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A RELIABILITY ANALYSIS APPROACH TO FATIGUE LIFE VARIABILITY OF AIRCRAFT STRUCTURES

I. C. WHITTAKER

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The Boeing Company

APRIL 1969

TECHNICAL REPORT AFML-TR-69-65

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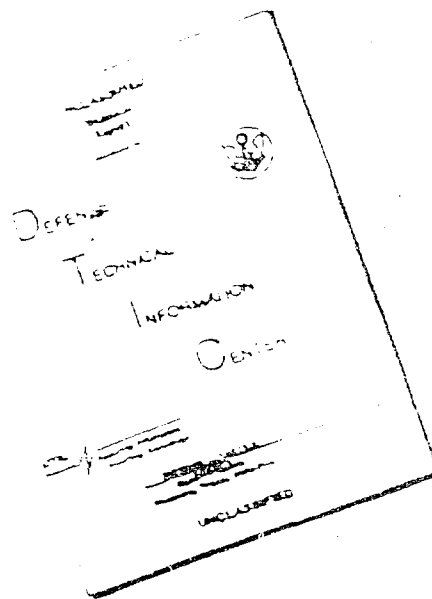
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FOREWORD

The research work reported herein was conducted by The Boeing Company for the Metals and Ceramics Division, Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, under USAF Contract No. F33615-68-C-1232. This contract was initiated under Project No. 7351, "Metallic Materials," Task No. 735106, "Behavior of Metals," with Mr. R. C. Donat acting as project engineer.

The study was conducted at The Boeing Company's Commercial Airplane Division, Structures Developmental Staff, in Renton, Washington, under the technical supervision of Mr. J. P. Butler, supervisor of the Fail-Safe and Fatigue Group. The period covered by this effort is February 1968 through January 1969, and the report was submitted March 1969.

The research was conducted by Mr. Philip M. Besuner and Mr. Ian C. Whittaker of the Fail-Safe and Fatigue Group of the Commercial Airplane Division. Acknowledgement is due Dr. S. C. Saunders for his many important contributions to the mathematical developments contained within, including all work in Appendix I. A suggestion by Professor A. M. Freudenthal of Columbia University, whose theory and concepts of structural reliability formed the basis for the initiation of this study, led to the adoption of a two-ordered statistic estimator, which subsequently became the backbone of the studies on the dispersion of fatigue life. Professor M. Shinozuka of Columbia University provided valuable aid during the initial stages of the study. Dr. Nancy Mann of Rocketdyne provided timely mathematical consultation vital to the application of a two-ordered statistic and other estimators. Data processing, presentation, and Monte-Carlo simulation by computer would not have been possible without the support of Mrs. Joan Naidu and Mr. T. A. Bray of Boeing's Computing Department. Mr. P. E. Borgwardt and Mr. M. C. McElroy contributed substantially to the data collection and presentation of results. The majority of the typing of the report was done by Mrs. Carol Daves.

This technical report has been reviewed and is approved.



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ABSTRACT

The application of reliability analysis methods to the estimation of probable aircraft structural fatigue performance was investigated. Use was made of order statistics to establish the means of assessing the fatigue performance reliability of a fleet or number of fatigue-exposed details. A reliability analysis plan for application to aluminum alloy structural fatigue performance was developed and compared with the current fixed-scatter-factor procedure for determining the safe life of a structural detail. Both the two-parameter Weibull distribution and the log-normal distribution with empirically defined shape parameters were used to make the reliability plan tractable as compared to a distribution-free approach. Maximum-likelihood estimators, including one that considers only the first two-ordered failures, were employed to examine the many variables that might influence fatigue scatter, to qualify fatigue data that represented aluminum structural scatter, and to establish shape parameter values that typified structural fatigue scatter. The sampling distributions of these estimators were required to work the problem and were calculated by means of existing theory or Monte-Carlo simulation. More than 2,000 groups of fatigue performance data were collected, analyzed, and used to demonstrate the feasibility of establishing a shape-parameter value. Based on this estimate, scatter factors have been generated to account for the penalty of limited input information, the degree of desired reliability, and the size of the exposed fleet. Using these factors, the possible effects of the reliability analysis on structural weight, payload, or range were explored for a jet-engined military tanker/transport-type airplane.

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LIST OF ABBREVIATIONS AND SYMBOLS

1. ABBREVIATIONS

E	= mathematical expectation
exp	= exponential function
ln	= natural logarithm
log	= common logarithm
ML	= maximum likelihood
MLE	= maximum likelihood estimator or estimate
P ()	= probability of that event described within parentheses
Var	= mathematical variance

2. SYMBOLS

α	= Weibull distribution shape or scatter-controlling parameter
β	= Weibull distribution scale parameter or characteristic life
B_n	= coefficients, depending on sample size n, used to unbiased Weibull shape MLE
b_n	= coefficients, depending on n, used to unbiased Weibull two-ordered-statistic estimates
γ	= confidence coefficient, showing probability that an estimator takes on values within a given interval
δ	= a nonnegative number
ϵ	= standard normal variate
F	= when used alone, probability of failure event or, when used with a random variable, a symbol of any time-to-failure distribution function
$\bar{F}_{M:N}$ or $\bar{F}$	= probability of failure of the component destined to have the M th lowest fatigue life of N independent exposed components
G_i	= the i th ordered censored test observation, where the test or exposure has been terminated for reasons other than failure
η	= population average of log failure times, when the population distribution is not necessarily assumed to be log-normal

LIST OF ABBREVIATIONS AND SYMBOLS---Continued

- h = hazard function; also known as the intensity or failure rate function or as the force of mortality
- α = $1/\alpha$, the Weibull parameter that is actually estimated in this report, rather than α itself
- k_p = the standardized normal deviate corresponding to some probability number, p . More than one definition has been discovered in the literature; in this report, k_p is defined by

$$\frac{1}{\sqrt{2\pi}} \int_{k_p}^{\infty} \exp(-\xi^2/2) d\xi = p$$

- λ = any unknown parameter
- L = likelihood function
- μ = log-normal distribution scale parameter or median life
- M = order number given to the M^{th} lowest fatigue life in a fleet
- N = fleet size; the number of nominally identical, independent structural components exposed to one fatigue environment
- n = test sample size
- n_f or k = number of failure observations in the test sample
- n_g = $n - n_f$, the number of observations not involving failures
- Q_n = coefficient, depending on n, proportional to the variance of an estimator's sampling distribution
- R = $1 - F$; when used alone, R is the single, randomly chosen fleet member's reliability or probability of no failure. When used with a random variable, it is a symbol denoting any reliability function.
- $\bar{R}_{M;N}$ or $\bar{R}$ = $1 - \bar{F}$, the reliability of the structural component destined to have the M^{th} lowest fatigue life in a fleet of N identically exposed independent components
- σ or $\sigma(\log X)$ = log-normal shape parameter
- σ^2 = log-normal parameter actually estimated in this report, rather than σ itself

LIST OF ABBREVIATIONS AND SYMBOLS---Continued

- s^2 - sample variance of the logarithm of failure observations only from a test sample
- S - total scatter factor ($= S_{n_f} \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$); defined as the ratio of the best estimate of the scale parameter (characteristic life or average log life) to the final (interval) estimate of safe life
- S_{n_f} - factor to account for finite size of the full-scale fatigue test sampling
- $S_{\bar{R}}$ - factor required to provide a desired level of reliability for a fleet of just one airplane, component, or detail
- S_N or $S_{N_{\bar{R}}}$ - factor to account for fleet size exposed; double subscript is used where this factor also depends on the preassigned reliability
- S_R - $S_{\bar{R}} \cdot S_{N_{\bar{R}}}$, factor required to provide reliability R to a fleet of size one or, equivalently to provide a lower reliability $\bar{R}$ to all or most of a fleet of size N
- T - a discrete random variable denoting the number of failures occurring in an exposed fleet
- U - the statistic $\hat{a}/\alpha$ (see definitions of accent marks that follow)
- V - the statistic $(\hat{b}/\beta)^{\hat{a}}$
- W - the statistic $(\hat{b}/\beta)^{\alpha}$
- χ^2 - symbol of the chi-squared distribution
- $\chi^2_{\gamma}(f)$ - the γ -fractile of the chi-squared distribution with f degrees of freedom
- X - a continuous time-to-failure random variable usually referring to tests useful in estimating fatigue scatter only
- X_L - $\log X$
- Y - a time-to-failure variable usually referring to the fatigue performance of one structure or structural component in service or to fatigue results from full-scale tests useful in estimating mean life

LIST OF ABBREVIATIONS AND SYMBOLS---Concluded

- $Z_{M;N}$
or Z = a time-to-failure random variable denoting the M^{th} lowest fatigue life in a fleet service exposure of size N
- $Z_{\bar{R}}$ or Y_R = safe life, $Z_{\bar{R}}$ represents the $(1-\bar{R})$ fractile of the distribution of Z ; Y_R represents the $(1-R)$ fractile of the distribution of Y . ("Life" is defined as the time to initial appearance of fatigue cracking at a detail or in a structure.)

NOTE: The standard practice of using uppercase letters to denote random variables and corresponding lowercase letters to denote numerical values the variables may take is followed, in most instances, in this report.

3. ACCENT MARKS DENOTING ESTIMATION

- (a) Bar, as in $\bar{X}_L$ or $\bar{n}$, may denote an average or any sort of point estimator. It is to be noted that the bars in $\bar{F}$ and $\bar{R}$ do not have this meaning (see Par. 2, "Symbols," above).
- (b) Boat, as in $\check{Y}_R$, denotes a one-sided bound of a confidence interval estimate. This accent mark may be replaced by or used in conjunction with the subscript γ as in $\hat{\beta}_\gamma$ or $\check{\beta}_\gamma$.
- (c) Hat, as in $\hat{\sigma}$, symbolizes the maximum-likelihood point estimate
- (d) Double hat, as in $\hat{\hat{\sigma}}$ represents an estimator (usually the MLE) that is free or has been freed of bias.
- (e) Prime, as in $\tilde{\kappa}'$, denotes an estimator taken from more than one sample.
- (f) Squiggle, as in $\tilde{\kappa}$, stands for an unbiased two-ordered-statistic estimator of a shape parameter.
- (g) Vee, as in $\vee\hat{\beta}$, denotes a scale-parameter MLE that must depend on an estimated value rather than on a true shape-parameter value.

SECTION I

INTRODUCTION

The structural reliability of an airplane is dependent on the likelihood of a fatigue failure or a static failure, or a combination of both. At the present stage in the evaluation of the aluminum alloy airframe the expectancy of fatigue crack initiation can be of a higher order than that of a static failure. On the other hand, it should be realized that with a well-designed, fail-safe structure, subjected to regular and correctly scheduled inspections, the fatigue damage initiation incident should not progress beyond the detectable crack stage to the level where a structural failure is imminent. The aircraft designer still has a real requirement to assess the expected time at which cracks may initiate on a particular structure, in order to insure a sufficiency of trouble-free performance. This report is primarily concerned with the development of a reliability analysis method for application to this fatigue problem as affected by safety or maintenance requirements.

Some clarification of the term "reliability analysis" is necessary as its application to structures is not the usual one of component reliability leading directly to the system's reliability or to total reliability through an accounting of the interdependence of components, fault-tree analyses, or other such procedures. Structural reliability as envisaged here is concerned with a specific structural detail and is heavily dependent on the testing of full-scale structural details or primary structural components. For example, Raithby (1) has shown that this form of testing is essential to obtain an estimate of available fatigue performance that bears any resemblance to that actually achieved. It has also been observed that structural fatigue problems are frequently initiated by fretting, a process that is not reproduced in the well-designed simple laboratory specimen and its test program. Likewise, estimates of the mean performance based on such simple tests would probably be larger than that demonstrated by a structure in service. The significant goal of a reliability analysis is to determine the probable time to the initial appearances of fatigue damage in structures or details, a task even more obviously beyond the scope of the simple specimen.

Other real hazards--beyond those of the test specimen--confront the designer. Load environment, physical environment, and actual local stress response of a detail to its loading environment all lend a confounding element to the task. Gross misrepresentation of airplane fatigue performance through inadequate fatigue test design and interpretation will generally lead to poor reliability estimates. However, it is as meaningless to associate these errors with the reliability analysis as it would be to regard the errors in the assumed functional form of the fatigue life distribution as weaknesses in the structural analyses.

Current analytical practice (Ref. 2) for military aircraft for insuring an adequate or safe level of fatigue performance by aircraft structures does contain some of the characteristics of a reliability plan. Namely, a structural detail, component, or complete airframe is fatigue-tested to a defined and representative loading environment. Additionally, a goal is selected at some multiple of the defined and expected service life of the structure. The applied safety factor is usually selected quite arbitrarily either on the basis of judgment or with guidance from some possible consideration of confidence and probability levels of statistical analysis.

In past assessments of fatigue scatter, the log-normal distribution has often been used. Attention has also been given to the Weibull-type distribution for defining fatigue variability and predicting potential fatigue performance. The important consideration is that a level of fatigue performance, statistically defined or otherwise considered acceptable, is set for the structural detail. A vital part in this assessment has been the use of mean or median fatigue performance for the detail. However, these past analyses have not considered the likely appearance of early or first fatigue damage during the exposure of a quantity of details to the fatigue environment. The expected time to first failure, rather than either a probable level or the average performance with its implied high number of failures (about half of the fleet, prior to the design goal), has been proposed by Freudenthal (3) as an important design parameter for structural reliability. The early failure is also a serious economic consideration that could possibly influence future decisions; consequently, this added factor must be investigated and carefully weighed by the design engineer. It is known that if fatigue life comes from a population whose probability density is of a specified limited type, the extreme values (initial failures) of an indefinitely large sample will have a Weibull distribution. For the problem of the airplane fleet, where a substantial number of structural details are involved, the use of this asymptotic form seems appropriate. Some recent papers describing or using this approach are available in the literature (4 through 9), and this report is an extension or development of this work, with special emphasis on the estimation procedure part of the problem.

Section II presents a complete outline of the proposed reliability analysis and makes comparisons with the existing procedure for determining the safe life of an aircraft structure. The plan has been divided into five steps. The first four steps describe the assumptions, estimating procedure, and the influence of sample size. The final step defines the influence of fleet or number of detail exposed to the fatigue environment.

Section III contains discussions on the processing techniques used on the mass of collected data, the procedures developed for coping with problems that arose during processing, and the results that were obtained from the evaluated fatigue performance data. A dissertation is presented on a revised scatter-factor approach for calculating the safe life, as defined in Sec. II, of an aluminum structure. The possible performance penalties suffered by adoption of this proposed method are also discussed.

Section IV presents an outline of the analytical groundwork needed for estimating the distribution shape parameters from the mass of collected fatigue data. The techniques for obtaining bias and variance values, the method of weighting estimates from groups of varying sample size, and the procedure for obtaining interval estimates are presented.

Section V summarizes all the additional formulations that were used for estimating a safe life for an aircraft structure, which include the techniques for calculating the scale parameters and the so-called scatter factors.

Section VI presents a list of the conclusions made, together with a few suggested recommendations.

Appendix I contains proofs for the important theorems used in the analysis, and some aspects of the Monte-Carlo techniques that were adopted are discussed.

Appendix II lists all the source references and tabulates the salient features, including the point estimates of the shape and scale parameters, of the collected fatigue performance data.

Finally, Appendix III lists the cyclic life for every individual specimen assessed in this report.

SECTION II

OUTLINE OF THE RELIABILITY ANALYSIS

The basic objective of this investigation is the application of reliability analysis to aircraft structural fatigue performance, in terms of the first- and second-ordered times-to-fatigue-damage initiation. Statistical definition of fatigue variability is essential to the achievement of this objective.

The generality, definition, and input data requirements of distribution-free methods may make their application impractical and economically forbidding. Furthermore, rationale just seems to point toward a more tractable definition of fatigue variability by some reasonable and determinable distribution. The two-parameter log-normal distribution, by virtue of its easy transformation from the well-known normal or Gaussian distribution, has been a useful engineering tool for evaluating reliability in fatigue performance. The two-parameter Weibull distribution function has also found an application to fatigue variability studies. Presuming knowledge of the shape parameters of these distributions, statistical analysis procedures that account for sample size are readily developed. Using these procedures, the analyst can calculate interval estimates of the true fatigue life distribution at any desired level of confidence. The additional tolerance for probability of failure of any one detail is then also definable. Order statistics carry the fatigue reliability analysis a step forward by focusing on the likelihood of the first or the second failure in an exposed fleet or in groups of details. In any case, development of a reliability analysis as either a probable level of fatigue performance or, even more detailed, in terms of an ordered statistic has considerable complication over the simple exercise of applying a scatter factor to an estimated average or median fatigue performance.

The main effort of this research project has been devoted to the development of the reliability analysis tools that can be applied to the aircraft structural fatigue performance task. Attempts have been made to fully utilize all applicable fatigue data and to employ only mathematically precise estimation procedures in the analysis and detection of important variables and vagaries of structural fatigue performance.

The analysis does not account for all unknown or inadvertent systematic errors that may cause the full-scale fatigue test result and/or the ensuing life calculations to grossly misrepresent the actual aircraft fatigue performance. Such errors could arise from the assumed load environment, customer usage, and cumulative damage theory as well as from the specimen design and fatigue test setup. In all that follows, it is assumed that the life estimate arising from full-scale tests is drawn from the same statistical population as are the corresponding aircraft's structural lives and that this population distribution

represents fatigue strength variability only. In analyzing strength variability, specific attention has been given to accounting for the sample size of full-scale developmental fatigue tests and for the eventual size of the fleet to be exposed to a defined fatigue environment. This has been done through the application of statistical inference theory and of order statistics concepts respectively.

The need for this accounting is clear when the current approach to create reliability, represented by Fig. 1, is compared to the proposed, more comprehensive approach outlined and described schematically in Fig. 2.

In the current approach, the symbol $\bar{Y}$ in Fig. 1 is a measure of the average performance of developmental fatigue test specimens and is usually taken to be the mean of log times or cycles to failure. This average performance is then divided by a so-called scatter factor, whose value may range from two to four, to obtain Y_S , which is traditionally known as the "safe life," a life at which the probability of the initial appearance of fatigue cracking at a detail is sufficiently low. These values of the scatter factor have been subject to interpretation. Hopefully, these factors would provide an estimate of the service life prior to initiation of fatigue cracking. In other circumstances, they are credited with providing a fatigue performance with reasonable maintenance throughout the economical life of the structure. Fail-safe design concepts--with their damage containment capability--have considered that the magnitude of the factor can be reduced over that required for non-fail-safe structure. Seemingly, the scatter-factor value chosen is independent of the number of details to be exposed in service and of the sample size of the full-scale airplane test(s).

In contrast, the difference between mean test performance and subsequently calculated probable or safe life is, in the proposed approach, strongly dependent on sample and fleet size. Recognition of the relative importance of the structural detail, including the degree of redundancy, may still be accomplished using the plan outlined in Fig. 2. However, in this new approach, an acceptable level of reliability must be specified. Scatter factor may then be calculated; to specify scatter factor a priori is equivalent to specifying a reliability that is almost certainly not of the desired level.

As the first of five major steps in applying statistical techniques it was decided to consider the untruncated two-parameter Weibull distribution as a random time-to-failure model because of certain desirable mathematical properties it possesses (these are discussed in Sec. III). That is, the fatigue life Y is assumed to be a random variable with distribution given by

$$F(y) = 1 - \exp [-(y/\theta)^\alpha] \text{ for unknown } \alpha, \theta > 0 \quad (\text{II-1})$$

The traditionally cited log-normal model was also applied to the problem in a less complete manner due to difficulties in working with estimates of its two parameters from incomplete or censored samples.

These are samples in which the testing of one or more specimens is regarded as being terminated for reasons other than failure.

At this time, no attempt has been made to test the validity of any one distribution or even to reject one model for another. However, somewhat different conclusions may be reached from applying different distribution functions to the same data. Of course, the necessity to generate very large samples of controlled fatigue data may preclude adequate resolution of this problem. To emphasize the need for making realistic assumptions about the distribution of fatigue lives, the Tchebycheff inequality will also be applied to the problem to indicate a possible conclusion when no assumption is made about the functional form of the true time-to-failure distribution.

Given reasonable accuracy in the chosen model, the second step is the most important, necessary, and critical step in the analysis. It was assumed that, for a wide variety of structure and structural simulation configurations and types of loading, the variability or dispersion of the logarithms of times-to-failure is nearly constant. More specifically, with reference to the distribution function itself, the assumption is that the scatter-controlling or shape parameter of the assumed Weibull (or log-normal) model has a unique value for this same set of conditions. This unknown value of the Weibull shape α has been estimated from a collection of more than a thousand applicable samples of two or more fatigue specimens each, and the errors in the uniqueness assumptions are considered to be small enough for practical application. A large proportion of the later sections of this report is devoted to discussing and justifying this important conclusion.

With the shape parameter α accurately estimated and subsequently regarded as being fixed, we need only obtain from full-scale testing an accurate estimate, $\hat{\beta}$, of the scale parameter β to complete the third stage of the plan. This step establishes Curve A in Fig. 2 and produces the best point estimate possible of the complete distribution of fatigue lives. It is from this curve, with equation

$$\hat{F}(y) = 1 - \exp [-(y/\hat{\beta})^\alpha] \quad (\text{II-2})$$

that the most likely probability of failure at a given fatigue life is estimated.

It is standard procedure in any engineering discipline to specify allowables as values somewhat less than the most likely estimates. One sensible way to do this was chosen as step four, where a confidence interval estimate $\check{\beta}_\gamma$ of β is made that accounts for the finite size of the full-scale fatigue sampling so that

$$P(\check{\beta}_\gamma > \beta) = \gamma \quad (\text{II-3})$$

The confidence coefficient γ is generally specified at some acceptable level. The estimate $\hat{\delta}_\gamma$ along with the "known" shape parameter α completely determines Curve B, a plot of the interval estimate of the complete distribution, with equation

$$\hat{F}_\gamma(y) = 1 - \exp [-(y/\hat{\delta}_\gamma)^\alpha] \quad (\text{II-4})$$

It follows immediately from Eqs. (II-3) and (II-4) that

$$P \{ \hat{F}_\gamma(y) \geq F(y) \} = \gamma \quad (\text{II-5})$$

In other words, with probability γ , the estimated failure probability (reliability) from Eq. (II-4) will be greater than (less than) the unknown true failure probability (reliability).

As a structural design specification, the type of confidence statement given above is certainly not without precedent. For example, the "A" and "B" values of ultimate strength of structural alloys quoted in MIL-HDBK-5A (Ref. 10) are based on a confidence interval estimate analysis that differs from the aforementioned one in only two respects. The first difference is that the random variable ultimate static strength was assumed to have a two-parameter normal distribution. The second difference, one of greater practical importance, is that both parameters were assumed to be unknown in Ref. 10 and were estimated from one large sampling, of at least 100 observations, of tensile specimens. As outlined before, the shape parameter was, in this study, assumed to be common to the actual aircraft as well as to the large collection of data from which it was estimated. Some assumption regarding prior information about the degree of fatigue scatter, as measured by the shape-parameter estimates, is obviously required in this study because the full-scale fatigue test sample size typically does not exceed one or two observations. Two parameters cannot, of course, be estimated at all from a sample of one and cannot be estimated accurately from a sample of two observations.

The first four stages of the reliability plan have led to Curve B, which is simply a statement, at some confidence level, of the reliability of an aircraft or aircraft structural detail (depending on the nature of the full-scale test), chosen randomly from a universe of nominally identical counterparts, as a function of time of exposure to the loading environment. If the reliability R of an arbitrary fleet member is judged to be a suitable measure of safety or of freedom from repair, the plan terminates upon administrative specification of an acceptable value of R and upon reference to Curve B to certify a corresponding "safe life."

In many or possibly in most instances, the arbitrary specification of an acceptable value of R is not a sufficient basis for certifying safe life for a number of details or a fleet of airplanes. With regard to the safe or repair-free operation of a fleet, both customer and

vendor usually expect that the entire or nearly the entire fleet demonstrate acceptable reliability. Precise definition is one step toward this goal.

With reference to the proverbial chain that is no stronger than its weakest link, it is only a matter of definition to equate the reliability of the majority of the fleet with the reliability of one of the weakest of its (assumed) independent nominally identical members. That is, the reliability of the entire fleet is not different from the reliability of its weakest member. In general, the reliability of the vast majority of the fleet, considered as a package and excluding only the weakest $M-1$ members, is defined as the reliability of the M^{th} weakest fleet member.

The random variable $Z_{M;N}$, used to denote the fatigue life of the detail destined to have the M^{th} lowest of N fatigue lives, is an example of an order statistic. It has its own statistical distribution. This distribution is completely determined by the randomly chosen member's fatigue life distribution. Note that the two distributions are never equal except in the trivial case of $M = N = 1$.

Fortunately, the precise calculation of the order statistic's distribution from any assumed, estimated, or known parent distribution function is a simple matter whenever the trials are independent, however complex the parent function. The derivation of the cumulative binomial distribution, which may always be used to map the parent into the order statistic's distribution, is given in many standard statistical texts (e.g. Ref. 11). In Fig. 3 this summed binomial formula is plotted for several combinations of M and N . The resultant curves are worth examination by all readers, but they will be especially enlightening to those not familiar with the behavior of order statistics, since they point out significant trends that are perhaps not obvious. The most striking examples arise from the way the curve slopes increase with M , leading to such surprising facts as:

- 1) Greater fleet member reliability R and therefore larger scatter factors and more weight on the airplane results from a specified reliability of 99% for the weakest of 10 than from the same specification for the second weakest of 100. The reverse is true for lesser reliabilities such as $R = 0.90$.
- 2) In a similar vein, if the reliability of the single, randomly chosen fleet member is greater than 0.97, it is more likely to experience one or more failures in a fleet of size 4 than it is to experience two or more failures in a fleet of 20. For $R < 0.97$, this trend is reversed.

This trend, which depends vitally on the independence of fleet members but which in no way depends on the assumed failure distribution could be interpreted by the engineer or administrator in a practical manner. It points out the fact that, except for cracks or failures that are "intolerable," it would be quite worthwhile to be able to specify reliability for the second or third weakest fleet member rather than to specify a similar reliability level for the weakest fleet member.

Returning to the final stage of the reliability plan as outlined in Fig. 2, it is proposed that an acceptable reliability level $R_{a;n}$ be specified from which the cumulative binomial distribution can be used to calculate the corresponding "general" reliability R . The certifiable safe life may then be found from Curve B to complete the exercise.

In summary, the object of the overall statistical analysis is to obtain an accurate and reliable estimate Z_R of the "true" design life Z_R , where Z_R satisfies the probabilistic statement:

The proportion of the failure times Z that will exceed life Z_R is equal to R , where Z denotes the M th failure time in each fleet of a universe of fleets of size N .

In equation form this is expressed as

$$P(Z > Z_R) = R \quad (II-6)$$

Since Z_R can only be estimated from sample data we can, at best, obtain an estimate $\hat{Z}_R$, which is conservative with confidence γ , such that

$$P(\hat{Z}_R \leq Z_R) = \gamma \quad (II-7)$$

Specification of levels of reliability and confidence, the fatigue test sample size, and the fleet exposure must remain a joint managerial effort between customer and vendor. It is recognized that, as a practical matter, these specifications will depend partly on their resulting calculated scatter factors and ultimately on structural weight. The relationship of structural weight and level of reliability is explored in Sec. III.

SECTION III

DISCUSSION

1. DATA EVALUATION PROCEDURES

a. General Procedure

The choice of the Weibull statistical model can be justified on the basis that it belongs to the class of asymptotic distributions of the extreme (smallest) values and may adequately reflect the distribution of the proposed design parameter, namely, the time to first failure in complicated, multicomponent, fatigue-critical structures. Moreover, the Weibull distribution does reflect an increasing hazard rate that does seem to be a logical argument for the fatigue process. The two parameters composing the statistical model represent fatigue variability, shape parameter α , and the fatigue performance of the structural detail--the scale parameter β . It was decided that with the assumption that both parameters are unknown, computed analyses would be overly conservative and a more acceptable solution could result if some value for one of the parameters was established. The scale parameter was known to be influenced by all the variables of material, geometry, loads, environment, etc.--and therefore was obviously not the appropriate parameter for this exploratory task. Consequently, effort was concentrated on establishing the behavior of the shape parameter under actual fatigue conditions. Unfortunately, available fatigue data have been almost entirely obtained from tests with groups of limited size, usually involving from two to five specimens. The results of these tests taken on their own merits are worthless for assessing the typical parameter of the parent population, but it was assumed that the evaluation of a large mass of data obtained from numerous fatigue tests would demonstrate the possibility of establishing the shape parameter. This task was of sufficient magnitude that it was decided to limit the study to only the aluminum alloys and to test the feasibility of a reliability approach on aluminum aircraft structures.

A comprehensive literature search of the available aluminum fatigue performance data was conducted, and more than 2,000 groups of data representing approximately 11,000 specimens were summarized and analyzed. It should be noted that not all the groups were independent of each other since, on a minority of occasions, a few smaller groups were pooled to form larger groups to facilitate evaluation of certain specified variables within the data sample. More data were collected during the literature search than were actually analyzed; some obvious trends observed during the reduction of the previously mentioned groups of data rendered unnecessary an analysis of all the data collected. These observed trends concerned data from rotating bending tests, data on hand forgings, and data from tests on unnotched specimens. The first two types of data both demonstrated considerably greater scatter than was noted for typical aircraft structures, whereas the third type showed notably lower scatter. Similar trends can be observed by examining the tabulated results presented in Ref. 12.

b. Analytical Procedure

The analytical technique adopted for estimating the Weibull shape parameter α involved the numerical solution for the maximum likelihood estimate (MLE), which was considered to provide either the best¹ estimate or nearly so for this test and indeed for most other applications. The estimating equations for both complete and censored samples given in Ref. 13 are not explicit and had to be solved numerically by the Newton iterative procedure, which required the use of a computer.

A comprehensive computer program was generated that encompasses some of the many variables contained in the test data. For example, the variables of differing materials, geometries, loading conditions, laboratory types versus full-scale specimens, etc., have been identified, and the computer output has been arranged to provide this information. A breakdown of the 11-digit description code used in the program is given in Appendix II. The initial values generated for each data group were point estimates of the shape parameter $\hat{\alpha}$ obtained from the unbiased maximum likelihood estimates of κ , where $\alpha = 1/\kappa$, and the unbiased MLE of the scale parameter or characteristic life $\hat{\theta}$. The value of characteristic life has been included to complete the description of the data only and has not been used for any ensuing analyses.

A study of these point estimates of the shape parameter showed that several data resulted in very small values of α , signifying high scatter. A closer scrutiny revealed a consistent trend in these data, namely, the existence of stronger specimens with correspondingly higher cycles-to-failure within what may be called a typical sampling of fatigue data. The results studied would suggest that these high values occur within the upper 10% band of the failure times of a fatigue sample. The Weibull model cannot accept the existence of high-time outliers and when operating on data containing this phenomenon attempts to account for them by first overcompensating and then indicating very low time failures. To illustrate this point a few simulated groups of data were analyzed and the results given in Table I.

An examination of examples 1 and 2 from Table I shows that the bulk of the data was kept constant but that, in the first case, one specimen had a life an order of magnitude above the average, whereas the second example had an early failure an order below the average. It was notable that example 1 with the high-time outlier showed extremely high scatter with correspondingly low cyclic values at the 10% or less failure probabilities, but example 2 with the low-time failure was treated as moderately high scatter, with computed probabilities of failure that were more consistent with the data.

¹The word "best", as used here, has a mathematical definition. An estimator is best if it possesses minimum variance among all estimators. It can be shown that the MLE is the best asymptotically normal estimate.

This problem does not disqualify the Weibull distribution as untypical of fatigue data; it merely suggests that the minority of data, containing specimens that were much stronger than the average, should be censored to exclude these specimens, which obviously come from a different population, that is, have a different scale parameter β . This process is by no means unprecedented, as Weibull himself has observed (14 and 15): "Some of the specimens may endure a number of stress cycles much larger than estimated from the distribution function" and "There is no sense trying to fit a single function, normal or not, to the complete distribution. For this reason, the data have been censored, choosing a point of truncation well below the 'knee' ($p = 90\%$)."

It should be reemphasized that the best estimate comes from a consideration of all the results in a data set except for those groups containing specimens from mixed populations when it would be erroneous to fit all the data to one distribution.

As a result of the previous arguments a criterion was established in the MLE computer program such that whenever high-time outliers were involved, a reiterative estimation procedure was conducted to remove their influence on the shape parameter. The technique that was developed is best described by referring to the examples given in Table II. The three groups of simulated data presented are identical, except that the second group contains two additional high-time outliers that are an order of magnitude above the majority of the data, and the third group with two low-time failures an order of magnitude below the average of the remaining results. In example 1, the estimate of the reciprocal shape parameter fell within the acceptable range of $\hat{k} < 0.50$ and so no censoring was attempted. However, both examples 2 and 3 contained data that resulted in estimates of the reciprocal shape parameter that were above the arbitrary threshold and that consequently initiated the censoring procedure. It was noted that in example 2 the rejection of the first high-time outlier did not cause much fluctuation in the estimate of $\hat{k}$, but with rejection of the second outlier a dramatic change in $\hat{k}$ was effected. (See second and third estimate, where the ratio of second estimate/third estimate > 1.50). Further censoring of the data verified this estimate of the reciprocal shape parameter as stable and therefore acceptable. In example 3, censoring was again attempted because of the high scatter indicated by the initial estimate. However, this scatter was the result of the two low-time failures and the censoring of any longer lived specimens could not improve on the initial estimate, which consequently remained unchanged. In summary, this heuristic procedure was used to calculate maximum-likelihood-point estimates of the data shape parameters, where--for the large majority of the groups--all the results were utilized in the analysis, but for the remaining minority of groups some censoring of the data was necessary to obtain reliable estimates.

An additional, more theoretically acceptable estimation procedure, which also circumvented the problem of the high-time outlier, has been investigated and a program developed around this estimator. The ensuing Analysis estimates the Weibull shape parameter after considering

only the first- and second-ordered failures from any group of data of any size n . The argument for this estimator was, as before, the great interest of the airplane designer regarding the expected minimum fatigue performance of a structure. Furthermore, it was known that the extremal values of a population tended toward the Weibull distribution in behavior, and the examination of the initial failures using this statistical model appeared justified. This report has used the unique, linear, unbiased invariant estimator of the Weibull shape parameter for the two-ordered-failure estimation procedure, namely, a derivative of the maximum-likelihood estimator of κ ($\approx 1/a$), from consideration of the first and second of n total failures [Mann (16)].

One further problem, namely, how to evaluate the estimates of the shape parameters resulting from the analyses of the mass of collected fatigue data, was investigated. It must be remembered that the vast majority of the data came from a multiplicity of test groups of small sample size that were of limited use individually but that collectively were of sufficient mass to substantiate the premise that their average value would converge on the true value. The problem of weighting estimates from groups of differing sample size was examined in two separate ways. It had been noted that groups of a sample size of two, three, four, and five specimens appeared to be sufficiently numerous that a separate treatment of each sample size was feasible and consequently it was attempted. It was later observed that in Mann's recent paper (17) a procedure for weighting unbiased estimates from groups of differing size had been used; this procedure was therefore incorporated into the investigation, thereby providing the means for generating an unbiased estimate of the weighted average value of the shape parameter for the mass of fatigue performance data. Unfortunately, it was not possible to weight in the minority of data of small sample size that had been censored either during testing or by the high-time-outlier censoring process described earlier. This comment applies only to the MLE procedure and results because two requisites of the weighting process, namely, a knowledge of the bias and variance values for censored data, were unknown. Monte-Carlo methods had been used to generate some of the desired values, but further results are necessary to establish a comprehensive listing that can then be incorporated into the weighting procedure. This limitation is of no real consequence, however, because only a few groups of data were affected and unaccounted for. Exceptions to this limitation occurred whenever the groups of censored data were sufficiently large that asymptotic theory could obviously be applied.

More detailed descriptions of the analytical techniques mentioned in the preceding paragraphs are given in Sec. IV.

2. RESULTS OF THEORETICAL STUDIES ON POPULATION PARAMETERS

An examination of the maximum-likelihood estimating equations of complete or certain censored data revealed that the following quantities were parameter-free, that is, independent of the parent population parameters (refer to Appendix I):

$$\begin{aligned}U &= \hat{\alpha}/\alpha \\V &= (\hat{\beta}/\beta) \hat{\alpha} \\W &= (\hat{\beta}/\beta)^3\end{aligned}$$

The unknown population parameters α and β are the true Weibull shape and scale values respectively, whereas $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\beta}$ are the corresponding MLE, with $\hat{\beta}$ the value when α is known and $\hat{\beta}$ when α is unknown.

Because the distribution of the statistic W is known exactly from theory, but those of U and V were unknown, computer simulation techniques were used in conjunction with MLE procedures to obtain empirical distributions for the unknown quantities mentioned above. Some numerical results are given in Tables III, IV, and V; these results were plotted on normal probability paper (Figs. 4, 5, and 6) to indicate, graphically, the deviation of the important statistics $1/U$, V , and W , from the "perfect" value unity for various groups of data of finite sample size.

Figure 4 shows the reciprocal transformation of the empiric distribution of $\hat{\alpha}/\alpha$. This reciprocal of U was considered because it had received recent attention in the literature (18). The distribution $1/U$ for the sample size $n = 2$ was also known exactly from theory and has been included to demonstrate the "goodness" of the simulation results obtained in this study.

Figure 5 shows the empirical distribution of the MLE of the Weibull scale parameter β , without the benefit of any prior knowledge regarding the shape parameter α . It is obvious that under this restriction a designer, given the results of a test on five or fewer specimens, must make an unfortunate choice between low confidence in average or characteristic life prediction or excess weight. Figure 6 shows, however, that given a prior knowledge of the exact value of α , samples of only one may be adequate for obtaining both high confidence levels and reasonable weight simultaneously. Some stage between these extremes of no knowledge and complete knowledge of the shape parameter would be representative of reality.

Tables III and IV include results to provide some insight into high-time, single-stage, type-II censoring. Type II censoring involves the cessation of testing after the occurrence of a predetermined number of failures, whereas type I censoring refers to that form of testing in which the maximum number of load applications is predetermined and thus results in the cessation of testing either by specimen failure or by the expiration of the preset time period. Single-stage, type II censoring was of paramount interest not only because it typified the majority of the censored data groups but also because it was the model for the

two-ordered-failure estimation procedure used in this report. Appendix I establishes that under this form of censoring $1/U$, V , and W are parameter-free.

Tables III and IV give the empirical distributions of $1/U$ and V for two examples, namely, the complete case of three failures from a sample of three, and the censored case of three failures from a sample of five specimens. It can be seen that the scale parameter β is more accurately estimated from the censored case of the three weakest in five, but the shape parameter α is estimated equally well from the smaller, complete sample. Now consider the example when all five failure times, in the sample of five, were known, rather than only the three weakest in five. The tables show that the estimation of α is improved by the increased knowledge, but that the estimate of β is improved only slightly. These limited examples do reflect some important trends, such as the improvement in estimation of scatter, or α , gained by the knowledge of both low and high times to failure rather than just one of the extremes. Furthermore, it seems that the third failure in a sample of five is a better indicator of central tendency, or of β , than, for example, is the second failure in a sample of three.

Figure 7 is a joint presentation of computational results obtained during this study and of results given in a recent paper (18). Sampling error in the maximum-likelihood estimate of α was measured by the plot of the variance and of the expected loss of $1/U$ (i.e. $\alpha/\hat{\alpha}$) versus sample size (complete samples). Some additional (rectangular) points were located on this plot and give the expected loss of $\alpha/\bar{\alpha}$. The latter estimate, called the simplified method of moments, is obviously more easily obtained than $\hat{\alpha}$, but is also, as shown in Fig. 7, less accurate. In fact, Ref. 18, which reviews all estimating procedures for the Weibull parameters, obtained results showing that in most cases the maximum-likelihood estimates had the least expected loss and hence the most accuracy of all reviewed estimators.

3. RESULTS OF DATA ANALYSES

a. General Observations

Appendix II itemizes the individual characteristics of each of the collected data groups. Data for 2,000 groups representing 11,000 specimens are listed and include fatigue performance data on the well-known aluminum alloys of 2024, 7075, and 7178, together with some of the lesser used alloys such as 2014 and a variety of the European alloys like DTD687A, DTD610B, etc. Specimens formed from sheet, plate, bar, extrusion, and forging are represented in several configurations ranging from the simple unnotched and notched types to structural simulators--such as mechanically fastened, or bonded, or spot-welded joints--to structural components and full-scale structures. Testing conditions encompassed axial loading, both tensile and compressive; flexural and rotating bending; both constant-amplitude and variable-amplitude testing techniques; and ranged from low cycle (below 10^2 cycles) through to high cycle (above 10^6 cycles) fatigue performance testing. It is also notable that the great majority of the data comes from groups of a sample

size of two to five specimens and that only a small minority of groups contain 20 or more specimens.

A study of the resultant point estimates of the shape parameter given in Appendix II revealed some obvious trends. These concerned the large scatter demonstrated by rotating bending tests and by fatigue data on hand forgings, with both groups responsible for some of the largest scatter values recorded (e.g. $\hat{\sigma} < 0.5$). It was also noted that several tests on axially loaded, edge-notched specimens demonstrated consistently lower scatter than normal. Further investigation revealed that the specimens used in these tests had been manufactured with exceptional care from a controlled stock of material so as to minimize the effects of fatigue scatter on the ensuing tests (Refs. 19, 20, and 21).

The obvious trends just mentioned demonstrated the existence of some data within the collected mass of fatigue results that could be disqualified as untypical of the dispersion expected from aluminum airplane structures. It also suggested the advisability of a closer scrutiny of all the data, which was subsequently undertaken.

b. Factors Influencing Fatigue Scatter

The two-order-statistic estimator in conjunction with a weighting technique, which are both explained in Sec. IV, was used to examine several of the known variables within the fatigue performance data. The results of the analyses have been tabulated in Table VI and plotted in Figs. 8 through 14, which reveal several interesting aspects of the fatigue performance of aluminum. It is apparent from Table VI that the itemized variables are not wholly independent, as any one test result may be included in several of the listed categories. Nevertheless, the comparisons made are justified and demonstrate that with few exceptions fatigue data come from a parent population having a Weibull shape parameter in the range $4 < \alpha < 5$.

The initial run consisted of all the gathered data, which contained data that had very high scatter (e.g. hand forgings, unnotched rotating bending, etc.) and other data with very low scatter from carefully controlled tests. The opposite trends of these data tended to be self-canceling, and the resultant weighted average estimate of κ (i.e. $\hat{\sigma}$) was a fairly acceptable value. The next result summarized only that data suspected of being at some disagreement with the general trends, that is, the items just enumerated. These results were plotted in Fig. 8 and describe the greater scatter that was expected. The third result, represented in Table VI and plotted in Fig. 9, shows the effect of isolating only that data found to typify the fatigue scatter experienced by aircraft structural components. These data included results from:

- 1) All the investigated aluminum alloys
- 2) All the notched configurations, ranging from the simple monolithic notched specimen to the full-scale structural component
- 3) Both axially loaded and flexurally loaded tests
- 4) Both constant- and variable-amplitude tests
- 5) The fatigue performance range of 10^2 to 10^6 cycles

It is obvious that the criteria listed above cover a broad range of data, and the subsequent results and figures are presented to substantiate this conclusion. Before proceeding, however, it should be noted that with the rejection of specific data that had demonstrated untypically large scatter (e.g. notched rotating bending tests, results from hand forgings, low-amplitude/high-life fatigue data, compression-compression test results, and data on bonded joints, together with data showing untypically low scatter [e.g. fatigue tests on unnotched specimens and also one particular set of notched data that had been extremely carefully machined to specifically minimize scatter]), the weighted average estimate of κ is reduced from $R' = 0.26$ for all data to $R' = 0.22$ for the specified data.

Figure 10 compares the cumulative frequencies of the three aluminum alloys: 2024, 7075, and 7178. Only those data meeting the specified criteria (listed in the preceding paragraph) have been analyzed, and it can be seen that there are no obvious differences in the distributions of these materials. The 7178 curve shows some deviation over part of the range, but it should be noted that the sample size was comparatively limited. Figure 11 compares the differing specimen configurations of simple monolithic notched small structural simulators, such as lap joints, and the full-scale structures and structural components. Again no real differences were noted between the various geometries, and a comparison with the data in Fig. 10 showed that the cumulative frequency plots were similar for the differing variables of material and geometry. Figure 12 compares the results of constant-amplitude and variable-amplitude testing techniques, and it can be seen that variable-amplitude testing does show slightly lower scatter. It should be noted that the sample of variable-amplitude data contained considerably fewer groups than the constant-amplitude data, but this alone might not account for all the difference. A closer study of the variable-amplitude data revealed that one set of results obtained from Ref. 22, showed behavior different from the observed trend. It had been noted during the course of this study that the ratio of time to second failure versus time to first failure was, on average, approximately 1.4 [i.e. $E(X_2/X_1) = 1.4$], but for these data it was noted that the initial three or four failures were all within that ratio and that the first and second failures were right on top of each other. An estimate of this sample of data gave a value of $R' = 0.12$, which was considerably below the rest of the variable-amplitude data, where $R' = 0.19$. However, because no obviously acceptable reason was available for the rejection of these data, they were retained in the variable-amplitude sample.

Figure 13 plots the simple monolithic unnotched data, bonded joints data, and low-amplitude/high-life fatigue performance data. It is obvious that these results are substantially different from those given by the qualified data, and they were consequently disqualified as being untypical of the variability expected from aluminum aircraft structures. Furthermore, it could be argued that laboratory-type unnotched specimens were sufficiently different from structural details containing a multitude of holes and discontinuities that their worth as a test specimen was doubtful. The bonded data came from some older reports, which

exhibited some inconsistencies in the bonding process and thus contained test results with extremely early failures and therefore large scatter. Finally, low-amplitude/high-cycle data reflect the effects of the endurance limit where the shallow slope of the S-N curve tends to exaggerate any differences in the test loading. The airplane structure is designed for more finite lifetimes, and the exaggerated scatter of the very-long-lived tests would be unrepresentative of this design parameter. The comments enumerated above add some further justification for neglecting these data from the estimation of the typical shape parameter.

Having observed the large scatter of the data from high-life testing, the remaining mass of data was examined to check for any trends showing increase in scatter with increase in cyclic lives. The range of data between 70 and 10^6 cycles of constant-amplitude loading was broken into five ranges that were considered of general interest to the designer, and estimates of the shape parameter were conducted for these ranges. Figure 14 shows these results and demonstrates that within the broad range of 70 to 10^6 cycles fatigue scatter does not increase with cyclic life. However, above and below this range scatter was noted to increase, which could be expected considering the flat tails at either end of the S-N curve.

These analyses of the mass of collected data have revealed several important facts regarding the fatigue scatter of aluminum alloys. They have shown that, with certain specific restrictions, fatigue scatter did not vary with:

- 1) The material of the aluminum alloy specimen
- 2) The geometry of the notched specimen
- 3) The cyclic life of the specimen
- 4) The fatigue test machine
- 5) The type of loading (whether constant or variable amplitude)

Actually, a trend toward marginally lower scatter was observed from variable-amplitude data when compared with constant-amplitude data, but, because the variable-amplitude data contained considerably fewer samples, further work would be necessary to make any more of this slight trend.

It is realized that these results do not substantiate some published conclusions (Refs. 23 and 24) that were based on a limited amount of test data of which many were judged to be untypical of aluminum structures. It should be emphasized that conclusions made about population parameters must be generated from a background that is sufficiently large to reduce the problem of both systematic and sampling error, and it is believed that this current investigation has taken a major step toward this goal.

c. Comparison of Empirical and Theoretical Sampling Distributions

During the analysis of the data an observation had been made of the great preponderance of samples of size two, three, four, and five specimens. These individual groups were examined more closely to circumvent the problem of weighting information from groups of differing

sample size. Table VII presents the results of the three analyses conducted: (1) the MLE procedure for data that include high-time-outliers, (2) the ad hoc high-time-outlier censoring procedure, and (3) the two-ordered-failure estimator. The tabulated results demonstrate the improvements in the estimates of $\bar{x}$ that were obtained by the censoring of data containing high-time outliers. The samples of size two could not be censored, for obvious reasons, and therefore do not alter, but the remaining groups all reflect lower scatter with rejection of the high-time outlier and follow a consistent trend regardless of the censoring method used.

Figures 15 through 18 show plots of the percentage frequency and cumulative frequency of $\bar{z}$ for samples of two to five specimens. These empirical distributions have been compared with the theoretical cumulative sampling distributions that were determined from Eq. (IV-13) by using the value of $\bar{z}'$ for the 1,298 groups of qualified data, that is, $\bar{z}' = 0.224$. (See Table VII.) All four figures exhibit the same trends, a similarity of the empirical and theoretical curves, with the data showing slightly less conservatism than that predicted by theory, except at the higher percentiles where a crossover of the curves is observable.

To compensate for this latter behavior it was necessary to adopt some interval estimate of the shape parameter, and a 95% confidence level was assumed to provide as severe an interval as desirable. The qualified data were of such a considerable mass that the resultant deviation of the collective estimator was very small, being in the order of 0.006. As nothing further was known about the distribution of the estimate, the Tchebycheff inequality, which leads to the statement $P(\bar{z} < \bar{z}' - \gamma) > \gamma$, was used for establishing the desired upper bound, $\bar{z}'\gamma$. This resulted in a value of $\bar{z}'0.95 = 0.25$, and curves generated from this number have also been plotted in Figs. 15 through 18. These plotted curves help demonstrate the expected improvement in reliability to be gained by using the interval value of $\bar{z}'$, and it can be seen from the proximity of the theory curves of the weighted mean value and the interval value of $\bar{z}'$ that the added conservatism given by the interval estimate should not result in an excessive increase in the overall "scatter factor."

Figures 19 through 24 are plots of the percentage frequency and cumulative frequency of $\bar{z}$ for specific sample sizes from the total mass of collected data. These have been included to facilitate comparisons between the total collected data and that finally qualified as typical of aluminum aircraft structures. A comparison of these graphs with Figs. 15 through 18 demonstrate the greater divergence between the empirical and theoretical curves for the total data. This is further accentuated by observing the much closer correlation of the sample mean values with the average mean value given in the plots of the qualified data in Figs. 15 through 18. These trends are further verification of the improvement (i.e. reduction) in systematic error that was obtained through rejection of specific data.

Table VIII has been included to substantiate the improvement gained by the editing of the total mass of collected data to exclude those considered to be untypical or unrepresentative of aluminum structural behavior. The results tabulated include the sample size, the number of groups, the estimated value $\hat{\kappa}$, the variance of the observed distribution of $\hat{\kappa}$; and then two theoretical variances, the first based on the individual estimate of κ and the second calculated from the overall weighted average estimate $\hat{\kappa}'$ obtained from all the qualified fatigue performance data. The initial results presented are comparisons of the observed and theoretical values for samples of size two, three, four, and five obtained from an examination of all the collected data. It is obvious from these results that the observed variance was greater than that predicted by theory. The remaining results were obtained from only the data that were qualified as typifying current structural performance, and it can be seen that the observed variance has now reduced to almost the equivalent value as was obtained theoretically. A further comparison of the empirical variance with the theoretical variance obtained from the weighted average value of $\hat{\kappa}'$ also shows a good correlation for the qualified data but a rather poor agreement for the total collected data.

4. DETERMINATION OF SCATTER FACTORS

Table VII gives the results of the analyses conducted on fatigue performance data. The two methods used for compensating for the influence of high-time outliers within certain groups of data resulted in two slightly different estimates of κ , namely: $\hat{\kappa} = 0.2416$ for the MLE method using all the data points and $\hat{\kappa}' = 0.2244$ for the two-ordered failure estimating method. Naturally these two estimators are weighted differently; the deviation of the former was approximately 0.003, whereas the latter was approximately 0.006. Using these values, interval estimates of κ were established at the 95% confidence level through the Tchebycheff inequality, and the resultant values were found to be almost identical at: $\hat{\kappa}_{0.95} = 0.2575$ and $\hat{\kappa}'_{0.95} = 0.2525$.

As a consequence of this equality in the results it was decided to adopt the first-two-ordered-failures estimating procedure for the following reasons:

- a) Ease of computation (does not require iterative techniques)
- b) Handles the problem of the high-time outlier without resorting to heuristic techniques
- c) Is an order-statistic approach to the problem

Having established an upper bound for the Weibull shape parameter at $\hat{\alpha}'_{0.95} = 4.0$ (i.e. $\hat{\kappa}'_{0.95} = 0.25$) for all typical aluminum airplane structure, it is possible to study the effects of the variables that combine to produce the "scatter factor." In this report, scatter factor is defined as the ratio of the tested or calculated average or characteristic life versus the design or certifiable life. The scatter-factor variables proposed in this report are defined as:

- a) The sample size factor S_{n_f} , which regulates for the improvement in the estimates of the scale or location parameter that result from increasing the test input information from a single failed specimen to an infinite number of data points.
- b) The reliability factor $S_{\bar{R}}$, which provides the relationship between some level of performance (e.g. mean or characteristic life) and the performance at the desired level of safety for a fleet of one.
- c) The fleet size factor $S_{N_{\bar{R}}}$, which compensates for the decreasing reliability caused by varying the fleet exposure from a single to a multiplicity of units.

The proposed scatter factor is the product of these three variables:

$$\text{Scatter Factor (S)} = S_{n_f} \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$$

The arguments for this approach have already been presented in Sec. II, and the analytical definition of this reliability plan is given in Sec. V.

Table IX has been presented to illustrate the relative influence of any one variable on the overall scatter factor. The characteristic life is the Weibull scale parameter δ , which is estimated by using the MLE equations on the results of full-scale structural fatigue tests. The values presented for the variation of sample size (i.e. S_{n_f}) include the factor for converting the point estimate of δ to a one-sided lower bound estimate at the 95% confidence level. It is readily apparent from the table that only a small penalty is incurred by testing the minimum number of full-scale developmental tests. However, it is equally obvious that the reliability specification and fleet size are critical components on the final magnitude of the scatter factor and therefore require careful consideration when establishing a desired performance goal.

5. APPLICATION OF RELIABILITY ANALYSIS TO AIRPLANE STRUCTURES

a. Example Problems

The proposed reliability analysis plan has been applied to a few structural details for which both full-scale laboratory test results and actual service performance data were available. The airplane considered was a military, jet-engined tanker/transport-type aircraft of approximately 300,000-lb maximum gross weight.

The first example concerned a trailing-edge discontinuity detail on the wing lower surface. From full-scale structural test:

- Time to detected crack = 3,697 spectra on starboard wing only
- Equivalent flight time per load spectrum application = 5 hours
- Time to first detected crack = 18,500 hours

A retrofit package planned to extend the service life had been initiated and, as of January 1969, 268 airplanes of the same particular type had been inspected and modified. Low time for a crack out of this group of inspected airplanes = 2,720 hours.

A comparison of the current fatigue evaluation method and the proposed reliability analysis method is itemized below:

- 1) Arbitrary scatter factor of 4
 - Test life = 18,500 hours
 - Safe life = $18,500/4 = \underline{4,600 \text{ hours}}$
- 2) Reliability analysis
 - Test life on starboard wing = 18,500 hours and the port wing > 18,500 hours
 - Test characteristic life = 22,000 hours

$$\text{from } \hat{\theta} = \left[\frac{1}{n_f} \sum_1^{n_f} Y_1^a + (n-n_f) Y_{(n_f)}^a \right]^{1/a} \quad (V-2)$$

and from Table IX:

Test sample size = 1 failure	$S_{n_f} = 1.32$
Fleet size (268 airplanes) = 536 wings	$S_N = 4.81$
Reliability of mean life of weakest	$S_R = 1.102$
75% reliability of weakest	$S_R = 1.365$
• Mean life of weakest of fleet, therefore,	$= 22,000/7.0$
	$= \underline{3,140 \text{ hours}}$
• 75% reliability of weakest of fleet, therefore,	$= 22,000/8.7$
	$= \underline{2,530 \text{ hours}}$

However, several other structural details were also inspected and modified during installation of the previously mentioned retrofit package, and these results--together with that just given in the example--are tabulated in Table XI. The expected performance given by the reliability analyses and based on test lives of the details or calculated performance based on a test result, all at the 95% confidence level, are also compared. The several differing versions of the reference tanker/transport airplane were examined and are also included in the table. It is immediately obvious that the proposed scatter factors vary widely on both sides of the current value of 4, depending on the size of the exposed fleet and, consequently, estimate safe lives that are different from those currently computed. It is also obvious that the fatigue improvement packages were installed at times that were based on scatter factors ≥ 4 .

A second example again concerns wing structure in which skin cracks were discovered at a critical skin/doubler detail. From the full-scale structural test:

- Time to detected crack = 1,498 spectra on starboard wing only
- Equivalent flight time per load spectrum application = 5 hours
- Time to first detected crack = 7,500 hours

Low-time failure in fleet = 655 hours

A comparison of the current fatigue evaluation method and the proposed reliability analysis method is itemised below:

- 1) Arbitrary scatter factor of 4
 - Test life = 7,500 hours
 - Safe life = $7,500/4 = 1,875$ hours
- 2) Reliability analysis
 - Test life on starboard wing = 7,500 hours and the port wing > 7,500 hours
 - Test characteristic life = 8,920 hours [(from Eq. (V-2))]

and from Table IX:

- | | |
|---|-----------------|
| Test sample size = 1 failure | $S_{nf} = 1.32$ |
| Fleet size (500 airplanes) = 1,000 wings | $S_N = 5.63$ |
| Reliability of mean life of weakest | $S_R = 1.102$ |
| 75% reliability of weakest | $S_R = 1.365$ |
| • Mean life of weakest in fleet, therefore, | $= 8,920/8.2$ |
| | $= 1,100$ hours |
| • 75% reliability of weakest of fleet, therefore, | $= 8,920/10.1$ |
| | $= 880$ hours |

It is readily apparent that the order-statistic application of reliability analysis forecasts a minimum service life that is recognizably less than the conventional approach. Most noteworthy is the closer approximation of actual service data by this proposed approach. An obvious hazard of the proposed reliability analysis plan is its total dependence on the test result, with its assumed equality of test and service environment. It is imperative, therefore, that as accurate and reliable an approximation to service conditions as is practical be considered in establishing the characteristic life of the structure. At this time, however, the actual correlation between service and prediction seems promising.

One further point regarding the preceding examples concerns the choice of degree of reliability of the weakest members. If it is extremely important that the weakest members be guarded against the likelihood of failure, some reliability interval other than median or mean should be considered. A 75% level of reliability was also assumed in the preceding examples for demonstrative reasons only and not as a suggested value for the reliability interval. It can be seen, however, that even this fairly low specification would have proved adequate for predicting the failure in the first example and approached the performance level of the weakest in the second example. It should be added that the second example, although a fatigue failure, had been aggravated by poor initial assembly, thus causing an extremely early failure.

b. Possible Design Penalty From Application of Reliability Analysis Plan

Some additional work was completed to provide a measure of the penalty that might be incurred by the introduction of this proposed reliability analysis. Fatigue performance analyses were conducted at several fatigue critical locations on the jet-engined military tanker/transport aircraft referred to earlier in the discussion. A typical

5-hour mission profile was used in conjunction with gust and maneuver data that had been reduced from SAC VHC data measured on the reference airplane at Castle and Walker Air Force Bases (Ref. 25). Figures 25, 26, and 27 describe the mission profile, gust data, and maneuver data respectively. Reference locations were selected from each of the major components of the airframe and comprehensive fatigue damage analyses conducted to determine their respective performances. These analyses were based on the Palmgren-Miner fatigue damage hypothesis together with stress versus cyclic life data obtained from fatigue tests on full-scale structural components. An example family of S-N curves is shown in Fig. 28. Figure 29 was plotted from the results of the computations and describes the gain in fatigue performance obtained by the reduction in the gross allowable design stress.

At this time weight estimates were conducted for all fatigue-critical primary structure on the reference airplane, and the increase in structural weight for a given reduction in gross allowable stress was determined. With this information and the stress increment versus life increment data given in Fig. 29, it was possible to study the effects of the reliability analysis on design weight and then, by reference to Fig. 30, to translate this into the effects on payload or range.

Figure 31 gives the relationship between reliability and weight increase for a structural component designed by fatigue considerations, whereas Fig. 32 shows a plot of the percent increase in structural weight versus the level of reliability of the weakest airplanes in a fleet of 600 aircraft. The initial weight of the airplane reflects current design practice, which includes the scatter factor of 4 for fatigue-critical structure. The increase in weight results directly from the increase in the scatter factors as computed from Table IX. These values were normalized to the current factor of 4, and the resultant ratios represent the increased life factors required by the proposed reliability analysis. Any of the reference structural locations that were examined during this study and that did not meet these new criteria had their gross stress lowered sufficiently to meet them, and the increase in structural weight was subsequently computed. It should be realized that major structural airframe components may have quite different fatigue performance capability, as some components may be almost entirely designed by fatigue considerations, whereas other locations have to meet static requirements primarily, but also have built-in fatigue capacity. As a consequence of these design requirements all the reference components that were analyzed were not found to be equally penalizing, and the plotted curves showing weight increase with specified reliability (Fig. 32) reflect this aspect of aircraft structural design.

One other very important assumption made for this weight increase study needs further clarification. It was considered essential that in order to test the feasibility of the reliability analysis an upper bound condition was necessary to determine the maximum penalty that could be incurred by this proposed approach. Consequently, it was assumed that

the only way of meeting the new design goal was by lowering the gross design stress for all structural components that were both fatigue oriented and related to the reference locations that had been affected by the new analysis. This is obviously a pessimistic assumption, as no allowance was made for the possibility of reaching the revised goal by a redesign or modification of the existing detail structure. Nevertheless, Fig. 32 demonstrates that, even for this upper bound condition, a weight penalty of 3.6% of the primary structural weight was sufficient to provide a median reliability on the weakest of a fleet of 600 airplanes, and as much as 95% reliability was obtained by a 7% increase in the weight of the primary structure.

The lower curve on Fig. 32 represents the maximum weight penalty that would be incurred if the designer were to specify reliability on the second failure in the fleet. This plotted result was based on the values presented in Table X, which tabulates scatter factors for the second failure of a fleet. It is immediately obvious from a comparison of the weight plots that if a criterion based on the second failure were acceptable, a much lower weight penalty would be incurred. For example, it can be seen that the weight increment that would provide median reliability of the weakest member in 600 airplanes would also result in an 80% level of reliability of the second weakest. Putting this another way, a design criterion based on the second failure of the fleet would require about two-thirds of the weight increment necessary for the same level of reliability of the first failure in the fleet.

The plots in Fig. 30 give the percent decrease in payload and range respectively versus percent increase in structural weight. These plots were used to develop Figs. 33 and 34, which show the decrease in payload or range versus degree of reliability of the weakest airplanes in a fleet of 600. As in Fig. 32 the upper and lower curves represent the penalty incurred by specification of the first or second failures respectively and, as before, an effective lowering of the required additional weight is demonstrated. The maximum payload condition used in this analysis amounts to approximately 27.5% of the gross weight of the reference airplane. It is obvious that the plotted results of payload versus reliability are intrinsically dependent on this figure and that other airplanes of greater or lower payload capability would be affected either less or considerably more than the reference airplane. However, although this argument is undoubtedly true, it should be remembered that the particular airplane was chosen because of the availability of specific data and without prior knowledge of the outcome.

It must be reemphasized that these studies are limited to aluminum structures only, as the reliability analysis can account for only this material at the present time. However, the large majority of the airplane structure is composed of this material and consequently it is believed that the results presented are representative of the entire airplane and serve to demonstrate the feasibility of the proposed reliability plan.

To further illustrate the application of the reliability plan, it is assumed that:

- Airplane average life = 40,000 hours
then, under present criteria,
safe life = $40,000/4 = 10,000$ hours
- Scatter factor from reliability estimate obtained from Table IX:

$S_{n_f} = 1.32$ (for one test detail)	}	$S = 7.2$
$S_N = 4.96$ (for $N = 600$)		
$S_{\bar{R}} = 1.102$ (mean life)		
- Mean life of weakest = $40,000/7.2 = 5,600$ hours
- Ratio of life = $10,000/5,600 = 1.79$

That is, the Weibull-distribution-based reliability criterion requires a 79% increase in life to compare with the currently specified value of 10,000 hours. From Fig. 29, a 79% life improvement requires a 15% reduction in stress, which translates into a 3.6% increase in structural weight, as shown in Fig. 32.

In other words a 3.6% increase in structural weight would be sufficient to provide enough reliability that the mean performance of the weakest of a fleet of 600 airplanes would equal or exceed 10,000 hours. Furthermore, this increase in structural weight translates into a 2.8% decrease in payload or a 3.0% decrease in range for the type of airplane under consideration. Most importantly, it should be reemphasized that the number of exposed details (i.e. fleet size) as well as the number of test details demonstrating the fatigue performance level are the significant elements of this reliability approach.

6. RELIABILITY ANALYSIS BASED ON THE LOG-NORMAL DISTRIBUTION

a. Results of Data Analyses

Historically the log-normal distribution has been accepted as a reasonable distribution function for fatigue life even at small probabilities of failure. Consequently, it is a very familiar tool within the aircraft industry and as such has been the basis of many past and present assessment techniques. Furthermore, a great deal is known about estimating and establishing confidence bounds for the two normal parameters, especially for uncensored samples. For these reasons it was decided that the log-normal model merited investigation as a possible basis for a reliability analysis.

The approach used parallels the work described in the preceding discussion on the Weibull distribution, except that the two-ordered-failure-estimation procedure was not extended to the log-normal model. This does not imply that the work accomplished with this distribution model was inferior to that performed with the Weibull model but simply that the timely application of order statistics was not possible for estimating the shape parameter of the parent population. As a result this was obtained by the MLE procedure (Ref. 26) after censoring of data that contained high-time outliers.

The results of the point estimates of the shape and scale parameters are given in Appendix II, and the estimates of the weighted average values of shape parameter are summarized in Table XII. These tabulated results demonstrate trends similar to those observed for the Weibull model, namely, an improvement in the magnitude of the answers with the censoring of the high-time outliers. This effect is illustrated in Figs. 35 through 38. These are plots of the percentage frequency and cumulative frequency distributions of the unbiased shape parameter σ for the samples of size two to five specimens that do not contain high-time outliers. Cumulative frequency plots for data that have not been censored for high-time outliers are compared on these figures and can be observed to exhibit greater scatter.

Figures 39 through 42 are plots of the empirical and theoretical sampling distributions for the same groups of size two to five specimens. These theoretical curves have been generated from the weighted average value of all the qualified data, that is, $\bar{\sigma} = 0.135$. (See Table XII.) An interval estimate of this point value was calculated from assumptions of normality and was found to be $\bar{\sigma}_{0.95} = 0.14$. The normal assumption was justified, for it was known that the estimate followed a χ^2 -distribution, which reduced to normality because of the very large data sample. It is worth mentioning that as a result of the weighting techniques used in this analysis, the 1,121 groups of data used in estimating the above values of the shape parameter are theoretically the equivalent of a test sample containing in excess of 3,500 data points. Curves representing the 95% confidence upper bound value have been included in Figs. 39 through 42. These figures demonstrate that the empirical and theoretical values are similarly distributed but that the theoretical values are displaced toward slightly higher scatter except at the upper percentiles.

Figures 39 through 42 show that the sample averages were higher than the interval estimate given by all the qualified data, even though only 15% of the data was distributed to the right of the values predicted by theory. However, these data result in increasing the estimated weighted average value of the shape parameter, especially as the estimation procedure used for the log-normal model computes the variance rather than the shape parameter. It is believed that the direct estimation of the unbiased shape parameter rather than the traditional procedure of taking the square root of the unbiased variance would result in a slight lowering in the value of the average shape parameter and consequently an improvement in the proximity of the empirical and theoretical distribution plots. This expected trend can be demonstrated by referring to Figs. 43 and 44, which are the plots of the Weibull shape parameters obtained by the MLE procedure. A comparison of these graphs with Figs. 40 and 41 demonstrates similar behavior, except that the Weibull empirical and theoretical curves are in closer proximity than those for the log-normal case. This explanation does not preclude the additional possibility that part or all of the improved fit is inherent to the Weibull model itself.

In keeping with the procedures described earlier for the Weibull model, scatter factors were computed based on the interval estimate $0.95 = 0.14$. As before, factors were generated for the influence of sample size, degree of reliability, and fleet size factor, and are tabulated in Tables XIII and XIV to illustrate the relative importance of the three variables. These factors are noted to be of relatively equivalent weight, unlike the Weibull model in which only a small penalty can be attributed to the lack of an infinitely large test sample. It is also obvious that the factors are generally of a lower order than the equivalent Weibull values and that they do not increase as rapidly with expanded fleet sizes or higher reliability.

b. Example Problems

The examples worked out on pages 21, 22, and 23 may now be reevaluated using assumptions of log-normality.

The first example concerned a trailing-edge discontinuity detail. From full-scale structural test: Time to first crack = 18,500 hours and low-time failure in 268 inspected airplanes = 2,720 hours. From Table XIII:

Test sample size = 1 failure	$S_n = 1.70$
Reliability of median life of weakest	$S_R = 1.0$
Fleet size of 268 airplanes	$S_{NR} = 2.50$
then median life of weakest of fleet	$= 18,500/4.25 = 4,350$ hours
and current method computes safe life	$= 18,500/4.0 = 4,600$ hours

The second example concerned a critical skin/doubler detail. From full-scale structural test, time to crack = 7,500 hours and low-time failure in 500 airplanes = 655 hours. From Table XIII:

Test sample size = 1 failure	$S_n = 1.70$
Reliability of median life of weakest	$S_R = 1.00$
Fleet size of 500 airplanes	$S_{NR} = 2.65$
then median life of weakest of fleet	$= 7,500/1.70 \times 1.0 \times 2.65$
	$= 1,670$ hours
and current method computes safe life	$= 7,500/4.0 = 1,875$ hours

It is again apparent that despite a change in the assumed distribution to the log-normal model, the results still demonstrate the lower order of reliability that can be expected by application of the arbitrary scatter factor of 4, that is, less than 50% reliability on the weakest members of a large fleet.

One additional item needs further discussion, namely, the technique used in establishing the mean life of the respective details. A comparison with the earlier examples on pages 21, 22, and 23 shows that in the former case account was taken of the failed and unfailed starboard and port test wings, whereas in the log-normal case the wing was considered as one total unit. This was a necessity at this time, for although tools are available for obtaining point estimates from censored data of limited sample size

their bias and variance are not known and hence it is not currently possible to determine a suitable interval estimate. However, the test was considered as a complete sample and by adopting the same criterion for the fleet- that is, each airplane has one complete wing--it was possible to work the problem.

SECTION IV

MATHEMATICAL RESULTS FOR SHAPE-PARAMETER ESTIMATION

The mathematical results necessary to obtain a numerical estimate of aluminum alloy structural fatigue "scatter" are listed and briefly described in this section. With reference to the schematic (Fig. 2) of the reliability analysis, this section corresponds to the second stage of the plan. Unlike the third, fourth, and fifth stages, this part of the analysis, once completed, does not have to be repeated for subsequent applications.

1. STATEMENT OF THE PROBLEM

From a large number of small samples of applicable fatigue data obtain a precise one-sided confidence interval estimate of the distribution shape parameter for both the Weibull and log-normal time-to-failure models.

2. GENERAL SOLUTION

It must first be assumed that the k selected samples of data come from populations with different scale parameters but equal shape parameters when applying either the Weibull or log-normal model. The error in this assumption may be evaluated at the conclusion of the exercise by comparing the theoretical sampling distributions of the shape-parameter estimator with the observed distributions of the data estimates.

Because of the above assumption the estimators of the shape parameter used must be invariant estimators, that is, independent of the scale-parameter values. Since the large number of estimates of the various data groups or samples can be averaged to obtain one comparatively accurate estimate, it is obviously advisable to work with unbiased estimators.

In addition to these reasons, invariant unbiased shape parameter estimators will be used so that the following important theorem,² stated without proof, can be applied to provide interval estimates.

Theorem: Let $\hat{\lambda}_i$ be an unbiased invariant estimate of the true parameter λ from the i th of k data groups. If the variance of $\hat{\lambda}_i$ is equal to $Q_i \lambda^2$, then the estimate

$$\hat{\lambda} = \frac{\sum_{i=1}^k \hat{\lambda}_i / Q_i}{\sum_{i=1}^k 1 / Q_i} \quad (\text{IV-1})$$

is an unbiased estimate of λ with variance

²Refer to Mann (Ref. 17, p. 643) for a different usage of this theorem.

$$\text{Var } (\hat{\lambda}') = \frac{\lambda^2}{\sum_{i=1}^k 1/Q_i} \quad (\text{IV-2})$$

Equation (IV-1) is being used to obtain point estimates of the shape parameters from k selected subsets. By combining Eqs. (IV-1) and (IV-2) and using the Tchebycheff inequality (since the distribution of $\hat{\lambda}'$ is not generally known) we obtain precise bounds for λ given by

$$P \left(\frac{\hat{\lambda}'}{1 + C_Y} \leq \lambda \leq \frac{\hat{\lambda}'}{1 - C_Y} \right) \geq \gamma \quad (\text{IV-3})$$

for $C_Y \leq 1$ where

$$C_Y = \left[(1-\gamma) \sum_{i=1}^k (1/Q_i) \right]^{-\frac{1}{2}} \quad (\text{IV-4})$$

Equation (IV-3) will be used in conjunction with all shape-parameter "subestimates" to pinpoint an accurate, but still conservative, value of the shape parameters for use in the reliability assessment plan.

3. SHAPE-PARAMETER ESTIMATORS TO EVALUATE STRUCTURAL FATIGUE SCATTER
Three methods for estimating fatigue scatter have been employed in conjunction with the Weibull model. These are:
 - a) The two-order-statistic estimator in which only the two lowest failure times in each qualified group of data are used to estimate κ .
 - b) The maximum-likelihood estimator with censoring in which all failure times in qualified complete samples are used except those high times judged, by the previously specified procedures, to be outliers
 - c) The maximum-likelihood estimator without censoring in which all failure times in complete samples are used to estimate κ .

Estimators of the type corresponding to the categories in b and c were also employed to estimate σ , the log-normal shape parameter. It probably would have been enlightening to derive and apply a useful two-order-statistic estimator for the log-normal model if time had permitted.

It is emphasized that in all cases the bias, variance, and sampling distributions of these invariant estimators were required and were calculated by means of existing theory, when possible, or by means of Monte-Carlo simulation adopted for this study.

4. WEIBULL TWO-ORDERED-STATISTIC ESTIMATOR

All statistical analyses in this project have been directed toward estimating the earliest failure times in a fleet and, accordingly, it is pertinent to consider estimating the scatter itself from only the earliest two failures in each of the selected groups of data. Since it has been demonstrated (Sec. III) that the Weibull estimates are most affected by relatively unimportant high-time outliers, it is especially relevant to estimate the Weibull shape α from the first and second time-to-failure order statistics. This approach should be nearly insensitive to the effects of high-time outliers that cannot be explained by the Weibull model. The final weighted two-failure estimate will be compared with the weighted likelihood estimate using all the data both with and without the arbitrary procedure for censoring outliers described in Sec. III.

As explained before, a best unbiased invariant estimator of κ is sought so that Eqs. (IV-1) and (IV-3) may be used to obtain a weighted average. Following is an outline of the derivations, developed by Mann (16), of:

- a) The estimator itself [Eq. (IV-12)]
- b) The sampling distribution of the estimator [Eq. (IV-13)]
- c) The variance of this sampling distribution [Eq. (IV-14)]

Let $X_{1,n}$ and $X_{2,n}$ be the first- and second-ordered observations respectively from a sample of n independent Weibull random variables, each with frequency function

$$f(x) = \frac{\alpha}{\beta} \left(\frac{x}{\beta}\right)^{\alpha-1} \exp \left[-\left(\frac{x}{\beta}\right)^{\alpha} \right] \quad \text{for } x > 0 \quad (\text{IV-5})$$

where $\alpha, \beta > 0$ are the parameters of the distribution.

