *									
-2	≠ + / •3296	• 2549	1161.				•			
	* • 3103	• 2446	1381°	5/EI·	.1010	·				
4.	* .2548	.2403	.1847	.1385	.1022	•0745	•0239			
•5	1962° *	• 2400	. 1865	.1418	.1055	-0775	•0564	-3407	.0292	
.	* 2940 *	•2424	.1914	•1469	.1105	5180*	•0630	• 7435	\$160	1022
	* . 2959	• 2464	.1973	.1535	.1163	4L80°	•0646	.0472	• 7342	,4Zu
8.	* * .2973	•2514	.2041	•101C	.1242	3450°	.0701	1156.	-0377	1201
6.	* •300 L	•2509	.2114	1691.	.1322	•101•	.0765	•1569	•7419	-0E0 -
1-0	* * .3033	•2624	•2188	•1775	1407	£601.*	.0835	.0629	-046T	•034
2.0	* *		.2756	•2465	.2176	.1898	.1035	.1392	.1170	160.
3.0	* *				.2615	•2453	•2194	1661.	•1795	.160
4.0	* *						• 2531	.2367	•2265	• 204
5	4 1			•					LLTC	- 234

-5.1	1.00
11	łi
IAI	
Ш	VI
N	Ē
ŝ	Ę
1	A2
OX J	Thet

ų

3 THETA

Φ

ł

×°

I _مه

THETA 1

10.0 ۳°

9° ି **ଚ** 8**.**5

ς. φ

5-1

7.0

0

0

61/62

• •

8

.005L .0127

.0177

-91oI

٩

1910.

3.

•C142 .clóf .0222

6•

.9052 •0316 .0059 •000a •0073 •0400 -0082 • CC95 .01Cl •ċ115 -0132 .0514

•C035 .1534 .0186 •0605 .1203 6400* .0244 •0713

.0633

• 0964

.1158

•1č54

• 1431

3.0

• 0644

.0796

.0182

.0251

1.0

.1329

.1461

.1559

.1743

•1893

0.4

.0018

į

.0030

-9042

·:105

•0025 .0510 .0141 .0972 •1432 1791

.1712

.1832

.1956

.2082

•2211

2.0

.1999

•21C6

.2215

.2326

.2438

6.0

0•2

8.0

0°6

10.0

.2213

•2314

.2410

.2383

.0425

•0868

.1269

.1593

•1850

.2056

•2358

;

.2222

.2296

.2372

1601. .2137 .1373 • 194C •2220 •2<u>0</u>31 .1894 •2124 .1555 •2304

Weibull ł

STRENGTH DISTRIBUTION - Weibull STRESS DISTRIBUTION

344

2•0

THETA2/TH	ETA1 =	- - -						ETA 2 =	с н ^о	
₽ *	1									
B1/82 *	1.Č :********	1 • 5 • + + + + + +	2.cC :*******	2+5 :******	3.C *******	3.5 *******	4 • () ******	4 • 5 :++++++	5.0 ******	5*5 *****
•	.2209									
- 7	.2366	• 1255	•0728							
ਸਾਂ ਜੋ ' ਹੈ। •	1531	1237	•0729	.0417	• 0234		:			
* * •	0851.	.1265	• 3759	.0439	.0249	•0140	-0078			
ч ч	2019	.1322	•0869	.0476	• 9273	•0154	•6686	.0248	-9027	
• • • 34	. 2080	.1396	•0874	• 9523	+03C4	.0173	•0198	• 0055	1600.	100.
 -	2412. 1	.1482	1550-	. 35dl	•0343	.0198	•C113	, 0764	.0036	• 005,
. 00	* * .2228	.1273	¢£01.	• 0647	•0389	•0228	•6131	S110.	•0342	•C02•
• •	* .2304	<u>. 1667</u>	.1126	1270.	• 0443	•0264	•0154	•3388	•1050	*UC3
	2379	.1761	•1220	*C8C1	.0503	.03 <u>0</u> 6	.0181	•0109	.0060	•003°
2.0 4			1402.	.1044	.1278	2960*	•0102	• 3495	•0339	.022
3•0	ж. ж.			3	.•1¢94	.1668	.1340	•1096	•0880	690*
- + 0• +	* *						.1814	Ĵ65I.	.1380	.118
									.1760	.157

' . ''

(XC - 1 THETA2	Y©)/TrcTAL = //hEla'i =	rai 			·	;	THETA 1 THETA 2	6 × 6 × 6 × 6	
*	lu I								
b1/B2	4 *4 *******	r	1 = C - C	7•5 \$******	14444444 し。20 19 19	8。5 *******		.9 . 5 ⊨≠≠≠≠≠≠	**** C*C*C
. .	÷000° + +	ı				:			
۲.	1100. *	.0CC6	5000-						
8.	# •CCI3	• 6667	• 0004	-0002	C00•				
6.	\$100° *	5000*	4300 .	£900°.	*0CC2	.010.	1000-		
C•1	÷ •0019	1100.	.3666	ເບັບ.	2000-	10 00.	Teus*	1000.	000*
2-0	₹ •0145	. 2650*	1500*	• Cu34	• 0(21	21JC.	1003*	•006•	. 600
3.3	* * *	.6403	• J298	e120.	• 6152	-0105	-001	1400*	ECC*
0• 4	• 1005	.5863	.0658	.0570	•6450*	•364	•C285	6120-	.016
5+0	* .1407 *	• 1245	£50T*	-0952	• C 25 3	\$0£0*	•C598	.3503	140.
6.0	* .1725	1721.	.l420	.1288	.1157	•1C34	•018	ITRJ.	120.
7.0	₩-44-i		.1050	•1565	•1440	.1320	•1275	•1056	660.
8•0					.1675	.1562	.1451	.1345	.124
0.6	4. 4						.166C	.1558	•146

STRESS DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

1647

0**°** 6

- 10-0

۱.

, 4

Downloaded from http://www.everyspec.com

.....

	ThETAL =	. 607						7 VIJNI.	, , ,×∞≻ , ,,	4° p.º
**	19									i.
# B1/B2	≠ <u>1</u> .℃ *********	1.5 6******	Z = € :*******	2•5 :*****	3•0 *****	3.5 *******	4 • ? • * * * * * * * *	4.5 1******	5 = C + + + + + +	5•5 *****
.1	* * .1257									
•2		-037	.0232							
÷.	* ,1195	• 6568	.0251	.3167	•6645					
4.	* .1272	•9626	•0284	•123	5600 .	•0022	6000-			
ŝ	* * .ljo6	.0706	•032B	•0140	.0263	1220.	1100	· 500ć*	2000.	
9	€2÷1° *	.0786	5820 ·	•0175	1200.	•603•	•0014	• 3006	E003-	10001
L •	* .1571	. 5885	•0444	÷020-	• GC 55	•0542	81J0*	.1008	E000*	2600*
8	* * .1684	•0579.	.0514	•0520	•0110•		•0023	olît."	+000-	N C Q U *
6	* .1789	.1082	• C9 30	• 1258	. 6142	•0066	•0030	£100*	9000*	• 000
1.0	* * .1839	. 1186	.0673	•0352	.0173	• <u>31 82</u>	• CC38	7100.	8002*	:00.
2-0	**		•154ē	950T*	.736	9742¢	• (233	-0162	-0049	-004
3•0	* *				.1380	.1:73	4 6 6 7 8 7	• 7583	-040 1	.5274
4•0	* *						•13.5	•1764	• 351	• <u>C</u> éot
0° 5 .	* *	·							.1254	• 106(

.

ł

•			•		5 	1			
(k0 - Y) TheTA2/T *	1/THEFAL = hcTAL =)	1941 1941	8 8 	к К К	: :
*	13								
61/62 .#	C	6.5 ******		7.5 :*******	6.c r******	8 . 5 *****	5 * C	9 • 5 ******	10.0 ******
Ş.	1590. *								
	1000 *	0000-	5230*						
8.	+ .00Ci	1000*	°000°	- 2000	• 000 3		·		
6*	1000 *	-000	.0000	•••••	0000-	• 0000	0500*		
1.0	* .0002	•00C1	- 0000	• 0060	0000.	9050.	0000*	0000*	•0000
2.0	* .3024 .	•0012	• 00:26	• GCC3	1000-	1000.	000u*	0000-	000Q*
3.0	* •0177	0110	•0000	• 3038	• 6321	21-6-	9003	£300*	
0.4	* •0510	.0380	LL73.	•0196	•0Ì35	0650*	•0058	1600.	.:022
5.0	* .0884	.0727	. 3588	5940*	1960.	.0282	•0213	.0157	. 2114
6.0	* • 1220 ·	.1057	839C.	• 6772	-0649	°6534	.C443	• 3359	• 2288
7.0			.1195	.1056	.0920	•9356	•{ 696	• 3596	•0506
8.0	• • •				111.	.l: 55	•046	. 1235	4ELU"
0•6	é 44 4						.1103	•1054	.0952
10.0	+ +		. *						.1151

STRESS DISTRIBUTION - Welbull STRENGTH DISTRIBUTION - Welbull

.

1 į

e •

14-1-146年代11時級份容,中国建筑在北部市上水市

ţ

ť

「日本」の「日本」

348

.
91/82 1.0 1.5 2.6 2.6 2.6 2.6 3.6 3.5 4.5 5.6 <td< th=""><th></th><th>**</th><th>18</th><th></th><th></th><th></th><th></th><th></th><th>-</th><th></th><th></th><th></th></td<>		**	18						-			
•1 • .0523 •2 • 0676 •0179 •0052 •3 • 0676 •0226 •0726 •0726 •0703 •4 • •0791 •0226 •0723 •0008 •0703 •0001 •5 • •0791 •0226 •0032 •0122 •0394 •0122 •0394 •0008 •0701 •0300 •3001 •5 • •071 •072 •0394 •0122 •0393 •0012 •0003 •0001 •3000 •3001 •3000 •3001 •3000 •3001 •500 •3030 •5001 •500 •5002 •5002 •5002 •5002 •5002 •5002 •5001 •5000 •5000 •5000 •5000 •5000 •5000 •5000 •5001 •500 •5001 <t< th=""><th></th><th>B1/B2</th><th>* 1°0 ********</th><th>1.5 *******</th><th>2, C ******</th><th>2.5 ******</th><th>3.C F########</th><th>3.5 :*******</th><th>4 • 0 + • 0</th><th>4.5 ********</th><th>5°0 ******</th><th>5,5 ######</th></t<>		B1/B2	* 1°0 ********	1.5 *******	2, C ******	2.5 ******	3.C F########	3.5 :*******	4 • 0 + • 0	4.5 ********	5°0 ******	5,5 ######
-2 -0576 -0179 -0052 -0026 -0026 -0026 -0026 -0026 -0026 -0020 -0			* * • C523	-	 		•	• • •	2		<u> </u> 	i : !
· · · · · · · · · · · · · · · · · · ·		•2	+ .0576	. 6119	•0052	ı						:
• •		.	+ .0676	• 0226	590 <u>0</u>	• 0220	• 0006			:		i
 .5 .0312 .0354 .0122 .0012 .0004 .0004 .0001 .0000 .0001 		4	1620 *	• 6285	• 0032	•70Z8	• 0008	£000°	1000*			
 /ul>		S.	* * 0512	.0354	.0122	•0036	.0012	+000+	1000*	•0000	0000-	
.7	349	•0	*1036	• C431	•015ó	• 0053	100.	•0002	• C002	locc.	°0000°	0000.
····································	,	1.	*	.0516	• 1200	1100*	•0024	•0008	-0003	1000.	0000	• 0 000
•9 • 1401 •0703 •0306 •016 •005	:	8	*1232	.0607	.0250	.0093	•0033	1150.	+CC0+	1006*	-000	0000 -
1.0		6	+ 1041	• 0703	• 0306	•0120	*0044	9100.	-0005	• 0002	1060.	•0000
2.0 * .1167 .0733 .0424 .0226 .0152 .0053 .001 3.0 * .1167 .0733 .0424 .0226 .012 .0523 .001 3.0 * .1167 .0733 .0716 .0478 .0363 .011 4.0 * .071 .1023 .0716 .0478 .0365 .036 5.0 * .0743 .0711 .0519 .036 .071		1.0	*151b	.0802	.0369	.ois2	•0058	1200.	1000.	• 0-03	1000-	0000*
3.0 * .0.5 .152.) .116 .0363 .111 .036 4.0 * .0716 .0716 .0719 .0716 .0716 5.0 * .0716 .0719 .0716 .0716 .0716 5.0 * .0716 .0716 .0716 .0716 .0716 5.0 * .0716 .0716 .0716 .0716 .0716		2-0	• +• -		.1167	•0733	•0424	-9226	.0112	-0152	.0323	155.
4.0 * .036 .036 .036 .036 .036 .036 .036 .036		3.0	• • •				.1020	•0172.	.C478	•0303	.181	0.0
1/2° 9680° * 0°5		4 ° 0	• • •						• 0943	1120.	5 I SJ.	- 0 36 C
		5.0				·					•0896	51200
					STREM	INTERIO HEE	BUTION - F	leibull				

Downloaded from http://www.everyspec.com

٩.

:

CARL STREET, NO.

0') 9 •	.571	
il	ų	
(KO - YO)/THETAL	THETA2/THETAL	#

1 State Internet

į

アイ・ドー しんさくざ しき

いい あいおかえ

あるとしているのから

æ

THETA 1 THETA 2 |

3

۲ Ħ

******************************* 9.5 **ං** 6 8**.**5 ų•3 **č•**1 2.2 č.5 81/62

10.0

.000. ja. Ø

. •

.0000 0000. .0000ų

.9 .0000 .0	8•	CC00• *	0000*	0000.	9000*	0000.			• •	
1.0 * .0000 .0000 <td< th=""><th>6•</th><th>2000 *</th><th>0000¹</th><th>0000-</th><th>• 2000</th><th>-0<u>-</u>0-</th><th>• ၁၄၄၀</th><th>0000-</th><th></th><th></th></td<>	6•	2000 *	0000 ¹	0000-	• 2000	-0 <u>-</u> 0-	• ၁၄၄၀	0000-		
2.0 * .0004 .0001 .0000	1-0	000C* +	0000	• 0000	.0000	C000.	- 000C	0000*	• 0000	•
3.0 * .0055 .0026 .0003 .0001	2.0	+000° +	- 0002	1200-	. cocc.	• 0000	0000*	0000*	0000-	•
4.0 * .0249 .5163 .0162 .0051 .0616 .0005 .00005 .00005 .00005 .0	3.0	÷ - 0055	• 0028	•0.113	9000*	-0003	1000.	+ ñoñ+	0000-	•
5.0 * .0550 .0416 .0307 .0221 .C154 .0104 .6068 .3043 . 6.0 * .0865 .C710 .0573 .0455 .0355 .0271 .0203 .0149 . 7.0 * .0844 .3710 .0551 .0485 .0394 .0315 . 8.0 * .0828 .3711 .0628 .0311 .0510 .0510 .	4.0	* • 0249	.0163	-0102	1900*	•0 <u>0</u> 35	6100*	-0010	• 1005	•
6.0 * 10865 .C710 .0573 .0455 .0355 .0271 .0203 .0149 . 7.0 * .0394 .03710 .0551 .0485 .0394 .0315 . 8.0 * .0311 .0625 .0510 .0510 .	5.0	+ •0550	.0416	.0307	.0221	•0154	-010-	•0068	• 3043	•
7.0 * .0394 .0710 .0551 .0485 .0394 .0315 . 8.0 * .0828 .0711 .0625 .0510 .	Ū•9	* * 20865	.0110	.0573	• 3455	•0355	.0271	•0203	• 0149	•
8.0 * .0510 .0510 .0510 .	7.0			•0844	0110.	1550.	-0485	-0394	-0315	٠
	8 . 0	• •				•0828	1116.	• ୯୧୬୭	- 2510	•

350

Downloaded from http://www.everyspec.com

-0617

.0712

..0815

0.6

1C • 0

.03.)6

STRENGTH DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

11

..

*

*	J/HELIAL = HETAI =	• 500	:	• •			:	THETA	3 4 6 7 7 7 7 7 7 7 7 7 7	×° ×°
e1/82 *		1.5 *******	2°C *******	2.5	3.0	3.5 :*******	4.0 *******	4.5 ******	5.0 ******	5°5 ****
•	• • 3112					4 4 1	1 1 1 1 1			
2	≠ + ,c229 <u>.</u>	• 0038	•0005	•						
m •	* *	.0073	•0013		0000	•	•	-	; ; ;	
4.	• •04/3	.0116	• 0024	-2005	1000*	0000-	0000-			
	• • 0600	•0169	• 0040	600C*	\$000	0000*	•0000	0000-	0000-	·
	1210.	• 0229	1930°	÷100=	• 0003	- 0001	0000-	0000.	- 0000	•0000-
. N	+ -C455	• C298	-0067	-0022	0002	1000-	•6000	0000.	000à*	• 0000
 	* .0982	. 0374	-0119	-0033	6000*	•0003	1000.	0000-	0000*	0000-
6.	• 1106	• 3456	1510-	-0047	£100.	•0003	1000-	.0000		0000+
0.1	• •1226	• 0 2 4 4	•0201	• 0065	•100 •	•00cs	1000*	0030.	-0000	•0000
5-0			1680.	• 6452	.0243	- 0108	-0044	- 7017	-0076	- 9092
3•0				•	•0754	•0478	•0283	, 2155	6200 ^{°°}	.2037
4 • 0							•0684	·1475	•0315	661C.
5.0		•		•						1

STREESS DISTRIBUTION - Weibuil STRENGTH DISTRIBUTION - Weibuil

. Д

Downloaded from http://www.everyspec.com

٩4

ŝ, $\frac{1}{h}$

(Å.) – Y [HETA2/	01/TreIal = TheIal =	ເ ເ ເ • •					THETA 1	1 6 1	్లం
* *	41						THETA 2	1 0 ²	പ °
* 11/52 .	* C=0 *******	い。 ひ。 ひ	·★本华华华女女女 し。」	1 • j *******	単一 で、単一 一 一 一 一 一 一 一 一 一 一 一 一 一 一 一 一 一 一	4 19 19 19 19 19 19 19 19 19 19 19 19 19	**************************************	3 • 5 *******	0•)1
	**		• • •						
٠٢	• • • •	* (0) [*]	• 2030					,	
-10 •	- 	() () ()	903C*	• 3030	(374.				
6•	* • • • • • • • •	•0100	000 C *	0000°	0000-	3300+	0 000*		
C•1		000 00 1	.0000	• 966.9	(0.7*	3900-	.0000	∂ ∂∂∂∂•	•00
2.0	100(* *	. 0ate•	. JC 3.	- JC 00	°060•	049C.	1596	0000-	000*
0•0	* .0917	1000-	.0003	1000.	• • • • • •	0000.	0000-		000*
0• 4	* •0119	• 0067	• 4630	.0018	60JD*	• 000	2000*	1000.	000-
5.0	+ • 0340	• 6235	1516.	J011 .	•CC62	.2:36	•C12C	1150.	÷000*
6.0	+ .0615	. [476	9 5€€•	• 32 65	610.	•132	9600-	• 00 5 9	600°.
1.0	; 4; 4		165	1740.	c750.	• 7289	•0218	• 3162	.110-
£•0	• +• •				• • • • • •	•0478	-6387	•0305	•024
9°C	6° 476 - M						•^572	•0479	• 03 91
0.0									-020 -

1

Downloaded from http://www.everyspec.com

ډر

STRESS DISTRIBUTION - Wetbull STRENGTH DISTRIBUTION - Wetbull

K0 - 1 HETA21	r3)/THETA1 = /THETA1 = 81					• .		THETA 1 THETA 2		×° ×°
1/82	₩ ₩ ₩₩₩₩₩₩ ₩₩₩₩	1.5 :*******	2 • 5 54444	2.5 *******	3.(*******	3.5 *******	4.0 *******	4.5 *******	5.0 ******	5*5 :*****
	* * •ČCuš									
•2	• °CC00	.0005								
	* .3162	L 105 *	1950*	0000	-000					
• •		•00 41	• ±C.05	0000.	600°.	•0000	0000*			
•	* • 0387 *	•0.75	1100*	1000.	•0009	0000*	00v0°	.	0000-	
•	€ •050.8 •	.6116	•0021	- 0003	0000-	0000*	00 00 *	1000.	0000°.	5695.
	+ .0c31 +	• C169	•0636	• 3006	1000-	3365.	ŭ ŭ603*	0000-	1000-	3000.*
80	- ĉĉľĉ	.0229	• 3055	1109*	-000 -	• 1000	0163.	. 3960	0000-	0000*
6•	* •0876	• 3296	5LD0.	•00IB	•000•	-001	•(020	000C*	0060*	° 600 C
0-1	6460° *	0763.	691C-	.0027	•3-66	1000*	20-2*	0006*	-0000	5565*
0.2	• •• •	·	•0685	.0332	• 0140	.9352	-101-	5000*	-000	3000"
0.0	• •• •				• 5 561	.032C	7017.	6L0r.	•603e	* I J D *
0.1	· • •	ł					•6498	.1317	961 0*	101.
U.	• •									

н	H
- YJJ/THETAL	A2/THETAL
CX J	THET

ġ . . .

a 3 THETA 1 THETA

10.0

9.5

() () ()

8**.**5

8.5

14

81/82

•

Ť.

7.5 2.0 **6**•5 ***** 0000-् • •

.6000 .0000 -000-.000. ø

00000. 0000. 00000. .0000 0000 0000. .0000 1000-0000. .0000 -c202 .000. · 3005 · J000 .0000 -0000 .0006 •0C12 1000° 000u-. ລະວວ. • ĠĊĊ**2** .2000 .9027 060C. .2056 .0005 . 9000 1.0 2-0 3.0

0000. .0000

-000C

.0000

້ວວວວ•

.0000

.0000

0000-

.0000

.0003

9

354

e000.

•CC3C

0000.

2233.

.0000

.0000.

00060-

.0000

.0000

.0001

• 3503

.0006

.0012

.0024

·0044

+0C78

1610.

.0209

0.4 5.0 °C015

. 3022

•0038

• 0063

C010.

.0152

•0224

elen.

·0439

6-0

1.0

8.0

0.6

10.0

Welbull I STRESS DISTRIBUTION 28

.....