Given Eq. (IV-5), the joint density of the first- and second-order statistics can be derived and is given by

$$f(x_{1,n}, x_{2,n}) = \frac{n!}{(n-2)!} \left(\frac{\alpha}{\beta}\right)^2 (x_{1,n} \cdot x_{2,n})^{\alpha-1} \exp \left\{ -\frac{1}{\beta} \left[x_{1,n}^{\alpha} + (n-1) x_{2,n}^{\alpha} \right] \right\} \quad (\text{IV-6})$$

where: $0 < X_{1,n} \leq X_{2,n} < \infty$

The density of the scale invariant statistic $Z_n = X_{2,n}/X_{1,n}$ can be derived from Eq. (IV-6) as

$$g(z) = \frac{n(n-1) \alpha z^{\alpha-1}}{[1 + (n-1)z^\alpha]^2} \quad \text{for } z \geq 1 \quad (\text{IV-7})$$

It follows that the distribution of Z_n is

$$\begin{aligned} G(z) &= P(Z_n \leq z) \\ &= n \int_1^z \frac{(n-1) du}{[1 + (n-1)u^\alpha]^2} = 1 - \frac{n}{1 + (n-1)z^\alpha} \end{aligned} \quad (\text{IV-8})$$

Since Z_n has scale invariance, it follows that any estimator of $\kappa = 1/\alpha$ that is a function of Z_n alone is also invariant. Mann (16) has derived the maximum-likelihood estimator of κ from the first two of n failures and found it to be expressible in the form

$$\hat{\kappa} = u_n \ln Z_n \quad (\text{IV-9})$$

where the coefficient u_n depends only on n . This led Mann to consider all estimators of the same general form as in Eq. (IV-9), namely, the product of a constant depending on n and $\ln Z_n$. Among these estimators there is only one unbiased invariant estimator $\bar{\kappa}$, and it may be expressed as

$$\bar{\kappa} = b_n \ln Z_n \quad (\text{IV-10})$$

so that the coefficient b_n is given by

$$b_n = \frac{\kappa}{E(\ln Z_n)}$$

It should be noted now that there is no difference between this unbiased two-ordered statistic estimator $\bar{\kappa}$ and the unbiased likelihood estimator $\hat{\kappa}$, which will be introduced later, provided that $\hat{\kappa}$ is calculated at the second observed failure time. However, there will generally be a small numerical difference since the to-be-discussed coefficients B_n are determined approximately by computer simulation, whereas the coefficients b_n can be calculated exactly from the results that follow.

$$\text{The expectation of } \ln Z_n = \int_1^\infty \ln z g(z) dz \quad (\text{IV-11})$$

After several intermediate steps (not shown here) the right side of Eq. (IV-11) can be integrated to obtain

$$E(\ln Z_n) = n \ln \left(\frac{n}{n-1} \right) \kappa$$

so that

$$b_n = \frac{1}{n \ln \left(\frac{n}{n-1} \right)}$$

Therefore, the desired best invariant unbiased estimator $\tilde{\kappa}$ of κ has been completely determined as

$$\tilde{\kappa} = \frac{\ln Z_n}{n \ln \left(\frac{n}{n-1} \right)} \quad (\text{IV-12})$$

The distribution of $\tilde{\kappa}$ is calculated from Eqs. (IV-8) and (IV-12) as

$$P(\tilde{\kappa} < t) = 1 - \frac{n}{1 + (n-1) \left(\frac{n}{n-1} \right)^{\frac{nt}{b_n}}} \text{ for } t > 0 \quad (\text{IV-13})$$

Mann has also calculated the expectation of $\ln^2 Z_n$ and subsequently the variance of $\tilde{\kappa}$ as

$$\text{Var}(\tilde{\kappa}) = b_n^2 \left[2 n \text{Ri} \left(\frac{n}{n-1} \right) - \frac{1}{b_n^2} \right] \kappa^2 \quad (\text{IV-14})$$

where $\text{Ri}(x)$ is Spence's integral with argument (x) , which can be evaluated from the power series

$$\text{Ri}(x) = - \sum_{j=1}^{\infty} \frac{(1-x)^j}{j^2} \text{ for } x \geq 1$$

Equations (IV-12) and (IV-14) have been used with the weighted average-type estimators in Eqs. (IV-1) and (IV-3) to determine κ . Equation (IV-13), the theoretical distribution of the subestimator $\tilde{\kappa}$, has been compared with the observed distribution of the data group estimates in Figs. 15 through 18. The resulting close fit between theory and observation attests to small error in the initial assumption regarding the existence of a unique value of κ that controls the scatter of fatigue lives.

5. WEIBULL MAXIMUM-LIKELIHOOD ESTIMATOR

Prior to application of the two-ordered-statistic type of estimator to minimize the problem of high-fatigue-life outliers, an estimation procedure was sought that would best account for all fatigue life observations in each sample. The MLE was a suitable choice since, for general application, it provides either a best estimate, or nearly so, and for specific application to Weibull shape estimation it outperforms all investigated alternatives. (Refer to Ref. 18.)

On this basis, when high-life outliers do not occur, which has apparently been the case in tests on large multidetailed components, the MLE is recommended for pinpointing the shape-parameter value. However, since the vast majority of the data consists of small, monolithic specimens of the type that contains a minority of definite high outliers, the two-ordered-statistic estimator was relied on in this work to obtain the estimate of κ most relevant to the lower portion of the fatigue life distribution.

As discussed before, this two-ordered-statistic estimator is simply a special case of the MLE where all fatigue life observations in a sample have been ignored except for the two lowest. In view of this relationship and because the problem of high-time outliers may be coped with in any number of other ways (such as by looking at all observations except those judged to be outliers), it was considered worthwhile to discuss some MLE results obtained during this task and prior to application of the order-statistic approach.

a. Weibull MLE Equations

The derivation of the estimators given below for $\alpha, \beta > 0$ was first given by Cohen (13) and, for completeness, is included in Appendix I.

$$\frac{\sum_{i=1}^{n_f} X_i^{1/\hat{\kappa}} \ln K_i + \sum_{i=1}^n G_i^{1/\hat{\kappa}} \ln G_i}{\sum_{i=1}^{n_f} X_i^{1/\hat{\kappa}} + \sum_{i=1}^n G_i^{1/\hat{\kappa}}} - \hat{\kappa} = \frac{1}{n_f} \sum_{i=1}^{n_f} \ln X_i \quad (\text{IV-15})$$

$$\hat{\beta} = \left[\frac{1}{n_f} \left(\sum_{i=1}^{n_f} X_i^{1/\hat{\kappa}} + \sum_{i=1}^n G_i^{1/\hat{\kappa}} \right) \right]^{\hat{\kappa}} \quad (\text{IV-16})$$

Equation (IV-15) is not explicit in $\hat{\kappa}$ and must be solved by an iterative procedure for each new data sampling. The correct value of $\hat{\kappa}$ may then be substituted into Eq. (IV-16) to obtain the MLE of the Weibull scale, termed $\hat{\beta}$. This estimate $\hat{\beta}$ is to be used only when κ is assumed to be unknown. For the case to be considered in the next section, that of known κ , the following equation is applicable:

$$\hat{\beta} = \left[\frac{1}{n_f} \left(\sum_{i=1}^{n_f} X_i^{1/\kappa} + \sum_{i=1}^{n_g} G_i^{1/\kappa} \right) \right]^\kappa \quad (IV-17)$$

b. Sampling Distribution of Weibull MLE $\hat{\kappa}$, $\hat{\beta}$, and $\hat{\beta}^V$

It is believed that, except for the case of $n_f = 2$ studied by Mann (16), the distributions of the MLE $\hat{\kappa}$ and $\hat{\beta}$ of Weibull distribution parameters have never been calculated. However, the distribution of $\hat{\beta}$ is known precisely for samples that are either complete or censored by failure time, and its formulation is included in Appendix I.

The key to the concise description of all three sampling distributions is to express the estimator within an invariant or parameter-free statistic and to find the distribution of that statistic.

For the previously solved case of $\hat{\beta}$ it is shown in Appendix I that the known distribution of the statistic

$$W = \left(\frac{\hat{\beta}}{\beta} \right)^{1/\kappa} \quad (IV-18)$$

is independent of true values of parameters α and β . Likewise, it is shown that the unknown marginal distributions of

$$U = \frac{\hat{\alpha}}{\alpha} = \frac{\kappa}{\hat{\kappa}} \quad (IV-19)$$

and of

$$V = \left(\frac{\hat{\beta}^V}{\beta} \right)^{1/\hat{\kappa}} \quad (IV-20)$$

do not depend on α and β . A method is then outlined in Appendix I for finding these distributions approximately through Monte-Carlo computer simulation. The results of the work, where 2,000 independent random samples were generated per distribution, are presented in Tables III and IV and in Figs. 4 and 5. Notice the excellent agreement between the empirical and the exactly known distributions of U for samples of two observations.

c. Bias and Variance of the Estimator $\hat{\kappa} = 1/\hat{a}$

The bias and variance of $\hat{\kappa}$, in terms of κ , have been evaluated for several complete sample sizes from the empirical distributions of $1/U$. The results are given below in a form easily combined with Eqs. (IV-1) and (IV-3) to obtain an overall estimate of κ from all qualified complete samples:

Complete Sample Size n	Bias Factor B_n	Variance Factor Q_n
2	1.73	0.71
3	1.37	0.35
4	1.25	0.22
5	1.187	0.164
10	1.088	0.073
20	1.047	0.033
∞	1	0

where $E(B_n \hat{\kappa}) = \kappa$ and $\text{Var}(B_n \hat{\kappa}) = Q_n \kappa^2$.

The workable subestimate is then formed by multiplying the likelihood estimate $\hat{\kappa}$ by the coefficient B_n to obtain

$$\hat{\kappa} = B_n \hat{\kappa}$$

an invariant unbiased estimate of κ .

6. LOG-NORMAL MAXIMUM-LIKELIHOOD ESTIMATORS

Assume that the logarithm X_L of the life span is a random variable with a normal distribution, where μ , $\sigma > 0$ are the two parameters of the distribution. Cohen (26) has derived the maximum-likelihood estimators $\hat{\mu}$ and $\hat{\sigma}$ of μ and σ for incomplete samples, as given by

$$\begin{aligned} \bar{X}_L &= \hat{\mu} - \frac{1}{n_f} \sum_{i=1}^{n_g} h_i \\ s^2 &= \hat{\sigma}^2 \left[1 - \frac{1}{n_f} \sum_{i=1}^{n_g} \epsilon_i h_i - \left(\frac{1}{n_f} \sum_{i=1}^{n_g} h_i \right)^2 \right] \end{aligned} \quad (\text{IV-21})$$

where h_i is the estimated hazard function or failure rate at time Z_i of one of the n_g test terminations for reasons other than failure. Thus,

$$h_1 = h(\epsilon_1) = \frac{\phi(\epsilon_1)}{1 - \Phi(\epsilon_1)}$$

$$\Phi(\epsilon_1) = \int_{-\infty}^{\epsilon_1} \phi(t) dt$$

where: $\epsilon_1 = \frac{G_1 - \hat{\mu}}{\hat{\sigma}}$

$$\phi(t) = \frac{1}{\sqrt{2\pi}} \exp \left[-t^2/2 \right]$$

and where $\bar{X}_L$ and s^2 are the mean and variance of the log lives of n_f specimens that failed; that is

$$\bar{X}_L = \sum_{i=1}^{n_f} \frac{X_{L_i}}{n_f} \text{ and } s^2 = \sum_{i=1}^{n_f} (X_{L_i} - \bar{X}_L)^2 / n_f$$

Neither $\hat{\mu}$ nor $\hat{\sigma}$ is given explicitly by Eq. (IV-21) for $n_g \geq 1$, so $\hat{\sigma}$ must be solved by an iterative procedure. For complete samples ($n_g = 0$), Eq. (IV-21) reduces to

$$\hat{\mu} = \bar{X}_L \quad (\text{IV-22})$$

and

$$\hat{\sigma}^2 = s^2 \quad (\text{IV-23})$$

The bias, variance, and sampling distributions of the estimator in Eq. (IV-23) are well known (for example, refer to Ref. 27) and are listed below:

a. Bias of $\hat{\sigma}^2$

$$E(\hat{\sigma}^2) = \frac{n-1}{n} \sigma^2$$

so that

$$E(\hat{\sigma}^2) = \sigma^2$$

in which

$$\hat{\sigma}^2 = \frac{n}{n-1} \hat{\sigma}^2 \quad (\text{IV-24})$$

b) Sampling Distribution and Variance of $\hat{\sigma}^2$

The statistic $(n-1) (\hat{\sigma}^2/\sigma^2)$ is parameter-free and has χ^2 distribution with $(n-1)$ degrees of freedom and, therefore, with variance $2(n-1)$, so that

$$\text{Var} \left[(n-1) \left(\frac{\hat{\sigma}^2}{\sigma^2} \right) \right] = 2 (n-1)$$

therefore,

$$\text{Var} (\hat{\sigma}^2) = \frac{2}{(n-1)} (\sigma^2)^2 \quad (\text{IV-25})$$

For the case of small, incomplete samples, the bias and variance of the estimators in Eq. (IV-21) are not known, but additional computer simulation studies could be attempted to provide these values. At this time only the complete samples and the censored samples with more than 50 observed failure times are used to estimate σ .

The resultant 0.95 confidence interval value $\sigma = 0.14$ was used in all log-normal applications that follow and, somewhat arbitrarily, for application of the Tchebycheff inequality to gage the effect of assuming no failure model.

SECTION V

INTERVAL ESTIMATION OF CERTIFIABLE LIFE FOR THE FLEET

All the estimation and probability theory corresponding to the last three steps of the analysis is discussed in this section. Referring again to Fig. 2, these steps are:

- Step 3: Obtaining a most likely estimate of the distribution of fatigue lives.
- Step 4: Moving back to a high confidence bound estimate of the fatigue life distribution.
- Step 5: Mapping the distribution of step 4 into an order statistical distribution from which a life may be certified for the safety of all or most of the exposed fleet.

To facilitate these steps, which must be repeated with each application of the plan, all relevant equations have been translated into simple relations from which scatter-factor values may be easily calculated. The total scatter factors are henceforth defined as the ratio of one of the best estimators of central life (either $\hat{\theta}$, $10\bar{\mu}$, or $10\bar{\eta}$) and the calculated safe life $\hat{Z}_R$.

1. STATEMENT OF THE PROBLEM

From one sample of structural fatigue data, use a selected time-to-failure model with known shape parameter to specify a valid procedure for estimating, to any desired confidence level, either (1) the distribution of the M^{th} -ordered failure time in a fleet of size N or (2) simply the distribution of an arbitrary (unordered) failure time. Choose one of these distributions at a desired fractile to certify a design life.

2. GENERAL METHOD OF SOLUTION

To obtain as much accuracy as possible or, more precisely, to obtain uniformly minimum (mean-squared) error, maximum-likelihood point estimators of the distribution scale parameters will be used. The sampling distributions of these (unbiased) estimators are, for the most part, known so that interval estimates of the scale parameters may be calculated exactly from the point estimates.

The known shape parameter and the scale-parameter interval estimate completely determine the confidence interval bound on the distribution of unordered times to failure. Since the shape parameter is assumed to be known, this bound has the same failure distribution (Weibull or log-normal) as the point estimate, except that it is scaled backward in time by a constant multiplying factor.

The fractiles of the order-statistic's distribution may then be calculated precisely by means of the well-known cumulative binomial formula. This completes the theoretical application. A fleet life can then be estimated that corresponds to administrative specifications.

3. BEST ESTIMATE OF FATIGUE-LIFE DISTRIBUTION

With the shape-parameter value assumed known, we depend on the full-scale fatigue test to obtain the most likely value of the parent population's central tendency or scale parameter. For this reason it is recognized that the occurrence of high-time outliers in this testing could lead to overly high safe-life estimates. Fortunately, as has been observed in the data, large, complex, multicomponent specimens are not characterized by outliers to anywhere near the extent that simple monolithic specimens are.

This will complete the job of obtaining the fatigue life distribution most representative of the data for the given two-parameter failure model.

a. Point Estimate of Weibull Characteristic Life

As given in Sec. IV [Eq. (IV-17)], the MLE of β , with $\alpha = 1/k$ known, is

$$\hat{\beta} = \left[\frac{1}{n_f} \left(\sum_{i=1}^{n_f} Y_i^\alpha + \sum_{i=1}^n C_i^\alpha \right) \right]^{1/\alpha} \quad (V-1)$$

This estimate is workable, in the sense that its important properties are known, only for those small samples that are complete or censored by failure time. Considering the case of single-stage censoring at the n_f^{th} failure time only, Eq. (V-1) becomes

$$\hat{\beta} = \hat{\beta} = \left[\frac{1}{n_f} \left(\sum_{i=1}^{n_f} Y_i^\alpha + (n-n_f) Y_{(n_f)}^\alpha \right) \right]^{1/\alpha} \quad (V-2)$$

Equation (V-2) gives an unbiased³ uniformly minimum variance estimator for which the sampling distribution is known.

b. Point Estimate of Log-Normal Median Life

For small samples ($n_f \leq 50$), only the case of uncensored samples will be considered here. The relevant MLE is simply the data log-average

$$\hat{\mu} = \hat{\mu} = \frac{1}{n} \sum_{i=1}^n \log Y_i \quad (V-3)$$

This scale parameter estimator is free of bias and possesses minimum variance of expected loss (mean-squared error).

³Actually $E(\hat{\beta}) = \beta$ and $E(\hat{\beta}^\alpha) = \beta^\alpha$

c. Point Estimate of Single Parameter: Tchebycheff Inequality

For this case of no assumed failure model, we will choose to estimate the average of logarithmic failure times $\bar{n} = \log \bar{Y}$. This is consistent with the arbitrary use of $\sigma = 0.14$ as the known value of the standard deviation of logarithms. The arbitrariness arises from the fact that this particular value was influenced by previous assumptions of log normality and here we are applying it as a "known" quantity in a distribution-free limit theorem.

4. LOWER BOUND INTERVAL ESTIMATE OF FATIGUE-LIFE DISTRIBUTION

It is in this step that knowledge of the scatter-controlling shape parameter yields the greatest dividends. For one thing, the analysis is greatly simplified; but far more importantly, the lack of a sampling of many full-scale structural fatigue life observations becomes a small rather than an insurmountable problem. The sampling distributions of the Weibull $\hat{\beta}$ and log-normal $\hat{\eta}$ estimators are given below in terms of a probability statement of confidence level and in terms of a scatter factor S_{n_f} , accounting for finite sample size alone. The same task is done with the data log-average estimator $\bar{n}$, using distribution-free methods.

a. Exact Lower Confidence Bounds for Weibull Scale Parameter

Appendix I contains the proof of a theorem important for our applications; namely, that the statistic $2n_f W = 2n_f (\hat{\beta}/\beta)^\alpha$ has the chi-squared distribution with $2n_f$ degrees of freedom. It is therefore possible to express an interval estimate of β as

$$\hat{\beta}_Y = \hat{\beta} \left[\frac{1}{2n_f} \chi_Y^2 (2n_f) \right]^{-1/\alpha} \quad (V-4)$$

where $\chi_Y^2 (2n_f)$ is the γ -fractile of the chi-squared variate with $2n_f$ degrees of freedom and where $\hat{\beta}_Y$ satisfies

$$P(\hat{\beta}_Y \leq \beta) = \gamma$$

The scatter factor S_{n_f} can then be defined that shows the penalty paid to gain confidence γ from a finite sample size. This factor is expressed as

$$S_{n_f} = \frac{\hat{\beta}}{\hat{\beta}_Y} = \left[\frac{1}{2n_f} \chi_Y^2 (2n_f) \right]^{1/\alpha} \quad (V-5)$$

b. Exact Lower Confidence Bounds for Log-Normal Scale Parameter

One of the most widely used statistics is $\frac{\hat{\mu} - \mu}{\sigma/\sqrt{n}}$, which, for the case of complete samples, has standard normal distribution. It is therefore possible to obtain an exact lower bound of μ as

$$\check{\mu}_\gamma = \hat{\mu} + k_\gamma \frac{\sigma}{\sqrt{n}} \quad (V-6)$$

where the standard normal deviate k_γ is a negative number when γ is greater than 0.5.

Equation (V-6) leads directly to the statement of confidence

$$P(\check{\mu}_\gamma \leq \mu) = \gamma \quad (V-7)$$

since from properties of the normal distribution we can say

$$P(\check{\mu} \geq \hat{\mu} + k_\gamma \sigma/\sqrt{n}) = \gamma \quad (V-8)$$

Since $\check{\mu}_\gamma$ and μ are in terms of log life, we define S_n as

$$S_n = 10^{(\mu - \check{\mu}_\gamma)} = 10^{-k_\gamma \frac{\sigma}{\sqrt{n}}} \quad (V-9)$$

c. Precise Confidence Bounds, No Distribution Assumed

If absolutely nothing is known or assumed about the distribution of fatigue lives except the value of its (logarithmic) variance, one (weak) tool that may be applied to bound η is the distribution-free Tchebycheff inequality. If the variance of log lives is σ^2 , the variance of $\bar{\eta}$ is known to be σ^2/n , regardless of the distribution. We may then write, for any number, $\delta \geq 1$,

$$P(|\bar{\eta} - \eta| \leq \delta \frac{\sigma}{\sqrt{n}}) \geq 1 - \frac{1}{\delta^2} = \gamma \quad (V-10)$$

This allows the construction of a lower bound, $\check{\eta}_\gamma$, given by

$$\check{\eta}_\gamma = \bar{\eta} - \frac{\sigma}{\sqrt{n} (1-\gamma)} \quad (V-11)$$

which satisfies

$$P(\check{\eta}_\gamma \leq \eta) \geq \gamma \quad (V-12)$$

We can evaluate the scatter factor by means of Eq. (V-11) as

$$S_n = 10^{(\hat{n} - \bar{X}_Y)} = 10^{\left(\frac{\sigma}{\sqrt{n(1-\gamma)}}\right)} \quad (V-13)$$

5. FACTORS FOR LOWER BOUND ESTIMATE OF A CERTIFIABLE LIFE

At this stage, the final part of the analysis, all estimation work has been concluded. In all that follows, the lower bound interval estimate $\hat{F}_Y(y)$ is treated mathematically as if it were the true fatigue-life distribution $F(y)$. Of course, the resultant safe-life calculation is only an estimate at the same chosen level of confidence γ .

It is assumed here that the following specification, recommended in Sec. II, is made by customer and/or vendor management for a particular component.

With probability $\bar{R}$, the safe life that is being estimated at confidence level γ shall be exceeded by at least $N-M+1$ of the N exposed structural components.

The first task is to transform $\bar{F} = 1-\bar{R}$, the failure probability of the weakest of N identical components, into an equivalent value of F , the failure probability of any randomly selected component. This may be done precisely through the cumulative binomial formula, whose derivation appears in Ref. 28.

The probability of exactly M failures and the probability of at least M failures (equal to the failure probability of the " M^{th} weakest" member) are given, respectively, by

$$P(T = M) = \binom{N}{M} F^M (1-F)^{N-M} \quad (V-14)$$

$$P(T \geq M) = \sum_{i=M}^N \binom{N}{i} F^i (1-F)^{N-i} \quad (V-15)$$

A form of Eq. (V-15) that is easy to calculate for small values of M and large N is

$$P(T \geq M) = \bar{F}_{M;N} = \bar{F} = 1 - \sum_{i=0}^{M-1} \binom{N}{i} F^i (1-F)^{N-i} \quad (V-16)$$

This equation, as mentioned before, was plotted for several values of M and N in Fig. 3.

Strictly speaking, Eq. (V-16) is not the cumulative binomial distribution as implied but simply one minus same. It can always be used to calculate the "general" reliability, associated with a random fleet member, that corresponds to the specified reliability for the M^{th} failure among N members for all integer values; thus,

$$1 < M < N$$

However, since the design parameter advocated is usually associated with the first- or second-order statistic, attention may be restricted to the special cases:

(1) $M = 1, N \geq 1$
where Eq. (V-16) reduces to

$$\bar{F} = \bar{F}_{1;N} = 1 - (1-F)^N \quad (V-17)$$

or, in terms of reliabilities, to

$$\bar{R} = R^N \quad (V-18)$$

(2) $M = 2, N \geq 2$
where Eq. (V-16) reduces to

$$\bar{F} = \bar{F}_{2;N} = 1 - (1-F)^N - NF(1-F)^{N-1} \quad (V-19)$$

or, in terms of reliabilities, to

$$\bar{R} = NR^{N-1} \left[1 - R \left(\frac{N-1}{N} \right) \right] \quad (V-20)$$

a. Estimate of Safe Life: Weibull Model

As shown previously, the lower bound interval estimate of reliability R as a function of component age y is given by

$$\check{R}(y) = 1 - \check{F}(y) = \exp \left[-(y/\check{\beta})^a \right] \quad (V-21)$$

Assume now that the minimum acceptable value of R has been calculated, as a function of specified values of M , N , and $\bar{R}$, by means of Eq. (V-16). Then we need only solve for y in Eq. (V-21) to obtain the "inverse reliability function" and, therefore, the safe life

$$\check{Y}_R = \check{Y}(R) = \check{\beta} [\ln(1/R)]^{1/a} \quad (V-22)$$

The scatter factor accounting for both the fleet exposure and the specified fleet reliability R is simply

$$S_R = \frac{\check{\beta}}{\check{Y}_R} = [\ln(1/R)]^{-1/a} \quad (V-23)$$

For the case where the entire fleet (weakest member) is being protected, we have $M = 1$ and

$$R = \bar{R}^{1/N}$$

So that safe life and scatter factor are given, respectively, by

$$\check{Y}_R = \left[\frac{1}{N} \ln (1/\bar{R}) \right]^{1/\alpha} \quad (V-24)$$

and

$$S_R = \left[\frac{1}{N} \ln (1/\bar{R}) \right]^{-1/\alpha} \quad (V-25)$$

For this case, the safe life and the total scatter factor S can be written as

$$\check{Y}_R = \check{Z}_{\bar{R}} = \hat{\beta} \left[\frac{2n_f}{N} \frac{\ln(1/\bar{R})}{\chi_Y^2(2n_f)} \right]^{1/\alpha} \quad (V-26)$$

and

$$S = S_{n_f} \cdot S_R = \frac{\hat{\beta}}{\check{Y}_R} = \left[\frac{N}{2n_f} \frac{\chi_Y^2(2n_f)}{\ln(1/\bar{R})} \right]^{1/\alpha} \quad (V-27)$$

b. Estimate of Safe Life: Log-Normal Model

The development for the case of the reliability being specified in terms of the time to first failure is no more difficult for this model than for the Weibull model. The resultant safe life and scatter factors are listed below:

$$\check{Y}_R = 10^{\left[\hat{\mu} + k_R \sigma \right]} = 10^{\left[\hat{\mu} + \left(\frac{k_Y}{\sqrt{n}} + k_R \right) \sigma \right]} \quad (V-28)$$

$$S_R = \frac{10^{\hat{\mu}}}{\check{Y}_R} = 10^{-k_R \sigma} \quad (V-29)$$

$$S = S_n \cdot S_R = \frac{10^{\hat{\mu}}}{\check{Y}_R} = 10^{-\left(\frac{k_Y}{\sqrt{n}} + k_R \right) \sigma} \quad (V-30)$$

where $R = \bar{R}^{1/N}$.

c. Estimate of Safe Life: No Model

We again make use of the generally applicable Tchebycheff limit theorem to establish the reliability function for this case as

$$R(y) \geq 1 - \frac{\sigma^2}{(n - \log y)^2}, \quad \log y < n - \sigma \quad (V-31)$$

and for known σ .

The safe-life and scatter-factor equations can then be derived as

$$\check{Y}_R = 10^{\left(\check{n} - \frac{\sigma}{\sqrt{1-\bar{R}} 1/N}\right)} \quad (V-32)$$

or

$$\check{Y}_R = 10^{\left[\check{n} - \left(\frac{1}{\sqrt{n(1-\gamma)}} + \frac{1}{\sqrt{1-\bar{R}} 1/N}\right) \sigma\right]} \quad (V-33)$$

and

$$S_R = \frac{10^{\check{n}}}{\check{Y}_R} = 10^{\left[\frac{\sigma}{\sqrt{1-\bar{R}} 1/N}\right]} \quad (V-34)$$

and, therefore, the total scatter factor is

$$S = S_n \cdot S_R = \frac{10^{\check{n}}}{\check{Y}_R} = 10^{\sigma \left[\frac{1}{\sqrt{n(1-\gamma)}} + \frac{1}{\sqrt{1-\bar{R}} 1/N} \right]} \quad (V-35)$$

To facilitate numerical comparisons and safe-life computations, scatter factors corresponding to various values of all relevant parameters were computed and presented in Tables IX, X, XIII, XIV, and XV and in Fig. 45 through 50. In the tabulations it was arbitrarily decided to subdivide S_R into two factors, $S_{\bar{R}}$ and $S_{N_{\bar{R}}}$, such that for fixed M ,

$$S_R = S_{\bar{R}} \cdot S_{N_{\bar{R}}}$$

This was done to enable a comparison of the factor $S_{\bar{R}}$ required for reliability in just a one-member fleet and of the factor $S_{N_{\bar{R}}}$ required to account for the size N of the exposed fleet. The factor $S_{N_{\bar{R}}}$, as can be inferred from the double subscripts, depends on $\bar{R}$ as well as on N . This condition arises because the order statistic's distribution is usually of a different form than the parent distribution,

so that one simple factor (scalar translation) cannot be used to compute all fractiles of the order statistic's distribution. One exception to this is the Weibull model for $M = 1$, where the distribution of times to first failure is also Weibull with the same shape as the parent. In this case we take the liberty of changing the notation S_{NR} to S_N to symbolize the lack of dependence of S_N upon R .

The parametric study of these scatter factors brought out several expected trends. The log-normal model, with low failure rates or mortality at old age, predicts more chance for a long-lived test specimen and, therefore, higher values of S_{Nf} . The Weibull model, with monotonically and rapidly increasing failure rate, leads to scatter factors S_{NR} and $S_{\bar{R}}$ higher than those of the log-normal model, especially when the fleet is large or the specified reliability is high. Therefore, for the typically large ($N > 100$) fleets of aircraft in operation, the Weibull model would lead to a higher total scatter factor S and a lower safe-life estimate than the log-normal would for a given specification.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

A study of the available options for formulating a reliability plan based on the collected aluminum fatigue test data has induced the following conclusions:

- a) The most feasible method of using the Weibull, or log-normal, time-to-failure model as a basis for aircraft reliability assessment is to first calculate and fix shape-parameter values from a large mass of applicable fatigue data and then to base all subsequent analytical work on these "known" values.
- b) Considering that the applicable fatigue performance data comprised samples from:
 - all the investigated aluminum alloys, which contained both the major 2000- and 7000-series alloys;
 - all the notched configurations, including simple monolithic notched, the less simple structural simulators such as laboratory-type lap joints, butt joints, etc., and the full-scale structural components and structures;
 - axially loaded and flexurally loaded test programs;
 - constant-amplitude and variable-amplitude testing procedures; and
 - a fatigue-life range between 10^2 and 10^6 cycles, it was demonstrated that the estimated shape parameter was not influenced by:
 - 1) material alloy type
 - 2) specimen geometry
 - 3) fatigue test machine
 - 4) test loading procedure
 - 5) cyclic life
- c) Considering the very general conditions listed in conclusion b, it is believed that for most aluminum structural applications a reasonable value of the Weibull shape parameter is $\alpha = 4.0$ and for the log-normal case $\sigma = 0.14$.
- d) Fatigue scatter is greater for the following:
 - 1) rotating beam tests
 - 2) hand forgings
 - 3) compression testing
 - 4) adhesively bonded joints
 - 5) low-amplitude/high-life testing
- e) Fatigue scatter is lower for the following:
 - 1) unnotched specimens
 - 2) ultracarefully manufactured test specimens
- f) Currently the two-ordered-statistic estimator $\tilde{\alpha}$ is the preferred estimator for the task of determining the Weibull shape parameter α from fatigue data, because:
 - 1) $\tilde{\alpha}$ is simple to calculate, as no iterative-type solutions are necessary;

- 2) the idea of emphasizing the lowest failure times in each data group to calculate fatigue scatter is consistent with the concept of specifying safe life as a fractile of the distribution of the lowest failure time in the fleet;
 - 3) an estimation procedure that considers only the lowest two failure times must be nearly insensitive to the occurrence of high-time outliers that are not predicted by the failure time model; and
 - 4) it was demonstrated that a fairly close agreement exists between the observed and theoretical sampling distributions of $\tilde{k}$, which lends credence to the belief that the fatigue performance of the weaker members of a sample or a fleet may be adequately described by the Weibull model.
- g) In the majority of cases, the use of the Weibull distribution model will lead to a lower estimate of safe life than that determined from the log-normal model.
 - h) The Weibull distribution is characterized by a failure rate that increases monotonically and rapidly; consequently, the calculated Weibull scatter factors are largely dependent on specified (high) reliability and fleet exposure.
 - i) The log-normal distribution, by reason of a failure rate that eventually decreases to zero, predicts more chance for possible high-time test failures than does the Weibull model. The calculated log-normal scatter factors reflect this and demonstrate greater dependence on fatigue test sample size than the corresponding Weibull values.
 - j) The results from a reliability analysis based on either of the considered distribution models relative to the current approach to safe-life estimation (i.e. the arbitrary scatter factor of 4) shows that the latter approach may result in a very low degree of reliability of the weakest members of the fleet, and this is emphasized by the large size of some of the current operational fleets.
 - k) The initial results of the reliability analysis demonstrate some promise of correlation between service and predicted fatigue performance.
 - l) The application of the proposed analysis could result in an improvement in fatigue reliability at the cost of some increase in structural weight, with subsequent loss in payload or range.

Having demonstrated the applicability of the reliability plan, the following recommendations can be made.

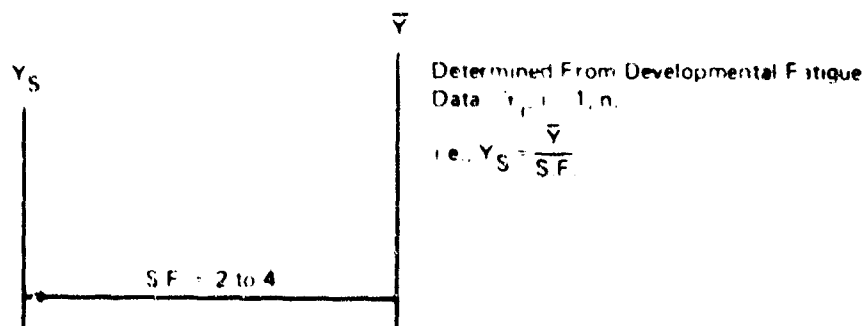
2. RECOMMENDATIONS

- a) The analysis should be extended to cover some other common aircraft materials, such as titanium and high-strength steel.
- b) The Monte-Carlo studies should be continued to complete the listing of bias and variance values for shape-parameter estimates from censored samples of small size for inclusion into the computer program to provide the capability of assimilating these data into the overall weighted estimate.
- c) Other distribution functions should be considered, especially those of a fairly general nature but not necessarily as indefinite as the Tchebycheff limit theorem or other distribution-free assumptions.

It is expected that the collected fatigue data could be used as a guideline toward selection of representative models.

- d) The possibility of devising and applying a two-ordered-statistic estimator for the shape parameters of the log-normal and other time-to-failure models should be investigated.
- e) The results of this study should be incorporated into previously explored failure models that combine the chance static and fatigue modes of failure.

CURRENT APPROACH SCATTER FACTOR METHOD

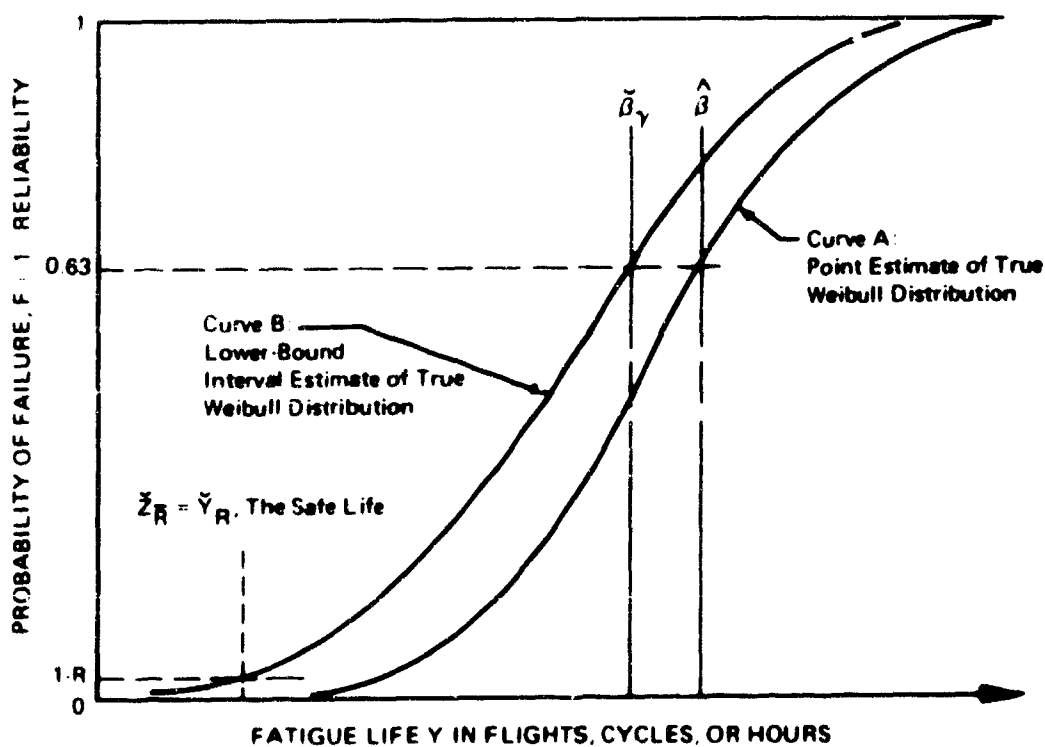


NOTE The design life is taken to be Y_S , the inference seems to be that $P(Y > Y_S)$ is acceptable although undefined.

Figure 1 Schematic Representation of Current Reliability Plan

PROCEDURE

- 1 Assume fatigue life is a random variable with a two-parameter Weibull distribution.
- 2 Estimate the shape parameter α from all applicable data and regard it as fixed in all that follows.
- 3 Estimate the scale parameter β from full-scale fatigue test(s), thereby defining Curve A.
- 4 Using the small full-scale test sample only, obtain a lower interval estimate $\tilde{\beta}_\gamma$ of β , thereby defining Curve B at the confidence level γ .
- 5 Specify or compute a desired reliability R of an arbitrary fleet member. Use Curve B to obtain the corresponding certifiable life $\tilde{Y}_R$.



Specification of Desired Reliability

The value of R , the minimum allowable reliability of a randomly chosen fleet member, may be arbitrarily specified or may be based on and calculated precisely from a specification of the reliability $\tilde{R}$ of the m^{th} weakest of N fleet members.

Figure 2. Outline and Schematic Representation of Proposed Reliability Plan

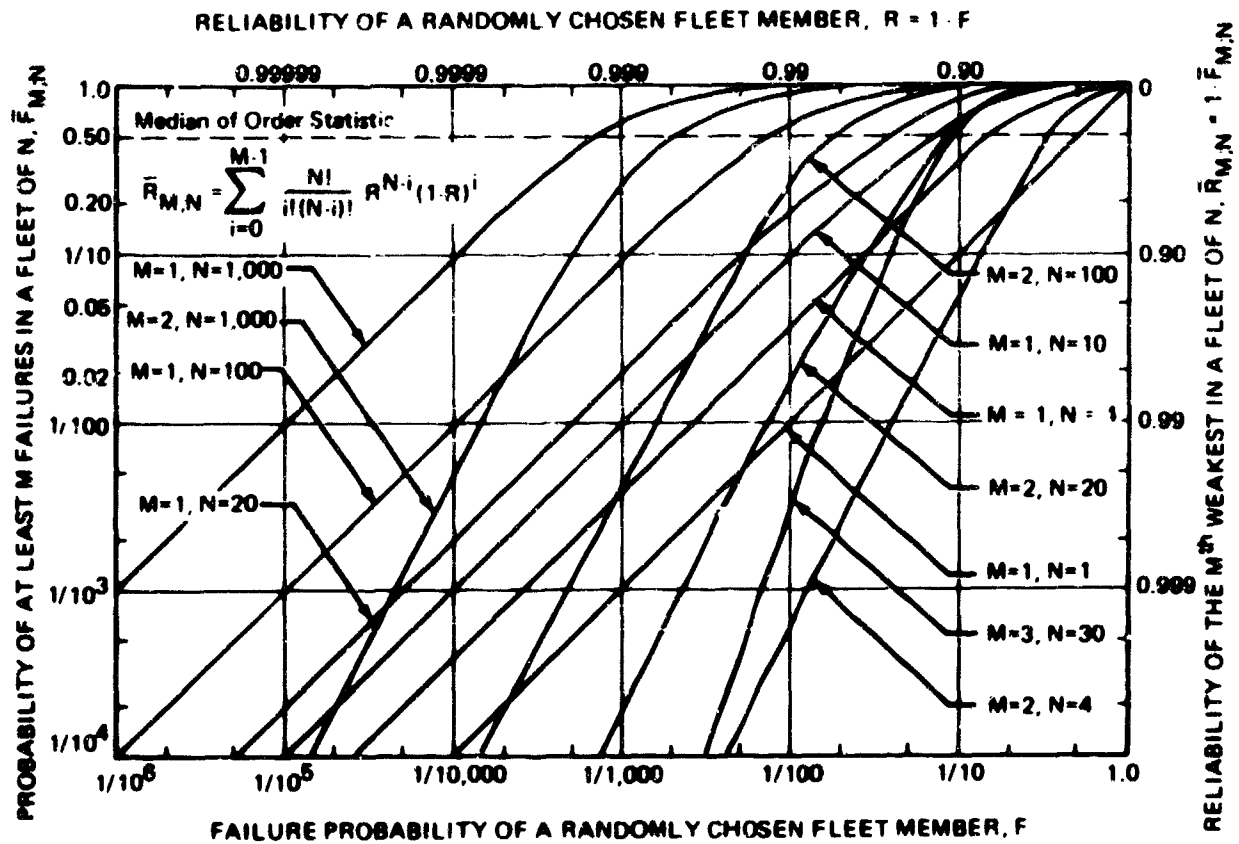


Figure 3. Distribution of Several Order Statistics

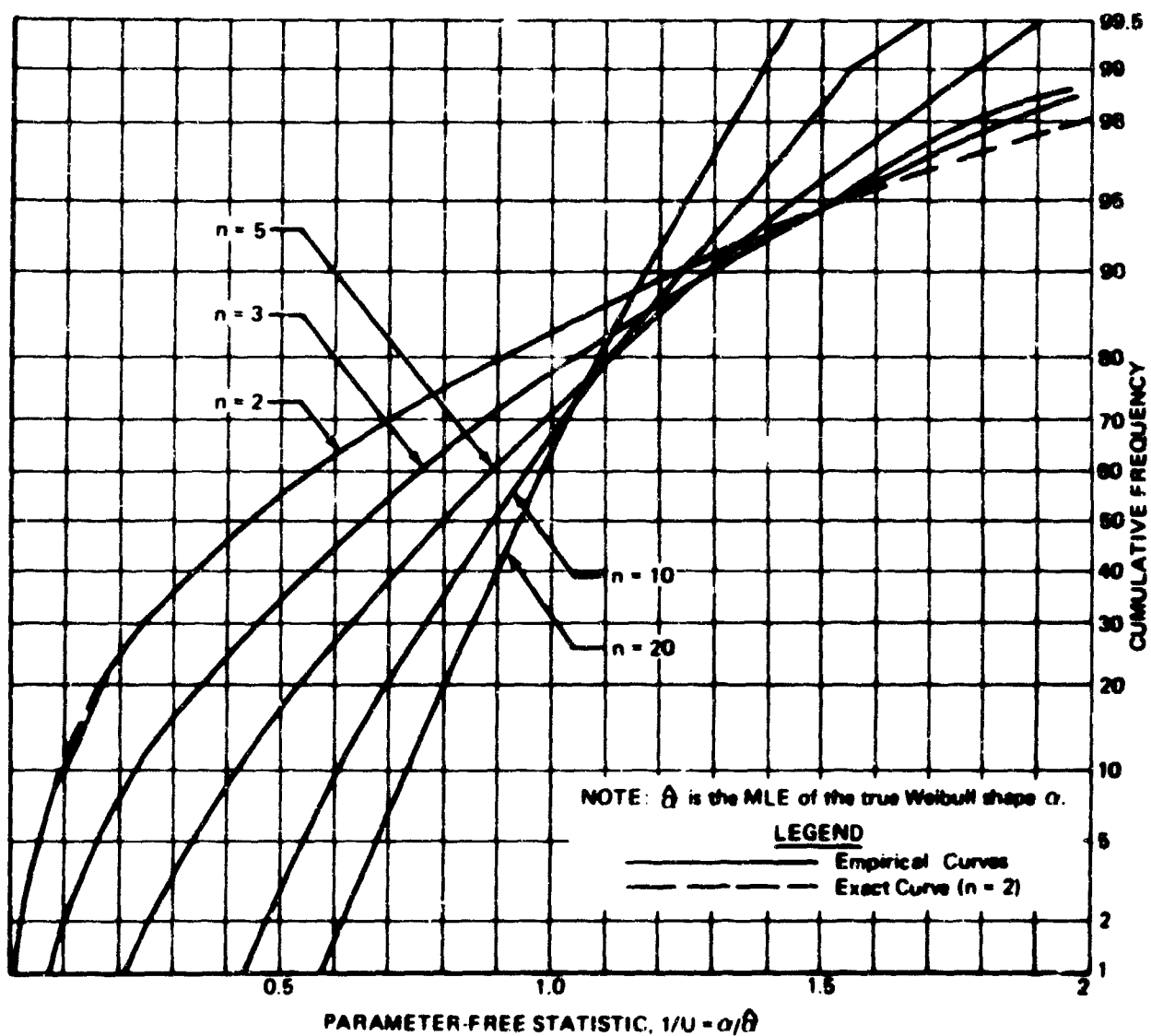


Figure 4. Empirical Distribution of the MLE of the Weibull Shape Parameter α for Complete Samples

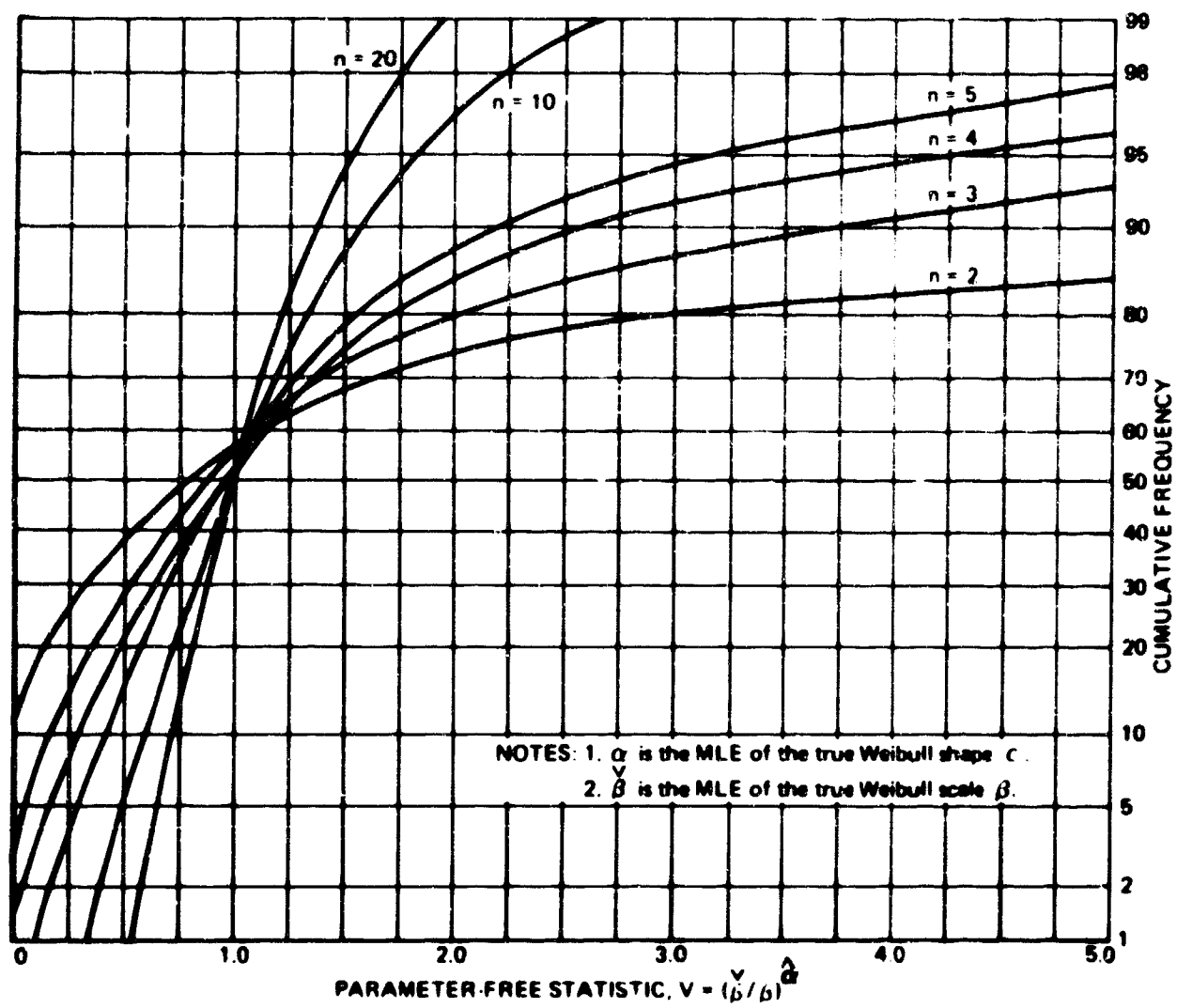


Figure 5. Empirical Distribution of the MLE of the Weibull Scale Parameter β for Complete Samples of Size $n = m = 2, 3, 4, 5, 10$, and 20 (Weibull Shape Assumed To Be Unknown)

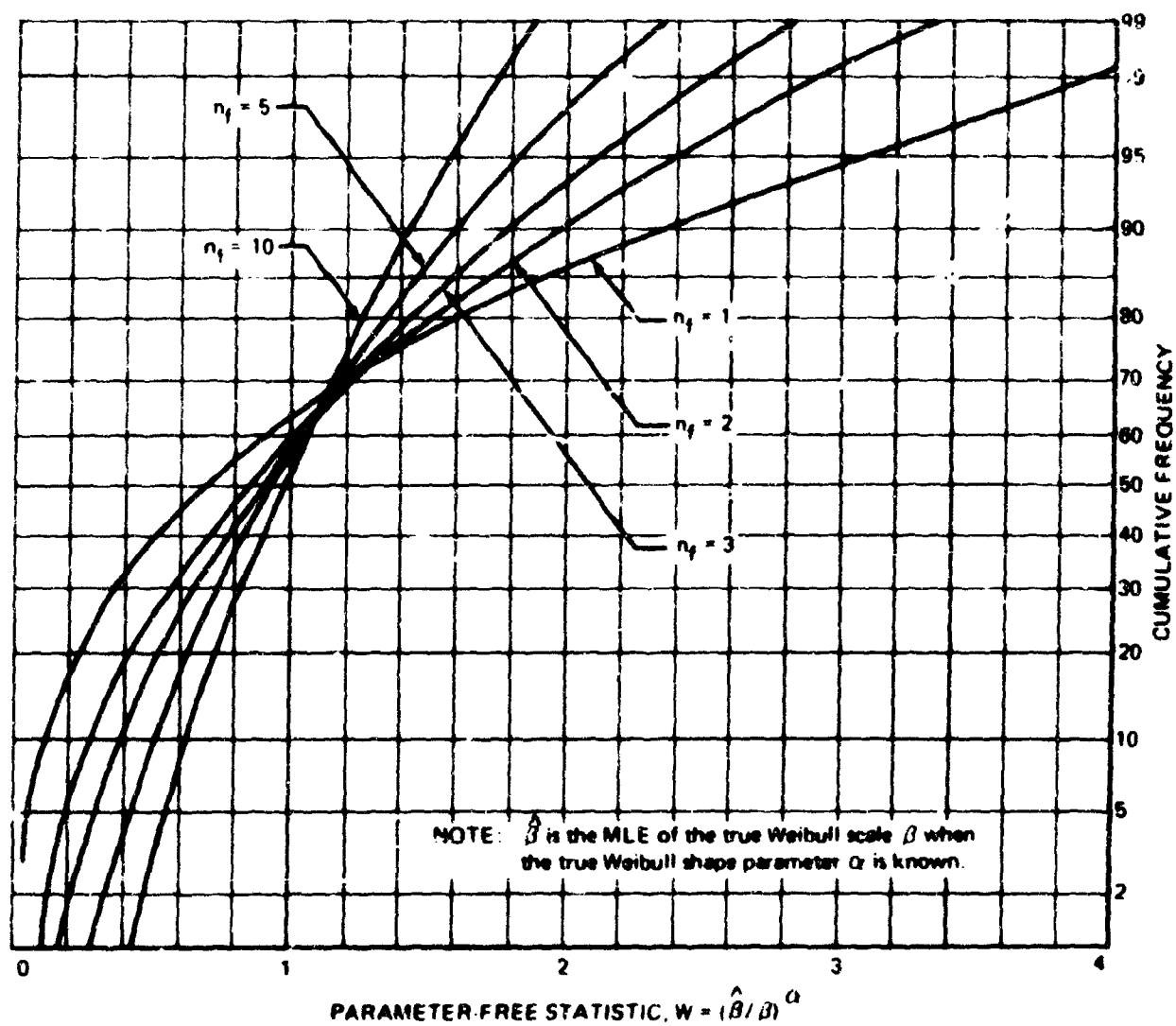


Figure 6. Theoretical Distribution of the MLE of the Weibull Scale Parameter β for Complete Samples (Weibull Shape Assumed To Be Known)

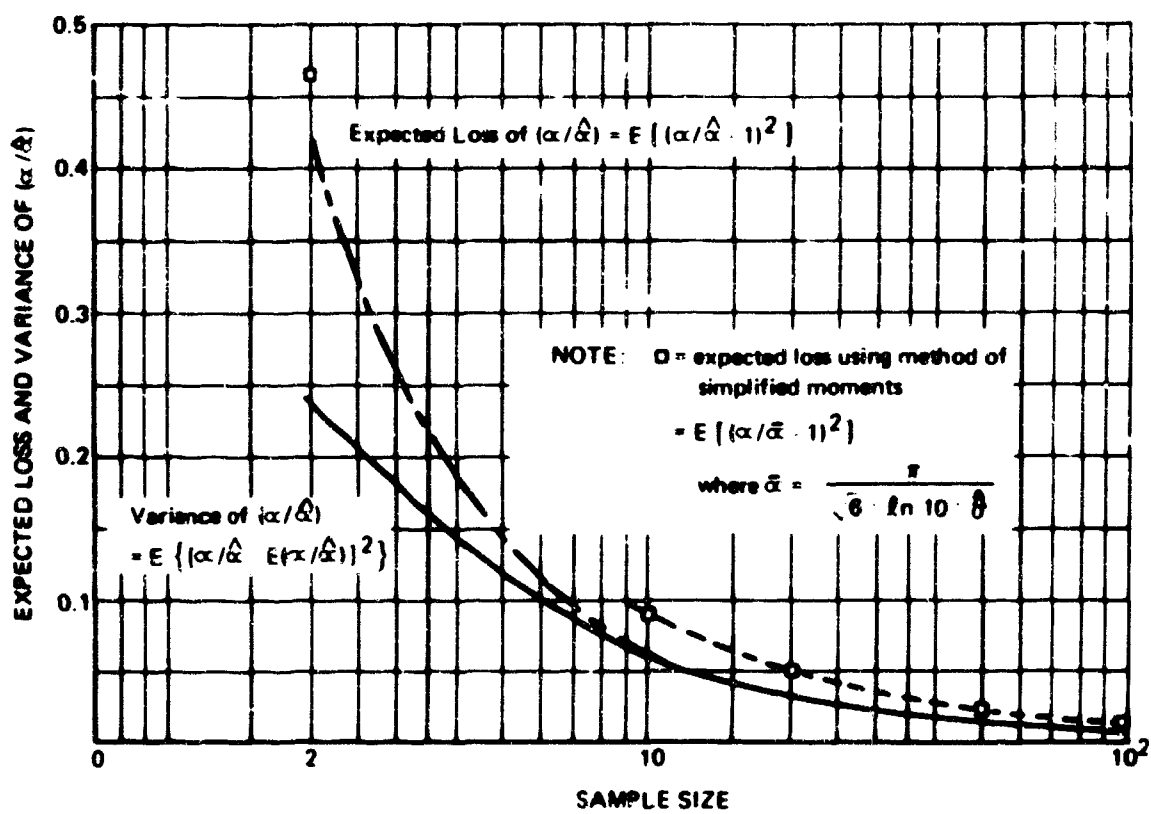


Figure 7. A Measure of Sampling Error of the MLE of the Weibull Shape From Complete Samples

ALUMINUM FATIGUE TEST DATA: TOTAL OF EXAMINED DATA

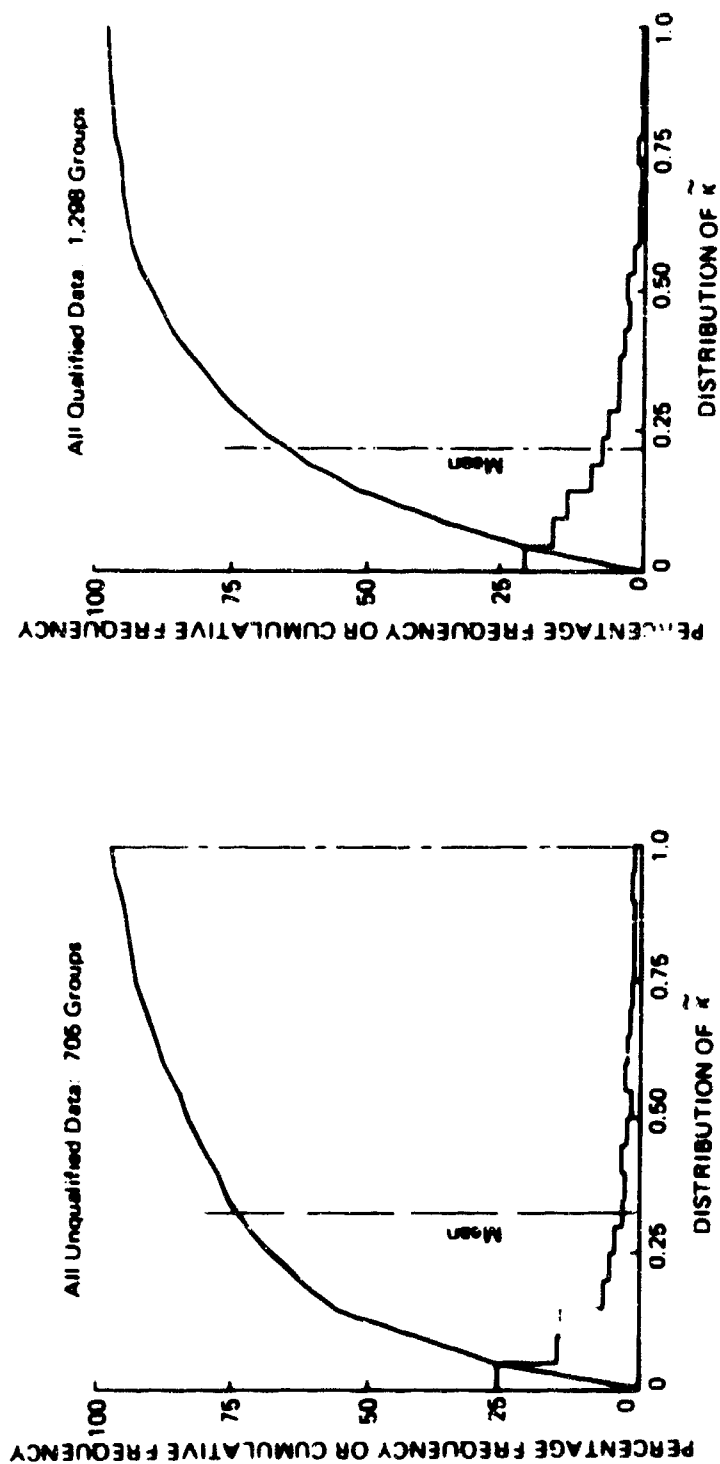


Figure 8. Distribution of Observed Estimates of the Weibull Shape Parameter for All Unqualified Data

Figure 9. Distribution of Observed Estimates of the Weibull Shape Parameter for All Qualified Data

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

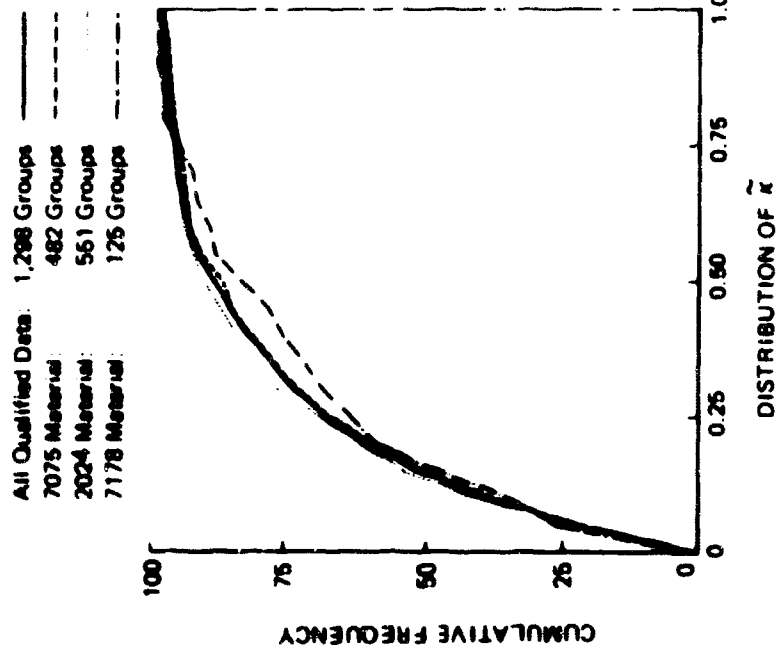


Figure 10. Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Several Alloys

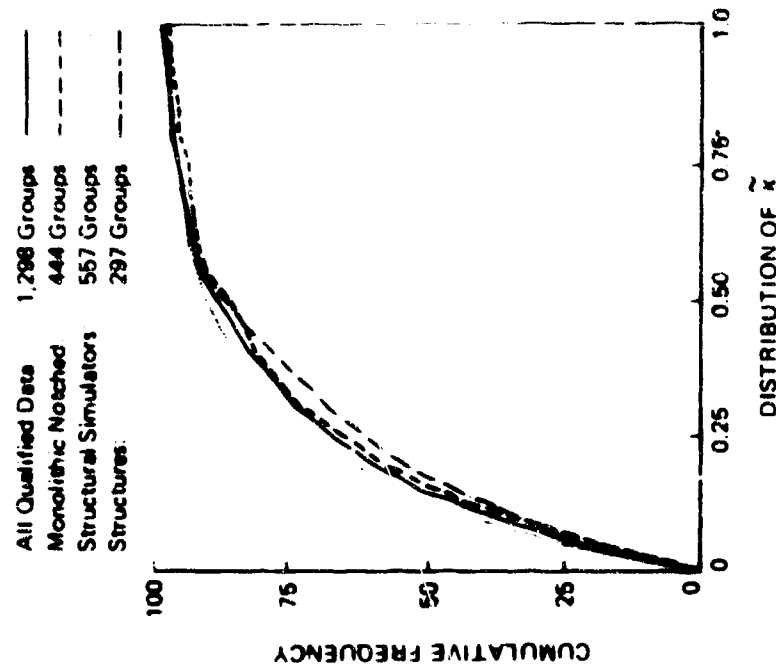


Figure 11. Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Several Specimen Types

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures,
excluding low-amplitude, high-cycle data)

All Qualified Data: 1,298 Groups
Constant-Amplitude Data: 1,174 Groups
Variable-Amplitude Data: 124 Groups

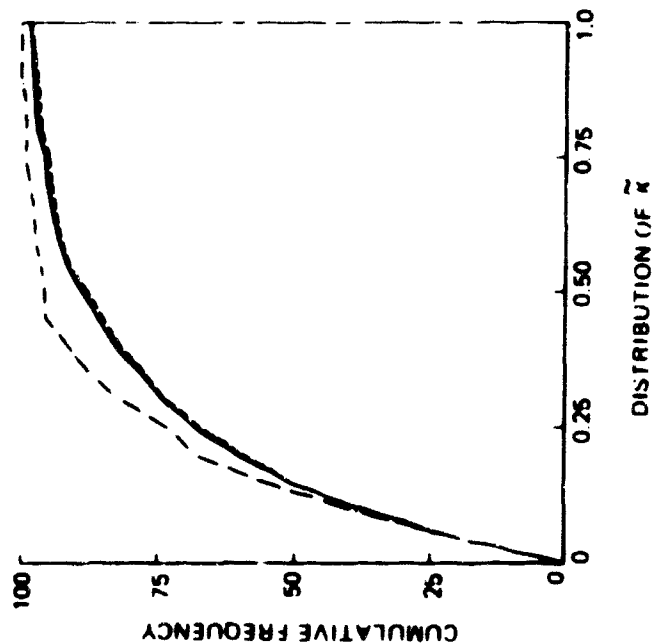


Figure 12. Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Different Types of Loading

(Sample categories of rejected data)

All Qualified Data: 1,298 Groups
Unnotched Data: 179 Groups
High Life Data: 111 Groups
Bonded Data: 183 Groups

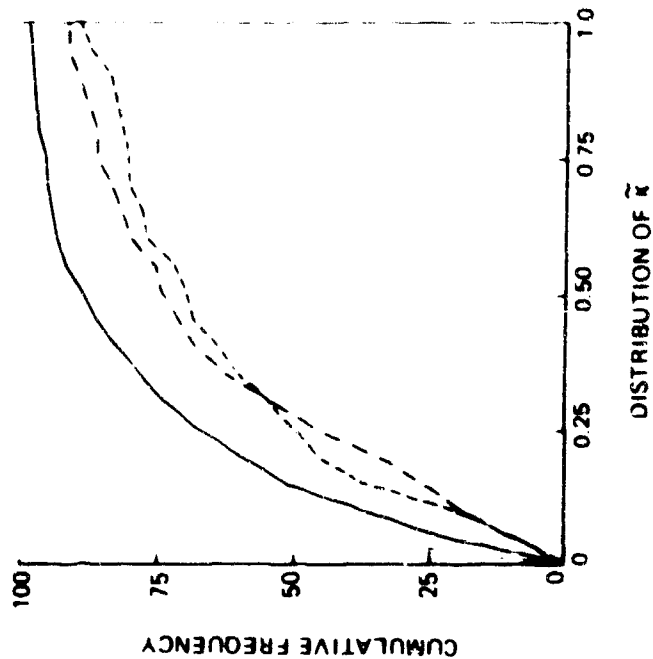


Figure 13. Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Various Unacceptable Data

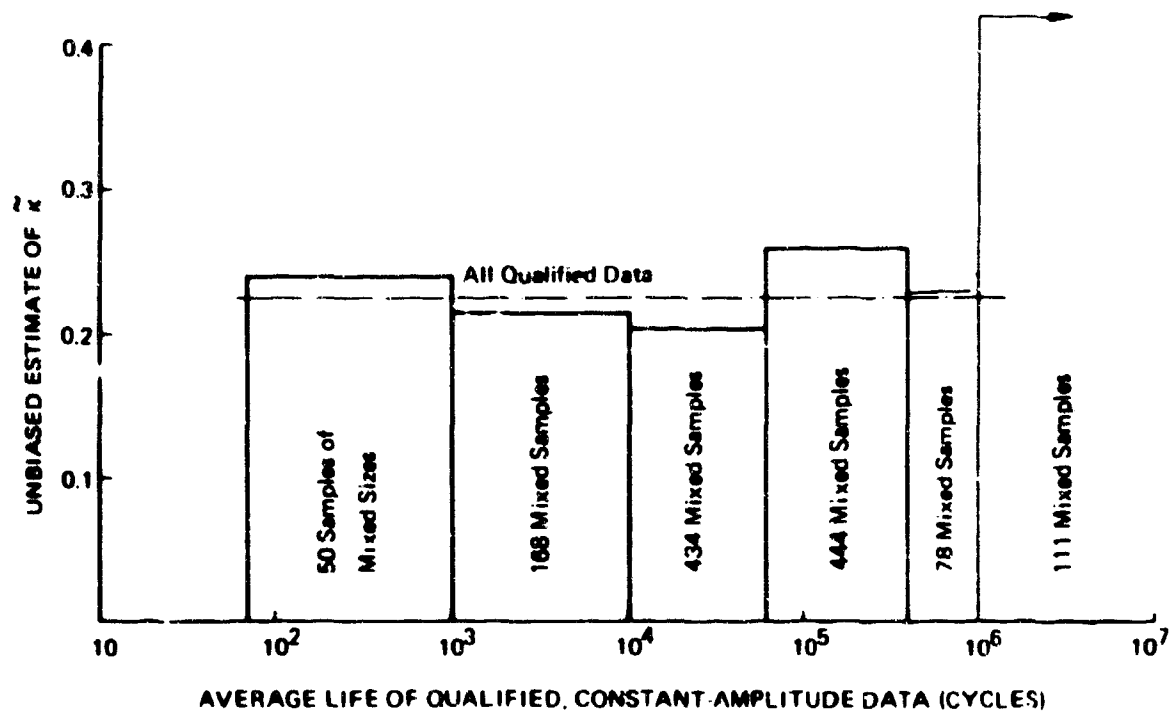


Figure 14. Observed Variation of Fatigue Scatter With Cyclic Life for 1,174 Constant-Amplitude Samples of Mixed Sizes

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

Test Data Distribution

Theoretical Distribution: $\kappa = \tilde{\kappa}' = 0.224$ -----

Theoretical Distribution: $\kappa = \tilde{\kappa}'_{0.95} = 0.253$ -----

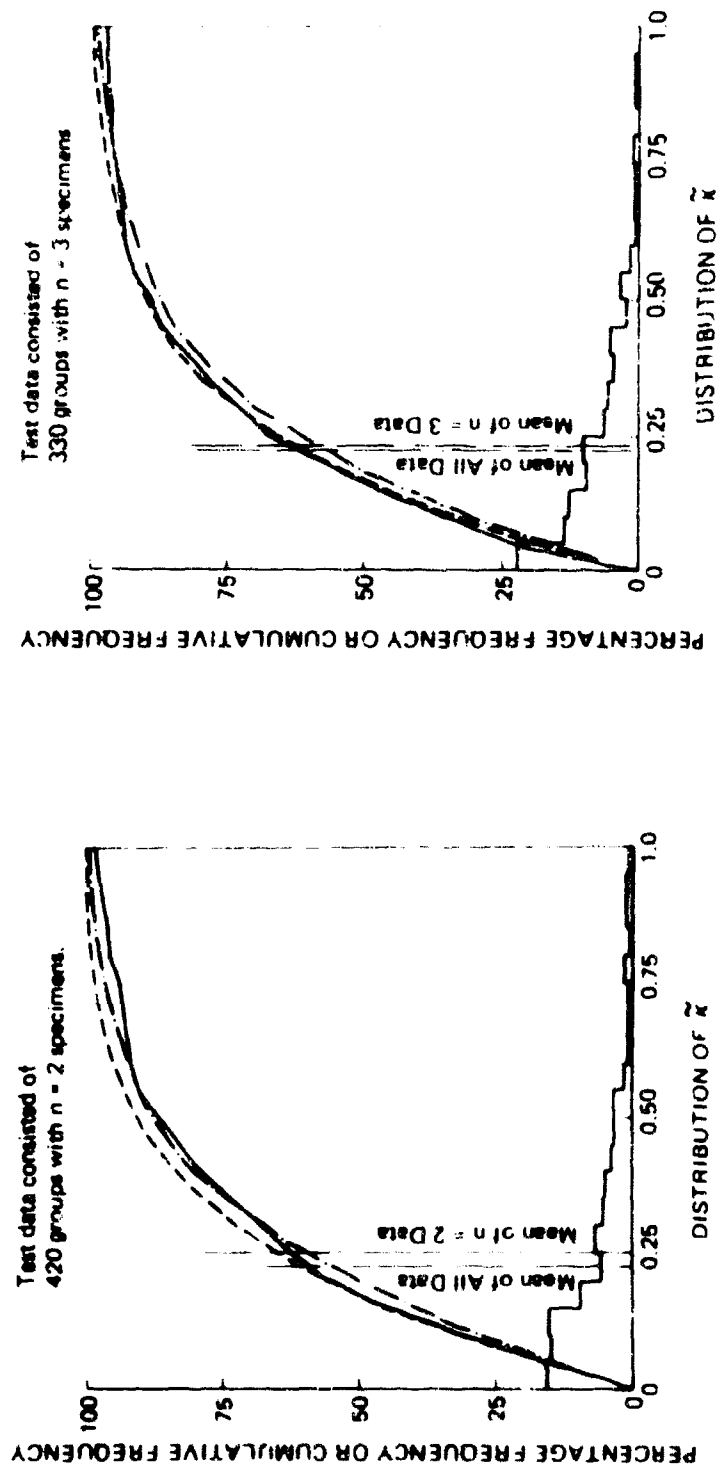


Figure 15. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter for Only Qualified Data of Sample Size = 2

Figure 16. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two Ordered Failures of Only Qualified Data of Sample Size = 3

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low amplitude high cycle data)

Test Data Distribution

Theoretical Distribution $\alpha = 0.224$ - - - - -

Theoretical Distribution $\alpha = 0.253$ - - - - -

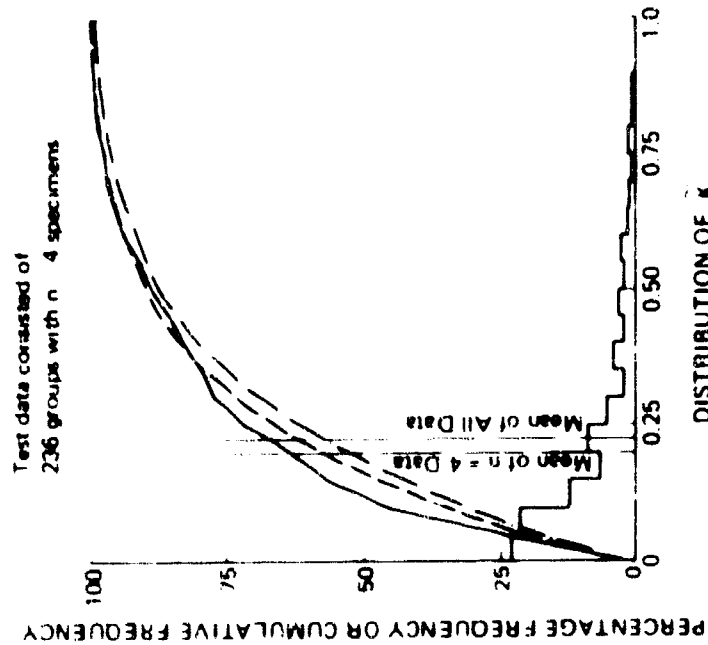


Figure 17. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of Only Qualified Data of Sample Size = 4

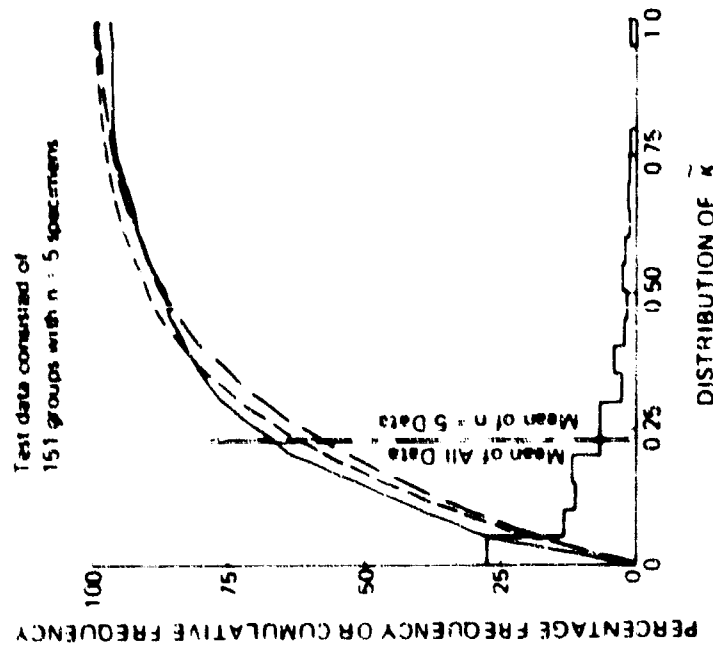


Figure 18. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of Only Qualified Data of Sample Size = 5

ALUMINUM FATIGUE TEST DATA TOTAL OF EXAMINED DATA

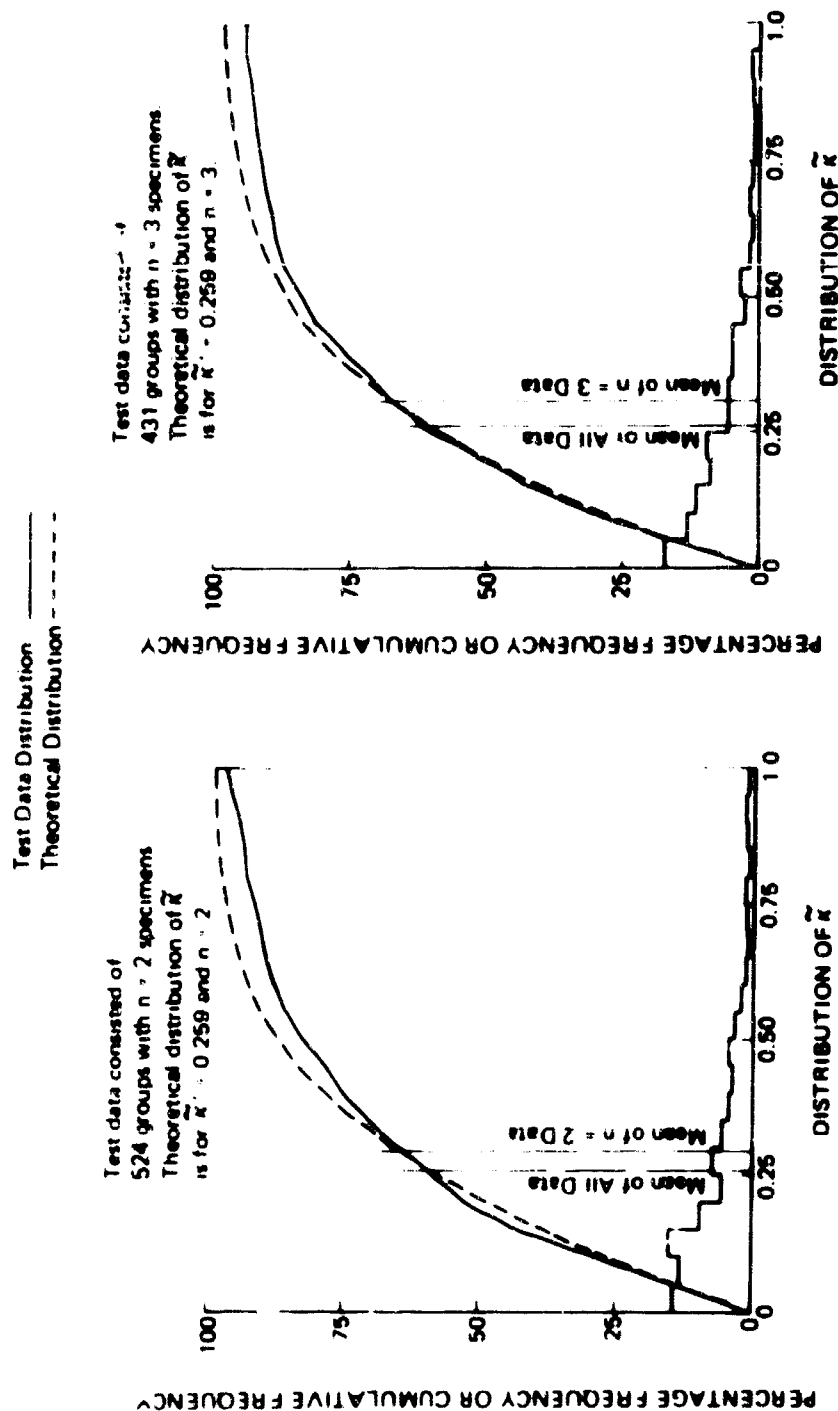


Figure 19. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter for All Collected Data of Sample Size = 2

Figure 20. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 3

ALUMINUM FATIGUE TEST DATA: TOTAL OF EXAMINED DATA

Test Data Distribution ———
Theoretical Distribution - - -

Test data consisted of
496 groups with $n = 4$ specimens.
Theoretical distribution of $\tilde{\kappa}$
is for $\kappa' = 0.269$ and $n = 4$.

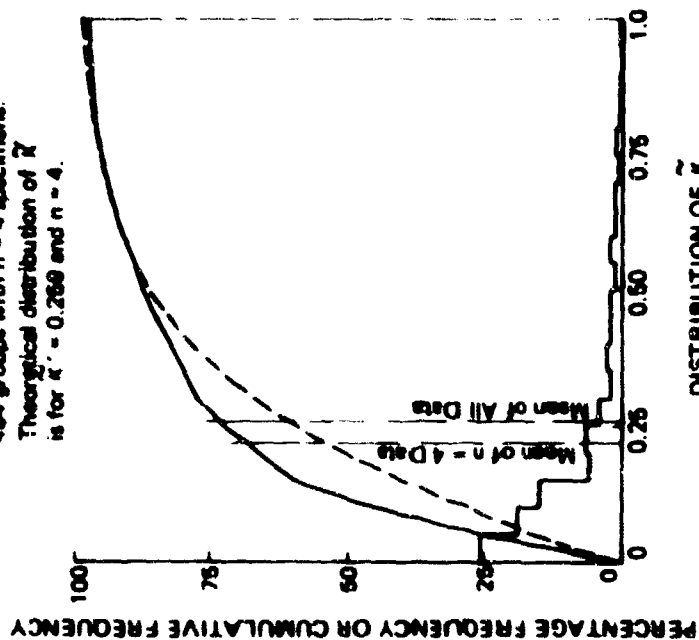


Figure 21. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 4

Test data consisted of
166 groups with $n = 5$ specimens.
Theoretical distribution of $\tilde{\kappa}$
is for $\kappa' = 0.269$ and $n = 5$.

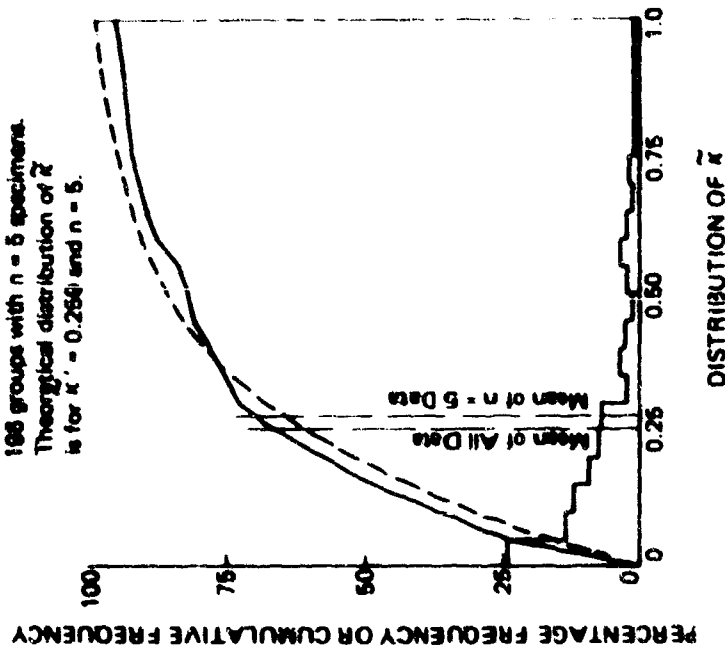


Figure 22. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 5

ALUMINUM FATIGUE TEST DATA: TOTAL OF EXAMINED DATA

Test Data Distribution
Theoretical Distribution

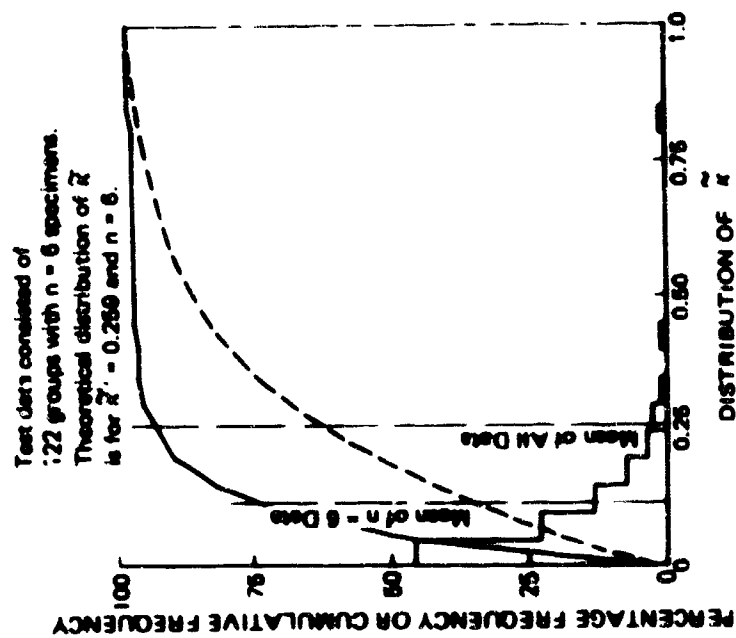


Figure 23. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using the First Two - Ordered Failures of All Collected Data of Sample Size = 6

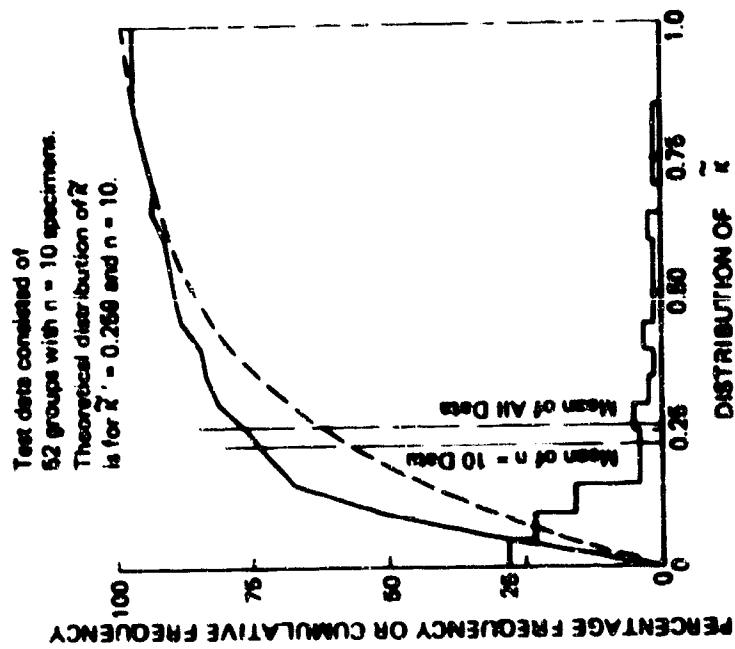
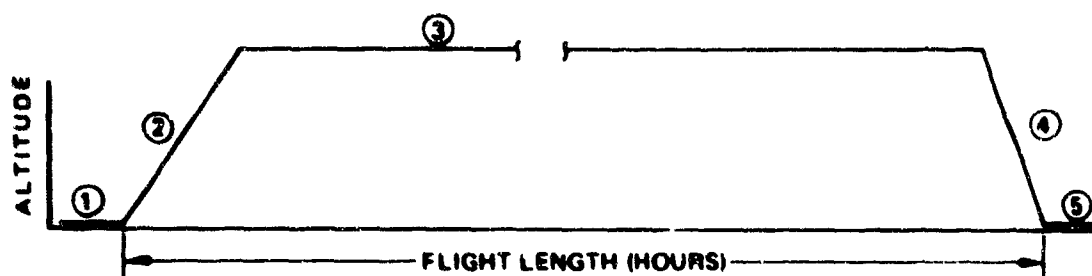


Figure 24. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using the First Two - Ordered Failures of All Collected Data of Sample Size = 10



- ① Taxi and Takeoff
- ② Climb to Cruise Altitude
- ③ Cruise at Cruise Altitude
- ④ Descent (Gear Down)
- ⑤ Landing and Taxi in

Figure 25 Typical Flight Profile for a Military Jet Tanker/Transport Airplane

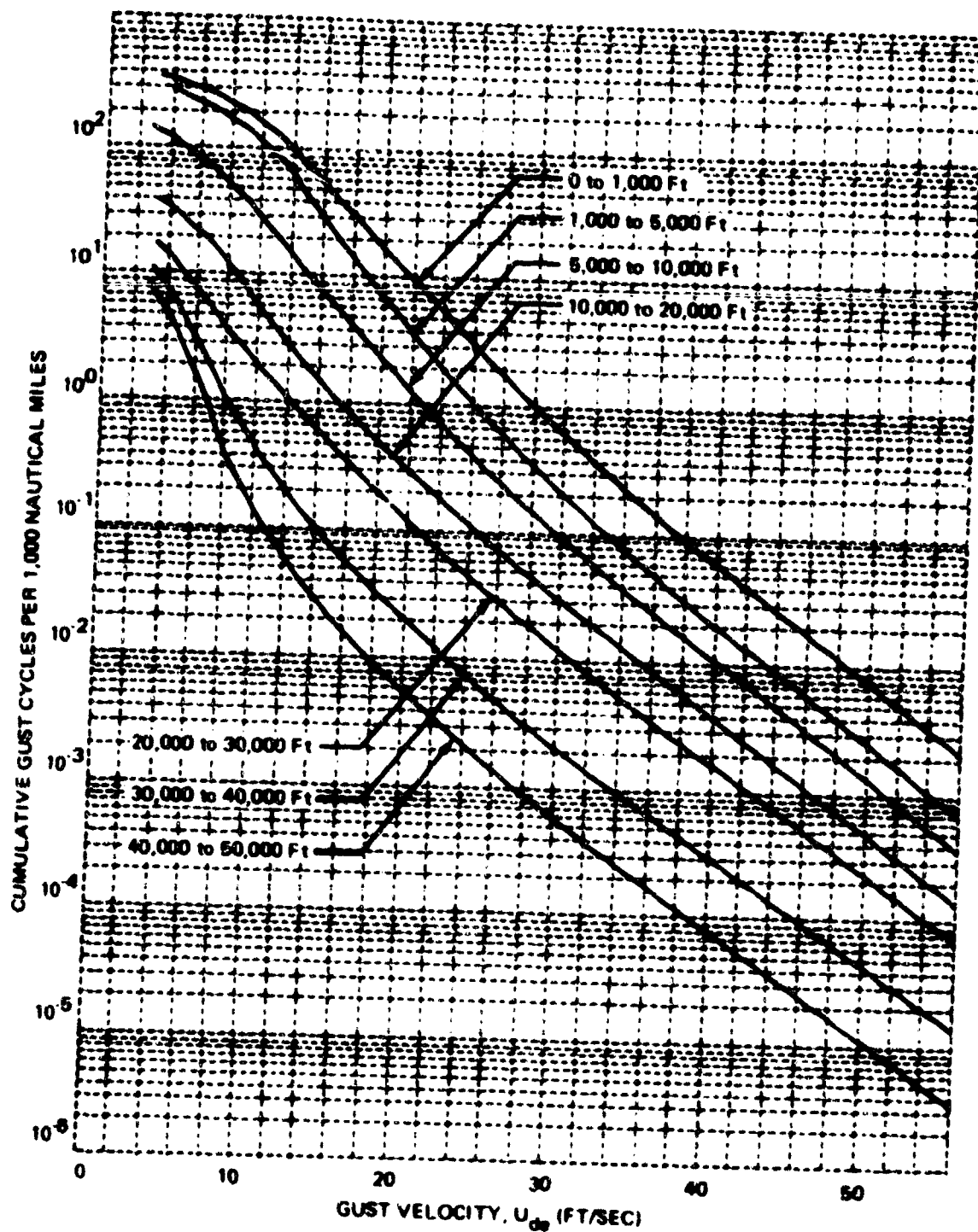


Figure 26. Gust Spectrum From SAC VGH Data on Military Jet Tanker/Transport Airplane

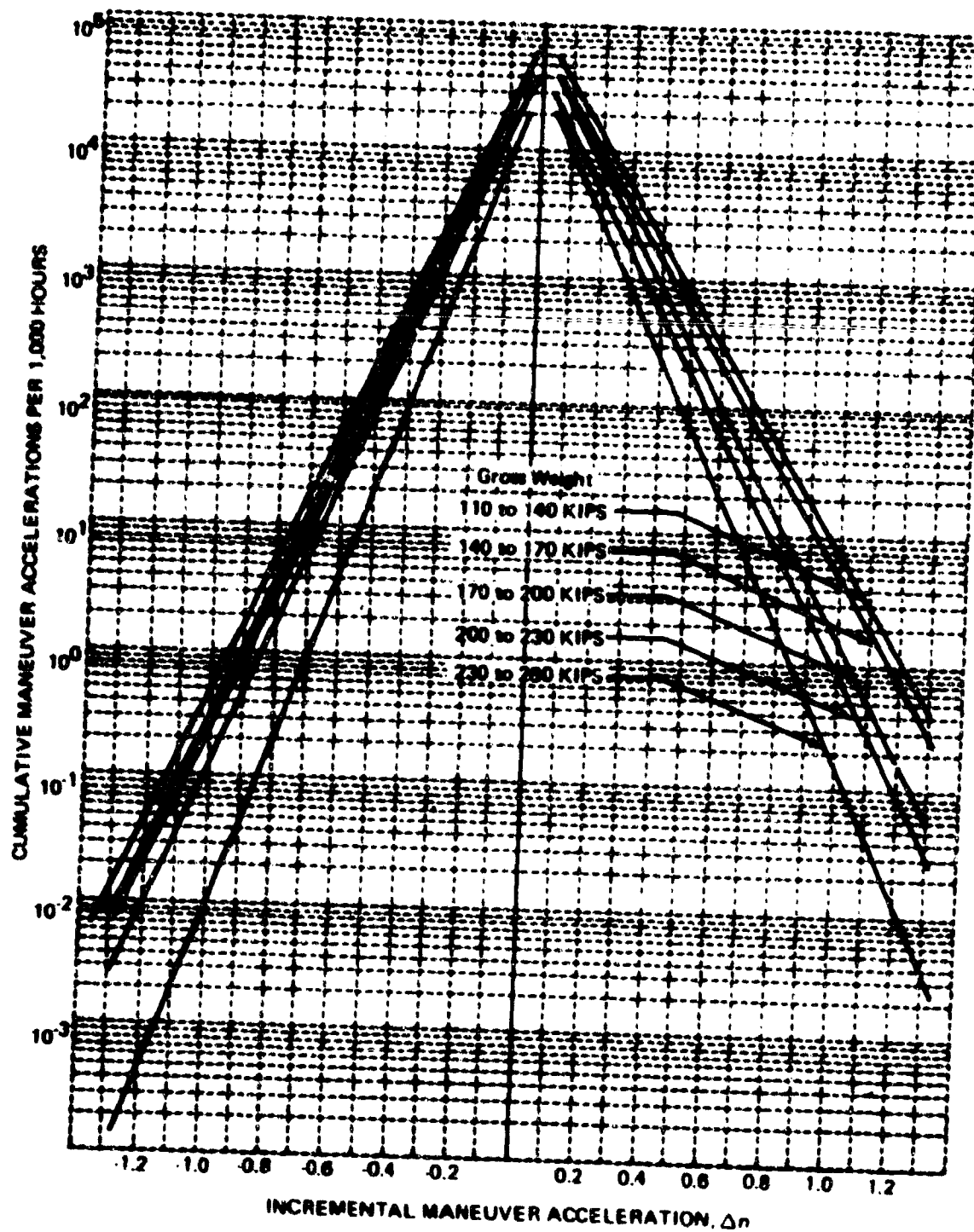


Figure 27. Maneuver Spectrum From SAC VGH Data on Military Jet Tanker/Transport Airplane

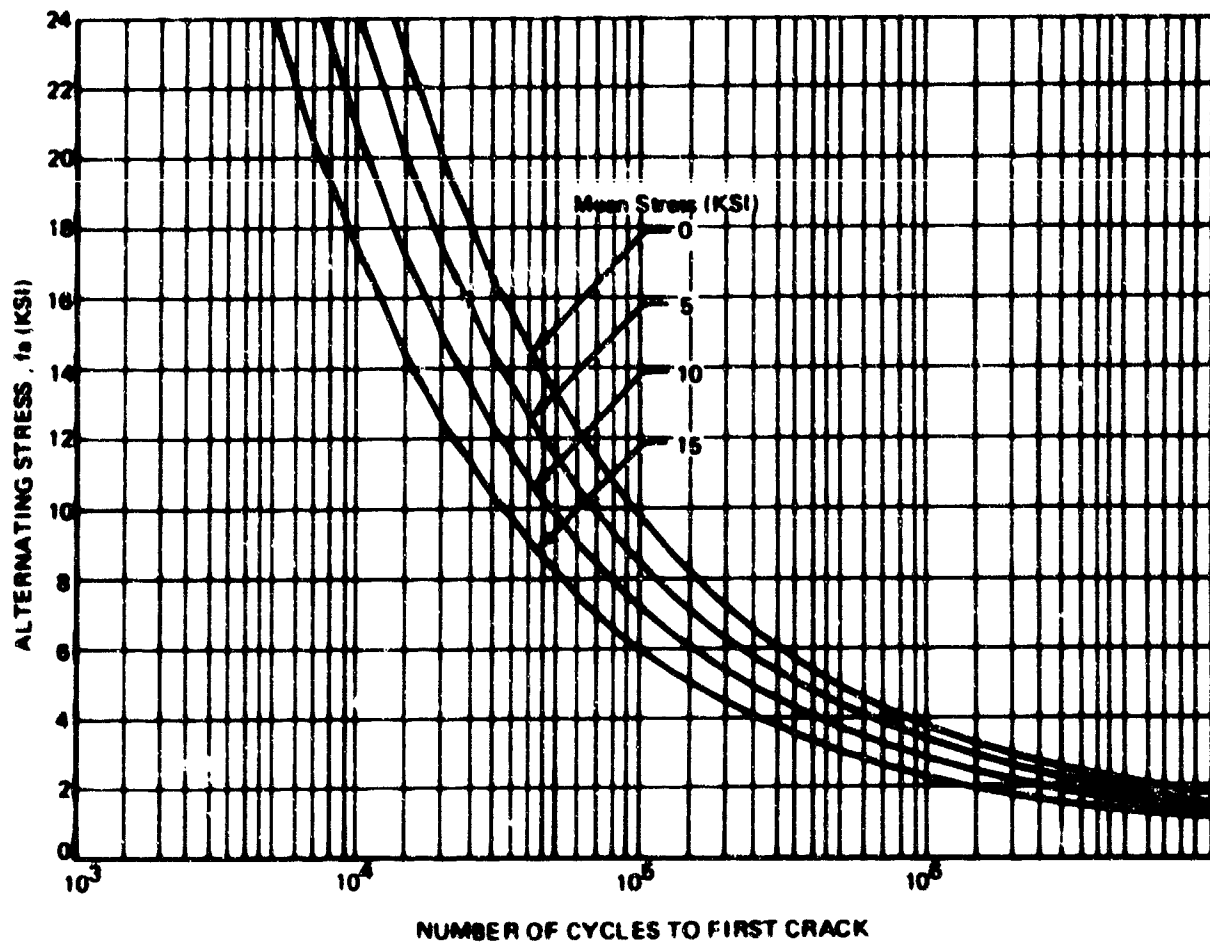


Figure 28. Typical Family of S-N Diagrams for a Structural Component on a Military Jet Tanker/Transport Airplane

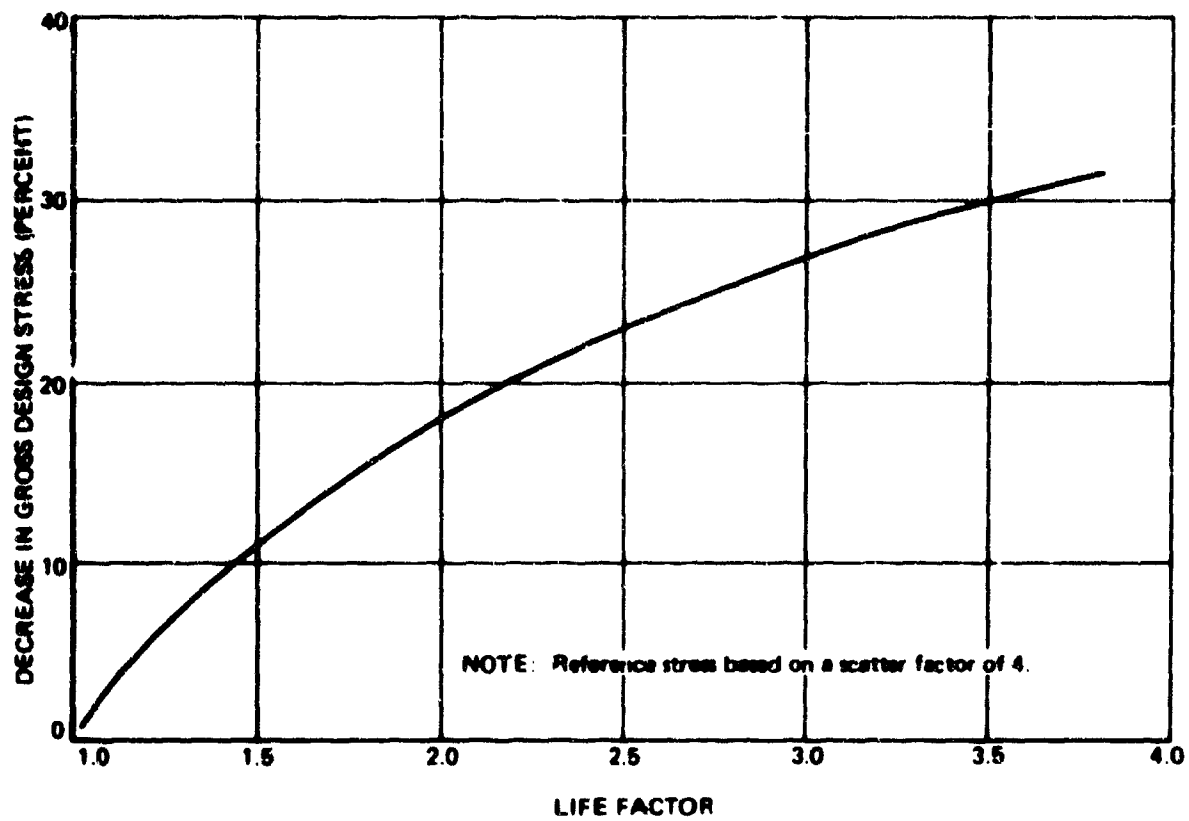


Figure 29. Relationship of Fatigue Life With Stress for the Fatigue-Critical Aluminum Structure of the Reference Military Tanker/Transport Airplane

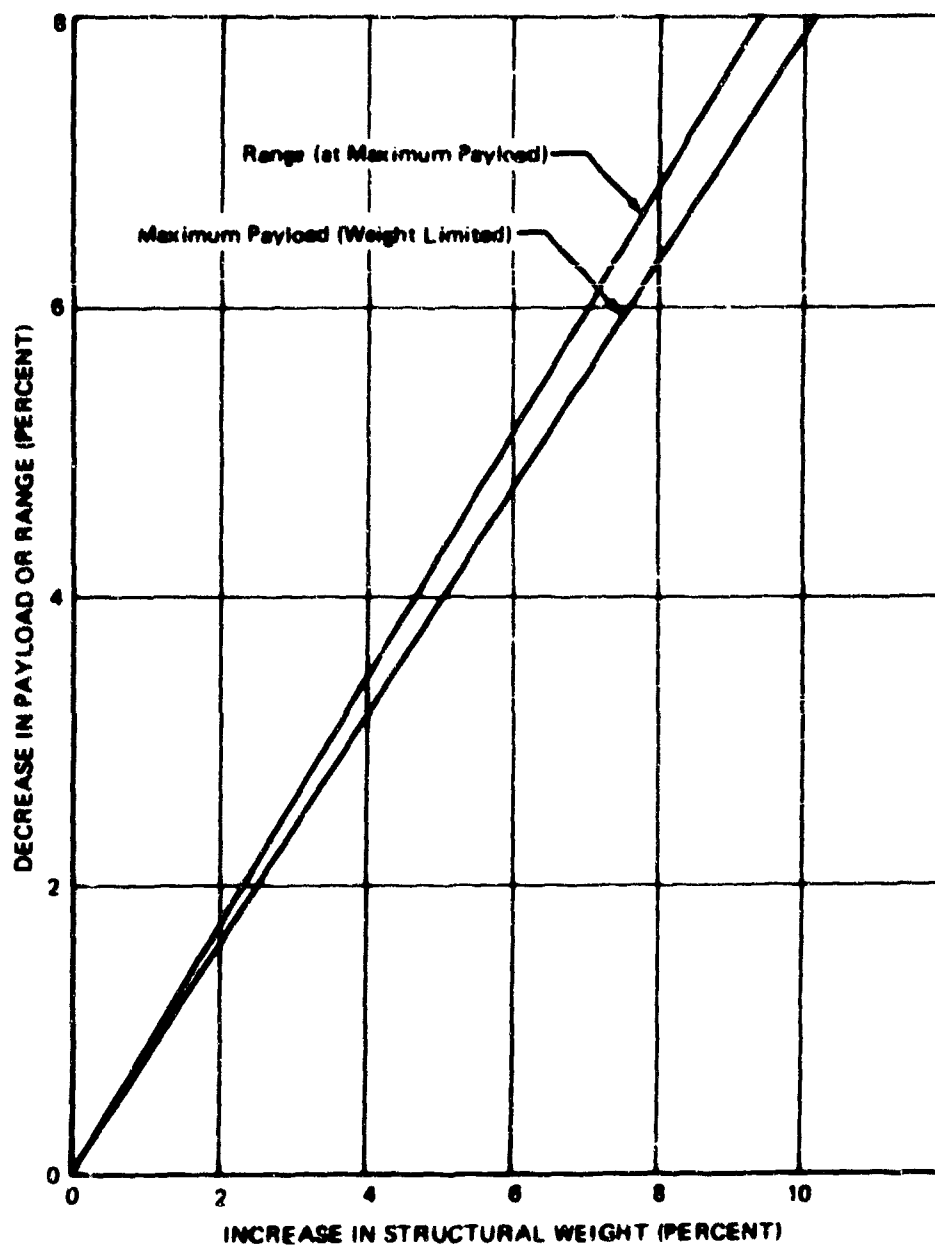


Figure 30. Relationship of Primary Structural Weight With Payload and Range of the Reference Military Tanker/Transport Airplane

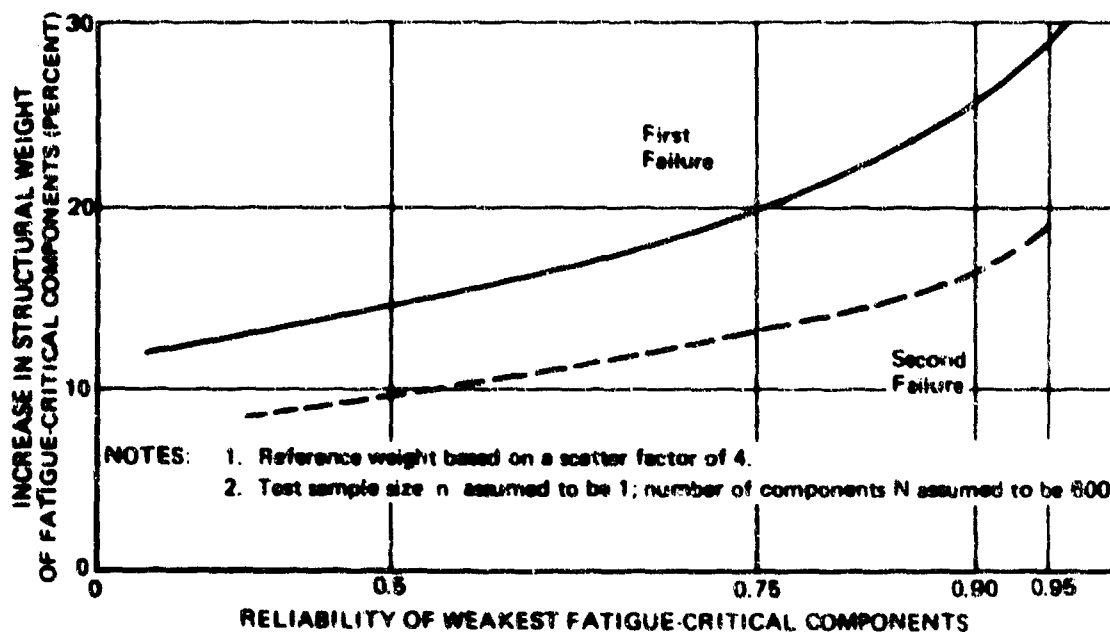


Figure 31. Relationship of Structural Weight of Fatigue-Critical Component With Degree of Reliability of Weakest Components

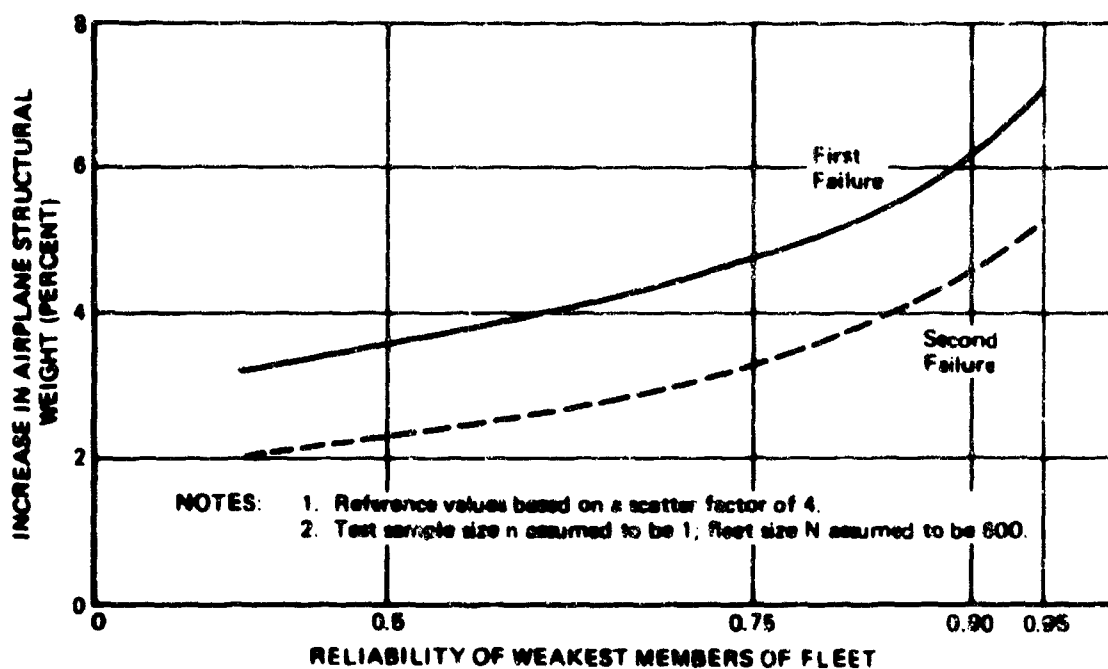


Figure 32. Relationship of Primary Structural Weight With Degree of Reliability of Weakest Members in Fleet, Military Tanker/Transport Airplane

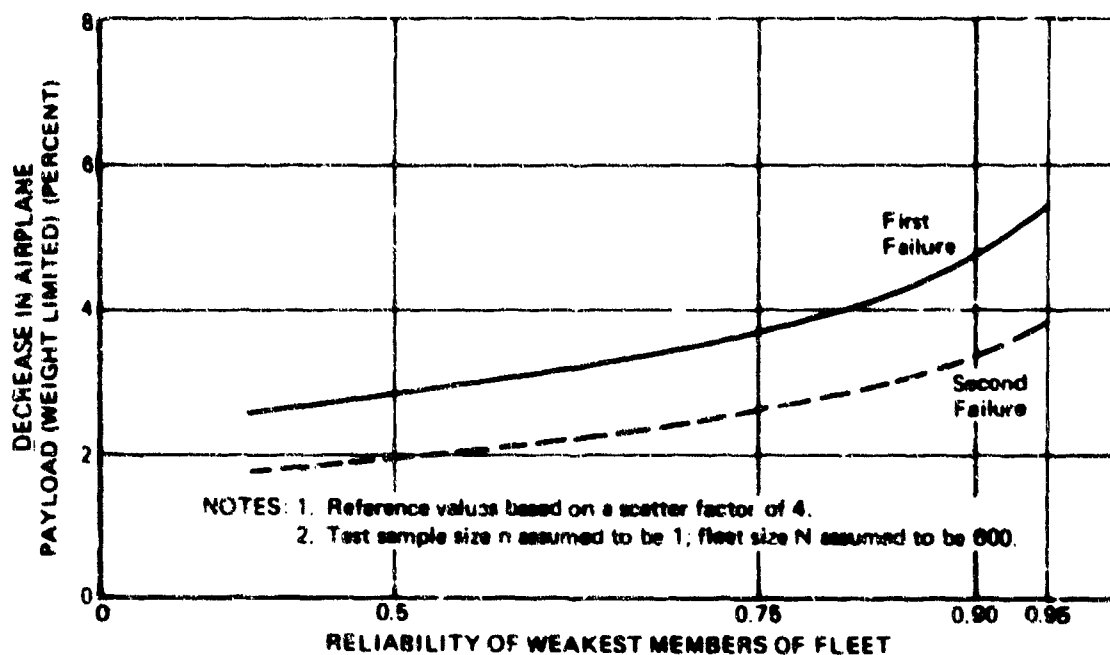


Figure 33. Relationship of Airplane Payload With Degree of Reliability of Weakest Members in Fleet, Military Tanker/Transport Airplane

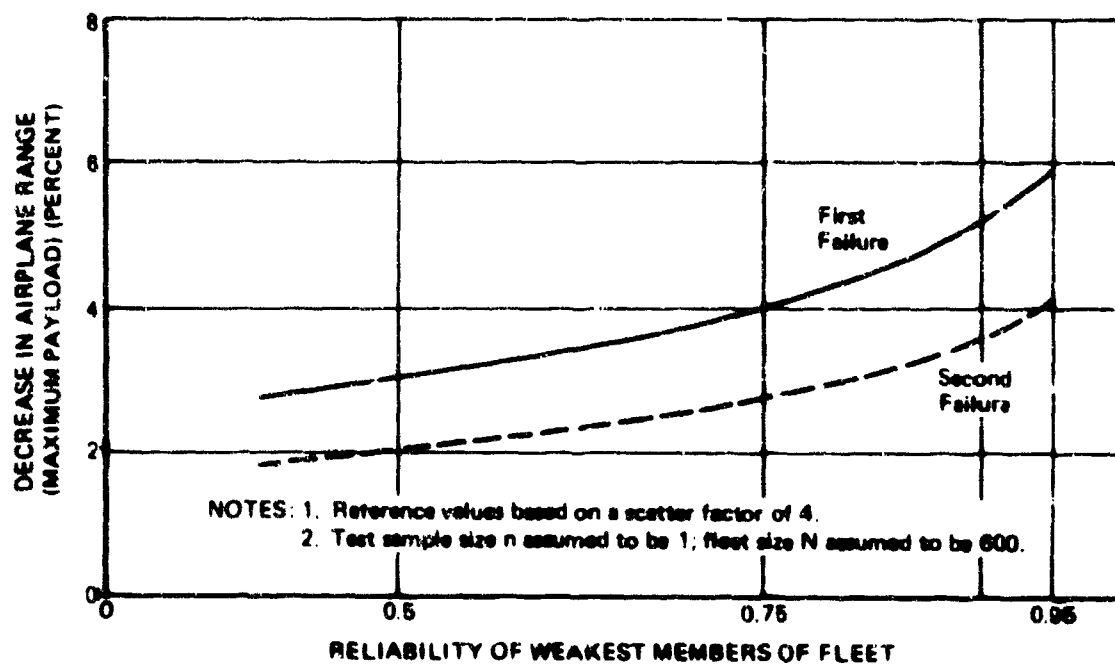


Figure 34. Relationship of Airplane Range With Degree of Reliability of Weakest Member in Fleet, Military Tanker/Transport Airplane

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low amplitude, high cycle data)

----- Distribution for Complete Groups
 ----- Distribution for Censored Groups

Test data consisted of 420 groups
 with $n = 2$ specimens

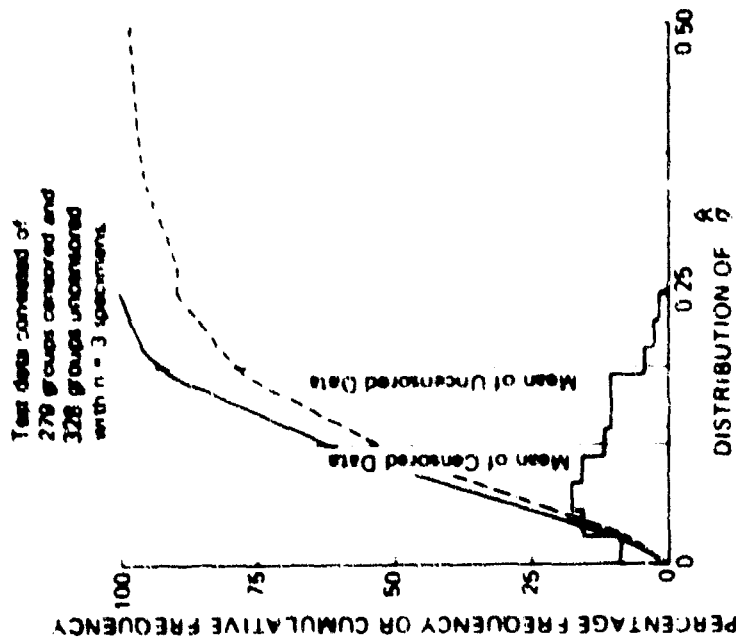
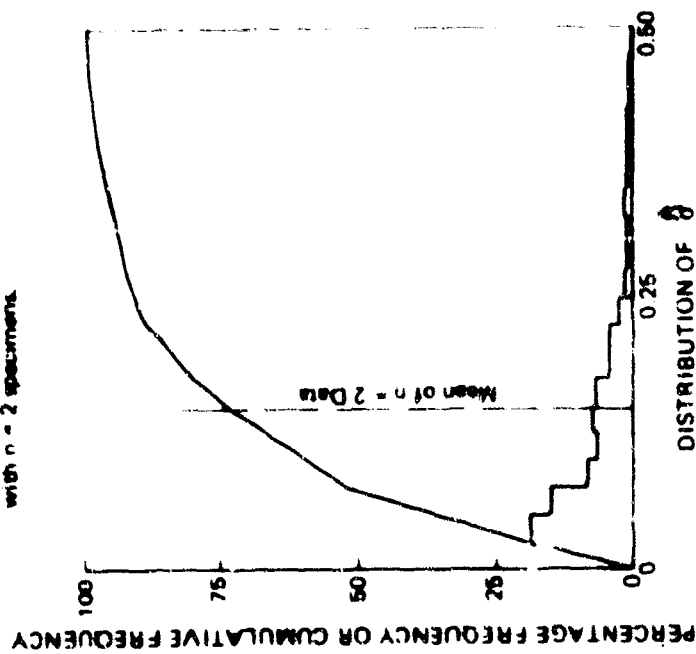


Figure 35. Distribution of the Observed Estimates of the Log-Normal Shape Parameter for All Qualified Data of Sample Size = 2

Figure 36. Comparison of the Distributions of Observed Estimates of the Log-Normal Shape Parameter Obtained From Uncensored and Censored Data (All Qualified Data of Sample Size = 3)

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low amplitude, high cycle data)

Distribution for Complete Groups
 Distribution for Censored Groups

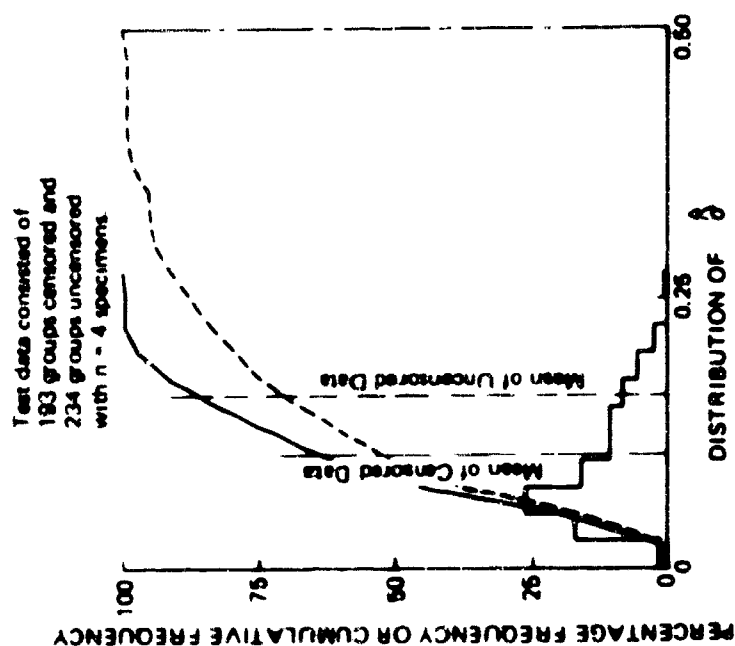


Figure 37. Comparison of the Distributions of Observed Estimates of the Log-Normal Shape Parameter Obtained From Uncensored and Censored Data (All Qualified Data of Sample Size = 4)

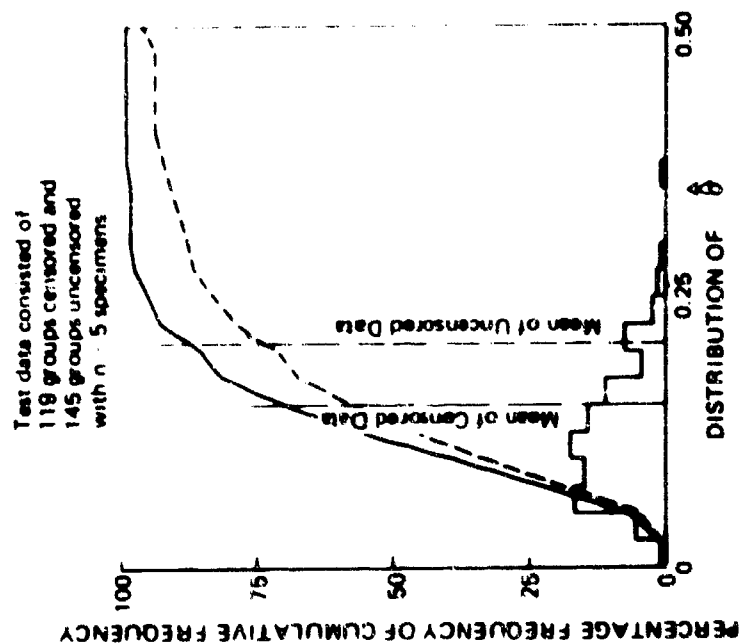


Figure 38. Comparison of the Distributions of Observed Estimates of the Log-Normal Shape Parameter Obtained From Uncensored and Censored Data (All Qualified Data of Sample Size = 5)

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

Test Data Distribution
 Theoretical Distribution: $\sigma = 0.136$
 Theoretical Distribution: $\sigma = 0.139$

Test data consisted of
 420 groups with $n = 2$
 specimens.

Test data consisted of
 278 groups with $n = 3$
 specimens.

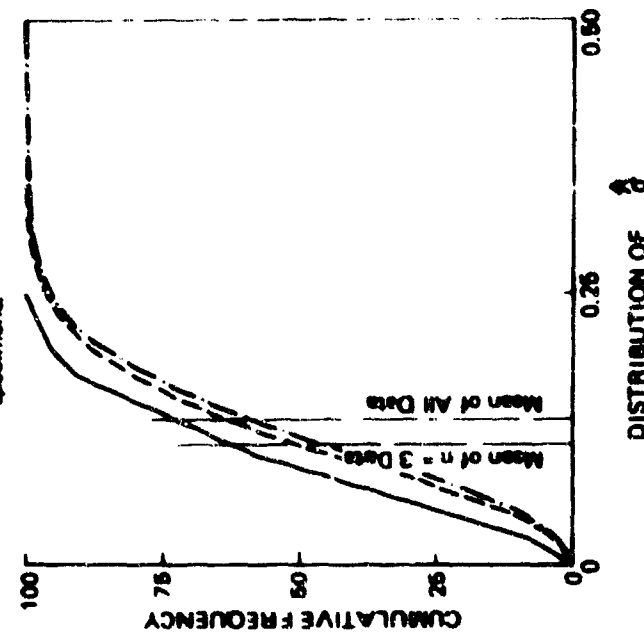
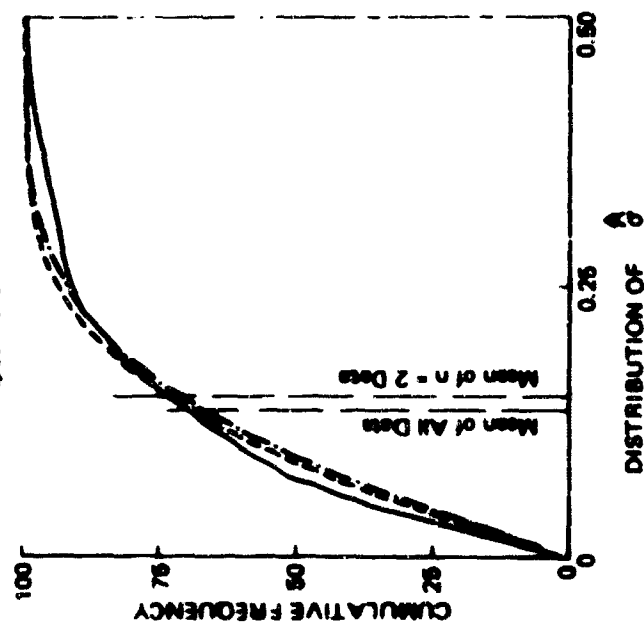


Figure 39. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 2

Figure 40. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 3

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

Test Data Distribution

Theoretical Distribution: $\sigma = \frac{1}{5}, \beta = 0.136$ -----

Theoretical Distribution: $\sigma = \frac{1}{5}, \beta = 0.139$ -----

Test data consisted of
183 groups with $n = 4$
specimens.

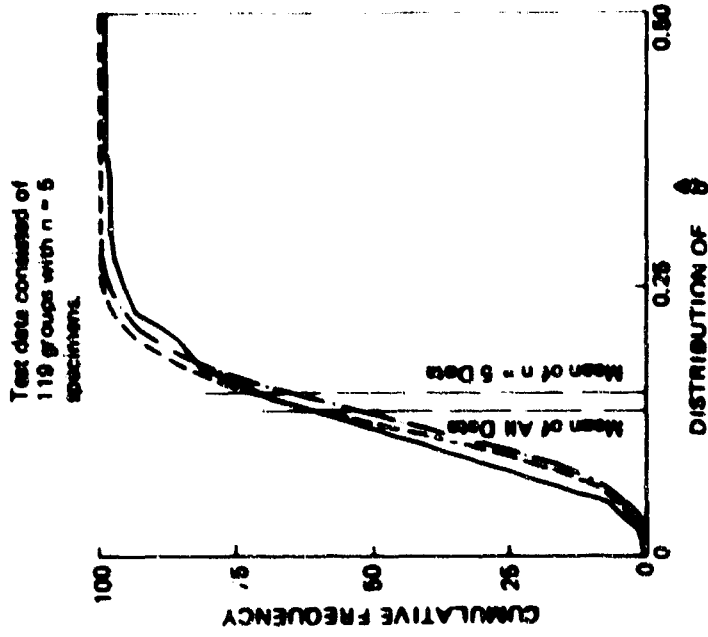
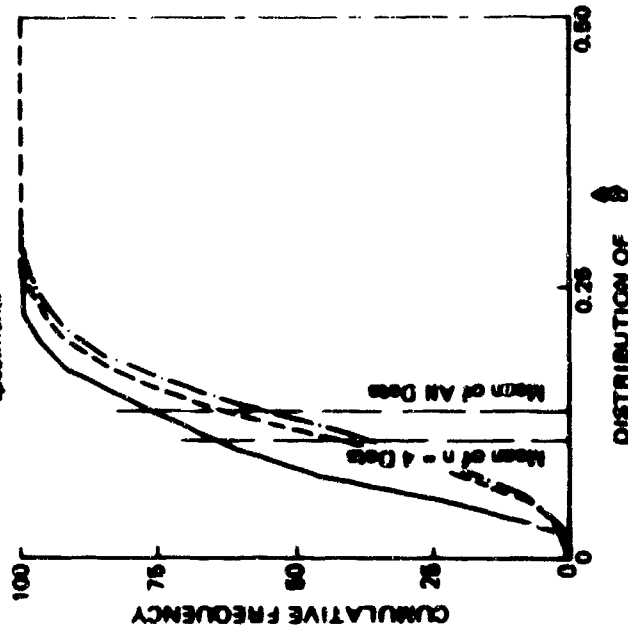


Figure 41. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 4

Figure 42. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 5

ALUMINUM FATIGUE TEST DATA: CENSORED MLE-QUALIFIED DATA

Test Data Distribution ———
Theoretical Distribution - - - -

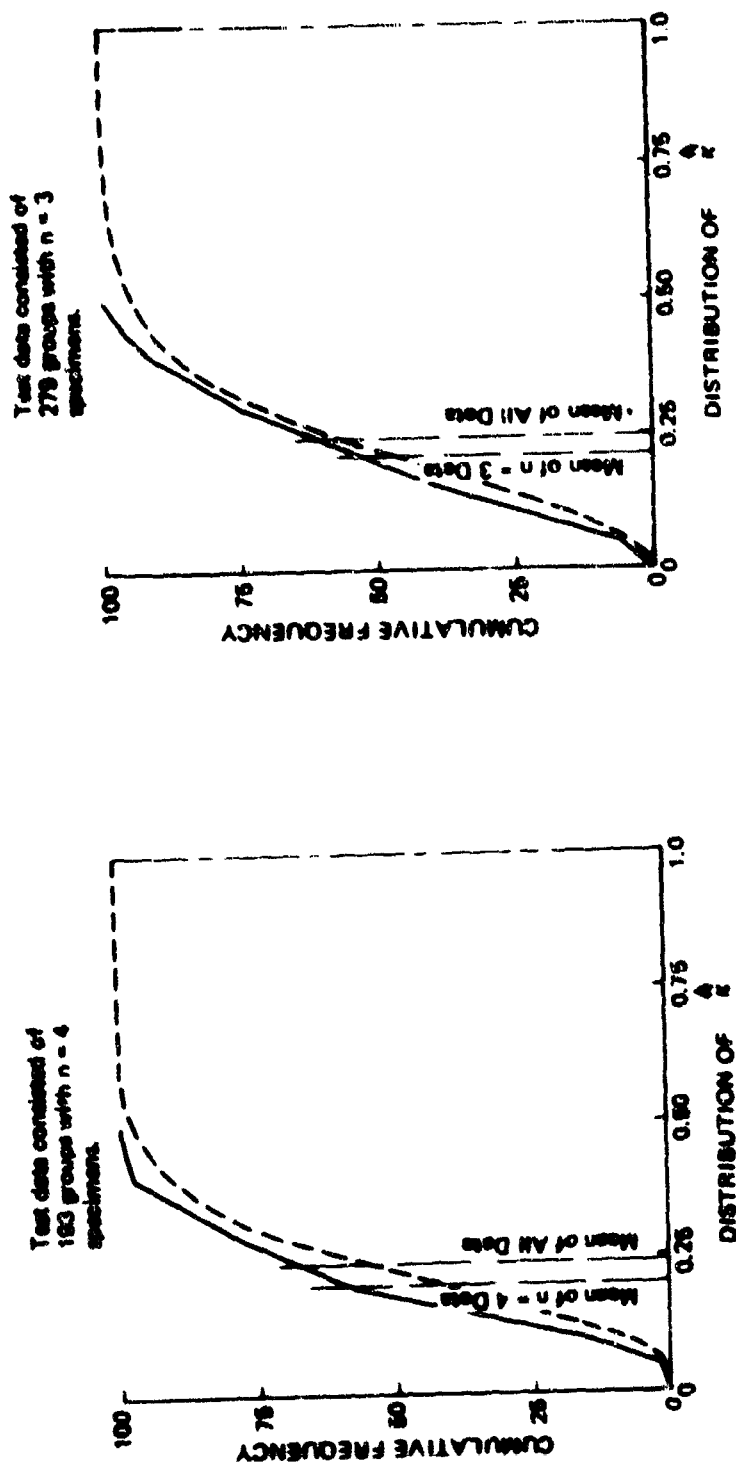


Figure 4.3. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter Using Censored MLE. Qualified Data of Sample Size = 4

Figure 4.4. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter Using Censored MLE. Qualified Data of Sample Size = 3

NOTE: Data based on $\alpha = 1$, fleet size of 800 and on a 95% confidence interval estimate from one fatigue life observation.

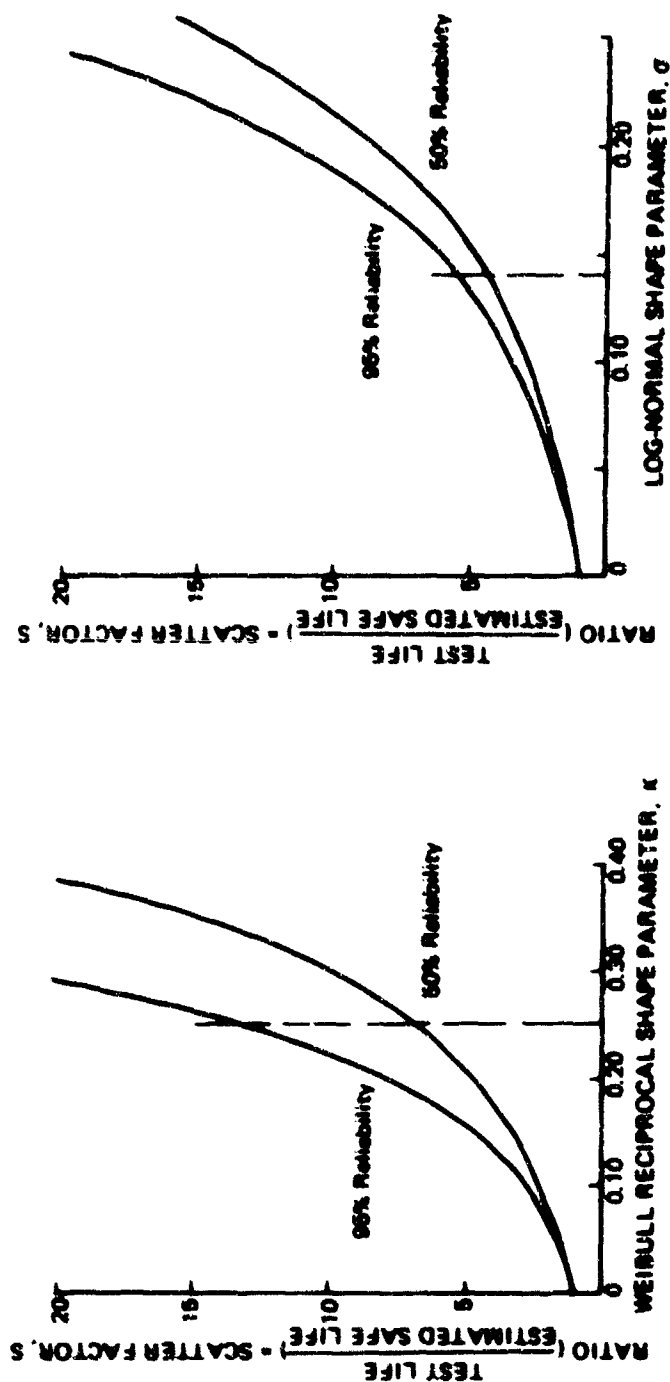


Figure 45. Scatter Factors Required To Attain 50% and 95% Fleet Reliability as a Function of True Value of the Distribution Shape Parameters, Weibull Model

Figure 46. Scatter Factors Required To Attain 50% and 95% Fleet Reliability as a Function of True Value of the Distribution Shape Parameters, Log-Normal Model

NOTE: Data based on a fleet size of 600 and on a 95% confidence interval estimate from one fatigue life observation.

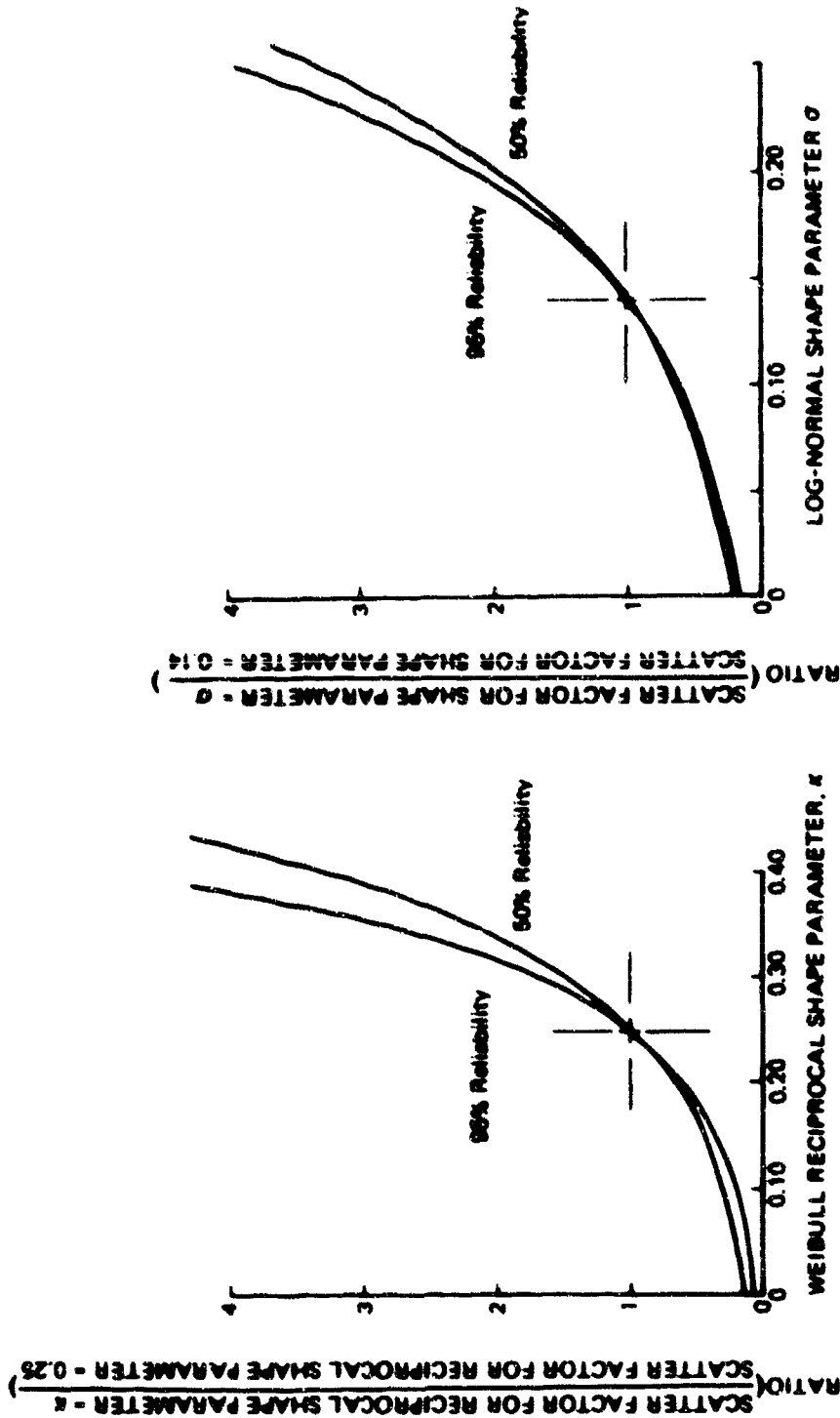


Figure 47. Effect of Distribution Shape Parameter Values on the Scatter Factors Used To Certify the Life of the "Weakest" in the Fleet, Weibull Model

Figure 48. Effect of Distribution Shape Parameter Values on the Scatter Factors Used To Certify the Life of the "Weakest" in the Fleet, Log-Normal Model

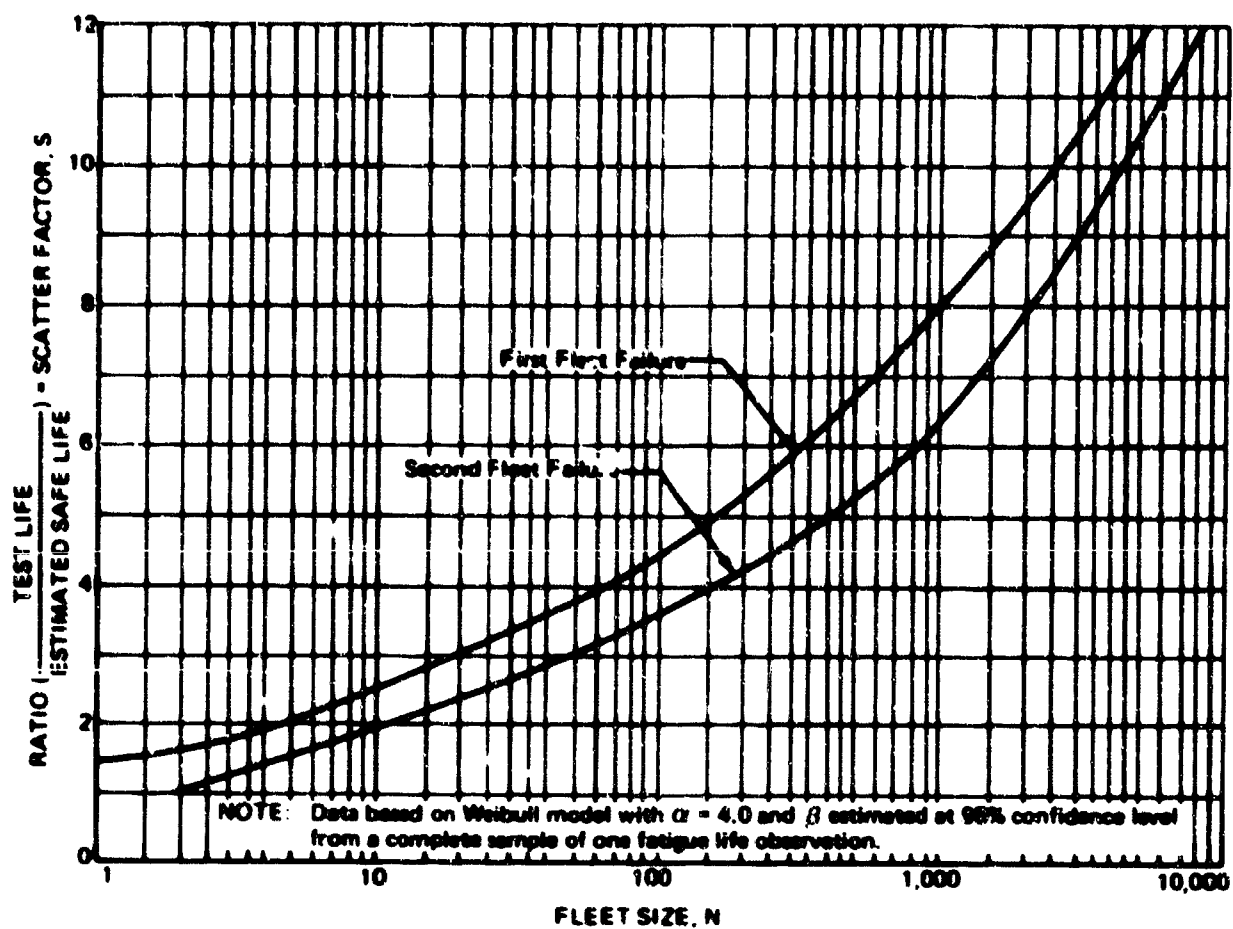


Figure 49. Influence of Fleet Size on Scatter Factors Required to Provide 50% Reliability for the First and Second Fleet Failures, Weibull Model

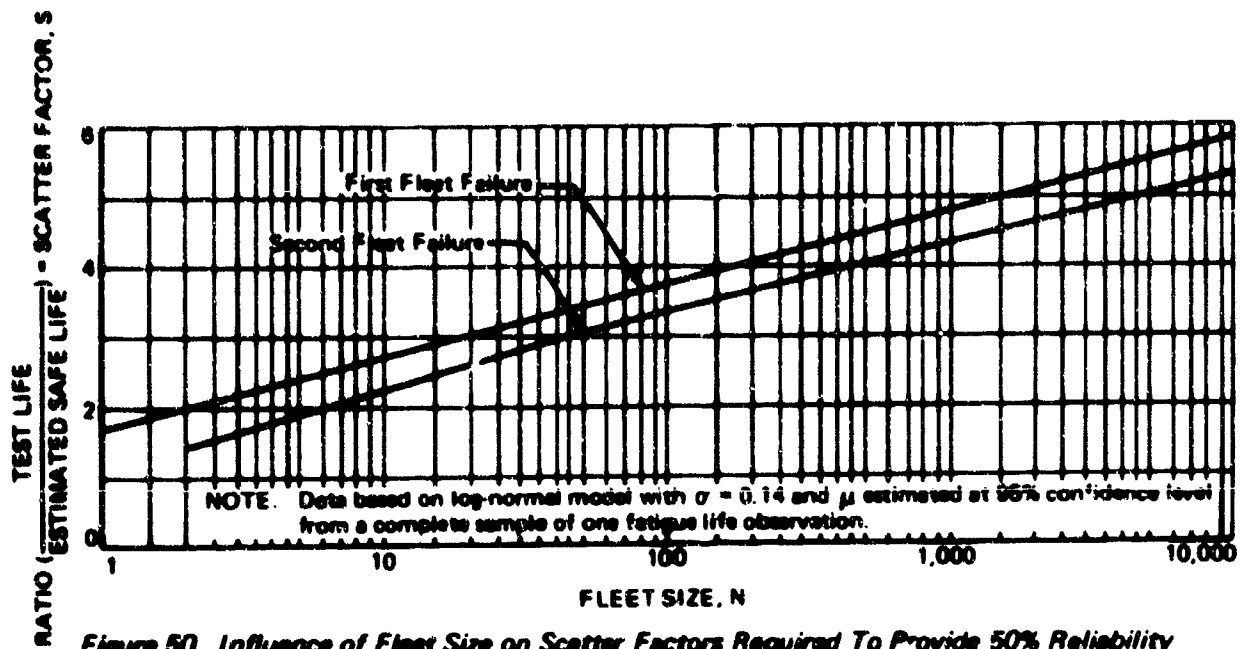


Figure 50. Influence of Fleet Size on Scatter Factors Required To Provide 50% Reliability for the First and Second Fleet Failures, Log-Normal Model

Table 1. Simulated Examples To Illustrate the Effects of Isolated Long-Life Specimens

Example	Fatigue life (cycles)	Estimates of:				Point estimates of life (cycles) at some failure probabilities	
		Log-average life μ (cycles)	Log-standard deviation σ	Characteristic life β (cycles)	Weibull shape α	Log-normal	Weibull
1	42,000	69,440	0.3817	108,040	0.887	50% = 69,438	71,480
	45,000					10% = 22,514	8,554
	48,000					5% = 16,360	3,800
	52,000					1% = 8,989	605
	55,000					0.1% = 4,594	45
	60,000					0.01% = 2,644	3
2	5,000	35,970	0.3815	47,680	2.541	50% = 35,965	41,273
	42,000					10% = 11,668	19,662
	45,000					5% = 8,480	14,811
	48,000					1% = 4,661	7,798
	52,000					0.1% = 2,383	3,145
	60,000					0.01% = 1,372	1,270

Table II. Simulated Examples to Illustrate Censoring Procedure

	Example 1			Example 2			Example 3		
	Fatigue life (cycles)	Log-standard deviation σ	Weibull shape β ($\hat{\beta}$)	Fatigue life (cycles)	Log-standard deviation σ	Weibull shape β ($\hat{\beta}$)	Fatigue life (cycles)	Log-standard deviation σ	Weibull shape β ($\hat{\beta}$)
Original estimate	42,000 45,000 48,000 52,000 55,000 60,000	0.06	9.07 (0.11)	42,000 45,000 48,000 52,000 55,000 60,000 400,000 500,000	0.44	0.95 (1.06)	4,000 5,000 42,000 45,000 48,000 52,000 55,000 55,000	0.49	1.63 (0.61)
Second estimate				42,000 45,000 48,000 52,000 55,000 60,000 400,000 400,000	0.44	1.05 (0.96)	4,000 5,000 42,000 45,000 48,000 52,000 55,000 55,000	0.50	1.50 (0.67)
Third estimate				42,000 45,000 48,000 52,000 55,000 60,000 60,000 60,000	0.07	9.07 (0.11)	4,000 5,000 42,000 45,000 48,000 52,000 52,000 52,000	0.55	1.35 (0.74)
Fourth estimate				42,000 45,000 48,000 52,000 55,000 55,000 55,000 55,000	0.06	11.70 (0.085)	4,000 5,000 42,000 45,000 48,000 48,000 48,000 48,000	0.62	1.20 (0.83)
Answer	Because original was O.K., no attempt was made to censor.			Third estimate	0.07	9.07	Original estimate	0.49	1.63

Table III. Seven Empirical Distributions of the Parameter-Free Statistic
 $1/U = \alpha/\bar{\alpha}$

NOTE: Tabulated values are $L_\gamma(1/U)$, where $P[1/U > L_\gamma(1/U)] = 1 - \gamma$

Coefficient of confidence γ \ Sample size n	2	3	4	5	10	20	Censored 3 of 5
0.01	(0.008) ^b 0.01	0.08	0.15	0.22	0.44	0.59	0.68
0.05	(0.042) 0.05	0.17	0.26	0.35	0.55	0.68	0.76
0.10	(0.084) 0.09	0.24	0.36	0.44	0.63	0.74	0.83
0.25	(0.213) 0.22	0.42	0.52	0.60	0.75	0.84	0.97
0.50	(0.458) 0.46	0.66	0.75	0.80	0.90	0.95	0.97
0.75	(0.811) 0.81	0.96	1.01	1.05	1.07	1.07	0.95
0.90	(1.228) 1.25	1.30	1.30	1.28	1.25	1.18	1.29
0.95	(1.528) 1.54	1.54	1.50	1.46	1.35	1.25	1.60
0.99	(2.207) 2.20	2.08	1.80	1.79	1.58	1.40	2.14
Smallest of 2,000 ^a	(0.0008) 0.001	0.018	0.07	0.08	0.26	0.44	0.64
Mean	(0.578) 0.58	0.73	---	0.84	0.92	0.95	---
Variance of distribution	(0.238) 0.24	0.19	---	0.12	0.06	0.03	---
Largest of 2,000 ^a	(3.449) 3.41	3.02	3.00	2.25	2.18	1.62	2.9

^aFor each sample size, $1/U$ was calculated for each of 2,000 independent groups of generated exponential ($\alpha=1$) variates. The empirical distributions were taken to be the ordered arrays of these estimates.

^bValues in parentheses are obtained from theory.

**Table IV. Seven Empirical Marginal Distributions of the Parameter-Free
Statistic $V = (\hat{\gamma}/\beta)^n$**

NOTE: Tabulated values are v , where $P(V \leq v) = \gamma$

Coefficient of confidence γ Sample size n	2	3	4	5	10	20	Censored 3 of 5
0.01	10^{-15}	0.0005	0.03	0.10	0.39	0.54	10^{-5}
0.10	0.01	0.19	0.31	0.44	0.62	0.72	0.05
0.25	0.23	0.45	0.58	0.64	0.79	0.84	0.25
0.50	0.81	0.87	0.97	0.95	1.00	0.99	0.69
0.75	2.08	1.64	1.55	1.41	1.26	1.17	1.24
0.90	11.0	3.6	2.70	2.17	1.60	1.39	1.86
0.95	70.0	6.4	4.08	3.1	1.83	1.53	2.6
0.98	5,000.0	17.0	7.7	5.2	2.21	1.75	4.2
0.99	10^7	80.0	17.0	8.0	2.7	1.89	8.0
Smallest of 2,000*	10^{-30}	10^{-9}	5×10^{-6}	0.0004	0.137	0.39	10^{-10}
Mean	10^{-22}	10^6	3.1	1.38	1.08	1.03	1.30
Largest of 2,000*	10^{26}	10^9	78.0	100.0	7.4	2.68	400.0
Variance of distribution	(10^{48})	(10^{16})	(80)	(10)	(0.24)	(0.078)(100)	

*For each sample size, V was calculated for each of 2,000 independent groups of generated exponential ($\alpha = 1$) variates. The empirical distributions were taken to be the ordered arrays of these estimates.