4

• •

4

STRENGTH DISTRIBUTION - Welbull

-0054

.0081

•0110•

-0110

.0230

.0320

.n423

.0137

• 3186

.5247

.0321

.C411

36£3°

+C255

.3323

•0402

4 61 91/62 1.0 1.5 2.4 2.5 3.5 3.5 4.2 4.5 5.0 5.5 1 5.0 5.5 .1 5.0 5.5 5.0 5.5 5.0 5.5 .1 5.0 5.0 5.00 .<	6 XO 116 11	- Y0)/Tt A2/The TA	-51Al = Ll =	- 502 - 405						ETA 1 -	е ж х - ж х - х	
91/62 1.4 1.5 2.6 2.5 3.6 3.5 4.5 5.0 5.0 5.0 5.5 1 .CCC3 .CCC3 .0001 .0003 .C003 .C000 .0003<		¢ * 81									• 	
 .1 c. CCCC 	9/16	5 *	L.C. Beerreen	1.5 +++++++	2.C	2.5	3.C	3.5	C.4	4*5 *******	5.0	5•5 *****
• • • • • • • • • • • • • • • • • • •	.1	* + 1	• ୧୯୦୦	I								
3. 0148 012 .0003 .0003 .0003 .0003 .0003 .0000 .	Ţ.	• • •	• 3012	• 300C	•0000							•
 • • • • • • • • • • • • • • • • • • •	, ity	• • •	.0365	• 2003	0000-	000°	• 0000					
.6 .0445 .0003 .0003 .0003 .0000 .0	*	• + •	*C148	.0012	1000-	.1966	-0000	0000°	0000-			
1 .0352 .6558 .0561 .0267 .0661 .0760 .0760 .0760 .0000 .1 .0465 .6034 .6014 .0662 .0603 .0666 .6736 .0966 .9096 .8 .0582 .0139 .0023 .0003 .0660 .6736 .2996 .9096 .9 .0319 .0024 .0003 .0660 .6736 .3996 .5096 .0036 .9 .0319 .0132 .0003 .0660 .6736 .3067 .5097 .0036 .9 .0319 .0232 .0611 .0662 .0066 .6936 .0076 .0076 .0 .0319 .0236 .0226 .0061 .0076 .0076 .0076 .0076 .0 <td< td=""><td>S.</td><td>* ** **</td><td>.0495</td><td>1600.</td><td>•0003</td><td>00cc-</td><td>-000-</td><td>0000*</td><td>0000-</td><td>. 3000</td><td>0.00.</td><td></td></td<>	S.	* ** **	.0495	1600.	•0003	00cc-	-000-	0000*	0000-	. 3000	0.00.	
.7 .0465 .6034 .6014 .0662 .0603 .0766 .6796 .6796 .9796 .6796 .9796 .9079 .8 .0582 .0139 .0023 .0003 .0560 .0796 .5003 .0796 </td <td>4 355</td> <td>∳.∳.∮</td> <td>.0352</td> <td>.0058</td> <td>• 000T</td> <td>1995.</td> <td>0000-</td> <td>2020-</td> <td>2000-</td> <td>0000.</td> <td>0000*</td> <td>0000;*</td>	4 355	∳.∳.∮	.0352	.0058	• 000T	1995.	000 0 -	2020-	2000-	0000.	0000*	0000;*
	1.	* * *	•0465	•603•	°0014	•0662	- 0000 •	-0266	0063*	JJC J.	-00Co	0506*
•9 • 3790 • 0192 • 0039 • 0046 • 0061 • 0000 • 0030 • 0030 I.0 • • 0019 • 0252 • 0059 • 0011 • 0662 • 0030 • 0030 • 0030 Z.0 • • 0019 • 00530 • 00511 • 0662 • 0030 • 0030 • 0030 Z.0 • • 0119 • 0625 • 0031 • 00302 • 0030 • 0030 3.0 • • 0326 • 0215 • 0302 • 0302 • 0030 3.0 • • 0419 • 0215 • 01902 • 015 • 0215 • 0215 4.0 • • 0419 • 0215 • 0115 • 015 • 0215 • 0215 • 0215 5.0 • • 0419 • 0215 • 0215 • 0115 • 0213 • 0213 • 0213 5.0 • • • 0419 • 0215 • 0115 • 0233 • 0233 • 0233 • 0233 5.0 • • • • • • • 02333 • 02333 • 02333 <td>10 •</td> <td>F 944, 4 ₁</td> <td>-0582</td> <td>•0139</td> <td>*C02*</td> <td>• 0003</td> <td>-000-</td> <td>0000*</td> <td>•000</td> <td>3000-</td> <td>0000-</td> <td>• 0000</td>	10 •	F 944, 4 ₁	-0582	•0139	*C02*	• 0003	-000-	0000*	•000	3000-	0000-	• 0000
I.0 • .0319 .0252 .0C59 .3G11 .0GC2 .030C .2C60 .9C90 .0C30 Z.0 • .0319 .0253C .0226 .0081 .0C25 .5007 .0032 .0076 .0076 .0076 Z.0 • .053C .0226 .0226 .0215 .0702 .0076 .0076 J.0 • .0611 .0625 .0081 .0625 .0076 .0076 .0076 J.0 • .0419 .0215 .0799 .9245 .0115 .0051 4.0 • .0419 .0215 .0716 .0051 .0051 5.0 • .0419 .0215 .0115 .0115 .0051 5.0 • .015 .0115 .0115 .0115 .0233 .0211 5.0 • • .015 .0115 .0115 .0115 .0115 5.0 • • .015 .0115 .0115 .0233 .0211 5.0 • • .0115	•	s • •	0020-	-0192	-0039	•0004	1000*	2020*	3500*	• 3369	0000-	0101
2.0 • .0536 .0226 .061 .6625 .5002 .0016 .0002 3.0 • • .0419 .0215 .0032 .0016 .0002 4.0 • • .0419 .0215 .003 .003 4.0 • • • .0419 .0215 .015 .003 5.0 • • • .0419 .0215 .0115 .003 5.0 • • • • • • • .053 .003 5.0 • • • • • • .0533 .0216 .0033 5.0 • • • • • • .05333 .0216 5.0 • • • • • • .0313 .0216 5.0 • • • • • .0313 .0216	I.0	¢	\$T60-	-0252	\$530.	1196-	-0662	0000.	•603	- 2000	0000-	0000*
3.0 * .0015 .000 4.0 * .0115 .000 5.0 * .0115 .0015 .005 5.0 * .0115 .005	2-0	> 4 4	·	•	•0530	.0226	-0081	•0025	-1000-	2000 *	9600-	0000°
4.0 *	3.0	ः • के प	-				6140*	.0215	6600*	- 2040	š1 0j•	• 0005
5.0 ¢ .0333 .02hi STRESS DISTRIBUTION - Weibell STERICTE DISTRIBUTION - Weibell	4-0	• • •							•6364	.)212	511 0.	•0057
STRISS DISTRIBUTION - Weibell STRINGTH DISTRIBUTION - Weibell	5=0	t 49									•0333	-72h2
		•				IS DISTRU	NOLTON	Weibell - Veibell				

ý.

: N. 49. 4

'(X° - Y°)/TFLIAI = THETA2/THETAI =

5.

α THETA 1 THEFA 2

	ļ
∢° ⊳ °	
1 1	
* * *	•

10.0

9.5

C•6

8.5

6°9

1.5

7.C

č•5

. • J

61/82

2

;

	***	***	****	******	****	******	***	******	****
¢.	+ •0000								
۰.	6200° *	.	, 3000		•				
3 9	• • • • •	• 2033 •	0000*	•0000	. 000*			-	
6.	• • 0000	1000 *	9090.	0007 •	•000	ວວມດ.	0000*		·
C•1	• • • • •	0000 .	2500*	• 3090	ະວອວ*	0050*	0000 *	0000*	0000
2.0	* * 603	. 52 35° •	0000*	-3000	0050*	0000*	0000*	•0000	0000*
3•0	* •J002-	0	0000*	000C*	€050°•	0000*	0000*	• 0 00 0	0000.
0• 4	* • JC26	1102.	• 2004	•0005	1000*	0000	0000*	• 0000	0005*
5•0	* •0128	• 6673	10039	6100*	6000*	• 0004	20031	1000*	0000*
ó.0	• •0313.	•6213	.0139	.0047	•0652	\$230*	910ū*	. 0308	+000e-
.c.1	* * 4		••03(5	•0214	.0149	2010-	•0064	-0040	.0024
ğ.0	• •	•			-0520°	•0216	•0156	.1110.	•0016
0°6							•C283	1120.	•0163
1C.0	• •							•	.0277

356

Downloaded from http://www.everyspec.com

Ŧ

+#

. •

.

٩

. .

•

-

STRESS DISTRIBUTION - Weibull STRENGTE DISTRIBUTION - Weibull

		}	· 1	5.5	:					0600.	0600*	0000	• 0000	2000-	2020*	2000	° 0030	-0142		
**		°×°°×°°×°°×°°×°°×°°×°°×°°×°°×°°×°°×°°×°		5 a0		, ,	•	١	0000	0000-	•0000	0000	0000-	0000	.0000	9000	•0369	.0241		
		ETA 1 = ETA 2 =		4.5 ++++++++++++++++++++++++++++++++++++			ł	·	• 0000	• • • • • •	.0000	0000-	0000°	• 1000	1000-	1200-	.0142			
•				0.4	, 1 1			0000°	0000	0000*	0000-	0000-	•0000	ດັ້ນວິດ.	•0003	6500*	. C2ó8		•	
				3.5		ן י		• 0000	0000	.0000	•0000	• 0000	- 2000	000°	-0012	•0145			detbull	Hadbull
•		-	;	3.0	: : :		.0000	.000	0000	.0000	0000-	• 0000	C000•	- 3000	•0647	- 0315				- HOILDE
•	·		•	2.5	• :	•	•0000	•0000	0000°-	•0000	•0000	1000-	-0002	4000 ⁺	•0154		I			LISIO HIS
	3	1 1 4 4	:	2.0		•0000	.0000	-0000	• 0000	-0002	.0005	0100.	.0019	. Ó031	.0413		1			
		. 304	·	1.5		.0000	,0000	.0003	.0011		.0051		-0124	.0172	1 ,1	1 1]	1		
••				1.0	.0000	.000	.0023	.0076	.0152	0242	0343	0450	1980	.0474					,	
ð		- Y01/11	, 18 *			۲ ۰۰ ۲ ۰ ۱	* *	•	: ++	1. 1 1) 	• • •			• • •	• • •	• *	* 0	
		THET	÷	81/6	•	-			1		• 197	•	•	• - 7	:	•	n -	4	, n	•

ŝ

Downloaded from http://www.everyspec.com

5.	5
· •	
1	
H	H
<	
have	
цц.	-
_ I	<
- Jean	-
~	1
	Ξ
	2
	2
	2
. •	2
n	Ш
1	Ŧ
- 2	1

THETA

THETA 1

10.01

9.5

6°0

8.5

8.C

7.5

0.1

6.5

-0000-

ģ

*** 6. ئ

BL/B2

计存在分词 法法律法律法法 法法律法律法律法律法律法律法律法律

0000 0000" 0000" 0000" .0042 0000" 1100" .0195 1000 .0104 .0000 0000. • 0003 0000°* -00020 • 0066 .0000 .0145 .0000 • 0000 0000--0034 •0000 •0000* .0000 •0000 0000. •0099 ·C199 -0000 -0000 .0000 0000-.0000 +100-•0058 •0145 .0001 0000-•0000 0000-0000* •0000 0000-•0003 .0053 •0205 +0027 0000* 0000. 0000-.0000-.0000 .0000 .0008 .0049 •0144 0000-• 0000 .0213 •0000 -0000 0000-1000. .3086 .0000 e100. 2002* 9000--0000 •0000 0606. •0000 +000+ .0409. -0143 .0225 0000. 0000-0000-.0078 -0000 .0000 -3012 1000 · C*1 2.0 3.0 0-4 5,0 6.0 8.0 9.0 10-01 S. 0 · 1

Weibull

ı

STRESS DISTRIBUTION

STREAGTH DISTRIBUTION - Wefbull

358

(x0 - Y)/THETA1 = .50C hETA2/THETA1 = .50C * B1 * B200 * 2000		
* 81 *.10 1.5 2.6 2.5 3.0 3.5 4.0 *.1 *.0000 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 *.1 *.0001 .0000 .0000 .0000 .0000 .0000 .0000 *.1 *.01666 .0012 .0000 .0000 .0000 .0000 .0000 .0000 *.1 *.0259 .0150 .0000 .0000 .0000 .0000 .0000 *.1 *.0105 .0000 .0000	THETA 1 = $\begin{pmatrix} 0 \\ 3 \\ 1 \end{pmatrix}$ THETA 2 = $\begin{pmatrix} 0 \\ 3 \\ 3 \end{pmatrix}$	и И И И И И И И И И И И И
1 * .3603 .0000 .0000 .0000 .3 * .0001 .0000 .0000 .0000 .0000 .4 * .0037 .0030 .0000 .0000 .0000 .0000 .4 * .0037 .0031 .0030 .0000 .0000 .0000 .5 * .0012 .0000 .0000 .0000 .0000 .0000 .7 * .0166 .0012 .0000 .0000 .0000 .0000 .7 * .0166 .0012 .0000 .0000 .0000 .0000 .7 * .0253 .0050 .0000 .0000 .0000 .0000 .7 * .0256 .0116 .0000 .0000 .0000 .0000 .9 .0349 .0050 .0000 .0000 .0000 .0000 .0000 .9 .0451 .0056 .0000 .0000 .0000 .0000 .0000 .0 * .0056 .0010 .0000	4.5 5.0 *************	5.5 144844441
-2 -0000 -0000 -0000 -0000 -0000 -3 -0001 -0000 -0000 -0000 -0000 -0000 -5 -0032 -0000 -0000 -0000 -0000 -0000 -0000 -5 -0032 -0012 -0000 -0000 -0000 -0000 -0000 -6 -0166 -0012 -0000 -0000 -0000 -0000 -0000 -7 -0253 -0227 -0002 -0000 -0000 -0000 -0000 -8 -0259 -050 -0004 -0000 -0000 -0000 -0000 -9 -0451 -0050 -0004 -0000 -0000 -0000 -0000 -9 -0451 -0050 -0000 -0000 -0000 -0000 -0000 -9 -0451 -0050 -0000 -0000 -0000 -0000 -0000 -9 -0451 -0056 -0000 -0000 -0000 -0000 -0000 -9 -0451 -0056		N ;
.3 .0007 .0000 .0		I :
• •		
.5 .0092 .0004 .0000 .0	·	
. .	-0000 -0000	Ċ
.1 .0253 .0C27 .0000 .0	1000	0000 - 0
 8 • 0349 0050 0004 0000 0000 0000 0000 0000 9 • 0451 00060 0000 0001 0000 0000 0000 9 • 0451 00060 0000 0000 0000 0000 0000 0000 0000 0000 0000 1.0 • 0556 0116 0016 0002 0000 0000 0000 0000 2.0 • 0556 0118 0016 0002 0000 0000 0000 3.0 • 0556 0118 0016 0000 0000 0000 	1000" 0000"	0000- 0
• • 0451 • 0060 • 0000 • 0000 • 0000 • 0000 1.0 • • 0556 • 0116 • 0000 • 0000 • 0000 • 0000 2.0 • • 0324 • 0106 • 0028 • 0000 • 0000 • 0000 3.0 • • 0324 • 0106 • 0238 • 0006 • 0001	000 0000	0 °0000°
1.0 * .0558 .0118 .0016 .00000 .00000 .0000 .00	000 0000	0 •000
2.0 * .0324 .0106 .0028 .0306 .0091 3.0 * .0238 .0098 .035	.000.	0000-0
3.0 * 0098 .0038	000* 000*	0 -000
	000 · 1100 ·	1000 . 60
	+00+ °04	÷ •0016
	210*	15 .0095

.

, n •	• 3 2 5
1417 =	H
Y CH / THE	/ InETAL
(× 2 × 1	InëTA2/

5

子律学学术: 本当本学者来学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校 8.5 7.> **************** 1 · 5 6.5 . • •

61/82

10.0

9. 5

0°0

8.5

I

Ð

THETA 1

2

THETA

.000.

9 ~ 30

- 000C CSC2*

0000°. 00000. 0000-0036. -0000-.3000 - 700C • .3300 •0000 2309. - 300C • 0000. 0.00. .0360 •0030 .000. .030. 00n0*****

00001 0000. 0000. 0000. 10005 0000. 0000. ţ 0000. 00000. 60CC. -0000 0000-----1000. .0000 -3003 0000-•2503 .0018 00000-0000* 0000 -0630-.0000 -000°. •0034 -0000 .000C .0336 .0058 •0000 .0009 .000. 1003. +0C14 •0000• - JOCG .0528 9500-+00C* .3050 - 30.00 • 900L • 0053 .0152 ecce. . 2006 • 00 J 0 . 2.122 -3162 •0000 .0000 900C * 2000ł 84C0. .OIO. , 0.4 5.0 3•0 6 • J **1.**0 2.0 C*1 ¢.

360

3

• C366

\$6CC*

.[4].

0•6

8.0

10.01

.2137

STRENS DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

۰,

States and the second s

•

.0023

• 3039

.0003

2600-

.0140

(X0 - V0)/THETA1 = .750 THETA2/THETA1 = 1.000 * B1 91/B2 * 1.0 1.5 2.0 91/B2 * 1668 .0950 .056 * 1668 .0950 .056 * 1758 .1075 .061	2 - 2 - 5	\$210°.	3.55	94CG*	THETA 1 THETA 2		
 81/62 81/62 1.0 1.5 2.5 91/62 1.5 2.5 1.0 1.0 2.5 1.0 /ul>	2.5 	4210* 0510*	3.5	94C2*	· • • • • • • • • • • • • • • • • • • •	× 2°0	o 50 10 10 10
8:/62 * 1.0 1.5 2.0 1 * 1809 2 * 1663 0950 350 3 * 1683 0992 954	2.5 9 6 .0289	€210°.	3.5	9500°	4 6 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	2 2	10 # 1 • # • #
•1 * •1809 •2 * •1663 •0950 •350 •3 * •1683 •0992 •354 •4 * •1758 •1075 •061	9 60289 0 .0337	•0174.	0630*	94Cú*			
•2 * •1663 •0950 •350 •3 * •1683 •0992 •354 •4 * •1758 •1075 •061	9 60289 00337	•0174	0630*	•0346	,		
•3 * •1683 •0992 •054 •• * •1758 •1075 •061	6 • 0289 0 • 0337	•0174	0650*	94 <u>0</u> 0*	, .		
•• • • 1758 • 1075 • 061	0337	•210.	0630*	•0346	·		
	•						
•5 • •1857 •1180 •069		•0208	ollo.	1 500*	• 3029	•0015	
• • • • • • • • • • • • • • • • • • •	9	.0251	•0135	1200.	-0937	6100-	105.
* ************************************	6 .0533	:0303	-0167	0630*	.1348	•0025	1001
* •8 * •2175 •1539 •100	9 .0622	¢960°	-0206	•0113	.3061	•0033	109.
•9 • • 2272 • <u>1657</u> • 112	5 .0716	•0435	• 2253	•0143	97CC.	2400'	•005
1.0 * .3362 .1771 .124	.I .ŭ820	.0514	.e3C8	-0173	JUL?	•0055	• 003
2 <u>•0</u> *214	6 .1765	.1413	0011.	. 0831	•190.	.0433	• 029
• • •		• 2035	.1705	.1509	.1272	.1356	•086
* D*+				1971.	.1763	.1563	1:1.
5°0 *						.1929	.176

₩ ₩	ы. в1							X	,0 ,
₽ 2₽/42	к * ***********	0。5 4******	/ • () :******	7 • Ú 1 • Ú 1 • A + + + + + +	4 本 本 水 小 小 子 本 本 本	ち。5 ドキキハ キキキギ	9 *.) F#4444444	9 • 5 14 # # # # # #	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04
1 - 0 -	* *0002 *		•	•	•			• • •	• :
۲.	2007 • · · ·	4000 *	• 3002						
• 20	• • • • • • • • • • • • • • • • • • •	•0002	°0063	1996 -	1000.				
5°	* * * 1012	9005*	. JOC3	• 2002 •	1000*	1000-	9000*	I	•
	* * .)Cló	5000*	* 10.05	-0002	1007*	1000.	1050"	0000.	•0000
2•0	6610° *	•6710*	1800,	000°	-6030	9100.°	0100.	9 000*	•0003
3•0	• 3692	• (:546	• 5423	.0321	.0233	e110.	-0123	• 7386	•0058
4.0	* •1199 -	.1035	- n 885	, 744	.0627	•0519	• <u>04</u> 24	~ 0342	.0272
5.0	* •1597	.1442	.1294	•1:55	.1524	1060*	.0788	. 7684	.0590
6.0	= + 1699 -	.1758	-1621	.1488	.1362	•1241	.1125	.1016	•0.913
7.6	* * 1		.1877	.1756	.1637	.1523	.1412	•1305	.1203
8•0	• # 1				, 186 0	.1754	.1650	• 1549	.1450
0*6	¥-44-1						.1847	.1752	,1560
10-0	• •								.1837

÷

í

Downloaded from http://www.everyspec.com

t XO – Ý Theta2/ *	©)/IFETAl = Thetai =	. 750 . 800						THETA	1 = 0 = 1	M ^o M ^o
* B1/B2	81 * 1•0	1•5	2 • C S	2.5	3.0	3.5	4 •3	4+5	5.0	5.5
-	********* * *		******	***		***	****			
	* * * .0546	• C161	• 0043	·		·				
	* • C705	.0237	1733.	•0520-	•000					
	*	.0328	8010°	• 0033	0100-	E000-	1000.			
.	* • 1031	• 6430	•0156	•0052	•0016	•0065	1000.	0000*	• • • • • •	
: م و ب ا	* • LL85	• C542	• 0214	.0076	• 0025	•0008	•0003	10(0.	0000-	, rea (
٠٦	* .1339	.9051	-0282	-0108	• 0038	•0013	40u0*	1000-	1330*	0000-
8 •	* * .1482	.6784	. 3360	•0149	• 3656	0700*	1000*	2000-	1000-	0000
6 ,	* * .1610	0150.	1440.	÷155	•0079	.0636	1100*	•0004	1003-	[[39.
1-0	0521° * *	. 1034	• 3541	.0252	1010.	•0043	•0016	• 3006	2003*	1000.
2.0	* *		.1501	.1062	.0708	6443.	.0260	•0143	•202•	• 0034
0 •	; * *				•1390	•1:79	•0312	1650.	•C414	.727.
4.0	* *						.1327	•1385	.2877	• 2692
5.0	* *	-		•					.1287	1,94

• *

2

J.

A READER FOR THE

TheTAL - d

THETA2/THETA1

73

۰.6 8**.**5 8.0 2.5 7.5 0°.5 0•9

13.0

9.5

Q Ø

ļ

THETA 1 THETA 2

> ŝ 1

J1/32

-000r.

.0000 0000-1000-•c129 61 Eù--0545 .0784 .1005 •12<u>05</u> ·0125 ·1107 •0176 **•**0394 .2384 - **330**00 .2641 .0000 E000. .0040 -0005-.0743 .1214 1660. •0064 .0236 3000* 0000. •0481 0000 0100* 5600* •0309 .1105 0000. 0000. •1)854 .C580 . JOCG •0146 1960. 9190° .1226 0000-1000. .0520 .0691 0000. .0000 .3815 .3211 .1103 .0000 1502. -000°* •0000 1000. .0502 .0255 1960. 9906* ·2000 .0623 .1241 .0000 .0000 .00r3 00000 .1100 .0007 1110. 00000 0060. .0103 5000° • C4)2 .0000 C021. -Cr00-C810. .0534 .0921 0000-7100. -090C 0000. **0°** 7.0 0°8 6. 3.0 **0**•**4** 5.0 6.0 2.0 i∙1 8. ~

Downloaded from http://www.everyspec.com

.*

STRENGTH DISTRIBUTION - Weibull

Weibull

1

STRESS DISTRIBUTION

0-01

	ETA 1 = $\begin{pmatrix} 0 & - \\ x & - \\ 0 $	4.5 5.0 1444444444444					0000 0000	0000 • 0000	0000 *0000	0000* 0000*	5000 - 5000	0000* 0000*	1100- 0600		.9570 .0483	- 365.	
		4 °C 4 *C				•0000	. 0000.	• 6665	• 5033•	. 0000.	• 5003 •	• T 000•	• 0074	.3427			
		3 . 5 ********				.0000.	0 00 °	5050*	1000-	1000*	•0003	5000*	•0169	•2654			11
		3.6 ******			•0000	COCO.	1000-	10u0*	£003*	1000-	210.	• 0620	946 0°	* 560*			
		2.5 *******		' er	- 20¢6	1050.	+000°*.	•000	1100.	CE00.	8930.	.0071	•3636				
	;	Z•C :*******		• 0000	-3623	1100-	• 0025	7+00+	• 0C78	2110°		.5220	• 1059				
	• 755 • 60 7	15 1.45		•000•	.3031	. 0074	• C133	.0201	•0292	. 0388	16+C•	0090*					
•)/THETAL = 461A1 = 31	1 =0 ############	000	• • 6098		• • C389	• • • 0548	-1016 ·	• • • 0863	• 1015		• •1299	* *		• •	* *	
	X0 - Y0 HETA2/11	1./82 *		Ŋ	с. М.	•	۰ الا		۲.	80	5 •	1-0	5.0		0.1	5.0	•

 ij

.....

 $\mathbb{C}^{n}_{\mathcal{A}}$

5. 2

. Tor 100. 11 11 [xc - Ye]/THETAL THESA2/SHLTAL

THETA 1 VIJHI

31

*********** 9.5 ********** C. 6 8.5 ************************ 8°C ۲.5 7.5 ****** ς•2 **** 0°0

10-0

0000-	
٠	ł
ŝ.	

81/82

1

. 3360 .0000 • 000C • .0000 0000. 0000

80

366

0000-

•<u>°</u>236. .C412 •0003 .0922 .0298 000CC. 0000-30C 0. - 0000 .0003 TECC. 1050. -1495 0000. .0138 COOC. •0289° .0378 6000. .0020 T000. 0900-ບຕີວີບີ• C61C* 5000. •0014 .0093 •0256 0000°. •0693 0000. .C001 .0468 0000-.0572 5000° ±0803 0000-.0028 .0140 10000. .0337 0000. .3435 • <u>0000</u> 6000. 6650* . <u>36</u>90 .0003 • J203 .0050 • <u>0</u>286 **•**0000 .3208 .0087 .0550 .0821 .0000 -9036-.0000. • 0685 •100• .0000 -000C. .C143 .0352 •0638 •022÷ 0000 -<u>-------</u> C000. .0522 1000. Ú.8 3.5 0-4 5.0 6•0 7.0 1.0 2.0 5

Weibull - Weibull I STRENGTH DISTRIBUTION STRESS DISTRIBUTION

•0.602

.3696

6510.

6

10.3

1625*

1		ETA 1 -	ы мо н и и мо н и и мо н и и мо н	
,	• 1 • •	, , , , ,	•	
3.0 3.!	, 4.0	~4.5 *******	5.6	5.5
		7		
:		-		
0000				
000 0000	0000 • 0000			
000° 000ō	0000.00	.0000	0000	
0000 + 000	0000- 0	-0000	•0000	0000.
000 0000	0000- 00	0000*	•0000	0000*
1000 1000	0000* 01	• 5600	0000-	0000.
00. 1000	0000 0	- 0000+ -	.0000	0000
0003 -000	0000° 0	0000-	0000	0000*
0165\$336	-00200°-	.0006	•000	0000*
0659	8 .0221	-0112	.0052	• 0021
	•0609	• 341C	•0262	.0158
			6250-	10415
os - Veibul Tios - Veibul	. <u>5</u> 4			
0001	000 000 000 000 000 000	.0000 .0006 .0006 .0006 .0000 .0006 .0000 .0006 .0000 .0006 .0000 .0000	.0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000	-0000 -0000 -0000 -0000 -0000 -0006 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0000 -0398 -0221 -0112 -0052 -0398 -0221 -0112 -0052

 (\cdot)

1

2

a.

PR AS

;,

Downloaded from http://www.everyspec.com

ž. Έ.

(XG - Y) THETA2/1))/I+=IA1 = HETA1 =	- 150			•	THE DBU		а н н н н н н	
• • '	6 L								-
81/82 +	- 0°U	6.5 ******	7.C ++++++++	7.5	8.G F######	8.5 8.5 8.88	9,0	9 • 1 4 4 4 4 4 4	12+0 12+0
ġ.	* . 2002	2 •	• • •			9 9 9	1 4	; 1 ; ; ;	• • •
٠٦	• • • • • • •	5555.	0006* -						
80 •	• • • • • • •	-000	.000 .	0000*	•0:0*		•		
6	* .000	0000-	-000u	• 0000	0035*	•0000	-0000°		
1-0	• • • • • •	C)*)*	-000	0000*	6062*	0000.	ú500°	-00C+	0000.
2 •0	* •000C	-0300	• 2036	C200*	•000	1000.	6000*	6000.	.0000
3•0	* .cc28	• 60 u 3	1000*	0000	•0000	5000*	0000*	•0000	0000-
4.0	₩ ₩ 1089	1990.	• 3023	1100.	•000•	2000*	1000*	-1000	0000*
0•5	* • •6292	• 6136	.0126	• 3376	•0C45	• 3025	E160*	1000-	•0003
6•C	* .0559	.0425	•0315	•0227	.6159	*0108	-0371	**0C*	
7.0	* * *		•Ū545	.0430	°C333	•02 52	1810-	9E1C.	• 00.96
. 8 . ĵ					•653•	464 5*	.0347	. 1273	1120-
Ǖ6	• • •						.0526	764C.	• <u>0</u> 358
15.0	* *			•				,	•0250
			STRES	S DISTRIB	- HOLLON	Veibull Veibull			

Downloaded from http://www.everyspec.com

JITHETAL THETAL			, ,	•			TA 1 • 6 TA 2 • 6	No Ho	1
81 • 1.0	1.5	2.0	2.5 14868461	3.0	- : 3.5 :#####3#1	4.0	4•5 *******	5.0 	5.5 5.5
* • • • • • •						 			. i
• 0000	.0000	• 0000						1	;
	.0000	• 0000	0000-	0020*	!	1 1 1		1	; ;
+500 *]ĉoo* -	000C*	•0000	0000-	0000*	0000*		1	:
+	1000-	0200*	0000-	• 0000	0000-	0000.	0000.	0000-	
9620- +	.0022	1000	5000	0000	•0000	0000-	-0000-	.0300	0000.
* •0354	• 0C48	*200*	• 2000	0000	•0000	0000.	• 2000	0000-	0000-
* * •0481	.0087	-0000	1000.	6600.	0000-	-0000	0000	•000	-0000
	9E10°		- 0005	.0000	• 9000	ວັດຄວ•		0000*	0000
• 0144	6610 *	• 2030	+000-	0000-	ີ ວດດວ.*	0000 -	-0900	0000-	• 0000
: 	ſ	•0 54 0	.0228	6100*	.0023	-0005	1000-	0000	.000
6 19 19	4	•		1540*	-0242	+110-	1400-	1100.	• 0006
* *						•0415	-325J	1410.	e100.
•	•								

÷

* 41 * -35.0 -5.5 1.5 1.5 9.5 10.0 * -35.0 -37.0 -37.0 -37.0 9.5 10.0 * -35.0 -37.0 -37.0 -37.0 -37.0 -37.0 9.5 10.0 * -35.0 -30.0 -40.0 -5	 #1/32 #1/32 # al 6.3 6.3 6.4 5.00 6.7 /ul>					•	
BL/B2 0.17 6-5 1.5 1.5 1.6 9.5 1.6 6	B1/B2 6 5 6 5 7.5 7.5 .6 .0000 .0000 .0000 .0000 .0000 .0000 .7 .0000 .0000 .0000 .0000 .0000 .0000 .9 .0000 .0000 .0000 .0000 .0000 .0000 .9 .0000 .0000 .0000 .0000 .0000 .0000 .9 .0000 .0000 .0000 .0000 .0000 .0000 .9 .0000 .0000 .0000 .0000 .0000 .0000 .9 .0000 .0000 .0000 .0000 .0000 .0000 .9 .0000 .0000 .0000 .0000 .0000 .0000 2.0 .0000 .0000 .0000 .0000 .0000 .0000 3.0 .0000 .0000 .0000 .0000 .0000 .0000 3.0 .0000 .0000 .0000 .0000 .0000 .0000 3.0 .0000 .0000 .0000			•			
 	 		6 • 3 . • • • • • • •	8*5 \$******	9*3 6	9.5 *******	++++++ 6 • J1
 .7	 .7 	, ,			•	•	
	 .6 .9 .0000 .0179 .0117 .0261 	500					
.9 .0000 .0	 4 • 0000 • 0000 • 0000 • 0000 • 0000 1.0 • 1000 • 0000 • 0000 • 0000 • 0000 2.0 • 0002 • 0000 • 0000 • 0000 3.0 • 0002 • 0000 • 0000 • 0000 4.0 • 00054 • 00054 • 0002 5.0 • 00054 • 00054 • 0002 6.0 • 00073 • 00054 • 0002 7.0 • 00073 • 00074 • 0000 	ecoa- 6000	000 0 *	·			
1.0 • .3000 .5000 <td< td=""><td>1.0 </td><td>2539 . 9636</td><td>• COC 3</td><td>0000*</td><td>0150.</td><td></td><td></td></td<>	1.0	2539 . 9636	• COC 3	0000*	0150.		
2.0 .000	2.0 * .0000 -0000 -0000 -0000 3.0 * .0052 .0010 .0000 -0000 -0000 4.0 * .0056 .0015 .0000 .0000 -0000 4.0 * .0056 .0056 .0056 .0000 -0000 5.0 * .0155 .0056 .0056 .0056 .0028 5.0 * .0373 .0263 .0179 .0117 7.0 * .0362 .0179 .0147 .0267	0000* 0000	C060*	2000-	0000.	3000.	• C-1 C-0
3.0 * .3662 .3676 .9660 .9600 .9700 .7600 .7601 .7101 .7101 .712 .712 .712 <td>3.0 * .3062 .3076 .9062 .3096 .3096 4.0 * .3054 .0015 .7066 .3092 . 5.0 * .3054 .0056 .3092 . .3092 . 5.0 * .3054 .0056 .3054 .0028 . 5.0 * .3162 .0056 .3054 .0028 . 5.0 * .3162 .0056 .3054 .0028 . 6.0 * .3173 .6263 .0179 .0117 . 7.0 * .3373 .6263 .0179 .0117 .</td> <td>500C - 500G</td> <td>-0000</td> <td>0000</td> <td>0530*</td> <td>0000*</td> <td>0000-</td>	3.0 * .3062 .3076 .9062 .3096 .3096 4.0 * .3054 .0015 .7066 .3092 . 5.0 * .3054 .0056 .3092 . .3092 . 5.0 * .3054 .0056 .3054 .0028 . 5.0 * .3162 .0056 .3054 .0028 . 5.0 * .3162 .0056 .3054 .0028 . 6.0 * .3173 .6263 .0179 .0117 . 7.0 * .3373 .6263 .0179 .0117 .	500C - 500G	-0000	0000	0530*	0000*	0000-
4.0 • .0036 .0005 .0005 .00000 <t< td=""><td> 4.0 5.0 5.0 5.0 5.15 5.2 5.15 5.15 5.15 5.15 5.15 5.15 5.15 5.17 5.17 5.117 5.</td><td>ออ้อก• อวออ</td><td>ວັນດິວ•</td><td>ດວນດີ*</td><td>0000</td><td>0000</td><td>• • • • •</td></t<>	 4.0 5.0 5.0 5.0 5.15 5.2 5.15 5.15 5.15 5.15 5.15 5.15 5.15 5.17 5.17 5.117 5.	ออ้อก• อวออ	ວັນດິວ•	ດວນດີ *	0000	0000	• • • • •
5.0 * .5162 .6056 .0354 .6628 .5013 .0031 .7003 6.0 * .3373 .6263 .0179 .6117 .6073 .0644 .6725 .5013 .6501 7.0 * .3373 .6263 .0179 .6117 .6073 .0644 .6725 .5013 .6501 7.0 * .3362 .3267 .6192 .6134 .6291 .3059 .5031 8.0 * . .3362 .3267 .6192 .6134 .6291 .3059 .0136 9.0 * . .0354 .0271 .7273 .2149 .0136 10.0 * . .0354 .0271 .7273 .212 .6342 .6342 .6342	5.0 * .9162 .0956 .0054 .0028 . 6.0 * .0373 .6263 .0179 .0117 . 7.0 * .0367 .	1000 - 3002	Loộc.		3000*	0000-	6 50 3
6.0 .0373 .6263 .0179 .6117 .6673 .0644 .6725 .0013 .6003 7.0 * .03467 .6192 .0134 .0591 .0059 .0031 8.0 * .0354 .0271 .7273 .0149 .0106 9.0 * .0354 .0271 .7273 .0106 10.0 * .0354 .0271 .7273 .0106 10.0 * .0354 .0271 .7273 .0106	6.0 * .3373 ,5263 .0179 .LL7 . * .3362 .3267 .	054 .0028	•100•	• 0006	£060°	1000*	0000.*
7.0 * .0362 .0192 .0134 .0291 .0059 .0031 8.0 * .0354 .0271 273 .0106 .0106 9.0 * .0354 .0271 273 212 212 10.0 * .0354 .0271 273 212 212 10.0 * .0354 .0354 .0347 273 212	7•0 * •362 •3267 •	1117* 621(°C013	.0044	•E125	.0013	1003°
8.0 * .0271 .^273 .2149 .01.06 9.0 * .0273 .212 10.0 * .0347 .0273 .0342	•	362 . 3267	.0192	-C134	1650*	•0059	.0037
9.0 * .273 .273 .212 10.0 * .0342			•0354	.0271	Euzu"	6\$lā*	•010•
1C-0 * .0342	* * ° 6	÷			1463.	•0273	.212
	10-0 +	•		•	:		•0342

Downloaded from http://www.everyspec.com

(X0 - THETA2	Y0)/THETAL = /THETAL =	. 750	1	}				• • • •	м ^о м ^о	
*	81	 			ļ	• † • • •		y :		:
81/82	* * 1.0 *******	1.5	2.0	2.5	3.0	3.5	4.0	4•5 *******	5.0	5°5
	÷ • CCOO				•					
194	• • • • •	•0000	•0000		-					
, m	1000. *	.0000	-0000	•0000	.0000					
	* . 0017	• 0000	0000	0000-	-0000	-6000	0000-			.
S	• • •	-0001	• 0000	0000-	•0000	•0000	5000-	0000*	0000 •.	
9	• • 0132	.0006	• 0000	0000-	v000°	•0000	•0000	• 0000	•0000	0000
 	* .0225	. 0018	1000.	0000	.000.	.0000	•0000	0000	•0000	0000-
8	* • <u>0332</u>	- 0039	• 0002	05,00.	•0000	0000	-0000	• 00:00	.00007	0000-
6	* .0448	1100.	,0006	.0000	•0000	• • 0000	.0000	•0000	•0000	0000-
1.0	+ .0569	•0114	• 0013	1000-	0000-	0000	0000-	0000	.0500	• 0000
2.0	• •	*	•0390		•0038	•0008	1000-	• 0000	0000*	• 00:00
3.0	• •				.0319	1410*	-0058	.0020	•0000	1000.
0.4	 	· ·					.0284	ESIC-	•0075	.0033
5.0	• •	. •	-	•					-0263	.0158
			STAF	LINESIG SS	HOLLON	Weibull Warhull	1			
			THE PO							

 \mathcal{L}_{i}^{2}

(XC − X. TheTA27	3)/{+ETAL = Thefal =	• 755 • 444					5TA 1 = 5	а К С К С К С К С К С К С К С К С К С К	
**	18	•						a a	
÷ 61/82	≠ 6.0 ≠≠≠≠≠≠≠≠	645 ******	7.05 14 000000000000000000000000000000000000	7.5 :*******	· 8 •0 r*****	8.5 *******	9 • 0 • • • • • • • • •		10°0 144444
\$ •	(J)] *		1 1		ì				4
tha ∎	+ ,	- 2000 -	0000-					·	
8	- - - - - - - - - - - - - - - - - - -	acaa .	0000*	0000*	• 0000	١			
6•	• • • • • •	.000	0000 -	0000-	0000-	• 0000	0000*	;	
1-0		6263*	.0000	0000-	0000*	0000	- • 0 000 0	3000.	• 0000
ž•0	* * °000	. 0000	0000-	• 2000	0000	-0000	0000-	• 2000	-000°
3•0	-0000	- 0c 00 ·	<u>ออ้</u> กอ•	0000.	6000*	0000*	0000*	0000	0000*
0-4	E 100. *	•0005	1000.	0000	.0000	0000 *	0000*	° 9060	••0000
5.0	+ • 30ay	.047	.0023	0100-	+000·	1000*	1000*	• 9000	0000*
0 • 0	*. •6250	• CI 63	1010.	3002×	• 0933	100*	800 0 *	+000.	-0002
7.0	• • •		.6241	•0156	°0113	-0670	·CC43	• 3025	+10J*
8•0	• • • • •				•0234	-010 -	817J*	າມະນີ	°0053
0•6	÷ ** *	:					.0229	1215.	.0125
10-0	ŧ 1ŧ					, ;			.0225

•

STRESS DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

372

Downloaded from http://www.everyspec.com

Rent Contained in

X0 - Y0)/TH HETA2/THET/			÷							
	-ETAL = \l =	.156		1	1			ETA 1 ==	θ × − × 0 y − − ×	
18 *	!	• •	1	. !	i I	i .		· · ·		
1/82 * ****	1 .0 F###\$3##	1.5 *******	2 - C r******	2.5 F 444444	3.0 *******	3°5	4 • 0 • 4 • 4 • •	4.5 ******	5.0	5°5 ****
* *	• 0000	:	 				:		-	
* *: 2. •	6000.	• 0000	6000	,! • !		ļ	ļ	•		
• •	• 0000	• 0000	•0000	- 2000	.0000		1			
* *	.0004	•0000	0000-	0000*	.000-	•0000	000 0 -	ł		. ' i
* * 1	• 0026	0000.	0000	• 0000	• 0000	2 0000*	•0000	•0000	• 0000	!
• • •	.0073	.050.	1000	0000	•0000	000c+	•000	0000-	.0000	• 0000
* * • • * •	-0142	• 0000	000ō*	0000-	•0000	0000-	0000*	0000-	•0000	0000-
eo,	.0229	100-	0033*	.000.	-000 <u>0</u>	0000.	0000-	00Cī-	0000-	0000
• * •	• 0329	•0036	• 0002	•0000	c:00.	0000	•0000	0000	•0000	0000.
1°0 *	.0438	-0065	.0005	• 0000		0000*	0000-	0000-	0000-	• 0000
2.0 *		:	••0284	.6683	• 6019_	-0003	0000-	0000-	0000	0000+
2•0 - + -	ł	; }		•	. 3224	• CC85	•0030	80Cu*	•0005	0000 *
• * •							-0195	*600*	•040	\$100*
5.0 *									.0178	1600*

٠.

Downloaded from http://www.everyspec.com

:

5

ţ

Ì

ł

2

	•	

. 153

H 4

2

- X 0

TPUTA 1

<mark>ب</mark>

1 ۰D 🏲 æ

> 2 THETA

(XĈ - Y9)/TFETAL Theta2/Thetal

19

ō.5 **6.**0 **B1/B2**

8.5 8°C 7.5 7.0

10.0

9.5

0-6

. 0000 **.** 1.

374

14

Weibull STRENGTH DISTRIBUTION - Welbull I STRESS DISTRIBUTICY

•0000

0000.

.0000.

.0000

.0203

•0000•

-0000

-0000-

-0000

2.0

0000.

.0000

0000-

00000-

.0000

.0000

• 0000

.0000

.0000

0.1

•0000

0000

0000-

•0000

•0000

•0000

.0000

¢.

.0000

•0000

-0000

.6000

.0000.

η,

.0000

• CCCC •

C000-

.0000

0000-•0000

•0000

00000

0000*

0000-

0000

.0000

.0000

3.0

.0000

0000-

2020-

0000

• 0000

JCOC.

.0001

.0005

4.0

0000-

• 0000

.0000

0000.

• 0C CI

.0003

.0009

.0022

.0049

5.0

.0000

1000.

•0003

1000-.0037

.0014

.0030

-0056

.0100

•C168

6.0

7.0

6 °.)

0.6

10.01

•0000

0100.

•0C020

•0063

• č103

.0161

.0026

-0043

• CC68

•0105

.0155

.0073 **\$†IC•**

-01C-

.0152

*	81								2.	
e1/82	► ★ 1.0 ★ \$\$\$\$\$\$\$\$\$	1.5 +*******	2 • Ú i e * * * * * *	2+5 :*******	。 3.0 44444444	3+5 ********	4 °() ********	4.5 *******	5.0	
•1	* "3260									
•2	• • 0000	0000-	• 0000					:		
		2000-	0000*	• 0000	.0000	·	į	: - 		
4	+	•0000	0000.	• 3000	.000	• 0000	• 0000			
Ś	* * C011	3000.	0000.	5005*-	• 0000	0000°	9 000*	°0000	•0000	-
9	* •0039	0000*	ပစ္စစ်-	.000	0000*	.0000	0000*	0000-	1000.	OCOC .
; en : •	* •C089	-0002	• 3006	. 1000	.0000	-0000	•0000	0000.	0000	0000 -
8.	* .0158	. 3067	0000.	. 0030	0000-	•0000	0000-	0000-	-0000	0000 *
6 !	* * .0243	• 9028	• 3366	.0000	0000*	0000*	0000-	• 0000	- 3000 -	000c • -
1-0	* • 0234	.0037	-0002	0000-	•0000	0000:	2000.	• 2000	-2000	0000*
2.0	• • • •		•0208	• 0050	6000*	1000*	0000-	• 0000	0000-	• 0000
3.0	₩				.0158	• 0055	•0015	•0003	1000-	0000-
. 4	H 44 (.0135	-3057	-002I	1000-
5.0	* *	·							.0121	- 00 60

}'

ł

X0 - Y0 HETA2/T)/THETAL = Hetal =	. 750 . 364		• • •		THE'		и и и и и и и и и и и и и и и и	1
* *	81								
* 1/82 *	6.) *********	6 - 5 +++++++	7 • C	7.5 :*******	8.0	8 • 5 b# + + + + + + +	9 ° 0	9*5 ****	10= 7
Ŷ.	* • • • • • •	١					••	,	
۲.	*	- 000	• 0000				•		
8.	* .0000	• 0000	•000	• 0000	• 000				
; 6•	£ 000 +	0000	0000	0000	•0000	0000.	0000-	•	:
1.0	2000* +	0000.	• 3000	-0000	0000*	0000	-0000	0000-	00.00*
2.0	* .0000	. 0000-	0000.	.0000	0000.	0000*	0000.	0000*	0066-
3•0	* • • • • • • •	0000-	0000-	6000.	•0000	•0000	0000	000C -	•0000
4.0	* •3002	10000	0000.	-0000	• 0000	0000*	00-jû•	0000-	-c:)00
5•0	* .027	1100.	•0064	1000.	0000*	•000•	0000*	0000-	0000*
6•0	* * •1112 _	-9062		• 0015	•0:0e	*0003	1000.	0000+	0000-
. 0.1	₩- ₩[·		1010.	• 306 •	•0036	• 100 •	6000*	•000	-0003
8•0	••				20102	• 2065	6Eù2*	•0023	.0012
0• 5	#* # .						0010-	.0066	-0042
ر•0	* *								•003

: •

376

,

Downloaded from http://www.everyspec.com

لب

. .