Table V Some Theoretical Distributions of the Parameter-Free Statistic
 $W = (\hat{\beta} - \beta) / \hat{\sigma}$

NOTES: 1. Tabulated values are w , where $P(W < w) = \gamma$
 2. From theory, $E(W) = 1$
 $\text{Var}(W) = 1/n_f$

Coefficient of confidence γ	Number of failure observations in sample n_f					
		1	2	3	5	10
0.01		0.010	0.07	0.14	0.26	0.41
0.02		0.020	0.11	0.19	0.31	0.46
0.05		0.05	0.18	0.27	0.39	0.54
0.10		0.11	0.27	0.37	0.49	0.62
0.20		0.22	0.41	0.51	0.62	0.73
0.30		0.36	0.55	0.64	0.73	0.81
0.50		0.69	0.84	0.89	0.93	0.97
0.70		1.20	1.22	1.21	1.18	1.13
0.80		1.61	1.50	1.43	1.34	1.25
0.90		2.30	1.94	1.77	1.60	1.42
0.95		3.00	2.37	2.10	1.83	1.57
0.98		3.91	2.92	2.51	2.11	1.75
0.99		4.61	3.32	2.80	2.32	1.87

Table VI. Results of Analyses Determining the Typical Shape Parameters for Fatigue Performance of Aluminum Structures

Data description	Number of groups	Unbiased estimate $\bar{\alpha}'$ of reciprocal shape parameter α
All collected data	2,003	0.259
All unqualified data	705	0.325
All qualified data: Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data	1,298	0.224
All qualified data:		
2024	551	0.213
7075	482	0.227
7178	125	0.246
Monolithic notched	444	0.240
Laboratory structures simulator	557	0.200
Full-scale structures	297	0.243
Constant amplitude	1,174	0.229
Variable amplitude	124	0.177
* { Bonded	83	0.419
* { Low amplitude, high life	111	0.419
* { Unnotched	179	0.110
70 to 10^3 cycles	50	0.240
10^3 to 10^4 cycles	168	0.215
10^4 to 6×10^4 cycles	434	0.204
6×10^4 to 4×10^5 cycles	444	0.259
4×10^5 to 10^6 cycles	78	0.227

*Rejected data

Table VII. Comparison of Results Between Uncensored Fatigue Data and Data Censored for High-Time Outliers

	Size of groups (n specimens)	Weibull model	
		Number of groups	Unbiased estimate $\hat{\alpha}, \hat{\beta}$ of reciprocal shape parameter α
MLE-uncensored	2	420	0.253
	3	328	0.301
	4	234	0.286
	5	145	0.380
	Weighted value of all groups	1,250	0.300
MLE-censored	2	420	0.253
	3	279	0.211
	4	193	0.201
	5	117	0.270
	Weighted value of all groups	1,119	0.242
Estimate from first two-ordered failures	2	420	0.253
	3	330	0.229
	4	236	0.200
	5	151	0.227
	Weighted value of all groups	1,298	0.224

Table VIII. Comparison of Results From Total Collected Fatigue Data and Qualified Structural-Equivalent-Type Data

	Sample size n	Number of samples	$\bar{\kappa}$	Observed Var $\bar{\kappa}$	Theoretical* Var $\bar{\kappa}$ (for $\kappa = \bar{\kappa}$)	Theoretical* Var $\bar{\kappa}$ (for $\kappa = 0.224$)
Total collected fatigue test data	2	524	0.293	0.1056	0.0611	0.0357
	3	431	0.304	0.1526	0.0756	0.0410
	4	494	0.215	0.0855	0.0401	0.0435
	5	196	0.273	0.1271	0.0667	0.0449
Only qualified fatigue test data	2	420	0.253	0.0585	0.0456	0.0357
	3	330	0.229	0.0537	0.0429	0.0410
	4	236	0.200	0.0391	0.0347	0.0435
	5	151	0.227	0.0841	0.0461	0.0449

*In theory, $\text{Var } \bar{\kappa} = C_n \kappa^2$ [See Eq. (IV-14)]

where: $C_2 = 0.712$
 $C_3 = 0.818$
 $C_4 = 0.867$
 $C_5 = 0.895$

Table IX. Scatter Factors To Obtain Reliability $\bar{R}$ in the Weakest of a Fleet of Size N , When n_f Specimens Are Tested to Failure (Weibull Model)

NOTES: 1. Data based on Weibull model with known shape parameters ($\alpha = 4.0$) and with unknown scale parameter β estimated at the 95% confidence level.
 2. Scatter factor $\beta/\bar{Z}_{\bar{R}} = S_{n_f} \cdot \bar{S} \cdot \bar{R} \cdot S_N$

Number of failures n_f in a complete or one-stage, type II, censored sample	S_{n_f}	Reliability $\bar{R}$	$\bar{S}\bar{R}$	Fleet size N	S_N
1	1.32	0.368 (characteristic life)	1.0	1	1.0
2	1.24	0.500 (median life)	1.096	3	1.316
3	1.20	0.507 (mean life)	1.102	10	1.777
4	1.18	0.750	1.365	20	2.12
5	1.16	0.900	1.755	50	2.66
10	1.12	0.950	2.10	100	3.16
∞	1.00	0.980	2.65	200	3.76
		0.990	3.16	500	4.74
		0.999	5.63	1,000	5.63
				10,000	10.0

$$\hat{\beta} = \text{MLE of Weibull scale } (\beta) = \left\{ \frac{1}{n_f} \left[\sum_{i=1}^{n_f} (Y_i^{4.0}) + (n - n_f) Y_{n_f}^{4.0} \right] \right\}^{1/4.0}$$

$\bar{Z}_{\bar{R}}$ design or certifiable life

Table X. Scatter Factors To Obtain Reliability $\bar{R}$ in the Second Weakest of a Fleet of Size N , when n_f Specimens Are Tested to Failure (Weibull Model)

NOTES: 1. Data based on Weibull model with known shape parameter ($\alpha = 4.0$) and with unknown scale parameter β estimated at the 95% confidence level.

2. Scatter factor $\frac{\beta}{\bar{Z}_{\bar{R}}} S_{n_f} \cdot S_{\bar{R}} \cdot S_{N\bar{R}}$

Number of failures n_f in a complete or one-stage, type II, censored sample	S_{n_f}	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	$S_{N\bar{R}}$ $\bar{R}$ 0.500	$S_{N\bar{R}}$ $\bar{R}$ 0.750	$S_{N\bar{R}}$ $\bar{R}$ 0.900	$S_{N\bar{R}}$ $\bar{R}$ 0.950
1	1.32	0.50	1.10	10	1.40	1.30	1.14	1.06
2	1.24	0.75	1.37	50	2.12	1.96	1.78	1.67
3	1.20	0.90	1.76	200	3.0	2.77	2.50	2.38
4	1.18	0.95	2.10	1,000	4.5	4.2	3.7	3.5
5	1.16							
10	1.12							
∞	1							

$$\hat{\beta} = \text{MLE of Weibull scale } (\beta) \left\{ \frac{1}{n_f} \left[\sum_{i=1}^{n_f} Y_i^{4.0} + (n-n_f) Y_{n_f}^{4.0} \right] \right\}^{1/4.0}$$

$\bar{Z}_{\bar{R}}$ design or certifiable life

Table XI. Comparison of Predicted Performance and Fleet Experience

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan 1969	Total number of airplanes in fleet	Table IX median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factors 4	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
A	1	1	4,600	---	268	592	3,200	2,550	3,500 to 5,000	2,720
		2	---	4,600	↑	↑	3,200	2,550	↑	None
		3	---	4,600	↑	↑	3,200	2,550	↑	None
		4	---	8,900	↑	↑	6,200	5,050	↑	None
		5	---	4,300	↑	↑	3,000	2,440	↑	None
		6	---	5,100	268	592	3,550	2,900	3,500 to 5,000	None
B	1	1	4,600	---	33	56	5,400	4,800	3,500 to 5,000	None
		2	---	4,600	↑	↑	5,400	4,800	↑	None
		3	---	4,600	↑	↑	5,400	4,800	↑	None
		4	---	8,900	↑	↑	10,500	9,200	↑	None
		5	---	4,300	↑	↑	5,100	5,300	↑	None
		6	---	5,100	33	56	6,000	6,200	3,500 to 5,000	None
C	1	1	---	6,000	11	11	---	9,350	4,500 to 6,000	None
		2	---	6,000	↑	↑	---	9,350	↑	None
		3	---	6,000	↑	↑	---	9,350	↑	None
		4	---	14,400	↑	↑	---	22,400	↑	None
		5	5,400	---	↑	↑	---	8,400	↑	None
		6	---	6,500	↑	↑	---	10,100	↑	None
		7	---	7,900	↑	↑	---	12,300	↑	None
		8	7,900	---	11	11	---	12,300	4,500 to 6,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX: median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factors ^a (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
D	1	1	---	6,000	10	10	---	9,500	4,500 to 6,000	None
		2	---	6,000	10	10	---	9,500	4,500 to 6,000	None
		6	---	6,600	10	10	---	10,400	4,500 to 6,000	None
		7	---	7,000	10	10	---	11,000	4,500 to 6,000	None
		8	---	7,000	10	10	---	11,000	4,500 to 6,000	None
E	1	1	---	5,600	8	8	---	9,400	4,000 to 5,500	None
		2	---	5,600	8	8	---	9,400	4,000 to 5,500	None
		3	---	5,600	8	8	---	9,400	4,000 to 5,500	None
		4	---	13,400	8	8	---	22,500	4,000 to 5,500	None
		5	---	6,200	8	8	---	10,400	4,000 to 5,500	None
		6	---	7,200	8	8	---	12,100	4,000 to 5,500	None
F	1	1	---	6,000	6	6	---	10,900	4,500 to 6,000	None
		2	---	6,000	6	6	---	10,900	4,500 to 6,000	None
		6	---	6,600	6	6	---	10,900	4,500 to 6,000	None
		7	---	7,000	6	6	---	12,700	4,500 to 6,000	None
		8	---	7,000	6	6	---	12,700	4,500 to 6,000	None
G	1	1	4,600	---	5	6	8,600	8,400	3,500 to 5,000	None
		2	---	4,600	5	6	8,600	8,400	3,500 to 5,000	None
		3	---	4,600	5	6	8,600	8,400	3,500 to 5,000	None
		4	---	8,900	5	6	16,700	16,200	3,500 to 5,000	None
		5	---	4,300	5	6	8,100	7,800	3,500 to 5,000	None
		6	---	5,100	5	6	9,600	9,100	3,500 to 5,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX: median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factors ⁴ (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
H	I	1	---	5,700	4	6	11,400	10,400	4,500 to 6,000	None
		2	---	5,700			11,400	10,400		
		3	---	5,700			11,400	10,400		
		4	---	13,500			27,000	24,500		
		5	---	7,400	4	6	14,800	13,400		
		6	---	8,600			17,200	15,600	4,500 to 6,000	None
J	I	1	---	6,500	5	5	---	12,200	5,000 to 6,500	None
		2	---	6,500			---	12,200		
		3	---	6,500			---	12,200		
		4	---	14,300			---	26,800		
		5	---	7,300			---	13,700		
		6	---	8,000	5	5	---	15,000	5,000 to 6,500	None
K	I	1	4,600	---	5	5	---	8,600	3,500 to 5,000	None
		2	---	4,600			---	8,600		
		3	---	4,600			---	8,600		
		4	---	8,900			---	16,700		
		5	---	4,300			---	8,100		
		6	---	5,100	5	5	---	9,600	3,500 to 5,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1, 69	Total number of airplanes in fleet	Table IX—median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor of 4 (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
L	I	1	4,600	---	2	4	10,400	9,100	3,500 to 5,000	None
		2	---	4,600	2	4	10,400	9,100	3,500 to 5,000	None
		3	---	4,600	2	4	10,400	9,100	3,500 to 5,000	None
		4	---	8,900	2	4	20,800	17,700	3,500 to 5,000	None
		5	---	4,300	2	4	10,100	8,500	3,500 to 5,000	None
		6	---	5,100	2	4	12,000	10,200	3,500 to 5,000	None
M	I	1	---	5,600	3	3	---	12,000	4,000 to 5,500	None
		2	---	5,600	3	3	---	12,000	4,000 to 5,500	None
		3	---	5,600	3	3	---	12,000	4,000 to 5,500	None
		4	---	13,400	3	3	---	28,600	4,000 to 5,500	None
		5	---	6,200	3	3	---	13,200	4,000 to 5,500	None
		6	---	7,200	3	3	---	15,400	4,000 to 5,500	None
N	I	1	4,600	---	2	2	---	10,400	3,500 to 5,000	None
		2	---	4,600	2	2	---	10,400	3,500 to 5,000	None
		3	---	4,600	2	2	---	10,400	3,500 to 5,000	None
		4	---	8,900	2	2	---	20,800	3,500 to 5,000	None
		5	---	4,300	2	2	---	10,100	3,500 to 5,000	None
		6	---	5,100	2	2	---	12,000	3,500 to 5,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX—median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor of 4 (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
P	I	1	---	3,100	2	2	---	7,250	1,500 to 3,000	None
		2	---	3,100			---	7,250		
		3	---	3,100			---	7,250		
		4	---	11,800			---	27,600		
		5	---	5,400			---	12,600		
		6	---	7,100	2	2	---	10,600	1,500 to 3,000	None
C	II	12	---	10,800	10	11	17,000	16,700	9,500 to 11,000	None
		13	---	11,100	10	11	17,500	17,200	9,500 to 11,000	None
D	II	12	---	11,300	2	10	26,400	17,800	9,500 to 11,000	None
		13	---	10,900	2	10	25,500	17,200	9,500 to 11,000	None
E	II	7	---	7,900	7	8	13,700	13,300	6,500 to 11,000	None
		9	7,900	---			13,700	13,300		
		11	8,300	---			14,400	14,000		
		12	---	10,000			17,400	16,400		
		13	---	10,300	7	8	17,900	17,300	6,500 to 11,000	None
F	II	12	---	11,300	4	6	22,400	20,500	9,500 to 11,000	None
		13	---	10,900	4	6	21,600	19,800	9,500 to 11,000	None

Table XI—Concluded

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX: median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor ²⁴ (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
J	II	7	---	10,800	3	5	23,100	20,200	9,500 to 11,000	None
		9	---	10,800			23,100	20,200		
		11	---	11,300			24,200	21,200		
		12	---	11,600			24,800	21,700		
		13	---	12,000	3	5	25,600	22,500	9,500 to 11,000	None
M	II	7	---	7,900	2	3	18,500	16,900	6,500 to 8,000	None
		9	7,900	---			18,500	16,900		
		11	8,500	---			19,400	17,700		
		12	---	10,000			23,400	21,400		
		13	---	10,300	2	3	24,100	22,000	6,500 to 8,000	None
P	II	7	---	3,500	1	2	9,800	8,200	2,000 to 3,500	None
		9	---	3,500			9,800	8,200		
		11	---	3,700			10,400	8,700		
		12	---	6,900			19,300	16,100		
		13	---	5,700	1	2	16,000	13,300	2,000 to 3,500	None

Table XII. Comparison of Results Between Uncensored Fatigue Data and Data Censored for High-Time Outliers (Log-Normal Distribution)

	Size of groups (n specimens)	Log-normal model	
		Number of groups	$\hat{\sigma}^2$ (log X)
MLE-uncensored	2	420	0.149
	3	328	0.181
	4	234	0.159
	5	145	0.208
	Weighted value of all groups	1,250	0.168
MLE-censored	2	420	0.149
	3	279	0.111
	4	193	0.108
	5	119	0.147
	Weighted value of all groups	1,121	0.135

Table XIII. Scatter Factors To Obtain Reliability $\bar{R}$ in the Weakest of a Fleet of Size N , When n Specimens Are Tested To Failure (Log-Normal Model)

NOTES: 1. Data based on log-normal model with known shape parameter ($\sigma = 0.14$) and with unknown scale parameter μ estimated at the 95% confidence level.

2. Scatter factor $\frac{10\mu}{Z_R} = S_n \cdot S_{\bar{R}} \cdot S_{N\bar{R}}$

Sample size n	S_n	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	$S_{N\bar{R}}$ $\bar{R}$ 0.500	$S_{N\bar{R}}$ $\bar{R}$ 0.600	$S_{N\bar{R}}$ $\bar{R}$ 0.750	$S_{N\bar{R}}$ $\bar{R}$ 0.900	$S_{N\bar{R}}$ $\bar{R}$ 0.950	$S_{N\bar{R}}$ $\bar{R}$ 0.990
1	1.70	0.500 (median life)	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00
2	1.45	0.600	1.09	3	1.30	1.27	1.24	1.19	1.16	1.13
3	1.36	0.750	1.24	10	1.62	1.56	1.49	1.39	1.35	1.28
4	1.30	0.900	1.51	20	1.80	1.72	1.64	1.51	1.45	1.36
5	1.27	0.950	1.70	50	2.03	1.95	1.82	1.67	1.57	1.48
10	1.18	0.990	2.12	100	2.24	2.11	1.97	1.77	1.70	1.56
∞	1	---	---	200	2.42	2.32	2.10	1.90	1.82	1.66
				500	2.64	2.50	2.31	2.05	1.94	1.77
				1,000	2.82	2.65	2.44	2.21	2.07	1.85
				10,000	3.45	3.24	2.96	2.62	2.45	2.18

$$\hat{\mu} = \text{MLE of log-normal scale } (\mu) = \frac{1}{n} \sum_{i=1}^n \log Y_i$$

Z_R design or certifiable life

Table XIV Scatter Factors To Obtain Reliability $\bar{R}$ in the Second Weakest of a Fleet of Size N, When n Specimens Are Tested To Failure (Log-Normal Model)

NOTES: 1. Data based on log normal model with known shape parameter ($\sigma = 0.14$) and with unknown scale parameter μ estimated at the 95% confidence level.

2. Scatter factor $\frac{10\hat{\mu}}{\hat{\sigma}_{\bar{R}}} = S_n \cdot S_{\bar{R}} \cdot S_{N\bar{R}}$

Complete sample size n	S_n	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	$S_{N\bar{R}}$ $\bar{R} = 0.500$	$S_{N\bar{R}}$ $\bar{R} = 0.750$	$S_{N\bar{R}}$ $\bar{R} = 0.900$	$S_{N\bar{R}}$ $\bar{R} = 0.950$
1	1.70	0.50	1.00	10	1.37	1.22	1.07	1.05
2	1.45	0.95	1.24	50	1.81	1.58	1.40	1.29
3	1.36	0.90	1.51	200	2.14	1.85	1.64	1.51
4	1.30	0.95	1.70	1,000	2.55	2.19	1.91	1.76
5	1.27	---	---	---	---	---	---	---
10	1.18	---	---	---	---	---	---	---
∞	1.00	---	---	---	---	---	---	---

$\hat{\mu}$ = MLE of log-normal scale (μ) $\cdot \frac{1}{n} \sum_{i=1}^n \log Y_i$
 $\hat{\sigma}_{\bar{R}}$ design or certifiable life

Table XV. Scatter Factors To Obtain Reliability $\bar{R}$ in the Weakest of a Fleet of Size N, When n Specimens Are Tested to Failure (No Failure Model Assumed)

NOTES: 1. Data based on the Tchebycheff Limit Theorem in lieu of an assumed failure model. The log-standard deviation σ is assumed to equal 0.14; the unknown log average $\bar{\eta}$ is estimated at a confidence level greater than 95%.

2. Scatter factor $\frac{10\bar{\eta}}{\bar{Z}_{\bar{R}}} = S = S_n = S_R$

Sample size n_f	S_{n_f}	Fleet size N	Reliability $\bar{R}$				
1	4.30	1 10 50	0.50	0.75	0.90	0.95	0.99
2	2.80		1.58	1.91	2.76	4.3	25
3	2.30		3.6	6.8	20.00	90.0	$>10^4$
4	2.06		15.0	76.0	1,100	$>10^4$	$>10^4$
5	1.91						
10	1.58		Tabulated values are of S_R				
=	1.00						

$\bar{\eta}$ = average of log lives of data

$\bar{Z}_{\bar{R}}$ = safe life

APPENDIX I

MATHEMATICAL DERIVATIONS, THEOREMS, AND PROOFS REQUIRED FOR APPLICATION OF THE WEIBULL MLE

INTRODUCTION

This appendix discusses all nonobvious mathematical statements introduced in the text that pertain to maximum-likelihood estimation of Weibull population parameters. These include:

- a) A derivation of the Weibull MLE for all samples.
- b) Proof that the following statistics are independent of α and β , for all complete and some censored samples,
 - 1) $U = \hat{\alpha}/\alpha$
 - 2) $V = (\hat{\beta}/\beta)^{\hat{\alpha}}$
 - 3) $W = (\hat{\beta}/\beta)^{\alpha}$
- c) A brief description of the computational procedure used to obtain the empirical marginal distributions of U and V .
- d) Some remarks pertaining to the adequacy of the random-number generator used to generate independent exponential variates needed to initiate the above computational procedure.
- e) A derivation of the theoretical distribution of W .

DERIVATIONS

Let X be a random variable with a Weibull distribution. The reliability of X then is

$$R(x) = \exp[-(x/\beta)^\alpha] \quad \text{for } x > 0 \quad (\text{AI-1})$$

where $\alpha, \beta > 0$ are the two parameters of the distribution.

We assume that a number of components, say n , each with the same Weibull distribution of life are put on test. However, what is observed at each trial is the time the component fails or the time the test is terminated. Let Z be a random time at which the test is terminated for any reason other than failure of the component. Then what we observe is the event

$$\{X = x\} \cap \{X < Z\} \quad \text{or} \quad \{Z = z\} \cap \{X \geq Z\} \quad (\text{AI-2})$$

We now state

Lemma 1: If $(Z_1, \dots, Z_n)$ is a vector of nonnegative random variables, possibly dependent on $(X_1, \dots, X_n)$, which are themselves independently and identically distributed nonnegative random variables with common

density function f and distribution F , then the likelihood of the event

$$\bigcap_{i=1}^k \{X_i \leq Z_i\} \{X_i = x_i\} \bigcap_{i=k+1}^n \{X_i > Z_i\} \{Z_i = z_i\} \quad (A1-3)$$

where k ($\leq n$) is the (random) number of failures observed, is of the form

$$C \prod_{i=1}^k f(x_i) \prod_{j=k+1}^n [1 - F(z_j)]$$

and the constant C depends on $(x_1, \dots, x_k)$ but not on F .

Proof: Let g be the joint density of $(Z_1, \dots, Z_n)$ given $X_1, \dots, X_n$. Then the probability of the event specified in Eq. (A1-3) is

$$\int_{\{z_i > x_i \mid i=1, \dots, k\}} \prod_{i=1}^k f(x_i) \prod_{i=k+1}^n [1 - F(z_i)] g(z_1, \dots, z_n \mid x_1, \dots, x_n) dz_1, \dots, dz_k$$

which upon simplification shows that

$$C = \int_{\{z_i > x_i \mid i=1, \dots, k\}} g(z_1, \dots, z_n \mid x_1, \dots, x_n) dz_1, \dots, dz_k \quad (A1-4)$$

and thus for an observed failure time $(x_1, \dots, x_k)$, C does not depend on F .

To simplify the notation in what follows we let $(t_1, \dots, t_k)$ denote the set of complete observations of X and $(t_{k+1}, \dots, t_n)$ denote the set of censored tests (i.e. the set of observations of Z). Then from the lemma we see that the log-likelihood, except for some constant independent of α, β , is

$$L = \sum_{i=1}^k \left[\ln\left(\frac{\alpha}{\beta}\right) + (\alpha-1) \ln\left(\frac{t_i}{\beta}\right) - \left(\frac{t_i}{\beta}\right)^\alpha \right] - \sum_{i=k+1}^n \left(\frac{t_i}{\beta}\right)^\alpha \quad (A1-5)$$

and we then obtain

$$\frac{\partial L}{\partial a} = \frac{k}{a} + \sum_{i=1}^k \ln\left(\frac{t_i}{a}\right) - \sum_{i=1}^n \left(\frac{t_i}{a}\right)^{\frac{1}{b}} \ln\left(\frac{t_i}{a}\right) \quad (\text{AI-6})$$

$$\frac{\partial L}{\partial b} = -k \frac{1}{b} + \frac{1}{b} \sum_{i=1}^n \left(\frac{t_i}{a}\right)^{\frac{1}{b}} \quad (\text{AI-7})$$

Thus the two maximum-likelihood estimators $\hat{a}, \hat{b}$ of a and b when both parameters are unknown are defined by

$$\frac{1}{k} \sum_{i=1}^n \left(\frac{t_i}{\hat{a}}\right)^{\hat{b}} = 1 \quad (\text{AI-8})$$

and

$$\frac{k}{\hat{b}} = \sum_{i=1}^n \left(\frac{t_i}{\hat{a}}\right)^{\hat{b}} \ln\left(\frac{t_i}{\hat{a}}\right) - \sum_{i=1}^k \ln\left(\frac{t_i}{\hat{a}}\right) \quad (\text{AI-9})$$

These results have been given previously by Cohen (13).

Let us define

$$y_i = \left(\frac{t_i}{a}\right)^{\frac{1}{b}} \quad \text{for } i=1, \dots, n$$

$$u = \frac{1}{a}, \quad v = \left(\frac{1}{b}\right)$$

then Eqs. (AI-8) and (AI-9) become, respectively--by using the fact that

$$\left(\frac{t_i}{\hat{a}}\right)^{\hat{b}} = \left(\frac{y_i}{v}\right)^u, \quad \left(\frac{t_i}{\hat{a}}\right)^{\frac{1}{\hat{b}}} = \frac{y_i}{v}$$

and simplifying:

$$v = \left[\frac{1}{k} \sum_{i=1}^n y_i^u \right]^{\frac{1}{u}} \quad (\text{AI-10})$$

and

$$\frac{\sum_{i=1}^n y_i^u \ln y_i}{\sum_{i=1}^n y_i^u} = \frac{1}{u} = \frac{1}{k} \sum_{i=1}^k \ln y_i \quad (\text{AI-11})$$

For $i=1, \dots, k$ we know that y_i is an independent observation from an exponential random variable with unit mean. Consider the condition:

$$(Y_{k+1}, \dots, Y_n) \perp (Y_1, \dots, Y_k) \quad (\text{AI-12})$$

has a distribution independent of α and β , where K is the random number of uncensored items.

We can now state:

Theorem 1: A necessary and sufficient condition that U and V , as defined in Eqs. (AI-10) and (AI-11), have a distribution independent of α and β is that Eq. (AI-12) be true.

Proof: It is clear from Eqs. (AI-10) and (AI-11) that U and V are parameter free if $Y_1, \dots, Y_n$ are, which is true iff condition (AI-12) is $\parallel$.

Note, for example, that condition (AI-12) is true if with probability one

$$K = k \text{ and } Z_{k+1} = \dots = Z_n = X_{k,n} \quad (\text{AI-13})$$

where $x_{k,n}$ is the k^{th} -ordered observation out of n . This is merely the case of sampling censored at the k^{th} failure time.

Let us briefly consider the case when Eq. (AI-13) is true. Under this condition we can obtain the distribution of U and V by Monte-Carlo simulation methods:

Let $n \geq k$ be given positive integers. Let $y_{(1)}, \dots, y_{(k)}$ be the first k -ordered observation from n independent machine-generated exponential variates each with unit mean. Solve for μ in the equation $\phi(u) = 0$, where

$$u = \frac{\sum_{i=1}^k y_{(i)}^u \ln y_{(i)} + (n-k)y_{(k)}^u \ln y_{(k)}}{\sum_{i=1}^k y_{(i)}^u + (n-k)y_{(k)}^u} - \frac{1}{u} - \frac{1}{k} \sum_{i=1}^k \ln y_{(i)}$$

Now compute

$$v = \frac{1}{k} \sum_{i=1}^k y_{(i)}^u + (n-k)y_{(k)}^u \frac{1}{u}$$

Repeat this procedure m times for independent samples of y 's, and so obtain a sample of size m of (U,V) . The sample size m can be made sufficiently large to determine the distribution of U,V to a degree of accuracy determined by the machine procedure that generates the pseudorandom numbers.

The random-number generators used in the simulation studies presented here are of the type called composite congruential generators. These "second generation" methods appear to be better; that is, they satisfy more stringent statistical tests of randomness than those of the simple congruential generators used previously. In the particular method adopted here, three generators are mixed for the IBM 360, each of which will produce a full period of residues relatively prime to the modulus 2^{32} (consequently, these mixed generators will produce 2^{30} distinct random numbers before repeating). This method is presented in detail and discussed by Marsaglia and Bray (29). To obtain our exponential variates with unit mean, we merely take the negative of the natural logarithm of the uniform variates generated by the mixed congruential method.

We now consider the sampling distribution of $\hat{\beta}$:

Theorem 2: If β is known, the maximum-likelihood estimate of β , call it $\hat{\beta}$, is

$$\hat{\beta} = \left[\frac{1}{k} \sum_{i=1}^n t_i \right]^{-1}$$

and

$$w = \left(\frac{\hat{\beta}}{\beta} \right)^{-1}$$

has a distribution independent of λ and β if condition (AI-12) is true. Moreover, in this case the distribution is the same as that of

$$W = \frac{1}{k} \sum_{i=1}^n Y_i$$

Proof: The proof is immediate.

In the special case when Eq. (AI-13) is satisfied, then

$$W = \frac{1}{k} \sum_{i=1}^k Y_{(i)} + (n-k)Y_{(k)}$$

where the $Y_{(i)}$ are the first k -ordered observations from independent exponential variates with unit mean. Thus:

$$W = \frac{1}{k} \sum_{j=1}^k (n-j+1)[Y_{(j)} - Y_{(j-1)}]$$

which by known results (e.g. Ref. 30, p.18) is the sum of k independent exponential variates with unit mean. By the well-known fact (e.g. Ref. 31) that two times an exponential variate with unit mean is a chi-square variate with two degrees of freedom, and the reproducing property of chi-square variables under convolution (Ref. 30, p. 10), there follows the result that $2kW$ has a chi-square distribution with $2k$ degrees of freedom.

APPENDIX II

LIST OF SALIENT FEATURES AND UNBIASED POINT ESTIMATES OF POPULATION PARAMETERS OF COLLECTED FATIGUE DATA

1. TABULATED RESULTS

The salient features of all the collected fatigue performance data, including the estimated population parameters, are tabulated in this appendix. The estimates of the scale parameters were included to complete the description of the data only, and no further use is made of the generated values.

An 11-digit description number is provided to catalog the variables of specimen thickness, material, grain direction, type of structure, type of specimen, finish, type of loading, and type of failure. A code is provided on the following page to facilitate usage of the tabulated data descriptions.

Also listed on the output are the test sample size and the number of samples tested to failure. Two additional columns, labeled "size used for MLE, log-normal and Weibull," are given. These columns demonstrate the number of specimens used for estimating the shape parameter after the high-time outliers have been censored from the sample. It can be seen from the tabulated results that the high-time outlier afflicts only a minority of the data and that a sample censored for the Weibull model is not necessarily censored for the log-normal model.

The initial two shape parameters are the unbiased point estimates for the log-normal and Weibull models using the MLE on data that had been censored for high-time outliers, and the last column is the unbiased point estimate of the Weibull shape parameter given by the two-ordered-statistic estimator.

Finally, a complete listing of the data references is presented, and corresponds with the REF column of the computer printout.

2. LIST OF REFERENCES

The following reference sources are those identified in the REF column of the computer printout tabulations in Appendixes II and III:

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- (70) K.D. Raithby: Fatigue Tests on Typical Two-Spar Light Alloy Structures (Meteor 4 Tailplanes) Under Reversed Loading, RAE Report No. Structures 108, May 1951
- (71) H. Yeomans: Programmed Loading Fatigue Tests on a Bolted Joint, RAE TN No. Structures 327, March 1963
- (72) C.R. Smith: Linear Strain Theory and the Smith Method for Predicting Fatigue Life of Structures for Spectrum-Type Loading, ARL 64-55, April 1964
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DATA CODING SYSTEM

X X X X X X X X X X X X X X X X

SPECIMEN THICKNESS: (three digits)

Thickness of Minimum
or Fractured Material
or Specimen Diameter
(10⁻³ in.)
000 - Thickness not
known or variable

MATERIALS: (two digits)

- 01 - 2024-T1 Bare
- 02 - 2024-T3 Clad
- 03 - 2024-T3 EXTR
- 04 - 2024-T6 Bare
- 05 - 2024-T6 Clad
- 06 - 2024-T6 EXTR
- 08 - 6061-T6
- 10 - 7075-T6 Bare
- 11 - 7075-T6 Clad
- 12 - 7075-T6 EXTR
- 13 - 7075-T6 Die-formed
- 14 - 7076-T6 Bare
- 15 - 7076-T6 Clad
- 16 - 7076-T6 EXTR
- 17 - 7079-T6 Bare
- 18 - 7079-T6 Clad
- 19 - 7079-T6 EXTR
- 20 - 7178-T6 Bare
- 21 - 7178-T6 Clad
- 22 - 7178-T6 EXTR
- 23 - 7076-T6l
- 24 - Al-Ni-Bronze
- 25 - Beryllium copper 25
- 26 - 6 Al-4V titanium alloy
- 27 - DTD 687A Al alloy
- 28 - 2024-0 (annealed)
- 29 - 1100-
- 30 - D.T.D. 343A
- 31 - D.T.D. 3648 EXTR
- 32 - D.T.D. 683 (RR, 77) EXTR
- 33 - D.T.D. 5468 Clad
- 34 - D.T.D. 610 Clad
- 40 - SAE 4130 (H.T. 300 ksi)
- 41 - 4130 Steel
- 43 - 4340 Steel
- 44 - 4405 Steel (Aon)
- 45 - SAE 1045
- 46 - SAE 1017 (or ASTM-285)
- 47 - SAE 1018
- 48 - SAE 1050
- 50 - Composed of more than
one kind of material

TYPE OF SPECIMEN:

- 0 - Open holes
- 1 - Riveted
- 2 - Spotwelded
- 3 - Bolted
- 4 - Riveted & bonded
- 5 - Edge-notched
- 6 - Pin-connected
- 7 - Riveted & bolted
- 8 - Bonded
- 9 - Others

TYPE OF LOADING:

- 0 - Axial (comp. comp.)
- 1 - Axial (other types)
- 2 - Bending flexural
- 3 - Bending rotating beam
- 4 - Torsion
- 5 - Spectrum (random)
- 6 - Spectrum (decreasing stress amplitude)
- 7 - Spectrum (increasing)
- 8 - Spectrum (up & down stress)
- 9 - Sonic fatigue

FINISH:

- 0 - Normal
- 1 - Hot-peened
- 2 - Chem-milled
- 3 - Corroded
- 4 - Machine milled & polished
- 5 - Chem-milled & shot-peened
- 6 - Chem-milled & chem-polished
- 7 - Different etchants
- 8 - Others
- 9 - Heat-treated

MAIN DIRECTION:

- 0 - Not known
- 1 - Diagonal
- 2 - Other directions
- 3 - Longitudinal
- 4 - Short transverse

TYPE OF STRUCTURE:

- 0 - Lug
- 1 - Butt joint
- 2 - Lap joint
- 3 - Double shear
- 4 - Scarf joint
- 5 - Monolithic unnotched
- 6 - Monolithic notched
- 7 - Partial load transfer
- 8 - Structural components and full-scale structures
- 9 - Service airplanes

TESTING PECULIARITIES:

- 0 - Normal complete failure
- 1 - First crack
- 2 - Special type
- 3 - Data revised

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLE SIZE	NUMBER FAILED	SIZE LIM	SIZE F10 MLE	SIZE USED	FIRST FAILURE (F11)	SECOND FAILURE (F12)	LAST FAILURE (F1NF)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-ETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)
1	1	04010400010	5	5	5	5	2144	6200	11840	6172	.2749	.7943	2.0100	1.0007	1.0007
2	1	04010400010	5	5	5	5	3100	2956	6377	4609	.1308	5281	5.1964	5.1900	5.1900
3	1	04010400010	5	5	5	5	2765	3130	8041	4589	.1068	5521	2.2711	4.9181	4.9181
4	1	04010400010	5	5	5	5	3272	3406	4200	4269	.0820	4629	6.0075	9.1178	9.1178
5	1	04010400010	5	5	5	5	1790	2445	4175	2842	.2240	.5493	2.2400	1.7669	1.7669
6	1	04010400010	5	5	5	5	6331	4500	8700	5044	.0644	5412	6.0923	2.1970	2.1970
7	1	04010400010	5	5	5	5	10900	37900	128300	17627	.3563	16751	5.6075	.8335	.8335
8	1	04010400010	5	5	5	5	10900	12400	41400	20430	.7411	26142	1.9645	7.2178	7.2178
9	1	04010400010	5	5	5	5	7995	10900	16800	12749	.1420	14221	2.9496	6.1194	6.1194
10	1	04010400010	5	5	5	5	7995	2722	11294	9789	.0652	10425	6.1278	12.4181	12.4181
11	1	04010400010	5	5	5	5	12600	12600	16200	14310	.0944	15127	6.0754	VERY HIGH	VERY HIGH
12	1	04010400010	5	5	5	5	3600	5607	7047	5716	.1217	4184	5.2042	2.7117	2.7117
13	1	04010400010	5	5	5	5	12400	12600	25200	15868	.1264	14264	2.9645	VERY HIGH	VERY HIGH
14	1	04010400010	5	5	5	5	7200	36700	26546	24997	.6409	13274	7.6645	.6337	.6337
15	1	04010400010	5	5	5	5	27600	27540	55800	40401	.1578	47223	3.3814	55.1013	55.1013
16	1	04010400010	5	5	5	5	23400	52400	44600	39657	.2087	34304	4.1773	3.6244	3.6244
17	1	04010400010	5	5	5	5	13400	14470	76743	16352	.0980	14700	8.5467	20.1111	20.1111
18	1	04010400010	5	5	5	5	27600	53007	63603	64044	.2179	78421	1.0643	1.3517	1.3517
19	1	04010400010	5	5	5	5	19450	16200	23460	204217	.0365	21503	9.1407	192.9537	192.9537
20	1	04010400010	5	5	5	5	17440	180707	44657	24243	.1499	292733	2.1553	55.2745	55.2745
22	1	04010400010	5	5	5	5	3400	4293	7200	5032	.1273	5747	3.4401	5.4279	5.4279
23	1	04010400010	5	5	5	5	1840	2520	6150	3446	.2325	2494	5.1342	1.7733	1.7733
24	1	04010400010	5	5	5	5	1471	2325	3170	2436	.1341	2784	6.3583	2.6172	2.6172
25	1	04010400010	5	5	5	5	84200	94200	127600	120194	.1227	110125	4.0141	VERY HIGH	VERY HIGH
26	1	04010400010	5	5	5	5	12314	14956	14454	13360	.0452	14080	6.5597	6.4116	6.4116
27	1	04010400010	5	5	5	5	1260	1400	4033	2357	.2746	2042	1.0627	3.7917	3.7917
28	1	04010400010	5	5	5	5	5240	26903	27400	31445	.0675	33731	5.5594	12.1157	12.1157
29	1	04010400010	5	5	5	5	9000	9400	27000	12428	.1544	11050	6.2167	17.2478	17.2478
30	1	04010400010	5	5	5	5	6300	6450	15440	8104	.1544	9174	2.2501	97.4142	97.4142
31	1	04010400010	5	5	5	5	25200	35700	57400	57874	.2525	61540	1.3743	1.1261	1.1261
32	1	04010400010	5	5	5	5	6150	6100	4620	7339	.0470	7441	7.4404	47.1300	47.1300
33	1	04010400010	5	5	5	5	14400	16740	34200	22114	.1606	26374	2.4406	7.4304	7.4304
34	1	04010400010	5	5	5	5	7000	17400	213600	272404	.3046	205117	1.4475	1.6115	1.6115
35	1	04010400010	5	5	5	5	2440	3174	7254	5645	.6402	6402	4.3174	1.6542	1.6542
36	1	04010400010	5	5	5	5	1	15503	361700	36651	.1506	100474	6.2454	1.7107	1.7107
37	1	04010400010	5	5	5	5	1	2450	2450	4400	.2074	3747	2.4406	2.7117	2.7117
38	1	04010400010	5	5	5	5	1	2450	2450	4400	.1681	46751	3.2035	1.3517	1.3517
39	1	04010400010	5	5	5	5	3530	3400	27400	4733	.5041	4424	1.4475	4.117	4.117
40	1	04010400010	5	5	5	5	2520	2450	4400	4733	.1005	41320	6.2742	6.2742	6.2742
41	1	04010400010	5	5	5	5	2520	2450	4400	4733	.1005	41320	6.2742	6.2742	6.2742
42	1	04010400010	5	5	5	5	1347	3445	4330	3731	.0480	3030	8.4041	10.1115	10.1115

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS															
ITEM	DES	DESCRIPTION	SAM- PLT	NUMBER FAILED	SIZE LNW	SIZE MLC	SIZE MLC	FIRST FAILURE (F123)	SECOND FAILURE (F123)	LAST FAILURE (F123)	LOG-NORMAL SCALE (MLE-NJ)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SCALE (MLE-ALPHA)
43	1	00010000010	5	5	6	6	9000	10000	10000	14700	12421	0.732	13379	6.6294	14.0123
44	1	00012000000	10	10	5	5	70000	70000	70000	331000	85078	0.050	91041	16.3531	12.8115
45	1	00012000000	10	10	9	8	92000	90000	90000	1160000	233604	0.3479	215514	2.0037	2.7125
46	1	00012000000	10	10	10	10	7100	7400	7400	9000	8487	0.049	2938	9.0609	25.5585
47	1	00012000000	10	10	10	10	15000	15000	15000	19200	16733	0.0267	17307	13.1077	12.9753
48	1	00012000000	10	10	10	10	40000	40000	40000	269000	61855	0.2351	56678	6.3503	11.0555
49	1	00012000000	10	10	10	10	121000	121000	121000	1849000	435406	0.252	658342	1.1527	1.0582
50	1	00012000000	10	10	10	10	41000	142000	142000	763000	341054	0.3943	493554	1.5853	1.0582
51	1	00012000000	10	10	10	10	17000	17000	17000	41000	28001	0.1429	32356	3.8922	VERY HIGH
52	1	00012000000	10	10	7	6	29000	11000	11000	649000	93822	0.1974	43279	6.5867	15.2382
53	1	00012000000	10	10	10	10	224000	224000	224000	842000	460234	0.2251	584007	2.2716	8.6543
54	1	00012000000	10	10	10	10	730000	962000	962000	1248000	1034149	0.0929	1146545	6.4095	21.0589
55	1	00012000000	5	5	5	5	13430	14000	14000	20570	15890	0.081	17138	5.3765	9.5134
56	1	00012000000	5	5	5	5	4000	5600	5600	4500	4916	0.0777	5251	7.6792	6.0532
57	1	00012000000	5	5	5	5	11400	12000	12000	12000	11896	0.0158	11889	20.1335	27.0748
58	1	00012000000	5	5	5	5	10000	11500	11500	11500	10724	0.0429	11101	9.8100	9.9192
59	1	00012000000	5	5	5	5	13300	14500	14500	14500	13934	0.0286	14260	16.7019	16.8852
60	1	00012000000	5	5	5	5	2600	2700	2700	2700	2650	0.0116	2642	27.6190	16.7376
61	1	00012000000	5	5	5	5	32000	39000	39000	4000	37125	0.0569	38999	9.5535	6.1488
62	1	00012000000	5	5	5	5	34500	45000	45000	45800	62534	0.0455	64119	9.2650	9.3579
63	1	00012000000	5	5	5	5	42500	140000	140000	140000	107471	0.1624	127488	2.5926	2.8716
64	1	00012000000	5	5	5	5	10500	10700	10700	10700	10600	0.058	10643	56.8355	21.6716
65	1	00012000000	5	5	5	5	7800	10000	10000	10000	8832	0.0763	9391	5.5182	5.5795
66	1	00012000000	5	5	5	5	16000	19000	19000	19000	17636	0.0528	18193	7.9782	8.0689
67	1	00012000000	5	5	5	5	19000	68000	68000	14000	51698	0.1707	49084	2.6662	2.8355
68	1	00012000000	5	5	5	5	81000	107000	107000	107000	93097	0.0855	99737	4.9751	4.9799
69	1	00012000000	5	5	5	5	136000	302000	302000	300000	201990	0.2430	245044	1.7330	1.7523
70	1	00012000000	5	5	5	5	4000	9100	9100	9100	9050	0.034	9082	93.5221	125.6386
71	1	00012000000	5	5	5	5	61000	67000	67000	67000	52412	0.1508	49181	2.7917	2.8227
72	1	00012000000	5	5	5	5	91000	96000	96000	96000	93467	0.0184	95072	19.3652	25.9111
73	1	00012000000	5	5	5	5	221000	719000	719000	719000	398631	0.3623	533677	1.1622	1.1751
74	1	00012000000	5	5	5	5	17000	27000	27000	27000	21424	0.1421	24021	2.9637	2.9864
75	1	00012000000	5	5	5	5	61000	55000	55000	55000	47487	0.0027	41085	6.7191	6.7191
76	1	00012000000	5	5	5	5	158000	274000	274000	228000	195714	0.0438	211049	6.4897	6.5194
77	1	00012000000	5	5	5	5	8000	9000	9000	9000	8485	0.0362	8746	11.6606	11.7699
78	1	00012000000	5	5	5	5	84000	124000	124000	124000	102470	0.1223	113055	3.4492	3.4874
79	1	00012000000	5	5	5	5	14000	16000	16000	16000	14967	0.0410	15469	10.2677	10.3412
80	1	00012000000	5	5	5	5	25000	64000	64000	64000	40000	0.2887	50469	1.4584	1.4745
81	1	00012000000	5	5	5	5	40000	82000	82000	82000	57271	0.2091	68394	1.9100	1.9112
82	1	00012000000	5	5	5	5	117000	140000	140000	140000	127984	0.0551	133791	7.6396	7.7264

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE	SIZE USED FOR MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
83	23 0911080010	2	2	2	2	14000	21000	21000	19442	-.0473	20198	8.8943	8.9931
84	23 0911080010	2	2	2	2	14000	42000	42000	39950	-.0307	40951	13.5992	13.8916
85	23 0911080010	2	2	2	2	139000	592000	592000	447321	-.1721	513630	2.4463	2.4739
86	23 0911080010	2	2	2	2	15000	43000	43000	25397	-.3234	32943	1.3019	1.3163
87	23 0911080010	2	2	2	2	32000	37000	37000	34409	-.0446	35667	9.4437	9.5687
88	23 0911080010	2	2	2	2	66000	124000	124000	90465	-.1937	105735	2.1741	2.1983
89	23 0911080010	2	2	2	2	15000	18000	18000	16971	-.0362	17472	11.6406	11.7698
90	23 0911080010	2	2	2	2	43000	53000	53000	47759	-.0642	50271	6.5972	6.6301
91	23 0911080010	2	2	2	2	15000	177000	177000	164563	-.0448	170602	9.4094	9.5139
92	11 1008080510	3	3	3	3	120000	295300	587300	275152	-.3425	376632	1.3491	1.3623
93	11 1008080510	2	2	2	2	21700	26500	26500	25014	-.0331	25690	12.7081	12.8493
94	11 1008080510	2	2	2	2	13000	12500	12000	11118	-.0449	11546	8.9751	9.0748
95	11 1008080510	2	2	2	2	370700	1272000	1272000	686681	-.3786	931512	1.1120	1.1246
96	11 1008080510	2	2	2	2	123400	287300	287300	188289	-.2595	232059	1.6224	1.6404
97	17 05611960210	6	6	6	6	31000	34000	49000	41513	-.1173	47180	3.5591	3.5591
98	17 05611960210	6	6	6	6	14000	16000	46000	39430	-.0520	41649	8.6223	8.6223
99	21 03211060010	4	4	4	4	2400	3190	3580	3266	-.0402	1422	10.7215	10.7215
100	21 03211060010	4	4	4	4	3800	4190	4800	4178	-.0466	4560	12.1742	12.1742
101	21 03211060010	4	4	4	4	5550	5570	6860	6084	-.0464	6373	9.6345	9.6345
102	21 03211060010	4	4	4	4	9680	10780	13520	11651	-.0689	12454	7.1267	7.1267
103	21 03211060010	4	4	4	4	23800	30010	36190	29850	-.0741	32057	6.3057	6.3057
104	21 03211060010	4	4	4	4	4180	6260	6710	5821	-.0967	6317	6.9496	6.9496
105	21 03211060010	4	4	4	4	9680	9810	12350	10393	-.0502	10978	7.2027	7.2027
106	21 03211060010	4	4	4	4	11470	11900	15500	13340	-.0673	14259	6.2739	6.2739
107	21 03211060010	4	4	4	4	26310	26660	31200	28128	-.0540	29634	9.3099	9.3099
108	21 03211060010	5	5	5	5	50770	62120	77570	68801	-.0506	72475	9.0897	9.0897
109	21 03211060010	4	4	4	4	4970	9410	12910	10505	-.0720	11307	5.8403	5.8403
110	21 03211060010	4	4	4	4	12380	12410	23340	15420	-.1308	17905	3.0442	3.0442
111	21 03211060010	4	4	4	4	27910	28740	34480	30875	-.0489	32421	9.2117	9.2117
112	21 03211060010	5	5	5	5	58210	64570	69220	71420	-.0727	77050	5.5411	5.5411
113	21 03211060010	4	4	4	4	28780	36410	43740	36314	-.0755	39001	6.4688	6.4688
114	21 03211060010	4	4	4	4	42610	72790	95450	71665	-.1588	82562	3.6810	3.6810
115	21 03211060010	4	4	4	4	109620	236790	284220	208074	-.1936	244910	1.8131	1.8131
116	21 03211060010	4	4	4	4	111710	118690	171200	139104	-.0936	142433	6.9903	6.9903
117	21 03211060010	4	4	4	4	175150	361160	541450	377990	-.2075	456470	2.7134	2.7134
118	23 0911080010	2	2	2	2	210000	198200	198000	315436	-.1428	353841	2.9486	2.9486
119	23 0911080010	2	2	2	2	12000	12100	12100	12050	-.0024	12082	124.4037	124.4037
120	23 0911080010	2	2	2	2	17000	48000	48000	27964	-.3057	35370	1.3776	1.3776
121	23 0911080010	2	2	2	2	13000	48000	48000	45166	-.2513	55294	1.6755	1.6755
122	23 0911080010	2	2	2	2	144000	243000	243000	233434	-.1676	246557	2.5130	2.5130

RELATIONSHIP BETWEEN DATA GROUPS AND ESTIMATE STATE PARAMETERS

[illegible]

1. The first of these is the fact that the majority of the population of the United States is now living in urban areas. This is a result of the process of urbanization, which has been going on since the beginning of the 20th century. The population of the United States has increased from about 100 million in 1900 to over 200 million in 1950, and the majority of this increase has been in urban areas. This has led to a concentration of population in a few large cities, which has in turn led to a number of problems, such as overcrowding, pollution, and traffic congestion.

SECRET AND NOT FOR PUBLICATION
UNLESS AND UNLESS SO INDICATED OTHERWISE

[illegible]

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

DATA GROUP	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SCALE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)
1	100000	0.0000	100000	0.0000	100000	0.0000
2	157000	0.1000	157000	0.1000	157000	0.1000
3	200000	0.2000	200000	0.2000	200000	0.2000
4	250000	0.3000	250000	0.3000	250000	0.3000
5	300000	0.4000	300000	0.4000	300000	0.4000
6	350000	0.5000	350000	0.5000	350000	0.5000
7	400000	0.6000	400000	0.6000	400000	0.6000
8	450000	0.7000	450000	0.7000	450000	0.7000
9	500000	0.8000	500000	0.8000	500000	0.8000
10	550000	0.9000	550000	0.9000	550000	0.9000
11	600000	1.0000	600000	1.0000	600000	1.0000
12	650000	1.1000	650000	1.1000	650000	1.1000
13	700000	1.2000	700000	1.2000	700000	1.2000
14	750000	1.3000	750000	1.3000	750000	1.3000
15	800000	1.4000	800000	1.4000	800000	1.4000
16	850000	1.5000	850000	1.5000	850000	1.5000
17	900000	1.6000	900000	1.6000	900000	1.6000
18	950000	1.7000	950000	1.7000	950000	1.7000
19	1000000	1.8000	1000000	1.8000	1000000	1.8000
20	1050000	1.9000	1050000	1.9000	1050000	1.9000
21	1100000	2.0000	1100000	2.0000	1100000	2.0000
22	1150000	2.1000	1150000	2.1000	1150000	2.1000
23	1200000	2.2000	1200000	2.2000	1200000	2.2000
24	1250000	2.3000	1250000	2.3000	1250000	2.3000
25	1300000	2.4000	1300000	2.4000	1300000	2.4000
26	1350000	2.5000	1350000	2.5000	1350000	2.5000
27	1400000	2.6000	1400000	2.6000	1400000	2.6000
28	1450000	2.7000	1450000	2.7000	1450000	2.7000
29	1500000	2.8000	1500000	2.8000	1500000	2.8000
30	1550000	2.9000	1550000	2.9000	1550000	2.9000
31	1600000	3.0000	1600000	3.0000	1600000	3.0000
32	1650000	3.1000	1650000	3.1000	1650000	3.1000
33	1700000	3.2000	1700000	3.2000	1700000	3.2000
34	1750000	3.3000	1750000	3.3000	1750000	3.3000
35	1800000	3.4000	1800000	3.4000	1800000	3.4000
36	1850000	3.5000	1850000	3.5000	1850000	3.5000
37	1900000	3.6000	1900000	3.6000	1900000	3.6000
38	1950000	3.7000	1950000	3.7000	1950000	3.7000
39	2000000	3.8000	2000000	3.8000	2000000	3.8000
40	2050000	3.9000	2050000	3.9000	2050000	3.9000
41	2100000	4.0000	2100000	4.0000	2100000	4.0000
42	2150000	4.1000	2150000	4.1000	2150000	4.1000
43	2200000	4.2000	2200000	4.2000	2200000	4.2000
44	2250000	4.3000	2250000	4.3000	2250000	4.3000
45	2300000	4.4000	2300000	4.4000	2300000	4.4000
46	2350000	4.5000	2350000	4.5000	2350000	4.5000
47	2400000	4.6000	2400000	4.6000	2400000	4.6000
48	2450000	4.7000	2450000	4.7000	2450000	4.7000
49	2500000	4.8000	2500000	4.8000	2500000	4.8000
50	2550000	4.9000	2550000	4.9000	2550000	4.9000
51	2600000	5.0000	2600000	5.0000	2600000	5.0000
52	2650000	5.1000	2650000	5.1000	2650000	5.1000
53	2700000	5.2000	2700000	5.2000	2700000	5.2000
54	2750000	5.3000	2750000	5.3000	2750000	5.3000
55	2800000	5.4000	2800000	5.4000	2800000	5.4000
56	2850000	5.5000	2850000	5.5000	2850000	5.5000
57	2900000	5.6000	2900000	5.6000	2900000	5.6000
58	2950000	5.7000	2950000	5.7000	2950000	5.7000
59	3000000	5.8000	3000000	5.8000	3000000	5.8000
60	3050000	5.9000	3050000	5.9000	3050000	5.9000
61	3100000	6.0000	3100000	6.0000	3100000	6.0000
62	3150000	6.1000	3150000	6.1000	3150000	6.1000
63	3200000	6.2000	3200000	6.2000	3200000	6.2000
64	3250000	6.3000	3250000	6.3000	3250000	6.3000
65	3300000	6.4000	3300000	6.4000	3300000	6.4000
66	3350000	6.5000	3350000	6.5000	3350000	6.5000
67	3400000	6.6000	3400000	6.6000	3400000	6.6000
68	3450000	6.7000	3450000	6.7000	3450000	6.7000
69	3500000	6.8000	3500000	6.8000	3500000	6.8000
70	3550000	6.9000	3550000	6.9000	3550000	6.9000
71	3600000	7.0000	3600000	7.0000	3600000	7.0000
72	3650000	7.1000	3650000	7.1000	3650000	7.1000
73	3700000	7.2000	3700000	7.2000	3700000	7.2000
74	3750000	7.3000	3750000	7.3000	3750000	7.3000
75	3800000	7.4000	3800000	7.4000	3800000	7.4000
76	3850000	7.5000	3850000	7.5000	3850000	7.5000
77	3900000	7.6000	3900000	7.6000	3900000	7.6000
78	3950000	7.7000	3950000	7.7000	3950000	7.7000
79	4000000	7.8000	4000000	7.8000	4000000	7.8000
80	4050000	7.9000	4050000	7.9000	4050000	7.9000
81	4100000	8.0000	4100000	8.0000	4100000	8.0000
82	4150000	8.1000	4150000	8.1000	4150000	8.1000
83	4200000	8.2000	4200000	8.2000	4200000	8.2000
84	4250000	8.3000	4250000	8.3000	4250000	8.3000
85	4300000	8.4000	4300000	8.4000	4300000	8.4000
86	4350000	8.5000	4350000	8.5000	4350000	8.5000
87	4400000	8.6000	4400000	8.6000	4400000	8.6000
88	4450000	8.7000	4450000	8.7000	4450000	8.7000
89	4500000	8.8000	4500000	8.8000	4500000	8.8000
90	4550000	8.9000	4550000	8.9000	4550000	8.9000
91	4600000	9.0000	4600000	9.0000	4600000	9.0000
92	4650000	9.1000	4650000	9.1000	4650000	9.1000
93	4700000	9.2000	4700000	9.2000	4700000	9.2000
94	4750000	9.3000	4750000	9.3000	4750000	9.3000
95	4800000	9.4000	4800000	9.4000	4800000	9.4000
96	4850000	9.5000	4850000	9.5000	4850000	9.5000
97	4900000	9.6000	4900000	9.6000	4900000	9.6000
98	4950000	9.7000	4950000	9.7000	4950000	9.7000
99	5000000	9.8000	5000000	9.8000	5000000	9.8000
100	5050000	9.9000	5050000	9.9000	5050000	9.9000

LIST OF SALIENT FEATURES OF DATA GROUPS
UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

LIST OF SALIENT FEATURES OF DATA GROUPS
UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM NO.	DESCRIPTION	SAM- PLE SIZE	NUMBER OF FAILURES	SIZE USED FOR MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
641	1 0001 000000	5	5	6	17391	20357	23412	20373	-.0417	21637	11.4066	6.9519
642	1 0001 000000	5	5	6	34511	52462	40457	34213	-.0472	35989	8.7291	11.4773
643	1 0001 000000	5	5	6	147705	156295	191054	164405	-.0372	173454	11.0701	18.4977
644	1 0001 000000	5	5	6	192131	215464	295454	231646	-.0505	246672	6.9965	9.5358
645	1 0001 000000	5	5	6	152298	158592	224124	183487	-.0774	201468	6.1237	27.0134
646	1 0001 000000	5	5	6	94148	94579	191350	127552	-.1373	146880	3.1013	72.5171
647	1 0001 000000	5	5	6	107347	102741	135515	109838	-.0495	116300	7.1123	46.3383
648	1 0001 000000	5	5	6	1451000	1470000	1976000	1648996	-.0626	1740097	7.2034	98.9277
649	1 0001 000000	5	5	5	458000	1030000	2105000	1231238	-.2721	1587238	2.0520	1.3767
650	1 0001 000000	5	5	5	3178000	3777000	5070000	4163255	-.0838	4524909	5.9085	6.4613
651	1 0001 000000	5	5	5	4551000	9386000	10056000	6004853	-.1315	6945924	2.4966	6.4405
652	1 0001 000000	5	5	6	1770000	202003	326000	228461	-.0967	293715	6.1444	5.7311
653	1 0001 000000	5	5	5	211000	278000	105000	256947	-.0673	273051	6.8704	14.3987
654	1 0001 000000	5	5	7	249000	248003	452000	358682	-.1526	424743	2.4147	29.1914
655	1 0001 000000	5	5	4	145000	153000	498000	247584	-.1891	304384	2.2764	19.8914
656	1 0001 000000	5	5	5	415000	441000	928000	578830	-.1635	688670	2.4025	18.3608
657	1 0001 000000	5	5	5	225000	257003	319000	274334	-.0587	289513	8.4744	8.1184
658	1 0001 000000	5	5	6	342000	522000	952000	56563	-.1245	65241	2.8627	3.8195
659	1 0001 000000	5	5	6	41000	55500	48003	57464	-.0747	61578	7.9368	3.7017
660	1 0001 000000	5	5	10	274000	239000	349000	270353	-.0805	290047	6.2484	22.3510
661	1 0001 000000	5	5	5	448000	740300	1020900	805641	-.1114	894316	4.9156	2.9740
662	1 0001 000000	5	5	5	157200	158700	249000	192975	-.0974	213448	6.1467	16.4923
663	1 0001 000000	5	5	5	114000	134000	147000	143705	-.0735	155602	5.2389	8.7745
664	1 0001 000000	5	5	6	444000	496100	743000	550408	-.0845	606103	4.2517	10.7477
665	1 0001 000000	5	5	6	744000	775000	1309000	977927	-.1039	1091766	6.2746	30.4496
666	1 0001 000000	5	5	7	174000	271000	440000	24493	-.1230	30542	3.1865	4.8357
667	1 0001 000000	5	5	5	47000	12300	14300	13612	-.1090	14237	3.8904	3.9134
668	1 0001 000000	5	5	5	47000	12300	17400	12748	-.1171	14843	3.9622	2.7517
669	1 0001 000000	5	5	5	31000	5400	14500	10845	-.0499	11674	5.4907	15.0553
670	1 0001 000000	5	5	5	654000	571000	1644000	901590	-.2394	1145011	2.0181	4.8559
671	1 0001 000000	5	5	5	43000	84000	140000	107738	-.1062	113401	4.5029	93.1813
672	1 0001 000000	5	5	5	117000	134000	141000	142000	-.0879	155460	6.5896	131.2962
673	1 0001 000000	5	5	5	177000	303000	370000	250095	-.0437	274694	5.1249	8.7441
674	1 0001 000000	5	5	5	133000	173300	2161000	363847	-.3567	2401545	1.2081	1.0143
675	1 0001 000000	5	5	5	3411000	3977100	8951300	44647604	-.2167	57944134	2.1111	182.9645
676	1 0001 000000	5	5	5	1410000	1743000	3871000	2037644	-.1560	2688945	2.0418	5.2201
677	1 0001 000000	5	5	5	1716000	1304000	2030000	1691147	-.1297	1990750	4.5286	2.4135
678	1 0001 000000	5	5	5	423000	473300	864000	4910756	-.0443	2179865	10.1491	11.2825
679	1 0001 000000	5	5	5	230000	370000	547000	447811	-.5467	1374061	1.1898	5.133
680	1 0001 000000	5	5	5	227000	234000	343000	625240	-.2414	4561434	2.1900	1.7201

LIST II SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

ITEM	REF	DESCRIPTION	SAM- PLC SIZE	NUMBER OF FAILS	TYPE OF LIM	FIRST FAILURE (F111)	SECOND FAILURE (F121)	LAST FAILURE (F1M1)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
547	1	3301245510	5	5	5	4740000	4424000	3374000	0.0343009	-0.200	0.3282879	1.1625	21.5096
548	1	3301245510	14	14	14	1546000	1546000	2640000	0.1910319	-0.054	2035771	7.3216	16.6352
549	1	3301245510	10	10	10	743300	865800	1904720	0.152524	-0.1170	1312521	3.5646	6.9053
550	1	0401045010	5	5	5	1004000	135000	365200	0.00301	-0.2403	295733	1.9246	3.0192
551	1	0401045010	5	5	5	374400	91800	1700000	0.97517	-0.2334	103617	2.5900	1.2440
552	1	0401045010	5	5	5	484200	524600	2719600	0.65602	-0.1049	610385	4.7632	13.5993
553	1	0401045010	5	5	5	93400	12600	52200	0.13043	-0.1021	13023	5.4825	6.0104
554	1	0401045010	5	5	5	145800	40140	148500	0.64482	-0.350	100417	1.2964	1.1017
555	1	0401045010	5	5	5	145000	249300	691700	0.30123	-0.2524	491861	1.9006	3.0070
556	1	0401045010	5	5	5	1460	2715	9011	0.3637	-0.2845	3261	2.3394	3.0402
557	1	0401045010	5	5	5	28800	45000	73000	0.53084	-0.1754	61497	3.3426	2.5203
558	1	0401045010	5	5	5	28800	36300	94200	0.42716	-0.1868	38222	6.3298	9.0003
559	1	0401045010	5	5	5	185600	342800	3216400	0.72243	-0.404	200246	0.8045	1.7361
560	1	0401045010	5	5	5	48800	45800	888400	0.11032	-0.3254	94246	1.5183	0.0761
561	1	0401045010	5	5	5	110720	416320	525460	0.417208	-0.0954	456416	5.1897	3.9430
562	1	0401045010	5	5	5	163000	199000	3601000	0.78055	-0.6123	1436247	0.8097	7.5388
563	1	0401045010	5	5	5	74300	74300	369000	0.141362	-0.2285	107485	6.0691	85.0324
564	1	0401045010	10	10	10	170000	204000	929000	0.346301	-0.2167	321019	3.3083	7.0109
565	1	0401045010	10	10	10	319000	374000	1844000	0.62484	-0.1578	644890	3.8091	6.6236
566	1	0401045010	11	11	11	490000	691700	1643000	0.1105793	-0.2573	1205531	2.6735	514.2659
567	1	0401045010	5	5	5	520000	574000	1293000	0.695419	-0.1817	582910	14.4034	11.4470
568	1	0401045010	5	5	5	429000	133300	2778000	0.1010307	-0.1651	939641	3.5501	1.7522
569	1	0401045010	5	5	5	72000	141000	161000	0.107646	-0.2471	131376	1.7037	1.7227
570	1	0401045010	5	5	5	62300	94600	48400	0.49702	-0.0991	53829	6.2310	6.2982
571	1	0401045010	5	5	5	54900	1249600	1249600	0.773437	-0.0429	104335	0.4465	0.515
572	1	0401045010	5	5	5	79700	121400	121400	0.98365	-0.1292	109154	3.2501	3.2543
573	1	0401045010	5	5	5	46100	142300	142300	0.87648	-0.2964	111276	1.4208	1.6366
574	1	0401045010	5	5	5	13100	28100	28100	0.23167	-0.1186	25488	3.5512	3.5907
575	1	0401045010	5	5	5	8400	14000	14000	0.11100	-0.1426	12450	2.9529	2.9837
576	1	0401045010	5	5	5	25000	26300	31000	0.28494	-0.0348	29470	16.5154	27.5124
577	1	0401045010	5	5	5	32000	42000	50000	0.50794	-0.1013	55256	7.3480	2.2532
578	1	0401045010	5	5	5	11470	12620	14920	0.13028	-0.0412	13613	9.1133	21.7516
579	1	0401045010	5	5	5	47900	51740	48470	0.5017	-0.0367	54947	12.5196	15.2522
580	1	0401045010	5	5	5	14540	14820	14150	0.15285	-0.0206	19604	21.3977	70.4805
581	1	0401045010	5	5	5	65140	40460	43410	0.48043	-0.0320	44714	11.6937	60.2332
582	1	0401045010	5	5	5	11970	12620	14920	0.13028	-0.0412	13613	9.1133	21.7516
583	1	0401045010	5	5	5	47900	51740	48470	0.5017	-0.0367	54947	12.5196	15.2522
584	1	0401045010	5	5	5	14540	14820	14150	0.15285	-0.0309	46493	19.5436	24.2405
585	1	0401045010	5	5	5	15770	17463	17463	0.16461	-0.0330	17089	12.7524	12.8341

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM NO.	DESCRIPTION	SAM. PL.	NUMBER OF FAILURES	SIZE OF LOT	TEST METHOD	FIRST FAILURE (P(1))	SECOND FAILURE (P(2))	LAST FAILURE (P(N))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
674	22 06411055010	2	2	2	2	51480	43300	53300	92742	.0187	92965	29.8040	39.9015
675	22 06411055010	4	4	4	4	15620	16290	16450	16104	.0101	16334	63.7694	27.3960
676	22 06411055010	4	4	4	4	12560	12870	13860	13224	.0204	91740	12.4079	7.7371
677	22 06411055010	4	4	4	4	12560	12870	13860	13224	.0204	13491	23.3781	47.1961
678	22 06411055010	4	4	4	4	63670	92160	94280	50719	.0439	92653	16.4415	6.4773
679	22 06411055010	4	4	4	4	12638	14120	17010	15254	.0538	16079	18.0806	10.0049
680	22 06411055010	4	4	4	4	19680	41450	50250	47009	.0698	50700	9.8776	25.5961
681	22 06411055010	4	4	4	4	13720	15140	17220	15377	.0407	16009	10.7723	11.0842
682	22 06411055010	4	4	4	4	93280	16130	99610	97026	.0225	98234	23.5142	20.0719
683	22 06411055010	4	4	4	4	12000	15190	17980	15161	.0637	16094	7.8280	6.7330
684	22 06411055010	4	4	4	4	47950	14090	57370	43982	.0302	55435	20.6735	9.3179
685	22 06411055010	4	4	4	4	11950	12510	14040	13237	.0425	13814	10.3670	25.1267
686	22 06411055010	4	4	4	4	46770	48500	56010	49312	.0405	91442	9.6985	14.3795
687	22 06411055010	4	4	4	4	2810	2820	3660	3136	.0586	3346	7.7195	323.9297
688	22 06411055010	4	4	4	4	50730	53050	68910	59697	.0709	64602	6.7706	25.7333
689	22 06411055010	4	4	4	4	2610	2810	3730	2992	.0584	3192	6.2783	15.1111
690	22 06411055010	4	4	4	4	35960	42060	52370	44689	.0794	48335	9.6475	7.3442
691	22 06411055010	4	4	4	4	5170	4280	6120	5582	.0346	5779	12.7511	54.0576
692	22 06411055010	4	4	4	4	60580	69970	86365	71134	.0609	75876	6.7904	13.0899
693	22 06411055010	4	4	4	4	3050	3600	4360	3759	.0702	4016	7.3409	6.9080
694	22 06411055010	4	4	4	4	59030	60085	74020	64020	.0440	67331	7.4421	64.0599
695	22 06411055010	4	4	4	4	2970	3480	3730	3423	.0430	3536	13.3038	7.2615
696	22 06411055010	4	4	4	4	54130	57800	60830	58286	.0232	99455	23.6710	17.5435
697	22 06411055010	4	4	4	4	2820	3245	3660	3267	.0446	3391	10.8206	8.1973
698	22 06411055010	4	4	4	4	59540	59820	68230	62862	.0282	64712	14.8931	245.2691
699	22 06411055010	4	4	4	4	3020	3470	3910	3472	.0442	3629	10.1879	8.2847
700	22 06411055010	4	4	4	4	13700	63450	76530	65789	.0609	70016	7.8991	6.8972
701	22 06411055010	4	4	4	4	1960	1970	2200	2060	.0244	2112	17.0931	226.1176
702	22 06411055010	4	4	4	4	43280	56740	62765	57645	.0381	99416	16.2681	21.2833
703	22 06411055010	4	4	4	4	1965	2045	2300	2145	.0397	2225	11.3366	19.4129
704	22 06411055010	4	4	4	4	43450	43810	52055	47044	.0391	49943	11.4468	199.4411
705	22 06411055010	4	4	4	4	2390	2690	2930	2719	.0488	2822	13.5940	9.7315
706	22 06411055010	4	4	4	4	46240	48500	53390	50647	.0370	52721	12.0092	26.1149
707	22 06411055010	4	4	4	4	3790	3860	4370	4042	.0290	4162	15.1086	82.8773
708	22 06411055010	4	4	4	4	50980	74770	77590	71482	.0513	74461	12.9184	5.2210
709	22 06411055010	4	4	4	4	38270	40680	54400	43942	.0708	48364	6.1720	18.0427
710	22 06411055010	4	4	4	4	58090	72730	75645	72767	.0206	74353	21.5118	17.0399
711	22 06411055010	4	4	4	4	50258	60490	65060	58264	.0576	61309	8.6937	6.5642
712	22 06411055010	4	4	4	4	93400	14090	62320	56744	.0388	58582	13.0261	95.1110
713	22 06411055010	4	4	4	4	669750	856610	973500	846496	.0724	905097	7.9904	6.6321

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLF	NUMBER FAILED	SIZE LNM	SIZE FOR MLE	USED MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (F3)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (LOG-ALPHA)
714	22	06411055010	4	4	4	4	4	50930	68370	85910	70714	0.021	75449	6.3422	9.0002
714	22	06411055010	4	4	4	4	4	51200	65120	78670	68967	0.023	72009	9.3206	10.0006
714	22	06411055010	4	4	4	4	4	51690	54200	68800	16706	0.040	99775	7.5689	24.2605
717	22	06411055010	4	4	4	4	4	51830	49140	64630	59447	0.029	61807	12.9059	8.7217
718	22	06411055010	4	4	4	4	4	52110	50160	60550	57905	0.030	99434	21.6727	9.0008
719	22	06411055010	4	4	4	4	4	51330	44020	55200	46966	0.054	49695	7.4700	18.2403
720	22	06411055010	4	4	4	4	4	49110	55680	60920	55253	0.045	57947	11.2232	9.1648
721	22	06411055010	4	4	4	4	4	54080	54610	56980	55256	0.009	5168	49.7254	117.9921
722	22	06411055010	4	4	4	4	4	52620	55400	55780	54837	0.120	55524	36.7706	22.3515
723	22	06411055010	4	4	4	4	4	66090	51040	61070	53013	0.097	55979	7.8282	11.2001
724	22	03211055010	4	4	4	4	4	17270	19800	44270	40597	0.353	42018	13.1115	32.0184
724	22	03211055010	4	4	4	4	4	12890	34570	35240	34072	0.123	34508	36.0609	32.0401
726	22	03211055010	4	4	4	4	4	205750	353240	715750	421791	0.2457	53308	2.0271	2.1165
727	22	03211055010	4	4	4	4	4	27940	42430	57640	44513	0.1297	50007	6.4951	2.6795
728	22	03211055010	4	4	4	4	4	24760	30390	35400	31342	0.054	32970	9.3768	9.0002
729	22	03211055010	4	4	4	4	4	178510	498770	534740	463005	0.1003	504047	6.6748	2.7825
730	22	03211055010	4	4	4	4	4	20850	27940	32190	27865	0.080	50157	6.5126	3.9316
731	22	03211055010	4	4	4	4	4	408630	630370	408950	446473	0.071	463931	11.0271	22.5438
732	22	03211055010	4	4	4	4	4	10710	17800	41640	37324	0.091	59328	9.9811	5.5398
734	22	03211055010	4	4	4	4	4	19150	27070	28600	25475	0.0834	27340	8.0075	3.3206
734	22	03211055010	4	4	4	4	4	441170	456380	591950	491485	0.0571	522297	6.6435	33.9403
734	22	06411055010	4	4	4	4	4	28150	29550	31350	29915	0.0204	30940	21.4770	23.7086
736	22	06411055010	4	4	4	4	4	29570	26590	33340	28158	0.0444	29717	7.2927	1529.3178
737	22	06411055010	4	4	4	4	4	25330	26290	28940	26845	0.0244	27534	16.3716	30.9342
739	22	06411055010	4	4	4	4	4	31470	35500	37480	34080	0.0909	39174	13.2028	18.4005
739	22	06411055010	4	4	4	4	4	27270	40220	33350	30288	0.0358	31365	12.6908	11.2829
740	22	06411055010	4	4	4	4	4	29650	33690	34040	32630	0.0279	33408	24.1791	9.4408
741	22	06411055010	4	4	4	4	4	19460	21880	32580	24901	0.0990	27397	6.3800	9.4409
742	22	06411055010	4	4	4	4	4	39400	41950	43210	41911	0.0189	42759	23.4009	18.3402
743	22	06411055010	4	4	4	4	4	18530	38730	38730	36630	0.0016	38696	198.9506	767.7022
744	22	06411055010	4	4	4	4	4	18930	39640	39640	38982	0.0072	39273	44.3383	59.3871
745	22	06411055010	4	4	4	4	4	34700	45560	48725	37050	0.0367	38507	10.3418	111.4018
746	22	06411055010	4	4	4	4	4	17960	38010	44940	40861	0.0374	42618	12.7505	876.2082
747	22	06411055010	4	4	4	4	4	20160	40320	49140	43145	0.0414	45054	9.4477	289.4078
749	22	06411055010	4	4	4	4	4	28170	31720	34700	32787	0.0516	34423	9.8619	9.4953
749	22	06411055010	4	4	4	4	4	18230	19450	21250	19761	0.0282	20310	16.4601	17.7641
750	22	06411055010	4	4	4	4	4	18820	21880	26130	22844	0.0578	24180	8.4594	7.4598
751	22	06411055010	4	4	4	4	4	19950	22900	30670	25952	0.0967	27263	5.5231	9.2264
752	22	06411055010	4	4	4	4	4	27910	23340	25400	23678	0.0201	24382	21.9427	61.9033
753	22	06411055010	4	4	4	4	4	14800	16730	21900	18988	0.0434	20206	8.1382	19.5077

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

ITEM	DESCRIPTION	NUM- BER OF ITEMS	SIZE OF GROUP	TYPE OF FAILURE	FIRST FAILURE (TIME)	SECOND FAILURE (TIME)	LAST FAILURE (TIME)	LOG-NORMAL SCALE (MLE- μ)	LOG-NORMAL SHAPE (MLE- σ)	WEIBULL SCALE (MLE- β)	WEIBULL SHAPE (MLE- α)	WEIBULL SCALE (MLE- β)	WEIBULL SHAPE (MLE- α)
754	22 0641105010	2	5	5	21800	22170	29190	25903	.0045	27577	8.4136	8.4136	86.7396
755	22 0641105010	2	5	5	20640	21990	31040	23690	.0055	26211	4.2765	4.2765	18.1626
756	22 0641105010	2	5	5	19940	17450	21340	18761	.0045	19466	9.2551	9.2551	36.7947
757	22 0641105010	2	5	5	17440	18140	20440	18030	.0264	10458	15.8141	15.8141	103.7946
758	22 0641105010	2	5	5	12470	12620	15230	13667	.0441	10240	10.3600	10.3600	72.0361
759	22 0641105010	2	5	5	11500	15220	18910	15125	.0894	10464	5.4054	5.4054	4.1059
760	22 0641105010	2	5	5	22420	26220	26720	26077	.0427	26139	8.0080	8.0080	19.3265
761	22 0641105010	2	5	5	22100	26610	30400	26746	.0031	27902	7.4631	7.4631	10.6970
762	22 0641105010	2	5	5	22045	22045	22940	22164	.0107	22410	41.3756	41.3756	62.0594
763	22 0641105010	2	5	5	17740	21143	21930	20320	.0481	21166	13.7677	13.7677	5.6626
764	22 0641105010	2	5	5	20930	23050	25370	22986	.0321	23717	16.0592	16.0592	11.9240
765	22 0641105010	2	5	5	19960	20950	24970	22824	.0362	24122	8.4183	8.4183	23.7713
766	22 0641105010	2	5	5	20550	20750	24110	21538	.0328	22327	11.0114	11.0114	110.8118
767	22 0641105010	2	5	5	20125	20220	29440	29440	.0030	29436	145.1481	145.1481	353.3641
768	22 0641105010	2	5	5	20610	20900	24785	31723	.0379	31014	10.2124	10.2124	110.0678
769	22 0641105010	2	5	5	37485	38170	42700	39621	.0240	40674	16.4541	16.4541	34.4403
770	22 0641105010	2	5	5	25460	33083	32600	29171	.0527	30584	10.5670	10.5670	5.6551
771	22 0641105010	2	5	5	27464	32430	36940	32794	.0093	33718	12.0299	12.0299	6.9249
772	22 0641105010	2	5	5	32450	37820	38210	36669	.0319	37640	21.8657	21.8657	8.1678
773	22 0641105010	2	5	5	37570	37485	37810	37741	.0009	37775	513.2520	513.2520	2890.6375
774	22 0641105010	2	5	5	31040	37530	40240	36137	.0553	37979	10.6840	10.6840	5.1602
775	22 0641105010	2	5	5	47040	52743	55470	51441	.0304	53410	17.4772	17.4772	11.0361
776	22 0641105010	2	5	5	40450	40650	40684	40611	.0012	40640	377.2536	377.2536	733.3097
777	22 0641105010	2	5	5	70100	74300	82000	76438	.0216	78170	20.4265	20.4265	42.6222
778	22 0641105010	2	5	5	60840	71943	79970	74644	.0279	764126	18.5324	18.5324	20.5473
779	22 0641105010	2	5	5	42300	54030	67030	48808	.0036	61976	8.6318	8.6318	30.0502
780	22 0641105010	2	5	5	49300	53370	62970	537151	.0496	564076	7.7510	7.7510	56.6809
781	22 0641105010	2	5	5	37400	41040	540263	443101	.0900	484204	6.3852	6.3852	14.9040
782	22 0641105010	2	5	5	49700	49410	49770	49132	.0049	493906	82.2533	82.2533	230.6174
783	22 0641105010	2	5	5	14440	32430	107440	43367	.3614	743924	1.5063	1.5063	1.5731
784	22 0641105010	2	5	5	42270	47340	52500	42770	.0009	424291	467.1313	467.1313	501.4968
785	22 0641105010	2	5	5	49465	62120	1035263	66497	.1211	780173	3.0245	3.0245	10.3331
786	22 0641105010	2	5	5	57400	48940	50440	48781	.0048	501379	75.9671	75.9671	50.3029
787	22 0641105010	2	5	5	47140	54000	61465	443102	.1703	587148	9.4017	9.4017	3.9930
788	22 0641105010	2	5	5	47040	46943	48420	443527	.0340	562170	15.7813	15.7813	8.4133
789	22 0641105010	2	5	5	40040	47140	51240	464741	.0447	483814	11.0822	11.0822	6.0528
790	22 0641105010	2	5	5	54730	65473	70943	60049	.0448	516721	8.2562	8.2562	33.0395
791	22 0641105010	2	5	5	14410	23060	20260	18451	.0598	198027	11.7604	11.7604	4.2897
792	22 0641105010	2	5	5	14570	14740	19740	19104	.0119	19444	17.0281	17.0281	115.6287
793	22 0641105010	2	5	5	14310	14310	16020	174132	.0317	183326	17.0729	17.0729	9.7313

- LIST OF SOLVENT FEATURES OF DATA GROUPS
- HOW TO ESTIMATE SHAPE PARAMETERS
- UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

[illegible]

LIST 14 SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	DESCRIPTION	SAM- PL	NUMBER OBS.	SIZE FOR MLE	SIZE USED FOR MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
1008	7 03111021010	3	3	3	3	11900	16100	17800	15052	-.0910	16297	5.7832	4.0241
1009	5 03111021010	3	3	3	3	2341	8705	9234	8646	-.0302	8886	15.3879	15.3306
1010	3 03111021010	3	3	3	3	40100	41600	67400	62956	-.0202	64402	15.0820	49.9426
1012	6 03111021010	2	2	2	2	32300	37200	37000	34409	-.0446	35667	9.4437	9.3487
1013	4 03111021010	2	2	2	2	704500	762300	742000	732426	-.0243	751121	13.0463	17.5107
1014	6 03111021010	2	2	2	2	4000	5000	4000	4472	-.0485	4726	6.1443	6.2126
1015	6 03111021010	2	2	2	2	453000	998300	998000	922654	-.0482	959184	8.7332	8.8383
1016	6 03111021010	3	3	3	3	10000	14000	19000	13856	-.1394	15759	3.2183	3.8151
1017	6 03111021010	3	3	3	3	78000	310000	312000	200231	-.3549	270640	1.0397	1.8815
1018	4 03111021010	3	3	3	3	43000	43000	56000	46958	-.0462	50157	5.6481	VERY HIGH
1019	6 03111021010	3	3	3	3	104000	118000	131000	118629	-.0470	123422	10.2959	13.7563
1020	6 03111021010	3	3	3	3	17000	40800	48000	44113	-.1043	48906	3.7602	15.5025
1021	6 03111021010	3	3	3	3	98000	118300	130000	114956	-.0424	121131	7.8833	6.5497
1022	6 03111021010	3	3	3	3	146000	141000	204000	183405	-.0472	192079	8.8978	16.0609
1023	4 03111021010	3	3	3	3	285000	344000	474000	366360	-.1105	406308	3.9583	6.9717
1024	6 03111021010	3	3	3	3	420000	430000	444000	434530	-.0134	440602	30.3402	28.0065
1025	6 03111021010	2	2	2	2	37000	40300	48300	46638	-.0779	50677	5.9372	13.8409
1026	6 03111021010	2	2	2	2	89000	98000	131000	112146	-.0425	119435	8.2218	11.2015
1027	7 03111021010	3	3	3	3	164000	181000	206000	183605	-.0472	192079	8.8978	16.0609
1028	4 03111021010	2	2	2	2	199000	244500	474000	361748	-.1362	406705	6.6072	3.0042
1029	7 03111021010	3	3	3	3	36700	42200	49700	42938	-.0499	45267	6.5613	8.7187
1030	7 03111021010	3	3	3	3	42400	40300	90200	67448	-.1765	78484	3.1697	1.9247
1031	7 03111021010	3	3	3	3	137200	142700	222800	181356	-.0830	177166	6.3031	28.3863
1032	7 03111021010	3	3	3	3	106100	44400	798400	478094	-.2096	467794	3.9705	5.1677
1033	7 03111021010	3	3	3	3	726600	963700	976600	881018	-.0729	936927	8.8261	4.3573
1034	7 03111021010	3	3	3	3	65500	114100	202500	130641	-.1488	194244	2.3467	7.2687
1035	7 03111021010	3	3	3	3	91900	112100	129800	110170	-.0753	118076	6.1637	6.1221
1036	7 03111021010	3	3	3	3	324900	378900	415300	371147	-.0239	399637	9.9233	7.9113
1037	7 03111021010	3	3	3	3	473000	576000	796600	608954	-.1143	670712	3.6367	6.1742
1039	7 03111021010	3	3	3	3	18700	19700	44500	23337	-.1475	27020	2.8340	29.3465
1040	7 03111021010	3	3	3	3	39900	59800	79800	57048	-.1332	65651	3.0138	3.0445
1041	7 03111021010	3	3	3	3	58700	200200	466700	188289	-.4178	275886	1.1129	1.8971
1042	7 03111021010	3	3	3	3	459300	513600	1148000	622591	-.2394	404971	6.0406	5.3587
1043	7 03111021010	3	2	2	2	954000	1139900	1139900	1042816	-.0387	1090067	7.7476	6.8324
1044	7 03111021010	2	2	2	2	74200	44000	44000	36817	-.1503	40650	2.8020	2.8331
1045	7 03111021010	3	3	3	3	77100	120100	162900	114485	-.1634	133086	2.6732	2.7444
1046	7 03111021010	3	3	3	3	199200	242300	269200	230683	-.0799	247558	6.3780	6.8141
1047	7 03111021010	3	3	3	3	384600	488300	564900	473394	-.0043	510849	5.6909	5.8954
1048	7 03111021010	3	3	3	3	21400	28400	33900	27414	-.1008	30033	6.7323	6.2982
1049	7 03111021010	2	2	2	2	75100	91400	91400	83400	-.0563	87246	7.4861	7.5672

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UN-BASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	DESCRIPTION	SAM- PLS SIZE	NUMBER FAILED	SIZE FOR MLE	FIRST FAILURE (F-1)	SECOND FAILURE (F-2)	LAST FAILURE (F-M)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
1040	0.03111021010	6	1	3	22400	22400	47400	296600	.1491	360399	2.1836	230.7704
1052	0.03111021010	11	11	11	39500	94500	202500	92600	.1976	115080	2.2156	2.6263
1053	0.03111021010	4	4	4	16700	19700	40000	27630	.1390	32019	3.1599	20.9098
1054	0.03111021010	13	12	12	58700	184200	474000	264359	.2184	330891	2.4981	1.0325
1055	0.03111021010	5	5	6	479300	473300	1148000	611677	.1457	735822	2.3152	7.9628
1056	0.03111021010	5	5	6	430400	442700	1139900	948431	.0503	1013764	6.9461	17.9104
1057	0.04211024010	6	6	6	28000	24000	70500	43952	.2262	94939	2.1094	VERY HIGH
1058	0.04211024010	7	6	2	57000	93000	312000	95189	.1539	82170	2.8007	2.3906
1059	0.04211024010	7	2	2	206000	312000	93000	253519	.0901	241056	3.3166	2.7723
1060	0.04211024010	7	2	2	57000	93000	93000	212515	.5184	334781	.5655	2.3506
1061	0.04211024010	5	5	6	10000	4000	5000	4229	.0485	4459	7.6260	VERY HIGH
1062	0.04211024010	5	5	6	13000	10000	17500	12193	.1102	13471	3.5643	VERY HIGH
1063	0.04211024010	5	5	6	56000	79000	174500	88861	.2123	77641	5.6269	3.0265
1064	0.04211024010	5	5	6	411000	433600	1020000	639849	.1838	768084	2.4760	5.3256
1065	0.04211024010	5	2	2	493000	811000	811000	819405	.1776	941195	1.7412	2.3118
1066	0.04211024010	5	2	2	411000	1000000	1020000	828975	.2084	957259	1.8260	1.2660
1067	0.04211024010	5	6	6	5300	9000	11000	8779	.1158	9733	4.9811	2.8383
1068	0.04211024010	5	6	6	14000	15100	15100	16547	.0773	17431	5.1648	16.6783
1069	0.04211024010	5	6	6	156000	112000	141000	119535	.0544	124414	7.4580	9.7593
1070	0.04211024010	5	5	6	264500	247000	477000	310472	.1295	356752	2.8839	12.7765
1072	0.04211024010	5	6	6	746300	443000	1073000	842461	.0599	941047	6.2206	19.8139
1073	0.04211024010	5	6	6	6300	4000	4500	6830	.1544	7741	6.4381	1.6501
1074	0.04211024010	5	6	6	23000	46000	108000	52964	.2894	70019	1.4499	1.7739
1075	0.04211024010	5	6	2	346000	642000	1131000	612694	.2111	634043	8.5657	7.1224
1076	0.04211024010	5	6	2	1000	5000	14500	5123	.1606	4304	2.6860	2.2527
1077	0.04211024010	5	6	2	13000	15000	45000	15102	.0450	14467	9.3811	8.0416
1078	0.04211024010	5	6	6	124300	465000	673300	340444	.2985	444721	1.6994	1.0353
1079	0.04211024010	5	6	6	5430	5000	9000	4916	.1282	4782	2.9519	5.7364
1080	0.04211024010	5	6	6	11000	14300	23000	18140	.2063	22331	2.1065	6.7715
1081	0.04211024010	5	6	6	72000	184000	166300	124093	.1647	143486	3.6224	2.0303
1082	0.04211024010	5	6	6	1500	2000	15500	1411	.0662	1932	8.1007	4.0006
1083	0.04211024010	5	6	6	13000	42000	135000	50412	.6501	76913	1.1390	1.0238
1084	0.04211024010	5	6	6	145000	345000	347000	260749	.1469	298894	3.4856	2.3983
1085	0.04211024010	5	6	3	1500	5000	4500	4443	.1035	5013	5.2260	3.6106
1086	0.04211024010	5	6	6	1000	17000	46000	21436	.2235	17227	12.6036	9.1938
1087	0.04211024010	5	6	6	48000	136000	473000	241112	.2147	311074	1.6473	1.6557
1088	0.04211024010	5	6	6	111000	214000	214000	951127	.2783	523497	5.1467	6.3492
1089	0.04211024010	5	6	6	24000	120000	120000	462070	.1090	597777	2.7183	26.7598
1090	0.04211024010	5	6	6	1000	11000	15000	6910	.4712	10447	1.1895	.7135
1091	0.04211024010	5	6	6	5000	24000	4000	24014	.0714	23447	18.6267	13.9707

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

ITEM NO.	DESCRIPTION	SAMPLE SIZE	NUMBER OF FAILURES	SIZE OF MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS				
								LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1096	41 06-11-1010	3	3	3	36000	38000	46000	39775	-0.559	42027	7.0747	22.4978
1097	41 06-11-21-10	3	3	3	59000	76000	79000	74547	-0.703	76564	16.9326	12.5985
1098	41 06-11-21-10	3	3	3	42000	47000	43000	42497	-0.072	42817	43.9862	58.9148
1099	41 06-11-21-10	3	3	3	496000	476000	574000	532500	-0.461	552638	9.1747	9.2362
1100	41 06-11-21-10	4	4	4	47800	42300	136000	92991	-1.413	107563	3.6036	16.2685
1101	41 06-11-21-10	7	7	7	41900	52100	80000	63154	-0.853	69099	5.5345	17.0231
1102	41 06-11-21-10	10	10	10	101000	134300	175000	130850	-0.827	143190	3.5105	35.9955
1103	41 06-11-21-10	10	10	10	145000	147000	382000	250441	-1.155	281425	6.2174	6.1419
1104	41 06-11-21-10	10	10	10	400000	400000	1234000	621188	-1.438	732188	2.6884	VERY HIGH
1105	41 06-11-21-10	4	4	4	7000	3000	12000	9125	-0.074	10250	4.7644	6.5788
1106	41 06-11-21-10	7	7	7	17000	17000	63000	43626	-1.095	49100	3.3726	VERY HIGH
1107	41 06-11-21-10	6	6	6	452300	504200	687000	533092	-0.775	578969	6.8821	10.1366
1108	41 06-11-21-10	6	6	6	4000	4000	15000	5041	-1.241	5765	3.6192	VERY HIGH
1109	41 06-11-21-10	3	3	3	3000	4000	15000	5683	-1.706	5138	3.3404	2.1841
1110	41 06-11-21-10	3	3	3	62000	48000	49000	46227	-0.364	47687	15.5553	9.1304
1111	41 06-11-21-10	4	4	4	196000	199000	204000	200227	-0.076	201813	58.0719	75.7548
1112	41 06-11-21-10	4	4	4	249000	177000	618700	421551	-1.402	484585	3.1499	6.3290
1113	41 06-11-21-10	4	4	4	4000	4000	4000	5573	-1.387	6409	3.4396	VERY HIGH
1114	41 06-11-21-10	4	4	4	4000	4000	14000	8271	-2.735	5415	3.3815	2.8303
1115	41 06-11-21-10	3	3	3	8000	13000	11300	9483	-0.710	10204	7.1512	5.6512
1116	41 06-11-21-10	3	3	3	27000	43000	51000	38974	-1.430	44189	3.6324	2.8139
1117	41 06-11-21-10	3	3	3	51000	58000	91000	65409	-1.084	73188	3.7110	8.9649
1118	41 06-11-21-10	3	3	3	121000	115000	253000	154536	-1.449	180850	2.5104	10.5104
1119	41 06-11-21-10	3	3	3	13000	15000	40000	18971	-1.924	22847	2.6661	2.7517
1120	41 06-11-21-10	3	3	3	10300	12300	27000	16178	-1.710	19275	2.5946	8.1195
1121	41 06-11-21-10	3	3	3	145000	126200	273000	211201	-0.758	229267	4.8351	19.9232
1122	41 06-11-21-10	3	3	3	9000	10000	13000	10400	-0.681	11183	5.5510	12.9218
1123	41 06-11-21-10	3	3	3	23000	28000	40000	27354	-0.917	28620	11.8696	5.8699
1124	41 06-11-21-10	3	3	3	47000	44000	534000	61498	-0.764	62537	7.0572	3.7272
1125	41 06-11-21-10	3	3	3	139000	143000	411000	265271	-2.116	326109	2.6446	6.0570
1126	41 06-11-21-10	3	3	3	4000	7000	9000	7172	-0.729	7737	5.4370	7.4650
1127	41 06-11-21-10	3	3	3	16000	14300	14300	16661	-0.295	17137	13.1156	VERY HIGH
1128	41 06-11-21-10	3	3	3	17000	50000	41000	59985	-1.498	68686	3.7242	2.3406
1129	41 06-11-21-10	3	3	3	107000	104000	152000	120656	-0.849	131442	4.4505	130.7616
1130	41 06-11-21-10	3	3	3	7000	7000	8000	7483	-0.335	7735	16.2607	VERY HIGH
1131	41 06-11-21-10	3	3	3	12000	13000	15000	13454	-0.417	14016	10.9320	16.3744
1132	41 06-11-21-10	3	3	3	23000	19300	48000	38217	-1.658	44745	2.4991	2.1791
1133	41 06-11-21-10	3	3	3	151000	146000	164000	157366	-0.254	161548	12.5449	16.7559
1134	41 06-11-21-10	3	3	3	173000	148700	814000	511047	-1.600	602344	2.5940	29.1864
1135	41 06-11-21-10	3	3	3	5000	7000	4200	6654	-0.871	7195	6.3772	3.4203

LIST OF SALIENT FEATURES OF DATA GROUPS
 USED TO ESTIMATE SHAPE PARAMETERS

BIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
 POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	NUM	NUMBER	SIZE	USED	FIRST	SECOND	LAST	LOG-NORMAL	WEIBULL	WEIBULL	WEIBULL
							SCALE	SCALE	SCALE	SCALE	SCALE	SCALE	SCALE
							(111)	(112)	(113)	(114)	(115)	(116)	(117)
1136	72	0001090010	2	4	2	4	1100	1300	2400	1676	1428	2.0669	6.0004
1137	73	0001090010	4	6	2	2	5100	5900	2400	6929	6732	15.0713	12.0000
1138	74	0001090010	1	3	2	2	5000	6000	2200	6334	8127	3.3015	3.0000
1139	75	0001090010	6	6	6	6	18000	19000	7500	51907	60030	1.3139	30.0000
1140	76	0001090010	3	2	2	2	631	934	934	891	907	11.7330	11.0000
1141	77	0001090010	5	4	4	4	1173	1734	2000	1439	1791	5.7920	2.0000
1142	78	0001090010	2	2	2	2	24	101	101	0	74	1.0000	1.1110
1143	79	0001090010	3	3	3	3	257	302	383	310	337	6.0253	7.5000
1144	80	0001090010	6	6	6	6	14	54	144	67	104	1.0403	0.0001
1145	81	0001090010	6	6	6	6	106	263	637	273	254	2.3360	1.1710
1146	82	0001090010	2	2	2	2	116	137	497	240	344	0.4423	0.0000
1147	83	0001090010	6	6	6	6	43	69	149	98	67	15.0713	12.0000
1148	84	0001090010	3	3	3	3	121	200	288	209	261	3.5054	1.7916
1149	85	0001090010	3	3	3	3	51	614	760	262	450	0.7932	0.0000
1150	86	0001090010	3	3	3	3	34	60	94	60	74	2.1291	1.0339
1151	87	0001090010	3	3	3	3	262	350	935	425	325	6.7345	6.2000
1152	70	0001090010	2	2	2	2	500	535	635	503	598	5.7303	5.0000
1153	71	0001090010	6	6	6	6	1278	1320	1540	1409	1469	11.4009	35.0000
1154	72	0001090010	6	6	6	6	1733	1752	2579	1923	2068	5.4067	95.2000
1155	73	0001090010	4	4	4	4	2735	3520	5000	3783	4180	6.5706	6.6217
1156	74	0001090010	3	3	3	3	7	42	57	25	37	1.1962	0.0000
1157	75	0001090010	4	4	4	4	574	625	749	640	696	8.4077	13.5105
1158	76	0001090010	4	4	4	4	1170	1230	1491	1348	1434	7.1193	23.0000
1159	77	0001090010	4	4	4	4	21	47	414	49	38	1.7019	1.4234
1160	78	0001090010	10	10	10	10	30	35	414	423	158	0.8009	6.0000
1201	79	0001090010	6	6	6	6	6334	6719	6017	5106	4442	7.0944	13.0000
1202	70	0001090010	3	3	3	3	5	85	471	58	144	0.0011	0.0000
1203	71	0001090010	4	4	4	4	23	298	4100	1131	2204	0.7902	0.0000
1204	72	0001090010	6	6	6	6	2045	3064	4161	3323	3573	5.5103	29.0000
1205	73	0001090010	2	2	2	2	8000	10000	13000	272132	579130	0.6050	2.7500
1241	74	0001090010	5	5	5	5	114400	159703	721900	2142554	1092942	2.7963	3.5276
1242	75	0001090010	3	2	2	2	643100	911000	864000	7529080	8094905	6.9810	5.0363
1243	76	0001090010	2	6	5	4	454600	1372900	1704000	1793960	1396197	3.1067	1.2361
1244	77	0001090010	3	3	2	2	1970400	4811100	14244200	4064204	3042010	1.5341	1.3610
1245	78	0001090010	3	3	3	2	1421400	5684500	10401200	6063807	5099345	3.5736	3.1705
1246	79	0001090010	3	2	2	2	2204000	4049000	4049000	7419622	13890329	0.4309	1.9740
1247	80	0001090010	3	2	2	2	2284000	4540000	4640000	3255420	3879171	1.9344	1.9559
1248	81	0001090010	3	3	3	3	1044000	1162000	1812000	1307257	1406419	3.0199	11.5661
1249	82	0001090010	3	3	3	3	749000	1474000	1674000	1232527	1444279	3.0219	1.0327
1251	83	0001090010	3	3	3	3	152000	759000	1938000	448493	1249940	1.9211	0.0000

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DATE 08-19-2010 BY SP7WAT/SABP DAWD/STB

[illegible]

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLE SIZE	NUMBER FAILED	SIZE FOR MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(M))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
1946	20	03211021010	7	7	7	794000	744000	1300000	931490	.0962	1034124	4.4500	79.7609
1947	0	03211021010	7	7	7	1132000	1142000	2120000	1594553	.1239	1021247	4.1194	122.4077
1948	20	03211021010	7	7	7	1549000	1819000	3290000	2224785	.1101	2502110	3.9916	6.7197
1949	20	03211021010	7	7	7	1141000	1630000	10432000	1744912	.1004	1644446	6.0901	3.0223
2300	31	00054143011	4	3	3	34200	49700	68300	49762	.1373	50566	3.2162	3.0716
2301	31	00054143011	4	3	3	274600	895400	1309500	1008941	.0986	1111840	3.9359	49.3500
2302	31	00054143011	2	2	2	16960	10000	30000	22557	.1752	25974	2.6099	2.4306
2303	31	00054143011	3	2	2	10000	35000	35000	32604	.0473	33663	8.0943	8.0931
2304	31	00054143011	3	2	2	250000	400000	400000	316228	.1443	395209	2.9171	2.9495
2305	31	00054143011	2	2	2	11432	13356	13356	12571	.0372	12953	11.3103	11.4420
2306	31	00054143011	4	3	3	42634	108674	161506	97393	.2449	121558	1.0756	1.0778
2307	31	00054143011	4	3	3	340000	369900	550700	430216	.1488	500029	2.0117	21.0968
2308	31	00054143011	3	3	3	11000	12000	17000	13092	.1091	14450	3.9309	13.9797
2309	31	00054143011	3	3	3	879400	1119200	1624700	1170446	.1358	1333412	3.0676	5.1255
2310	32	00054143011	3	2	2	59400	97000	97000	75907	.1506	84649	2.7497	2.0268
2311	32	00054143011	3	2	2	9000	11700	11700	10267	.0006	10950	5.2258	3.2939
2312	32	00054143011	3	3	3	6500	20400	31200	17652	.2854	22744	1.7439	1.4303
2313	32	00054143011	3	2	2	32000	39000	39000	35327	.0408	37098	6.9307	7.0077
2314	32	00054143011	3	2	2	451000	390000	390000	374049	.0300	391008	10.6186	14.2076
2315	32	00054143011	3	2	2	672600	1419400	1428400	983599	.2334	1167041	1.0037	1.0237
2316	32	00054143011	3	2	2	34500	40500	40500	37426	.0500	39964	8.6213	8.3149
2317	32	00054143011	3	3	3	202000	229700	270300	232015	.0432	246765	6.7443	9.0890
2318	32	00054143011	3	3	3	15164	18413	18413	15776	.0243	16179	13.0894	17.3169
2319	32	00054143011	3	2	2	3404	4169	4169	3768	.0622	3961	6.7730	6.4482
2320	32	00054143011	3	2	2	13000	16700	16000	14422	.0434	15182	6.0031	6.0765
2321	32	00054143011	3	2	2	13451	20329	26379	16786	.1176	18454	3.5001	3.0199
2322	32	00054143011	3	3	3	5496	8124	8124	7266	.0689	7680	6.1173	6.1853
2323	32	00054143011	3	2	2	7114	8671	8473	7766	.0535	8109	7.0680	7.9554
2324	32	00054143011	3	2	2	16011	15063	15063	14430	.0224	14871	14.2312	19.0433
2325	32	00054143011	3	2	2	470914	976004	476004	426726	.0318	957805	9.9993	13.3787
2326	32	00054143011	3	3	3	743401	911433	978001	871964	.0405	902562	14.1592	8.0067
2327	32	00054143011	3	3	3	23734	421264	473094	390180	.1048	427802	5.0067	3.3121
2328	32	00054143011	3	3	3	438764	747482	747482	695441	.0524	725620	8.0369	8.1261
2329	32	00054143011	3	2	2	214000	394309	364309	293780	.1409	339817	2.3293	2.3552
2330	32	00054143011	3	2	2	214000	254000	254000	408517	.2143	508422	2.2283	6.4113
2331	32	00054143011	3	2	2	214000	225300	272300	432961	.2379	446088	2.2777	15.8957
2332	32	00054143011	3	3	3	155300	204700	240300	198444	.0790	214039	6.1173	4.1158
2333	32	00054143011	3	3	3	136000	155300	170000	150699	.0338	155184	15.0432	10.4707
2334	32	00054143011	3	2	2	254000	414300	414300	362344	.2156	631145	1.9506	1.9722
2335	32	00054143011	3	2	2	474000	450300	450300	437421	.0176	445344	18.1726	26.2535

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

ITEM	REF	DESCRIPTION	SAMP- PLF SIZE	NUMBER PAIRED	SIZE FOR MLE	USED MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(M))	UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS				
										LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-DETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)
2336	64	00056081021	2	2	2	2	470000	480000	490000	474974	.0065	478172	49.1535	65.0405
2337	68	00056081021	6	6	6	130000	143000	143000	143000	193337	.2280	192719	16.3952	76.0268
2338	64	00056081021	6	6	6	5000	18000	18000	18000	9001	.2754	12307	2.1097	11.4776
2339	68	00056081021	5	5	5	11000	11000	11000	21000	14492	.1220	16450	3.5595	WEIB MLE
2340	64	00056081021	5	5	5	11000	14000	14000	27000	17803	.1465	21277	2.4155	2.2255
2341	68	00056081021	5	5	5	24000	30400	30400	41000	37446	.1154	42208	4.0170	6.0943
2342	68	00056081021	6	6	6	5000	5000	5000	51000	51000	.4353	27534	1.1925	11.4776
2343	64	00056081021	6	6	6	50000	51000	51000	73000	59491	.0714	64157	6.2777	59.2616
2344	68	00056081021	4	4	4	60000	86500	86500	95400	89493	.0721	89464	8.3951	4.2942
2345	68	00056081021	4	4	4	64000	44000	44000	90500	56441	.1434	65008	2.6195	29.0071
2346	68	00056081021	2	2	2	40000	82000	82000	82000	57271	.2205	68394	1.9100	1.9312
2347	64	00056081021	5	5	5	51500	54000	54000	54000	52735	.0146	53537	21.8500	29.2653
2348	64	00056081021	6	6	6	1534	2146	2146	24000	2077	.0903	2246	6.0940	9.4276
2349	64	00056081020	5	5	5	6654	5826	5826	20558	5208	.0489	5905	6.1161	6.1940
2350	64	00056081020	5	5	5	24288	29558	29558	29558	26794	.0403	28127	6.9020	7.0595
2351	64	00056081020	2	2	2	147837	152007	152007	152007	149908	.0060	151242	37.2170	69.8376
2352	64	00056081020	3	3	3	18544	45348	45348	52176	43293	.0709	44440	5.5100	34.6585
2353	64	00056081020	3	3	3	46765	45963	45963	41299	42759	.0314	40746	12.5400	40.0579
2354	64	00056081020	2	2	2	72291	82332	82332	82332	79772	.0194	81393	16.3954	21.9612
2355	64	00056081020	2	2	2	37575	48338	48338	58338	46814	.1351	52201	3.1167	3.1513
2421	31	00056081011	3	3	3	1192	1200	1200	1700	1345	.0082	1408	4.3929	101.0504
2422	31	00056081011	3	3	3	1000	1000	1000	2000	1260	.1730	1499	2.2287	WEIB MLE
2423	37	00056081011	3	3	3	3860	6410	6410	7100	5632	.1466	6441	3.0565	2.2613
2424	64	00056081021	2	2	2	1861	1873	1873	1873	1867	.0020	1871	168.4400	215.0036
2425	64	00056081020	2	2	2	614	900	900	900	746	.1150	819	3.6631	3.7650
2461	31	00056081011	2	2	2	1403408	1894600	1894600	1894600	1630608	.0022	179623	4.5405	6.6193
2500	31	00056081011	3	3	3	25782	26325	26325	26325	25050	.0743	26765	6.0074	5.0060
2502	31	00056081011	3	3	3	25600	34600	34600	42500	33771	.1115	37531	4.3524	3.7520
2503	31	00056081010	3	3	3	23140	29640	29640	30600	27600	.0460	29230	8.5060	4.9135
2524	31	00056081010	3	3	3	60000	42500	42500	47700	43284	.0309	44940	10.5005	20.0644
2505	37	00056081010	3	3	3	114000	121200	121200	164000	132271	.0028	143592	4.7001	27.7387
2621	31	00056081011	2	2	2	530	679	679	679	600	.0761	638	5.5942	5.5947
2622	37	00056081011	2	2	2	468	634	634	634	545	.0932	587	4.5163	4.5065
2623	37	00056081011	3	3	3	8250	9710	9710	9710	9222	.0419	9540	13.0795	7.4452
2624	37	00056081010	2	2	2	1260	2000	2000	2000	1632	.1491	1840	2.0240	2.0553
2625	37	00056081010	2	2	2	1225	1560	1560	1560	1382	.0742	1408	5.6215	5.7345
2641	31	00056081010	3	3	3	908007	1314000	1314000	2505000	1334358	.2406	996266	12.4922	11.0033
2701	31	00056081011	3	3	3	15400	26000	26000	44900	26197	.2324	3256	1.0913	2.3276
2702	37	00056081011	2	2	2	13000	14500	14500	14500	13730	.0335	14105	12.5556	12.0451
2733	37	00056081011	2	2	2	15300	17200	17200	17200	16227	.0360	16699	11.7126	11.0429

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLI SIZE	NUMBER FAILED	SIZE FOR MLE	USED MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (F3)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-DETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
2704	17	00055304011	2	2	2	2	790000	1070000	1070000	01402	0032	001042	0.3192	4.5495
2705	17	00046301011	5	5	5	7500	14700	20100	20100	16900	0230	20035	2.0005	1.0583
2706	17	00055301010	2	2	2	16000	21100	21100	21100	18020	0700	10019	0.0031	0.0031
2707	17	000463004010	2	2	2	22500	23500	23500	23500	22005	0134	23315	23.0107	31.0797
2708	17	00055301010	3	3	3	11200	17300	32100	32100	16300	0200	15400	3.1334	2.7976
2709	16	00411921011	3	3	3	9000	9000	9700	9700	9220	0100	9400	21.0367	VERY HIGH
2710	16	00411921010	3	3	3	9000	9300	9700	9700	9220	0100	9400	21.0367	VERY HIGH
2711	16	00411921011	6	6	6	32000	33300	131100	131100	50104	0270	50124	3.0040	72.1074
2712	16	00411921010	6	6	6	32000	34000	131100	131100	61436	0200	78275	1.0772	20.0759
2713	16	00411921011	6	6	6	40100	50000	162500	162500	60733	0240	53010	3.0500	2.0030
2714	16	00411921010	6	6	6	40100	60000	164000	164000	61100	0240	54100	3.0504	2.0034
2721	16	00411921011	2	2	2	10400	31600	31600	31600	30090	0040	31216	31.0013	42.0320
2722	16	00411921010	2	2	2	10400	33000	33000	33000	31673	0040	32512	12.0240	16.0020
2723	16	00411921011	6	6	6	21600	53200	176100	176100	60502	0300	60500	1.2250	1.2200
2724	16	00411921010	6	6	6	24000	50000	176100	176100	70010	0300	60133	1.2000	1.3320
2727	16	10211921011	2	2	2	20000	21200	21200	21200	20000	0050	21127	54.3191	72.7703
2728	16	10211921010	2	2	2	21000	22700	22200	22200	21000	0050	22127	56.0012	76.2441
2729	16	10211921011	6	6	6	20000	26700	41200	41200	27000	0200	31770	3.1325	4.2615
2730	16	10211921010	6	6	6	24100	26000	41200	41200	29240	0240	32050	3.0103	11.0500
2731	16	10211921011	6	6	6	28000	45700	74500	74500	50604	0170	60197	2.7005	2.4022
2732	16	10211921010	6	6	6	48200	62000	74500	74500	62370	0000	67100	6.0051	9.0101
2733	16	10211922011	2	2	2	32700	124500	124500	124500	63006	0100	60010	1.0299	1.0300
2734	16	10211922010	2	2	2	32700	126100	126100	126100	64216	0100	60061	1.0271	1.0271
2735	16	10211922011	2	2	2	50000	51200	51200	51200	51000	0020	51120	131.0002	176.7516
2736	16	10211922010	2	2	2	50000	52300	52300	52300	51545	0000	52025	35.5170	47.6500
2737	16	10211922011	2	2	2	21200	24000	24000	24000	22920	0040	23630	0.7416	0.0300
2738	16	10211922010	2	2	2	21200	24000	24000	24000	22920	0040	23630	0.7416	0.0300
2739	16	10211922011	2	2	2	43200	63000	63000	63000	52100	0150	47271	3.0330	3.0743
2740	16	10211922010	2	2	2	43200	63000	63000	63000	52100	0150	47271	3.0330	3.0743
2741	16	10211922011	6	6	6	11900	18200	52400	52400	22978	0100	21420	6.0050	6.0050
2742	16	10211922010	6	6	6	13400	18200	52600	52600	23000	0171	21420	4.0030	4.0030
2743	16	10211922011	2	2	2	19400	42000	42000	42000	27700	0230	34004	1.0013	1.0797
2744	16	10211922010	2	2	2	19400	42000	42000	42000	27700	0230	34004	1.0013	1.0797
2745	16	10211922011	5	5	5	20000	20400	34100	34100	27275	0100	30650	6.0050	50.3010
2746	16	10211922010	5	5	5	20400	21200	34100	34100	27701	0151	31060	4.7326	20.0051
2747	16	10211921011	6	6	6	24000	27300	70000	70000	34710	0232	26073	16.0000	12.5053
2748	16	10211921010	6	6	6	24000	27300	70000	70000	34710	0232	26073	16.0000	12.5053
2749	16	10211921011	6	6	6	91400	64700	101270	101270	65319	0240	65319	16.5597	13.0005
2750	16	10211921010	6	6	6	91400	64700	101270	101270	65319	0240	65319	16.5597	13.0005
2751	16	10211921011	3	3	3	65500	91300	64000	64000	70704	0101	81340	3.5040	2.1017

LIST 16 SALIENT FEATURES OF DATA GROUPS
USING TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	NUM- PLT SIZE	NUMBER FAILED	SIZE LMM	SIZE F74 MLE	USED MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (FINF)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-PETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
2752	34	10211A1010	1	3	3	3	3	46500	91100	64000	70773	-1612	81304	3.3929	2.1809
2753	37	04011A1010	6	6	6	6	6	4000	7200	9000	6533	-1519	7545	3.7296	2.0563
2754	37	04011A1010	6	6	6	6	6	21000	14000	43000	33494	-1422	37497	4.1500	2.3082
2755	37	04011A1010	5	6	6	6	6	21000	25000	60000	41964	-2367	52422	1.7908	6.3992
2756	37	04011A1010	3	2	2	2	2	40000	76000	76000	65952	-1650	76054	2.2119	1.8951
2757	37	04011A1010	6	6	6	6	6	10000	12000	14000	12157	-6628	12898	6.2263	6.3115
2758	37	04011A1010	6	6	6	6	6	10000	17000	40000	39780	-6965	45576	5.3682	5.4870
2759	37	04011A1010	3	3	3	3	3	9000	9000	13200	10475	-6799	11558	6.8909	VERY HIGH
2760	37	03211A1010	6	6	6	6	6	12000	13000	16200	14020	-6536	16777	6.4616	8.2555
2761	37	03211A1010	7	7	7	7	7	9600	9600	16200	12474	-6670	15937	5.6186	VERY HIGH
2762	37	06411A1010	6	6	6	6	6	5000	5000	7000	5434	-6731	5691	6.9248	VERY HIGH
2763	37	06411A1010	3	3	3	3	3	19000	22000	26000	22150	-6682	23619	6.3689	6.2872
2790	37	04011A1010	2	2	2	2	2	900	1100	1100	945	-6616	1646	6.8324	6.9083
2821	37	00055A1011	2	2	2	2	2	678000	1676000	1676000	1212367	-1962	1422133	2.1246	2.1682
2822	37	00055A1010	2	2	2	2	2	1218000	1667000	1967000	1507981	-1312	1675999	3.2180	3.2457
2823	37	00055A1010	2	2	2	2	2	1783000	1893000	1893000	1836147	-6187	1876151	17.0836	22.7524
2825	36	06411A1011	3	3	3	3	3	1755400	2001000	2067000	1936368	-6376	2009310	16.5633	9.2993
2826	36	06411A1010	3	3	3	3	3	1755400	2001000	2067000	1936368	-6376	2009310	16.5633	9.2993
2850	32	00012A1011	2	2	2	2	2	30000	35000	35000	32484	-6473	32483	6.8963	8.9931
2851	32	00012A1010	2	2	2	2	2	65000	309600	309600	141905	-6795	206797	6.8760	6.8770
2852	32	00010A1010	2	2	2	2	2	32400	60400	60400	39600	-1233	43732	3.6162	3.6542
2853	49	00056A1010	6	6	6	6	6	1352	1370	2252	1408	-6671	1643	3.7236	82.7123
2854	49	00056A1010	6	6	6	6	6	1343	1342	2246	1406	-6680	1627	3.6773	77.8092
2855	49	00056A1010	6	6	6	6	6	3316	3811	4188	3631	-6451	3991	12.3008	6.2787
2856	49	00056A1010	6	6	6	6	6	3146	3679	4072	3710	-6716	3860	16.9288	7.3925
2857	49	00056A1010	6	6	6	6	6	8566	9569	11546	10811	-6561	10574	6.2723	16.3924
2858	49	00056A1010	6	6	6	6	6	7797	9270	11382	9796	-6460	10042	6.6762	6.6499
2861	49	00056A1010	2	2	2	2	2	2863	4992	5892	4107	-2216	4910	1.6997	1.9200
2862	49	00056A1010	2	2	2	2	2	2854	5850	6050	4687	-2202	4681	1.6422	1.9336
2863	49	00056A1010	2	2	2	2	2	8877	12731	12731	10031	-1187	11622	3.0024	3.0047
2864	49	00056A1010	2	2	2	2	2	8067	12326	12326	10052	-1351	11208	3.1159	3.1505
2865	49	00056A1010	2	2	2	2	2	8468	12260	12260	10189	-1136	11166	3.7651	3.7663
2866	49	00056A1010	2	2	2	2	2	25454	35716	35716	30153	-1040	32787	6.0006	6.0036
2867	49	00056A1010	2	2	2	2	2	20000	32599	32599	29934	-1980	28013	2.0004	2.0176
2868	49	00056A1010	2	2	2	2	2	21000	22865	22865	21004	-6755	22446	12.5665	16.8123
2869	49	00056A1010	2	2	2	2	2	110946	193494	193494	146514	-1700	168123	2.4446	2.4922
2870	49	00056A1010	2	2	2	2	2	101000	181721	181721	135476	-1804	136458	2.3343	2.3682
2871	49	00056A1010	2	2	2	2	2	77000	190358	190358	109186	-1817	116121	2.6842	2.6831
2872	49	00056A1010	2	2	2	2	2	976	1367	1367	1163	-1679	1269	3.9613	3.9647
2873	49	00056A1010	2	2	2	2	2	949	1271	1271	1090	-6097	1181	6.4980	6.7481

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

ITEM	REF	DESCR (PTN)	SAMP SIZE	NUMBER FAILED	SIZE FOR MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (FIN)	UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS			
									LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)
2874	19	0001101021	2	2	2	949	1271	1271	1090	.0097	1101	6.6930
2875	19	0005001020	2	2	2	850	1700	1700	12307	.2267	14772	1.0703
2876	19	0001201021	2	2	2	7500	15050	15050	10903	.2240	13170	1.0923
2877	19	0001101021	2	2	2	7500	14000	14000	10903	.2344	13244	1.0819
2878	19	0005001020	2	2	2	10000	19160	19160	68732	.2900	61949	1.4200
2879	19	0001201021	2	2	2	21923	66999	66999	30327	.3430	90723	1.2010
2880	19	0001101021	2	2	2	21929	77550	77550	41221	.3078	40331	1.0070
2881	19	0005001020	2	2	2	103210	110427	110427	109624	.0970	112940	11.3099
2882	19	0001201021	2	2	2	95437	100000	100000	102207	.0991	105912	10.7710
2883	19	0001101021	2	2	2	95600	89000	89000	69949	.1410	79340	3.0192
2884	19	0005001020	2	2	2	1577	1401	1401	1510	.0990	1752	6.2009
2885	19	0001201021	2	2	2	640	1836	1836	1091	.3190	1411	1.3311
2886	19	0001101021	2	2	2	897	1836	1836	1203	.2200	1932	1.0350
2887	19	0005001020	2	2	2	8991	12120	12120	10940	.0916	11240	6.6456
2888	19	0001201021	2	2	2	8571	11300	11300	9937	.0637	10430	5.0030
2889	19	0001101021	2	2	2	7564	11099	11099	9527	.1617	10479	2.9714
2890	19	0005001020	2	2	2	61618	66427	66427	45001	.0192	45904	16.5001
2891	19	0001201021	2	2	2	36416	43406	43406	39758	.0539	41527	7.0003
2892	19	0001101021	2	2	2	35800	44000	44000	40239	.0640	42059	7.7500
2893	19	0005001020	2	2	2	22687	31092	31092	30997	.1207	34437	6.3099
2894	19	0005001021	2	2	2	29545	32293	32293	33441	.0796	35067	5.3522
2895	19	0005001020	2	2	2	67109	73770	73770	69400	.1143	74004	3.4400
2896	19	0005001021	2	2	2	55770	63231	63231	63231	.1075	65690	6.1527
2897	19	0005001020	2	2	2	74536	10560	10560	95722	.0944	103748	3.3169
2898	19	0005001021	2	2	2	66075	80131	80131	61429	.1640	70146	2.5030
2899	19	0005001020	2	2	2	35256	45659	45659	40893	.0816	44620	6.7057
2900	19	0005001021	2	2	2	36710	45982	45982	42031	.1174	44198	3.0200
2901	19	0005001020	2	2	2	31480	37020	37020	34114	.0924	37046	7.0300
2902	19	0005001020	2	2	2	45019	46833	46833	42496	.0493	45240	7.4100
2903	19	0005001021	2	2	2	32065	65002	65002	50391	.1564	47144	2.7234
2904	19	0005001020	2	2	2	158	243	243	198	.1397	222	3.0470
2905	19	0005001021	2	2	2	113	551	551	416	.1740	240	2.0357
2906	19	0005001020	2	2	2	449	764	764	710	.0434	736	9.3707
2907	19	0005001021	2	2	2	437	690	690	463	.0246	676	17.3456
2908	19	0001101021	2	2	2	450	750	750	703	.0307	724	10.7176
2909	19	0005001020	2	2	2	420100	1420303	1420303	1291886	.2706	1624369	1.1390
2910	19	0005001021	2	2	2	31000	32303	32303	30000	.0954	47193	6.1599
2911	19	0005001020	2	2	2	1600	3500	3500	3450	.0090	3407	67.0230
2912	19	0005001021	2	2	2	4000	7700	7700	7075	.0020	7377	8.1027
2913	19	0005001020	2	2	2	210000	244309	244309	194009	.3026	445401	1.0849

LIST 34 SALIENT FEATURES OF DATA GROUPS
USEFUL TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLE SIZE	NUMB- ER FAILED	SIZE FOR MLE	USED MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (FL)	LOG-NORMAL SCALE (MLE-SIGMA)	LOG-NORMAL SHAPE	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL LIFETIME (105-MEPA)
3004	14	0900140010	2	2	2	2	14500	17100	17100	16797	-.0110	16599	28.9910	30.8121
3005	14	0900140010	2	2	2	2	10100	16200	36200	35009	-.0567	34951	7.4290	7.3124
3006	14	0900140010	2	2	2	2	2900	3000	9000	2990	-.0104	2982	30.5490	40.0010
3007	14	0900140010	2	2	2	2	14900	14500	14500	15197	-.0121	15399	26.2317	35.1149
3008	14	0900140010	2	2	2	2	35000	43400	43400	30974	-.0061	41104	6.3737	6.4449
3009	14	0900140010	2	2	2	2	27100	30300	90000	28513	-.0512	29239	13.4042	13.4301
3010	14	0900140010	2	2	2	2	73200	75100	75100	74144	-.0072	74742	40.3932	94.0990
3011	14	0900140010	2	2	2	2	2300	3000	4000	3022	-.1202	3383	3.6371	4.5700
3012	14	0900140010	2	2	2	2	4000	9300	9300	7470	-.1346	9324	3.1205	3.1532
3013	14	0900140010	2	2	2	2	21400	25400	25300	23405	-.0457	24364	9.2003	9.3104
3014	14	0900140010	2	2	2	2	7200	64500	64500	23352	-.0428	39167	-.0550	-.0625
3015	14	0900140010	2	2	2	2	120500	218700	218700	167439	-.1633	191203	2.5705	2.6049
3016	14	0900140010	2	2	2	2	4300	4500	4500	4399	-.0140	4463	22.7016	30.0932
3017	13	0900140010	2	2	2	2	75700	25000	25000	24790	-.0012	25782	264.0406	396.0703
3018	14	0900140010	2	2	2	2	250200	315500	315500	285900	-.0004	300713	6.9753	7.0520
3019	14	0900140010	2	2	2	2	67000	95300	95300	66926	-.2171	79712	1.9590	1.9811
3020	14	0900140010	2	2	2	2	2000	4000	4000	7820	-.2129	3357	1.0700	2.0200
3021	14	0900140010	2	2	2	2	3000	5700	5700	4139	-.1971	4047	2.1301	2.1500
3022	16	0900140010	2	2	2	2	42000	67500	62500	57000	-.0505	90642	7.0545	7.5374
3023	14	0900140010	2	2	2	2	61500	71000	71000	66079	-.0441	68466	9.5440	9.6513
3024	14	0900140010	2	2	2	2	2400	3100	3100	2946	-.0713	3021	13.4706	13.6201
3025	14	0900140010	2	2	2	2	21000	44500	44500	30570	-.2306	34809	1.0257	1.0463
3026	14	0900140010	2	2	2	2	49000	80500	161500	96614	-.1954	77290	10.0523	8.9105
3027	23	0910140010	2	2	2	2	74000	24100	24100	24050	-.0013	24002	247.3206	333.4033
3028	23	0910140010	2	2	2	2	35000	60000	60000	40125	-.0039	42931	5.0108	5.0726
3029	23	0910140010	2	2	2	2	62000	74000	74000	67735	-.0543	70765	7.7498	7.8552
3030	23	0910140010	2	2	2	2	99500	192000	182000	134231	-.1870	150047	2.2518	2.2755
3031	23	0910140010	2	2	2	2	11000	18000	18000	14071	-.1512	15094	2.7040	2.8140
3032	23	0910140010	2	2	2	2	25000	34000	34000	30000	-.1120	32031	3.7000	3.8010
3033	23	0910140010	2	2	2	2	37000	64000	64000	59925	-.0307	61865	10.3525	13.0514
3034	23	0910140010	2	2	2	2	112000	192000	190000	145077	-.1423	166240	2.5901	2.6229
3035	23	0910140010	2	2	2	2	252000	290000	290000	279421	-.0595	280461	10.6494	10.7676
3036	23	0910140010	2	2	2	2	7000	10000	10000	8367	-.1090	9138	3.0040	3.0047
3037	23	0910140010	2	2	2	2	249000	274000	274000	261201	-.0294	260279	10.0295	16.4090
3038	23	0910140010	2	2	2	2	437000	741000	741000	697737	-.0170	724979	0.6120	11.5221
3039	23	0910140010	2	2	2	2	7000	10000	10000	8367	-.1090	9138	3.0040	3.0047
3040	23	0910140010	2	2	2	2	17000	17100	17100	17050	-.0010	17302	175.7301	236.3625
3041	23	0910140010	2	2	2	2	30000	44000	44000	40000	-.0450	42400	9.3522	9.4501
3042	23	0910140010	2	2	2	2	27000	32000	32000	29394	-.0522	30555	8.0099	8.1595
3043	23	0910140010	2	2	2	2	41000	70000	70000	65345	-.0423	67600	9.0626	10.0732

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLF SIZE	NUMBER FAILED	SIZE USED FOR MLE	FIRST FAILURE (P. 1.1)	SECOND FAILURE (P. 2.1)	LAST FAILURE (P. 10.1)	LOG-NORMAL SCALE (MLE-SIGMA)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)
3044	21	0320200010	4	4	4	1680	1950	2670	-0.710	-0.710	2195	0.3000	7.7212
3045	21	0320200010	4	4	4	2670	2910	3070	-0.008	-0.008	2745	0.0000	71.0315
3046	21	0320200010	3	3	3	2750	2870	2920	-0.700	-0.700	2735	0.7500	6.9970
3047	21	0320200010	4	4	4	5500	5700	5950	-0.110	-0.110	5707	37.2332	37.2170
3048	21	0320200010	4	4	4	6610	7040	8060	-0.303	-0.303	7575	12.7500	61.7502
3049	21	0320200010	4	4	4	10100	10300	11300	-0.210	-0.210	10941	20.0000	50.3503
3050	21	0320200010	4	4	4	1610	1710	25000	-0.543	-0.543	19102	1.0210	64.27
3051	21	0320200010	4	4	4	64340	55460	59000	-0.940	-0.940	99033	11.0070	5.1023
3052	21	0320200010	4	4	4	11530	1350	17500	-0.700	-0.700	15016	0.0000	5.2503
3053	21	0320200010	4	4	4	16420	27400	27700	-0.720	-0.720	24403	0.2320	5.0750
3054	21	0320200010	4	4	4	27300	33300	37100	-0.000	-0.000	30000	0.0130	5.0205
3055	21	0320200010	4	4	4	58400	81270	87700	-0.000	-0.000	81360	10.3000	0.7202
3056	21	0320200010	3	3	3	29020	35000	36700	-0.000	-0.000	35000	11.7000	0.0137
3057	21	0320200010	4	4	4	54340	57610	63000	-0.000	-0.000	62000	0.5100	10.0025
3058	21	0320200010	3	3	3	164050	174000	190200	-0.000	-0.000	177000	0.0100	0.2000
3059	21	0320200010	4	4	4	456100	503000	595700	-0.150	-0.150	700000	2.0000	11.7020
3060	21	0320200010	4	4	4	87250	90000	103000	-0.012	-0.012	112070	5.0000	45.1000
3061	21	0320200010	4	4	4	173000	170000	227000	-0.000	-0.000	200000	7.0000	315.0000
3062	21	0320200010	11	11	11	519320	500350	1205300	-1.170	-1.170	800000	3.5000	7.0011
3063	23	0910100010	2	2	2	91000	100000	100000	-0.010	-0.010	100000	10.2077	10.3010
3064	23	0910100010	2	2	2	132000	254000	254000	-0.200	-0.200	212000	2.0000	2.1100
3065	23	0910100010	2	2	2	5000	7000	7000	-0.030	-0.030	6420	0.0700	6.1201
3066	23	0910100010	2	2	2	22000	25000	25000	-0.000	-0.000	20000	10.7200	10.0000
3067	23	0910100010	3	3	3	99000	145000	171000	-0.000	-0.000	190000	0.1010	3.1075
3068	23	0910100010	3	3	3	397000	410000	421000	-0.100	-0.100	410000	30.1507	20.0107
3069	23	0910100010	2	2	2	17000	13000	13000	-0.000	-0.000	12012	12.0000	17.5100
3070	23	0910100010	2	2	2	15000	24000	24000	-0.000	-0.000	21000	3.0000	3.0100
3071	23	0910100010	2	2	2	51000	55000	55000	-0.000	-0.000	50000	13.7200	10.3507
3072	23	0910100010	2	2	2	50000	74000	74000	-0.000	-0.000	71015	10.5700	10.0000
3073	23	0910100010	2	2	2	153000	280000	280000	-0.000	-0.000	240000	2.0000	2.2000
3074	23	0910100010	2	2	2	217000	920000	920000	-0.000	-0.000	907500	10.0000	10.0100
3075	23	0910100010	2	2	2	8000	10000	10000	-0.000	-0.000	9000	0.1000	0.2100
3076	23	0910100010	3	3	3	24000	40000	40000	-0.000	-0.000	40000	1.0000	1.0000
3077	23	0910100010	4	4	4	135000	197000	237000	-0.000	-0.000	210000	3.0000	2.0000
3078	23	0910100010	2	2	2	15000	17000	17000	-0.000	-0.000	16000	10.0000	11.0000
3079	23	0910100010	2	2	2	18000	26000	26000	-0.000	-0.000	23000	3.0000	3.0000
3080	23	0910100010	2	2	2	31000	42000	42000	-0.000	-0.000	41000	3.0000	3.0000
3081	23	0910100010	2	2	2	39000	15000	15000	-0.000	-0.000	14000	0.0000	0.5100
3082	23	0910100010	2	2	2	51000	1300	63000	-0.000	-0.000	62000	32.0000	42.0000
3083	23	0910100010	2	2	2	142000	1000	105000	-0.000	-0.000	170000	10.3270	10.0000

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLF SIZE	NUMBER FAILED	SIZE LOW	SIZE HIGH	USED MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-DETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SCALE (MLE-ALPHA)
3084	23	09101800010	2	2	2	2	2	213000	752000	752000	600220	-.3074	546795	1.0000	1.0000
3085	23	09101800010	2	2	2	2	2	12000	15300	15000	13416	-.0405	14178	6.1443	6.2125
3086	23	09101800010	2	2	2	2	2	44000	64000	64000	60795	-.1906	71338	2.1263	2.1039
3087	23	09101800010	2	2	2	2	2	53000	65000	65000	50644	-.0427	61733	6.2177	6.2924
3088	23	09101800010	2	2	2	2	2	371000	361300	361000	340413	-.0341	353388	8.8234	11.0046
3099	23	09101800010	2	2	2	2	2	1650	2031	2031	1631	-.0430	1927	6.2993	6.0728
3090	23	09101800010	2	2	2	2	2	3516	4375	4375	3785	-.0453	3926	9.2404	9.3956
3091	23	09101800010	2	2	2	2	2	6000	14000	14000	10583	-.1719	12154	2.4509	2.4772
3092	23	09101800010	2	2	2	2	2	18000	26000	26000	21633	-.1129	29493	3.7285	3.7599
3093	23	09101800010	2	2	2	2	2	12000	14000	14000	32985	-.0106	33628	17.0070	22.0006
3094	23	09101800010	2	2	2	2	2	75000	113000	113000	92068	-.1299	101882	3.3449	3.3828
3095	23	09101800010	2	2	2	2	2	350000	555000	555000	440738	-.1916	409070	2.9739	3.0049
3096	23	09101800010	2	3	3	3	3	18000	23000	23000	21195	-.0015	22328	6.5072	6.5026
3097	23	09101800010	2	3	3	3	3	52000	58000	58000	62515	-.1093	64976	3.9669	11.1342
3098	23	09101800010	2	3	3	3	2	268000	374000	374000	412643	-.2121	343753	6.1148	3.0009
3099	23	09101800010	2	2	2	2	2	9470	19154	19154	12043	-.1412	13404	2.9821	3.0132
3100	23	09101800010	2	2	2	2	2	11000	38000	38000	34322	-.0425	36095	6.7341	6.8003
3101	23	09101800010	2	2	2	2	2	38000	65000	65000	49099	-.1649	56755	2.5541	2.5025
3102	23	09101800010	2	2	2	2	2	100000	184000	184000	181000	-.0121	183242	20.4041	35.3446
3103	23	09101800010	2	2	2	2	2	172000	400000	400000	265232	-.2668	320600	1.5828	1.6004
3104	23	09101800010	2	2	2	2	2	8000	9000	9000	8485	-.0362	8736	11.0408	11.7099
3105	23	09101800010	2	2	2	2	2	53600	63000	63000	37670	-.0013	40218	5.1700	5.2374
3106	23	09101800010	3	3	3	3	3	130000	186000	186000	177535	-.1008	164320	6.8082	6.8751
3107	23	09101800010	2	2	2	2	2	213000	411000	411000	344207	-.1824	340064	2.8059	1.8536
3108	23	09101800010	2	2	2	2	2	13000	19000	19000	15716	-.1165	17263	3.6129	3.6530
3109	23	09101800010	2	2	2	2	2	51000	56000	56000	53442	-.0287	55057	11.0708	14.8225
3110	23	09101800010	2	2	2	2	2	90000	158500	158500	119240	-.1728	137094	2.4362	2.4633
3111	23	09101800010	2	2	2	2	2	124000	155000	155000	138636	-.0605	146582	6.1643	6.2126
3112	23	09101800010	2	2	2	2	2	9000	9000	9000	9322	-.0304	9570	14.0449	14.0449
3113	23	09101800010	2	2	2	2	2	30000	31000	31000	30643	-.0002	30926	64.3006	37.0067
3114	23	09101800010	3	3	3	3	3	90000	112000	112000	120028	-.1472	139363	2.7712	5.5622
3115	23	09101800010	2	2	2	2	2	15000	16100	16100	16028	-.0019	16002	169.4006	222.4009
3116	23	09101800010	2	2	2	2	2	25000	29100	29100	25050	-.0012	25002	257.5206	347.2003
3117	23	09101800010	2	2	2	2	2	30000	44000	44000	42354	-.0287	44121	8.3096	8.3977
3118	23	09101800010	2	2	2	2	2	62000	71000	71000	69252	-.0376	68609	16.1131	8.0741
3119	23	09101800010	2	2	2	2	2	126000	163000	163000	144444	-.0742	153342	5.6721	9.7351
3120	23	09101800010	2	2	2	2	2	8000	9000	9000	8485	-.0362	8736	11.0408	11.7099
3121	23	09101800010	3	3	3	3	3	20000	32000	32000	32207	-.0470	33469	6.1730	12.3967
3122	23	09101800010	3	3	3	3	3	100000	127000	127000	118095	-.0346	121595	16.3356	9.0795
3123	23	09101800010	3	3	3	3	3	360000	516000	516000	400278	-.1400	342219	2.1719	2.0150

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLE SIZE	NUMBER FAILED	SIZE LMM	SIZE FOR MLE	USED MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE- μ)	LOG-NORMAL SHAPE (MLE- σ)	WEIBULL SCALE (MLE- β)	WEIBULL SHAPE (MLE- α)	WEIBULL SCALE (MLE- β)	WEIBULL SHAPE (MLE- α)
3124	23	0910180010	2	2	2	2	2	23000	34000	34000	27964	-1.200	30093	3.5078	3.5067	3.5067
3125	23	0910180010	2	2	2	2	2	10000	37000	37000	40343	-1.012	52447	6.1018	6.2375	6.2375
3126	23	0910180010	2	2	2	2	2	50000	62000	62000	59678	-0.041	50720	6.3737	6.4445	6.4445
3127	23	0910180010	3	3	3	3	3	15000	16000	16000	16503	-0.931	17466	7.9327	10.0076	10.0076
3128	23	0910180010	3	3	3	3	3	41000	55000	74000	59034	-1.282	62956	3.4436	6.1400	6.1400
3129	23	0910180010	3	3	3	3	3	131000	171000	190000	162959	-0.032	174393	6.1710	6.5649	6.5649
3130	23	0910180010	2	2	2	2	2	17000	61000	61000	47508	-1.375	53761	2.7426	2.7720	2.7720
3131	23	0910180010	3	3	3	3	3	80000	149000	400000	149000	-1.010	143294	2.1010	1.0040	1.0040
3132	23	0910180010	2	2	2	2	2	450000	616000	616000	579415	-0.930	579006	6.5257	6.5700	6.5700
3133	23	0910180010	2	2	2	2	2	12000	13000	13000	12400	-0.246	12812	12.0034	17.3106	17.3106
3134	23	0910180010	2	2	2	2	2	70000	45000	45000	36125	-1.349	40272	3.1205	3.1532	3.1532
3135	23	0910180010	2	2	2	2	2	77000	94000	94000	89076	-0.013	89779	6.0729	6.0902	6.0902
3136	23	0910180010	4	4	4	4	4	492000	654000	1777000	872677	-2.150	637746	13.7636	11.5536	11.5536
3137	23	0910180010	2	2	2	2	2	41000	51000	51000	45727	-0.070	46264	6.2020	6.3518	6.3518
3138	23	0910180010	2	2	2	2	2	62000	67000	67000	64452	-0.234	66063	13.3579	17.0742	17.0742
3139	23	0910180010	2	2	2	2	2	140000	797000	797000	352607	-0.909	527813	1.0000	0.9500	0.9500
3140	23	0910180010	2	2	2	2	2	140000	501000	501000	269596	-0.329	365612	1.0997	1.1110	1.1110
3141	23	0910180010	2	2	2	2	2	109000	594000	594000	429143	-2.017	504849	2.0072	2.1104	2.1104
3142	23	0910180010	2	2	2	2	2	18000	21000	21000	19442	-0.073	20190	8.0963	8.0931	8.0931
3143	23	0910180010	3	3	3	3	3	18000	132000	140000	88805	-0.319	116616	1.0200	0.9769	0.9769
3144	23	0910180010	3	3	3	3	3	240000	340000	452000	356082	-1.729	414425	2.5513	3.0050	3.0050
3145	23	0910180010	2	2	2	2	2	13000	131000	131000	71677	-0.371	94452	1.1316	1.1662	1.1662
3146	23	0910180010	3	3	3	3	3	130000	154000	302000	171258	-2.248	140778	3.4641	3.4282	3.4282
3147	23	0910180010	3	3	3	3	3	127000	176300	5218000	165750	-0.905	162053	4.2089	3.7279	3.7279
3148	23	0910180010	2	2	2	2	2	8000	9000	9000	8485	-0.362	8736	11.6606	11.7609	11.7609
3149	23	0910180010	2	2	2	2	2	15000	21700	21000	18330	-0.035	14604	5.0419	5.0379	5.0379
3150	23	0910180010	2	2	2	2	2	118000	124000	124000	120963	-0.152	122888	20.0037	27.0512	27.0512
3151	23	0910180010	2	2	2	2	2	47000	107000	107000	81449	-1.074	93218	2.5125	2.5604	2.5604
3152	23	0910180010	2	2	2	2	2	228000	278000	278000	251762	-0.009	264414	6.9149	6.9918	6.9918
3153	23	0910180010	3	3	3	3	3	451000	560000	546000	494232	-0.587	520255	7.1726	7.2523	7.2523
3154	23	0910180010	2	2	2	2	2	15000	30000	30000	21909	-1.931	25594	2.1011	2.2093	2.2093
3155	14	0500240010	4	4	4	4	4	143000	244700	244000	251778	-1.023	266010	3.6633	3.7827	3.7827
3156	14	0500240010	4	4	16	16	16	132000	143000	248000	257814	-1.770	312493	3.7506	12.6253	12.6253
3157	14	0500240010	4	25	25	25	25	128000	143000	248000	250088	-1.163	267024	5.2873	5.0600	5.0600
3158	14	0500240010	4	10	10	10	10	134000	180000	250000	351859	-1.669	365663	6.4277	3.7389	3.7389
3159	14	0500240010	4	24	24	24	24	141000	143100	250000	246079	-0.920	246624	6.0007	61.7504	61.7504
3160	14	0500240010	4	4	4	4	4	144000	196700	246200	369780	-1.299	367734	5.7801	26.2250	26.2250
3161	14	0500240010	11	3	3	3	3	171000	179000	215000	313454	-1.714	378839	2.9565	90.1526	90.1526
3162	14	0500240010	3	3	3	3	3	171000	179000	190000	219204	-1.125	245367	3.0432	26.4321	26.4321
3163	14	0500240010	3	3	3	3	3	147000	219300	218100	207236	-0.311	214025	10.2791	13.0962	13.0962

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	ID	DESC	PART	QTY	UNIT	COST	PRICE	AMT	TAX	TOTAL	STATUS	DATE	TIME	USER	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34	F35	F36	F37	F38	F39	F40	F41	F42	F43	F44	F45	F46	F47	F48	F49	F50	F51	F52	F53	F54	F55	F56	F57	F58	F59	F60	F61	F62	F63	F64	F65	F66	F67	F68	F69	F70	F71	F72	F73	F74	F75	F76	F77	F78	F79	F80	F81	F82	F83	F84	F85	F86	F87	F88	F89	F90	F91	F92	F93	F94	F95	F96	F97	F98	F99	F100	F101	F102	F103	F104	F105	F106	F107	F108	F109	F110	F111	F112	F113	F114	F115	F116	F117	F118	F119	F120	F121	F122	F123	F124	F125	F126	F127	F128	F129	F130	F131	F132	F133	F134	F135	F136	F137	F138	F139	F140	F141	F142	F143	F144	F145	F146	F147	F148	F149	F150	F151	F152	F153	F154	F155	F156	F157	F158	F159	F160	F161	F162	F163	F164	F165	F166	F167	F168	F169	F170	F171	F172	F173	F174	F175	F176	F177	F178	F179	F180	F181	F182	F183	F184	F185	F186	F187	F188	F189	F190	F191	F192	F193	F194	F195	F196	F197	F198	F199	F200	F201	F202	F203	F204	F205	F206	F207	F208	F209	F210	F211	F212	F213	F214	F215	F216	F217	F218	F219	F220	F221	F222	F223	F224	F225	F226	F227	F228	F229	F230	F231	F232	F233	F234	F235	F236	F237	F238	F239	F240	F241	F242	F243	F244	F245	F246	F247	F248	F249	F250	F251	F252	F253	F254	F255	F256	F257	F258	F259	F260	F261	F262	F263	F264	F265	F266	F267	F268	F269	F270	F271	F272	F273	F274	F275	F276	F277	F278	F279	F280	F281	F282	F283	F284	F285	F286	F287	F288	F289	F290	F291	F292	F293	F294	F295	F296	F297	F298	F299	F300	F301	F302	F303	F304	F305	F306	F307	F308	F309	F310	F311	F312	F313	F314	F315	F316	F317	F318	F319	F320	F321	F322	F323	F324	F325	F326	F327	F328	F329	F330	F331	F332	F333	F334	F335	F336	F337	F338	F339	F340	F341	F342	F343	F344	F345	F346	F347	F348	F349	F350	F351	F352	F353	F354	F355	F356	F357	F358	F359	F360	F361	F362	F363	F364	F365	F366	F367	F368	F369	F370	F371	F372	F373	F374	F375	F376	F377	F378	F379	F380	F381	F382	F383	F384	F385	F386	F387	F388	F389	F390	F391	F392	F393	F394	F395	F396	F397	F398	F399	F400	F401	F402	F403	F404	F405	F406	F407	F408	F409	F410	F411	F412	F413	F414	F415	F416	F417	F418	F419	F420	F421	F422	F423	F424	F425	F426	F427	F428	F429	F430	F431	F432	F433	F434	F435	F436	F437	F438	F439	F440	F441	F442	F443	F444	F445	F446	F447	F448	F449	F450	F451	F452	F453	F454	F455	F456	F457	F458	F459	F460	F461	F462	F463	F464	F465	F466	F467	F468	F469	F470	F471	F472	F473	F474	F475	F476	F477	F478	F479	F480	F481	F482	F483	F484	F485	F486	F487	F488	F489	F490	F491	F492	F493	F494	F495	F496	F497	F498	F499	F500	F501	F502	F503	F504	F505	F506	F507	F508	F509	F510	F511	F512	F513	F514	F515	F516	F517	F518	F519	F520	F521	F522	F523	F524	F525	F526	F527	F528	F529	F530	F531	F532	F533	F534	F535	F536	F537	F538	F539	F540	F541	F542	F543	F544	F545	F546	F547	F548	F549	F550	F551	F552	F553	F554	F555	F556	F557	F558	F559	F560	F561	F562	F563	F564	F565	F566	F567	F568	F569	F570	F571	F572	F573	F574	F575	F576	F577	F578	F579	F580	F581	F582	F583	F584	F585	F586	F587	F588	F589	F590	F591	F592	F593	F594	F595	F596	F597	F598	F599	F600	F601	F602	F603	F604	F605	F606	F607	F608	F609	F610	F611	F612	F613	F614	F615	F616	F617	F618	F619	F620	F621	F622	F623	F624	F625	F626	F627	F628	F629	F630	F631	F632	F633	F634	F635	F636	F637	F638	F639	F640	F641	F642	F643	F644	F645	F646	F647	F648	F649	F650	F651	F652	F653	F654	F655	F656	F657	F658	F659	F660	F661	F662	F663	F664	F665	F666	F667	F668	F669	F670	F671	F672	F673	F674	F675	F676	F677	F678	F679	F680	F681	F682	F683	F684	F685	F686	F687	F688	F689	F690	F691	F692	F693	F694	F695	F696	F697	F698	F699	F700	F701	F702	F703	F704	F705	F706	F707	F708	F709	F710	F711	F712	F713	F714	F715	F716	F717	F718	F719	F720	F721	F722	F723	F724	F725	F726	F727	F728	F729	F730	F731	F732	F733	F734	F735	F736	F737	F738	F739	F740	F741	F742	F743	F744	F745	F746	F747	F748	F749	F750	F751	F752	F753	F754	F755	F756	F757	F758	F759	F760	F761	F762	F763	F764	F765	F766	F767	F768	F769	F770	F771	F772	F773	F774	F775	F776	F777	F778	F779	F780	F781	F782	F783	F784	F785	F786	F787	F788	F789	F790	F791	F792	F793	F794	F795	F796	F797	F798	F799	F800	F801	F802	F803	F804	F805	F806	F807	F808	F809	F810	F811	F812	F813	F814	F815	F816	F817	F818	F819	F820	F821	F822	F823	F824	F825	F826	F827	F828	F829	F830	F831	F832	F833	F834	F835	F836	F837	F838	F839	F840	F841	F842	F843	F844	F845	F846	F847	F848	F849	F850	F851	F852	F853	F854	F855	F856	F857	F858	F859	F860	F861	F862	F863	F864	F865	F866	F867	F868	F869	F870	F871	F872	F873	F874	F875	F876	F877	F878	F879	F880	F881	F882	F883	F884	F885	F886	F887	F888	F889	F890	F891	F892	F893	F894	F895	F896	F897	F898	F899	F900	F901	F902	F903	F904	F905	F906	F907	F908	F909	F910	F911	F912	F913	F914	F915	F916	F917	F918	F919	F920	F921	F922	F923	F924	F925	F926	F927	F928	F929	F930	F931	F932	F933	F934	F935	F936	F937	F938	F939	F940	F941	F942	F943	F944	F945	F946	F947	F948	F949	F950	F951	F952	F953	F954	F955	F956	F957	F958	F959	F960	F961	F962	F963	F964	F965	F966	F967	F968	F969	F970	F971	F972	F973	F974	F975	F976	F977	F978	F979	F980	F981	F982	F983	F984	F985	F986	F987	F988	F989	F990	F991	F992	F993	F994	F995	F996	F997	F998	F999	F1000	F1001	F1002	F1003	F1004	F1005	F1006	F1007	F1008	F1009	F1010	F1011	F1012	F1013	F1014	F1015	F1016	F1017	F1018	F1019	F1020	F1021	F1022	F1023	F1024	F1025	F1026	F1027
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LIST OF CALIFORNIA FEATURES OF DATA GROUPS
USED TO ESTIMATE SCALE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REP.	DESCRIPTION	VAL.	NUMBER	SIZE	USED	FIRST	SECOND	FIRST	LOG-NORMAL	LOG-NORMAL	WEIBULL	WEIBULL	WEIBULL
				FAILED	LOW	MLE	FAILURE	FAILURE	(F100)	(MLE-MU)	(MLE-SIGMA)	(MLE - 0.5774)	SCALE	SHAPE
							(F100)	(F100)						(F05-MLE)
1400	14	09001405050	5	6	6	6	193471	191682	295506	195033	-0.181	109531	26.1478	26.0063
1401	14	09001405050	5	6	6	6	252344	261196	1400440	1114707	-0.757	1207119	5.9400	115.7316
1402	14	09001405050	5	6	6	6	24070	26245	30014	32166	-0.046	33769	10.2389	176.3127
1403	14	09001405050	5	6	6	6	23635	23640	31745	24734	-0.439	27072	7.9900	106.3646
1404	14	09001405050	5	6	6	6	21070	22785	30545	25627	-0.061	27237	7.0396	23.2511
1405	14	09001405050	5	6	6	6	23608	27049	31272	27771	-0.413	28925	11.9466	8.1926
1406	14	09001405050	5	6	6	6	25197	24747	35536	30437	-0.521	32166	6.6950	21.7104
1407	14	09001405050	5	6	6	6	26121	26124	110826	102437	-0.094	109049	7.5662	531.0300
1408	14	09001405050	5	6	6	6	26121	26124	30593	25965	-0.064	27407	8.1744	VERY HIGH
1409	14	09001405050	5	6	6	6	15925	21124	26220	21357	-0.063	27671	9.5546	3.0723
1410	14	09001405050	5	6	6	6	17640	89250	80033	72506	-0.182	84352	25.0862	60.0931
1411	14	09001405050	5	6	6	6	5710	70245	92085	75436	-0.491	79742	7.6729	21.1861
1412	14	09001405050	5	6	6	6	48774	73920	91945	70419	-0.499	83769	8.7867	15.1633
1413	14	09001405050	5	6	6	6	75309	41805	90767	86459	-0.408	90331	10.1382	16.5946
1414	14	09001405050	5	6	6	6	75466	74326	88343	78603	-0.357	81766	11.6579	67.0682
1415	14	09001405050	5	6	6	6	17749	17749	249646	211356	-0.032	225212	7.9570	2772.3929
1416	14	09001405050	5	6	6	6	57243	53148	80391	73435	-0.645	78223	7.3901	23.2282
1417	14	09001405050	5	6	6	6	52372	62407	86992	89132	-0.546	73495	7.0189	1940.9915
1418	14	09001405050	5	6	6	6	51615	52710	71350	59024	-0.910	61460	7.2280	63.9766
1419	14	09001405050	5	6	6	6	66555	49175	52765	49429	-0.206	51028	13.6276	11.0970
1420	14	09001405050	5	6	6	6	140245	141090	173215	151470	-0.365	157716	10.7495	93.0002
1421	14	09001405050	5	6	6	6	75705	77105	92575	81935	-0.413	85778	9.7904	50.6995
1422	14	09001405050	5	6	6	6	79520	93975	119280	70846	-0.578	104844	7.8125	6.5697
1423	14	09001405050	5	6	6	6	112700	114135	136370	120922	-0.370	125295	12.0500	86.4593
1424	14	09001405050	5	6	6	6	112580	136400	142390	141639	-0.224	164971	21.0415	83.2343
1425	14	09001405050	5	6	6	6	194164	196870	502985	419232	-0.499	446510	7.4321	31.0382
1426	14	09001405050	5	6	6	6	96560	91315	30095	92360	-0.249	94777	17.0673	16.2339
1427	14	09001405050	5	6	6	6	56655	62475	72640	66390	-0.436	69265	12.4831	10.7905
1428	14	09001405050	5	6	6	6	117495	126335	165350	144234	-0.672	154362	7.5975	16.5432
1429	14	09001405050	5	6	6	6	133040	112005	137040	120465	-0.449	126411	10.0322	13.1196
1430	14	09001405050	5	6	6	6	75075	60874	100495	90080	-0.434	94481	13.0118	5.7640
1431	14	09001405050	5	6	6	6	47665	76860	91815	82274	-0.543	86961	8.4616	8.3715
1432	14	09001405050	5	6	6	6	65545	65004	44145	76963	-0.608	82043	7.1659	205.0306
1433	14	09001405050	5	6	6	6	131605	112007	125965	114210	-0.309	117948	14.8813	11.2309
1434	14	09001405050	5	6	6	6	24424	101783	174930	108925	-0.428	114024	9.8881	29.2399
1435	14	09001405050	5	6	6	6	114310	126385	144900	131996	-0.365	136780	16.6397	10.0937
1436	14	09001405050	5	6	6	6	78120	83684	102710	93056	-0.634	99368	7.3778	13.0970
1437	14	09001405050	5	6	6	6	76615	100450	100450	90000	-0.400	87715	7.5876	34.1546
1438	14	09001405050	5	6	6	6	124880	139245	172060	149798	-0.510	157469	9.6362	10.0337
1439	14	09001405050	5	6	6	6	100427	136574	134674	115144	-0.521	121463	7.5711	10.0420