•

									•	
0 - Y0 ETA2/T)/THETA1 = HETA1 =	• 750 -						5 2 1 1 1 1	м ⁰ м ⁰ 1 1	
•	19) 4	1			•	•		
.	. 1.0	1.5	2.0	2.5	3.0	3.5	4.0 ******	4.5	5.0	5.5
	• • 0000		•						·	
2	• • • • • •	0000	• 0000	4	} 					
E	• 0000	• 0000	• 0000	0000	.0000					
	• 0000	• 0000	0000.	• 0000	0000	0000	0000		•	 !
	• • • • • •	0000	.000	0000	0000	.0000	0000	0000	0000	
Q	• •0020-	.0000	0000.	•0000	.0000	• 0000	0000-	•0000	.0000	000-
	• •0055	• 0001		.0000	•0000	.0000	•0000	00000	•0000	•000
	• • • • • • • • • • • • • • • • • • • •	.0003	0000+	.0000	• 0000	•0000	0000-	•0000	0000-	1000
0	• •0180	6000-	•0000	.0000	• 0000	• 0000	•0000	•0000	0000-	•000
•	* • 0263	. 0021	-000-	0000	•0000	0000-	.0000	0000	0000	000-
			-0153	1600.	+000-	0000-	,0000	0000	.0000	-00
0				•	-0112	•6033	.0008	1060.	.0000	-00
0	: 						£500°	5600.	1100.	000-
C	• •								2800-	00

1 X0 - Y ThETA2/))/[ht]al = [ht]al =	10 m 10 m 10 m 10 m				ahi The	TA 1 - 6 TA 2 - 6	M° M°	
• • • •	6 1								
e1/32	t 6.0 *********	Б.»Ъ 1000000000000000000000000000000000000	7.C 1464-24444	7.5 :******	8.0	8 • 5 • • • • • • • •		9.5 24444	0.01
9•	+ • • • • • • •		- - - -		•				•
۲.	CUDD* *	-0000	້ວວວວ•				·		
Ë.	* • • • • • • • • • • • • •	0000	0000.	0000	•0000				
6"	000C* +	2000-	2000-	.0000	•000	0630*	0000-		
1.0	* •0000	•6600	• 0000	.0000	•0000	0000*	-0000	0006.	-000
2+0	÷000°* *	.0000	00CC	. JOOC	.0000	0000	000ú*	0000-	.000
3.0	• 0000	ເ ວກອ•	0000*	•0000	• 0000	0000*	0000°	0000-	000
4.0	* * .001	• 0000	0050.	• 9063	0000*	•0000	0000*	0000.	000-
5.0	* .0015	.005	.0002	0000-	•000	.0000	•0000	• 2000	•000
, 0°,0	* .0075 *	• 6038	.0018	-0001	E000*	1000-	ວບວວ*	- JOOC -	-000-
7.0	* *		.3572	•0036	• 3027	0100*	+000*	- 1002	000*
8 °0	•				• 0069	- 0040	•0023	-2100	000
0°6	# #						•0766	1900*	° 02
10-01	* *								, C 06

10

. :

STRESS DISTRIBUTION - Weibull STRENGTH DISTRIBUTION - Weibull

Ļ

	•	5.5		; ;	ĺ	•		.0000	0000-	-0000	1000*	1000-	.0068	.0425	.0902	.1316	
•	×° ×° 1 1	5.0				-	0000	0000.	0000	1000-	1000.	£000°	•0128	.0586	•1093	-1502	
· .		4.5				!	- 0000-	1000.	1000 *	.0002	+000*	1000.	•0227	.0783	°1305		
		0.4	:			.0000	.0001	.0002	*000* "	8000°	• 100	-00 ² 1	.0378	1111°	.1535		
	•	3.5	;	1		-0002	+000°*	.0001	•0013	-2023	•0036	•0055	•0595	.1285			defbull defbull
•	· · · ·	3.0			.0003	-000	•100°	.0025		°0065	1900.	·0137	. 0884	.1586			- HOTLON
•		2.5		•	-0012	•0026	1400.	.0078	. c123	-0172	•0236	1150.	.1245			·	S DISTRIN
	, ,	2. C	-	.0022	1500.	•0695	.0153	.0226	.0312	.0411	6150 .	•0633	.1671.				STARS
	000*	1.5 ******	1	5010.	.0198	,0309	.0436		1170.	6863	.1008	.1148					
J.		L.0	. 6219	.0436	.0648	.0853	1048	tect.	5071	2951	1708	1839			1	-	
:	10 - 70)/11	* 81 * 1/82 *	* *	# # ~	* * * *			 		,	 0 1	·** #				• + •	• •
			 ال	• • •	•	•		1	79.'		379			•	•		

1.000 H (XC - YJ)/THETAÌ THET A2 / THE TA1

4

1.050

ŧ

8

61/82

9°. ************************ ට**ී**ර 8.5 8.0 7.5 ***************** 7.0 ¢.5 **0•0**

0"01

ø

THETA 2 THETA 1

9

0000.

.0243 .1010 .1234 -0065 0000-•000• .0760 0000-**+6+**0* 6080. •1334 .0583 .0000 9600. .0859 .1112 .0000 .0008 •1439 •0010 -0682 •0000 •0000 •0000 .0966 .1219 **•0138 1960.** 1620. .0029 .0192 0000 -2000 1000. •0478 .1080 1561. . 1449 6060* •0000 •0000 • 0050 **.12CO** •0263 .0583 .0000 .000 -0702 .1038 **•0003** - 0083 .0350 0000--0000 .1328 .0000 .1176 .1462 0000 -0007 -0132 .0457 .0835 .0000 .0000 0500. . 0016 .0202 • 0000 +R20-•C982 .1323 .0000 .0000 .0000 •0298 .1479 .1142 0000* .0034 -0732 - 300C 0000. .0000 8.0 2-0 3.0 4.0 5.0 **6.0** 7.0 1.0 ŝ •

Weibull STRENGTH DISTRIBUTION - Veibull NOLTHEISING SERVICE

9-0

1C.0.

۰,

۰.

.1430

10 - YOI	/THETAL = LETAL =	1.000	, I	۰ ۱	· · ·	1	THE	2 7 1 1 1 2 1 1	NO PO	•
.1 .1 	J.	1	•			1				
/82 *	1.0 	1.5 	2.0	2.5	3.0	3.5 :*******	4 °()	4.5	5.0	5°5 *****
	0000				•			,		
	1200-	3000	•0000	•		• .				1
	0126	.000	• 0000	•0000	0000-	-		1	- s -	
	•0275	•0034	• 0002	• 0000	0000-	• 0000	0000-	,		
S.	.044	• 3082	10100	1006*	0000.	0000.	•000	0000.	0000".	•
	• 0 6 1 9	-0152	.0026	00C3	0000	0000-	•0000	• 0000	0000	• 0690
• • • ·	£610.	• C24U	- 3052	• 0009	1000-	•0000	2000-	0000-	•0000	0000-
₩ ₩, 1	-0962	.0342	1500-	-0100	• 0003	• 0000	0000°	• 0000	•0000	0000*
۲ میں (م) (م)	.1123	.0455	1410.	•0034	2000-	1000-	.000	0000.	- 0000	0000
0 0	.1273	•0574	•020•	•0058	e100-	-0003	0000-	-0000	•0000	0000-
0	•	:	1098	• 0672	ZLEC.	.0185	-0082	•0032	TTOO.	- 000
• ••••• ••••	: 		1		101.	•0716	•0479	- J 302	6110.	•6600 •
0							1160.	1470.	•C548	16E0*
₩ 4		•		•						

 \mathbf{p} \mathbf{u}

(XC + Y0)/THETAL = 1.000 THETA2/THETAL = .600

Ó 0

THETA 1 THETA 2 ł

• 8 د ک

3

0.0.1 9.5 C. 7 ά.5 0 ° H í.5 7+0 **a.**5 .). 8

.0000.

9

61/82

ł

.0000 • 360 C

~

-0000

00000 00000 0000 .0033 .0436 .0132 .0293 CUCC. **:**000: 2000-.0005 *7053 e110. • **3365** +720. 1100. 0000-.0083 •0448 00000 0060* 0000. .0239 .0672 0000. 1000-.0123 •0313 .0021 •0000 .0779 0000. .0544 •0005 .0000 0000. •0174 •0000 •04<u>c</u>2 •0652 1980. 0000* .0039 .60.00 -0000 0000* .000+ • 0C68 .9251 .0506 .0000 •C77• .0000 .0906 .0000 -0000 າງນີ້ຍ. •C343 .0011 .C113 .0628 -0000 .5000 .0024 . 0178 0000. 0000-.0457 .0766 -0000-.0270 .0594 .0000 00000 .0001 .0051 .0922 6-0 2.0 3.0 4.0 5.0 1.0 8.0 1.0 \$

382

. **C882**

Weibull

1

STRESS DISTRIBUTION

STRENCH DISTRIBUTION - Weibull

\$

. (587

-0784

. **∂88**

0°6

10-01

ко - 70 НЕТА2/Т)/Thefal = Hetal = 	1.667				•		TTA 1 = =	е же и п и п и п	
1/82 *	0.1 1.0 644444444	15 t+++++++	2 • C	2.5	- 0*C	3.5	4 .0 :*******	4.5 ******	5.0	5.5 ++++
	÷									
N	• 0000	i 222	• 0000							
(¹)	* .CC13	0000*	- 3000	.0000	6000*	·			1	
4	• • 0C71	- 2002	• 30.00	0090*	ເວນດ.	0000°	0000-			
1	t0171	.0100	-0000	0000-	• 0003	00001	0000.	0000*	0000*	•
v	• • 0295	. 0033	.0002	0000-	0000-	0000-	0000*	0000.	0000-	- CC 0ē•
Pr.	* •0442	.0072	•0000	• 0000	• 0000	-0000	0000*	0000-	0000*	0000
20	• •0593	.0127	• 0016	•0001	C090*	-0000	-000	00-00-	-0000	• 1030
	÷ .0744	•0159	•0034	•003•	C000-	0000	•0000°	JUGU'	-000	0630*
0-1	£ 9893	.0281	• • • • • •	,000¢	1000*	•0000	0000*	0000.	• 100	• 0000
2•0			•0728	.0360		-0053-	9100*	+00C •	1000.	0000-
 	.				• 0056	•0396	•0219	0116.	• 6050	• 0200
	• • •						.0616	114	•C268	.0162
0.5									6630	10.00

N)

្ប

177130	HELAL -	• • • •					-	у 0	
• * '	19								,
1/82 *	. 6.0 *******	6.5 °	7.0 :*******	7.5 :#########	8 °C 14444444	8 • 5 :+++++++	9*3 5*6	9.5 :******	10.0
- - - - - -	* • 3003		i				i	•	
٠.	• • • • •	-0000	• JCCO			,			
	* *0000	-0000	0000*	• 0000	•000				
6.	* *	0000*	0000	• 0000	000 0 •	•0000	0000*		1
1•0	* • 0000	.0000	0000*	.0000	000 0 •	• 3060	0000*	• 0000	0000-
2.0	* .6000	- 0000 -	0000-	• 0000	•0000	.0000	-009 <u>6</u>	0000.	•0000
3.0	*	.0002	1000-	.5000	0000	0000	• 0000	0000-	• 0000
4•0	* * .0092	• 0049	. 3024	. 1100.	* 000*	•000°	1000*	• 0000	•0000
5.0	# #303	• 0205	•0133	.0082	•0648	.0027	4 LŪU.	10001	£0C0*
, 6•0	* <u>•0576</u>	1440.	.0329	•0239	+0169	.0116	•200*	5+00*	• G0 30
7.0	* *	·	• 0565	•0448	•0349	•0267	•0530	•9146	.0104
8.0	* *				•0556	°C454	•0365	.0290	•0226
0°6	#.#						•0549	.0458	•C378
0-0	* *						١		•0544

Downloaded from http://www.everyspec.com

4

د .

r,

`.*.

ų
		·				` . ``			:	
KC - YJ HELA2/TI *)/]hETAl = HETAL = Bl	1.00 .571				· · · · ·	3HL	TA 1 =	е же с т с с т с	
* 1/82 *	1.0 *********	لەتكە ئەتىنەتەتمەتەن	2 • 5 بج د جد جد جد	2.5 :*******	3.0 :*******	3.5 :########	4 ****	4.5 ********	5 • 0 t########	5 = 5 14 4 4 4 41
•	0000 • 0000 • * *						-			
~	* • C 000	J000.	2000 2							
n,	10727 #	0000	- 3000	•0000	0000					
4	* .0014	• 0000	2000-	-0000	0020-	0000*	00001			
۳ پ	• • 0000	1000-	0000-	.0603	°000	0000*	0000*	0000-	C COJ*.	
ý.	* ^ 0139	\$50 0 *	0060.	0000*	0000.	0000	•0000	, 0000	0000*	0000*
۲.	* * .0243	5 1 33°	1000.	.0000	5002°	0000*	0000*	• 2000	•0000	0000*
	* •0365	4400.	•0003	• 3000	2000*	0300*	0060.	000C*	0000"	0000°
с,	* .0497	.0283	-9667	•0000	.0000	0000-	0000-	0000	0000*	0000-
	* * .0632	.0136	•Cclo	1000.	0000.	0000.°	0000-	2506.	0600-	0000*
0.3	* +		•0480	2510*	Ú9 00*	*100 *	5000°	.0000	0000-	0000
	* *				.0425	9125.	8600*	.0338	£100°	* <u>0</u> 20*
0.	* *						•¢393	.3234	•0129	• 0005
¢									-17-	745

Downloaded from http://www.everyspec.com

	0000 T	.571
۰ı	H	II
		I A I
		/THE
•	I	LA2

THET

0.0

9.5

..6

8.5

0°8

7.5

7.0

6**.**5

6.0

B1/52

1

1 1 Ð THEIA 1 THETA 2

×° ر بر Ð

Downloaded from http://www.everyspec.com

00001

0000.

0000.

0000.

0000.

0000°

.0000

.0000

0000-

1.0

100J.

0000-

.0000

•0000

.0000

0000-

0000.

٩,

.0000

.0000

.0000

.0000

.0000

20.

.0000

.0000

0000.

~

.0000

¢.

0000.

.000

0000

0000-

0000

.0000

.0000

.0010

.000

2.0

9000

-J012

°0022

.0040

.0068

-0110-

.0170

.0253

•0361

6.0

7.0

8.0

0.5

ŗ

10.01

ŧ

1

.0035

• 2056

•0036

.0128

.0185

•0259

.0352

.0206

. 3267

.0340

.0336

.0102

•0144

1910

•0263

.0345

0000.

100ú.

-000**2**

•0r05

.0012

• 00 25

•0049

• CC89

.0152

5.0

0000 00001

00000

0000*

.0000

.0000 .0000.

.0000

-0000

•0000

.0001

3.0

¥.¹⁴

.0001

.0004

• CC12

.00.29

4.0

- JOCC -

00000

-0000

STRENGTH DISTRIBUTION - Weibull Weibull I STRESS DISTRIBUTION

	0 C.	*****				0000	0.0000	0• 0000	C° 0005	0" 0000	u" 2000	0. 0000	0° E000	2 61 . 3	9520	
ייי משאס אוו איייה איייה	4.5 • 4	* * * * * * * *				- 000C.	• 00000	- 2000 -	. 0000.	• 0000•		• 0000	• 513 • C	.)131 .(•	
THE	C • 4	****			0000-	0000*	0000-	0000.	0000-	0000-	3002-	3000-	•nc43	•0252		
	3.5				0000*	2000-	1000.	0000*	0000-	1000-	.0000	+000*	-0120			Llull
	ن ع•ر	• • •		0000.	• 0000	0000.	C000.	0000-	• 0000	• 0000	0000-	•0053	.0277			ION - H
	4 2 X	• • •		2000.	• 0000	900u*	3009.	6000 ·	.0000.	- 3000	0000-	•0102			ı	DISTRIBUT
	2.C 4444444		• 3000	2000-	0000 -	1036.	• 0000	. 0000.	0002.	1006.	•000•	•0328	•			STRESS
1 • Ĉ UQ • 5 - Ĉ	* * * * * *		0000-	.000	0050.	• (())	1000-	• 0004	• cc14	.0034	.(005	,				
/ТНЕТА́1 = Ета1 =	, ************************************	• 000	•0000	• 0000	2000*	6100*	• 3662	.0132	.0225	• 0333	1C40+	•	:			
(XC - 'YJ) THET42/TH	* + + * + 81/62 * *	• + + 	* * *	• •	· * *	* * د	ç, * *	* *	# # ~	* * °	1.0 *	2•0 ·*	3•℃ * *	** 0.4	5•0 #	

. Jan

Downloaded from http://www.everyspec.com

.

.

= 1.000 = .500 1 XU - Y) / THEIAL THETAZ/THETAL

57.

Φ

THETA 1 THETA

9

9.5 0°6 8.5 6. 0 7.5 7.0 6.5

********************** 10.0 ************* **** ***** 6. G 31/82

.0000

-000C

.0000

.0000

\$

0000. • 0000 0000-0000-0000. 1100. 1000' 0000-.0020 eroc. .0000 0000. -0000 00000. -0003 - 0000-0600. 0000* 0000. 0000* .0000 9000-•0036 0000. .0000 0000* .0000 0000-.0013 1900. 1000-0000-.0000 C000-0000-.0000 .6003 .0000 -0097 .0027 .00500 -0000 .0000 0000. .0000 .0000. .0000 1000. •0149 .0000 •0000 .0000 •0000 .0220 100. 1000. .0387 .0000 • COOC • 0000-• 00000 • 0000 .0000 .0003 .0038 •0144 .0000 C000-.0000 -0000-.0075 -0000 .0009 .0226 2.0 5.0 6.0 7.0 1.0 3+0 **0.**4 5

388

222

Downloaded from http://www.everyspec.com

• C045

<u>5</u>010-

-0152

.0214

8.0

0.6

10-01

•

.0112

.0155

.0211

,020B

STREESS DISTRIBUTION - Weibuil STREESTH DISTRIBUTION - Weibuil

	01/TFFTA] =	690 - 1			j. ,	•	63 HJ.	- - - -) 	
14E3A2/	THETAL =) .							о , , , , , , , , , , , , , , , , , , ,	
ê1/82	* 1.0 *********	1.5 :*******	2.C s*****	2 • 5 ******	3.0 ******	5 +++++++++	4**** *****	4 • 5 ******	5.0 ########	
nut T	* • ccoc						,			
°.	• • • • • • • • • • • • • • • • • • •	- 300C	• 0000	•						
(f) •	• • CCC	- 5000	9000*	, 666C	0000					
4	0000° +	.0000	-0000	•0000	•000•	5000*	•0000			
نې 4.	• • 0005	-000C	0000-	6006*	-0000	• 0000	0000*	0000.	• 0000	
وها	* • JC26	. 0000	.0000) 090	.0000	0000*	0000*	0000.*	0000.	00C.
2.•	+ :0071	-000	• 0000	.2000	0000.	.0000	0000	0000*	0000*	•00
9	* * •0138	. 0004	• 0000	1000°.	•0000	0000-	•000°	0000*	0000*	00-
6,	* .0224	.0013	-0000	0000°°	•0000	0000*	000 - -	0000.	•000-	ې ۲
1-3	₩ • • • • • • • • • • • • • • • • • • •	• 0630 •	1090.	•0000	•0000		6500*	0000	•0000	υ υ -
2-0			•0222	•0024	6000*	1000-	0000*	0000*	0000-	00
3.0	* *				.0182	•3C66	6100*	•000	1000*	òc."
Q• 2	* 4						-1152	.0-13	•6239	00.
5 . Ň	* *			,					.:15r	00.

(X0 - Y0)/Itefal = 1.000 Theta2/Ihefal = .444

TUFTA

м THETA 1

**	. 19							v 0	
• 11/82	× + + + + + + + + + + + +	6.5 F######	7.9 2	7.5	3.C :*******	8,5 1444444	9.) :*******	0.05 +++0+++	1.C • D :====================================
, 9 •	* • 3000		I	•					
£.	€000° +	•0000	0000*				·		
40	• • • • • •	-0000	• 2000	.JCCC.	000 0 *				
6	• • • • •	0000-	5000*	0000	•0000	0000*	0000-		
2+0	* • 5000	• 0000	• 9000	0000+	•0000	0000-	ວິດວນ*ີ	-00C*	0000*
2.0	+ •6309 +	. 0000-	.3000	• 000	.0000	2000*	ີດດາດ	0000.*	00001
9° £	* •0000	0000-	.0000	•0000	•0000	• 0000	0000*	•000u	0000.
6. 4	* •000	10001	- 2000	.0000	•0000	. •000	0000*	- 0000	0000"
5.0	* * .037	.0016	• 3006 •	• 9662	1000*	2000*	0000*	000L.	0000
6•9	* •0142*	.CC82	• 3044	•0522	0100*	•0064	2000*	100L.	5000*
7.0	• +		.0137	.0085	• 0650	.0028	5100*	1000.	£003*
8•0	, * *		•	·	•0133	88JQ.	•20156	+EÜC *	6100.
0°6	# *						1613.	.0096	ວຈ ະ∵•
10-0	* *								•0128

390

5

STRESS DISTRIBUTION - Wetbuil STRENGTH DISTRIBUTION - Wetbull

د

Downloaded from http://www.everyspec.com

: [A2/	THETAL ==	0) () 4 •				•	JHHL.	[A 2 = 6		
87 8	r ★ 1.•∂ \$\$\$\$\$\$\$\$	1.5	2°C	. 2.5 ******	3.0	3.5	4°0 4°0	. ***** *	5 . Û 1444444	5°2 ******
							·			· .
2	• • • • •	0000.	• 0000				1			
m		.0300	0000*	eobo.	•0000	,				
*		0000.	2000.	0000-	6000* -	. o'roc	•0000			
ŝ	1000 •	0000*	.0000	0000	.000	•0000	•000	0000-	•000	
4	• • • • • •	1209*	- 3000	0000*	.3000	0000*	0000.	.0000	•0000	0636.
~	• • ° ° ° 37	0000	-0000	-0000	• 0000	0000	-1 aac	0366*	JC00*	.0030
3	• • • • • • • • • • • • • • • • • • •	1000.	2020.	0000°*	0005*	•0000	0000	0 300*	0000*	0 - 20*
6	* *0152	500C *	• JOC •	• 3000	1000-	9000*	•دەرە	2000*	0000*	66CD.
0	* .0235	.9122*	• 9000	2020*	0000 *	0000	0000*	-0000	0000-	0000*
¢	₩.₩		-0152	• 0029	£000*	•0000	ວ ວວວ`•	0000-	0000*	(-600*
0	* *				•0120	•0036	8 00 08	1000.	-000	• 000 •
0	•••						•013•	. 1041	•0113	• 000 •
C	* *								.C 395	4400*

.

= 1.600 (XO - YO)/THETAL Theta2/Thetal

18

THETA 1 THETA 2

۹°

0°01

9.5

6°0

8.5

8.0

7.5

7.0

6.5

6.0

81/82

•0000

00000* •00000 00001. .0000 00000 1000. 8000. 0000. .0379 .0.32 000ú. -0000 .0000 .0016 00000. -0002 .0000 0000-. 0052 00000* 0000* 0000. 00000. 0000. -Cr3C •000• .0029 .0000 .0081 5000. 0000* 0000 0000-0000-0000. 1000-.0051 .0013 •0000 •0000 .0000 .0063 0000 0000* .0004 •0020 0000. 0000. 0000 .0000 •0030 -0000 .0000 .0010 .0000 1000-•0049 0000-.0000 .0000 . 3002 00000 00000. .0000 0000. .0022 .0086 ..2000 • 0000 00000. •0000 0000. 0000°* • 3306 2050--CC47 • 300 C 0000-.0000 0000:• .0000 .0018 C500. , UU09 .000 • 6.0 1.0 2.0 0. E ••• 5.0 8.0 0.6 7.0 10-0 •

STRENGTH DISTRIBUTION - Wetbull

Ļ

Weibull

1

STRESS DISTRIBUTION

Downloaded from http://www.everyspec.com

392

×

(X0 - Y THETA2/	9J/THETAL = THETAL =	1. 200 . 364.				•		TA 1 =	B B B B B B B B B B B B B B B B B B B	
• • •1/82	51 * 1.^ *	1.5	2 • C • • • • • • • • •	2.5	3.C 1446444	3•5 ******	, 0.01 ****	4*5***	5.0 *****	5°2 14444
.1	• • • • • •									
•2	• • • • • •	0000-	• 3000			•				
e.	•	-2000	9000 *	0000-	•0000					
4	CU20" +	-0000	5000.	.003.	C000*	• 0000	•0000*			
1 •	Cún0" +	• 0000	0000*	- 00 0 0	• 0000	0000	0000-	0000*	•0000	
<u>ن</u> •	• • • • •	0000-	0000.	• 0000	0000.	0000-	0000*	-000u	0000-	606.
1.	610C• +	-000	•000*	• 0000	0000*	0000-	0000*	2000	0000*	•000
60 •	• •3652	.0000	-9000	000ú	0000-	• 0000	-000 C	000c°	•0000	. 00 .
6.	• •0163	-0002	1000-	0000	6399.	0000*	0000*	0000°.	5600*	000 *
1•0	• • • 176	• 0300	0000-	• ၁၉၁၀	0000-	3000*	000u*	•0000	-0000	• 001
2-0	• • •		•010•	.0016	1000-	0000*	0000°	0000-	•000	200-
3•0	• • •				ເອຍປ*	•0020	\$600°	000e•	3960.	- JC •
4-0							• ر، و8	• 30 23	9665.	· 00'
5+0	• •								[903]	000

1.000 .364	
н н	
4x0 - Y0)/THETAL THETA2/THETAL	

S.

THEFA 1 THETA •

0.0 **B1/82**

*************** 9.5 **6 6** ** 8.5 8.0 7.5 ***** 7.0 *** ************ 6.5 .0000

۱

10.01

0000-.0000 •0000 .0000 • 0000 0000* .0000 .0000 0000-.0000 - 0000 •0000 .0000 .0000 - 3000 -0000 .0000 .0000

0000. -0000 •0000 •0000--0000 0000. £000* 0000-00000 0000 .0000 0000-.0000 .0008 .0000 1000. •0015 0000-•0000 0000* 0000-•0000 •6000 0000 •0002 .0029 -0000 .0000 0000--000C -0000 •0000 -0000 -0000 .0013 .0000 0000. .0000 -0001 .0052 .0000 .0000 +000-.0028 •0000 .0000 •0054 .000. .9000 000C* 1000. .0011 C000-.0027 •0000-.0000 .0003 .000 .0000 0000. .0000 1500.

2.0

1.0

3.0

4.0

5.0

6.9

7.0

•C049

Weibull

STRENGTH DISTRIBUTION - Welbull

STRESS DISTRIBUTION

100.

0E0C.

.0200

9-0

0°6 10.01

HETA2/TI	HETA1 =						THET		0 ×0	
•	61									
11/82 +	1.] teesesses	1.5 ********	2+C	2•5 }*******	3•C *******	3 • 5 :######	4 ≈C k≠≠≠≠≠≠4	4°5 +++++++	5.0	5*5 -
	• • : : : : :									
Ŋ	0000	còce•	-3006							
m •		0000°	• 3369	- 30 00	0000.					
•	(00)	• درون	-SUC-	C003-	• 0 000	¢000°	JCCD.			
υ η	0000 1	5000 *	1000.	6000*	•000	103Q.	<u>0</u> 00 . -	0000*	0000-	
•	2000.	3300 *	0000	0000.	0000*	3030-	0000*	9000-	•0000	6606-
		1000.	.0000	.000	•0000	0000*	2002-	0404.	•0000	ເພິ່ງທີ່.
20 20	1032	0000.	0000*		• 0000	3000*	0000°	-0000	• 0960	5 63 4*
	.100. 1	1000-	000C°	• 0000	- JC - L	0000°	000J*	0000	0000-	ວເວບ້
1 •0	6124	• 3003	. 0000	-0030	0000-	ົວນມີຍູ າ	•000đ	0060.	00 0 0	0C00*
2. 0			.9072	• 2008	000.	. 0500	0000-	- 2000	0000*	000 0
5. C.S.					• 1055	1100*	20-0-	•000	0000-	.0000
0.4							•0044	E1C0.	.0303	0 L ùu*
2.0		•	·						6ECJ*	+ 10C •
			STRESS STRENG	DIETRIDU STREE	H - HOLL	leibull leibull				

395

Downloaded from http://www.everyspec.com

1 X0 - Y) heta2/T)/[HETA1 = HETA1 =	1.000 .335				THE	TA 1 = 1	X ° H° • • •	1
* *	el l								
\$ 81/82 *	6.0 +++++++++	6=5 8#######	7.C	7.5	. 8.C	8 • 5	9 • C - C • 6		10.) ••*****
Ą	÷	- - -							
•	:00C•	0000.	• • • • •				·		
30	• • • • •	•0250*	•0000	• CC00	0000*				
0,	0000	້ວວວວີ"	ອ້ວຍບໍ່.	0000.	6000 ·	.0000.	0000		
1-0	• 0000	0000-	• 0000	• 0000	-0000	0000.	0000	JJ000*	0000*
2.3	C000 ·	.0067*	•000	.0000	0000.	• 0000	0000.	90 00 *	•0000
9	-0000	.000	0000-	.0000	0009.	-0000	•0:000	• 0000	0000
0.4	• • • • • • •	2005-	9 230°	• 0000	•000	000c	0000	0000.	•0003•
0 • 0	•000	1000-	0000.	• 9603	£000*	י מינג	ებსბ*	0000*	0003*
6	•	51 CJ *	• 3006	20.00*	0000*	.0000	0000-	1000-	0050
7-0	F 4 4	•	.0034	9130.	•0001	•000	1003*	0000-	0000*-
0	, • • •			•	.032	1120-	eco3.	•000-	.000
0				•			1623.	LICC.	• 0000
0-01	• •								leco-

396

Ĵ

9.11

ţ

ţ

STRESS DISTRIBUTION - WCIbull Strength Distribution - Weibull

,

Downloaded from http://www.everyspec.com

APPENDIX 3 MATHEMATICAL THEORIES OF ANALYTICAL FYPRESSION

Downloaded from http://www.everyspec.com

÷.

A-3 MATHEMATICAL THEORIES OF ANALYTICAL EXPRESSION

A-3.1 INTRODUCTION

A-3.1.1 The Concept of a Random Variable

Interference Theory is concerned with the interplay of two variables X and Y called the strength and stress respectively. Each variable is considered to arise as a consequence of performing some action and measuring the resulting value of the variable. Unlike other such problems frequently considered in engineering, however, one cannot predict with certainty what value of the variable will result as a consequence of a given action. For example, one cannot predict with certainty the strength of a manufactured part prior to performing a strength test on it. One feels from experience that the strength will lie in some finite interval or that in the past the average strength has been some known value. But that is quite different than knowing with certainty what strength this part will have. Hence it is convenient to consider both strength and stress to be random variables--variables whose values are not known with certainty prior to performing some test.

As is usual in studying random variables one associates with the possible values that the random variable can take, a set of numbers called the probability that the random variable takes less than that value. The function, F(y) that assigns these numbers is called a distribution function and its derivative, if it exists for all y,

$$f(y)dy = dF(y)$$

is called a probability density function. From data analysis of the type performed in Section 6 of this report one estimates the density function or distribution function from given data. Hence one starts the mathematical study of interference assuming that X, the strength and Y, the stress, are random variables with known distribution or density functions, F(x) and G(y) or f(x) and g(y) respectively.

A-3.1.2 Interference Theory and Random Variables

Interference theory is concerned with the problem of determining the probability of failure of a part which is subjected to a stress Y and which has a strength X. It is assumed that both X and Y are random variables with known probability density functions. One says failure occurs whenever stress exceeds strength. Hence, the probability that failure occurs

(1)

is equivalent to the probability that stress exceeds strength. In symbols:

$Pr(failure) = Pr (Y \ge X)$.

A-3.2 Determination of Probability of Failure

It is clear from A-3.1.2 that to determine the probability of failure one needs to explore the probability that one random variable, called strength. In practical application it is to be expected that the random variables are independent of each other in the sense that knowledge of one does not allow one to predict the other any more closely than would the absence of such knowledge. In symbols one would say that the random variables X and Y are independent if

$$\Pr(X|Y) = \Pr(X),$$

Roughly in words, this statement says that the probability of X is the same whether one knows the exact value of Y(P(X|Y)) or not, (P(X)).

There are four main ways to determine the probability of failure from the above considerations. In any given case we will use the form most easily calculated.

a. One can fix attention on some particular value of one of the random variables, say Y and determine the probability that the other random variable does not exceed this fixed value, say y. The probability that X does not exceed a fixed, given value of Y is written as

$$\Pr(X \leq y | Y = y) .$$

In terms of density and distribution functions this is equivalent to



for those cases where X takes only non-negative values. If one now multiplies (1) by the probability that Y is in the neighborhood of y,

one obtains a joint probability function

$$P(X \leq y; y < Y \leq y + dy) = \int_{0}^{y} f(x)g(y)dx$$

The probability that $X \leq Y$ for any value that the random variable y can take on is given by

(2)
$$P(X \leq Y) = \int_{0}^{\infty} \int_{0}^{y} f(x)g(y)dxdy$$

in the case the random variable Y is distributed on the non-negative axis. Since failure occurs whenever $X \leq Y$, formula (2) gives the probability of failure sought. It is expressed in terms of the double integral of the known density functions.

b. One can define a new dummy variable

$$\mathbf{Z} = \mathbf{X} - \mathbf{Y} \cdot \mathbf{I}$$

Since X and Y are random variables their difference, Z is a random variable. Further, if X and Y are distributed on $(0,\infty)$, Z is distributed on $(-\infty,\infty)$. The probability of failure then is equivalent to the probability that Z is non-positive, $\Pr(Z \leq 0)$. The problem the n is to find h(z), the probability density function for Z. From this the desired probability of failure can be obtained in a simple fashion.

To motivate the study of interest, let us solve for the following simple problem in detail. Assume X has a probability density function f'(x) = 1/6 and Y is identically distributed. Both are distributed on the integer 1, 2, ... 6. So formally

$$f(x) = \frac{1}{6}$$
 for $x = 1, 2, 3, 4, 5, 6$
= 0 elsewhere

and Y is independent and identically distributed.

Now consider a table of X and Y values and the difference. Y = Z .

		Х	value	1	5	3	4	5	6
			1	0	1	5	3	4	5
			2 ·	-1	0	l	2	3	4
Y	value		3	-2	-1	0	3.	2	3
			ц	-3	-2	-1.	00	1	2
			5	-4	-3	-2	-1	0	1
			6	-5	-4	-3	-2	-].	0

For X = 1 and Y = 1, Z = 0. The probability that X = 1 and Y = 1is 1/36 since X and Y are independent. The probability associated with each cell in the above table is 1/36 . Now notice that if Z = 0 then X = 1; Y = 1 or X = 2; Y = 2 or X = 3; Y = 3 etc. Hence the probability that Z = 0 is given by 1/36 + 1/36 + 1/36 + 1/36 + 1/36 + 1/36 = 1/6. If now, we let h(z) = the probability that X - Y = Z for fixed Z then h(z) is desired probability density function. From the above discussion, it is clear that f(x)f(y) is the probability that both X and Y take on desired values. In every case X = Z + Y for the X, Y, Z of interest. Hence f(y+z) f(y) is the probability that X = Z + Y and Y = Y for any Y and fixed Z . The above probability is the joint distribution of Y, Y + Z, say g(y,z). It is well known that to get the marginal distribution h(z) from g(y,z) one merely "sums over all y." One must remember that both X,Y are distributed on some interval (1, 2 ... 6 in this example) and hence the sum must be over "Permissable values of Y ." L_{CU} us see what these are in this example.

X is distributed on 1, 2... 6 and f(z+y) is the probability distribution of X. Hence, z+y cannot exceed 6 nor fall below 1. Thus at the upper limit z+y = 6 and at the low limit z+y = 1. Or y = 6 - z and y = 1 - z. Now let us look at the Y,Z plane. (See the Figure A-3.1).

Clearly g(y,z) can be summed only over the y values defined in the rectangle. But below the y axis this means y is summed from 1 - z to 6 and above the y axis, y is summed from 1 to 6 - z. Hence we must consider two parts of the sum as follows.



ł

$$h(z) = \sum_{y \in I} f(z+y) f(y)$$

$$= \sum_{y=1-z}^{G} f(z+y) f(y) \quad \text{if } 0 \ge z \ge -5,$$

$$= \sum_{y=1}^{G-z} f(z+y) f(y) \quad \text{if } 0 \le z \le 5.$$

(Note that Z = 0 could be in either sum--but not both--arbitrarily it has been put into the second.)

Now recall f(x) = 1/6 for all $x = 1, 2 \dots 6$ and similarly for y. Hence

$$h(z) = \sum_{y=1-z}^{6} \frac{1}{36}, \qquad 0 > z \ge -5,$$
$$= \sum_{y=1}^{6-z} \frac{1}{36}, \qquad 0 \le z \le 5.$$

From this it follows that:

h(0)	= 1/36 [1 + 1 + 1 + 1 + 1 + 1]	= 6/36,
h(1)	= 1/36 [1 + 1 + 1 + 1 + 1]	= 5/36,
h(2)	= 1/36 [1 + 1 + 1 + 1]	= 4/36,
h(3)	= 1/36 [1 + 1 + 1]	= 3/36,
h(4)	≖ 1/36 [1 + 1]	= 2/36,
h(5)	= 1/35 [1]	= 1/36,

Downloaded from http://www.everyspec.com

and

h(-1) = 1/36	[1 + 1 + 1 + 1 + 1]	= 5 /3 6,
h(-2) = 1/36	[1 + ! + 1 + 1]	- 4/36,
h(-3) = 1/36	[1 + 1 + 1]	= 3/36,
h(-4) = 1/36	[1 + 1]	= 2/36,
h(-5) = 1/36	[1]	= 1/36.

A picture of h(z) is given in Figure A-3.2.

The probability of failure in this case is given by

$$\Sigma h(z) = 1/2$$
.

Having solved the foregoing simple problem one is able to generalize. Because of the special nature of the interference problem we assume: X has probability density function f(x); Y has probability density function g(y) and both are distributed on $(0,\infty)$. Note that we are allowing f and g to be different. Hence we have dropped the assumption of identically distributed random variables although we continue to assume that they are independent.

As in the previous work it is clear that the only difficulty in finding h(z) is in finding the correct limits on the integrals. The probability arguments are trivial. Since we have assumed that both X and Y are distributed on $(0,\infty)$ we can give a complete solution to this problem. For consider the y,z plot again. Since x=0 is the minimum value that X can take we must have y + z = 0 or y = -z as the lower bound of the area to be considered. Since $x = \infty$ is the maximum value that x can take there is no upper bound on area. Hence all values of permissable y's are included in the area above. These are shown in Figure A-3.3.

404



Figure A = 3.2 Probability density function h(z)



9



Figure A - 3.3 Area of integration for the difference of two non-negative random variables

406

1. 1. **1**

'7

and one can pursue the probability arguments precisely as in the state $t_{\rm c}$ above to above

(3)

$$h(z) = \int_{y}^{\infty} f(z+y)g(y)dy, \quad z \ge 0,$$

$$= \int_{-z}^{\infty} f(z+y)g(y)dy, \quad z \ge 0,$$

Clearly this solves the problem in general for n_{1} x,y extensions to other domains for X,Y follow quite read.

It follows then that with the above iormulation one need not resort to Monte Carlo simulation. At worst one must evaluate, numerically, the the ve integrals. In some cases the h(z) can be obtained in closed form. In the often considered case in which X and Y are normally distributed, the probability density function of z is known to be normal. Hence $\Pr(z \leq 0)$ is obtainable from tables of the normal curve. We will show this to be true in A-3.3.1.

c. From the definition of a probability distribution function one sees from formula (2) that the probability of failure can be expressed as:

(4)
$$\Pr(X \leq Y) = \int_{O}^{\infty} F(y)g(y)dy$$

where F(y) is the probability distribution function of X evaluated at the point y. Formula(4) is convenient to use when F(y) is easily determined as in the case of strength's that are Weibull distributed.

An equivalent representation obtainable from Formula (2) is

(5)
$$\Pr(\mathbf{X} \leq \mathbf{Y}) = \int_{0}^{\infty} [1-G(\mathbf{x})] \mathbf{f}(\mathbf{x}) d\mathbf{x}$$

where $G(\mathbf{x})$ is the distribution function of the random variable Y. Again this is convenient to work with in some cases such as stresses that are Weibull distributed. Since

$$\int_{0}^{\infty} f(x) dx = 1,$$

formula (5) can also be written as

(6)
$$\Pr(X \leq Y) = 1 - \int_0^\infty G(x)f(x)dx .$$

Each of the formulas (2), (3), (4), (5), (6) are easier to work with in special cases than the others. In developing the examples and tables in this report we have chosen the particular integral that appeared easiest for the cases considered.

d. A fourth method that can be used to evaluate the probability of failure is to reconsider the equation

$$Z = X + (-Y)$$
.

From this it is clear that Z is the sum of two independent random variables X and -Y. It is well known in probability theory that the Laplace transform for the density function for the sum of two independent random variables is given by the product of the Laplace transforms of the density functions of the individual variables. Hence if $H^{*}(s)$ is taken for the Laplace transform of h(z), then

$$H^{*}(s) = F^{*}(s)G^{*}(-s)$$

where $F^{*}(s)$ and $G^{*}(-s)$ are respectively the Laplace transforms of f(x) and g(-x).

This method of finding the probability density function of Z and thence the probability of failure has not been used in this work.

A-3.3 Some Examples

A-3.3.1 Normally Distributed Strength (X), Normally Distributed Stress (Y)

It is well known that if X and Y are normally distributed with mean values μ_X and μ_Y and variances σ_X^2 and σ_Y^2 then Z = X - Yis normally distributed with mean value $\mu_Z = \mu_X - \mu_Y$ and variance $\sigma_Z^2 = \sigma_X^2 + \sigma_Y^2$. Consequently, the probability of failure will be given by the area under the normal curve whose mean and variance are μ_Z and σ_Z^2 respectively. The area is to found on the interval $(-\infty, 0)$. We proceed to prove these remarks to exemplify the ideas developed in A-3.2 part b.

The normal density function is given by

$$f(x) = \frac{1}{\sqrt{2\pi}} - e^{\frac{(x-\mu)^2}{2\sigma^2}}, \quad -\infty < x < \infty.$$

Since it is easiest to develop the results using method b in Section A-3.2, we consider the random variable, Z = X-Y. It is easy to see in this case that the probability density function of Z, say h(z) is given by

$$h(z) = \frac{1}{\sqrt{2\pi}\sigma_{y}\sigma_{y}} e^{-\frac{(y-\mu_{y})^{2}}{2\sigma_{y}^{2}}} e^{-\frac{(z+y-\mu_{x})^{2}}{2\sigma_{x}^{2}}} dy.$$

After laborious algebraic manipulation completing the square of the exponent and using the fact that

$$\int_{-\infty}^{\infty} e^{-r^2/2} dr = \sqrt{2\pi},$$

one is able to show

$$h(z) = \frac{1}{\sqrt{2\pi}(\sigma_x^2 + \sigma_y^2)} e^{-(z - (\mu_x - \mu_y))^2/2(\sigma_x^2 + \sigma_y^2)} -\infty < z < \infty.$$

That is, Z is normally distributed with mean value $\mu_X - \mu_Y$ and variance $\sigma_X^2 + \sigma_Y^2$. From this it follows immediately that the probability of failure, $\Pr(Z \leq 0)$, is the integral of the normal curve over $(-\infty, 0)$.

A-3.3.2 Exponentially Distributed Strength (X) and Exponentially Distributed Stress (Y)

Because of the simplicity of the integrals involved one can use this example to illustrate several of the methods discussed in Section A-3.2.

We take X to be distributed as

 $f(x) = ae^{-ax}$, $0 \le x < \infty$,

and Y to be distributed as

 $g(y) = be^{-by}$, $0 \le y < \infty$.

1. Using formula (2) in A-3.2 one fixes the value of one of the variables, say Y = y. For this fixed value one determines the probability that $X \leq y$. This is given by

$$\Pr(X \leq y | Y = y) = \int_{0}^{y} a e^{-ax} dx = 1 - e^{-ay}.$$

If we multiply this by

$$Pr(y < Y \leq y + dy) = g(y)dy ,$$

we obtain

$$Pr(X \le y | Y=y) Pr(y < Y \le y + dy) = Pr(X \le y; y < Y \le y + dy)$$
$$= (1-e^{-ay}) be^{-by} dy, 0 < y < \infty$$

Then

$$\Pr(X \leq Y) = \int_0^\infty (1 - e^{-ay}) b e^{-by} dy = 1 - \frac{b}{a+b},$$

which is the required probability of failure.

2. Using formula (3) of A-3.2 one must first find the probability density function of Z = X - Y. This is easily accomplished by using the formula

$$h(z) = \int_{-z}^{\infty} f(z + y) g(y) dy , \quad z \leq 0.$$

Since the probability of failure is equivalent to $\Pr(Z \le 0)$, one has, using formula (3) of A-3.2 that

$$\int_{-\infty}^{0} h(z) dz = \int_{-\infty}^{0} \int_{-z}^{\infty} a e^{-a(z+y)} b e^{-by} dy dz = \frac{a}{a+b} = 1 - \frac{b}{a+b} ,$$

which clearly agrees with the result found above.

3. Using formula (4) of A-3.2 one sees that

$$F(y) = \int_0^y a e^{-ax} dx = 1 - e^{-ay}.$$

Hence from formula (4) of A-3.2 one obtains the probability of failure as

$$\Pr(X \le Y) = \int_0^\infty (1 - e^{-Ay}) b e^{-by} dy .$$

This integral, of course is

$$\Pr(X \le Y) = 1 - \frac{b}{a+b} ,$$

which again agrees with the other results of this section.

A-3.3.3 Gamma Distributed Strength (X) and Gamma Distributed Stress (Y)

In some applications one finds typically that the probability density function for the random variable has a form as shown in Figure A-3.4, and that the gamma density function, given by the formula



.

1)
$$f(x) = \frac{\lambda^n x^{n-1} e^{-\lambda x}}{\Gamma(n)}, \quad n > 0, \quad o \le x < \infty, \quad \lambda > 0$$

can be used to closely fit the data. λ in the formula is a scale parameter. n is a shape parameter. For n = 1 the gamma density function is the negative exponential discussed above. For large values of n, the gamma density can be approximated by the normal density. Hence the gamma function supplies a family of densities that roughly fall between the two cases previously discussed.

It has been shown in formula (3) of Section A-3.2 that if one considers the problem of determining the distribution of the difference variate Z (i.e., Z = X-Y) for given distributions for X, Y, then the density function for Z can be found from

$$\int_{0}^{\infty} f(z+y)g(y)dydz , \quad 0 \le z < \infty ,$$

$$(2) \quad h(z)dz = \Pr[z \le Z < z + dz] = \int_{-Z}^{\infty} f(z+y)g(y)dydz , \quad -\infty < z \le 0 .$$

Hence one is interested in

$$\int_{-\infty}^{\circ} h(z) dz = \int_{-\infty}^{\circ} \int_{-\Sigma}^{\infty} f(z+y)g(y) dy dz .$$

Equivalently one is interested in

$$\int_{0}^{\infty} h(z) dz = \int_{0}^{\infty} \int_{0}^{\infty} f(z+y)g(y) dy ,$$

from which $P(Z \le 0) = 1 - \int_{0}^{\infty} h(z) dz$. Here we suppose

(3)
$$f(x) = \frac{2}{\Gamma(m)} x^{m-1} e^{-x}, \quad 0 \le x < \infty$$

(4)
$$g(y) = \frac{1}{\Gamma(n)} y^{n-1} e^{-y}, \quad 0 \le y < \infty$$
.

(Later we shall extend this definition of the gamma function to include the scale parameter λ in formula 1.)

Straight forward substitution of (3) and (4) into (2) leads to

$$h(z) = \frac{1}{\Gamma(m)\Gamma(n)} \int_{0}^{\infty} (z+y)^{m-1} e^{-(z+y)} y^{n-1} e^{-y} dy, z \ge 0.$$

The substitution v = y/z lead to

$$h(z)dz = \frac{dz}{\Gamma(m)\Gamma(n)} z^{m+n-1} e^{-z} \int_{0}^{\infty} v^{n-1} (1+v)^{m-1} e^{-2zv} dv, z \ge 0.$$

The integral can be expressed in terms of the well known confluent hypergeometric function $\Gamma(n)U(n, n + m, 2z)$ and the function h(z)dz can be expressed in terms of the well known Whittaker function $W_{k,m}(2z)$. In the special case m = n the Whittaker function can be expressed in terms of the Bessel function $K_m(X)$. Hence in general h(z)dz can be found in terms of well known functions.

The above results define the density function for $Z \ge 0$. The probability that $Z \ge 0$ is given by

 $\int_0^{\infty} h(z) dz.$

From the above discussion this is equivalent to

$$\int_{0}^{\infty} W_{k,m}(x) dx$$

where $W_{k,m}(x)$ is the Whittaker function. From the definition of h(z)dz this is also equivalent to the double integral

$$\frac{1}{\Gamma(m)\Gamma(n)} \int_0^\infty z^{m+n-1} e^{-z} dz \int_0^\infty v^{n-1} (1+v)^{m-1} e^{-2zv} dv.$$

* The expression of h(z)dz in terms of $K_n(x)$ was first found by Pearson, et al ¹³. The general result of h(z)dz is terms of the Whittaker function was first found by Kullback¹⁴. Our results follow directly from the definition of those functions ¹⁵.