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

ITEM	REF	DESC	ITEM	SAM- PLF	NUMBER FAILED	TYPE LNM	FOR MLE	FIRST FAILURE (F11)	SECOND FAILURE (F12)	LAST FAILURE (F13)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
3440	14	09001845050	4	4	4	4	4	113050	139475	145370	145376	.0508	193952	11.2251	5.2078
3441	14	09001845050	4	4	4	4	4	84490	100520	121500	104002	.0501	112362	8.6895	6.2970
3442	14	09001845050	4	4	4	4	4	105210	123130	132685	123228	.0459	127198	17.0181	6.9552
3443	17	19702845070	10	10	10	10	10	93	103	130	109	.0408	114	10.0461	16.3164
3444	17	19702845070	10	10	10	10	10	99	103	152	129	.0452	136	7.4906	26.6001
3445	17	19702845070	10	10	10	10	10	76	104	179	115	.0762	124	7.8220	3.3591
3446	17	19702845070	10	10	10	10	10	67	77	162	112	.1120	125	4.7773	7.5737
3447	17	19702845070	20	20	20	20	20	100	110	280	173	.1161	196	4.0284	10.7634
3448	21	03202045010	3	3	3	3	3	332040	374560	413760	371952	.0479	388719	9.5178	10.0943
3449	21	03202045010	4	4	4	4	4	2023610	4023600	5565740	3867636	.1465	4603194	2.9958	1.5748
3450	4	30006845830	10	10	10	10	10	15000	18000	28000	20553	.0835	22539	5.2461	5.7788
3451	4	30006845830	10	10	10	10	10	89000	114303	171300	137607	.0878	148874	6.6583	6.2559
3452	4	30006845830	11	11	11	11	11	377000	625000	2616000	572779	.1191	508911	5.7456	9.7481
3453	4	30006845830	10	10	10	10	10	376000	625000	1437000	854005	.1782	1014940	3.1988	1.5751
3454	4	30006845830	10	10	10	10	10	463000	716000	2481000	1271691	.1895	1596141	2.4863	10.0594
3455	4	30006845830	10	10	10	10	10	317000	597000	1224000	731999	.1532	848565	3.4597	1.6644
3456	4	30006845830	10	10	10	10	10	378000	591000	1483000	761934	.2057	84569	2.1432	31.1594
3457	4	30006845830	10	10	10	10	10	604000	645000	2505000	1087977	.2022	923930	4.5799	11.3404
3458	4	30006845830	10	10	10	10	10	141000	142000	648000	268613	.2673	160790	12.5834	1.49.8845
3459	4	30006845830	10	10	10	10	10	217000	252000	659000	398881	.1650	412012	2.8879	7.0460
3460	4	30006845830	10	10	10	10	10	185000	252000	704000	413.31	.2000	507712	2.6489	3.4089
3461	4	30006845830	10	10	10	10	10	210000	225000	838000	356711	.2262	288302	5.9887	15.2712
3462	4	30006845830	10	10	10	10	10	110000	113000	444000	218476	.2378	281678	2.8029	39.1566
3463	4	30006845830	10	10	10	10	10	223000	242000	386000	295957	.0791	322247	5.7126	12.8836
3464	22	03202045010	4	4	4	4	4	68400	57630	43380	57074	.0506	99738	18.9972	6.5928
3465	22	03202045010	3	3	3	3	3	26270	28600	34830	29716	.0627	31584	6.4679	13.8585
3466	22	03202045010	3	3	3	3	3	21040	235130	318700	258899	.0832	274810	4.2444	11.0954
3467	22	03202045010	4	4	4	4	4	67090	53650	58578	53679	.0410	95725	13.1927	6.0186
3468	22	03202045010	4	4	4	4	4	23380	26900	33410	28846	.0488	30011	6.6849	10.4925
3469	22	03202045010	4	4	4	4	4	188860	199240	209190	199160	.0295	209437	21.5684	17.9380
3470	22	03202045010	4	4	4	4	4	40490	42540	43170	42190	.0123	42729	34.8899	23.2989
3471	22	03202045010	4	4	4	4	4	32580	37190	47550	38428	.0882	41250	5.7969	6.0952
3472	22	03202045010	4	4	4	4	4	240460	285700	347680	298676	.0458	310049	6.7997	6.7876
3473	22	03202045010	4	4	4	4	4	397590	403908	610418	488185	.0931	527126	4.8116	78.0087
3474	22	03202045010	4	4	4	4	4	387740	393450	588740	677240	.0935	526042	5.1395	74.8294
3475	22	03202045010	3	3	3	3	3	26270	28600	34830	29716	.0627	31584	6.4679	13.8585
3476	22	03202045010	4	4	4	4	4	47330	99350	180250	99169	.0956	99747	78.7915	91.8238
3477	22	03202045010	4	4	4	4	4	116110	121110	204378	153111	.1391	177876	3.4415	18.8869
3478	22	03202045010	4	4	4	4	4	177990	189210	195400	188185	.0172	191575	29.4411	18.8079
3479	22	03202045010	4	4	4	4	4	34500	38330	51770	43114	.0875	44092	5.5483	10.9388

LIST OF SALINITY ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	AGE	DESC-PTION	SAM- PLE SIZE	NUMBER FAILED	SIZE USED	FIRST FAILURE TIME	SECOND FAILURE TIME	LAST FAILURE TIME	LOG-NORMAL SCALE (MLE-RU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOS-ALPHA)
1000	2	1000-1000000	4	4	4	44120	44370	42400	51968	.0537	52216	6.5059	222.0676
1001	2	1000-1000000	4	4	4	42600	154400	722370	143064	.1676	162204	3.3636	1.0312
1002	2	1000-1000000	4	4	4	174400	181710	104190	102775	.0059	102897	75.0003	61.3475
1003	2	1000-1000000	4	4	4	103000	640000	4700300	1276397	.2277	142242	2.9132	1.7915
1004	2	1000-1000000	4	4	4	222200	1000000	17470000	4208598	.2007	7926076	2.0269	1.9482
1005	2	1000-1000000	4	4	4	2224000	264000	4223000	2996224	.0968	3343726	6.3511	10.2912
1006	2	1000-1000000	4	4	4	1203300	1123300	50274300	91410294	.1055	20015657	3.0009	13.2108
1007	2	1000-1000000	4	4	4	17042000	31740000	317912000	692522816	.3493	92104110	2.6574	1.0395
1008	2	1000-1000000	4	4	4	47420000	41942000	514416000	66420136	.5630	9967657	.8567	0.1592
1009	2	1000-1000000	4	4	4	1154000	1134000	4972000	7163305	.2030	2725164	2.3042	8.5293
1010	2	1000-1000000	4	4	4	112000	4200000	24.74000	12078011	.3164	16642147	1.7533	2.3356
1011	2	1000-1000000	4	4	4	1447000	10783000	64429300	64418374	.1920	41993273	2.6047	0.9118
1012	2	1000-1000000	4	4	4	497000	1340000	6787000	2522628	.3037	343084	1.4044	1.3153
1013	2	1000-1000000	4	4	4	269000	1642000	4864000	4564103	.1124	5041824	5.2976	6.1363
1014	2	1000-1000000	4	4	4	475000	1156000	3929000	1032672	.1918	2348864	2.4254	3.7988
1015	2	1000-1000000	4	4	4	1130000	1340000	1371300	2255134	.2075	1844406	3.0155	7.8903
1016	2	1000-1000000	4	4	4	153000	1412300	30744300	7407142	.1923	6070640	3.5915	16.23102
1017	2	1000-1000000	4	4	4	1576000	1473000	5349000	2444003	.1769	3216819	2.4004	11.4542
1018	2	1000-1000000	4	4	4	1774000	3092000	11716300	4037304	.2403	4656754	1.9309	1.9241
1019	2	1000-1000000	4	4	4	1094000	4174300	10114000	5664521	.1943	6841377	2.0748	1.3912
1020	2	1000-1000000	4	4	4	441000	750700	5776000	1914558	.3732	2444349	1.3516	2.4458
1021	2	1000-1000000	4	4	4	443000	1353300	4797000	1656359	.2323	2116321	1.9520	1.2494
1022	2	1000-1000000	4	4	4	772300	443000	2409000	1230112	.1964	1542444	2.0763	4.7503
1023	2	1000-1000000	4	4	4	414700	349300	4754700	1061019	.2432	2020565	3.0002	32.40240
1024	2	1000-1000000	4	4	4	217500	1073370	2143630	1149374	.4623	1720414	1.4451	.5412
1025	2	1000-1000000	4	4	4	1141000	1547900	1949840	1584790	.0943	1744510	5.5138	3.5033
1026	2	1000-1000000	4	4	4	1547900	1757200	2601440	1974511	.0964	2180142	4.3075	2.3161
1027	2	1000-1000000	4	4	4	176490	784520	1454840	976443	.1467	1112744	2.0765	9.2043
1028	2	1000-1000000	4	4	4	4000	6201	8400	6780	.0547	2210	5.0463	33.9019
1029	2	1000-1000000	4	4	4	15600	15400	15500	10874	.0544	17814	7.1758	94.8057
1030	2	1000-1000000	4	4	4	44100	35200	30100	32095	.0911	34737	5.7360	4.0467
1031	2	1000-1000000	4	4	4	45700	43600	139400	102314	.1141	114007	3.4005	15.8975
1032	2	1000-1000000	4	4	4	217700	774700	774700	440470	.0899	740617	5.4655	3.0715
1033	2	1000-1000000	4	4	4	44000	44400	58200	54614	.0794	44714	4.0839	112.3811
1034	2	1000-1000000	4	4	4	117700	134500	134500	141244	.0577	144566	5.4646	23.4461
1035	2	1000-1000000	4	4	4	443000	644500	741600	662496	.0554	499330	7.3616	16.2707
1036	2	1000-1000000	4	4	4	31300	31700	24800	23914	.0544	23427	7.6215	16.9105
1037	2	1000-1000000	4	4	4	43000	44600	104700	94528	.0907	32074	6.7706	9.3375
1038	2	1000-1000000	4	4	4	134500	13100	13100	12474	.0544	13040	37.335	69.8904
1039	2	1000-1000000	4	4	4	44000	44100	44100	44437	.0544	44437	.4520	.4520

LIST OF SALIENT FEATURES OF DATA GROUPS
USED IN ESTIMATING SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	DEF	DESCRIPTION	SAM- SIZE	NUMBER FILLED	SIZE LMD	SIZE MDL	FIRST FAILURE (F111)	SECOND FAILURE (F121)	LAST FAILURE (F1MP)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-MU)	WEIBULL SHAPE (MLE-SIGMA)	WEIBULL SHAPE (MLE-MU)
4012	6	03902021010	1	1	1	1	114000	249000	400000	206640	-2261	250843	2.6722	1.4499
4013	6	03902021010	1	2	2	2	13000	249000	249000	131681	-6879	196803	7.957	3.553
4014	6	03902021010	1	3	3	3	4000	4000	7000	5192	-1224	5837	3.6286	5.6512
4015	6	03902021010	1	3	3	3	41000	61000	64000	55761	-0978	60584	5.9576	3.1048
4016	6	03902021010	1	3	3	3	481000	747000	940000	746470	-1113	650244	3.0782	6.7277
4017	6	03902021010	2	2	2	2	416000	616000	614000	405394	-1196	946477	3.5218	3.5400
4018	6	03902021010	1	3	3	3	47000	47000	70000	59261	-6661	63132	6.1298	13.2696
4019	6	03902021010	1	3	3	3	40000	40000	10000	59994	-0072	60447	56.0063	72.3738
4020	6	03902021010	1	3	3	3	119000	149000	249000	176314	-1316	200646	3.0146	9.0485
4021	6	03902021010	1	3	3	3	164000	141000	172000	155938	-0376	161824	10.6943	36.1234
4022	6	03902021010	1	3	3	3	201000	249000	408000	285242	-1438	379491	2.8482	3.5537
4023	6	03902021010	1	3	3	3	124000	368000	659000	180530	-0744	409019	5.6755	11.2065
4024	6	03902021010	2	2	2	2	47000	134000	134000	113714	-1745	1258170	3.3547	3.3923
4025	6	03902021010	1	3	3	3	610000	548000	876000	488854	-1490	676068	2.0108	6.3767
4026	6	03902021010	1	3	3	3	647000	619000	1015000	624150	-2094	799318	2.0960	2.5989
4027	6	03902021010	2	2	2	2	52000	57000	70000	60071	-0396	62498	18.3965	11.7536
4028	6	03902021010	1	3	3	3	119000	149000	249000	173314	-0973	193550	6.0440	21.0121
4029	6	03902021010	1	3	3	3	201000	249000	459000	329459	-1290	373097	6.0051	3.1873
4030	6	03902021010	1	3	3	3	187000	610000	1395000	794485	-1921	872174	2.3272	10.1392
4031	6	03902021010	1	3	3	3	12900	17000	40500	39420	-0783	47812	6.0783	9.5505
4032	6	03902021010	2	2	2	2	91200	68700	68700	64424	-0166	66090	19.2173	25.7196
4033	6	03902021010	1	3	3	3	73000	92600	161200	105650	-1826	123946	2.6344	7.6373
4034	6	03902021010	1	3	3	3	176000	423600	2949800	100831	-0833	44801	6.7877	8.0793
4035	6	03902021010	1	3	3	3	19400	43900	47900	63508	-0419	45326	18.7871	11.7716
4036	6	03902021010	1	3	3	3	21500	59900	64700	51817	-3089	67040	1.8873	1.1159
4037	6	03902021010	1	3	3	3	75100	127500	201400	124471	-2144	151767	2.1982	2.2981
4038	6	03902021010	1	3	3	3	275700	526103	764700	480898	-2247	988801	2.1482	1.8926
4039	6	03902021010	1	3	3	3	813700	944900	1108700	921193	-0709	987845	5.5464	19.2367
4040	6	03902021010	1	3	3	3	24500	34700	41800	34385	-1020	37619	5.0296	3.7355
4041	6	03902021010	1	3	3	3	67290	61607	83100	62216	-1274	46847	3.5266	6.0248
4042	6	03902021010	1	3	3	3	57300	48400	118800	81895	-1805	96324	7.6896	2.3175
4043	6	03902021010	1	3	3	3	707300	249903	288100	245534	-0824	276777	6.2348	6.6187
4044	6	03902021010	1	3	3	3	48100	47800	43100	67388	-0921	40871	7.1089	3.7717
4045	6	03902021010	1	3	3	3	61000	53100	64300	58100	-1411	67311	2.5749	5.9670
4046	6	03902021010	1	3	3	3	115200	121700	148400	127633	-0477	139043	6.6140	22.1409
4047	6	03902021010	1	3	3	3	126400	179100	523400	177820	-1019	161306	6.2274	3.5481
4048	6	03902021010	1	3	3	3	33200	17900	41000	37029	-0446	18427	9.0443	12.4462
4049	6	03902021010	1	3	3	3	61800	43300	69400	67309	-0802	41232	6.8490	36.5815
4050	6	03902021010	1	3	3	3	64700	79700	101800	70424	-1747	82549	2.7187	2.4534
4051	6	03902021010	1	3	3	3	261400	311100	640900	329643	-1414	373239	2.9568	6.8032

LIST 16 SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLS SIZE	NUMBER FAILED	SIZE FOR MLE	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE- μ)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)
4042	7	03102021010	3	3	3	170500	300200	714300	362213	-3123	481977	1.4878	1.4878
4043	7	03102021010	3	3	3	765000	779900	2042330	1146804	-2284	418714	5.0626	6.6735
4044	7	03102021010	12	12	12	245000	332000	853000	40273	-0946	44040	5.6310	4.8323
4045	7	03102021010	12	12	12	235000	418000	853000	54560	-1635	64563	5.1543	5.1543
4046	7	03102021010	12	12	12	451000	523000	2014000	97937	-1052	119253	2.5104	7.7602
4047	7	03102021010	13	13	13	1264000	1741000	7447000	312765	-2153	397021	2.8260	3.2004
4048	7	03102021010	13	13	13	1705000	3022000	2674530	1008669	-3509	1450972	1.6723	1.2548
4049	7	03102021010	3	3	3	850000	990000	1090000	97161	-0545	102075	8.7432	7.9783
4050	7	03102021010	3	3	3	1240000	1527000	1820000	140815	-0734	162918	5.6834	5.6834
4051	7	03102021010	3	3	3	2320000	2730000	3570000	270019	-1237	307811	3.0374	6.8304
4052	7	03102021010	3	3	3	5040000	6180000	6430000	591317	-0601	622227	9.7017	9.1904
4053	7	03102021010	2	2	2	1050000	1493000	1990000	137997	-0031	140637	162.2770	137.2423
4054	7	03102021010	3	3	3	4990000	6020000	6290000	573829	-0534	609008	18.2618	5.6822
4055	7	03102021010	2	2	2	6640000	10200000	18290000	826594	-1345	971180	3.1208	3.1208
4056	7	03102021010	3	3	3	2850000	4400000	5220000	400446	-1390	453041	3.6009	2.6812
4057	46	04002021010	4	4	4	640000	560000	970000	77269	-0091	84464	5.0507	37.3057
4058	20	03102021010	10	10	10	530000	61003	90004	76051	-0626	74900	7.0925	7.0925
4059	20	03102021010	10	10	10	1840000	1990000	2920000	226677	-0638	243214	7.0354	13.6401
4060	20	03102021010	10	10	10	4570000	4980000	11730000	646621	-1134	740287	3.1027	12.2638
4061	46	04002021010	2	2	2	1085000	2012000	2013000	190569	-0334	197771	9.5436	12.7608
4062	46	04002021010	2	2	2	1804000	1973000	1973000	180641	-0275	194117	11.5699	15.4009
4063	46	04002021010	3	3	3	551000	65603	83000	64944	-0093	72877	6.7579	6.7579
4064	46	04002021010	3	3	3	451000	65600	84000	62824	-0563	67619	16.7971	6.9737
4065	46	04002021010	4	4	4	927000	1057000	1490000	120011	-1043	133124	6.1626	8.7404
4066	46	04002021010	2	2	2	941000	992000	1092000	99150	-0004	89183	697.9262	1235.0019
4067	46	04002021010	4	4	4	584000	602000	637000	61430	-0122	62214	30.3727	46.4009
4068	46	04002021010	5	5	5	244000	629000	640000	44371	-1257	50509	3.6015	2.7908
4069	46	04002021010	4	4	4	379000	410000	506000	47404	-0733	51142	6.3304	13.9143
4070	46	04002021010	4	4	4	102000	142000	430000	35132	-0439	37945	6.1130	9.2516
4071	46	04002021010	4	4	4	224000	244000	400000	27599	-0905	30593	6.0137	13.4000
4072	46	04002021010	5	5	5	170000	216000	200000	22577	-0005	24489	6.1401	6.0509
4073	46	04002021010	6	6	6	254000	275000	682000	35606	-1536	47476	2.3008	15.2707
4074	46	04002021010	5	5	5	247000	247000	640000	34018	-1711	41143	2.1447	WEIBULL
4075	46	04002021010	20	20	20	670000	360000	1570000	115782	-0409	123734	7.0009	10.6212
4076	46	04002021010	16	16	16	600000	1140000	1350000	120594	-0513	126200	12.439	6.6571
4077	46	04002021010	7	7	7	3416	3881	5524	4393	-0747	4749	5.3361	66.1137
4078	46	04002021010	4	4	4	100000	113000	140000	11804	-0667	12609	7.0193	12.8735
4079	46	04002021010	4	4	4	820000	970000	1090000	91376	-0582	90907	7.1976	WEIBULL
4080	46	04002021010	5	5	5	1100000	1300000	1620000	202366	-2144	232041	7.1379	11.5201
4081	46	04002021010	4	4	4	3434	4054	7325	4752	-1266	5454	2.8700	39.6477

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	OFF	DESC	POSITION	SAM- PLT COUNT	NUMBER FAILED	SIZE LN4	USED LN4	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(N))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (MLE-ALPHA)
6092	72	00001804010		6	6	6	6	9000	9000	16000	11808	-1367	13514	3.4541	1.7041
6093	72	00001804010		6	6	6	6	25000	44000	55000	429320	-1520	408043	6.4076	1.7041
6094	72	00001804010		6	6	6	6	5000	8000	8000	7113	-1021	7744	6.0076	2.0000
6095	72	00001804010		6	6	6	6	4000	5000	4000	57541	-0360	50600	6.0076	62.7120
6096	72	00001804010		6	6	6	6	32500	61200	657000	408734	-0673	439009	6.4434	6.0760
6097	72	00001804010		6	6	6	6	32000	35000	64000	41074	-1399	40769	2.7276	12.0012
6098	72	00001804010		6	6	6	6	4000	4000	141000	97541	-1000	100492	3.4092	60.3000
6099	72	00001804010		6	6	6	2	17000	27000	41000	350701	-2495	242992	3.2000	2.7010
6100	72	00001804010		5	5	5	5	4000	4599	4000	4076	-0041	5211	6.5000	6.0020
6101	72	00001804010		2	2	2	2	4004	5638	5638	5307	-0371	5460	11.9412	11.4472
6102	72	00001804010		5	5	5	5	10000	11000	19000	13329	-1314	15316	3.2000	11.7042
6103	72	00001804010		6	6	6	6	19000	24000	62000	51093	-0934	40330	6.5000	3.2767
6104	72	00001804010		6	6	6	6	23000	23000	53000	316540	-1400	375134	2.3000	14.7000
6105	72	00001804010		6	6	6	6	2000	4000	4000	3076	-1900	4494	3.5032	1.2950
6106	72	00001804010		6	6	6	6	19000	17000	50000	10041	-1942	62783	3.0760	1.7260
6108	72	00001804010		3	3	3	3	4304	4554	5208	4674	-0424	4071	6.4076	21.5039
6109	72	00001804010		3	3	3	3	5049	5425	6129	5601	-0450	5405	12.2000	7.6320
6110	72	00001804010		6	6	6	6	7000	7000	8000	7403	-0335	7755	16.2007	16.7000
6111	72	00001804010		6	6	6	6	8000	9000	13000	10073	-0934	11062	6.4076	6.7070
6112	72	00001804010		6	6	6	6	10000	21000	37000	22713	-1060	24612	3.4000	7.4000
6113	72	00001804010		6	6	6	6	37000	41000	54000	45430	-0790	40093	6.0000	11.2000
6114	72	00001804010		6	6	6	2	125000	130000	412000	187049	-2355	13321	12.9150	10.0000
6115	72	00001804010		6	6	6	6	366000	421000	405000	417755	-0430	430093	11.2760	6.2195
6116	72	00001804010		3	3	3	3	45000	513000	641000	537520	-0016	501917	6.9614	10.7260
6117	72	00001804010		6	6	6	6	3614	4202	5601	4503	-0067	4009	3.5000	7.6330
6118	72	00001804010		6	6	6	6	8000	9000	11000	9434	-0595	10000	7.7252	6.7049
6119	72	00001804010		6	6	6	6	17000	22000	33000	23329	-1109	20311	3.5000	6.4034
6120	72	00001804010		6	6	6	6	4000	52000	100000	63940	-1434	34375	2.7646	14.3764
6121	72	00001804010		6	6	6	3	75000	654000	1000000	525940	-2602	404237	7.7252	2.0702
6122	72	00001804010		10	10	10	6	355000	621300	1497500	617764	-2132	404719	6.2440	7.5250
6123	72	00001804010		6	6	6	6	15	71	620	154	-0174	276	-0177	6.4413
6124	72	00001804010		3	3	3	3	1002	1375	1602	1336	-0059	1404	5.9334	5.0750
6125	72	00001804010		6	6	6	6	1600	1864	2055	1805	-0375	1052	13.4007	11.0720
6126	72	00001804010		6	6	6	6	2428	2545	2000	2625	-0302	2737	9.9320	24.4000
6127	72	00001804010		5	5	5	3	105	405	1200	405	-1061	374	3.1556	1.5265
6128	72	00001804010		6	6	6	6	642	650	1150	803	-1040	978	6.4205	3.0070
6129	72	00001804010		6	6	6	6	1359	1691	2010	1691	-0700	1000	6.4019	5.2640
6130	72	00001804010		6	6	6	6	1000	2500	3533	2741	-1119	3047	6.4570	6.0030
6131	72	00001804010		6	6	6	6	402	603	974	600	-1329	795	3.4017	5.0504
6132	72	00001804010		6	6	6	6	897	690	1296	1075	-0713	1154	6.2000	11.0000

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM #	DESCRIPTION	SAM- PLZ	NUMBER FAILED	SIZE LMD	USED FOR MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LOG-NORMAL FAILURE (F1)	LOG-NORMAL SCALE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SHAPE (TOT-ALPHA)
4100	00001-00010	4	4	4	4	1240	1495	1405	0.0316	1524	16.0035	11.1079
4101	00011-00020	4	4	4	4	1640	2102	2715	0.0004	2362	5.3361	6.0000
4102	00021-00030	4	4	4	4	2110	2161	2751	0.0413	2462	7.7750	60.1816
4103	00031-00040	4	4	4	4	0	10	642	0.0311	19	13.0130	10.0218
4104	00041-00050	4	4	4	4	420	660	871	0.1427	426	2.0000	61.6154
4105	00051-00060	4	4	4	4	303	677	705	0.0005	672	3.9000	1.0314
4106	00061-00070	4	4	4	4	920	1000	1310	0.0451	1154	6.9000	19.9000
4107	00071-00080	4	4	4	4	1710	1759	2013	0.0330	1920	13.7062	60.7013
4108	00081-00090	4	4	4	4	2703	3261	3491	0.0004	3533	6.6151	6.1316
4109	00091-00100	4	4	4	4	68	303	374	0.0033	279	1.4005	0.0101
4200	00011-00020	4	4	4	4	25	191	440	0.0009	271	1.0024	0.5559
4201	00021-00030	4	4	4	4	490	738	895	0.0479	800	8.0073	17.1106
4202	00031-00040	4	4	4	4	610	1304	1600	0.1121	1471	5.1678	2.0104
4203	00041-00050	4	4	4	4	20	24	284	0.0787	253	1.4005	6.7873
4204	00051-00060	4	4	4	4	261	293	293	0.0700	260	20.1909	10.5177
4205	00061-00070	4	4	4	4	547	721	847	0.0740	757	6.0037	6.0500
4206	00071-00080	4	4	4	4	1000	1303	2030	0.1004	1452	3.4675	VERY HIGH
4207	00081-00090	4	4	4	4	1200	1710	1634	0.0677	1726	0.0045	6.0754
4208	00091-00100	4	4	4	4	10	51	300	0.0078	1413	0.0023	0.0023
4209	00101-00110	4	4	4	4	0	0	320	0.1404	9	5.0050	3.7133
4210	00111-00120	4	4	4	4	114	1113	3334	0.3745	1869	1.1227	0.0722
4240	00131-00140	4	4	4	4	1870	2475	2740	0.0047	242029	6.0302	6.5232
4241	00141-00150	4	4	4	4	2253	4187	7127	0.2440	5152202	1.0072	2.0019
4242	00151-00160	4	4	4	4	5243	5127	6162	0.1918	5704194	2.0020	1.3730
4243	00161-00170	4	4	4	4	4000	1000	7000	0.3740	3050598	0.0074	0.5763
4244	00171-00180	4	4	4	4	4113	1302	2230	0.2001	14013222	1.5005	1.0150
4245	00181-00190	4	4	4	4	5000	5000	4550	0.3069	6115447	1.3720	1.3873
4246	00191-00200	4	4	4	4	2253	7162	7162	0.3421	5140800	1.1000	1.2393
4247	00201-00210	4	4	4	4	3000	3270	7162	0.2072	5902017	1.5105	10.0252
4248	00211-00220	4	4	4	4	5140	1153	1100	0.5107	2704194	0.5157	1.0354
4249	00221-00230	4	4	4	4	1000	2100	4000	0.1642	3070170	2.3707	11.0740
4250	00231-00240	4	4	4	4	1000	2100	4000	0.0964	2490040	0.2244	5.5051
4251	00241-00250	4	4	4	4	4180	4000	6270	0.3741	3163071	1.0155	0.5451
4252	00251-00260	4	4	4	4	1000	1000	1000	0.1271	1717233	3.3136	3.9504
4253	00261-00270	4	4	4	4	5000	1153	2000	0.2674	1120257	2.0501	1.5081
4254	00271-00280	4	4	4	4	5000	1153	2000	0.2147	1445741	2.0576	2.4005
4255	00281-00290	4	4	4	4	1000	1153	2000	0.3149	5400145	1.1221	1.0721
4256	00291-00300	4	4	4	4	3000	3000	4100	0.1162	3010470	3.2731	2.0030
4257	00301-00310	4	4	4	4	4100	3000	4270	0.3101	2304124	1.5050	1.0523
4258	00311-00320	4	4	4	4	1000	2100	4000	0.5307	1630500	0.0036	0.0020

SECRET
504 JUNE 20 1964
SECRETARY OF THE ARMY

[illegible]

LIST IV CALIBRATION PARAMETERS OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAM- PLF	NUMBER PAIRED	SIZE LIM	SIZE FRA	USED MLF	FIRST FAILURE (F111)	SECOND FAILURE (F121)	LAST FAILURE (F1N1)	LOG-NORMAL SCALE (MLF-MU)	LOG-NORMAL SHAPE (MLF-SIGMA)	WEIBULL SCALE (MLF-DETA)	WEIBULL SHAPE (MLF-BLFA)	WEIBULL SCALE (MLF-BLFA)
5302	31	00050301011	1	1	2	2	20009	10700	130000	130000	34276	-1031	22751	2-0770	1-0427
5303	31	00050301011	2	2	3	2	17500	80700	80700	80700	37603	-0400	505207	-0095	-0195
5304	32	00050301011	3	3	3	3	25000	367500	90800	90800	224335	-3971	103607	1-0342	-0743
5305	31	00050301010	1	1	3	3	51000	45900	17800	17800	62146	-0946	65110	10-3700	0-0013
5306	31	00050301010	2	2	3	3	31000	51000	50800	50800	45760	-1433	41824	3-7070	2-0095
5307	31	00050301010	3	3	3	3	54300	57400	67500	67500	63500	-0007	70125	3-0503	21-0001
5308	32	00050301010	1	1	3	3	39200	16400	160000	160000	137603	-1310	156021	3-7206	3-1202
5309	32	00050301010	2	2	3	3	20000	33400	34000	34000	222020	-3434	207907	1-0041	-0014
5310	34	00050301010	2	2	2	2	177000	742000	742000	742000	362000	-0401	510572	-0906	-0073
5311	31	00050301021	1	1	3	3	452000	101000	1102000	1102000	833004	-1605	971401	2-0153	2-0310
5312	31	00050301021	2	2	4	4	241000	515000	1120000	1120000	557720	-2774	727006	1-7253	1-6030
5313	31	00050301021	3	3	7	7	670000	675000	140000	140000	950004	-1230	1000451	3-5920	145-1322
5314	31	00050301020	5	5	5	5	774000	805000	1030000	1030000	1040227	-1607	1204366	2-2200	33-7000
5315	31	00050301020	2	2	2	2	3400	3500	5500	5500	3510	-0000	3502	36-3394	40-0556
5316	31	00050301020	3	3	2	2	4602	4451	6451	6451	5902	-0070	5952	6-3004	6-3943
5317	31	00050301020	2	2	2	2	5595	8136	8136	8136	6703	-1250	7517	3-3402	3-3094
5318	31	00050301020	3	3	3	3	7113	13503	13503	13503	9709	-1000	11402	2-1907	2-1535
5319	31	00050301020	2	2	2	2	7270	8403	8403	8403	7017	-0403	8130	0-0312	0-7271
5320	31	00050301020	3	3	3	3	9000	11700	11700	11700	10301	-0029	11012	5-0775	5-1330
5321	31	00050301020	4	4	4	4	15752	29115	77500	77500	31709	-3506	44007	1-3417	1-1552
5322	31	00050301020	2	2	2	2	45010	102730	102730	102730	99114	-0221	101407	14-4245	19-3021
5323	31	00050301020	3	3	3	3	75000	160742	160742	160742	110723	-1604	157200	3-5121	1-0332
5324	31	00050301020	2	2	2	2	40501	150077	150077	150077	110712	-1701	130173	2-3004	2-3006
5325	31	00050301020	3	3	2	2	25014	70970	61009	61009	29235	-0002	27601	7-1503	6-0003
5326	31	00050301020	3	3	2	2	32645	67103	163405	163405	44003	-1022	67905	3-7223	3-3024
5327	31	00050301020	2	2	2	2	170702	201131	201131	201131	109505	-0303	195211	11-5099	11-7207
5328	31	00050301020	2	2	2	2	225652	280495	280495	280495	250033	-0757	271000	5-3005	5-0278
5329	31	00050301020	3	3	2	2	400078	404057	804057	804057	700510	-1219	701007	3-4942	3-4920
5330	31	00050301021	2	2	2	2	1000000	1235581	1235581	1235581	1104428	-0071	1100000	0-0053	0-0046
5331	31	00050301021	3	3	2	2	602743	1123047	1123047	1123047	822071	-1013	900027	2-2014	2-2250
5332	31	00050301021	2	2	2	2	405000	405000	405000	405000	405000	-0019	400450	167-3399	225-2721
5333	31	00050301021	2	2	2	2	211307	91000	91000	91000	400427	-0511	033047	-0333	-0037
5334	31	00050301021	2	2	2	2	939200	961200	961200	961200	900136	-0071	947173	64-7005	90-0720
5335	31	00050301021	2	2	2	2	51053	905000	905000	905000	710275	-2007	000200	2-0070	2-1212
5336	31	00050301021	2	2	2	2	245745	260300	260300	260300	270334	-0900	203005	7-0370	7-1177
5337	31	00050301021	2	2	2	2	144303	144503	144503	144503	104463	-0004	104520	030-0503	1130-0703
5338	31	00050301021	2	2	2	2	163070	163270	163270	163270	143170	-0004	143235	725-0001	900-3703
5339	31	00050301021	3	3	2	2	93712	152650	152650	152650	110004	-1400	130044	2-0010	2-0012
5340	31	00050301021	3	3	2	2	70120	117501	117501	117501	95024	-1255	100013	3-3500	3-3033
5341	31	00050301021	2	2	2	2	251799	292701	292701	292701	260003	-0356	270552	11-0041	11-0737

- UNBIASED POINT ESTIMATES OF LOG-NORMAL AND GENERALIZED LOG-NORMAL POPULATION PARAMETERS
- UNBIASED POINT ESTIMATES OF LOG-NORMAL AND GENERALIZED LOG-NORMAL POPULATION PARAMETERS FOR DATA GROUPS
- UNBIASED POINT ESTIMATES OF LOG-NORMAL AND GENERALIZED LOG-NORMAL POPULATION PARAMETERS FOR DATA GROUPS

- UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
- POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESC	INVTY	SAM- PL	CITY	NUMBER FAILED	SIZE FRA ML	USED MOL	FIRST FAILURE (F111)	SECOND FAILURE (F121)	LAST FAILURE (F1NF3)	LOG-MON-MAL		LOG-MON-MAL SHAPE	METHOD SCALE (M1E-M1FA)	METHOD SHAPE (M1E-M1FA)	REASON REMARK (M1E-M1FA)
												SCALE	SHAPE				
5343	62	00032341021	2	2	2	2	2	2	170632	195534	195534	182650	-0418	100918	10-0047	10-1708	
5344	62	00032341021	3	2	2	2	2	2	171271	171671	171371	171371	-0004	171636	003-0770	1107-0770	
5345	62	00032341021	3	2	2	2	2	2	205000	205000	205000	254345	-0049	204003	0-0000	0-0000	
5346	62	00032341021	2	2	2	2	2	2	204448	230446	230446	220746	-0472	229356	0-0120	0-0110	
5347	62	00032341021	4	3	3	3	3	3	716670	014000	037600	85706	-0575	001000	0-0073	5-0000	
5348	62	00032341021	3	3	3	3	3	3	42000	40500	05500	55033	-1516	04070	2-0045	0-0000	
5349	62	00032341021	2	2	2	2	2	2	100130	300130	300130	30327	-0070	30647	00-7002	50-5000	
5350	62	00032341021	3	3	3	3	3	3	40275	76550	76550	67627	-0734	72004	5-7300	5-7300	
5351	62	00032341021	2	2	2	2	2	2	50674	02200	02200	60746	-1130	76041	3-0000	3-7000	
5352	61	00002341021	13	13	13	13	13	13	91700	160400	007700	209540	-2446	302130	1-0000	1-0000	
5353	61	00032341021	12	10	12	10	12	10	104000	210100	013000	470540	-7300	009105	2-0275	7-3000	
5354	61	00032341020	10	13	10	10	10	10	254520	085200	1066500	705640	-1930	007103	3-2111	1-0703	
5355	62	00052347051	5	5	5	5	5	5	450829	504000	706752	063273	-0500	706415	7-0253	20-0000	
5356	61	00052347050	4	5	6	6	6	6	714704	751004	114608	803081	-0727	004703	5-0420	29-0237	
5401	31	00053040010	5	2	2	2	2	2	044900	130000	130000	1140512	-1199	1204002	3-5130	3-9520	
5442	31	00053040011	2	2	2	2	2	2	1023000	1612200	1612200	1204006	-1304	1537477	3-0000	3-0020	
5443	32	00053040011	3	3	3	3	3	3	1275300	1540000	3202200	1017707	-2120	1500771	0-0700	0-0130	
5444	32	00053040011	4	4	4	4	4	4	1120000	1424000	3710500	2104046	-2710	1303020	5-0070	0-0200	
5445	31	00053040010	5	3	2	2	2	2	1004000	1536700	1536300	1263301	-1193	1300020	3-5205	3-5077	
5446	31	00053040010	3	3	3	3	3	3	1625600	1907100	4030200	2405427	-2017	1000700	0-0200	0-0570	
5447	31	00053040010	2	2	2	2	2	2	1431600	2201000	2201000	1005370	-0920	2041214	0-5700	0-0250	
5448	32	00053040010	3	3	3	3	3	3	1207000	1600400	3000200	2020001	-2407	1570047	5-1500	0-5720	
5449	32	00053040010	4	4	4	4	4	4	1150100	1850000	3720000	2341045	-2404	2002550	2-0500	2-0740	
5470	39	03203340000	2	2	2	2	2	2	0450000	2300000	2300000	012170001	-3005	10000401	1-0700	1-0000	
5471	41	00032347021	2	2	2	2	2	2	2320000	2670000	2670000	20762211	-9143	00093042	3-3100	3-0010	
5472	61	00032347020	2	2	2	2	2	2	1404700	4500000	4500000	60331023	-0750	0200015	5-5000	5-0317	
5473	61	00002347020	3	2	2	2	2	2	091000	1671000	1671000	1207370	-1213	1331278	3-0712	3-5500	
5474	60	00002347020	4	4	4	4	4	4	1060247	2350040	0265514	3203004	-2302	2237222	0-0010	0-7000	
5475	60	00002347020	4	4	4	4	4	4	553604	034034	2327100	1050634	-2632	0209734	2-0020	2-0000	
5476	60	00002347020	4	4	4	4	4	4	2275065	2567108	1102400	2067750	-0506	2032104	7-1023	0-5207	
5477	60	00032347020	2	2	2	2	2	2	2306042	5300400	5300400	3500020	-2502	0307505	1-0030	1-7017	
5478	60	00002347020	4	4	4	4	4	4	2003507	3080375	5140101	37000061	-1102	0155009	3-7172	30-0000	
5479	60	00032347020	4	4	4	4	4	4	1443195	3120757	4054370	3027004	-2260	3700044	2-5020	1-0000	
5480	61	00032347020	2	2	2	2	2	2	10491473	10551123	10551123	10521246	-0010	10540305	141-7003	200-0100	
5481	61	00032341021	13	13	13	13	13	13	2327000	2700000	1610700	010002	-2075	1002304	2-1705	5-0020	
5482	61	00032341021	9	9	9	9	9	9	004100	1161000	0097700	2200450	-2271	2007570	2-0000	5-0000	
5483	61	00072341021	10	10	10	10	10	10	1274000	2085000	0400500	2031770	-2045	3050006	2-1770	2-1007	
5701	36	04002021011	3	3	3	3	3	3	107200	113000	151500	120040	-0000	131403	0-0005	12-1007	
5702	36	04002021010	3	3	3	3	3	3	116000	127600	150000	133015	-0702	142431	5-7000	12-7025	
5704	36	04002021011	3	3	3	3	3	3	09100	05200	107000	70143	-1750	02070	2-3000	0-2001	

BIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS156

UNITED STATES DEPARTMENT OF JUSTICE
FEDERAL BUREAU OF INVESTIGATION

[illegible]

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

LOG-NORMAL ESTIMATES OF DATA GROUPS
WEIBULL ESTIMATES OF DATA GROUPS

ITEM	FILE	DESCRIPTION	NO. OF OBS.	NO. OF FAIL.	NO. OF CENS.	TYPE	ESTIMATED PARAMETERS	LOG-NORMAL SCALE	LOG-NORMAL SHAPE	WEIBULL SCALE	WEIBULL SHAPE	WEIBULL SCALE	WEIBULL SHAPE
ITEM	FILE	DESCRIPTION	NO. OF OBS.	NO. OF FAIL.	NO. OF CENS.	TYPE	ESTIMATED PARAMETERS	LOG-NORMAL SCALE	LOG-NORMAL SHAPE	WEIBULL SCALE	WEIBULL SHAPE	WEIBULL SCALE	WEIBULL SHAPE
5706	16	0403241011	3	3	3	3	57600	167000	0.4107	114245	2.7170	3.2755	3.2755
5707	16	0403241011	3	3	3	3	157200	268000	216010	237223	5.0210	9.2538	9.2538
5708	16	0403241011	3	3	3	3	159500	274400	221317	295555	5.0900	4.1315	4.1315
5709	16	0403241011	3	3	3	3	17600	37200	39940	49260	2.9320	5.2707	5.2707
5710	16	0403241011	3	3	3	3	21200	25300	41449	40568	2.5952	8.0423	8.0423
5711	16	0403241011	3	3	3	3	20300	23300	23316	24030	7.6204	9.2132	9.2132
5712	16	0403241011	3	3	3	3	21000	23000	23514	24734	8.0300	12.0403	12.0403
5713	16	0403241011	3	3	3	3	23000	46800	47363	44054	7.9336	1.6109	1.6109
5714	16	0403241011	3	3	3	3	23300	46800	47472	44967	3.0250	1.6500	1.6500
5715	16	0403241011	3	3	3	3	57500	73800	101185	67708	4.0201	3.3701	3.3701
5716	16	0403241011	3	3	3	3	70700	76500	109432	136209	2.2952	21.0700	21.0700
5717	16	0403241011	3	3	3	3	72700	75700	34971	40485	3.5006	9.5023	9.5023
5718	16	0403241011	3	3	3	3	23500	46800	35422	40862	3.0060	11.0362	11.0362
5719	16	0403241011	3	3	3	3	15500	40000	48475	55596	3.1691	9.6410	9.6410
5720	16	0403241011	3	3	3	3	57000	70700	71949	74998	11.5211	9.8637	9.8637
5721	16	0403241011	3	3	3	3	25500	100000	97466	90119	8.7522	8.0404	8.0404
5722	16	0403241011	3	3	3	3	64000	140700	111624	124058	3.0264	3.0502	3.0502
5723	16	0403241011	3	3	3	3	192000	2199700	6921570	23508173	-2720	-2366	-2366
5724	16	0403241011	3	3	3	3	51000	74000	61055	65072	7.6303	VERY HIGH	VERY HIGH
5725	16	0403241011	3	3	3	3	58000	144000	80233	97443	2.9116	8.1676	8.1676
5726	16	0403241011	3	3	3	3	64900	111200	80171	90694	3.1455	12.7630	12.7630
5727	16	0403241011	3	3	3	3	71400	111200	95673	94581	3.9636	11.7326	11.7326
5728	16	0403241011	3	3	3	3	28500	29700	22724	26464	3.2674	1.7205	1.7205
5729	16	0403241011	3	3	3	3	31600	36300	30468	39971	6.5228	2.3012	2.3012
5730	16	0403241011	3	3	3	3	15500	17000	20506	23101	3.0030	12.4576	12.4576
5731	16	0403241011	3	3	3	3	25100	34200	79659	31088	5.7004	10.6742	10.6742
5732	16	0403241011	3	3	3	3	44700	61700	49026	53533	6.0060	5.1123	5.1123
5733	16	0403241011	3	3	3	3	60900	71200	64176	67208	11.7165	7.1979	7.1979
5734	16	0403241011	3	3	3	3	44700	61700	49261	52429	5.6059	5.2553	5.2553
5735	16	0403241011	3	3	3	3	41900	71200	66334	68475	16.1515	64.9503	64.9503
5736	16	0403241011	3	3	3	3	28000	42700	33836	37071	4.4096	8.3391	8.3391
5737	16	0403241011	3	3	3	3	35000	44900	39091	41116	7.3101	63.1537	63.1537
5738	16	0403241011	3	3	3	3	60200	68500	43102	45110	8.0399	65.0502	65.0502
5739	16	0403241011	3	3	3	3	40200	41300	43102	45110	8.0039	65.0502	65.0502
5740	16	0403241011	3	3	3	3	238900	261400	26036	254395	16.8630	110.0459	110.0459
5741	16	0403241011	3	3	3	3	21800	241400	24036	254395	16.8630	110.0459	110.0459
5742	16	0403241011	3	3	3	3	45700	47700	91877	95466	9.0310	106.0405	106.0405
5743	16	0403241011	3	3	3	3	86700	87700	91877	95466	9.0310	106.0405	106.0405
5744	16	0403241011	3	3	3	3	77600	97600	101924	116638	2.0204	6.7040	6.7040
5745	16	0403241011	3	3	3	3	82600	95700	109366	121066	3.5016	70.0765	70.0765

3. POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

[illegible]

TABLE 10. SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	NO. OF OBSERVATIONS	SAMPLE SIZE	GROUP	SHAPE	SCALE	LOG-NORMAL	WEIBULL	WEIBULL	WEIBULL	WEIBULL
						SCALE	SCALE	SCALE	SCALE	SHAPE
						(MLE-MU)	(MLE-SIGMA)	(MLE -BETAS)	(MLE-ALFA)	(TOS-ALFA)
6524	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	3-2476
6525	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	5-6105
6526	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	9-2304
6527	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	12-9037
6528	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	7-3103
6529	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	8-5905
6530	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	VERY HIGH
6531	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	35-5462
6532	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	6-9219
6533	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	49-2615
6534	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	15-6025
6535	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	7-5445
6536	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	29-7136
6537	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	0-1253
6538	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	1-8810
6539	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	5-5404
6540	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	9-7161
6541	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	8-8132
6542	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	6-6567
6543	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	15-3010
6544	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	7-8121
6545	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	24-8935
6546	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	17-6377
6547	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	2-5537
6548	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	5-2964
6549	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	4-6385
6550	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	12-6251
6551	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	17-0342
6552	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	2-5700
6553	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	17-3080
6554	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	33-6472
6555	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	7-5459
6556	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	8-1722
6557	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	9-7901
6558	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	5-1364
6559	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	16-2112
6560	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	10-3740
6561	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	6-5442
6562	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	30-0159
6563	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	VERY HIGH
6564	1	12-17-1-1010	2	5	2	164000	618000	517967	504683	3-6514

LIST OF SALIENT FEATURES OF DATA GROUPS
 USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
 POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAFETY	NUMBER	SIZE	USED	FIRST	SECOND	LAST	LOG-NORMAL	WEIBULL	WEIBULL	WEIBULL	WEIBULL
							FAILURE	FAILURE	FAILURE	SCALE	SHAPE	SCALE	SHAPE	SHAPE
							(E111)	(E121)	(E111)	(MLE-MU)	(MLE-SIGMA)	(MLE-DETA)	(MLE-ALPHA)	(MLE-ALPHA)
6910	5	30022460410	3	3	3	3	74000	102000	120000	98467	.0945	107241	9.0746	4.3343
7000	5	30022460410	4	4	2	2	215000	463000	1278000	455232	-.2251	347125	1.0149	1.0000
7001	5	30022460410	5	5	5	5	97000	297300	400000	316173	-.3131	421034	1.0369	.9970
7002	5	30022460410	3	3	3	3	96000	177000	272000	165408	-.2321	204320	2.0264	1.0221
7003	5	30022460410	4	4	4	4	76000	172000	377000	190234	-.2404	246370	1.0908	1.3220
7004	5	30022460410	5	5	5	5	59000	67000	92000	69930	-.0943	74073	0.0131	0.7740
7005	5	30022460410	7	7	7	7	55000	55000	74000	62083	-.0449	65505	7.0002	VERY HIGH
7006	5	30022460410	4	4	4	4	40000	46000	95000	59354	-.1726	70632	2.5230	0.2339
7007	5	30022460410	4	4	4	4	52000	44000	174000	77244	-.1544	91911	2.0468	20.3093
7008	5	30022460410	5	5	5	5	35000	16000	61000	45018	-.1003	50012	4.2731	13.3609
7009	5	30022460410	2	2	2	2	60000	104000	104000	84095	-.1305	93413	3.2249	3.2020
7010	5	30022460410	2	2	2	2	85000	174000	104000	94021	-.0620	90831	6.7962	0.3717
7011	5	30022460410	2	2	2	2	242000	943000	943000	301313	-.2012	460151	2.0026	2.1190
7012	5	30022460410	2	2	2	2	85000	139000	109000	94619	-.0720	102604	5.7091	5.0495
7013	5	30022460410	2	2	2	2	86000	104000	104000	96814	-.0728	107644	5.7091	5.0493
7014	5	30022460410	2	2	2	2	161000	230000	230000	192432	-.1095	210178	3.0440	3.0667
7015	5	30022460410	2	2	2	2	226000	476000	476000	327988	-.2200	304336	1.0400	1.0411
7016	5	30022460410	2	2	2	2	131000	280000	280000	191520	-.2333	231102	1.0000	1.0291
7017	5	30022460410	2	2	2	2	365000	1038000	1038000	598423	-.3303	705020	1.2447	1.2503
7018	5	30022460410	5	5	5	5	22000	22000	25000	22466	-.0263	23627	15.0071	VERY HIGH
7019	5	30022460410	5	5	5	5	37000	39000	54000	44487	-.0737	47056	0.3100	41.0300
7020	5	30022460410	2	2	2	2	59000	104000	104000	84095	-.1305	93413	3.2249	3.2020
7021	5	30022460410	5	5	5	5	171000	205000	1247000	310831	-.2175	379101	2.1424	0.1524
7022	5	30022460410	2	2	2	2	85000	104000	104000	94021	-.0420	90831	6.7962	0.3717
7023	5	30022460410	2	2	2	2	242000	943000	943000	391313	-.2012	460151	2.0026	2.1190
7000	5	30022460410	2	2	2	2	176000	244000	244000	175340	-.2030	200475	2.0746	2.0076
7001	5	30022460410	2	2	2	2	271000	344000	344000	305326	-.0733	323000	5.7401	5.0129
7002	5	30022460410	3	3	3	3	36000	51000	53000	45946	-.0923	49770	6.1906	3.0023
7003	5	30022460410	4	4	4	4	141000	230000	287000	246289	-.1201	274104	3.3628	3.2203
7004	5	30022460410	5	5	5	5	52000	70000	70000	60332	-.0913	64495	4.6125	4.6437
7005	5	30022460410	3	3	3	3	226000	476000	476000	399151	-.4097	899402	0.0002	1.0339
7006	5	30022460410	2	2	2	2	51000	60000	60000	60057	-.0433	74702	5.0944	5.1120
7007	5	30022460410	2	2	2	2	145000	1038000	1038000	998423	-.3303	705020	1.2447	1.2503
7008	5	30022460410	2	2	2	2	19000	27000	22000	20445	-.0450	21200	0.3022	0.0541
7009	5	30022460410	2	2	2	2	32000	126000	126000	63440	-.4709	89120	1.0000	1.0114
7010	5	30022460410	2	2	2	2	57000	69000	92000	62714	-.2437	65740	7.1743	7.2540
7011	5	30022460410	2	2	2	2	75000	219000	219000	128160	-.3291	107033	1.2799	1.2937
7012	5	30022460410	2	2	2	2	24000	45000	45000	32863	-.4931	30301	2.1011	2.2059
7013	5	30022460410	2	2	2	2	110000	191000	191000	157575	-.1102	173306	3.5636	3.0032
7100	4	10020821410	3	3	3	3	13000	14000	17000	14572	-.0002	15454	6.6676	16.6136

LIST OF SALIENT FEATURES OF DATA GROUPS
AND ESTIMATES OF POPULATION PARAMETERS

ITEM NO.	TEST	NO. OF OBS.	SAMP. SIZE	NOMINAL	SIZE	USED	FIRST	SKEW	LAST	LOG-NORMAL LOG-NORMAL LOG-NORMAL LOG-NORMAL LOG-NORMAL					UNBIASED POINT ESTIMATES OF LOG-NORMAL AND METALL				
										SCALE	SCALE	SCALE	SCALE	SCALE	POPULATION PARAMETERS FOR DATA GROUPS	POPULATION PARAMETERS FOR DATA GROUPS	POPULATION PARAMETERS FOR DATA GROUPS	POPULATION PARAMETERS FOR DATA GROUPS	POPULATION PARAMETERS FOR DATA GROUPS
										(MLE-MU)	(MLE-SIGMA)	(MLE-BETA)	(MLE-ALFA)	(MLE-ALFA)					
7101	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7102	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7103	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7104	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7105	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7106	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7107	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7108	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7109	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7110	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7111	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7112	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7113	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7114	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7115	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7116	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7117	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7118	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7119	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7120	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7121	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7122	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7123	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7124	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7125	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7126	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7127	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7128	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7129	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7130	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7131	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7132	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7133	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7134	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7135	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7136	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7137	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7138	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7139	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
7140	1	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

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LIST OF SALIENT FEATURES OF DATA GROUPS
USEFUL TO ESTIMATE SHAPE PARAMETERS

ITEM	REF	DESCRIPTION	DATA FILE	NUMBER OBS	SIZE LN	USED FOR MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (F3)	LOG-NORMAL SCALE (MLF-MU)	LOG-NORMAL SHAPE (MLF-SIGMA)	WEIBULL SCALE (MLE - BETA)	WEIBULL SHAPE (MLE - ALPHA)	WEIBULL SHAPE (TOB - ALPHA)
8000	31	0005000001011	1	3	3	3	431300	971400	1460000	0.80406	-0.240	1096793	1.9010	1.7321
8001	31	0005000001010	3	3	3	3	130000	105100	216000	1.76593	-0.1173	1093377	0.6234	2.9002
8002	31	0005000001010	7	7	7	7	360000	400000	460000	4.2010	-0.566	105334	15.0614	10.2615
8003	36	0005000001010	6	6	6	6	410000	470000	720000	51576	-1.042	57571	3.7024	0.4236
8004	36	0005000001010	3	3	3	3	220000	250000	360000	2.7053	-0.1110	30101	3.9082	9.5155
8005	36	0005000001010	4	4	4	4	510000	470000	1130000	73177	-1.134	05570	2.7600	15.0199
8006	36	0005000001010	4	4	4	4	250000	260000	510000	32093	-1.021	37349	2.0003	20.3300
8121	31	0005000001010	3	3	3	3	093000	1408100	2160000	1395877	-1.007	1666718	2.3396	2.6900
8122	36	0005000001010	4	4	4	4	1451000	2456000	2456000	2050500	-2.095	3771406	-9019	2.3619
8123	36	0005000001010	2	2	2	2	2042000	2556000	2556000	2300020	-0.617	2627541	6.0220	6.0070
8150	70	0005000001010	2	2	2	2	315000	323000	373000	310075	-0.077	321534	41.2726	55.2756
8151	70	0005000001010	2	2	2	2	50000	65000	65000	50245	-0.569	62025	7.9950	7.9772
8300	31	0005000001011	3	3	3	3	136200	142700	247700	160853	-1.405	196631	2.6073	20.0016
8301	31	0005000001011	3	3	3	3	196800	426000	450000	423300	-0.274	435403	16.0507	17.0393
8302	31	0005000001011	3	3	3	3	11637	26310	27585	21367	-1.740	26700	3.3175	1.0399
8303	31	0005000001011	3	3	3	3	73500	273300	707000	251502	-0.5174	405102	-0.029	-0.0262
8304	31	0005000001011	3	3	3	3	112700	133000	201000	16613	-1.305	16370	3.0000	7.0702
8305	31	0005000001011	2	2	2	2	397000	198000	308000	30750	-0.000	49702	406.7236	551.0517
8306	31	0005000001011	2	2	2	2	336000	793600	793600	510074	-2.643	630404	1.5030	1.6107
8307	32	0005000001011	2	2	2	2	229000	61000	61000	3.819	-0.300	60009	1.3011	1.3006
8308	32	0005000001011	2	2	2	2	316000	351000	351000	33304	-0.323	36101	13.0523	13.1973
8309	32	0005000001011	5	5	5	5	106000	223000	294000	23732	-0.726	25507	5.0955	8.0311
8310	32	0005000001011	2	2	2	2	130000	157700	157700	14310	-0.093	15019	7.0901	7.1760
8311	32	0005000001011	2	2	2	2	130000	139400	139400	13413	-0.102	13604	16.5405	22.1405
8312	31	0005000001010	2	2	2	2	467200	967000	967000	753400	-1.532	042404	2.7605	2.7791
8314	31	0005000001010	3	3	3	3	251000	254000	481000	31300	-1.616	34762	2.3070	102.3907
8315	31	0005000001010	2	2	2	2	563000	561000	610000	55193	-0.100	55760	31.7409	42.5203
8316	31	0005000001010	3	3	3	3	379600	424000	865400	51062	-1.461	620730	2.0111	10.0124
8317	32	0005000001010	2	2	2	2	476000	495000	495000	49541	-0.120	49150	26.4506	35.4100
8318	32	0005000001010	2	2	2	2	82300	124100	124100	10106	-1.261	11107	3.3302	3.3753
8319	32	0005000001010	2	2	2	2	130000	139300	139300	13457	-0.212	13750	16.0932	20.0635
8320	31	0005000001010	3	3	3	3	155000	172000	193000	176030	-0.342	182670	11.6030	36.002
8321	31	0005000001010	3	3	3	3	254000	456000	502000	404081	-1.051	479284	2.7333	2.0707
8322	31	0005000001010	6	6	6	6	115000	130000	212700	163750	-1.034	100732	5.0510	0.0236
8323	34	0005000001011	3	3	3	3	239000	297000	358000	29400	-0.070	31606	5.1520	5.9006
8324	34	0005000001011	4	4	4	4	314000	326000	507000	40220	-0.004	44102	5.2401	44.0204
8325	34	0005000001010	4	4	4	4	355000	381000	561000	45177	-1.040	50039	4.6104	10.2005
8326	35	1605000001010	4	4	4	4	150000	770000	360000	36000	-0.736	23654	2.6209	2.1902
8327	35	1605000001010	4	4	4	4	190000	200000	230000	20490	-0.033	21463	11.0001	22.0303
8328	35	1605000001010	4	4	4	4	90000	150000	185000	14257	-1.372	16046	6.5000	2.2527

LIST OF SALIENT PLAYS OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

ITEM	FILE	SAMPLING	NUMBER OF PLAYS	STEP SIZE	USED IN MLE	FIRST FAILURE (F1)	SECOND FAILURE (F2)	LAST FAILURE (FIN)	UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS				
									LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALPHA)	WEIBULL SCALE (MLE-ALPHA)
8320	35	16050000000	3	3	3000	27000	27000	27000	30343	-.1045	32400	4.5206	7.1767
8330	35	16050000000	3	3	11000	16000	29000	29000	15067	-.1502	10400	2.2932	6.5264
8331	35	16050000000	3	3	11000	29000	29000	29000	27092	-.1109	30711	6.1536	6.0054
8332	35	16050000000	3	3	10000	14000	23000	23000	16316	-.1720	19220	2.9544	3.4200
8333	35	16050000000	3	3	30000	33000	33000	33000	40883	-.2063	33097	10.6036	12.8735
8334	35	16050000000	3	3	14000	30400	44100	44100	287406	-.2114	341900	2.2549	2.3513
8335	35	16050000000	3	3	223000	275000	293000	293000	229210	-.0174	233305	23.3391	136.2856
8336	35	16050000000	3	3	10000	11000	12000	12000	11645	-.0491	12010	9.3301	12.0735
8337	35	16050000000	3	3	37000	46000	45000	45000	42611	-.0411	44113	16.5417	6.6612
8338	35	16050000000	3	3	23000	100000	130000	130000	107348	-.1104	110903	6.0678	6.6202
8339	35	16050000000	3	3	19000	243000	355000	355000	261154	-.1129	291679	3.9766	3.4277
8340	35	16050000000	3	3	104000	113000	126000	126000	113221	-.0351	117398	11.4015	26.5155
8341	35	16050000000	3	3	309000	362000	400000	400000	461188	-.0506	370067	9.6704	7.2692
8342	35	16050000000	3	3	27000	31000	31000	31000	28931	-.0424	29037	9.0244	10.0367
8343	35	16050000000	3	3	91000	94000	98000	98000	86285	-.0181	89876	22.9199	39.6672
8344	35	16050000000	3	3	229000	250000	265000	265000	251151	-.0302	256492	17.1676	19.1154
8345	35	16050000000	3	3	32000	56000	63000	63000	42988	-.1624	44995	2.1925	2.6216
8346	35	16050000000	3	3	103000	198000	198000	198000	142008	-.2007	167061	2.0979	2.1212
8347	35	16050000000	3	3	58000	114000	114000	114000	88045	-.1507	100047	2.6535	2.6836
8348	35	16050000000	3	3	18000	28000	35000	35000	26531	-.1211	29631	6.2569	2.6344
8349	35	16050000000	3	3	59000	105000	105000	105000	91768	-.1200	102113	9.6788	1.9963
8350	35	16050000000	3	3	97000	141000	141000	141000	142391	-.1250	142395	6.1221	2.6061
8351	35	16050000000	3	3	19000	41000	60000	60000	47928	-.0926	52541	6.9088	23.0298
8352	35	16050000000	3	3	141000	141000	315000	315000	204083	-.1648	245402	2.5019	23.0298
8353	35	16050000000	3	3	240000	901000	940000	940000	589040	-.3364	766056	1.7223	.9195
8354	35	16050000000	3	3	189000	192000	242000	242000	709090	-.0513	221117	8.3635	73.0697
8355	35	16050000000	3	3	22000	28000	50000	50000	33177	-.1500	39758	2.9700	6.6264
8356	35	16050000000	3	3	51000	64000	95000	95000	74718	-.0900	82045	4.9169	23.2397
8357	35	16050000000	3	3	136	234	662	662	212	-.1505	204	2.5265	2.2415
8358	35	16050000000	3	3	3200	5120	6010	6010	4618	-.1473	5229	3.6072	2.5081
8359	35	16050000000	3	3	1290	1600	2970	2970	1830	-.1800	2200	2.1233	5.6482
8360	35	16050000000	3	3	670	680	1010	1010	772	-.1011	854	3.0329	82.1352
8361	35	16050000000	3	3	6000	9900	9400	9400	9049	-.0620	9400	6.7006	6.8040
8362	35	16050000000	3	3	2510	3870	3870	3870	3117	-.1330	3409	3.1666	3.2818
8363	35	16050000000	3	3	6000	7000	7000	7000	6481	-.0473	6735	8.0963	8.0931
8364	35	16050000000	3	3	699000	4436000	6330000	6330000	2697475	-.5130	6194237	1.0047	6.0583
8365	35	16050000000	3	3	750000	1178000	1339500	1339500	1062031	-.1291	1100589	2.1791	2.7799
8366	35	16050000000	3	3	226000	1370000	1370000	1370000	1063776	-.1954	1209564	2.7088	2.7999
8367	35	16050000000	3	3	660	790	900	900	796	-.0505	835	16.6329	6.2356
8368	35	16050000000	3	3	10000	12600	17200	17200	13414	-.0752	14526	5.3908	7.2378

APPENDIX III

LISTED VALUES OF FATIGUE-LIFE OBSERVATIONS FOR ALL COLLECTED SAMPLES

This appendix retabulates the item and description numbers given in Appendix II to provide a cross-referencing capability between the two tabulations. In addition, this tabulation itemizes all the individual observations from the collected data and categorizes them as either a failed or a suspended item.

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	2144	6200	7507	7573	11460	CYCLES AT SUSPENSION
1	1	04010860010	5	5	2144	6200	7507	7573	11460	NO SUSPENDED ITEMS
2	1	04010860010	5	5	3300	3954	3967	6315	6377	NO SUSPENDED ITEMS
3	1	04010860010	5	5	2765	3130	4641	6264	8091	NO SUSPENDED ITEMS
4	1	04010860010	5	5	3272	3904	4269	4944	5200	NO SUSPENDED ITEMS
5	1	04010860010	5	5	1790	2445	3377	3600	5179	NO SUSPENDED ITEMS
6	1	04010860010	5	5	6331	4500	4924	5400	6300	NO SUSPENDED ITEMS
7	1	04010860010	5	5	10900	37800	49607	43200	104000	NO SUSPENDED ITEMS
8	1	04010860010	5	5	10800	12600	23400	27000	41400	NO SUSPENDED ITEMS
9	1	04010860010	5	5	9000	10800	10400	16200	19800	NO SUSPENDED ITEMS
10	1	04010860010	5	5	7995	6722	10655	10707	11295	NO SUSPENDED ITEMS
11	1	04010860010	5	5	12600	12400	14400	16200	16700	NO SUSPENDED ITEMS
12	1	04010860010	5	5	3600	5400	6650	6900	7050	NO SUSPENDED ITEMS
13	1	04010860010	5	5	12600	12400	14400	17463	25200	NO SUSPENDED ITEMS
14	1	04010860010	5	5	7200	36000	75600	270000	295560	NO SUSPENDED ITEMS
15	1	04010860010	5	5	27000	27540	49680	52800	55400	NO SUSPENDED ITEMS
16	1	04010860010	5	5	23400	32400	34200	43400	84600	NO SUSPENDED ITEMS
17	1	04010860010	5	5	13960	14400	14920	34600	39740	NO SUSPENDED ITEMS
18	1	04010860010	5	5	27400	63000	92400	96400	93600	NO SUSPENDED ITEMS
19	1	04010860010	5	5	196560	198000	199540	201600	239400	NO SUSPENDED ITEMS
20	1	04010860010	5	5	176400	140000	232200	246600	460000	NO SUSPENDED ITEMS
21	1	04010860010	5	5	3600	4283	4484	6480	7200	NO SUSPENDED ITEMS
22	1	04010860010	5	5	1867	2500	2900	5945	6150	NO SUSPENDED ITEMS
23	1	04010860010	5	5	147	2325	2607	3543	3170	NO SUSPENDED ITEMS
24	1	04010860010	5	5	48200	48200	179600	491300	1296000	NO SUSPENDED ITEMS
25	1	04010860010	5	5	12015	14856				NO SUSPENDED ITEMS
26	1	04010860010	5	5	1200	1800	2310	3150	46330	NO SUSPENDED ITEMS
27	1	04010860010	5	5	26280	28800	29700	36180	37800	NO SUSPENDED ITEMS
28	1	04010860010	5	5	9000	9400	10507	12600	27000	NO SUSPENDED ITEMS
29	1	04010860010	5	5	6300	6450	7200	7950	15040	NO SUSPENDED ITEMS
30	1	04010860010	5	5	25200	36000	73440	82620	576000	NO SUSPENDED ITEMS
31	1	04010860010	5	5	5150	6300	7872	8179	8620	NO SUSPENDED ITEMS
32	1	04010860010	5	5	14400	16740	19800	32400	34200	NO SUSPENDED ITEMS
33	1	04010860010	5	5	61200	63000	64800	92800	872000	NO SUSPENDED ITEMS
34	1	04010860010	5	5	57000	174600	370400	416400	2194000	NO SUSPENDED ITEMS
35	1	04010860010	5	5	2880	6176	6443	6999	7258	NO SUSPENDED ITEMS
36	1	04010860010	5	5	51400	101400	102600	111300	441600	NO SUSPENDED ITEMS
37	1	04010860010	5	5	1500	2450	3607	4149	4950	NO SUSPENDED ITEMS
38	1	04010860010	5	5	2527	28000	30400	57400	64800	NO SUSPENDED ITEMS
39	1	04010860010	5	5	916	3600	6448	7200	22444	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESIGNATION	SAMPLE SIZE	NUMBER OF TESTS	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
					•	•	•	•
41	1	100100000010	6	6	25200	32600	41400	43400
42	1	100100000010	6	6	45000			43800
43	1	100100000010	6	6	3300	3465	3537	4330
44	1	100100000010	6	6	9000	10600	11900	14000
45	1	100100000010	6	6	14700			
46	1	100100000010	6	6	70000	76000	80000	84000
47	1	100100000010	6	6	109000	142000	144000	238000
48	1	100100000010	6	6	22000	24000	131000	207000
49	1	100100000010	6	6	229000	290000	349000	1100000
50	1	100100000010	6	6	7100	7400	7800	8000
51	1	100100000010	6	6	8700	9000	9600	9600
52	1	100100000010	6	6	15400	15900	16000	16300
53	1	100100000010	6	6	14400	17100	17600	19200
54	1	100100000010	6	6	40000	44000	46000	52000
55	1	100100000010	6	6	57000	59000	63000	269000
56	1	100100000010	6	6	121000	171000	209000	400000
57	1	100100000010	6	6	59200	64200	87200	1499000
58	1	100100000010	6	6	41000	142000	210000	434000
59	1	100100000010	6	6	423000	643000	722000	763000
60	1	100100000010	6	6	17000	17000	20000	29000
61	1	100100000010	6	6	33000	36000	36000	41000
62	1	100100000010	6	6	24000	31000	36000	47000
63	1	100100000010	6	6	52000	71000	394000	659000
64	1	100100000010	6	6	224000	253000	263000	423000
65	1	100100000010	6	6	541000	690000	724000	842000
66	1	100100000010	6	6	799000	840000	840000	984000
67	1	100100000010	6	6	112000	114600	127600	1384000
68	1	100100000010	6	6	13400	15000	15500	205700
69	1	100100000010	6	6	4000	5400	5500	
70	1	100100000010	6	6	11400	12000		
71	1	100100000010	6	6	10000	11500		
72	1	100100000010	6	6	13300	14000		
73	1	100100000010	6	6	2600	2700		
74	1	100100000010	6	6	32000	39000	41000	
75	1	100100000010	6	6	45000	45800		
76	1	100100000010	6	6	10500	14000		
77	1	100100000010	6	6	7800	10000		
78	1	100100000010	6	6	16000	17000		
79	1	100100000010	6	6	34000	44000		

[illegible]

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	DESCRIPTION	AMPLITUDE	NUMBER OF CYCLES	NUMBER OF CYCLES AT FAILURE	NUMBER OF CYCLES AT SUSPENSION		
106	21 03211060010	2	•	1147	11900	15500	NO SUSPENDED ITEMS
107	21 03211060010	2	•	2710	26400	31800	NO SUSPENDED ITEMS
108	21 03211060010	2	•	60770	77120	69000	NO SUSPENDED ITEMS
109	21 03211060010	2	•	8090	5410	1201	NO SUSPENDED ITEMS
110	21 03211060010	2	•	12381	12410	16000	NO SUSPENDED ITEMS
111	21 03211060010	2	•	27910	28240	32960	NO SUSPENDED ITEMS
112	21 03211060010	2	•	59210	64570	70720	NO SUSPENDED ITEMS
113	21 03211060010	2	•	24790	30410	37940	NO SUSPENDED ITEMS
114	21 03211060010	2	•	42610	72790	43210	NO SUSPENDED ITEMS
115	21 03211060010	2	•	100620	206790	277960	NO SUSPENDED ITEMS
116	21 03211060010	2	•	111710	117690	166950	NO SUSPENDED ITEMS
117	21 03211060010	2	•	195150	361160	511590	NO SUSPENDED ITEMS
118	21 03211060010	2	•	250000	394300		NO SUSPENDED ITEMS
119	21 03211060010	2	•	12000	12100		NO SUSPENDED ITEMS
120	21 03211060010	2	•	17000	46000		NO SUSPENDED ITEMS
121	21 03211060010	2	•	30000	69000		NO SUSPENDED ITEMS
122	21 03211060010	2	•	166000	281000		NO SUSPENDED ITEMS
123	21 03211060010	2	•	175700	247000		NO SUSPENDED ITEMS
124	21 03211060010	2	•	12000	13000		NO SUSPENDED ITEMS
125	21 03211060010	2	•	40000	67000		NO SUSPENDED ITEMS
126	21 03211060010	2	•	95000	17900	195700	NO SUSPENDED ITEMS
127	21 03211060010	2	•	243000	319000	578400	NO SUSPENDED ITEMS
128	21 03211060010	2	•	13000	16000		NO SUSPENDED ITEMS
129	21 03211060010	2	•	26500	27100		NO SUSPENDED ITEMS
130	21 03211060010	2	•	18000	70000		NO SUSPENDED ITEMS
131	21 03211060010	2	•	51000	287000	275100	NO SUSPENDED ITEMS
132	21 03211060010	2	•	134000	411000		NO SUSPENDED ITEMS
133	21 03211060010	2	•	33000	40000		NO SUSPENDED ITEMS
134	21 03211060010	2	•	156000	217000		NO SUSPENDED ITEMS
135	21 03211060010	2	•	28000	36000		NO SUSPENDED ITEMS
136	21 03211060010	2	•	25000	95000		NO SUSPENDED ITEMS
137	21 03211060010	2	•	61000	254000		NO SUSPENDED ITEMS
138	21 03211060010	2	•	11000	13000		NO SUSPENDED ITEMS
139	21 03211060010	2	•	21000	51000		NO SUSPENDED ITEMS
140	21 03211060010	2	•	182000	249000		NO SUSPENDED ITEMS
141	21 03211060010	2	•	71000	26000		NO SUSPENDED ITEMS
142	21 03211060010	2	•	14000	81000		NO SUSPENDED ITEMS
143	21 03211060010	2	•	20000	25000		NO SUSPENDED ITEMS
144	21 03211060010	2	•	30000	91000		NO SUSPENDED ITEMS
145	21 03211060010	2	•	23000	31000		NO SUSPENDED ITEMS

LISTED NUMBERS OF VEHICLES ARE NOT AVAILABLE TO ADEQUATELY REFLECT THE FAILURE RATE FOR ALL CARS IN THE DATA COLLECTION.