The last formulation is easiest to work with.

Interchanging the order of integration and noting that the integral involving z is by definition

 $\frac{\Gamma(m+n)}{(1+2v)^{m+n}}$

leads to the single integral

 \mathbf{C}

$$\frac{\Gamma(m+n)}{\Gamma(m) \Gamma(n)} \int_0^\infty \frac{(1+v)^{m-1} v^{n-1}}{(1+2v)^{m+n}} dv,$$

If now one takes u = v/(1+2v) it follows directly that the integral can be written as:

(5)
$$\Pr (Z \ge 0) = \frac{\Gamma(m+n)}{\Gamma(m)\Gamma(n)} \int_0^{1/2} (1-u)^{m-1} u^{n-1} du$$

This integral is the well known incomplete beta function $B_{1/2}$ (m,n). Hence, finally

$$Pr(Z \ge 0) = \frac{1}{B(m,n)} B_{1/2}(m,n)$$

where $B(m,n) = [\Gamma(m+n)/\Gamma(m)\Gamma(n)]^{-1}$. It follows directly that the probability of failure is given by $1 - \Pr(Z \ge 0)$.

In all the previous results we have taken the gamma distribution in the form

$$f(x) = \frac{1}{\Gamma(m)} x^{m-1} e^{-x}, \quad 0 \le x < \infty.$$

A simple generalization occurs if one admits the scale parameters λ , μ . It is easy to show that the resultant probability density function is given as

$$f(x) = \frac{\lambda}{\Gamma(m)} \quad x^{m-1} e^{-\lambda x}, \qquad \lambda > 0, \ 0 \le x < \infty, \ m > 0,$$
$$g(y) = \frac{\mu^n}{\Gamma(m)} \quad y^{n-1} e^{-\mu y}, \qquad \mu > 0, \ 0 \le y < \infty, \ n > 0.$$

_ **1**%

Downloaded from http://www.everyspec.com

If one introduces this into Equation (2) for h(z)dz it follows by previously used methods that

$$h(z)dz = \frac{\lambda m \mu n}{\Gamma(m) \Gamma(n)} z^{m+n-1} e^{-\lambda z} \int_0^\infty (1+v)^{m-1} v^{n-1} e^{-(\lambda+\mu)zv} dv, \quad 0 \le z \le \infty$$

which leads to h(z)dz being expressed in terms of the Whittaker function with argument $(\lambda+\mu)z$ instead of 2z as previously.

From the above one has, again using the previous methods,

$$\int_{0}^{\infty} h(z) dz = \frac{r^{n} \Gamma(m+n)}{\Gamma(m) \Gamma(n)} \int_{0}^{\infty} \frac{(1+v)^{m-1} v^{n-1}}{[1+(1+r) v]^{m+n}} dv,$$

where $r = \mu/\lambda$. The change of variable u = rv/(1 + (1+r)v) allows one to express the above integral as

$$\frac{\Gamma(m+n)}{\Gamma(m)}\int_{0}^{\frac{r}{1+r}} (1-u)^{m-1} u^{n-1} du$$

which involves r only in the limit of integration. Hence $P(Z \ge 0)$ can be expressed as the incomplete beta function whose truncation occurs at r/(1 + r) instead of 1/2 as found in formula (5).

Therefore, B (m, n)(6) $Pr(Z \ge 0) = \frac{1}{1+r}$ B(m, n)

Special Cases

- 1. It is clear that for $\lambda = \mu$, r = 1 and r/(1 + r) = 1/2. Hence all of the preceeding work involving $\lambda = \mu = 1$ holds for $\lambda = \mu \neq 1$.
- 2. If m = n = 1 then for $\lambda = \mu = 1$, $Pr(Z \ge 0) = 1/2$ and in general for $\lambda = \mu \neq 1$ it is clear from the above that this holds. But this is expected since in the case m = n, both X and Y are negative exponentially distributed and for

 $\lambda = \mu$ they are identically distributed no matter what λ or μ are. Hence this case corresponds to taking the difference between two identical negative exponential variates and as one would expect $P(Z \ge 0) = 1/2$ for any choice of λ and μ for which $\lambda = \mu$.

3. If in 1, above, m = n = 1 but $\lambda \neq \mu$ then it follows that

$$P(Z \ge 0) = \frac{\Gamma(2)}{\Gamma(1)\Gamma(1)} \int_{0}^{\frac{r}{1+r}} du$$
,

$$P(Z \ge 0) = \frac{r}{1+r}$$

The probability of failure = $1 - \frac{r}{1+r}$

4. If m = 1, $n \neq 1$ then

 $\Pr(Z \ge 0) = \frac{\Gamma(m+n)}{\Gamma(m)\Gamma(n)} \int_{0}^{\frac{T}{1+r_{u}}n-1} du = \frac{n\Gamma(n)}{\Gamma(n)} \left(\frac{r}{1+r}\right)^{n} \frac{1}{n}.$ Thus the probability of failure is $1 - \left(\frac{r}{1+r}\right)^{n}$. In the special case r = 1, this gives $1 - (1/2)^{n}$.

5. If $m \neq 1$, n = 1 then $\frac{\Gamma(m+n)}{\Gamma(m)\Gamma(n)} \int_{0}^{\frac{T}{1+r}} (1-u)^{m-1} du = 1 - \left(\frac{r}{1+r}\right)^{m}$

Thus the probability of failure is $\left(\frac{r}{1+m}\right)^m$ which gives $(1/2)^m$ in the case r = 1.

The incomplete beta function has been tabulated 16,17 . From these tables one can determine other probabilities of failure from formula (6).

417

1.

A- \hat{j} , 3.4 Weibull distributed Strength (X) and Weibull distributed Stress (Y)

The Weibull density function arises often in reliability studies (see Section 6 of this report). It is defined by the formula

 $f(x) = \frac{b}{\Theta - x_0} \left(\frac{x - x_0}{\Theta - x_0} \right)^{b-1} e^{-\left(\frac{x - x_0}{\Theta - x_0} \right)^b} dx , \quad x_0 \le x \le \infty .$

b is alled the slope, Θ is the characteristic value (characteristic strength for example) and x_0 is a location parameter for the left end point of the distribution. Graphs of the distribution are given in Section 6. Plotting the Weibull on ln-x vs. lnln 1 / (1 - F(x)) paper one finds the distribution to plot as a straight line. (see Section 6)

For purposes of interference theory the Weibull density function is rather difficult to work with. The probability of failure can not be obtained in closed form as we have been able to do in the case of the negative exponential densities. Neither is the integral expressable, except in certain cases in terms of well-known and tabulated functions as is true of the gamma and normal densities. Hence we derive an integral expression for the probability of failure when X and Y are both Weibull distributed random variables in this section. In the cases for which the resulting integral is well-known we give the results for future use. In section A-4.1 we will discuss numerical evaluations of the integral used to obtain the tabulation of the probability of failure given in the tables in section A-2.2.

We take

$$f(x) = \frac{b_x}{\Theta_x^{\dagger}} \left(\frac{x - x_0}{\Theta_x^{\dagger}} \right)^{b_x - 1} e^{-\left(\frac{x - x_0}{\Theta_x^{\dagger}} \right)^{b_x}}, \quad 0 \le x < \infty .$$

$$g(y) = \frac{b_y}{\Theta_y^{\dagger}} \left(\frac{y - y_0}{\Theta_y^{\dagger}} \right)^{b_y - 1} e^{-\left(\frac{y - y_0}{\Theta_y^{\dagger}} \right)^{b_y}} \quad 0 \le y \le \infty .$$

In these cases we have taken $\Theta_x^* = \Theta_x - x_0$ and $\Theta_y^* = \Theta_y - y_0$. Then using the formulas (4), (5), (6) of section A-3.2 one obtains:

$$\Pr(Y \ge X) = \Pr(Y \ge x \mid X = x) \Pr(X = x) .$$

$$\Pr(Y \ge x \mid X = x) = \int_{x}^{\infty} \frac{b_{y}}{\Theta_{y}} \left(\frac{y - y_{0}}{\Theta_{y}}\right)^{b_{y-1}} e^{-\left(\frac{y - y_{0}}{\Theta_{y}}\right)^{b_{y}}} dy = e^{-\left(\frac{x - y_{0}}{\Theta_{y}}\right)^{b_{y}}}$$

The joint probability $Pr(\forall \ge x \quad x \le X \le x + dx)$ is then given by

$$\frac{\mathbf{b}_{\mathbf{X}}}{\mathbf{\Theta}_{\mathbf{X}}^{*}} \left(\frac{\mathbf{x} - \mathbf{x}_{\mathbf{O}}}{\mathbf{\Theta}_{\mathbf{X}}^{*}}\right)^{\mathbf{b}_{\mathbf{X}}-1} = \left(\frac{\mathbf{x} - \mathbf{x}_{\mathbf{O}}}{\mathbf{\Theta}_{\mathbf{X}}^{*}}\right)^{\mathbf{D}_{\mathbf{Y}}} = \left(\frac{\mathbf{x} - \mathbf{y}_{\mathbf{O}}}{\mathbf{\Theta}_{\mathbf{Y}}^{*}}\right)^{\mathbf{D}_{\mathbf{Y}}} d\mathbf{x} .$$

The integral of this expression is then the probability of failure desired. Let

$$u = \left(\frac{\mathbf{x} - \mathbf{x}_{0}}{\mathbf{\Theta}_{\mathbf{x}}^{\dagger}}\right)^{D_{\mathbf{x}}}; du - \frac{b_{\mathbf{x}}}{\mathbf{\Theta}_{\mathbf{x}}^{\dagger}} \left(\frac{\mathbf{x} - \mathbf{x}_{0}}{\mathbf{\Theta}_{\mathbf{x}}^{\dagger}}\right)^{D_{\mathbf{x}} - \mathbf{1}}; u^{1/b} \mathbf{x} + \mathbf{x}_{0} = \mathbf{x}$$

$$\Pr(\text{failure}) = \int_{0}^{\infty} e^{-u} e^{-u} \left(\frac{\Theta_{\mathbf{x}}^{\dagger}}{\Theta_{\mathbf{y}}^{\dagger}} - u^{1/b} \mathbf{x} + \frac{\mathbf{x}_{0} - \mathbf{y}_{0}}{\Theta_{\mathbf{y}}^{\dagger}}\right)^{-b} \mathbf{y} \quad du .$$

In table A-2.2 we choose to work with the integral

(1)
$$\int_0^{\infty} e^{-u} e^{-\left(\frac{\partial x}{\partial y}\right)} \int_0^{b} \left(u^{1/b} x + \frac{x_0 - y_0}{\partial x} \right)^{b} du,$$

with identifiers for the table taken to be:

$$\frac{x_o - y_o}{\Theta'_x} = \frac{x_o - y_o}{\text{Theta 1}},$$

$$\frac{\Theta'_y}{\Theta'_x} = \frac{\text{Theta 2}}{\text{Theta 1}},$$

$$\frac{b_x}{b_y} = \frac{B1}{B2},$$

Three special cases can be computed in terms of well-known functions using integral (1). We derive these here for use in checking the tables developed in section A.2.2.

Case 1. $b_x = b_y = 1$.

We have already considered this case for $x_0 = y_0 = 0$, $\Theta'_x / \Theta'_y = 1$, since the Weibull's are then simply identical exponentials. If $x_0 \neq y_0$, one has from (1) that the probability of failure is:

$$\int_{0}^{\infty} e^{-u} e^{-\left[\frac{\Theta'_{x}}{\Theta'_{y}} + \left(\frac{x_{0} - y_{0}}{\Theta'_{y}}\right)\right]} du$$

Downloaded from http://www.everyspec.com

This integral can be expressed in closed form as

$$\frac{e^{\frac{f^{x} - y_{o}}{y}}}{1 + \frac{\varphi_{x}'}{\varphi_{y}'}}, \text{ for any } \frac{\varphi_{x}'}{\varphi_{y}'}.$$

For $x_0 = y_0$ and $\Theta'_X = \Theta'_y$ this expression gives the probability of failure as 1/2. For $x_0 = y_0$, $(\Theta'_X)/\Theta'_y \neq 1$ one can check this with the results given in section A-3.3.2.

For comparison with table A-2.2 we use the equivalent form

$$\frac{e^{-\frac{\Theta'_{x}}{\Theta'_{y}}}\left(\frac{x_{0}-y_{0}}{\Theta'_{x}}\right)}{1+\frac{\Theta'_{x}}{\Theta'_{y}}}$$

Case 2. $b_x = 1$, $b_y = 2$.

In this case the integral to be evaluated is:

$$\int_{O}^{\infty} e^{-u} e^{-\left(\frac{\Theta_{x}'}{\Theta_{y}'} + \frac{x_{O} - y_{O}}{\Theta_{y}'}\right)^{2}} dy.$$

To evaluate this integral we will expand the square on the exponent to give the integral in the form

 $\int_{0}^{\infty} e^{-(au^{2} + 2bu + c)} du,$

which can be expressed in terms of the error function. If this is done one finds that

$$\mathbf{a} = \left(\frac{\Theta_{\mathbf{x}}^{\mathbf{i}}}{\Theta_{\mathbf{y}}^{\mathbf{i}}}\right)^{2}; \ \mathbf{b} = \frac{1}{2} + \left(\frac{\Theta_{\mathbf{x}}^{\mathbf{i}}}{\Theta_{\mathbf{y}}^{\mathbf{i}}}\right)^{2} \left(\frac{\mathbf{x}_{\mathbf{0}} - \mathbf{y}_{\mathbf{0}}}{\Theta_{\mathbf{y}}^{\mathbf{i}}}\right); \ \mathbf{c} = \left(\frac{\mathbf{x}_{\mathbf{0}} - \mathbf{y}_{\mathbf{0}}}{\Theta_{\mathbf{y}}^{\mathbf{i}}}\right)^{2} \left(\frac{\Theta_{\mathbf{x}}^{\mathbf{i}}}{\Theta_{\mathbf{y}}^{\mathbf{i}}}\right)^{2}$$
It is well known (formula 7.4.2 of 'Ref., 15) that the integral (2) can be written in terms of the error function as:

(4)
$$1/2 \sqrt{\frac{\pi}{a}} e^{(\frac{b^2 - ac}{a})} \operatorname{erfc}\left(\frac{b}{\sqrt{a}}\right)$$

Computer subroutines for the error function exist and thus this expression can be evaluated easily for given values of the parameters a, b, c. This will be discussed further in section A-4.1.5.

Case B. $b_x = 2, b_y = 1.$

This case can be developed in a fashion similar to case 2. The integral to be evaluated is:

$$\int_{0}^{\infty} e^{-u} e^{-\left(\frac{\Theta_{x}^{*}}{\Theta_{y}^{*}} \frac{1}{u^{2}} + \frac{x_{0} - y_{0}}{\Theta_{y}^{*}}\right) du .$$

This can be expressed as:

$$\mathbf{e} = \left(\frac{\mathbf{o}_{\mathbf{x}}'}{\mathbf{o}_{\mathbf{y}}'}\right) \left(\frac{\mathbf{x}_{\mathbf{o}} - \mathbf{y}_{\mathbf{o}}}{\mathbf{o}_{\mathbf{x}}'}\right) \int_{\mathbf{v}}^{\infty} 2\mathbf{r} \mathbf{e}^{-\mathbf{x}^{2}} - \frac{\mathbf{o}_{\mathbf{x}}'}{\mathbf{o}_{\mathbf{y}}'} \mathbf{r} d\mathbf{x}$$

where $r^2 \approx u$. From this one expresses this integral as

(5)
$$e^{-\left(\frac{\Theta_{x}^{\prime}}{\Theta_{y}^{\prime}}\right)\left(\frac{x_{0}-y_{0}}{\Theta_{x}^{\prime}}\right)} \left[1 - \frac{\Theta_{x}^{\prime}}{\Theta_{y}^{\prime}}\int_{0}^{\infty} e^{-\left(at^{2}+2bt+c\right)}dt\right]}$$

where a = 1, $b = \frac{\Theta^{\dagger}}{X} \frac{\Theta^{\dagger}}{Y}$ and c = 0.

Thus the integral can be expressed in terms of the error function as above.

A-3.3.5 Weibull distributed strength (X) and Normally distributed stress (Y).

As shown in Section 8 one is often interested in the case in which the strength has a Weibull distribution and the stress is normally distributed. In this section we take

$$f(x) = \frac{b}{\Theta^{\dagger}} \left(\frac{x - x_0}{\Theta^{\dagger}} \right)^{b-1} e^{-\left(\frac{x - x_0}{\Theta^{\dagger}} \right)^{b}}, \quad x_c \leq x < \infty .$$

$$g(y) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(y - \mu)}{2\sigma^2}}^{2}, \quad -\infty \leq y < \infty .$$

In this case the probability of failure cannot be evaluated in closed form as was done for the negative exponential cases of section A-3.3.2 nor, except in special cases can the integral be reduced to well-known functions as was done in section A-3.3.3. In this section we will develop the integral that is used in the tables given in section A-2.1.

Since f(x) is truncated at x_0 one must consider 2 cases.

Case 1. If $y < x_0$

 $\Pr(X \leq y \mid Y = y) = 0.$

Case 2. If $y \ge x_0$

$$\Pr(X \leq y | Y = y) = \int_{X_0}^{Y} \frac{b}{\Theta'} \left(\frac{x - x_0}{\Theta'}\right)^{b-1} = -\left(\frac{x - x_0}{\Theta'}\right)^{b} dx ,$$
$$= 1 - e^{-\left(\frac{X - x_0}{\Theta'}\right)^{b}}, x_0 \leq y < \infty .$$

Hence using formula (4) section A-3.2 one has

$$\Pr(Y \ge X) = \int_{x_0}^{\infty} (1 - e^{-\left(\frac{y - x_0}{\varphi}\right)^b}) \frac{1}{\sqrt{2\pi\sigma}} e^{-\left(\frac{y - \mu}{2\sigma^2}\right)^2} dy ,$$
$$= \frac{1}{\sqrt{2\pi\sigma}} \int_{x_0}^{\infty} e^{-\frac{(y - \mu)^2}{2\sigma^2}} dy - \frac{1}{\sqrt{2\pi\sigma}} \int_{x_0}^{\infty} e^{-\left(\frac{y - x_0}{\varphi^2}\right)^b} - \frac{(y - \mu)^2}{2\sigma^2} dy.$$

The first integral is the area under the upper tail of the normal distribution. This area is usually denoted by:

$$1 - \frac{1}{2} \left(\frac{\mathbf{x}_0 - \mu}{\sigma} \right) \, .$$

The second integral is troublesome because as it stands it contains five parameters which must be considered separately for computing formulas. The problem can be reduced in size by the change of variable

$$u = \frac{y - x_0}{\Theta'}$$
, $du = \frac{dy}{\Theta'}$.

Then the second integral becomes

(1)
$$\frac{1}{\sqrt{2\pi}} \left(\frac{\Theta}{\sigma} \right) \int_{0}^{\infty} e^{-u^{b}} e^{-\frac{1}{2} \left(\frac{\Theta}{\sigma}' u + \frac{x_{0} - \mu}{\sigma} \right)^{2}} du$$

In this form there are only three free parameters, b, $\frac{\sigma}{\sigma}$, and $\frac{\sigma \sigma^{-r}}{\sigma}$. Tables in section A-3.1 have been built using these three parameters. Two special cases serve as checks for the numerical analysis used later.

If b = 1 or 2 the integral (1) can be evaluated in terms of the error function whose values have been tabulated.

Case 1: b = 1

For b = 1 one completes the square on the exponent inside the integral to obtain the integral in the form

(2)
$$\int_{0}^{\infty} e^{-(at^{2}+2bt+c)} dt$$

whose value in terms of the error function is ell known (see Ref. 15. Formula 7.4.2). Here

$$\mathbf{a} = \frac{1}{2} \left(\frac{\mathbf{a}}{\sigma} \right)^2; \quad \mathbf{b} = \frac{1}{2} \left[\frac{\mathbf{a}}{\sigma} \frac{\mathbf{x}_{\mathbf{0}} - \mu}{\sigma} + 1 \right]; \quad \mathbf{c} = \frac{1}{2} \left(\frac{\mathbf{x}_{\mathbf{0}} - \mu^2}{\sigma} \right)$$

ŧ?

Hence the probability of failure can be expressed in terms of: (a) the area under the normal curve $1 - \frac{1}{2} \frac{|X_0 - \mu|}{2}$; (b) the error function. Since the area under the normal curve can also be expressed in terms of the error function, one can find the probability of failure completely from a computer routine that calculates the error function. In checking Table A-2.1 numerical values for the probability of failure have been computed from this computer subroutine. A further discussion of the checking procedure, and results are given in A-4.1.7.

Case 2: b = 2

For b = 2; one can once again determine the value of integral (1) in terms of the error function. In terms of the parameters a, b, c, given in formula (2) above one finds

(3)
$$\mathbf{a} = \frac{1}{2} \left[\frac{\sigma}{\sigma} \right]^2 + 2 \qquad ; \quad \mathbf{b} = \frac{1}{2} \left[\frac{\sigma}{\sigma} \right] \frac{\mathbf{x}_0 - \mu}{\sigma} \quad \mathbf{c} = \frac{1}{2} \left[\frac{\mathbf{x}_0 - \mu}{\sigma} \right]^2$$

Again, as for b = 1 above, values for the probability of failure were determined from the computer subrouting giving the error function values. The values thus determined were used to check Tables A-3.2.2.

In Table A-2.1 we choose to identify the necessary parameters in shorter form for typographical simplification. Hence we identify

$$b = B(x) ,$$

$$A = \frac{x_0 - \mu}{\sigma} ,$$

$$C = \frac{Q'}{\sigma} .$$

1

.

•

APPENDIX 4 TABL

··.. ·

. . .

PPENDIX 4 TABLES OF THE INTEGRALS IN A-3.3.4 AND A-3.3.5

ŧĩ

A-4 DISCUSSION OF THE EVALUATION OF INTEGRALS IN A-3.3.4 AND A-3.3.5

A-1.1 NUMERICAL ANALYSIS

Both of the integrals obtained in sections $A-3\cdot3\cdot4$ and $A-3\cdot3\cdot5$ must be evaluated using numerical methods. We discuss our approach to this problem in the following sections.

A-4.1.1 The Problem.

The integrals to be evaluated in A-3.3.4 are of the form

$$\int_0^\infty e^{-u} f(u) du$$

where f(u) is a negative exponential with exponent of the form u^{b} .

The integrals to be evaluated in A-3.3.5 are of the form

$$\int_{0}^{\infty} e^{-u^{b}} f(u) du$$
.

where f(u) is a negative exponential with exponent of the form u^2 .

A-4.1.2 Method of Solution

Integrals of the form given in A-4.1.1 can be evaluated in several ways. We have chosen to use Simpson's rule with variable step sizes as discussed in sections $A-4 \cdot 1 \cdot 4$ and $A-4 \cdot 1 \cdot 7$. The approximation to the integral is given by

(1)
$$\frac{n_3}{3} \left[f(x_0) + 4f(x_1) + 2f(x_2) \dots + 2f(x_{2n-2}) + 4f(x_{2n-1}) + f(x_{2n}) \right]$$

with a remainder term given by:

 $\frac{h^{5}}{90}r^{iv}(t_{1}) ; x_{1} < t_{1} < x_{1+1}.$

In this formulation h is defined to be

$$h = (x_{i+1} - x_i)/2n$$

where h is the number of steps taken in the interval (x_i, x_{i+1}) .

The values for the probability of failure were calculated using Simpson's rule as an approximation to the integral given in A-4. 1.1. Simpson's rule was computed to 10^{-6} using the University of Michigan IEM 7090 and the MAD language. Values thus obtained were rounded to 10^{-4} as they appear in the table.

A-4.1.3 Properties of Simpson's Rule

The functions to be evaluated are reasonably well behaved. Tables of a few of the integrands are given in Tables A-4.1 — A-4.6 on the following pages. It is clear that the functions are monotone decreasing. They are probabilities and hence are bounded above by 1 and below by 0. The functions themselves decay quite rapidly.

Unfortunately, derivatives of the function for any value of b_x in those integrals given in section A-3.3.4 are asymptotically infinite at $u \rightarrow 0$. Derivatives up to order 4 of the functions for nonintegral b < 4 are asymptotically a for $u \rightarrow 0$ for those integrals given in section A-3.3.5 Because of this property of the higher order derivatives, it was deemed best not to use numerical approximations such as Gauss - Laguerre or Gauss - Legendre methods whose error terms depend only on higher order derivatives. Instead Simpson's rule was chosen so that some attempt could be made to control errors by varying the step sizes as the higher order derivatives become large.

A-4.1.4 Error Analysis - Weibull - Weibull Case

Since the remainder term of Simpson's rule depends on the fourth derivative of the integrand, this derivative was determined. An analytic expression is given by the following. We are interested in the case:

1.
$$b_y = 1, 2, \dots 10;$$

2. $b_x = 1, 2, \dots 10;$
3. $\frac{x_0 - y_0}{9_x} = 0, .25, .50, .75, 1.00;$
4. $\frac{9_x}{9_y} = 1, 1.25, 1.50, \dots 3.$

Parameters: B1 = 1, B2 = 1 Theta 1 = 1, Theta 2 = 1, Xo-Yo = 0

u	F(u)	$\mathbf{F^{IV}}(\mathbf{u})$
1x10 ⁻²⁰	1.	16.
15	.367879	5,88607
1.	.135335	2.16536
1.3	4.97871x10 ⁻²	796593
2.	1.83156x10 ⁻²	.29305
2.5	6.73795x10-3	.107807
3.	2.47875x10 ⁻⁵	.03965
3.5	9.11882x10 ⁻⁴	1.45901x10 ⁻²
4.	3.35463x10,-4	5.3674x10-3
4,5	1.2341×10^{-4}	1.97456x10-3
5.	4.53999x10-5	7.26399x10***
5.5	1.67017x10-5	2.67227x10-4
6.0	6.14421x10-0	9.83074×10-5
6,5	2.26033x10 ⁻⁰	3.61653x10 ⁻⁵
7.	8.31529x10"(1.33045x10-5
7.5	3.05902x10 ⁻⁷	4.89444x10 ⁻⁶

Table A-4.1 Integrands and Their 4th Derivative for Weibull-Weibull Case

;

С)own	loaded	from http:/	/www.evervspec.com
---	------	--------	-------------	--------------------

Parameters: Bl = 10, B2 = 1Theta l = 1, Theta 2 = 1, Xo-Yo = 1

u	F(u)	F ^{iv} (u)
1x10 ⁻²⁰	. 364219	> 1x1076
.1	.150419	7.84551x10 ²
1.	4.97871x10-2	.168733
1,5 2.	2.89733x10 ⁻² 1.70471x10-2	5.58241x10 ⁻²
2.5	1.00925×10-2	1.36768×10-2
3. 3.5	3.57617×10 ⁻³	4.33376x10 ⁻³
4. 4.5	2.13626x10 ⁻³ 1.27819x10 ⁻³	2.51207x10 ⁻³
5.	7.65778x10-4	8.66458x10-4
5.2 6.	4.59272x10 ⁻⁴ 2.75691x10 ⁻⁴	5.12927x10 3.04688x10 ⁻⁴
6.5 7.	1.65615x10 ⁻⁴ 9.95537x10 ⁻⁵	1.81464×10^{-4}
7.5	5.98766×10-5	6.47386x10 ⁻⁵

Table A-4.2 Integrands and Their 4th Derivative for Weibull-Weibull Case

1998 IN 1899

1.4.5.15

٩,

	Theta $1 = 1$,	Theta $2 = 1$, Xo-Yo = 0
u	F(u)	F ^{iv} (u)
1x10 ⁻²⁰	99005	> 2.9x10 ⁷⁶
.1	.408882	2132,63
•5	.238584	4.44245
٦	.135335	.4588

Parameters: Bl. = 10, B2 = 1

2

	•		
e de la compañía de la compañía de la compañía de la compañía de la compañía de la compañía de la compañía de l Compañía de la compañía	.1 .5 1. 1.5 2. 2.5 3. 3.5 4. 4.5 5. 5.5 6. 5.5 7.	.408882 .238584 .135335 7.87577x10 ⁻² 4.63389x10 ⁻² 2.74344x10 ⁻² 1.63076x10 ⁻² 9.72105x10 ⁻³ 5.80696x10 ⁻³ 3.47449x10 ⁻³ 2.0816x10 ⁻³ 1.24843x10 ⁻³ 7.49405x10 ⁻⁴ 4.50188x10 ⁻⁴ 2.70615x10 ⁻⁴	2132.63 4.44245 .4588 .151746 7.06358x10-2 3.71774x10-2 2.06439x10-2 1.17804x10-2 6.82852x10-3 3.99719x10-3 2.35528x10-3 1.39428x10-3 8.28227x10-4 4.93271x10-4 2.94384x10-4
	7. 7.5	2.70615x10 ⁻⁴ 1.62762x10 ⁻⁴	2.94384x10 ⁻⁴ 1.75978x10 ⁻⁴

Table A-4.3 Integrands and Their 4th Derivative for Weibull-Weibull Case

Parameters: $B = 1, \frac{\Theta}{\sigma} = 100, \frac{X_0 - \mu}{\sigma} = -4$

1x10 25 3.35463x10 5.39857x .05 .57695 -1.20005x .1 1.37807x10 8 1503.39 .15 4.5713x10 27 6.3861x1 .2 0 0 0	10 ⁶ 10 ⁸ 0 -1 5

Table A-4.4 Integrands and Their 4th Derivative for Weibull-Normal Case

431.

.

Parameters:	B	¥	1,	<u>e</u> '	u	10,	<u>Х₀- µ</u>	=	-7
				0			14		

u	F(u)	$F^{iv}(u)$
1x10 ⁻²⁵ .05 .1 .225 .35 .45 .55 .655 .75 .85 .955 1.05 1.15 1.225 .35 .45 .55 .655 .75 .85 .955 1.05 1.15 1.225 .35 .45 .55 .655 .75 .85 .955 1.15 .255 .255 .255 .255 .255 .255 .2	2.28973x10 ⁻¹¹ 6.36523x10 ⁻¹⁰ 1.37807x10 ⁻⁸ 2.32355x10 ⁻⁷ 3.05113x10 ⁻⁶ 3.12029x10 ⁻⁵ 2.48517x10 ⁻⁴ 1.5415x10 ⁻³ 7.44658x10 ⁻³ 2.80154x10 ⁻² .082085 .187308 .332871 .460704 .496585 .416862 .272532 .138761 5.50232x10 ⁻² 1.69922x10 ⁻² 1.69922x10 ⁻² 1.08677x10 ⁻³ 7.65 1 35x10 ⁻⁴ 1.11666x10 ⁻⁴ 1.2245x10 ⁻⁶ 7.73443x10 ⁻⁸ 4.15066x10 ⁻⁹ 1.73473x10 ⁻¹⁰ 5.64642x10 ⁻¹²	4.54295 \times 10 ⁻⁴ 9.13387 \times 10 ⁻³ .138616 1.57617 13.2852 81.6422 355.588 1037.02 1732.68 453.178 -4619.66 -9212.57 -4007.44 9516.3 1460c.1 4041.9 -7619.72 -8057.04 -2207.48 1382.76 1540.39 713.445 206.265 41.0759 5.87556 .617431 4.83271 \times 10 ⁻² 2.84342 \times 10 ⁻³ 1.26576 \times 10 ⁻⁴

Table A-4.5 Integrands and Their 4th Derivative for Weibull-Normal Case

Parameter	rs: B = 1, <u>9'</u> = 10	ο, <u>X₀ -μ</u> = -7 σ
u	F(u)	F ^{iv} (u)
1.45 1.5	1.43133×10 ⁻¹³ 2.82576×10 ⁻¹⁵	4.28349x10 ⁻⁶
1.55	4.34466x10 ⁻¹⁷	2.18507x10 ⁻⁹
1.6	5.20239x10 ⁻¹⁹	3.31061x10 ⁻¹¹
1.65	4.85151x10 ⁻²¹	3.8538x10 ⁻¹³
1.7	3.52352×10 ⁻²³	3.45198x10 ⁻¹⁵
1.75	1.99295×10 ⁻²⁵	2.38233x10 ⁻¹⁷
1.8	8.7792x10 ⁻²⁰	1.26811x10 ⁻¹⁹
1.85	3.01185x10 ⁻³⁰	5.21112x10 ⁻²²

Table A-4.5 Integrands and Their 4th Derivative for Weibull-Normal Case (continued).

Parameters: $B = 1, \frac{\Theta}{\sigma}$ = 10, <u>X</u>___ = -10 ۵

¥

u	F(u)	F ^{iv} (u)
1x10 ⁻²⁵	5 1.92875x10-22	1.73991x10 ⁻¹⁴
.05	2.40296x10-20	1.74943x10-12
.1	2.33155x10 ⁻¹⁸	1.35275x10 ⁻¹⁰
.15	1.76184×10^{-16}	8.03111x10-9
.2	1.03685x10 ⁻¹⁴	3.65341x10 ⁻⁷
.25	4.75219x10-13	1,27031x10 ⁻⁵
.3	1.69628x10-11	3.3655x10-4
.35	4.71548x10 ⁻¹⁰	6.76653x10-3
.4	1.0209x10 ⁻⁸	. 102689
.45	1.72133x10-7	1.16765
.5	2.26033x10 ⁻⁶	9.84193
•55	2.31157x10 ⁻⁵	60.482
.6	1.84106x10 ⁻⁴	263.426
.65	1.14197x10 ⁻³	768.245
•7	5.51656x10 ⁻³	1283.6
•75	2,07543x10 ⁻²	335.722
.8	6.08101x10 ⁻²	3422.33
.85	.138761	-6824.84
•9	.246597	-2968.78
•95	.341298	7049.85
1.	.367879	10816.
1.05	.308819	2994.31
1.1	.201897	-5644.82
1.15	.102797 _2	-5968.8
1.2	4.07622x10 ⁻²	-1635.34
1.25	1.25881x10 ⁻²	1024.41
1.3	3.02756x10-5	1141.10
1.35	5.67086x10 ⁻⁺	528.533
1.4	8.27214x10-5	152.605
1.45	9.39813x10 ⁻⁰	30, 4298
1.5	8.31529x10 ^{-/}	4.35272
1.55	5.72981x10 ⁻⁰	,每57404

Table A-4.6 Integrands and Their 4th Derivative for Weibull-Normal Case

,434

Parameters: B = 1, $\frac{\Theta}{\sigma} = 10$, $\frac{X_0 - \mu}{\sigma} = -10$

F(u) F^{iv}(u)

1.6 1.65 1.7 1.75 1.8 1.85 1.9 1.95 2. 2.05 2.1	3.07488×10^{-9} 1.28512×10^{-10} 4.18297×10^{-12} 1.06036×10^{-13} 2.09338×10^{-15} 3.21861×10^{-17} 3.85403×10^{-19} 3.59409×10^{-23} 1.47644×10^{-25} 6.5038×10^{-28}	3.58016×10^{-2} 2.10646×10^{-3} 9.37701×10^{-5} 3.17329×10^{-6} 8.1935×10^{-8} 1.61874×10^{-9} 2.45256×10^{-11} 2.85496×10^{-13} 2.55729×10^{-15} 1.76487×10^{-17} 9.39437×10^{-20}
2.05	1.47644x10-25	1.76487x10-17
2.1 2.15	2.23124x10-30	3.8605×10-22
2.2	0	0

Table A-4.

u

Integrands and Their 4th Derivative for Weibull-Normal Case (continued)



Let

$$q(u) = e^{-u};$$

$$\sigma = \frac{\Theta'_x}{\Theta'_y} (u^{\frac{1}{b_x}} + \frac{x_o^{-y_o}}{\Theta'_x}),$$

$$h(u) = e^{-\sigma^{b_y}}.$$

F(u)

 $e^{-u}e^{-\left[\frac{\Theta'_{x}}{\Theta'_{y}}\left(u^{\frac{1}{b_{x}}}+\frac{x_{o}-y_{o}}{\Theta'_{x}}\right)\right]^{b_{y}}}$

$$q'(u)h(u) + q(u)h'(u) = -F(u) - F(u) \{w\}$$
$$= b_y(\sigma)^{b_y-1} (\frac{\Theta'_x}{\Theta'_y})(u)^{(\frac{1}{b_x}-1)} (\frac{1}{b_x}),$$

where

F'(u)

and
$$F'(u)$$
 denotes, as is usual, the first derivative of $F(u)$ with respect to u .

$$F''(u) = -F'(u)[1 + w] - F(u)[w']$$

$$w' = b_{y}(b_{y}-1)(\sigma)^{b_{y}-2}(\frac{\theta'_{x}}{\theta'_{y}})^{2}(\frac{1}{b_{x}})^{2}(u^{(\frac{1}{b_{x}}-1)})^{2}$$

$$+ b_{y}(\sigma)^{b_{y}-1}(\frac{\theta'_{x}}{\theta'_{y}})(\frac{1}{b_{x}})(\frac{1}{b_{x}}-1)(u^{(\frac{1}{b_{x}}-2)})$$

$$F'''(u) = -F''(u)[1+w] - 2F'(u)[w'] - F(u)[w'']$$

$$w'' = b_{y}(b_{y}-1)(b_{y}-2)(\sigma)^{b_{y}-3}\frac{\theta'_{x}}{\theta'_{y}}^{3}(\frac{1}{b_{x}})^{3}(u^{(\frac{1}{b_{x}}-1)})^{3}$$

$$+ 3b_{y}(b_{y}-1)(\sigma)^{b_{y}-2}(\frac{\theta'_{x}}{\theta'_{y}})^{2}(\frac{1}{b_{x}})^{2}(\frac{1}{b_{x}}-1)(u^{(\frac{2}{b_{x}}-3)})$$

$$+ b_{y}(\sigma)^{b_{y}-1}\frac{\theta'_{x}}{\theta'_{y}}(\frac{1}{b_{x}})(\frac{1}{b_{x}}-1)(\frac{1}{b_{x}}-2)(u^{(\frac{1}{b_{x}}-3)})$$

where

ji,

where

.w

3.44

$$F^{tv}(u) = -F^{tv}(u)[1+v] - 3F^{tv}(u)[v'] - 3F^{tv}(u)[v''] - F(u)[v''']$$
where $v''' = b_{y}(h_{y}-1)(b_{y}-2)(b_{y}-3)(\sigma)^{b_{y}-1}(\frac{\theta_{x}}{\theta_{y}})^{4}(\frac{1}{b_{x}})^{4}(u^{-1})^{4}$

$$+ 3b_{y}(b_{y}-1)(b_{y}-2)(\sigma)^{b_{y}-3}(\frac{\theta_{x}}{\theta_{y}})^{3}(\frac{1}{b_{x}})^{3}(\frac{1}{b_{x}}-1)(u^{-1})(u^{-1})^{2}$$

$$+ 3(b_{y})(b_{y}-1)(b_{y}-2)(\sigma)^{b_{y}-3}(\frac{\theta_{x}}{\theta_{y}})^{3}(\frac{1}{b_{x}})^{3}(\frac{1}{b_{x}}-1)(u^{-1})^{2}$$

$$+ 3b_{y}(b_{y}-1)(\sigma)^{b_{y}-2}(\frac{\theta_{x}}{\theta_{y}})^{2}(\frac{1}{b_{x}})^{2}(\frac{1}{b_{x}}-1)(u^{-1})^{2}$$

$$+ b_{y}(b_{y}-1)(\sigma)^{b_{y}-2}(\frac{\theta_{x}}{\theta_{y}})^{2}(\frac{1}{b_{x}})^{2}(\frac{1}{b_{x}}-1)(\frac{2}{b_{x}}-3)(u^{-1})^{2}$$

$$+ b_{y}(\sigma)^{b_{y}-1}(\frac{\theta_{x}}{\theta_{y}})(\frac{1}{b_{x}})(\frac{1}{b_{x}}-1)(\frac{1}{b_{x}}-2)(u^{-1})^{2}(\frac{1}{b_{x}}-1)^{2$$

Full exploration of this derivative appears to be unreasonable. One would hope that maximum values could be obtained as functions of the parameters so that step sizes appropriate to minimize the error term could be determined. Such appears to be hopeless from the form of the derivative. Instead, tables of the fourth derivative were ohtained in an attempt to find where the derivative took maximum values, how large these maxima were and how they behaved with respect to the four parameters of interest. Some examples of these tables are given in Tables A-4.1, A-4.2, A-4.3. . From examination of the derivative and it's value at some points, it seems clear that for $b_{\chi} \neq 1$, the fourth derivative approaches infinity for $u \rightarrow 0$, $b_x = 1$ was considered along with the other b, values and not treated separately. b, non-integer and less than 4 causes the derivative to become infinite for $u \rightarrow 0$ if $(x_0 - y_0)/9$ = 0. In either event, it appears from the plots of the fourth derivative that it rapidly approaches zero for u > 0. It was therefore decided to evaluate the integral over 5 distinct intervals, (0,.01), (.01,1), (1,5), (5,10), (10,...).

For the interval (0,.01), it did not appear feasible to make a full exploration of the fourth derivative to determine the optimum di la

step size. Instead the value of the integral was found using Simpson's rule with 50 and 500 steps within the interval (0,.01). The integrals did not differ by more than 10^{-6} . Hence it was decided that in the interval (0,.01) one should take n = 50.

Downloaded from http://www.everyspec.com

Values of n were determined for the intervals (.01,1), (1,5), (5,10) by looking at the maximum values of the fourth derivatives, as computed, in each of these intervals. From these observations, n was taken so that the maximum remainder in the interval was less than 10^{-6} . The values of n used within these intervals were

ij.

<u>n</u>
50 20
7 2(L(

The interval $(10,\infty)$ was eventually eliminated as being "practically C" based on the following:

Connider

$$g(u) = (au^{\chi} + ac)^{\chi} + u$$

for

$$\geq 1$$
, $u \geq 1$, $o \leq c \leq 1$, $1 \leq x \leq 1$, $1 \leq y \leq 10$.

For x = 1 and any combination of the other parameters:

$$g(u) = (au + ac)^{y} + u = a^{y}u^{y} + ya^{y-1}u^{y-1} + \dots + u,$$

$$g(u) \ge a^{y}u + u = u(a^{y} + 1)$$

since over the values of u, y considered $u^y \ge u$ with equality occurring when y = 1. Consequently

$$-g(u) \leq -u(a^y+1) \leq -2u$$

 $e^{-g(u)} \leq e^{-u(a^y+1)} \leq e^{-2u}$

and

 $\int_{10}^{\infty} e^{-g(u)} du \leq \int_{10}^{\infty} e^{-2u} du \leq 1/2e^{-20} \approx 1 \times 10^{-9}.$

and

In a similar way it can be shown that for $.1 \le x \le 1$, but with $xy \ge 1$ then the value of the integral for the interval $(10,\infty)$ is less than 1 x 10⁻⁹. For suppose $.1 \le x \le 1$ and $xy \ge 1$. Then

$$g(u) = (au^{x} + ac)^{y} + u$$
$$= (au^{x})^{y} + y(au^{x})^{y-1}(ac)^{y} + \dots + u$$
$$\geq a^{y}u^{xy} + u \geq a^{y}u + u \geq 2u$$

since a > 1. Then as before

$$\int_{10}^{\infty} e^{-g(u)} du \leq \int_{10}^{\infty} e^{-2u} du \approx 1 \times 10^{-9}.$$

Hence for $xy \ge 1$ and $.1 \le x \le 1$ the contribution that the tail of the function makes to the integral is no bigger than 10^{-9} .

For xy < 1, the above analysis is no longer valid since $u^{XY} < u_*$. However,

$$g(u) \geq a^{y} 10^{xy} + u$$

since

$$g(u) \geq (au^X)^Y + u \geq a^Y 10^{XY} + u$$
, for $u \geq 10$.

Also

$$10^{XY} \ge 10^{11} = 1.258$$
, for $xy \ge .1$.

Hence

 $g(u) \geq 1.258a^{y} + u$

and

臣言語

$$-g(u) \leq -(1.258a^y + u)$$

 $e^{-g(u)} < e^{-(1.258a^{y} + u)}$

$$\int_{D}^{\infty} e^{-g(u)} du \leq \int_{10}^{\infty} e^{-(1.258a^{y}+u)} = e^{-1.258a^{y}+10}.$$

N .:

Since $a \ge 1$, $e^{-1.258a^{y}+10} \le e^{-11.258} \approx 1 \times 10^{-5}$.

Hence if one identifies $a = (\Theta'_X)/(\Theta'_Y)$; $c = (x_0-y_0)/(\Theta'_X)$; $x = 1/(b_X)$ and $y = b_Y$ one sees that no matter what the values of $(x_0-y_0)/\Theta'_X \ge 0$, $b_Y/b_X \ge .1$, $\Theta'_X/\Theta'_Y \ge 1$ and $b_Y \ge 1$ the truncation error obtained by not including the integral in the interval $(10,\infty)$, is at most approximately 1 x 10⁻⁵. In fact one finds easily that only one tabular value will have this much truncation error, and that will be the special case $\Theta'_X/\Theta'_Y = 1$ (the strength and stress distributions have the same characteristic values), $b_Y/b_X = .1$ (the slope parameter of the strength distribution is 10 times the slope of the stress distribution) and the two distributions have the same x_0 points. For the values of b_Y and b_X used in the tables, this set of conditions requires that the stress distribution be exponential (i.e. $b_Y = 1$). One expects this case to arise seldom enough to justify this moderate error. Consequently we truncate the integral at u = 10 in all cases considered.

A-4.1.5 Conclusions Concerning Errors

In summary then the integral evaluated was $\int_{x}^{10} e^{-u} e^{-\left[\frac{\Theta_{x}^{i}}{\Theta_{y}^{i}}\left(u^{\frac{1}{D_{x}}} + \frac{x_{0} - y_{0}}{\Theta_{x}}\right)\right]^{b} y} du,$

with parameters taken as

$$\frac{x_0 - y_0}{\theta_x} = 0_{j,25, \dots 50, \dots 75, 1};$$

$$b_x = 1_{j2, \dots 10, \dots 10};$$

$$b_y = 1_{j2, \dots 10, \dots 10};$$

$$\frac{x_0 - y_0}{\theta_x} = 1.00, 1.25, 1.50, 1.75, 2.00, \dots 3.$$

The maximum truncation error (the error caused by not including the value of the integral in $(10,\infty)$), is 10^{-5} which occurs for one tabular value. For most of the table, the truncation error is 1×10^{-6} or less, and for b. (b. > .1, it is as small as 1×10^{-9} . The error of approximation using Simpson's rule was not determined precisely. Using the number of steps given on page 5, it appears that the maximum error of this type does not exceed, 1×10^{-6} . This conjecture was tested

once more by comparing the results obtained for $b_x = b_y = 1$, $b_x = 2$, $b_y = 1$, $b_x = 1$, $b_y = 2$ as discussed in Section A-3.3.4. Tables A-4.7 and A-4.8 show the computed values of formula 4 ' in Section A-3.3.4 and formula 5 in Section A-3.3.4. These tabulated values can be compared to those given in Tables A-2.2. for the corresponding parameters. In no case was the disagreement found to exceed 1×10^{-6} . Hence the conjecture is valid in those cases where it can be tested. We conclude on the basis of this verification that the tables are correct to 1×10^{-4} after rounding.

A-4.1.6 A Note on Interpolation

One notes that the tabulated values are highly non-linear in general. Simple linear interpolation can produce errors of the order of 10^{-2} . Hence higher order interpolation formulas should be used for more accuracy.