[illegible]

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION		
320	1	04010280010	4	5	2098500	3979000	5440000	6378000	81097200	NO SUSPENDED ITEMS
323	3	10012805830	10	10	340000	375000	766000	967000	13880000	NO SUSPENDED ITEMS
324	2	30012805830	10	10	1515000	4611000	4494000	12838000	229180000	NO SUSPENDED ITEMS
325	3	30012805830	4	4	11348000	11785000	11924000	12560000	152230000	NO SUSPENDED ITEMS
326	3	30012805830	4	4	18995000	19132000	23875000	27558000	322750000	NO SUSPENDED ITEMS
327	3	30012805830	4	4	2571000	7020000	11389000	60276000	610150000	NO SUSPENDED ITEMS
328	3	30012805830	4	4	48463000	107573000	118243000	150412000	5095170000	501931000 512303000 592740000
329	3	30012805830	4	4	9888000	29402000	278180000	309694000	658449000	NO SUSPENDED ITEMS
330	3	30012805830	10	10	242000	1051000	1107000	1122000	15920000	NO SUSPENDED ITEMS
331	3	30012805830	10	10	1565000	1880000	2212000	3732000	62740000	NO SUSPENDED ITEMS
332	3	30012805830	10	10	1280000	1296000	1772000	2429000	30330000	NO SUSPENDED ITEMS
333	3	30012805830	4	4	3074000	4625000	12840000	13434000	716450000	NO SUSPENDED ITEMS
334	3	30012805830	4	4	1980000	4938000	11440000	48090000	492080000	NO SUSPENDED ITEMS
335	3	30012805830	10	10	63237000	108446000	240710000	248102000	3544550000	515284000
336	3	30012805830	10	10	11703000	108395000	118135000	240980000	143900000	NO SUSPENDED ITEMS
337	3	30012805830	10	10	364450000	43242000	484409000	48868000	24490000	NO SUSPENDED ITEMS
338	3	30012805830	10	10	735000	1116000	1132000	1430000	14390000	NO SUSPENDED ITEMS
339	3	30012805830	10	10	1445000	1479000	1490000	1766000	24490000	NO SUSPENDED ITEMS
340	3	30012805830	10	10	1458000	1688000	2045000	2249000	28450000	NO SUSPENDED ITEMS
341	3	30012805830	10	10	5439000	8755000	32072000	33530000	177740000	503134000 503823000 515239000
342	3	30012805830	10	10	3611000	3682000	11485000	13089000	177740000	787812000
343	3	30012805830	10	10	122545000	2965000	5764000	349840000	1978690000	616445000 715839000 999999999
344	3	30012805830	10	10	267124000	505327000				30875000
345	3	30012805830	10	10	282300	1079400				NO SUSPENDED ITEMS
346	3	30012805830	10	10	1198700	1771600				NO SUSPENDED ITEMS
347	3	30012805830	10	10	1185350	1241840	1289160	1411370	1050000	NO SUSPENDED ITEMS
348	3	30012805830	10	10	1982590	2500000	6061190	6717590	1050000	NO SUSPENDED ITEMS
349	3	30012805830	10	10	79000	81000	91000	100000	1050000	NO SUSPENDED ITEMS
350	3	30012805830	10	10	1040000	110000	110000	130000	3760000	NO SUSPENDED ITEMS
351	3	30012805830	10	10	68000	202000	234000	340000	3760000	NO SUSPENDED ITEMS
352	3	30012805830	10	10	412000	921000	1452000	1579000	3760000	NO SUSPENDED ITEMS
353	3	30012805830	10	10	271000	271000	293000	346000	6670000	NO SUSPENDED ITEMS
354	3	30012805830	10	10	304000	397000	483000	594000	6670000	NO SUSPENDED ITEMS
355	3	30012805830	10	10	74000	92000	100000	100000	6090000	NO SUSPENDED ITEMS
356	3	30012805830	10	10	262000	331000	497000	549000	6090000	NO SUSPENDED ITEMS
357	3	30012805830	10	10	544000	978000	990000	1050000	6090000	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	AGE	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE	CYCLES AT SUSPENSION
407	3	09010865080	15	14	188629 203860 227150 97380 142120 115111 140900 97380 115759 140900 12374 13974 14754 15470 19550	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
408	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
409	13	09010865080	6	6	181135 213300 247060 114450 115759 114450 171450 12410 14212 14756 17631 19788	199250 214060 247300 121450 115759 115111 123035 13498 14756 15300 19312 20842
410	13	09010865080	12	12	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
411	13	09010865080	25	25	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
412	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
413	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
414	13	09010865080	7	7	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
415	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
416	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
417	13	09010865080	31	31	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
418	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
419	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
420	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842
421	13	09010865080	6	6	175500 208560 225530 99170 115560 99170 115759 12120 12410 14212 14756 17631 19788	200740 220280 280115 125690 123035 115560 125690 13498 14756 15300 19312 20842

LISTED NUMBER OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF DESCRIPTION	SAMPLE SIZE	NUMBER OF FAILURES	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
422 13 09010805050	6	6	16944	19074	20604	222020
423 13 09010805050	6	6	22446	167049	198202	1982020
424 13 09010805050	6	6	227632	35530	37774	390660
425 13 09010805050	6	6	43426	33600	34822	406980
426 13 09010805050	6	6	40766	480100	496405	5321650
427 13 09010805050	6	6	592111	99567	100775	107987
428 13 09010805050	6	6	87458	478873	655373	6553730
429 13 09010805050	6	6	119000	100576	100576	1217330
430 13 09010805050	6	6	763099	84780	93043	998700
431 13 09010805050	6	6	140023	12410	15232	195500
432 13 09010805050	7	7	76923	13498	15470	191080
433 13 09010805050	6	6	171310	15300	16754	149260
434 13 09010805050	6	6	12376	14754	14754	201960
435 13 09010805050	6	6	19490	14212	14254	546940
436 13 09010805050	6	6	13498	54083	59815	644130
437 13 09010805050	6	6	19312	49478	53229	699020
438 13 09010805050	7	7	14722	52672	66927	699020
439 13 09010805050	7	7	17631	59805	62600	699020
440 13 09010805050	7	7	20442	38221	39221	429970
441 13 09010805050	7	7	54083	60466	60466	405860
442 13 09010805050	7	7	69811	46478	54747	605860
443 13 09010805050	7	7	47065	79064	20940	211590
444 13 09010805050	7	7	64653	20357	20700	357050
445 13 09010805050	7	7	54651	32462	32466	357050
446 13 09010805050	7	7	72748	40457		
447 13 09010805050	7	7	32174			
448 13 09010805050	7	7	46300			
449 13 09010805050	7	7	6978			
450 13 09010805050	7	7	60584			
451 13 09010805050	7	7	17393			
452 13 09010805050	7	7	21417			
453 13 09010805050	7	7	29511			
454 13 09010805050	7	7	40457			

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER OF FAILURES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
442	15 09010860500	8	0	147705 184430 191175 192131 215564 285454 152298 228124 94148 191360 100347 135515	162504 251000 214201 168979 115572
443	15 09010860500	6	0	158592	214201
444	15 09010860500	6	0	95579	168979
445	15 09010860500	6	0	102741	115572
446	15 09010860500	6	0	147000 103000 377000 538000 200000 170000 176000	193600 210300 507000 10056000 252000
447	15 09010860500	6	0	211000	305000
448	15 09010860500	6	0	239000	396000
449	15 09010860500	6	0	657000	304000
450	15 09010860500	6	0	145000	928000
451	15 09010860500	6	0	306000	319000
452	15 09010860500	6	0	224000	566000
453	15 09010860500	6	0	39200	63000
454	15 09010860500	6	0	95700	260000
455	15 09010860500	6	0	41300	359000
456	15 09010860500	6	0	68000	260000
457	15 09010860500	6	0	228000	260000
458	15 09010860500	6	0	262000	309000
459	15 09010860500	6	0	536000	1020000
460	15 09010860500	6	0	157000	1020000
461	15 09010860500	6	0	114000	187000
462	15 09010860500	6	0	490000	579000
463	15 09010860500	6	0	783000	1258000
464	15 09010860500	6	0	775000	264000
465	15 09010860500	6	0	27000	264000
466	15 09010860500	6	0	64000	143000
467	15 09010860500	6	0	9700	174000

LISTED NUMBERS OF CYCLES TO FAILURE AND
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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILS	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
448	1 04010860050	5	5	9100	9800	10300	12100	13500	NO SUSPENDED ITEMS		
449	1 04010860070	5	5	454000	571000	1092000	1242000	1694000	NO SUSPENDED ITEMS		
470	1 04010860070	5	5	83000	84000	110000	134000	138000	NO SUSPENDED ITEMS		
471	1 04010860070	5	5	117000	118000	149000	151000	191000	NO SUSPENDED ITEMS		
472	1 04010860070	5	5	177000	200000	221000	259000	269000	NO SUSPENDED ITEMS		
540	3 30012865830	3	3	276000	301000	338000			NO SUSPENDED ITEMS		
541	3 30012865830	3	3	1200000	373000	17741000	21681000		NO SUSPENDED ITEMS		
542	3 30012865830	3	3	29101000	29279000	47911000	74000000	394512000	NO SUSPENDED ITEMS		
543	3 30012865830	3	3	1410000	1780000	3371000			NO SUSPENDED ITEMS		
544	3 30012865830	3	3	1204000	1993000	2030000			NO SUSPENDED ITEMS		
545	3 30012865830	3	3	4480000	4990000	5494000			NO SUSPENDED ITEMS		
546	3 30012865830	3	3	100000	879000	1316000	1711000	2347000	NO SUSPENDED ITEMS		
547	3 30012865830	3	3	2527000	4834000	6933000	31443000	380000000	NO SUSPENDED ITEMS		
548	3 30012865830	14	14	4760000	44868000	153059000	25558000	337566000	NO SUSPENDED ITEMS		
549	3 30012865830	10	10	155400	1668837	1675620	1773000	1781230	NO SUSPENDED ITEMS		
550	3 30012865830	10	10	1789600	1893000	1906420	1989780	2004547	NO SUSPENDED ITEMS		
551	3 30012865830	10	10	2019440	2116700	2328710	2450000		NO SUSPENDED ITEMS		
552	3 30012865830	10	10	743350	865886	968240	1104390	1109730	NO SUSPENDED ITEMS		
553	3 30012865830	10	10	1110100	1326350	1337950	1438740	1904770	NO SUSPENDED ITEMS		
554	1 04010860010	5	5	100800	135000	203400	302400	385200	NO SUSPENDED ITEMS		
555	1 04010860010	5	5	37400	91800	117000	124200	3700000	NO SUSPENDED ITEMS		
556	1 04010860010	5	5	484200	525600	698400	1674000	2719600	NO SUSPENDED ITEMS		
557	1 04010860010	5	5	9500	12600	14400	41400	52200	NO SUSPENDED ITEMS		
558	1 04010860010	5	5	14590	60140	102780	147600	148500	NO SUSPENDED ITEMS		
559	1 04010860010	5	5	185000	248000	390400	651600	691700	NO SUSPENDED ITEMS		
560	1 04010860010	5	5	16400	2215	3215	4500	90110	NO SUSPENDED ITEMS		
561	1 04010860010	5	5	28800	45000	66600	72000	73800	NO SUSPENDED ITEMS		
562	1 04010860010	5	5	29800	36000	36000	43200	88200	NO SUSPENDED ITEMS		
563	1 04010860010	5	5	185400	352800	658800	1420200	3216600	NO SUSPENDED ITEMS		
564	1 04010860010	5	5	48600	55800	144000	824760	888480	NO SUSPENDED ITEMS		
565	21 032110 J10	4	4	310720	416020	445970	525560		NO SUSPENDED ITEMS		
566	1 04010860010	5	5	163000	189000	1306800	1998000	1601000	NO SUSPENDED ITEMS		
567	3 300128	9	9	75000	76000	103000	105000	134000	NO SUSPENDED ITEMS		
568	3 300128	10	10	186000	190000	209000	369000	298000	NO SUSPENDED ITEMS		
569	3 300128	10	10	179000	208000	219000	266000	298000	NO SUSPENDED ITEMS		
570	3 300128	10	10	314000	401000	430000	763000	929000	NO SUSPENDED ITEMS		
571	3 300128	10	10	319000	374000	504000	600000	665000	NO SUSPENDED ITEMS		
572	3 300128	10	10	664000	776000	776000	2993000	1844000	NO SUSPENDED ITEMS		

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
653	3 10012855010	11	11	490000	491000	803000	880000	1021000	NO	SUSPENDED	ITEMS
				1034000	1160000	1249000	1740000	1809000	NO	SUSPENDED	ITEMS
654	3 10012855010	4	4	3663000	574000	606000	1293000	2778000	NO	SUSPENDED	ITEMS
655	3 10012855010	4	4	520000	1000000	1033000	2718000		NO	SUSPENDED	ITEMS
656	11 10080855010	2	2	72000	161000				NO	SUSPENDED	ITEMS
657	11 10080855010	2	2	42300	58400				NO	SUSPENDED	ITEMS
658	11 10080855010	2	2	58900	1269400				NO	SUSPENDED	ITEMS
659	11 10080855010	2	2	79700	121400				NO	SUSPENDED	ITEMS
660	11 10080855010	2	2	54100	142000				NO	SUSPENDED	ITEMS
661	11 10080855010	2	2	19100	28100				NO	SUSPENDED	ITEMS
662	11 10080855010	2	2	8800	14000				NO	SUSPENDED	ITEMS
663	57 06311055020	7	7	25000	26000	29000	29000	30000	NO	SUSPENDED	ITEMS
664	57 06311055020	4	4	30000	31000	52000	58000		NO	SUSPENDED	ITEMS
665	22 06411055010	4	4	59000	12620	12780	14920		NO	SUSPENDED	ITEMS
666	22 06411055010	4	4	11970	51740	54430	58470		NO	SUSPENDED	ITEMS
667	22 06411055010	4	4	47980	16820	15640	16150		NO	SUSPENDED	ITEMS
668	22 06411055010	4	4	45150	46440	47550	53410		NO	SUSPENDED	ITEMS
669	22 06411055010	4	4	11970	12620	12780	14920		NO	SUSPENDED	ITEMS
670	22 06411055010	4	4	47980	51740	54430	58470		NO	SUSPENDED	ITEMS
671	22 06411055010	4	4	13890	14520	15180	15740		NO	SUSPENDED	ITEMS
672	22 06411055010	4	4	41550	43570	47810	47940		NO	SUSPENDED	ITEMS
673	22 06411055010	2	2	15770	17500				NO	SUSPENDED	ITEMS
674	22 06411055010	2	2	51480	53300				NO	SUSPENDED	ITEMS
675	22 06411055010	4	4	19620	16290	16310	16450		NO	SUSPENDED	ITEMS
676	22 06411055010	4	4	43590	50580	50890	54790		NO	SUSPENDED	ITEMS
677	22 06411055010	4	4	12560	12870	13650	13860		NO	SUSPENDED	ITEMS
678	22 06411055010	4	4	43670	52160	53520	54280		NO	SUSPENDED	ITEMS
679	22 06411055010	5	5	12630	14170	16360	16440	17010	NO	SUSPENDED	ITEMS
680	22 06411055010	5	5	39680	41450	47000	50550	59250	NO	SUSPENDED	ITEMS
681	22 06411055010	4	4	13720	15140	15630	17220		NO	SUSPENDED	ITEMS
682	22 06411055010	4	4	53280	56330	59110	59610		NO	SUSPENDED	ITEMS
683	22 06411055010	5	5	12000	15190	15260	15910	17980	NO	SUSPENDED	ITEMS
684	22 06411055010	5	5	47950	54050	55470	55580	57370	NO	SUSPENDED	ITEMS
685	22 06411055010	4	4	11950	12510	13840	14840		NO	SUSPENDED	ITEMS
686	22 06411055010	4	4	44770	48500	48620	56010		NO	SUSPENDED	ITEMS
687	22 06411055010	4	4	2810	2820	3420	3660		NO	SUSPENDED	ITEMS
688	22 06411055010	4	4	50730	53050	68480	68910		NO	SUSPENDED	ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	AGE	DESCRIPTION	SAMPLES SIZE	FAILURE	2610	2810	2900	3020	3730	CYCLES AT FAILURE	CYCLES AT SUSPENSION
689	22	06411055010	5	1	2610	2810	2900	3020	3730	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
690	22	06411055010	4	4	35960	42060	47710	55270		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
691	22	06411055010	4	4	5170	5280	5910	6120		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
692	22	06411055010	4	4	40580	65970	68150	77250	86565	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
693	22	06411055010	4	4	3050	3600	4170	4340		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
694	22	06411055010	4	4	59030	60085	63300	74820		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
695	22	06411055010	4	4	2970	3480	3560	3730		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
696	22	06411055010	4	4	54130	57800	60310	60830		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
697	22	06411055010	4	4	2820	3245	3300	3660		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
698	22	06411055010	4	4	59540	59820	64240	69250		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
699	22	06411055010	4	4	3020	3470	3545	3910		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
700	22	06411055010	4	4	53700	63450	73770	74530		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
701	22	06411055010	4	4	1960	1970	2120	2200		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
702	22	06411055010	4	4	53280	56240	58710	62745		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
703	22	06411055010	4	4	1965	7085	2160	2390		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
704	22	06411055010	4	4	63450	43910	49515	52055		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
705	22	06411055010	4	4	7390	2690	2900	2930		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
706	22	06411055010	4	4	46240	48500	53610	55390		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
707	22	06411055010	4	4	3790	3860	4175	4370		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
708	22	06411055010	4	4	59980	74770	75070	77550		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
709	22	06411055010	4	4	38270	40680	48420	54600		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
710	22	06411055010	4	4	68090	72730	74845	75645		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
711	22	06411055010	3	3	50758	60490	65060			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
712	22	06411055010	4	4	53400	54050	57640	62370		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
713	22	06411055010	4	4	669250	856610	928735	973500		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
714	22	06411055010	4	4	60930	68370	69870	85910		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
715	22	06411055010	4	4	63200	65120	69875	78670		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
716	22	06411055010	4	4	51690	54200	55250	66800		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
717	22	06411055010	4	4	51830	59140	63040	64630		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
718	22	06411055010	4	4	52110	59160	60230	60950		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
719	22	06411055010	4	4	41330	44020	48380	55280		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
720	22	06411055010	4	4	49110	55580	58420	60920		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
721	22	06411055010	4	4	54080	54610	55790	56580		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
722	22	06411055010	4	4	52620	55400	55610	55780		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
723	22	06411055010	4	4	46090	51040	54180	61970		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
724	22	03211055010	4	4	37270	39600	42650	44270		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
725	22	03211055010	4	4	32890	34070	34130	35240		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
726	22	03211055010	4	4	206250	355240	587140	735750		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
727	22	03211055010	5	5	27940	42430	46110	56050	57040	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
728	22	03211055010	4	4	26760	30390	33520	35400		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS

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COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
729	22 06411055010	4	4	329510	496770	526620	534740
730	22 06411055010	4	4	20850	27940	32150	32190
731	22 06411055010	4	4	408430	430030	453610	498950
732	22 06411055010	4	4	30710	37800	40150	41640
733	22 06411055010	4	4	19150	21070	28150	28860
734	22 06411055010	4	4	541170	456380	489580	591950
735	22 06411055010	4	4	28150	29550	30710	31350
736	22 06411055010	4	4	26570	26590	26650	33300
737	22 06411055010	4	4	25330	26290	26950	28940
738	22 06411055010	4	4	31470	33500	34230	37380
739	22 06411055010	4	4	27270	30220	30620	33350
740	22 06411055010	4	4	29650	33490	33540	34040
741	22 06411055010	4	4	19460	21980	27150	32580
742	22 06411055010	4	4	39400	41940	43200	43210
743	22 06411055010	2	2	39530	38730		
744	22 06411055010	2	2	39530	39440		
745	22 06411055010	4	4	34700	35060	37040	41225
746	22 06411055010	4	4	37960	39010	42090	46940
747	22 06411055010	4	4	40160	40320	43550	49140
748	22 06411055010	4	4	28170	31720	35240	36700
749	22 06411055010	4	4	18230	19450	20240	21250
750	22 06411055010	4	4	18820	21990	22570	25630
751	22 06411055010	4	4	19950	22400	28530	30620
752	22 06411055010	4	4	22910	23340	23460	25440
753	22 06411055010	4	4	15800	16730	20300	20920
754	22 06411055010	4	4	21980	22170	28460	28940
755	22 06411055010	4	4	20640	21990	22470	31940
756	22 06411055010	4	4	16940	17450	19640	21340
757	22 06411055010	4	4	17940	18160	19340	20440
758	22 06411055010	4	4	17420	17620	18530	19730
759	22 06411055010	4	4	11500	15220	15410	18910
760	22 06411055010	4	4	22420	24220	24520	28720
761	22 06411055010	4	4	22100	24510	28700	30400
762	22 06411055010	4	4	21640	22730	23050	27940
763	22 06411055010	4	4	17240	21140	21230	21630
764	22 06411055010	4	4	20930	23740	23380	25070
765	22 06411055010	4	4	19560	20950	24940	25970
766	22 06411055010	4	4	20450	20750	20930	24130
767	22 06411055010	4	4	24124	23270	29500	29540
768	22 06411055010	4	4	29610	29900	31960	35745

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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
769	22 06411055010	4	4	37485	38770	39710	42700	NO	SUSPENDED	ITEMS	
770	22 06411055010	4	4	24540	30080	30990	32400	NO	SUSPENDED	ITEMS	
771	22 06411055010	4	4	27465	32430	34940	34950	NO	SUSPENDED	ITEMS	
772	22 06411055010	4	4	32850	37820	38085	38210	NO	SUSPENDED	ITEMS	
773	22 06411055010	4	4	37670	37685	37800	37810	NO	SUSPENDED	ITEMS	
774	22 06411055010	4	4	30040	37530	37590	40240	NO	SUSPENDED	ITEMS	
775	22 06411055010	4	4	47090	52280	53210	55570	NO	SUSPENDED	ITEMS	
776	22 06411055010	4	4	40450	40650	40660	40685	NO	SUSPENDED	ITEMS	
777	22 06411055010	4	4	730100	750080	760080	820090	NO	SUSPENDED	ITEMS	
778	22 06411055010	4	4	699630	739930	749900	799700	NO	SUSPENDED	ITEMS	
779	22 06411055010	4	4	520030	540330	634730	670330	NO	SUSPENDED	ITEMS	
780	22 06411055010	4	4	490020	500070	539460	629770	NO	SUSPENDED	ITEMS	
781	22 06411055010	3	3	378300	410470	560260		NO	SUSPENDED	ITEMS	
782	22 06411055010	3	3	487000	489510	497700		NO	SUSPENDED	ITEMS	
783	22 06411055010	5	5	159440	376060	735020	1060740	NO	SUSPENDED	ITEMS	10748400
784	22 06411055010	4	4	522370	523570	524100	525080	NO	SUSPENDED	ITEMS	
785	22 06411055010	4	4	539665	602120	606475	1005280	NO	SUSPENDED	ITEMS	
786	22 06411055010	4	4	576500	589840	590470	594480	NO	SUSPENDED	ITEMS	
787	22 06411055010	4	4	435140	580900	600400	616465	NO	SUSPENDED	ITEMS	
788	22 06411055010	4	4	479360	569620	566030	585220	NO	SUSPENDED	ITEMS	
789	22 06411055010	4	4	400140	472160	480080	512150	NO	SUSPENDED	ITEMS	
790	22 06411055010	4	4	452000	468020	479960	569550	NO	SUSPENDED	ITEMS	
791	22 06411055010	4	4	153310	200480	202300	202400	NO	SUSPENDED	ITEMS	
792	22 06411055010	4	4	185970	187830	193080	197600	NO	SUSPENDED	ITEMS	
793	22 06411055010	4	4	160710	180950	181350	190920	NO	SUSPENDED	ITEMS	
794	22 06411055010	4	4	158070	169050	176580	179480	NO	SUSPENDED	ITEMS	
795	22 06411055010	4	4	159240	162120	170160	186140	NO	SUSPENDED	ITEMS	
796	22 06411055010	4	4	143870	168680	185900	198920	NO	SUSPENDED	ITEMS	
797	22 06411055010	4	4	710210	995990	1038310	1114830	NO	SUSPENDED	ITEMS	
798	22 06411055010	3	3	399140	418490	462420		NO	SUSPENDED	ITEMS	
799	22 03211055010	4	4	154530	226620	227510	228220	NO	SUSPENDED	ITEMS	
800	22 03211055010	4	4	223110	251750	276930	298370	NO	SUSPENDED	ITEMS	
801	22 03211055010	4	4	83440	92490	92812	95950	NO	SUSPENDED	ITEMS	
802	22 03211055010	4	4	134500	134610	138530	142150	NO	SUSPENDED	ITEMS	
803	22 03211055010	4	4	90080	87110	104600	153870	NO	SUSPENDED	ITEMS	
804	22 03211055010	4	4	126960	139260	146750	147030	NO	SUSPENDED	ITEMS	
805	22 03211055010	4	4	15410	78510	83240	89410	NO	SUSPENDED	ITEMS	
806	22 03211055010	4	4	129210	132310	133560	136140	NO	SUSPENDED	ITEMS	
807	22 03211055010	4	4	715780	815120	874440	1009280	NO	SUSPENDED	ITEMS	10407300
				1046470	1064180	1362480					

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ITEM REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
008 22 0011055010	4	4	39370	145700	195140	214600	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
009 22 0011055010	4	4	27250	37440	44940	62735	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
010 22 0011055010	3	3	400470	459330	574900		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
011 22 0011055010	4	4	2660	1040	3210	3053	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
012 22 0011055010	4	4	700700	700710	800750	901347	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
013 1 30012055010	10	10	902000	979000	1738000	1876000	3005000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
012 1 30012055010	11	10	4902000	7449000	16223000	26681000	42229000	50937000	504590000	506378000
013 1 30012055010	10	8	2590000	16089000	25108000	27358000	57408000	517318000	405082000	516049000
014 1 30012055010	9	7	6390000	85167000	196662000	243662000	291754000	544945000	544945000	547322000
014 1 30012055010	9	7	2310000	2408300	3454000	4040000	8161000	863224000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
014 1 30012055010	9	7	104613000	205292000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
014 1 30012055010	9	7	117207000					NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
014 1 30012055010	9	7	2430000	4632000	8070000	22652000	34908000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
017 1 30012055010	4	4	1194300	1525000	3410000	10121000	3058000	405467000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
018 1 30012055010	7	6	1265000	1346000	2230000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
017 1 30012055010	7	7	66256000	96170000	1433000	20594000	21925000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
040 1 30012055010	5	5	1966000	3821000	4944000	58277000	94420000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
041 1 30012055010	4	4	540000	108802000	10640000	78816000	193961000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
042 1 30012055010	5	5	3060000	3065000	10640000	175183000	202210000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
043 1 30012055010	3	3	2470000	5190000	6240000	3370000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
044 1 30012055010	5	5	2909000	4591000	12780000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
045 1 30012055010	4	4	1325000	1773000	2501000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
046 1 30012055010	2	2	61080000					NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
047 1 30012055010	4	4	2687000	9341000	10493000	116334000	237102000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
048 1 30012055010	3	3	258006000	1202000	2015000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
049 1 30012055010	3	3	1113000	4291000	219102000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
050 1 30012055010	3	3	546000	29194000	146551000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
052 11 10080855010	2	2	158000	16646500				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
053 11 10080855010	2	2	701000	1207600				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
054 11 10080855010	2	2	403700	3696100				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
054 11 10080855010	2	2	489200	4328400				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
054 22 0011055010	4	4	1182125	1532990	1928870	2234550		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
057 22 0011055010	4	4	2012460	2436020	2563630	2718000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
058 22 0011055010	4	4	946970	1042680	1383520	2285000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
059 22 0011055010	4	4	1119280	1444320	2084990	3094980		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
060 22 0011055010	5	5	1422410	1630680	1994020	2132800	2263680	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS

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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
991	22 06411095010	4	4	656600	789400	1214920	1482630
992	22 06411095010	3	3	1364040	1913280	2786490	
993	22 06411095010	4	4	992530	964250	1210360	7986650
994	22 06411095010	4	4	1615230	2014510	2838655	3849310
995	22 06411095010	4	4	1514730	1136020	1218810	2028130
996	22 06411095010	4	4	1677290	1831830	2147420	2822060
997	22 06411095010	4	4	1701590	1922390	2538730	3216780
998	22 06411095010	4	4	1471360	1678460	2511580	2696790
999	22 06411095010	4	4	1289480	2215280	2275400	2684050
990	22 06411095010	4	4	542240	925150	1083980	1722320
971	22 06411095010	4	4	727160	1238670	1858730	2715180
972	22 06411095010	4	4	1223430	1942970	2031220	3021420
973	22 03211095010	3	3	1319780	1022620	1313100	
974	22 03211095010	4	4	1309440	1321730	1374520	1403060
975	22 03211095010	4	4	1130350	1341870	1748120	2029090
976	22 06411095010	4	4	642240	840155	1922180	2747270
977	22 06411095010	4	4	1480430	1719880	2239280	2270570
978	22 06411095010	4	4	919450	1603860	1800850	2024170
979	22 06411095010	4	4	968980	1549380	2371140	2406560
980	22 06411095010	4	4	1124040	1264490	1471740	1488100
981	22 06411095010	4	4	439160	951900	1004430	1251210
982	22 06411095010	4	4	987700	1200120	1248660	1448350
983	22 06411095010	4	4	946550	957260	1049110	1236500
984	22 06411095010	4	4	1041980	1049020	1140030	1175490
985	22 06411095010	4	4	300080	1048270	1047650	1148500
986	22 06411095010	3	3	305250	1600710	3260450	
987	22 06411095010	4	4	200810	842700	1177760	1444130
1000	5 03111021010	3	3	1780	2110	3250	
1001	5 03111021010	4	4	6400	11100	11800	15600
1002	5 03111021010	4	4	21300	23600	24000	24100
1003	5 03111021010	4	4	13700	37100	40500	47500
1004	5 03111021010	3	3	197800	211400	231400	
1005	5 03111021010	3	3	17100	21100	24400	
1006	5 03111021010	3	3	44500	50600	70100	
1007	5 03111021010	4	4	217600	217700	277800	307200
1008	5 03111021010	3	3	11900	14100	17800	
1009	5 03111021010	3	3	4041	4705	9234	
1010	5 03111021010	3	3	67100	41400	47400	
1011	5 03111021010	3	3	33200	33200	71500	
1012	5 03111021010	3	3	37000	17000		

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	OFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE	CYCLES AT SUSPENSION
1012	6	03011021010	2	2	762000	NO SUSPENDED ITEMS
1014	6	03011021010	2	2	4000	NO SUSPENDED ITEMS
1016	6	03011021010	2	2	998000	NO SUSPENDED ITEMS
1018	6	03011021010	3	3	14000	NO SUSPENDED ITEMS
1020	6	03011021010	3	3	332000	NO SUSPENDED ITEMS
1022	6	03011021010	3	3	43000	NO SUSPENDED ITEMS
1024	6	03011021010	3	3	131000	NO SUSPENDED ITEMS
1026	6	03011021010	3	3	40000	NO SUSPENDED ITEMS
1028	6	03011021010	3	3	114000	NO SUSPENDED ITEMS
1030	6	03011021010	3	3	206000	NO SUSPENDED ITEMS
1032	6	03011021010	3	3	474000	NO SUSPENDED ITEMS
1034	6	03011021010	3	3	440000	NO SUSPENDED ITEMS
1036	6	03011021010	3	3	43000	NO SUSPENDED ITEMS
1038	6	03011021010	3	3	108000	NO SUSPENDED ITEMS
1040	6	03011021010	3	3	118000	NO SUSPENDED ITEMS
1042	6	03011021010	3	3	206000	NO SUSPENDED ITEMS
1044	6	03011021010	3	3	364000	NO SUSPENDED ITEMS
1046	6	03011021010	3	3	49700	NO SUSPENDED ITEMS
1048	6	03011021010	3	3	90200	NO SUSPENDED ITEMS
1050	6	03011021010	3	3	159300	NO SUSPENDED ITEMS
1052	6	03011021010	3	3	798400	NO SUSPENDED ITEMS
1054	6	03011021010	3	3	963700	NO SUSPENDED ITEMS
1056	6	03011021010	3	3	114100	NO SUSPENDED ITEMS
1058	6	03011021010	3	3	112100	NO SUSPENDED ITEMS
1060	6	03011021010	3	3	129800	NO SUSPENDED ITEMS
1062	6	03011021010	3	3	378900	NO SUSPENDED ITEMS
1064	6	03011021010	3	3	419300	NO SUSPENDED ITEMS
1066	6	03011021010	3	3	796600	NO SUSPENDED ITEMS
1068	6	03011021010	3	3	982700	NO SUSPENDED ITEMS
1070	6	03011021010	3	3	16700	NO SUSPENDED ITEMS
1072	6	03011021010	3	3	34500	NO SUSPENDED ITEMS
1074	6	03011021010	3	3	79800	NO SUSPENDED ITEMS
1076	6	03011021010	3	3	466700	NO SUSPENDED ITEMS
1078	6	03011021010	3	3	1148000	NO SUSPENDED ITEMS
1080	6	03011021010	3	3	1139400	NO SUSPENDED ITEMS
1082	6	03011021010	3	3	46000	NO SUSPENDED ITEMS
1084	6	03011021010	3	3	28200	NO SUSPENDED ITEMS
1086	6	03011021010	3	3	77100	NO SUSPENDED ITEMS
1088	6	03011021010	3	3	159200	NO SUSPENDED ITEMS
1090	6	03011021010	3	3	346400	NO SUSPENDED ITEMS
1092	6	03011021010	3	3	21400	NO SUSPENDED ITEMS
1094	6	03011021010	3	3	28400	NO SUSPENDED ITEMS
1096	6	03011021010	3	3	91400	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE NUMBER SIZE	FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION	
1090	7 03111021010	4	1	224400	225400	479400	195400	NO SUSPENDED ITEMS
1092	7 03111021010	11	11	39500	58900	74100	748000	NO SUSPENDED ITEMS
				91400	96500	114100	162900	
				202500				
1093	7 03111021010	8	8	18700	19700	21400	284000	NO SUSPENDED ITEMS
				33900	34500	40000		
1094	7 03111021010	13	13	68700	188200	208200	2254000	195400
				242300	249200	324900	4153000	
				466700	479600			
1095	7 03111021012	4	6	407300	473000	513400	576000	NO SUSPENDED ITEMS
				1148000			7966000	
1096	7 03111021010	4	4	830400	882700	954000	1139900	705700
1097	8 08211028010	4	4	24000	28000	68000	70000	786400
1098	8 08211028010	4	4	57050	93000	206000	312000	NO SUSPENDED ITEMS
1099	8 08211028010	4	2	206800	312000			57000
1060	8 08211028010	4	2	57000	93000			93000
								204000
1061	8 08211028010	4	4	4000	4000	4000	5000	312000
1062	8 08211028010	4	4	10000	10000	13000	17000	NO SUSPENDED ITEMS
1063	8 08211028010	4	4	54000	79000	84007	174000	NO SUSPENDED ITEMS
1064	8 08211028010	4	4	411000	493000	811000	1020000	NO SUSPENDED ITEMS
1065	8 08211028010	4	2	493000	811000			411000
								1020000
1066	8 08211028010	4	2	411000	1020000			493000
1067	8 08211028010	4	4	4000	9000	10000	11000	811000
1068	8 08211028010	4	4	14000	15000	17000	21000	NO SUSPENDED ITEMS
1069	8 08211028010	4	4	104000	117000	119000	141000	NO SUSPENDED ITEMS
1070	8 08211028010	4	4	244000	267000	290000	477000	NO SUSPENDED ITEMS
1072	8 08211028010	4	4	786000	833000	860000	1077000	NO SUSPENDED ITEMS
1073	8 08211028010	4	4	4000	8000	8000	4500	NO SUSPENDED ITEMS
1074	8 08211028010	4	4	23000	44000	72000	108000	NO SUSPENDED ITEMS
1075	8 08211028010	4	4	185000	452000	716000	1131000	NO SUSPENDED ITEMS
1080	8 08211028010	4	4	3000	5000	14000	14500	NO SUSPENDED ITEMS
1081	8 08211028010	4	4	13000	15000	32000	85000	NO SUSPENDED ITEMS
1082	8 08211028010	4	4	128000	166000	461000	622000	NO SUSPENDED ITEMS
1083	8 08211028010	4	4	4500	5400	5500	9000	NO SUSPENDED ITEMS
1084	8 08211028010	4	4	11000	14000	22000	32000	NO SUSPENDED ITEMS
1085	8 08211028010	4	4	72000	128000	159000	164000	NO SUSPENDED ITEMS
1086	8 08211028010	4	4	1500	2000	2000	15500	NO SUSPENDED ITEMS
1087	8 08211028010	4	4	13000	40000	92000	135000	NO SUSPENDED ITEMS
1088	8 08211028010	4	4	164000	265000	290000	367000	NO SUSPENDED ITEMS
1089	8 08211028010	4	4	1500	3000	9500		NO SUSPENDED ITEMS

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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	FAIL	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
1040	4	0341102010	4	4	15000	17000	18000	46000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1041	4	0341102010	4	4	80000	194000	396000	427000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1042	8	0341102010	4	4	111000	467000	1107000	2169000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1043	7	03111221010	7	4	169400	194600	386700	468300	674700	674700	674700	674700
1044	41	06411421010	3	3	1283500	11000	15000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1045	41	06411421010	3	3	22000	24000	24000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1046	41	06411421010	3	3	36000	38000	46000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1047	41	06411421010	3	3	69000	76000	76000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1048	44	15410421010	2	2	42000	43000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1049	44	15410421010	2	2	496000	576000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1100	47	06411421010	4	4	57900	62300	77000	92300	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1101	47	06411421010	7	7	113200	128900	136000		110100	110100	110100	110100
1102	20	03211221010	10	10	77200	80000	56300	62300	72600	72600	72600	72600
1103	20	03211221010	10	10	101000	104000	110000	115000	134000	134000	134000	134000
1104	20	03211221010	10	10	145000	142000	149000	165000	179000	179000	179000	179000
1105	20	03211221010	10	10	241000	243000	284000	286000	382000	382000	382000	382000
1106	20	03211221010	10	10	400000	400000	498000	566000	640000	640000	640000	640000
1107	20	03211221010	10	10	463000	675000	706000	759000	1236000	1236000	1236000	1236000
1108	72	00010806010	4	4	7000	9000	10000	12000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1109	72	00010806010	4	4	17000	37000	42000	63000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1110	72	00010806010	4	4	452000	506000	514000	687000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1111	72	00010806010	4	4	4000	4000	4000	7000	15000	15000	15000	15000
1112	72	00010806010	4	4	17000	5000	6000	13000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1113	72	00010806010	4	4	42000	48000	49000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1114	72	00010806010	4	4	196000	199000	202000	204000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1115	72	00010806010	4	4	289000	377000	469000	618000	80000	80000	80000	80000
1116	72	00010806010	4	4	4000	4000	4000	7000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1117	72	00010806010	4	4	4000	6000	13000	15000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1118	72	00010806010	4	4	8000	10000	11000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1119	72	00010806010	4	4	27000	43000	51000	91000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1120	72	00010806010	4	4	51000	58000	68000	253000	30000	30000	30000	30000
1121	72	00010806010	4	4	121000	135000	138000	26000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1122	72	00010806010	4	4	10000	15000	21000	26000	27000	27000	27000	27000
1123	72	00010806010	4	4	10000	12000	18000	19000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1124	72	00010806010	4	4	165000	196000	201000	273000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1125	72	00010806010	4	4	9000	10000	10000	13000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1126	72	00010806010	4	4	23000	26000	29000	30000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS

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COLLECTION

ITEM REF DESCRIPTION	SAMPLE SIZE	NUMBER OF FAILURES	CYCLES AT FAILURE			CYCLES AT SUSPENSION		
1174 72 00010800010	4	4	47000	64000	534000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	190000	311000	404000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	4000	7000	9000	411000	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	14000	18000	18000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	17000	60000	81000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	107000	108000	192000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	7000	7000	8000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	12000	13000	14000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	23000	39000	41000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	191000	194000	279000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	173000	38000	579000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	5000	7000	7000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	11000	13000	22000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	43000	60000	135000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	60000	90000	279000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	189000	196000	507000	•	2490000 2522000	•
1174 72 00010800010	4	4	831	934	707000	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	1173	1736	1770	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	257	302	381	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	14	56	137	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	106	283	291	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	116	497	637	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	63	69	113	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	121	230	239	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	51	498	769	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	34	66	96	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	262	350	835	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	500	635	1511	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	1278	1320	1546	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	1732	1752	1807	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	2529	3520	4373	2006	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	2735	42	52	5000	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	7	42	52	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	574	625	698	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	1170	1230	1440	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	21	47	3301	•	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	30	35	120	450	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	3210	3318	3459	4135	NO SUSPENDED ITEMS	•
1174 72 00010800010	4	4	4338	4719	5520	•	NO SUSPENDED ITEMS	•

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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION		
1202	72	000100000010	3	3	5	85	471		NO SUSPENDED ITEMS	
1204	72	000100000010	4	4	63	2298	2755	4100	NO SUSPENDED ITEMS	
1206	72	000100000010	4	4	2945	3064	3248	4161	NO SUSPENDED ITEMS	
1208	5	0011021010	4	2	838600	1305000			8104000	
1211	4	00111021010	4	4	1104200	1597300	7359000	5771100	72190000	
1212	5	00111021010	2	2	6561000	8640000			NO SUSPENDED ITEMS	
1213	5	00111021010	4	2	566600	1372800	1500800	1594000	34845000	
1214	5	00111021010	3	3	17040000	4816100	16245200		NO SUSPENDED ITEMS	
1215	5	00111021010	3	3	1970400	5608500	10403200		NO SUSPENDED ITEMS	
1216	5	00111021010	3	3	1821400	4099000			NO SUSPENDED ITEMS	20677000
1217	5	00111021010	3	3	2784000	4440000			NO SUSPENDED ITEMS	
1218	5	00111021010	3	3	1046300	1162000	1838000		NO SUSPENDED ITEMS	
1219	5	00111021010	3	3	759300	1474000	1674000		NO SUSPENDED ITEMS	
1221	5	00111021010	3	3	162300	759000	1046300	1184000	14740000	
1222	5	00111021010	3	3	1074000	1838000			NO SUSPENDED ITEMS	
1223	5	00111021010	3	3	2051300	6000000	13138000		NO SUSPENDED ITEMS	
1224	7	00111021010	3	3	1547500	2136200	3012700		NO SUSPENDED ITEMS	
1225	7	00111021010	3	3	2219500	3223000			21000000	
1226	7	00111021010	3	3	6147100	7151600			20000000	
1227	7	00111021010	3	3	6055100	6692700			20000000	
1228	7	00111021010	3	3	984100	937900	1113000	1204000	NO SUSPENDED ITEMS	
1229	7	00111021010	3	3	1306300	1425200	1516000	1655300	NO SUSPENDED ITEMS	
1230	7	00111021010	3	3	1147100	1549700			735800	20000000
1231	7	00111021010	3	3	4055100	6167100	6692700	7151600	20000000	200000000
1232	5	00111021010	4	3	954000	1218000	1493000		20000000	
1233	5	00111021010	4	3	1161300	1301000	1364000		45283000	
1234	5	00111021010	4	3	10376000	26373000			25427000	
1235	5	00111021010	4	2	1298000	1521000	1673000	1701000	10949000	33542000
1236	5	00111021010	4	2	4926000	12200000			NO SUSPENDED ITEMS	
1237	5	00111021010	4	3	1403000	4754000	11302000		10373000	51944000
1238	5	00111021010	4	3	534000	1212000	2417000		10000000	
1239	5	00111021010	4	3	6504000	9555000			8743000	
1240	5	00111021010	4	3	406900	1411000	1919000	3276000	22121000	49821000
1241	5	00111021010	4	3	4701000	29110000			NO SUSPENDED ITEMS	
1242	5	00111021010	4	3	423000	991000	1711000	2445000	22671000	34021000
1243	5	00111021010	4	3	1549000	2144000	11297000	46574000	NO SUSPENDED ITEMS	
1244	5	00111021010	4	3	4474000	8944000			41962000	70000000

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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
1277	7 03111021010	8	0	864100	957900	1113000	1187100	12066000	135800	20000000	
1278	42 06411021010	3	3	1540700	2558000	4203000			NO SUSPENDED ITEMS		
1279	20 03211021010	10	10	1720000	1197000	1218000	1658000	16680000	NO SUSPENDED ITEMS		
				2590000	2038000	2455000	2847000	16533000			
1300	20 03211021010	7	7	1989000	643000	744000	773000	8100000	NO SUSPENDED ITEMS		
				910000	972000						
1301	20 03211021010	7	7	488000	706000	796000	815000	8400000	NO SUSPENDED ITEMS		
				1448000	1467000						
1302	20 03211021010	7	7	453000	489000	651000	708000	7220000	NO SUSPENDED ITEMS		
				808000	814000						
1303	20 03211021010	7	7	644000	444000	483000	489000	5620000	NO SUSPENDED ITEMS		
				569000	583000						
1304	20 03211021010	7	7	406000	643000	652000	699000	7470000	NO SUSPENDED ITEMS		
				815000	978000						
1305	20 03211021010	7	7	515000	633000	816000	842000	8420000	NO SUSPENDED ITEMS		
				894000	941000						
1306	20 03211021010	7	7	532000	614000	696000	697000	7880000	NO SUSPENDED ITEMS		
				900000	941000						
1307	20 03211021010	7	7	560000	572000	674000	735000	7750000	NO SUSPENDED ITEMS		
				776000	923000						
1308	20 03211021010	4	4	487000	627000	830000	930000		NO SUSPENDED ITEMS		
1340	20 03211021010	7	7	656000	955000	982000	984000	10730000	NO SUSPENDED ITEMS		
				1148000	1283000						
1341	20 03211021010	7	7	1084000	1261000	1261000	1295000	12950000	NO SUSPENDED ITEMS		
				1302000	1825000						
1342	20 03211021010	3	3	7734000	10769000	12225000			NO SUSPENDED ITEMS		
1343	20 03211021010	4	4	4556000	4556000	4776000	5624000		NO SUSPENDED ITEMS		
1344	20 03211021010	4	4	163000	1214000	3228000	8722000	93370000	NO SUSPENDED ITEMS		
1345	20 03211021010	7	7	1923000	2355000	2366000	2608000	35650000	NO SUSPENDED ITEMS		
				4155000	4229000						
1346	20 03211021010	7	7	734000	744000	806000	887000	10830000	NO SUSPENDED ITEMS		
				1107000	1300000						
1347	20 03211021010	7	7	1132000	1142000	1294000	1784000	19560000	NO SUSPENDED ITEMS		
				2118000	2120000						
1348	20 03211021010	7	7	1549000	1819000	1953000	2201000	26040000	NO SUSPENDED ITEMS		
				2632000	3250000						
1349	20 03211021010	7	7	1141000	1630000	1793000	1793000	26170000	NO SUSPENDED ITEMS		
				4972000	10432000						
2300	31 0005403011	3	3	36300	49700	68300			NO SUSPENDED ITEMS		

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM NO.	DESCRIPTION	SAMPLE SIZE	NO. OF CYCLES	NO. OF FAILURES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
2301	000560001011	3	2	0	895400	NO SUSPENDED ITEMS
2302	000560001011	3	2	0	30000	NO SUSPENDED ITEMS
2303	000560001011	3	2	0	30000	NO SUSPENDED ITEMS
2304	000560001011	3	2	0	250000	NO SUSPENDED ITEMS
2305	000560001011	3	2	0	11832	NO SUSPENDED ITEMS
2306	000560001011	3	2	0	52734	NO SUSPENDED ITEMS
2307	000560001011	3	2	0	108676	NO SUSPENDED ITEMS
2308	000560001011	3	2	0	169900	NO SUSPENDED ITEMS
2309	000560001011	3	2	0	11000	NO SUSPENDED ITEMS
2310	000560001011	3	2	0	479600	NO SUSPENDED ITEMS
2311	000560001011	3	2	0	1115200	NO SUSPENDED ITEMS
2312	000560001011	3	2	0	97000	NO SUSPENDED ITEMS
2313	000560001011	3	2	0	11700	NO SUSPENDED ITEMS
2314	000560001011	3	2	0	20500	NO SUSPENDED ITEMS
2315	000560001011	3	2	0	32000	NO SUSPENDED ITEMS
2316	000560001011	3	2	0	198000	NO SUSPENDED ITEMS
2317	000560001011	3	2	0	143840	NO SUSPENDED ITEMS
2318	000560001011	3	2	0	4080	NO SUSPENDED ITEMS
2319	000560001011	3	2	0	27900	NO SUSPENDED ITEMS
2320	000560001011	3	2	0	16413	NO SUSPENDED ITEMS
2321	000560001011	3	2	0	4143	NO SUSPENDED ITEMS
2322	000560001011	3	2	0	13000	NO SUSPENDED ITEMS
2323	000560001011	3	2	0	20313	NO SUSPENDED ITEMS
2324	000560001011	3	2	0	818	NO SUSPENDED ITEMS
2325	000560001011	3	2	0	843	NO SUSPENDED ITEMS
2326	000560001011	3	2	0	1509	NO SUSPENDED ITEMS
2327	000560001011	3	2	0	976015	NO SUSPENDED ITEMS
2328	000560001011	3	2	0	911533	NO SUSPENDED ITEMS
2329	000560001011	3	2	0	42164	NO SUSPENDED ITEMS
2330	000560001011	3	2	0	757582	NO SUSPENDED ITEMS
2331	000560001011	3	2	0	396309	NO SUSPENDED ITEMS
2332	000560001011	3	2	0	245000	NO SUSPENDED ITEMS
2333	000560001011	3	2	0	765000	NO SUSPENDED ITEMS
2334	000560001011	3	2	0	210000	NO SUSPENDED ITEMS
2335	000560001011	3	2	0	772000	NO SUSPENDED ITEMS
2336	000560001011	3	2	0	145000	NO SUSPENDED ITEMS
2337	000560001011	3	2	0	255000	NO SUSPENDED ITEMS
2338	000560001011	3	2	0	425000	NO SUSPENDED ITEMS
2339	000560001011	3	2	0	470000	NO SUSPENDED ITEMS
2340	000560001011	3	2	0	138000	NO SUSPENDED ITEMS
2341	000560001011	3	2	0	545000	NO SUSPENDED ITEMS
2342	000560001011	3	2	0	200000	NO SUSPENDED ITEMS
2343	000560001011	3	2	0	225000	NO SUSPENDED ITEMS
2344	000560001011	3	2	0	205000	NO SUSPENDED ITEMS
2345	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2346	000560001011	3	2	0	15000	NO SUSPENDED ITEMS
2347	000560001011	3	2	0	40000	NO SUSPENDED ITEMS
2348	000560001011	3	2	0	155000	NO SUSPENDED ITEMS
2349	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2350	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2351	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2352	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2353	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2354	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2355	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2356	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2357	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2358	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2359	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2360	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2361	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2362	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2363	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2364	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2365	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2366	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2367	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2368	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2369	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2370	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2371	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2372	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2373	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2374	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2375	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2376	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2377	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2378	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2379	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2380	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2381	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2382	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2383	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2384	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2385	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2386	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2387	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2388	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2389	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2390	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2391	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2392	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2393	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2394	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2395	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2396	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2397	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2398	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2399	000560001011	3	2	0	160000	NO SUSPENDED ITEMS
2400	000560001011	3	2	0	160000	NO SUSPENDED ITEMS

[illegible]

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM NO.	TEST REPORT NO.	SAMPLE SIZE	NOMINAL STRESS	CYCLES AT FAILURE	CYCLES AT SUSPENSION
2701	31 00050001011	1	15400	26000	NO SUSPENDED ITEMS
2702	32 00050001011	1	13000	44900	NO SUSPENDED ITEMS
2703	33 00050001011	1	15400	17200	NO SUSPENDED ITEMS
2704	34 00050001011	1	190000	107000	NO SUSPENDED ITEMS
2705	35 00050001011	1	7500	14700	28100
2706	36 00050001010	1	15400	21100	NO SUSPENDED ITEMS
2707	37 00050001010	1	22500	23500	NO SUSPENDED ITEMS
2708	38 00050001010	1	11700	17300	NO SUSPENDED ITEMS
2709	39 00050001011	1	7000	92100	NO SUSPENDED ITEMS
2710	40 00050001011	1	9000	9700	NO SUSPENDED ITEMS
2711	41 00050001011	1	12400	59400	74900
2712	42 00050001010	1	131100	34600	80900
2713	43 00050001011	1	60100	153200	167500
2714	44 00050001011	1	60100	153200	164000
2715	45 00050001011	1	30400	33300	NO SUSPENDED ITEMS
2716	46 00050001011	1	21400	22700	NO SUSPENDED ITEMS
2717	47 00050001011	1	20900	24700	41200
2718	48 00050001011	1	24100	26400	41200
2719	49 00050001011	1	24800	65700	74500
2720	50 00050001011	1	48740	62600	74500
2721	51 00050001011	1	52700	124500	NO SUSPENDED ITEMS
2722	52 00050001010	1	32700	126100	NO SUSPENDED ITEMS
2723	53 00050001010	1	50800	51200	NO SUSPENDED ITEMS
2724	54 00050001010	1	50800	52300	NO SUSPENDED ITEMS
2725	55 00050001011	1	21200	24800	NO SUSPENDED ITEMS
2726	56 00050001010	1	21200	24800	NO SUSPENDED ITEMS
2727	57 00050001011	1	43700	63000	NO SUSPENDED ITEMS
2728	58 00050001011	1	43200	63000	NO SUSPENDED ITEMS
2729	59 00050001011	1	13900	18700	25400
2730	60 00050001010	1	52500	20200	21600
2731	61 00050001010	1	13900	18700	21600
2732	62 00050001011	1	52500	20200	25400
2733	63 00050001011	1	13900	18700	NO SUSPENDED ITEMS
2734	64 00050001011	1	13900	18700	NO SUSPENDED ITEMS
2735	65 00050001011	1	13900	18700	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
2745	16 10211922011	5	5	20000	21400	32100	33800	34300	34300	NO SUSPENDED ITEMS	
2746	16 10211022010	5	5	20400	21200	33200	33600	34300	34300	NO SUSPENDED ITEMS	
2747	16 10211011011	4	4	24900	27300	38200	70000			NO SUSPENDED ITEMS	
2748	16 10211011010	4	4	24900	27300	38200	70000			NO SUSPENDED ITEMS	
2749	16 10211011011	4	4	61400	66700	130500	196800			NO SUSPENDED ITEMS	
2750	16 10211011010	4	4	61400	66700	130500	196800			NO SUSPENDED ITEMS	
2751	16 10211011011	3	3	46500	81000	94000				NO SUSPENDED ITEMS	
2752	16 10211011010	3	3	46500	81000	94000				NO SUSPENDED ITEMS	
2753	17 04011083010	4	4	4000	7000	9000	9000			NO SUSPENDED ITEMS	
2754	17 04011083010	4	4	21000	34000	41000	43000			NO SUSPENDED ITEMS	
2755	17 04011083010	4	4	21000	25000	50000	56000			65000	
2756	17 04011083010	3	2	40000	76000					70000	
2757	17 04011083010	4	4	30000	12000	13000	14000			NO SUSPENDED ITEMS	
2758	17 04011083010	4	4	30000	37000	47000	48000			NO SUSPENDED ITEMS	
2759	17 03211081010	3	3	9000	9000	13200				NO SUSPENDED ITEMS	
2760	17 03211081010	4	4	12000	13800	14400	16200			NO SUSPENDED ITEMS	
2761	17 03211081010	7	7	4600	9400	12000	13200	13800		NO SUSPENDED ITEMS	
2762	17 04411083010	4	4	5000	16200		7000			NO SUSPENDED ITEMS	
2763	17 04411083010	3	3	19000	5000	26000				NO SUSPENDED ITEMS	
2764	17 04011083010	2	2	900	1100					NO SUSPENDED ITEMS	
2821	32 00055081011	2	2	878000	1674000					NO SUSPENDED ITEMS	
2822	32 00055081010	2	2	1218000	1847000					NO SUSPENDED ITEMS	
2823	32 00055081010	2	2	1793000	1849000					NO SUSPENDED ITEMS	
2824	36 06411912011	3	3	1755400	2001000	2067000				NO SUSPENDED ITEMS	
2825	36 06411912010	3	3	1755400	2001000	2067000				NO SUSPENDED ITEMS	
2850	32 00012081011	2	2	30000	35000					NO SUSPENDED ITEMS	
2851	32 00010081010	2	2	65000	309900					NO SUSPENDED ITEMS	
2852	32 00010081010	2	2	32400	48400					NO SUSPENDED ITEMS	
2853	40 00096091020	6	6	1332	1370	1371	1382	1431		NO SUSPENDED ITEMS	
2854	40 00096091021	6	6	2232						NO SUSPENDED ITEMS	
2855	40 00096091021	6	6	1343	1362	1363	1378	1398		NO SUSPENDED ITEMS	
2856	40 00096091020	4	4	3316	3811	4077	4180			NO SUSPENDED ITEMS	
2857	40 00096091020	4	4	3146	3679	4070	4072			NO SUSPENDED ITEMS	
2858	40 00096091020	4	4	6566	9569	10611	11546			NO SUSPENDED ITEMS	
2859	40 00096091021	4	4	7797	9270	9500	11352			NO SUSPENDED ITEMS	
2860	40 00096091020	4	4	36135	36295	36307	40134	72836		NO SUSPENDED ITEMS	
				113073							

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
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COLLECTION

ITEM NO	TEST DESIGNATION	SAMPLE NUMBER	TEST	FAILURE	CYCLES AT FAILURE	CYCLES AT SUSPENSION
2841	0005081021	2	2	2	35110	NO SUSPENDED ITEMS
2842	0005081022	2	2	2	107500	NO SUSPENDED ITEMS
2843	00011081021	2	2	2	2863	NO SUSPENDED ITEMS
2844	00056081020	2	2	2	2856	NO SUSPENDED ITEMS
2845	00012191021	2	2	2	8877	NO SUSPENDED ITEMS
2846	00011081021	2	2	2	9027	NO SUSPENDED ITEMS
2847	00011081021	2	2	2	5448	NO SUSPENDED ITEMS
2848	0005081020	2	2	2	25456	NO SUSPENDED ITEMS
2849	00012081021	2	2	2	20000	NO SUSPENDED ITEMS
2850	00011081021	2	2	2	21000	NO SUSPENDED ITEMS
2851	0005081020	2	2	2	110940	NO SUSPENDED ITEMS
2870	00012081021	2	2	2	101000	NO SUSPENDED ITEMS
2871	00011081021	2	2	2	77000	NO SUSPENDED ITEMS
2872	0005081020	2	2	2	976	NO SUSPENDED ITEMS
2873	00012081021	2	2	2	949	NO SUSPENDED ITEMS
2874	00011081021	2	2	2	949	NO SUSPENDED ITEMS
2875	0005081020	2	2	2	9509	NO SUSPENDED ITEMS
2876	00012081021	2	2	2	7500	NO SUSPENDED ITEMS
2877	00011081021	2	2	2	7500	NO SUSPENDED ITEMS
2878	0005081020	2	2	2	30000	NO SUSPENDED ITEMS
2879	00012081021	2	2	2	21925	NO SUSPENDED ITEMS
2880	00011081021	2	2	2	21925	NO SUSPENDED ITEMS
2881	0005081020	2	2	2	77500	NO SUSPENDED ITEMS
2882	00012081021	2	2	2	110427	NO SUSPENDED ITEMS
2883	00011081021	2	2	2	95837	NO SUSPENDED ITEMS
2884	0005081020	2	2	2	55600	NO SUSPENDED ITEMS
2885	00012081021	2	2	2	1377	NO SUSPENDED ITEMS
2886	00012081021	2	2	2	648	NO SUSPENDED ITEMS
2887	0005081020	2	2	2	897	NO SUSPENDED ITEMS
2888	00012081021	2	2	2	8993	NO SUSPENDED ITEMS
2889	00012081021	2	2	2	2571	NO SUSPENDED ITEMS
2890	00011081021	2	2	2	7564	NO SUSPENDED ITEMS
2891	0005081020	2	2	2	93618	NO SUSPENDED ITEMS
2892	00011081021	2	2	2	36416	NO SUSPENDED ITEMS
2893	00011081021	2	2	2	34800	NO SUSPENDED ITEMS
2894	0005081020	3	3	3	22682	NO SUSPENDED ITEMS
2895	0005081071	2	2	2	29555	NO SUSPENDED ITEMS
2896	0005081071	2	2	2	30293	NO SUSPENDED ITEMS
2897	0005081071	3	3	3	93770	NO SUSPENDED ITEMS
2898	0005081071	2	2	2	93231	NO SUSPENDED ITEMS
2899	0005081071	2	2	2	105360	NO SUSPENDED ITEMS
2900	0005081071	2	2	2	90331	NO SUSPENDED ITEMS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBERS FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
2000	00	00000001070	3	1	50883	50883	NO	SUSPENDED ITEMS
2001	00	00000001071	3	1	50882	50882	NO	SUSPENDED ITEMS
2002	00	00000001072	3	1	50881	50881	NO	SUSPENDED ITEMS
2003	00	00000001073	3	1	50880	50880	NO	SUSPENDED ITEMS
2004	00	00000001074	3	1	50879	50879	NO	SUSPENDED ITEMS
2005	00	00000001075	3	1	50878	50878	NO	SUSPENDED ITEMS
2006	00	00000001076	3	1	50877	50877	NO	SUSPENDED ITEMS
2007	00	00000001077	3	1	50876	50876	NO	SUSPENDED ITEMS
2008	00	00000001078	3	1	50875	50875	NO	SUSPENDED ITEMS
2009	00	00000001079	3	1	50874	50874	NO	SUSPENDED ITEMS
2010	00	00000001080	3	1	50873	50873	NO	SUSPENDED ITEMS
2011	00	00000001081	3	1	50872	50872	NO	SUSPENDED ITEMS
2012	00	00000001082	3	1	50871	50871	NO	SUSPENDED ITEMS
2013	00	00000001083	3	1	50870	50870	NO	SUSPENDED ITEMS
2014	00	00000001084	3	1	50869	50869	NO	SUSPENDED ITEMS
2015	00	00000001085	3	1	50868	50868	NO	SUSPENDED ITEMS
2016	00	00000001086	3	1	50867	50867	NO	SUSPENDED ITEMS
2017	00	00000001087	3	1	50866	50866	NO	SUSPENDED ITEMS
2018	00	00000001088	3	1	50865	50865	NO	SUSPENDED ITEMS
2019	00	00000001089	3	1	50864	50864	NO	SUSPENDED ITEMS
2020	00	00000001090	3	1	50863	50863	NO	SUSPENDED ITEMS
2021	00	00000001091	3	1	50862	50862	NO	SUSPENDED ITEMS
2022	00	00000001092	3	1	50861	50861	NO	SUSPENDED ITEMS
2023	00	00000001093	3	1	50860	50860	NO	SUSPENDED ITEMS
2024	00	00000001094	3	1	50859	50859	NO	SUSPENDED ITEMS
2025	00	00000001095	3	1	50858	50858	NO	SUSPENDED ITEMS
2026	00	00000001096	3	1	50857	50857	NO	SUSPENDED ITEMS
2027	00	00000001097	3	1	50856	50856	NO	SUSPENDED ITEMS
2028	00	00000001098	3	1	50855	50855	NO	SUSPENDED ITEMS
2029	00	00000001099	3	1	50854	50854	NO	SUSPENDED ITEMS
2030	00	00000001100	3	1	50853	50853	NO	SUSPENDED ITEMS
2031	00	00000001101	3	1	50852	50852	NO	SUSPENDED ITEMS
2032	00	00000001102	3	1	50851	50851	NO	SUSPENDED ITEMS
2033	00	00000001103	3	1	50850	50850	NO	SUSPENDED ITEMS
2034	00	00000001104	3	1	50849	50849	NO	SUSPENDED ITEMS
2035	00	00000001105	3	1	50848	50848	NO	SUSPENDED ITEMS
2036	00	00000001106	3	1	50847	50847	NO	SUSPENDED ITEMS
2037	00	00000001107	3	1	50846	50846	NO	SUSPENDED ITEMS
2038	00	00000001108	3	1	50845	50845	NO	SUSPENDED ITEMS
2039	00	00000001109	3	1	50844	50844	NO	SUSPENDED ITEMS
2040	00	00000001110	3	1	50843	50843	NO	SUSPENDED ITEMS
2041	00	00000001111	3	1	50842	50842	NO	SUSPENDED ITEMS
2042	00	00000001112	3	1	50841	50841	NO	SUSPENDED ITEMS
2043	00	00000001113	3	1	50840	50840	NO	SUSPENDED ITEMS
2044	00	00000001114	3	1	50839	50839	NO	SUSPENDED ITEMS
2045	00	00000001115	3	1	50838	50838	NO	SUSPENDED ITEMS
2046	00	00000001116	3	1	50837	50837	NO	

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	OFF	DES.	DESCRIPTION	SAMPLE SIZE	NUMBERS FAILING	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
1029	23	09101800010		2	2	46000		NO SUSPENDED ITEMS	
1029	23	09101800010		2	2	74000		NO SUSPENDED ITEMS	
1030	23	09101800010		2	2	142000		NO SUSPENDED ITEMS	
1031	23	09101800010		2	2	18000		NO SUSPENDED ITEMS	
1032	23	09101800010		2	2	36000		NO SUSPENDED ITEMS	
1033	23	09101800010		2	2	43000		NO SUSPENDED ITEMS	
1034	23	09101800010		2	2	112000		NO SUSPENDED ITEMS	
1035	23	09101800010		2	2	260000		NO SUSPENDED ITEMS	
1036	23	09101800010		2	2	10000		NO SUSPENDED ITEMS	
1037	23	09101800010		2	2	274000		NO SUSPENDED ITEMS	
1038	23	09101800010		2	2	657000		NO SUSPENDED ITEMS	
1039	23	09101800010		2	2	7000		NO SUSPENDED ITEMS	
1040	23	09101800010		2	2	17000		NO SUSPENDED ITEMS	
1041	23	09101800010		2	2	39000		NO SUSPENDED ITEMS	
1042	23	09101800010		2	2	27000		NO SUSPENDED ITEMS	
1043	23	09101800010		2	2	61000		NO SUSPENDED ITEMS	
1044	21	03202000010		4	4	1950	2170	NO SUSPENDED ITEMS	
1044	21	03202000010		4	4	2510	2470	NO SUSPENDED ITEMS	
1045	21	03202000010		4	4	2870	3020	NO SUSPENDED ITEMS	
1046	21	03202000010		4	4	5700	5850	NO SUSPENDED ITEMS	
1047	21	03202000010		4	4	7040	7370	NO SUSPENDED ITEMS	
1048	21	03202000010		4	4	10390	10930	NO SUSPENDED ITEMS	
1049	21	03202000010		4	4	17170	18860	NO SUSPENDED ITEMS	
1050	21	03202000010		4	4	55400	56300	NO SUSPENDED ITEMS	
1051	21	03202000010		4	4	14350	16010	NO SUSPENDED ITEMS	
1052	21	03202000010		4	4	19470	23420	NO SUSPENDED ITEMS	
1053	21	03202000010		4	4	33390	39020	NO SUSPENDED ITEMS	
1054	21	03202000010		4	4	60480	62400	NO SUSPENDED ITEMS	
1055	21	03202000010		4	4	29020	36700	NO SUSPENDED ITEMS	
1056	21	03202000010		4	4	54340	61360	NO SUSPENDED ITEMS	
1057	21	03202000010		4	4	144050	180200	NO SUSPENDED ITEMS	
1058	21	03202000010		4	4	656100	961430	NO SUSPENDED ITEMS	
1059	21	03202000010		4	4	97250	119630	NO SUSPENDED ITEMS	
1060	21	03202000010		4	4	175360	204700	NO SUSPENDED ITEMS	
1061	21	03202000010		4	4	519320	590350	NO SUSPENDED ITEMS	
1062	21	03202000010		4	4	906730	614330	NO SUSPENDED ITEMS	
1063	21	03202000010		4	4	1295460	850660	NO SUSPENDED ITEMS	
1064	23	09101800010		2	2	91000	104000	NO SUSPENDED ITEMS	
1065	23	09101800010		2	2	132000	254000	NO SUSPENDED ITEMS	

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
1065	23 09101840010	2	2	5000	7000	NO	SUSPENDED ITEMS
1066	23 09101840010	2	2	22000	25000	NO	SUSPENDED ITEMS
1067	23 09101840010	3	3	90000	145000	NO	SUSPENDED ITEMS
1068	23 09101840010	3	3	397000	416000	NO	SUSPENDED ITEMS
1069	23 09101840010	2	2	12000	13000	NO	SUSPENDED ITEMS
1070	23 09101840010	2	2	16000	24000	NO	SUSPENDED ITEMS
1071	23 09101840010	2	2	51000	55000	NO	SUSPENDED ITEMS
1072	23 09101840010	2	2	65000	74000	NO	SUSPENDED ITEMS
1073	23 09101840010	2	2	153000	280000	NO	SUSPENDED ITEMS
1074	23 09101840010	2	2	937000	924000	NO	SUSPENDED ITEMS
1075	23 09101840010	2	2	8000	10000	NO	SUSPENDED ITEMS
1076	23 09101840010	3	3	26000	48000	NO	SUSPENDED ITEMS
1077	23 09101840010	4	4	133000	197000	NO	SUSPENDED ITEMS
1078	23 09101840010	2	2	15000	17000	NO	SUSPENDED ITEMS
1079	23 09101840010	2	2	18000	26000	NO	SUSPENDED ITEMS
1080	23 09101840010	2	2	31000	46000	NO	SUSPENDED ITEMS
1081	23 09101840010	2	2	39000	53000	NO	SUSPENDED ITEMS
1082	23 09101840010	2	2	61000	63000	NO	SUSPENDED ITEMS
1083	23 09101840010	2	2	162000	185000	NO	SUSPENDED ITEMS
1084	23 09101840010	2	2	213000	752000	NO	SUSPENDED ITEMS
1085	23 09101840010	2	2	12000	15000	NO	SUSPENDED ITEMS
1086	23 09101840010	2	2	4000	84000	NO	SUSPENDED ITEMS
1087	23 09101840010	2	2	53000	65000	NO	SUSPENDED ITEMS
1088	23 09101840010	2	2	321000	361000	NO	SUSPENDED ITEMS
1089	23 09101840010	2	2	1650	2031	NO	SUSPENDED ITEMS
1090	23 09101840010	2	2	3516	4075	NO	SUSPENDED ITEMS
1091	23 09101840010	2	2	8000	14000	NO	SUSPENDED ITEMS
1092	23 09101840010	2	2	18000	24000	NO	SUSPENDED ITEMS
1093	23 09101840010	2	2	32000	34000	NO	SUSPENDED ITEMS
1094	23 09101840010	2	2	75000	113000	NO	SUSPENDED ITEMS
1095	23 09101840010	2	2	150000	555000	NO	SUSPENDED ITEMS
1096	23 09101840010	3	3	18000	23000	NO	SUSPENDED ITEMS
1097	23 09101840010	3	3	52000	91000	NO	SUSPENDED ITEMS
1098	23 09101840010	3	3	268000	374000	NO	SUSPENDED ITEMS
1099	23 09101840010	2	2	9570	15156	NO	SUSPENDED ITEMS
1100	23 09101840010	2	2	31000	38700	NO	SUSPENDED ITEMS
1101	23 09101840010	2	2	38000	65000	NO	SUSPENDED ITEMS
1102	23 09101840010	2	2	100700	104000	NO	SUSPENDED ITEMS
1103	23 09101840010	2	2	172000	409000	NO	SUSPENDED ITEMS
1104	23 09101840010	2	2	8000	9400	NO	SUSPENDED ITEMS

ITEM	DESCRIPTION	QTY	AMOUNT	NUMBER	FAIL	CYCLES AT FAILURE	CYCLES AT SUSPENSION
1100	23 091018A0010	2	33000	2	2	43000	NO SUSPENDED ITEMS
1101	23 091018A0010	4	138000	4	3	180000	NO SUSPENDED ITEMS
1102	23 091018A0010	3	213000	3	2	411000	NO SUSPENDED ITEMS
1103	23 091018A0010	2	13000	2	2	19000	NO SUSPENDED ITEMS
1104	23 091018A0010	2	31000	2	2	46000	NO SUSPENDED ITEMS
1110	23 091018A0010	2	90000	2	2	158000	NO SUSPENDED ITEMS
1111	23 091018A0010	2	124000	2	2	155000	NO SUSPENDED ITEMS
1112	23 091018A0010	4	9000	4	3	10000	NO SUSPENDED ITEMS
1113	23 091018A0010	3	30000	3	3	31000	NO SUSPENDED ITEMS
1114	23 091018A0010	3	90000	3	3	112000	NO SUSPENDED ITEMS
1115	23 091018A0010	2	16000	2	2	14100	NO SUSPENDED ITEMS
1116	23 091018A0010	2	25000	2	2	25100	NO SUSPENDED ITEMS
1117	23 091018A0010	2	39000	2	3	46000	NO SUSPENDED ITEMS
1118	23 091018A0010	3	62000	3	2	71000	NO SUSPENDED ITEMS
1119	23 091018A0010	2	128000	2	2	163000	NO SUSPENDED ITEMS
1120	23 091018A0010	2	8000	2	2	9000	NO SUSPENDED ITEMS
1121	23 091018A0010	3	29000	3	3	32000	NO SUSPENDED ITEMS
1122	23 091018A0010	3	108000	3	3	122000	NO SUSPENDED ITEMS
1123	23 091018A0010	3	340000	3	3	516000	NO SUSPENDED ITEMS
1124	23 091018A0010	2	23000	2	2	34000	NO SUSPENDED ITEMS
1125	23 091018A0010	2	41000	2	2	517000	NO SUSPENDED ITEMS
1126	23 091018A0010	2	50000	2	2	62000	NO SUSPENDED ITEMS
1127	23 091018A0010	3	15000	3	3	16000	NO SUSPENDED ITEMS
1128	23 091018A0010	3	41000	3	3	39000	NO SUSPENDED ITEMS
1129	23 091018A0010	3	31000	3	3	55000	NO SUSPENDED ITEMS
1130	23 091018A0010	2	37000	2	2	117000	NO SUSPENDED ITEMS
1131	23 091018A0010	2	98000	2	3	41000	NO SUSPENDED ITEMS
1132	23 091018A0010	2	45000	2	2	169000	NO SUSPENDED ITEMS
1133	23 091018A0010	2	12000	2	2	616000	NO SUSPENDED ITEMS
1134	23 091018A0010	2	29000	2	2	13000	NO SUSPENDED ITEMS
1135	23 091018A0010	2	77000	2	2	45000	NO SUSPENDED ITEMS
1136	23 091018A0010	4	582000	4	4	94000	NO SUSPENDED ITEMS
1137	23 091018A0010	2	41000	2	2	654000	NO SUSPENDED ITEMS
1138	23 091018A0010	2	62000	2	2	51000	NO SUSPENDED ITEMS
1139	23 091018A0010	2	156000	2	2	67000	NO SUSPENDED ITEMS
1140	23 091018A0010	2	144000	2	2	797000	NO SUSPENDED ITEMS
1141	23 091018A0010	2	309000	2	2	901000	NO SUSPENDED ITEMS
1142	23 091018A0010	3	18000	3	2	596000	NO SUSPENDED ITEMS
1143	23 091018A0010	3	38000	3	3	21000	NO SUSPENDED ITEMS
1144	23 091018A0010	3	240000	3	3	132000	NO SUSPENDED ITEMS
1145	23 091018A0010	3	240000	3	3	148000	NO SUSPENDED ITEMS
1146	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1147	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1148	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1149	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1150	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1151	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1152	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1153	23 091018A0010	3	240000	3	3	532000	NO SUSPENDED ITEMS
1154	23 091018A0010	3	240000	3	3	532000	

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM #	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
3145	23 0910180010	2	2	39000	131000	NO SUSPENDED ITEMS	
3146	23 0910180010	3	3	108000	154000	NO SUSPENDED ITEMS	
3147	23 0910180010	3	3	127000	176000	NO SUSPENDED ITEMS	
3148	23 0910180010	2	2	8000	9000	NO SUSPENDED ITEMS	
3149	23 0910180010	2	2	16000	21000	NO SUSPENDED ITEMS	
3150	23 0910180010	2	2	118000	124000	NO SUSPENDED ITEMS	
3151	23 0910180010	2	2	62000	107000	NO SUSPENDED ITEMS	
3152	23 0910180010	2	2	228000	278000	NO SUSPENDED ITEMS	
3153	23 0910180010	2	2	651000	546000	NO SUSPENDED ITEMS	
3154	23 0910180010	2	2	18000	30700	NO SUSPENDED ITEMS	
3155	19 0902280010	4	2	180000	244000	250000	250000
3157	19 0902280010	48	14	137000	147000	ALL VALUES -	250000
				162000	191000	150000	150000
				236000	240000	204000	204000
				248000	240000	245000	245000
3158	19 0902280010	51	25	128000	153000	177000	180000
				198000	190000	195000	199000
				199000	200000	207000	210000
				210000	211000	215000	223000
				228000	235000	248000	226000
3159	19 0902280010	54	10	138000	180000	193000	249000
				215000	270000	236000	200000
				161000	163000	170300	250000
3160	19 0902280010	54	20	185000	187000	178000	178000
				204000	206000	209000	204000
				219000	227000	230000	211000
				233000	237000	245000	233000
				248000	248000	250000	247000
3161	19 0902280010	55	5	188000	196000	234000	246000
3162	19 0902280010	11	3	171000	171000	235000	250000
3163	19 0902280010	5	3	171000	179000	190000	250000
3164	19 0902280010	2	2	197000	218000	250000	250000
3165	19 0902280010	5	3	172000	174000	249000	250000
3167	19 0902280010	49	33	105000	110000	115000	143000
				146000	150000	153000	162000
				171000	176000	180000	187000
				184000	190000	202000	215000
				214000	216000	223000	228000
				233000	234000	236000	229000
				245000	248000	250000	238000

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM OFF DESCRIPTION	SAMPLE NUMBER	SIZE	FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
3167	19 05902960010	48	20	139000	139000	153000	153000	158000	ALL VALUES =	250000	
				160000	171000	171000	175000	177000			
				178000	183000	184000	186000	187000			
				188000	191000	197000	200000	211000			
3168	19 05902960010	48	12	211000	216000	218000	222000	229000	ALL VALUES =	250000	
				230000	238000	247000	248000	200000			
				175000	177000	177000	200000	237000			
				214000	218000	221000	230000				
3169	19 05902960010	48	30	242000	248000	121000	123000	137000	ALL VALUES =	250000	
				96000	120000	144000	149000	153000			
				139000	144000	163000	164000	168000			
				159000	170000	176000	178000	182500			
3170	19 05902960010	48	8	183000	197000	197000	203000	206000	ALL VALUES =	250000	
				209000	210000	215000	220000	223000			
				161000	170000	180000	194000	230000			
				241000	241000	290000	211000				
3171	19 05902960010	13	4	178000	202000	207000	210000		ALL VALUES =	250000	
3172	19 05902960010	8	3	169000	182000	192000	210000	240000	250000	250000	
				159000	190000	203000					
3173	19 05902960010	8	5	74000	95000	103000	110000	115000	ALL VALUES =	250000	
				119000	126000	128000	140000	140000			
				140000	162000	166000	166000	169800			
				150000	154000	156000	160000	163000			
3174	19 05902960010	53	33	172300	174000	175000	176000	189000	ALL VALUES =	250000	
				189000	190800	196000	200000	223000			
				234000	240800	247000	190000	165000			
				109000	127000	136000	180000	193000			
3175	19 05902960010	53	23	174000	178000	181000	211000	210000	ALL VALUES =	250000	
				194000	204000	211000	228000	238000			
				220000	220000	226000	247000	134000			
				241000	244000	247000	130000	153000			
3176	19 05902960010	53	13	101000	113000	139000	148000	153000	ALL VALUES =	250000	
				135000	137000	139000	168000	172000			
				164000	169000	169000	187000	193000			
				177000	183000	187000	214000	219000			
3177	19 05902960010	53	13	208000	212000	213000	237000	244000	ALL VALUES =	250000	
				220000	223000	234000	240000	240000			