A-4.1.7 Error Analysis - Weibull - Normal Case

Since the remainder term of Simpson's rule depends on the fourth derivative of the integrand, this derivative was determined. An analytic expression for it is given by the following. We are interested in

(1)
$$b = 1, 2, ... 10;$$

(2) $\frac{9}{\sigma} \ge 10;$
(3) $-10 \le \frac{x_0 - \mu}{\sigma} \le 3.$
 $F(u) = e^{-u} e^{-1/2} \left[\frac{9}{\sigma} u + \frac{x_0 - \mu}{\sigma}\right]^2.$
 $g(u) = e^{-u}$; $s = \frac{9}{\sigma} u + \frac{x_0 - \mu}{c}$
 $h(u) = e^{-1/2} s^2$.
 $F'(u) = g'(u)h(u) + g(u)h'(u)$
 $= -F(u)[v]$

Let

1201 N. 147

The Property of the Property o

.441

			X <u>o-Y</u> o Theta 1			
		.00	.25	.50	• 75	1,00
	1.00	.545641	422042	.295115	.185734	.104844
	1.25	.475575	.335056	.201889	.103137	.044382
	1.50	.420811	.268297	.136622	.054750	.017089
	1.75	.377041	.216191	.091224	.027694	.005960
ete 1	2.00	.341350	.174942	.059959	.013309	.001875
ata 2	2.25	.311735	.141924	.038716	.006060	.000530
	2,50	.286789	. 115273	.024517	.002609	.000134
	2.75	.265503	.093633	.015205	.001060	.000030
	3.00	.247133	.075991	.009225	.000406	.000006

B1 = 1, B2 = 2

Downloaded from http://www.everyspec.com

Th

K h Te mil r

Table A-4.7 Numerical Values of Formula 4 of Section A-3.3.4

ţ

B1 = 2, B2 = 1

<u>X_-Y_</u> Theta 1

		.00	.25	.50	.75	2 00
	1.00	.454358	.353855	.275582	.214623	.167149
	1.25	:383170	.280333	.205096	.150051	.109780
	1.50	.326107	.224130	.154042	.105871	.072764
<u>Theta 1</u>	1.75	.279900	.180717	.116680	.075334	.048639
Theta 2	2.00	.242128	.146858	.089073	.054026	.032768
	2,25	.210974	.120209	.068493	.039026	.022236
	2.50	.185063	.099057	.053021	.028380	.015190
	2.75	.163345	.082135	.041300	.020767	.010442
	3.00	.145007	.068496	.032355	.015283	.007219

Table A-4.8 Numerical Values of Formula 5 of Section A-3.3.4

. . .

where

$$= \frac{\underline{\Theta}'}{\sigma}s + b(u^{b-1}).$$

$$F''(u) = -F'(u)(w) - F(u)(w')$$

where

$$= (\frac{0}{\sigma})^2 + b(b-1)(u^{b-2})$$
.

$$\mathbf{F}^{i+i}(\mathbf{u}) = -\mathbf{F}^{i+1}(\mathbf{u})(\mathbf{w}) - 2\mathbf{F}^{i}(\mathbf{u})(\mathbf{w}^{i+1}) - \mathbf{F}(\mathbf{u})(\mathbf{w}^{i+1})$$

where

$$w'' = b(b-1)(b-2)(u^{b-3})$$

$$F^{iv}(u) = -F^{i'i'}(u)(w) - 3F^{i'i}(u)(w^{i'}) - 3F^{i}(u)(w^{i'}) - F(u)(w^{i'i'})$$

where

$$f(b-1)(b-2)(b-3)(u^{-4})$$
.

One can see some behavior of the fourth derivative from this expression. First, if b is non-integer and b < 4 the fourth derivative becomes infinite at zero as before. However, this is not true for all b (as it was for all b_x in the previous case), for if b is an integer, or if b > 4, $u^{b-4} \rightarrow 0$ for $u \rightarrow 0$ except for b = 4 in which case $u^{0-4} = 1$ for all u. If the fourth derivative is not infinite at the origin, then the maximum error occurs away from the origin and is of the order of $(\Theta'/\sigma)^4$ for b > 4 and is less than this for b integer and < 4. Since Θ'/σ can be as large as 100, the maximum error is of the order of 10° . The difficulty in using these facts lies in finding where this maximum occurs. In the neighborhood of the maximum steps of size 10^{-3} will give maximum errors due to approximation on the order of $10^{\circ 9}$.

To locate approximately where the maximum occurs the fourth derivative was computed for selected values of u, and several values of the parameters. Examples of these calculations are given in tables A-4.4 - A-4.6. One notes from these plots that for $(x_0-\mu)/\sigma > 0$, the maximum occurs near the origin and the derivative falls off rapidly to zero. For $(x_0-\mu)/\sigma < 0$, such is not the case, and the u value at which the maximum occurs depends on the parameters. In all cases in which $-10. \leq (x_0-\mu)/\sigma < 0$, the maximum occurs between .2 and 1.4. However, this range is too large to take steps of size 10^{-3} along, and an approximation is needed to more precisely locate the u's at which the maximum occurs as a function of the parameters. This will be discussed in detail later in this section.

For $(x_0-\mu)/\sigma > 0$, the interval (0,.1) was explored with 50, 500 steps and the integrals were found to agree to 10^{-6} . Hence 50 steps were taken in this interval for this case. The number of steps in the intervals (0.1,1); (1,5) were chosen to make the error term no larger than 10^{-6} . The number of steps used then were:

interval	<u>n</u>
(.1,1)	25
(1,5)	10

The interval $(5,\infty)$ was not computed for $(x_{o}-\mu)/\sigma > 0$ since it is "practically 0" as is shown in the following.

For

$$u \ge 1$$
, $b \ge 1$, $\frac{x_0^{-\mu}}{\sigma} \ge 0$ and $\frac{\Theta}{\sigma} \ge 10$,
 $g(u) = u^b + (\frac{\Theta}{\sigma}u + \frac{x_0^{-\mu}}{\sigma})^2 \ge u + (\frac{\Theta}{\sigma})^2 u$.

Hence

$$-u - \left(\frac{\Theta'}{\sigma}u + \frac{x_0 - \mu}{\sigma}\right)^2 \leq -\left[u + \left(\frac{\Theta'}{\sigma}\right)^2 u\right]$$
$$-u_0 - \left(\frac{\Theta'}{\sigma}u + \frac{x_0 - \mu}{\sigma}\right)^2 \leq -\left[\left(\frac{\Theta'}{\sigma}\right)^2 + 1\right]u$$

and

Hence

$$\int_{5}^{\infty} e^{-g(u)} du \leq \int_{5}^{1^{\infty}} e^{-\left[\left(\frac{\Theta}{\sigma}\right)^{2}+1\right]u} = \frac{-\left(\left(\frac{\Theta}{\sigma}\right)^{2}+1\right)^{5}}{\left(\frac{\Theta}{\sigma}\right)^{2}+1}.$$

Thus, even if Θ'/σ is as small as 2, which it is not, the area from $(5,\infty)$ contributes less than 1 x 10-9 to the total area.

In any event (whether
$$\frac{x_0^{-\mu}}{\sigma} \ge 0$$
 or not)
 $\left(\frac{\Theta'}{\sigma}u + \frac{x_0^{-\mu}}{\sigma}\right)^2 \ge \left(\frac{\Theta'}{\sigma}(5) + \frac{x_0^{-\mu}}{\sigma}\right)^2$ for $u \ge 5$.

Since we only consider cases in which $\frac{\varphi}{\sigma} \ge 10$ and $\frac{x_0 \cdot \mu}{\sigma} \ge -10$,

 $\left(\frac{\varphi'}{\sigma}(5) + \frac{x_{o}-\mu}{\sigma}\right)^{2} \geq 10$.

Consequently

· · ·

4445

 $\int_{5}^{\infty} e^{-g(u)} du \leq e^{-20} \approx 2 \times 10^{-9}.$

Thus the function error in any case is less than 2×10^{-9} . Of course it is much less than this. However, one sees that it is negligible.

For $(x_0-\mu)/\sigma < 0$, the function in question is no longer a monotone decreasing exponential due to the exp. $\{-1/2[\theta/\sigma(u)+(x_0-\mu)/\sigma]^2\}$ term. Instead it has the properties of Tables A-4.4 - A-4.6 and the maximum point Y can be seen to shift as the parameters change.

1

停

L.

For $(x_0-\mu)/\sigma < 1$, the fourth derivative has large values (as large as 10°) at some point u > 0. Precisely where that point u is and how large the neighborhood in which the fourth derivative remains largely depends on all the parameters.

By evaluating the fourth derivative for several values of the parameter, it was found that for fixed b one had two bounding functions for adjacent setting of the parameters. These bounding functions intersect at some value u*, for $u < u^*$, $f_1^{iv}(u) > f_2^{iv}(u)$ while for $u > u^*$, $f_1^{iv}(u) < f_2^{iv}(u)$ where f_1^{iv} and f_2^{iv} depend on the parameters $(x_0 - \mu)/\sigma$ and θ'/σ . It was found for

1.
$$\frac{x_0^{-\mu}}{\sigma} = -x_1$$
 $x = 1,2...10$
 $\frac{9'}{\sigma} = 10(1+1),$ $1 = 1,2...10$
2. $\frac{x_0^{-\mu}}{\sigma} = -(x+1),$ $x = 1,2...10$
 $\frac{9'}{\sigma} = 101,$ $1 = 1,2...10$
 $f_1^{iv}(u) = f^{iv}(u)$ with parameter set 1

$$f_2^{iv}(u) = f^{iv}(u)$$
 with parameter set 2

then for some $u = u^*$

and

and

$$f_1^{iv}(u) > f_2^{iv}(u), \qquad u < u*,$$

 $f_2^{iv}(u) > f_1^{iv}(u), \qquad u > u*.$

Furthermore, for any setting of the parameters in the inter-

[(-(x + 1), -x); (1, 1 + 1)]

the fourth derivative for these parameters were dominated by either $f_2^{iv}(u)$ or $f_2^{iv}(u)$. Hence for all $u < u^*$ any setting of the parameters in the interval above, $f^{iv}(u)$ was largest while for all $u > u^*$ and any setting of the parameters in the interval above $f_2^{iv}(u)$ was largest.

vals

First, it was decided to evaluate the integral for $-10 \le (x_0 - \mu)/\sigma \le 1$ over from subintervals, $0 \le u \le x_1$, $x_1 \le u \le x_2$, $x_2 \le u \le x_3$, $x_3 \le u \le 10$. This was done to reduce as much as possible the size of the interval over which many steps had to be taken.

x was taken to be that u such that $f_1^{iv}(u) < 1x10^3$ for $u < x_1$ and $f_1^{iv}(u) > 1x10^3$ for $u = x_1 + .05$.

 x_2 was taken to be that u such that $f_2^{iv}(u) > 1:10^3$ for $x_1 < u \le x_2$ while $f_2^{iv}(u) < 1:10^3$ for $u = x_2 + .05$.

 x_3 was taken to be that a such that $f_2^{iv}(u) > 1x10^{-9}$ for $x_2 < u \le x_3$ while $f_2^{iv}(u) < 1x10^{-9}$ for $u = x_3 + .05$.

Since b = 1 gave the maximum length of the intervals over which the error of approximation remained relatively large, the x_1 , x_2 , x_3 were chosen for that b and used for all b_1 .

It was found that $x_1 < .3$, $x_2 < 1.1$ and for $f^{1v}(u) \rightarrow 10^9$, the interval $x_2 - x_1$ became small. Hence, in the interval $(0, x_1)$ 5 steps were taken, in (x_1, x_2) , 50 steps were taken and in each of (x_2, x_3) and $(x_3, 10)$, 5 steps were taken. For all of the values of the parameters studied, these intervals and steps gave

 $\frac{h^5}{90} f^{iv}(u) < 10^{-6}.$

Hence, in all cases, the errors of approximation were less than 1×10^{-6} , and consequently, the maximum error of approximation is less than 10^{-6} .

To check the logic used in attempting to reduce the errors of truncation and approximation, the formulas 2 and 3 of section A-3.3.5 were computed using the error function subroutine available on the University of Michigan 7090. These same integrals were evaluated

using Simpson's rule with the intervals discussed above. Comparisons can be made from Tables A-4.9-A-10 following with those of section A-2.1 for some selected values of the parameters. In no case do the failure probabilities differ by more than 10^{-6} .

A-4.1.6 Conclusions Concerning Errors.

In summary the integral evaluated was

 $\int_{0}^{10} e^{-u^{b}} e^{-(\frac{b}{4}u+\frac{x_{0}-\mu}{\sigma})^{2}} du$

with the parameters taken as

b = 1,2,...10; $\frac{\Theta}{\sigma} = 10,15,20,23,...100,$ $\frac{-\mu}{\sigma} = 1,1.2,1.4,...3 \text{ and } -10,-9,...$

The maximum truncation error is less than 10^{-9} for all values of the parameters.

The maximum approximation errors are less than 10^{-6} using the steps noted in A-4.1.7.

4

The values of the integrals using Simpson's rule differs from the values obtained using the error function formula of section A-3.3.5 by no more than 1×10^{-6} .

Since the tabular values in Table A-2.1 have been found by rounding off the computed values, the tabulation are correct to $+5 \times 10^{-5}$.

A-4.1.9 A Note on Interpolation

One notes that the tabulated values are non-linear. Simple linear interpolation can introduce significant errors (errors greater than 10^{-4}). Hence higher order interpolation formulas should be used for more accuracy.

3

Y

5

, , ,	х ,	-		<mark>χ⁰ - π</mark>	-		
	;	-10	- 5	-1	1	2	3
•) 10	.63028	. 39043	.09935	.00797	.00082	.00004
	20	. 39271	.22023	.05184	.00407	.00042	.00002
	30	.28307	.15305	.03507	.00274	.00028	.00001
. t	40	.22096	.11723	.02649	.00206	.00021	.00001
a ·	50	.18111	.09498	.02129	.00165	.00017	.00001
-	60	.15340	.07983	.01779	.00138	.00014	.00001
	70	.1.3303	.06884	,01528	.00118	.00012	.00001
	80	.11743	.06051	.01339	.00104	.00011	.00000
	90	.10511	.05398	.01192	.00092	.00009	.00000
	100	.09512	.04872	.01074	.00083	.00008	.00000

B = 1

Table A-4.9 Numerical Values of Formula 2 of Section A-3.3.5

1.

Ŷ

B	=	2	
---	---	---	--

		Xo	<u>σ</u> μ	
		-10	-5	-1
	10	.62853	.22508	.01877
	20	.22217	.06264	.00478
	30	.10593	.02841	.00213
•۵	40	.06110	.01610	.00120
T.	50	•03956	.01034	.00077
*	60	.02765	.00719	.00053
·	7 0.	.02039	.00529	.00039
	80	.01565	.00405	.00030
	90	.01239	.00320	.00024
	100	.01005	.00260	.00019

Table A-4.10 Numerical Values of Formula 3 Using Parameters Given by Formula 3 of Section A-3.3.5

DOCIMENT /	ONTROL DATA - PA	<u></u>
(Security classification of little, body of abstract and inde	wing annotation must be a	nierod when the averall report is classified)
1. ORIGINATING ACTIVITY (Corporate author) University of Michigan		UNCLASSIFIED
Ann Arbor, Michigan 48104		2. enoup N/A
S. REPORT TITLE		
RELIABILITY PREDICTION- MECHANICAL	STRESS/STRENOTH	INTERFERENCE
Final Report, April 1965 to November	r 1966	
S. AUTHOR(3) (Lost name, Mai name, initial) Lipson, Charles Sheth, Narendra J. Disney, Balph L.		
. REPORT DATE	74. TOTAL NO. OF	PA4ES 75. NO. 37 HEFS
March 1967	400	
AF30(602)-3684	Sar ONIGINATON'S R	
ь разист но. 5519	None	
• Thek No.	SA. OTHER AEPORT	NG(\$) (Any other numbers that may be evaluated
3,200	RADC-1R-66-	710
11. SUPPLEMENTARY NOTES Donald W. Fulton, Project Engineer (EMERR)	12. SPONSORING ML RADC (EMERR) Griffiss AFE	NY 13440
11. SUPPLEMENTARY NOTES Donald W. Fulton, Project Engineer (EMERR) 13. ASSIRACY This study addressed itself to th tool based on the Stress-Strength Ind and quantitatively predicting the rei mechanical loading.	12. SPONSORING ML RADC (EMERR) Griffiss AFE he development o terference Theor liability of med	NY 13440 NY 13440 of a practical engineering ty to be used for designing chanical parts subjected to
 11. SUPPLEMENTARY NOTES Donald W. Fulton, Project Engineer (EMERR) 13. ASSIRACY This study addressed itself to the tool based on the Stress-Strength Instant quantitatively predicting the rest mechanical loading. Fatigue data was gathered for van surface conditions, etc. and was constrained to be the most effective means the Interference Theory. For each means the Interference Theory. For each means the required stress distribution 	13. SPONSORING MU RADC (IMERR) Griffiss AFE terference Theor liability of med verted to streng ibull distributi of representing sterial parameter ular and graphic , in this study.	NY 13440 of a practical engineering ry to be used for designing chanical parts subjected to aterials, heat treatments, gth data to obtain the scatte on best fit the data and was g the strength distribution is or studied, Weibull parameter o form. , is obtained by converting
 11. SUPPLEMENTARY MOTES Donald W. Fulton, Project Engineer (EMERR) 13. ASSIRACY This study addressed itself to the tool based on the Stress-Strength Internatively predicting the reimechanical loading. Fatigue data was gathered for vanishing of strength at a given life. The West found to be the most effective means the Interference Theory. For each means the Interference Theory. For each means the stress spectrum, known or assume Goodman diagram. The required stress stress, is obtained using Miner's rules. 	12. SPONSORING MUL RADC (EMERR) Griffiss AFT he development of terference Theor liability of med rious ferrous me verted to streng ibull distributi of representing aterial paramete ular and graphic , in this study, d, to a zero mea s spectrum, expr le.	NY 13440 of a practical engineering by to be used for designing chanical parts subjected to aterials, heat treatments, gth data to obtain the scatter ion best fit the data and was g the strength distribution is er studied, Weibull parameter of form. , is obtained by converting an stress spectrum using the ressed in terms of equivalent
 11. SUPPLEMENTARY MOTES Donald W. Fulton, Project Engineer (EMERR) 13. ASSIRACY This study addressed itself to the tool based on the Stress-Strength Internatively predicting the reimechanical loading. Fatigue data was gathered for vanishing and quantitatively predicting the reimechanical loading. Fatigue data was gathered for vanishing and quantitatively predicting the reimechanical loading. Fatigue data was gathered for vanishing and quantitatively predicting the reimechanical loading. Fatigue data was gathered for vanishing and quantitatively predicting the reimechanical loading. Fatigue data was gathered for vanishing and the stress systemation of strength at a given life. The West found to be the most effective means the Interference Theory. For each mover calculated and presented in table The required stress distribution the stress spectrum, known or assumed Goodman diagram. The required stress stress, is obtained using Miner's ru In the literature, it has general follow the normal distribution. The normal can be easily evaluated. In one of the attress the complex integral butions using the IRM-7090 Computer. for the stress-normal, strength-Weib 	13. SPONSORING MUL RADC (EMERR) Griffiss AFE terference Theor liability of med verted to streng ibull distributi of representing aterial paramete ular and graphic , in this study, d, to a zero mes s spectrum, expr le. Lly been assumed resulting inter other cases wher ecommended. In resulting from to Tabulated inter ull case and the	NY 13440 of a practical engineering ry to be used for designing chanical parts subjected to aterials, heat treatments, ght data to obtain the scatter ion best fit the data and was g the strength distribution is or studied, Weibull parameter c form. , is obtained by converting an stress spectrum using the ressed in terms of equivalent i that both stress and streng rference distributions are not this study a method was deve the interference of two distribution e stress-Weibull, strength- (commin)
 11. SUPPLEMENTARY MOTES Donald W. Fulton, Project Engineer (EMERR) 13. ADSTRACY This study addressed itself to the tool based on the Stress-Strength In- and quantitatively predicting the reimechanical loading. Fatigue data was gathered for van surface conditions, etc. and was com of strength at a given life. The Wei found to be the most effective means the Interference Theory. For each m were calculated and presented in tabu The required stress distribution the stress spectrum, known or assume Goodman diagram. The required stress stress, is obtained using Miner's ru In the literature, it has general follow the normal distribution. The normal, Monte-Carlo techniques are r ed to evaluate the complex integral butions using the IEM-7090 Computer. for the stress-normal, strength-Weib 	13. SPONSORING MUL RADC (EMERR) Griffiss AFT be development of terference Theor liability of med rious ferrous may verted to streng ibull distributi of representing sterial parameter ular and graphic , in this study, d, to a zero meas s spectrum, expr le. Lly been assumed resulting inter other cases wher ecommended. In resulting from t Tabulated inter ull case and the	NY 13440 of a practical engineering ry to be used for designing enanical parts subjected to aterials, heat treatments, gth data to obtain the scatter ion best fit the data and was g the strength distribution in ar studied, Weibull parameter of form. , is obtained by converting an stress spectrum using the ressed in terms of equivalent i that both stress and streng reference distributions are not this study a method was deve the interference of two distr e stress-Weibull, strength- (CONDID) UNCLASSIFIED
 11. SUPPLEMENTARY NOTES Donald W. Fulton, Project Engineer (EMERR) 13. ASSIMACY This study addressed itself to t: tool based on the Stress-Strength In and quantitatively predicting the reimechanical loading. Fatigue data was gathered for van surface conditions, etc. and was com of strength at a given life. The Wer found to be the most effective means the Interference Theory. For each m were calculated and presented in tabu The required stress distribution the stress spectrum, known or assumed Goodman diagram. The required stress stress, is obtained using Miner's ru In the literature, it has general follow the normal distribution. The normal can be easily evaluated. In normal, Monte-Carlo techniques are re ed to evaluate the complex integral butions using the ISM-7090 Computer. for the stress-normal, strength-Weib Distribution 	13. SPONSORING MUL RADC (IMERR) Griffiss AFT he development of terference Theor liability of med verted to streng ibull distributi of representing aterial parameter ular and graphic , in this study, d, to a zero mea s spectrum, expr le. Lly been assumed resulting inter other cases wher ecommended. In resulting from t Tabulated inter ull case and the	NY 13440 of a practical engineering ty to be used for designing manical parts subjected to aterials, heat treatments, gth data to obtain the scatter ion best fit the data and was g the strength distribution in ar studied, Weibull parameter form. , is obtained by converting an stress spectrum using the ressed in terms of equivalent i that both stress and streng rference distributions are not this study a method was deve the interference of two distr erference values are presente e stress-Weibull, strength- (CONDID) UNCIASSUFTED Security Classification
 11. SUPPLEMENTARY MOTES Donald W. Fulton, Project Engineer (EMERR) 13. ASSIMACY This study addressed itself to t: tool based on the Stress-Strength In and quantitatively predicting the reimechanical loading. Fatigue data was gathered for vari surface conditions, etc. and was com of strength at a given life. The Wei found to be the most effective means the Interference Theory. For each m were calculated and presented in table The required stress distribution the stress spectrum, known or assume Goodman diagram. The required stress stress, is obtained using Miner's ru In the literature, it has genera follow the normal distribution. The normal can be easily evaluated. In normal, Monte-Carlo techniques are re ed to evaluate the complex integral butions using the IBM-7090 Computer. for the stress-normal, strength-Weib 	13. SPONSORING MUL RADC (EMERR) Griffiss AFE terference Theor liability of med verted to streng ibull distributi of representing sterial paramete ular and graphic , in this study, d, to a zero mea s spectrum, expr le. Lly been assumed resulting inter other cases when ecommended. In resulting from t Tabulated inter ull case and the	NY 13440 of a practical engineering ry to be used for designing manical parts subjected to aterials, heat treatments, gth data to obtain the scatter ion best fit the data and was g the strength distribution in ar studied, Weibull parameter form. , is obtained by converting an stress spectrum using the ressed in terms of equivalent i that both stress and streng rference distributions are not this study a method was deve the interference of two distr erference velues are presente e stress-Weibull, strength- (CONNID) UNCLASSIFIED Security Classification

¥