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF DESCRIPTION	SAMPLE NUMBER SIZE	FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION				
3177 19 05902860010	52	41	78000	111000	128000	132000	1340000	ALL VALUES =	250000			
			141000	142000	142000	150000	1560000					
			161000	166000	171000	182000	1900000					
			191000	191000	197000	197000	1980000					
			199000	201000	212000	214000	2190000					
			221000	222000	223000	223000	2260000					
			229000	229000	230000	235000	2380000					
			240000	240000	248000	248000	2490000					
3178 19 05902860010	11	4	79000	85000	126000	175000	1810000	250000	250000	250000	250000	
			237000					250000	250000	250000	250000	
3179 19 05902860010	11	6	149000	166000	176000	183000	2200000	250000	250000	250000	250000	
3180 19 05902860010	11	3	239000	228000	249000	216000	2480000	ALL VALUES =	250000	250000	250000	
3181 19 05902860010	10	4	135000	174000	189000			250000	250000	250000	250000	
			166000									
3182 19 05902860010	10	7	112000	134000	151000	161000	2410000	250000	250000	250000	250000	
			246000	249000								
3193 19 05902860010	10	3	160000	225000	226000			250000	250000	250000	250000	
3184 19 05902960010	47	34	91000	100000	108000	111000	1180000	ALL VALUES =	250000			
			122000	134000	142000	142000	1430000					
			143000	143000	146000	153000	1620000					
			162000	163000	168000	173000	1760000					
			179000	180000	182000	182000	1940000					
			199000	200000	208000	208000	2080000					
			224000	228000	236000	244000	2480000					
3185 19 05902960010	47	24	117000	126000	131000	154000	1600000	ALL VALUES =	250000			
			169000	173000	179000	180000	1860000					
			189000	190000	194000	194000	2000000					
			218000	231000	239000	240000	2440000					
			245000	248000	248000	249000	2490000					
3186 19 05902960010	47	27	101000	113000	119000	123000	1360000	ALL VALUES =	250000			
			138000	141000	147000	147000	1500000					
			151000	161000	163000	165000	1740000					
			189000	192000	193000	199000	2060000					
			211000	213000	227000	273000	2770000					
			241000	245000								

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
								ALL VALUES *		
1147 19 0500290010	44	29	57000	84000	100000	106000	106000	106000	250000	
			112000	113000	117000	124000	125000	125000		
			126000	128000	142000	148000	153000	153000		
			154000	177000	180000	187000	197000	197000		
			211000	216000	223000	227000	237000	237000		
			240000	249000	249000	248000				
1148 19 0500290010	13	7	143000	173000	210000	214000	216000	216000	250000	250000
			223000	248000				250000	250000	250000
1149 19 0500290010	13	10	111000	155000	179000	190000	195000	195000	250000	250000
			196000	212000	226000	233000	244000	244000		
1150 19 0500290010	17	6	124000	159000	203000	223000	232000	232000	250000	250000
			249000					250000	250000	250000
1151 19 0500290010	13	6	149000	171000	183000	188000	213000	213000	250000	250000
			228000					250000	250000	250000
1152 19 0500290010	13	11	103000	138000	142000	142000	162000	162000	250000	250000
			169000	185000	190000	207000	213000	213000		
			246000							
1153 19 0500290010	13	4	176000	194000	200000	222000	238000	238000	250000	250000

2424

203

2490000
2500000

249000
250000

249000
250000

249000
249000

249000
249000
250000

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LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITH-OUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM OR DESIGNATION	SAMPLE NUMBER SIZE	ALL VALUES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
11-A 15 (54000001)	450	222	94000	120000
			121000	132000
			137000	139000
			143000	146000
			147000	153000
			153000	158000
			159000	160000
			161000	162000
			163000	166000
			168000	170000
			170000	171000
			171000	175000
			175000	177000
			177000	178000
			178000	180000
			180000	182000
			182000	184000
			185000	186000
			188000	190000
			190000	192000
			192000	195000
			194000	198000
			197000	200000
			199000	203000
			202000	206000
			204000	209000
			206000	210000
			209000	211000
			211000	215000
			214000	218000
			216000	221000
			219000	223000
			221000	228000
			225000	230000
			229000	233000
			230000	235000
			231000	236000
			234000	240000
			237000	242000
			240000	245000
			244000	248000
			246000	249000
			248000	250000
			250000	

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF DESCRIPTION SAMPLE SIZE NUMBER FAILED					CYCLES AT FAILURE			CYCLES AT SUSPENSION			
3201	17	19702005010	3	3	83000	89000	110000	•	NO	SUSPENDED ITEMS	
3202	17	19702005010	3	3	82000	127000	137000	•	NO	SUSPENDED ITEMS	
3203	17	19702005010	2	2	136000	167000	•	•	NO	SUSPENDED ITEMS	
3204	17	19702005010	2	2	237000	247000	•	•	NO	SUSPENDED ITEMS	
3205	17	19702005010	20	20	122000	145000	161000	163000	•	NO	SUSPENDED ITEMS
					163000	184000	194000	194000	•	NO	SUSPENDED ITEMS
					195000	199000	204000	205000	•	NO	SUSPENDED ITEMS
					212000	212000	212000	214000	•	NO	SUSPENDED ITEMS
3206	17	19702005010	14	14	455000	478000	707000	734000	•	NO	SUSPENDED ITEMS
					841000	867000	884000	915000	•	NO	SUSPENDED ITEMS
					908000	1000000	1011000	1018000	•	NO	SUSPENDED ITEMS
					1270	1270	1300	1400	•	NO	SUSPENDED ITEMS
					1520	1610	1650	1920	•	NO	SUSPENDED ITEMS
					183471	191682	193906	200997	•	NO	SUSPENDED ITEMS
					205504	•	•	•	•	NO	SUSPENDED ITEMS
					932346	941106	997016	1242870	•	NO	SUSPENDED ITEMS
					1400440	•	•	•	•	NO	SUSPENDED ITEMS
3407	14	09001005090	6	6	28070	28245	32305	33215	•	NO	SUSPENDED ITEMS
					36815	•	•	360150	•	NO	SUSPENDED ITEMS
3403	14	09001005090	6	6	23695	23940	24710	25025	•	NO	SUSPENDED ITEMS
					31045	•	•	266780	•	NO	SUSPENDED ITEMS
3404	14	09001005090	6	6	21070	22005	23075	27125	•	NO	SUSPENDED ITEMS
					30555	•	•	292250	•	NO	SUSPENDED ITEMS
3405	14	09001005090	4	4	23660	27040	27100	29055	•	NO	SUSPENDED ITEMS
					31272	•	•	293000	•	NO	SUSPENDED ITEMS
3406	14	09001005090	6	6	26107	26757	29310	32904	•	NO	SUSPENDED ITEMS
					35556	•	•	330100	•	NO	SUSPENDED ITEMS
3407	14	09001005090	4	4	88191	88366	101631	101631	•	NO	SUSPENDED ITEMS
					119828	•	•	1197930	•	NO	SUSPENDED ITEMS
3408	14	09001005090	4	4	24123	24123	24158	24294	•	NO	SUSPENDED ITEMS
					30593	•	•	293230	•	NO	SUSPENDED ITEMS
3409	14	09001005090	4	4	19825	21124	21124	23375	•	NO	SUSPENDED ITEMS
					24220	•	•	235850	•	NO	SUSPENDED ITEMS
3410	14	09001005090	6	6	87640	88250	91560	94710	•	NO	SUSPENDED ITEMS
					98053	•	•	947100	•	NO	SUSPENDED ITEMS
3411	14	09001005090	4	4	66710	70245	72005	73000	•	NO	SUSPENDED ITEMS
					82005	•	•	791700	•	NO	SUSPENDED ITEMS
3412	14	09001005090	6	6	68775	73020	74585	80325	•	NO	SUSPENDED ITEMS
					91045	•	•	896000	•	NO	SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF DESCRIPTION SAMPLE NUMBER	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
3413 14 00001005050	76300	91005	93103	88376	91331	NO	SUSPENDED ITEMS	
3414 14 00001005050	99767	74326	74326	77641	85600	NO	SUSPENDED ITEMS	
3415 14 00001005050	90353	177439	212622	224931	237940	NO	SUSPENDED ITEMS	
3416 14 00001005050	240654	63148	74462	74370	828040	NO	SUSPENDED ITEMS	
3417 14 00001005050	60243	62407	64953	64493	704930	NO	SUSPENDED ITEMS	
3418 14 00001005050	60391	52710	56105	54415	602350	NO	SUSPENDED ITEMS	
3419 14 00001005050	62372	49175	49175	40409	404000	NO	SUSPENDED ITEMS	
3420 14 00001005050	84092	141600	143115	151900	1611750	NO	SUSPENDED ITEMS	
3421 14 00001005050	51415	77105	77420	70120	925750	NO	SUSPENDED ITEMS	
3422 14 00001005050	71330	93975	99540	100765	1044000	NO	SUSPENDED ITEMS	
3423 14 00001005050	44555	114135	115500	122220	1260750	NO	SUSPENDED ITEMS	
3424 14 00001005050	55265	134400	142415	143955	1450400	NO	SUSPENDED ITEMS	
3425 14 00001005050	140245	346070	613900	622200	6740050	NO	SUSPENDED ITEMS	
3426 14 00001005050	173215	91315	91315	91315	904600	NO	SUSPENDED ITEMS	
3427 14 00001005050	75705	62475	65030	71575	717050	NO	SUSPENDED ITEMS	
3428 14 00001005050	92575	174635	137220	163405	1653500	NO	SUSPENDED ITEMS	
3429 14 00001005050	79520	112000	117145	125620	1334200	NO	SUSPENDED ITEMS	
3430 14 00001005050	119200	90825	92750	93065	950600	NO	SUSPENDED ITEMS	
3431 14 00001005050	117405	70060	83265	87900	879000	NO	SUSPENDED ITEMS	
3432 14 00001005050	165950	65005	70405	81305	822150	NO	SUSPENDED ITEMS	
	103040							
	137060							
	75075							
	100005							
	67445							
	97015							
	65555							
	94105							

LISTED NUMBERS ON CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	OFF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE	CYCLES AT SUSPENSION
1413	14 00001865050	6	6	112000	114600
1434	14 00001865050	6	6	101700	113000
1415	14 00001865050	6	6	126305	136015
1416	14 00001865050	6	6	83405	100135
1417	14 00001865050	6	6	76415	79450
1418	14 00001865050	6	6	130265	144000
1419	14 00001865050	6	6	108375	115700
1440	14 00001865050	6	6	139475	150200
1441	14 00001865050	6	6	100520	103405
1442	14 00001865050	6	6	123130	124100
1443	17 19702865070	10	10	103	103
1444	17 19702865070	10	10	113	113
1445	17 19702865070	10	10	137	140
1446	17 19702865070	10	10	104	111
1447	17 19702865080	20	20	129	131
1448	17 19702865080	20	20	77	114
1449	17 19702865080	20	20	121	124
1450	17 19702865080	20	20	110	110
1451	17 19702865080	20	20	163	165
1452	17 19702865080	20	20	189	200
1453	17 19702865080	20	20	215	240
1454	17 19702865080	20	20	374340	413700
1455	17 19702865080	20	20	4023400	4918410
1456	17 19702865080	20	20	10000	10000
1457	17 19702865080	20	20	20000	20000
1458	17 19702865080	20	20	114000	121000
1459	17 19702865080	20	20	190000	161000
1460	17 19702865080	20	20	332046	413700
1461	17 19702865080	20	20	2023410	4918410
1462	17 19702865080	20	20	15000	10000
1463	17 19702865080	20	20	20000	20000
1464	17 19702865080	20	20	114000	121000
1465	17 19702865080	20	20	190000	161000
1466	17 19702865080	20	20	332046	413700
1467	17 19702865080	20	20	2023410	4918410
1468	17 19702865080	20	20	15000	10000
1469	17 19702865080	20	20	20000	20000
1470	17 19702865080	20	20	114000	121000
1471	17 19702865080	20	20	190000	161000
1472	17 19702865080	20	20	332046	413700
1473	17 19702865080	20	20	2023410	4918410
1474	17 19702865080	20	20	15000	10000
1475	17 19702865080	20	20	20000	20000
1476	17 19702865080	20	20	114000	121000
1477	17 19702865080	20	20	190000	161000
1478	17 19702865080	20	20	332046	413700
1479	17 19702865080	20	20	2023410	4918410
1480	17 19702865080	20	20	15000	10000
1481	17 19702865080	20	20	20000	20000
1482	17 19702865080	20	20	114000	121000
1483	17 19702865080	20	20	190000	161000
1484	17 19702865080	20	20	332046	413700
1485	17 19702865080	20	20	2023410	4918410
1486	17 19702865080	20	20	15000	10000
1487	17 19702865080	20	20	20000	20000
1488	17 19702865080	20	20	114000	121000
1489	17 19702865080	20	20	190000	161000
1490	17 19702865080	20	20	332046	413700
1491	17 19702865080	20	20	2023410	4918410
1492	17 19702865080	20	20	15000	10000
1493	17 19702865080	20	20	20000	20000
1494	17 19702865080	20	20	114000	121000
1495	17 19702865080	20	20	190000	161000
1496	17 19702865080	20	20	332046	413700
1497	17 19702865080	20	20	2023410	4918410
1498	17 19702865080	20	20	15000	10000
1499	17 19702865080	20	20	20000	20000
1500	17 19702865080	20	20	114000	121000

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COLLECTION

ITEM	OFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION		
1657	4	30006855830	11	1	377000	425000	445000	493000	523000	NO SUSPENDED ITEMS
					606000	1012000	1167000	1250000	2082000	
1653	4	10006855830	10	10	2616000	652000	690000	782000	805000	NO SUSPENDED ITEMS
					134000	1040000	1110000	1114000	1427000	
1654	4	30006855830	10	10	1076000	714000	960000	1064000	1152000	NO SUSPENDED ITEMS
					643000	1563000	1771000	1941000	2481000	
1655	4	30006855830	10	10	1469000	547000	650000	734000	745000	NO SUSPENDED ITEMS
					317000	846700	846000	890000	1224000	
1656	4	10006855830	10	10	378000	391000	494000	513000	608000	NO SUSPENDED ITEMS
					697000	1013000	1074000	1161000	1483000	
1657	4	30006855830	10	10	406000	642000	667000	824000	842000	NO SUSPENDED ITEMS
					946000	1057000	1133000	1943000	2505000	
1658	4	30006855830	10	10	141000	342000	154000	160000	169000	NO SUSPENDED ITEMS
					328000	383000	498000	505000	698000	
1659	4	10006855830	10	10	217000	252700	430000	506000	526000	NO SUSPENDED ITEMS
					368000	391000	430000	449000	650000	
1660	4	30006855830	10	10	185000	252000	263000	353000	405000	NO SUSPENDED ITEMS
					543000	567000	587000	651000	704000	
1661	4	30006855830	10	10	210000	225000	250000	263000	275000	NO SUSPENDED ITEMS
					317000	399000	516000	811000	830000	
1662	4	10006855830	10	10	118000	113000	129000	138000	294000	NO SUSPENDED ITEMS
					272000	300000	320000	422000	434000	
1663	4	30006855830	10	10	223000	242000	261000	272000	276000	NO SUSPENDED ITEMS
					316000	323000	323000	378000	386000	
1664	22	03202055010	4	4	48460	57630	60020	61300		NO SUSPENDED ITEMS
1665	22	03202055010	3	3	26270	28480	34830			NO SUSPENDED ITEMS
1666	22	03202055010	3	3	210650	235150	318700			NO SUSPENDED ITEMS
1667	22	03202055010	4	4	47090	53660	56100	58510		NO SUSPENDED ITEMS
1668	22	03202055010	4	4	23300	26090	30340	33410		NO SUSPENDED ITEMS
1669	22	03202055010	4	4	186860	199240	202010	209190		NO SUSPENDED ITEMS
1670	22	03202055010	4	4	40400	42540	42610	43170		NO SUSPENDED ITEMS
1671	22	03202055010	4	4	32590	37190	37820	47550		NO SUSPENDED ITEMS
1672	22	03202055010	4	4	240660	285700	298630	347680		NO SUSPENDED ITEMS
1673	22	03202055010	4	4	307900	403900	542180	610410		NO SUSPENDED ITEMS
1674	22	03202055010	4	4	387740	393450	394040	544640	5486100	NO SUSPENDED ITEMS
					598740					
1675	22	03202055010	4	4	26270	28480	34830			NO SUSPENDED ITEMS
1676	22	03202055010	4	4	97330	99550	99570	100250		NO SUSPENDED ITEMS
1677	22	03202055010	4	4	114110	121110	202430	206170		NO SUSPENDED ITEMS

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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
1020	22 03202055010	4	4	177000	180210	190500	195400	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1021	22 03202055010	4	4	145000	38330	50470	51770	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1022	22 03202055010	4	4	48120	48370	49020	62900	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1023	22 03202055010	4	4	92400	154400	162630	202370	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1024	22 03202055010	4	4	178440	181710	182810	184190	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1025	4 30000855010	20	20	393000	699000	776000	796000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1026	4 30000855010	20	20	1147000	1147000	1190000	1220000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1027	4 30000855010	20	20	1370000	1474000	1510000	1595000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1028	4 30000855010	20	20	1726000	1796000	1796000	2242000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1029	4 30000855010	20	20	2292000	3993000	4013000	4130000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1030	4 30000855010	20	20	4901000	5093000	5170000	5343000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1031	4 30000855010	20	20	6521000	6957000	7331000	7422000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1032	4 30000855010	20	20	8236000	8239000	11844000	12493000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1033	4 30000855010	20	20	2224000	2464000	2482000	2706000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1034	4 30000855010	20	20	2882000	3096000	3450000	4162000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1035	4 30000855010	20	20	12090000	13093000	13204000	13631000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1036	4 30000855010	20	20	17967000	22119000	23178000	24890000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1037	4 30000855010	20	20	14082000	33740000	43674000	89681000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1038	4 30000855010	20	20	100725000	106442000	117843000	118000000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1039	4 30000855010	20	20	317912000	53962000	91034000	183979000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1040	4 30000855010	20	20	474250000	53962000	91034000	183979000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1041	4 30000855010	20	20	499437000	516414000	1505000	1544000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1042	4 30000855010	20	20	1158000	1704000	1905000	1954000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1043	4 30000855010	20	20	2225000	2467000	2709000	3139000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1044	4 30000855010	20	20	4972000	5700000	6594000	9014000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1045	4 30000855010	20	20	3312000	12670000	23186000	24456000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1046	4 30000855010	20	20	13260000	18783000	22354000	28510000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1047	4 30000855010	20	20	14540000	40983000	47717000	56163000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1048	4 30000855010	20	20	39360000	1330000	1704000	2028000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1049	4 30000855010	20	20	597000	3302000	6026000	6666000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1050	4 30000855010	20	20	1138000	3442000	3903000	4334000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1051	4 30000855010	20	20	2668000	5447000	5614000	5656000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1052	4 30000855010	20	20	4338000	1144000	1451000	1806000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1053	4 30000855010	20	20	976000	2246000	2569000	2899000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1054	4 30000855010	20	20	7061000	1360000	1384000	1555000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1055	4 30000855010	20	20	2632000	5830000	5920000	7664000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1056	4 30000855010	20	20	1560000	1832000	6092000	7895000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
1057	4 30000855010	20	20	10900000	15438000	21517000	28917000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS

ITEM	DESCRIPTION	SAMPLE	NUMBERS	CYCLES AT FAILURE			CYCLES AT FAILURE			CYCLES AT SUSPENSION		
4014	6 030202055010	10	10	1524000	1673000	1997300	2103000	2599000	NO SUSPENDED ITEMS			
4015	6 030202055010	10	10	2534000	2828000	3616000	4224000	5443000	NO SUSPENDED ITEMS			
4016	6 030202055010	10	10	1778000	1092000	1121000	3628000	4545000	NO SUSPENDED ITEMS			
4017	6 030202055010	10	10	5208000	7605000	8118000	9470000	11716000	NO SUSPENDED ITEMS			
4018	6 030202055010	10	10	1924000	4124000	5231000	5444000	5592000	NO SUSPENDED ITEMS			
4019	6 030202055010	10	10	6210000	6842000	7680000	8076000	10114000	NO SUSPENDED ITEMS			
4020	6 030202055010	10	10	4810000	7470000	8330000	1224000	2041000	NO SUSPENDED ITEMS			
4021	6 030202055010	10	10	2414000	1441000	4240000	4371000	5776000	NO SUSPENDED ITEMS			
4022	6 030202055010	10	10	540000	1255000	1302000	1462000	1497000	NO SUSPENDED ITEMS			
4023	6 030202055010	10	10	1801000	1879000	2197000	2673000	4097000	NO SUSPENDED ITEMS			
4024	6 030202055010	10	10	772000	2400000	928000	932000	1035000	NO SUSPENDED ITEMS			
4025	6 030202055010	10	10	1045000	1051000	1314000	2340000	2403000	NO SUSPENDED ITEMS			
4026	6 030202055010	10	10	938000	969000	1592000	1845000	1875000	NO SUSPENDED ITEMS			
4027	6 030202055010	4	4	1915000	1940000	2235000	3008000	6748000	NO SUSPENDED ITEMS			
4028	6 030202055010	4	4	217900	1827370	2064240	2143430		NO SUSPENDED ITEMS			
4029	6 030202055010	4	4	1151800	1587980	1768730	1949860		NO SUSPENDED ITEMS			
4030	6 030202055010	4	4	1562890	1767900	2121510	2603550		NO SUSPENDED ITEMS			
4031	6 030202055010	4	4	696690	788620	1139140	1454940		NO SUSPENDED ITEMS			
4032	6 030202055010	4	4	6000	6206	6340	6790	7320	NO SUSPENDED ITEMS			
4033	6 030202055010	3	3	15600	15800	19400			NO SUSPENDED ITEMS			
4034	6 030202055010	3	3	26107	35200	39103			NO SUSPENDED ITEMS			
4035	6 030202055010	3	3	86500	89400	130500			NO SUSPENDED ITEMS			
4036	6 030202055010	3	3	521780	775200	779100			NO SUSPENDED ITEMS			
4037	6 030202055010	3	3	49007	68400	66200			NO SUSPENDED ITEMS			
4038	6 030202055010	3	3	127707	134500	164200			NO SUSPENDED ITEMS			
4039	6 030202055010	3	3	592300	645000	761900			NO SUSPENDED ITEMS			
4040	6 030202055010	3	3	20000	21700	25600			NO SUSPENDED ITEMS			
4041	6 030202055010	3	3	69000	83600	114700			NO SUSPENDED ITEMS			
4042	6 030202055010	2	2	129000	131400				NO SUSPENDED ITEMS			
4043	6 030202055010	3	3	3080	31000				NO SUSPENDED ITEMS			
4044	6 030202055010	3	3	114000	258000	300000			NO SUSPENDED ITEMS			
4045	6 030202055010	3	3	30000	258000				NO SUSPENDED ITEMS			
4046	6 030202055010	3	3	4000	4000	7000			NO SUSPENDED ITEMS			
4047	6 030202055010	3	3	43000	63000	64000			NO SUSPENDED ITEMS			
4048	6 030202055010	2	2	593000	767000	960000			NO SUSPENDED ITEMS			
4049	6 030202055010	3	3	416000	614000				NO SUSPENDED ITEMS</			

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION (IF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF OF DESCRIPTION				SAMPLE SIZE		NUMBER CALLED		CYCLES AT FAILURE		CYCLES AT SUSPENSION	
4021	6	03002021010	3	3	140000	151000	172000			NO	SUSPENDED ITEMS
4022	6	03002021010	3	3	201000	283000	408000			NO	SUSPENDED ITEMS
4023	6	03002021010	3	3	328000	366000	458000			NO	SUSPENDED ITEMS
4024	6	03002021010	2	2	927000	1395000				NO	SUSPENDED ITEMS
4025	6	03002021010	3	3	430000	468000	816000			NO	SUSPENDED ITEMS
4026	6	03002021010	3	3	387000	619000	1015000			NO	SUSPENDED ITEMS
4027	6	03002021010	7	7	52000	57000	90000	616000		NO	SUSPENDED ITEMS
4028	6	03002021010	7	7	63000	70000	151000	172000		NO	SUSPENDED ITEMS
4029	6	03002021010	6	6	199000	248000	328000	406000		NO	SUSPENDED ITEMS
4030	6	03002021010	6	6	201000	283000	328000	406000		NO	SUSPENDED ITEMS
4031	6	03002021010	6	6	459000	430000	548000	619000		NO	SUSPENDED ITEMS
4032	6	03002021010	6	6	387000	1015000	1395000			NO	SUSPENDED ITEMS
4033	6	03002021010	6	6	328000	37000	34600	50500		NO	SUSPENDED ITEMS
4034	6	03002021010	6	6	63200	66700	161200			NO	SUSPENDED ITEMS
4035	6	03002021010	6	6	374500	423600	499300	681400	10676300	NO	SUSPENDED ITEMS
4036	6	03002021010	6	6	2999000					NO	SUSPENDED ITEMS
4037	6	03002021010	6	6	39500	43800	47900			NO	SUSPENDED ITEMS
4038	6	03002021010	6	6	23500	69900	84700			NO	SUSPENDED ITEMS
4039	6	03002021010	6	6	75100	127500	201400			NO	SUSPENDED ITEMS
4040	6	03002021010	6	6	279700	526100	766700			NO	SUSPENDED ITEMS
4041	6	03002021010	6	6	819700	866900	1108200			NO	SUSPENDED ITEMS
4042	6	03002021010	6	6	26500	36700	41800			NO	SUSPENDED ITEMS
4043	6	03002021010	6	6	47200	61400	83100			NO	SUSPENDED ITEMS
4044	6	03002021010	6	6	52300	88400	118800			NO	SUSPENDED ITEMS
4045	6	03002021010	6	6	207000	269500	299100			NO	SUSPENDED ITEMS
4046	6	03002021010	6	6	38100	52600	53100			NO	SUSPENDED ITEMS
4047	6	03002021010	6	6	43300	53100	85300			NO	SUSPENDED ITEMS
4048	6	03002021010	6	6	115200	121700	148300			NO	SUSPENDED ITEMS
4049	6	03002021010	6	6	126600	175100	367600	523400		NO	SUSPENDED ITEMS
4050	6	03002021010	6	6	33200	37300	41000			NO	SUSPENDED ITEMS
4051	6	03002021010	6	6	41800	43300	58500			NO	SUSPENDED ITEMS
4052	6	03002021010	6	6	45700	75000	101900			NO	SUSPENDED ITEMS
4053	6	03002021010	6	6	241500	311100	460900			NO	SUSPENDED ITEMS
4054	6	03002021010	6	6	170500	302000	714300			NO	SUSPENDED ITEMS
4055	6	03002021010	6	6	746800	979900	2062000			NO	SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM #	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION	
4044	2 03102021010	12	12	26500	31200	36700	37100	38100	NO SUSPENDED ITEMS
				39500	41000	41800	41800	47900	
4045	2 03102021010	12	12	52600	51100	43500	43500	47200	NO SUSPENDED ITEMS
				21500	41800	41400	49900	83100	
4046	2 03102021010	12	12	53100	98500	12000	75100	88400	NO SUSPENDED ITEMS
				84700	49300	118000	121700	127500	
4047	2 03102021010	12	12	101900	115200	207000	241500	269500	NO SUSPENDED ITEMS
				144300	201400	311100	367600	460900	
4048	2 03102021010	12	12	124600	175100	207000	241500	269500	NO SUSPENDED ITEMS
				275700	299100	311100	367600	460900	
4049	2 03102021010	12	12	523400	526100	768700	714100	813700	NO SUSPENDED ITEMS
				170500	390200	563900	1276300	2080400	
4050	2 03102021010	12	12	466900	1104200	1185800	1276300	2080400	NO SUSPENDED ITEMS
				2505300	2942000	2674500			
4051	2 03102021010	12	12	49000	402000	109000	109000		NO SUSPENDED ITEMS
4052	2 03102021010	12	12	124000	152000	182000	182000		NO SUSPENDED ITEMS
4053	2 03102021010	12	12	202000	279000	357000	357000		NO SUSPENDED ITEMS
4054	2 03102021010	12	12	504000	618000	643000	643000		NO SUSPENDED ITEMS
4055	2 03102021010	12	12	147000	149000				NO SUSPENDED ITEMS
4056	2 03102021010	12	12	499000	402000	679000	679000		NO SUSPENDED ITEMS
4057	2 03102021010	12	12	644000	1079000	522000	522000		NO SUSPENDED ITEMS
4058	2 03102021010	12	12	280000	460000	87000	87000		NO SUSPENDED ITEMS
4059	2 03102021010	12	12	84000	66300	67000	67000		NO SUSPENDED ITEMS
4060	2 03102021010	12	12	53000	61000	67000	67000		NO SUSPENDED ITEMS
4061	2 03102021010	12	12	71000	73000	76000	76000		NO SUSPENDED ITEMS
4062	2 03102021010	12	12	184000	199000	207000	207000		NO SUSPENDED ITEMS
4063	2 03102021010	12	12	234000	246000	255000	273000		NO SUSPENDED ITEMS
4064	2 03102021010	12	12	457000	490000	585000	592000		NO SUSPENDED ITEMS
4065	2 03102021010	12	12	641000	663000	667000	602000		NO SUSPENDED ITEMS
4066	2 03102021010	12	12	180500	201200				NO SUSPENDED ITEMS
4067	2 03102021010	12	12	180400	197300				NO SUSPENDED ITEMS
4068	2 03102021010	12	12	45100	63600	83000	83000		NO SUSPENDED ITEMS
4069	2 03102021010	12	12	45100	63600	83000	83000		NO SUSPENDED ITEMS
4070	2 03102021010	12	12	92700	105700	132400	159900		NO SUSPENDED ITEMS
4071	2 03102021010	12	12	99100	84200	61400	62100		NO SUSPENDED ITEMS
4072	2 03102021010	12	12	50800	60200				NO SUSPENDED ITEMS
4073	2 03102021010	12	12	63700	42900	46200	46500		NO SUSPENDED ITEMS
4074	2 03102021010	12	12	28800					NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	OFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE	CYCLES AT FAILURE	CYCLES AT FAILURE	CYCLES AT SUSPENSION
4074	58	04002020010	4	4	37000	41000	45200	50500
4080	58	04002020010	4	4	58600	34200	34300	43000
4081	58	04002020010	4	4	30200	24400	24600	27000
4082	58	04002020010	4	4	40000			
4083	58	04002020010	4	4	17000	21400	23100	24700
4084	58	04002020010	4	4	25600	27500	30900	35700
4085	58	04002020010	4	4	69200			
4086	58	04002020010	4	4	24700	24700	33500	34400
4087	58	04002020010	4	4	87000	94000	106000	104000
4088	58	04002020010	4	4	105000	106000	112000	115000
4089	58	04002020010	4	4	121000	121000	122000	123000
4090	58	04002020010	4	4	126000	128000	130000	139000
4091	58	04002020010	4	4	90000	114000	115000	119000
4092	58	04002020010	4	4	124000	128000	131000	133000
4093	58	04002020010	4	4	3416	3483	4548	5524
4094	58	04002020010	4	4	10000	11000	13000	14000
4095	58	04002020010	4	4	82000	92000	96000	104000
4096	58	04002020010	4	4	114000	13000	205000	294000
4097	58	04002020010	4	4	3934	4055	4360	7325
4098	58	04002020010	4	4	9000	9000	15000	16000
4099	58	04002020010	4	4	254000	499000	501000	535000
4100	58	04002020010	4	4	5000	8000	8000	8000
4101	58	04002020010	4	4	54000	55000	56000	65000
4102	58	04002020010	4	4	125000	431000	436000	457000
4103	58	04002020010	4	4	32000	35000	42300	46000
4104	58	04002020010	4	4	43000	85000	91000	141000
4105	58	04002020010	4	4	178000	270000	509000	619000
4106	58	04002020010	4	4	4000	4595	5000	5000
4107	58	04002020010	4	4	4996	5638	11185	14000
4108	58	04002020010	4	4	10000	11000	57000	62000
4109	58	04002020010	4	4	38000	54000		
4110	58	04002020010	4	4	214000	253000	320000	530000
4111	58	04002020010	4	4	2000	5000	5000	5000
4112	58	04002020010	4	4	19000	17000	48000	50000
4113	58	04002020010	4	4	250000	268000	274000	294000
4114	58	04002020010	4	4	4304	4554	5208	59000
4115	58	04002020010	4	4	5049	5925	6129	8000
4116	58	04002020010	4	4	7000	7000	8000	8000
4117	58	04002020010	4	4	8000	9000	11000	13000

CONFIDENTIAL

CYCLES AT FAILURE				CYCLES AT SUSPENSION			
ITEM	NO	SUSPENDED	ITEMS	NO	SUSPENDED	ITEMS	ITEMS
101	10000	21000	22000	100	SUSPENDED	ITEMS	100
102	10000	21000	22000	100	SUSPENDED	ITEMS	100
103	10000	21000	22000	100	SUSPENDED	ITEMS	100
104	10000	21000	22000	100	SUSPENDED	ITEMS	100
105	10000	21000	22000	100	SUSPENDED	ITEMS	100
106	10000	21000	22000	100	SUSPENDED	ITEMS	100
107	10000	21000	22000	100	SUSPENDED	ITEMS	100
108	10000	21000	22000	100	SUSPENDED	ITEMS	100
109	10000	21000	22000	100	SUSPENDED	ITEMS	100
110	10000	21000	22000	100	SUSPENDED	ITEMS	100
111	10000	21000	22000	100	SUSPENDED	ITEMS	100
112	10000	21000	22000	100	SUSPENDED	ITEMS	100
113	10000	21000	22000	100	SUSPENDED	ITEMS	100
114	10000	21000	22000	100	SUSPENDED	ITEMS	100
115	10000	21000	22000	100	SUSPENDED	ITEMS	100
116	10000	21000	22000	100	SUSPENDED	ITEMS	100
117	10000	21000	22000	100	SUSPENDED	ITEMS	100
118	10000	21000	22000	100	SUSPENDED	ITEMS	100
119	10000	21000	22000	100	SUSPENDED	ITEMS	100
120	10000	21000	22000	100	SUSPENDED	ITEMS	100
121	10000	21000	22000	100	SUSPENDED	ITEMS	100
122	10000	21000	22000	100	SUSPENDED	ITEMS	100
123	10000	21000	22000	100	SUSPENDED	ITEMS	100
124	10000	21000	22000	100	SUSPENDED	ITEMS	100
125	10000	21000	22000	100	SUSPENDED	ITEMS	100
126	10000	21000	22000	100	SUSPENDED	ITEMS	100
127	10000	21000	22000	100	SUSPENDED	ITEMS	100
128	10000	21000	22000	100	SUSPENDED	ITEMS	100
129	10000	21000	22000	100	SUSPENDED	ITEMS	100
130	10000	21000	22000	100	SUSPENDED	ITEMS	100
131	10000	21000	22000	100	SUSPENDED	ITEMS	100
132	10000	21000	22000	100	SUSPENDED	ITEMS	100
133	10000	21000	22000	100	SUSPENDED	ITEMS	100
134	10000	21000	22000	100	SUSPENDED	ITEMS	100
135	10000	21000	22000	100	SUSPENDED	ITEMS	100
136	10000	21000	22000	100	SUSPENDED	ITEMS	100
137	10000	21000	22000	100	SUSPENDED	ITEMS	100
138	10000	21000	22000	100	SUSPENDED	ITEMS	100
139	10000	21000	22000	100	SUSPENDED	ITEMS	100
140	10000	21000	22000	100	SUSPENDED	ITEMS	100
141	10000	21000	22000	100	SUSPENDED	ITEMS	100
142	10000	21000	22000	100	SUSPENDED	ITEMS	100
143	10000	21000	22000	100	SUSPENDED	ITEMS	100
144	10000	21000	22000	100	SUSPENDED	ITEMS	100
145	10000	21000	22000	100	SUSPENDED	ITEMS	100
146	10000	21000	22000	100	SUSPENDED	ITEMS	100
147	10000	21000	22000	100	SUSPENDED	ITEMS	100
148	10000	21000	22000	100	SUSPENDED	ITEMS	100
149	10000	21000	22000	100	SUSPENDED	ITEMS	100
150	10000	21000	22000	100	SUSPENDED	ITEMS	100
151	10000	21000	22000	100	SUSPENDED	ITEMS	100
152	10000	21000	22000	100	SUSPENDED	ITEMS	100
153	10000	21000	22000	100	SUSPENDED	ITEMS	100
154	10000	21000	22000	100	SUSPENDED	ITEMS	100
155	10000	21000	22000	100	SUSPENDED	ITEMS	100
156	10000	21000	22000	100	SUSPENDED	ITEMS	100
157	10000	21000	22000	100	SUSPENDED	ITEMS	100
158	10000	21000	22000	100	SUSPENDED	ITEMS	100
159	10000	21000	22000	100	SUSPENDED	ITEMS	100
160	10000	21000	22000	100	SUSPENDED	ITEMS	100
161	10000	21000	22000	100	SUSPENDED	ITEMS	100
162	10000	21000	22000	100	SUSPENDED	ITEMS	100
163	10000	21000	22000	100	SUSPENDED	ITEMS	100
164	10000	21000	22000	100	SUSPENDED	ITEMS	100
165	10000	21000	22000	100	SUSPENDED	ITEMS	100
166	10000	21000	22000	100	SUSPENDED	ITEMS	100
167	10000	21000	22000	100	SUSPENDED	ITEMS	100
168	10000	21000	22000	100	SUSPENDED	ITEMS	100
169	10000	21000	22000	100	SUSPENDED	ITEMS	100
170	10000	21000	22000	100	SUSPENDED	ITEMS	100
171	10000	21000	22000	100	SUSPENDED	ITEMS	100
172	10000	21000	22000	100	SUSPENDED	ITEMS	100
173	10000	21000	22000	100	SUSPENDED	ITEMS	100
174	10000	21000	22000	100	SUSPENDED	ITEMS	100
175	10000	21000	22000	100	SUSPENDED	ITEMS	100
176	10000	21000	22000	100	SUSPENDED	ITEMS	100
177	10000	21000	22000	100	SUSPENDED	ITEMS	100
178	10000	21000	22000	100	SUSPENDED	ITEMS	100
179	10000	21000	22000	100	SUSPENDED	ITEMS	100
180	10000	21000	22000	100	SUSPENDED	ITEMS	100
181	10000	21000	22000	100	SUSPENDED	ITEMS	100
182	10000	21000	22000	100	SUSPENDED	ITEMS	100
183	10000	21000	22000	100	SUSPENDED	ITEMS	100
184	10000	21000	22000	100	SUSPENDED	ITEMS	100
185	10000	21000	22000	100	SUSPENDED	ITEMS	100
186	10000	21000	22000	100	SUSPENDED	ITEMS	100
187	10000	21000	22000	100	SUSPENDED	ITEMS	100
188	10000	21000	22000	100	SUSPENDED	ITEMS	100
189	10000	21000	22000	100	SUSPENDED	ITEMS	100
190	10000	21000	22000	100	SUSPENDED	ITEMS	100
191	10000	21000	22000	100	SUSPENDED	ITEMS	100
192	10000	21000	22000	100	SUSPENDED	ITEMS	100
193	10000	21000	22000	100	SUSPENDED	ITEMS	100
194	10000	21000	22000	100	SUSPENDED	ITEMS	100
195	10000	21000	22000	100	SUSPENDED	ITEMS	100
196	10000	21000	22000	100	SUSPENDED	ITEMS	100
197	10000	21000	22000	100	SUSPENDED	ITEMS	100
198	10000	21000	22000	100	SUSPENDED	ITEMS	100
199	10000	21000	22000	100	SUSPENDED	ITEMS	100
200	10000	21000	22000	100	SUSPENDED	ITEMS	100
201	10000	21000	22000	100	SUSPENDED	ITEMS	100
202	10000	21000	22000	100	SUSPENDED	ITEMS	100
203	10000	21000	22000	100	SUSPENDED	ITEMS	100
204	10000	21000	22000	100	SUSPENDED	ITEMS	100
205	10000	21000	22000	100	SUSPENDED	ITEMS	100
206	10000	21000	22000	100	SUSPENDED	ITEMS	100
207	10000	21000	22000	100	SUSPENDED	ITEMS	100
208	10000	21000	22000	100	SUSPENDED	ITEMS	100
209	10000	21000	22000	100	SUSPENDED	ITEMS	100
210	10000	21000	22000	100	SUSPENDED	ITEMS	100
211	10000	21000	22000	100	SUSPENDED	ITEMS	100
212	10000	21000	22000	100	SUSPENDED	ITEMS	100
213	10000	21000	22000	100	SUSPENDED	ITEMS	100
214	10000	21000	22000	100	SUSPENDED	ITEMS	100
215	10000	21000	22000	100	SUSPENDED	ITEMS	100
216	10000	21000	22000	100	SUSPENDED	ITEMS	100
217	10000	21000	22000	100	SUSPENDED	ITEMS	100
218	10000	21000	22000	100	SUSPENDED	ITEMS	100
219	10000	21000	22000	100	SUSPENDED	ITEMS	100
220	10000	21000	22000	100	SUSPENDED	ITEMS	100
221	10000	21000	22000	100	SUSPENDED	ITEMS	100
222	10000	21000	22000	100	SUSPENDED	ITEMS	100
223	10000	21000	22000	100	SUSPENDED	ITEMS	100
224	10000	21000	22000	100	SUSPENDED	ITEMS	100
225	10000	21000	22000	100	SUSPENDED	ITEMS	100
226	10000	21000	22000	100	SUSPENDED	ITEMS	100
227	10000	21000	22000	100	SUSPENDED	ITEMS	100
228	10000	21000	22000	100	SUSPENDED	ITEMS	100
229	10000	21000	22000	100	SUSPENDED	ITEMS	100
230	10000	21000	22000	100	SUSPENDED	ITEMS	100
231	10000	21000	22000	100	SUSPENDED	ITEMS	100
232	10000	21000	22000	100	SUSPENDED	ITEMS	100
233	10000	21000	22000	100	SUSPENDED	ITEMS	100
234	10000	21000	22000	100	SUSPENDED	ITEMS	100
235	10000	21000	22000	100	SUSPENDED	ITEMS	100
236	10000	21000	22000	100	SUSPENDED	ITEMS	100
237	10000	21000	22000	100	SUSPENDED	ITEMS	100
238	10000	21000	22000	100	SUSPENDED	ITEMS	100
239	10000	21000	22000	100	SUSPENDED	ITEMS	100
240	10000	21000	22000	100	SUSPENDED	ITEMS	100
241	10000	21000	22000	100	SUSPENDED	ITEMS	100
242	10000	21000	22000	100	SUSPENDED	ITEMS	100
243	10000	21000	22000	100	SUSPENDED	ITEMS	100
244	10000	21000	22000	100	SUSPENDED	ITEMS	100
245	10000	21000	22000	100	SUSPENDED	ITEMS	100
246	10000	21000	22000	100	SUSPENDED	ITEMS	100
247	10000	21000	22000	100	SUSPENDED	ITEMS	100
248	10000	21000	22000	100	SUSPENDED	ITEMS	100
249	10000	21000	22000	100	SUSPENDED	ITEMS	100
250	10000	21000	22000	100	SUSPENDED	ITEMS	100
251	10000	21000	22000	100	SUSPENDED	ITEMS	100
252	10000	21000	22000	100	SUSPENDED	ITEMS	100
253	10000	21000	22000	100	SUSPENDED	ITEMS	100
254	10000	21000	22000	100	SUSPENDED	ITEMS	100
255	10000	21000	22000	100	SUSPENDED	ITEMS	100
256	10000	21000	22000	100	SUSPENDED	ITEMS	100
257	10000	21000	22000	100	SUSPENDED	ITEMS	100
258	10000	21000	22000	100	SUSPENDED	ITEMS	100
259	10000	21000	22000	100	SUSPENDED	ITEMS	100
260	10000	21000	22000	100	SUSPENDED	ITEMS	100
261	10000	21000	22000	100	SUSPENDED	ITEMS	100
262	10000	21000	22000	100	SUSPENDED	ITEMS	100
263	10000	21000	22000	100	SUSPENDED	ITEMS	100
264	10000	21000	22000	100	SUSPENDED	ITEMS	100
265	10000	21000	22000	100	SUSPENDED	ITEMS	100
266	10000	21000	22000	100	SUSPENDED	ITEMS	100
267	10000	21000	22000	100	SUSPENDED	ITEMS	100
268	10000	21000	22000	100	SUSPENDED	ITEMS	100
269	10000	21000					

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBERS FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
A206	72 00001800010	8	0	1000	1000	1000	1245	13340	NO	SUSPENDED	ITEMS
A207	72 00001800010	4	0	1354	1629	2000	1804	0	NO	SUSPENDED	ITEMS
A208	72 00001800010	7	0	1283	1710	1772	2219	27080	NO	SUSPENDED	ITEMS
A209	72 00001800010	8	0	10	51	987	0	12910	NO	SUSPENDED	ITEMS
A210	72 00001800010	4	0	2641	1908	0	10	13350	NO	SUSPENDED	ITEMS
A211	72 00001800010	4	0	0	8	1492	2078	0	NO	SUSPENDED	ITEMS
A212	72 00001800010	4	0	1443	3099	2045	0	0	NO	SUSPENDED	ITEMS
A213	72 00001800010	4	0	118	1113	0	0	0	NO	SUSPENDED	ITEMS
A214	72 00001800010	4	0	1878100	2657000	2744100	0	0	NO	SUSPENDED	ITEMS
A215	72 00001800010	4	0	2293000	4161700	7102700	0	0	NO	SUSPENDED	ITEMS
A216	72 00001800010	4	0	224000	5304400	5304400	5187500	0	NO	SUSPENDED	ITEMS
A217	72 00001800010	4	0	230000	1894000	7950000	0	0	NO	SUSPENDED	ITEMS
A218	72 00001800010	4	0	6131000	13021000	23230000	0	0	NO	SUSPENDED	ITEMS
A219	72 00001800010	4	0	2045000	5555000	0	0	0	NO	SUSPENDED	ITEMS
A220	72 00001800010	4	0	2276000	7162000	0	0	0	NO	SUSPENDED	ITEMS
A221	72 00001800010	4	0	2045000	2276000	5555000	7162000	0	NO	SUSPENDED	ITEMS
A222	72 00001800010	4	0	514500	1169500	0	0	0	NO	SUSPENDED	ITEMS
A223	72 00001800010	4	0	1908200	2180500	5963700	0	0	NO	SUSPENDED	ITEMS
A224	72 00001800010	4	0	2040400	2505300	7674500	0	0	NO	SUSPENDED	ITEMS
A225	72 00001800010	4	0	418300	4061900	4229100	0	0	NO	SUSPENDED	ITEMS
A226	72 00001800010	4	0	17607000	19084100	0	0	0	NO	SUSPENDED	ITEMS
A227	72 00001800010	4	0	563900	1185800	1274300	2542000	0	NO	SUSPENDED	ITEMS
A228	72 00001800010	4	0	923800	1512100	2483100	0	0	NO	SUSPENDED	ITEMS
A229	72 00001800010	4	0	1711400	5322100	0	0	0	NO	SUSPENDED	ITEMS
A230	72 00001800010	4	0	2221100	3378200	8151000	0	0	NO	SUSPENDED	ITEMS
A231	72 00001800010	4	0	418300	744600	923000	979000	15121000	NO	SUSPENDED	ITEMS
A232	72 00001800010	4	0	1908200	2062000	2180500	2483100	39637000	NO	SUSPENDED	ITEMS
A233	72 00001800010	4	0	4061900	4229100	0	0	0	NO	SUSPENDED	ITEMS
A234	72 00001800010	4	0	1711400	2125100	2222100	3378200	53221000	20000000	20000000	20000000
A235	72 00001800010	4	0	8151000	12407000	19084100	0	0	NO	SUSPENDED	ITEMS
A236	72 00001800010	4	0	615000	1690000	2293000	0	0	NO	SUSPENDED	ITEMS
A237	72 00001800010	4	0	1710000	1800000	2323000	2505300	0	NO	SUSPENDED	ITEMS
A238	72 00001800010	4	0	1502000	3294000	0	0	0	NO	SUSPENDED	ITEMS
A239	72 00001800010	4	0	3535000	6500000	0	0	0	NO	SUSPENDED	ITEMS
A240	72 00001800010	4	0	790000	1301000	1962000	0	0	NO	SUSPENDED	ITEMS
A241	72 00001800010	4									

LISTED NUMBERS OF CYCLES TO FAILURE AND
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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM NO	DESCRIPTION	SAMPLE SIZE	NUMBER FAILURES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
4274	20 03102021010	10	10	4497000 7045000 774000 9007000 9007000 1012000 1154000 8700000 1000000	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4274	73 03102021010	20	20	17413000 700000 930000 1070000 1250000 923000 1100000	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4277	73 03102021010	10	10	67 107 95 114	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4300	73 03102021040	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4301	73 03102021060	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4302	73 03102021060	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4303	73 03102021040	5	5	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4304	73 03102021040	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4304	73 03102021040	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4304	73 03102021040	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4307	73 03102021040	5	5	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4309	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4309	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4310	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4311	73 03102021070	5	5	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4312	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4313	73 03102021070	5	5	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4314	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4314	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4314	73 03102021070	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS
4317	73 03102021040	10	10	74 96 74 111	NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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ITEM REF DESCRIPTION	SAMPLE NUMBER STYP FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
4318 73 03102021080	10	87	124	110	110	NO	SUSPENDED	ITEMS	
4318 73 03102021080	10	121	136	155	155	NO	SUSPENDED	ITEMS	
4318 73 03102021080	10	89	127	147	147	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	174	201	205	205	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	6440000	12100000	13405000	13405000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	15983000	16663000	6057000	6057000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	5666000	5666000	6057000	6057000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	7794000	10630000	7472000	7472000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	6681000	7472000	6034000	6034000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	12270000	19370000			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	4313000	4491000	5559000	5559000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	7330000	9013000	14587000	14587000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	11575000	12517000	17411000	17411000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	22530000	31700000	4759000	4759000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	3572000	4693000	30793000	30793000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	4328000	7784000	61000	61000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	27243000	28102000	30793000	30793000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	14019000	45413000			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	40000	61000			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	30400	45900	70400	70400	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	20000	30700	130000	130000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	175400	800000	340000	340000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	84000	340500	67000	67000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	53800	65000	54000	54000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	31500	51000	54000	54000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	94300	97400	82500	82500	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	99000	144400	190000	190000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	99400	330400	343400	343400	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	177000	742000			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	552000	801000	1102000	1102000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	241000	535000	670000	670000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	670000	670000	964000	964000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	1192000	1400000	975000	975000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	774000	800000	1041000	1041000	NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	3400	3400			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	4602	6451			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	5535	8134			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	7113	13500			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	7220	8443			NO	SUSPENDED	ITEMS	
4440 20 03102021010	7	9500	11700			NO	SUSPENDED	ITEMS	

[illegible]

LISTED NUMBERS OF CYCLES TO FAILURE AND
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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILURES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
5342	64	00042087050	4	2	710705 1146648	9243120
5441	31	00040000011	2	2	1394000	
5442	31	00040000011	2	2	1612700	
5443	32	00040000011	3	3	1600000	
5444	32	00040000011	4	4	1624900	3710500
5445	31	00040000010	2	2	1534300	
5446	31	00040000010	3	3	1625400	
5447	31	00040000010	2	2	2701800	
5448	32	00040000010	3	3	1600400	
5449	32	00040000010	4	4	1604100	3779000
5470	39	03202080090	2	2	2300000	
5471	61	00002087021	4	2	2570000	
5472	41	00002087020	2	2	4500000	
5473	41	00002087020	2	2	991000	
5474	60	00002087020	4	4	1949247	6265514
5475	60	00002087020	4	4	553444	
5476	40	00002087020	4	4	2275045	2327100
5477	60	00002087020	2	2	2306842	3162490
5478	60	00002087020	4	4	2493567	
5479	40	00002087020	4	4	1443195	5140101
5480	60	00002087020	2	2	10491473	4054376
5481	41	00002081021	13	13	232700	
5482	43	00002081021	6	6	744400	7247000
5483	41	00002081020	10	10	1225400	12254000
5701	34	04002021011	3	3	102200	
5702	34	04002021010	3	3	11200	
5703	34	04002021010	3	3	61600	
5704	34	04002021010	3	3	49100	
5705	34	04002021010	3	3	64100	
5706	34	04002021011	3	3	55900	
5707	34	04002021010	3	3	58500	
5708	34	04002021011	4	4	172800	241300
5709	34	04002021010	4	4	170800	241300
5710	34	04002021011	4	4	104100	243000
5711	34	04002021010	4	4	108200	243000

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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
5712	16 04002921011	4	4	137700	184200	230100	295000	NO	SUSPENDED	17EWS	
5713	16 04002921011	4	4	137700	200000	252000	299000	NO	SUSPENDED	17EWS	
5714	16 04002921011	4	4	63900	134000	204000	237000	NO	SUSPENDED	17EWS	
5715	16 04002921011	4	4	63900	137500	204000	375000	NO	SUSPENDED	17EWS	
5716	16 04002921011	3	3	180100	210400	270300		NO	SUSPENDED	17EWS	
5717	16 04002921011	3	3	189400	210400	281700		NO	SUSPENDED	17EWS	
5718	16 04002921011	3	3	44200	52200	75100		NO	SUSPENDED	17EWS	
5719	16 04002921011	3	3	46200	79100	92400		NO	SUSPENDED	17EWS	
5720	16 04002921011	3	3	106700	104000	213500		NO	SUSPENDED	17EWS	
5721	16 04002921011	3	3	123100	201500	223700		NO	SUSPENDED	17EWS	
5722	16 04002921011	3	3	45500	73000	227400		NO	SUSPENDED	17EWS	
5723	16 04002921011	3	3	62500	83000	279400		NO	SUSPENDED	17EWS	
5724	16 04002921011	5	5	41700	41400	118000	141400	215000			
5725	16 04002921011	5	5	98400	104000	118000	154000	223300			
5726	16 04002921011	5	5	111900	126000	143500	199400	214200			
5727	16 04002921011	5	5	150400	180000	202000	224000	253500			
5728	16 04002921011	5	5	92400	92400	107600	131300	190400			
5729	16 04002921011	5	5	99400	102300	117200	131300	190400			
5730	16 04002921011	5	5	70800	80600	103500	170100	250600			
5731	16 04002921011	5	5	70800	80600	111000	180000	288700			
5732	16 04002921011	3	3	63600	95400	121400					
5733	16 04002921011	3	3	64300	105000	128500					
5734	16 04002921011	3	3	59500	107600	117700					
5735	16 04002921011	3	3	62000	109400	123000					
5736	16 04002921011	3	3	17300	24300	66300					
5737	16 04002921011	3	3	37200	43700	73600					
5738	16 04002921011	3	3	41700	42500	42700					
5739	16 04002921011	3	3	42500	42700	45100					
5740	16 04002921011	4	4	58900	61000	63700	64900				
5741	16 04002921011	4	4	58900	61300	63700	64100				
5742	16 04002921011	3	3	38000	67300	104400					
5743	16 04002921011	3	3	43200	84000	131400					
5744	16 04002921011	4	4	25500	21700	36300	119300				
5745	16 04002921011	4	4	25500	27500	45900	142300				
5746	16 04002921011	4	4	16900	20100	21200	26400				
5747	16 04002921011	4	4	25000	25400	27500	37800				
5748	16 04002921011	3	3	64000	76400	127900					
5749	16 04002921011	3	3	64000	88000	139800					
5750	16 04002921011	4	4	21000	37500	47500	58300				
5751	16 04002921011	4	4	21000	37500	48200	58700				

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ITEM REF	DESCRIPTION	SAMPLE NUMBER SIZE	FAILER	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
5752	36 04002022011	4	4	42000	43500	53100	50200	NO	SUSPENDED	ITEMS	•
5753	36 04002022010	4	4	42000	44500	53100	50200	NO	SUSPENDED	ITEMS	•
5754	36 04002022011	4	4	33000	44000	48000	115300	NO	SUSPENDED	ITEMS	•
5755	36 04002022010	4	4	33000	44000	48000	116000	NO	SUSPENDED	ITEMS	•
5756	36 04002022011	4	4	49000	53200	99400	172200	NO	SUSPENDED	ITEMS	•
5757	36 04002022010	4	4	49000	54400	105700	172400	NO	SUSPENDED	ITEMS	•
5758	36 04002022011	4	4	48000	93700	126000	240300	NO	SUSPENDED	ITEMS	•
5759	36 04002022010	4	4	49700	96500	126200	240300	NO	SUSPENDED	ITEMS	•
5760	36 04002022011	4	4	36000	50400	100000	240000	NO	SUSPENDED	ITEMS	•
5761	36 04002022010	4	4	30000	50400	104300	250000	NO	SUSPENDED	ITEMS	•
5762	36 04002022011	3	3	24400	43000	65000		NO	SUSPENDED	ITEMS	•
5763	36 04002022010	3	3	24400	43000	66000		NO	SUSPENDED	ITEMS	•
5764	36 04002022011	3	3	54700	89400	116100		NO	SUSPENDED	ITEMS	•
5765	36 04002022010	3	3	54700	89400	116100		NO	SUSPENDED	ITEMS	•
5766	36 04002022011	3	3	102500	100900	133500		NO	SUSPENDED	ITEMS	•
5767	36 04002022010	3	3	102500	100900	133500		NO	SUSPENDED	ITEMS	•
5768	36 04002022011	3	3	97000	228700	245000		NO	SUSPENDED	ITEMS	•
5769	36 04002022010	3	3	97000	245000	245300		NO	SUSPENDED	ITEMS	•
5770	36 04002022011	4	4	49900	51400	55300	92400	NO	SUSPENDED	ITEMS	•
5771	36 04002022010	4	4	62300	69000	103600	605000	NO	SUSPENDED	ITEMS	•
5772	36 04002022011	4	4	77600	150400	196000	214400	NO	SUSPENDED	ITEMS	•
5773	36 04002022010	4	4	85500	212000	214400	268000	NO	SUSPENDED	ITEMS	•
5774	36 04002022011	3	3	66500	67700	121600		NO	SUSPENDED	ITEMS	•
5775	36 04002022010	3	3	73000	76500	127400		NO	SUSPENDED	ITEMS	•
5776	36 04002022011	3	3	127000	181000	274400		NO	SUSPENDED	ITEMS	•
5777	36 04002022010	3	3	129400	187400	274400		NO	SUSPENDED	ITEMS	•
5778	36 04002022011	4	4	18900	33200	39600	50500	NO	SUSPENDED	ITEMS	•
5779	36 04002022010	4	4	33200	37500	39600	50500	NO	SUSPENDED	ITEMS	•
5780	36 04002022011	9	9	28400	30400	33100	35100	NO	SUSPENDED	ITEMS	•
5781	36 04002022010	9	9	52200	64100	83500	96500	NO	SUSPENDED	ITEMS	•
5782	36 04002022011	9	9	33300	34000	35300	37100	NO	SUSPENDED	ITEMS	•
5783	36 04002022010	10	10	57200	70400	87100	94500	NO	SUSPENDED	ITEMS	•
5784	36 04002022011	10	10	34700	35000	37800	39700	NO	SUSPENDED	ITEMS	•
5785	36 04002022010	10	10	47600	47900	55800	64000	NO	SUSPENDED	ITEMS	•
5786	36 04002022011	3	3	52200	52700	55800	60000	NO	SUSPENDED	ITEMS	•
5787	36 04002022010	3	3	58600	82900	136500		NO	SUSPENDED	ITEMS	•
5788	36 04002022011	4	4	67600	98000	142000	268000	NO	SUSPENDED	ITEMS	•
5789	36 04002022010	4	4	167200	219000	233100		NO	SUSPENDED	ITEMS	•
5790	36 04002022011	4	4	169500	224400	233100	273000	NO	SUSPENDED	ITEMS	•

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION	
5700	36 04002812011	4	0	19800	31500	40000	NO SUSPENDED ITEMS
5701	36 04002812011	4	0	58500	72200	42400	NO SUSPENDED ITEMS
5702	36 04002812011	4	0	21200	31500	42500	NO SUSPENDED ITEMS
5703	36 04002812011	4	0	59100	72200	42600	NO SUSPENDED ITEMS
5704	36 04002812011	4	0	20300	23100	27400	NO SUSPENDED ITEMS
5705	36 04002812011	4	0	21000	23100	27400	NO SUSPENDED ITEMS
5706	36 04002812011	4	0	23000	51400	93800	NO SUSPENDED ITEMS
5707	36 04002812011	4	0	23300	51500	11200	NO SUSPENDED ITEMS
5708	36 04002812011	4	0	52500	137300	172000	NO SUSPENDED ITEMS
5709	36 04002812011	4	0	70700	158300	172000	NO SUSPENDED ITEMS
5710	36 04002812011	4	0	22700	42500	45200	NO SUSPENDED ITEMS
5711	36 04002812011	4	0	23500	42500	45500	NO SUSPENDED ITEMS
5712	36 04002812011	4	0	35500	55000	70700	NO SUSPENDED ITEMS
5713	36 04002812011	4	0	62900	75800	79500	NO SUSPENDED ITEMS
5714	36 04002812011	4	0	85500	100000	100000	NO SUSPENDED ITEMS
5715	36 04002812011	4	0	89000	140000	21997000	NO SUSPENDED ITEMS
5716	36 04002812011	4	0	86000	89000	81000	NO SUSPENDED ITEMS
5717	36 04002812011	4	0	64900	71400	75000	NO SUSPENDED ITEMS
5718	36 04002812011	4	0	71400	79200	79200	NO SUSPENDED ITEMS
5719	36 04002812011	4	0	14100	28500	29200	NO SUSPENDED ITEMS
5720	36 04002812011	4	0	21400	36300	36300	NO SUSPENDED ITEMS
5721	36 04002812011	4	0	15400	24400	27500	NO SUSPENDED ITEMS
5722	36 04002812011	4	0	23600	33300	34200	NO SUSPENDED ITEMS
5723	36 04002812011	4	0	36300	44700	50000	NO SUSPENDED ITEMS
5724	36 04002812011	4	0	55600	61700	63900	NO SUSPENDED ITEMS
5725	36 04002812011	4	0	70900	71200	69500	NO SUSPENDED ITEMS
5726	36 04002812011	4	0	36300	44700	50000	NO SUSPENDED ITEMS
5727	36 04002812011	4	0	61700	62400	69500	NO SUSPENDED ITEMS
5728	36 04002812011	4	0	11200	63900	70900	NO SUSPENDED ITEMS
5729	36 04002812011	4	0	28000	42700	42700	NO SUSPENDED ITEMS
5730	36 04002812011	4	0	34000	44900	44900	NO SUSPENDED ITEMS
5731	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5732	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5733	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5734	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5735	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5736	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5737	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5738	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5739	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5740	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5741	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5742	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5743	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5744	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5745	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5746	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5747	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5748	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5749	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS
5750	36 04002812011	4	0	40700	48500	48500	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	OFF	REPLICATION	SAMPLE SIZE	NUMBER FAILURES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
5710	16	04002811010	1	1	21000	244000
5711	16	04002811011	1	1	84700	102000
5712	16	04002811012	1	1	86700	102000
5713	16	04002811013	1	1	77400	140000
5714	16	04002811014	1	1	92600	140000
5715	16	04002811015	1	1	72300	259000
5716	16	04002811016	1	1	72300	259000
5717	16	04002811017	1	1	212000	325000
5718	16	04002811018	1	1	197000	231000
5719	16	04002811019	1	1	463000	3320000
5720	16	04002811020	1	1	47000	42000
5721	16	04002811021	1	1	91700	102000
5722	16	04002811022	1	1	45000	140000
5723	16	04002811023	1	1	40000	67000
5724	16	04002811024	1	1	71000	76000
5725	16	04002811025	1	1	41300	102600
5726	16	04002811026	1	1	71300	102600
5727	16	04002811027	1	1	472000	391000
5728	16	04002811028	1	1	391000	469700
5729	16	04002811029	1	1	126000	245000
5730	16	04002811030	1	1	127600	370000
5731	16	04002811031	1	1	243700	344000
5732	16	04002811032	1	1	34000	35000
5733	16	04002811033	1	1	48000	52300
5734	16	04002811034	1	1	80000	85000
5735	16	04002811035	1	1	114000	117000
5736	16	04002811036	1	1	11450	3317
5737	16	04002811037	1	1	48667	114000
5738	16	04002811038	1	1	4567	10733
5739	16	04002811039	1	1	14230	17600
5740	16	04002811040	1	1	1033	3500
5741	16	04002811041	1	1	4600	5267
5742	16	04002811042	1	1	352900	553700
5743	16	04002811043	1	1	205200	401100
5744	16	04002811044	1	1	99000	220000
5745	16	04002811045	1	1	45300	124000
5746	16	04002811046	1	1	48000	55000
5747	16	04002811047	1	1	13100	13201
5748	16	04002811048	1	1	77000	842700
5749	16	04002811049	1	1	91100	105000
5750	16	04002811050	1	1	91100	105000
5751	16	04002811051	1	1	91100	105000
5752	16	04002811052	1	1	91100	105000
5753	16	04002811053	1	1	91100	105000
5754	16	04002811054	1	1	91100	105000
5755	16	04002811055	1	1	91100	105000
5756	16	04002811056	1	1	91100	105000
5757	16	04002811057	1	1	91100	105000
5758	16	04002811058	1	1	91100	105000
5759	16	04002811059	1	1	91100	105000
5760	16	04002811060	1	1	91100	105000
5761	16	04002811061	1	1	91100	105000
5762	16	04002811062	1	1	91100	105000
5763	16	04002811063	1	1	91100	105000
5764	16	04002811064	1	1	91100	105000
5765	16	04002811065	1	1	91100	105000
5766	16	04002811066	1	1	91100	105000
5767	16	04002811067	1	1	91100	105000
5768	16	04002811068	1	1	91100	105000
5769	16	04002811069	1	1	91100	105000
5770	16	04002811070	1	1	91100	105000
5771	16	04002811071	1	1	91100	105000
5772	16	04002811072	1	1	91100	105000
5773	16	04002811073	1	1	91100	105000
5774	16	04002811074	1	1	91100	105000
5775	16	04002811075	1	1	91100	105000
5776	16	04002811076	1	1	91100	105000
5777	16	04002811077	1	1	91100	105000
5778	16	04002811078	1	1	91100	105000
5779	16	04002811079	1	1	91100	105000
5780	16	04002811080	1	1	91100	105000
5781	16	04002811081	1	1	91100	105000
5782	16	04002811082	1	1	91100	105000
5783	16	04002811083	1	1	91100	105000
5784	16	04002811084	1	1	91100	105000
5785	16	04002811085	1	1	91100	105000
5786	16	04002811086	1	1	91100	105000
5787	16	04002811087	1	1	91100	105000
5788	16	04002811088	1	1	91100	105000
5789	16	04002811089	1	1	91100	105000
5790	16	04002811090	1	1	91100	105000
5791	16	04002811091	1	1	91100	105000
5792	16	04002811092	1	1	91100	105000
5793	16	04002811093	1	1	91100	105000
5794	16	04002811094	1	1	91100	105000
5795	16	04002811095	1	1	91100	105000
5796	16	04002811096	1	1	91100	105000
5797	16	04002811097	1	1	91100	105000
5798	16	04002811098	1	1	91100	105000
5799	16	04002811099	1	1	91100	105000
5800	16	04002811100	1	1	91100	105000
5801	16	04002811101	1	1	91100	105000
5802	16	04002811102	1	1	91100	105000
5803	16	04002811103	1	1	91100	105000
5804	16	04002811104	1	1	91100	105000
5805	16	04002811105	1	1	91100	105000
5806	16	04002811106	1	1	91100	105000
5807	16	04002811107	1	1	91100	105000
5808	16	04002811108	1	1	91100	105000
5809	16	04002811109	1	1	91100	105000
5810	16	04002811110	1	1	91100	105000
5811	16	04002811111	1	1	91100	105000
5812	16	04002811112	1	1	91100	105000
5813	16	04002811113	1	1	91100	105000
5814	16	04002811114	1	1	91100	105000
5815	16	04002811115	1	1	91100	105000
5816	16	04002811116	1	1	91100	105000
5817	16	04002811117	1	1	91100	105000
5818	16	04002811118	1	1	91100	105000
5819	16	04002811119	1	1	91100	105000
5820	16	04002811120	1	1	91100	105000
5821	16	04002811121	1	1	91100	105000
5822	16	04002811122	1	1	91100	105000
5823	16	04002811123	1	1	91100	105000
5824	16	04002811124	1	1	91100	105000
5825	16	04002811125	1	1	91100	105000
5826	16	04002811126	1	1	91100	105000
5827	16	04002811127	1	1	91100	105000
5828	16	04002811128	1	1	91100	105000
5829	16	04002811129	1	1	91100	105000
5830	16	04002811130	1	1	91100	105000
5831	16	04002811131	1	1	91100	105000
5832	16	04002811132	1	1	91100	105000
5833	16	04002811133	1	1	91100	105000
5834	16	04002811134	1	1	91100	105000
5835	16	04002811135	1	1	91100	105000
5836	16	04002811136	1	1	91100	105000
5837	16	04002811137	1	1	91100	105000
5838	16	04002811138	1	1	91100	105000
5839	16	04002811139	1	1	91100	105000
5840	16	04002811140	1	1	91100	105000
5841	16	04002811141	1	1	91100	105000
5842	16	04002811142	1	1	91100	105000
5843	16	04002811143	1	1	91100	105000
5844	16	04002811144	1	1	91100	105000
5845	16	04002811145	1	1	91100	105000
5846	16	04002811146	1	1	91100	105000
5847	16	04002811147	1	1	91100	105000
5848	16	04002811148	1	1	91100	105000
5849	16	04002811149	1	1	91100	105000
5850	16	04002811150	1	1	91100	105000
5851	16	04002811151	1	1	91100	105000
5852	16	04002811152	1	1	91100	105000
5853	16	04002811153	1	1	91100	105000
5854	16	04002811154	1	1	91100	105000
5855	16	04002811155	1	1	91100	105000
5856	16	04002811156	1	1	91100	105000
5857	16	04002811157	1	1	91100	105000
5858	16	04002811158	1	1	91100	105000
5859	16	04002811159	1	1	91100	105000
5860	16	04002811160	1	1	91100	105000
5861	16	04002811161	1	1	91100	105000
5862	16	04002811162	1	1	91100	105000
5863	16	04002811163	1	1	91100	105000
5864	16	04002811164	1	1	91100	105000
5865	16	04002811165	1	1	91100	105000
5866	16	04002811166	1	1	91100	105000
5867	16	04002811167	1	1	91100	105000
5868	16	04002811168	1	1	91100	105000
5869	16	04002811169	1	1	91100	105000
5870	16	04002811170	1	1	91100	105000
5871	16	04002811171	1	1	91100	105000
5872	16	04002811172	1	1	91100	105000
5873	16	04002811173	1	1	91100	105000
5874	16	04002811174	1	1	91100	105000
5875	16	04002811175	1	1	91100	105000
5876	16	04002811176	1	1	91100	105000
5877	16	04002811177	1	1	91100	105000
5878	16	04002811178	1	1	91100	105000
5879	16	04002811179	1	1	91100	105000
5880	16	04002811180	1	1	91100	105000
5881	16	04002811181	1	1	91100	105000
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LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE		CYCLES AT SUSPENSION		
6015	11	10047965410	2	2	45100	45000	NO SUSPENDED ITEMS	•	
6016	11	10047965410	2	2	24600	33500	NO SUSPENDED ITEMS	•	
6017	11	10047965410	2	2	9600	12100	NO SUSPENDED ITEMS	•	
6018	11	10047965410	2	2	170000	725000	NO SUSPENDED ITEMS	•	
6019	11	10047965410	2	2	16400	17000	NO SUSPENDED ITEMS	•	
6020	11	10049965410	2	2	118200	321700	NO SUSPENDED ITEMS	•	
6022	11	10049965410	2	2	725700	1469400	NO SUSPENDED ITEMS	•	
6009	10	05104854020	1002	1002	233000	258000	268000	276000	290000
					310000	312000	315000	316000	321000
					321000	329000	335000	336000	338000
					338000	342000	342000	342000	344000
					349000	350000	350000	351000	351000
					357000	357000	358000	358000	358000
					360000	362000	363000	366000	367000
					370000	370000	372000	372000	374000
					375000	376000	379000	379000	380000
					382000	389000	389000	395000	396000
					400000	400000	400000	403000	404000
					406000	408000	408000	410000	417000
					414000	415000	416000	416000	420000
					422000	423000	426000	428000	432000
					432000	433000	433000	437000	438000
					439000	439000	443000	445000	445000
					452000	456000	456000	460000	464000
					468000	469000	470000	470000	473000
					474000	476000	476000	486000	488000
					489000	490000	491000	496000	517000
					540000	560000		501000	

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM #	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION	
601	10 05100055020	101	101	70000	90000	96000	97000	99000	NO SUSPENDED ITEMS
				100000	103000	104000	104000	105000	
				107000	108000	108000	108000	109000	
				109000	112000	112000	113000	114000	
				114000	114000	116000	119000	120000	
				120000	120000	121000	121000	123000	
				124000	124000	124000	124000	126000	
				129000	129000	129000	129000	130000	
				130000	130000	131000	131000	131000	
				131000	131000	132000	132000	132000	
				133000	134000	134000	134000	134000	
				134000	134000	134000	137000	138000	
				138000	138000	139000	139000	141000	
				141000	142000	142000	142000	142000	
				142000	142000	144000	144000	145000	
				146000	148000	148000	149000	151000	
				151000	152000	155000	156000	157000	
				157000	157000	157000	159000	159000	
				162000	163000	163000	164000	166000	
				166000	168000	170000	174000	190000	
602	9 06111055410	9	9	212000	265000	271000	294000	304000	NO SUSPENDED ITEMS
				237000	314000	370000	390000		
603	11 10087055410	2	2	305000	314000				NO SUSPENDED ITEMS
604	11 10087055410	2	2	469300	565300				NO SUSPENDED ITEMS
605	11 10087055410	2	2	108100	150400				NO SUSPENDED ITEMS
				45500	51500				
606	11 10087055410	2	2	251500	309200				NO SUSPENDED ITEMS
607	11 10087055410	2	2	68600	87600				NO SUSPENDED ITEMS
608	11 10087055410	2	2	16400	32000				NO SUSPENDED ITEMS
609	11 10087055410	2	2	461800	1011400				NO SUSPENDED ITEMS
610	11 10087055410	2	2	96500	121000				NO SUSPENDED ITEMS
611	11 10087055410	2	2	42800	49100				NO SUSPENDED ITEMS
612	11 10087055410	2	2	44000	104500				NO SUSPENDED ITEMS
613	11 10087055410	2	2	10000	11500				NO SUSPENDED ITEMS

[illegible]

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION	
6514	12 12833818010	7	7	307000	542000	698000	813000	829000	NO SUSPENDED ITEMS
6515	12 12833818010	2	2	954000	1003000				NO SUSPENDED ITEMS
6516	12 12833818010	2	2	48400	109700				NO SUSPENDED ITEMS
6517	12 12833818010	2	2	123400	232600				NO SUSPENDED ITEMS
6518	12 12833818010	2	2	104000	443000				NO SUSPENDED ITEMS
6519	12 12833818010	2	2	25200	95100				NO SUSPENDED ITEMS
6520	12 12827818010	3	3	240000	266000				NO SUSPENDED ITEMS
6521	12 12827818010	4	4	3000	9000	13700			NO SUSPENDED ITEMS
6522	12 12827818010	4	4	10200	14800	51000	57000		NO SUSPENDED ITEMS
6523	12 12827818010	4	4	124000	151000	153000			NO SUSPENDED ITEMS
6524	12 12827818010	4	4	157000	177000	189000	187000		NO SUSPENDED ITEMS
6525	12 12827818010	6	6	344000	418000	483000	559000	614000	NO SUSPENDED ITEMS
6526	12 12827818010	4	4	809000					NO SUSPENDED ITEMS
6527	12 12827818010	3	3	8400	11100	26800	26900		NO SUSPENDED ITEMS
6528	12 12827818010	3	3	51600	56700	58400			NO SUSPENDED ITEMS
6529	12 12827818010	3	3	80200	94700	140200			NO SUSPENDED ITEMS
6530	12 12827818010	3	3	355000	409000	448000			NO SUSPENDED ITEMS
6531	12 12827818010	2	2	911000	911000	1095000			NO SUSPENDED ITEMS
6532	12 12827818010	2	2	174000	183000				NO SUSPENDED ITEMS
6533	12 12827818010	2	2	230000	281000				NO SUSPENDED ITEMS
6534	12 12827818010	3	3	8000	8200	8500			NO SUSPENDED ITEMS
6535	12 12827818010	3	3	18500	20000	21700			NO SUSPENDED ITEMS
6536	12 12827818010	3	3	26300	30900	35700			NO SUSPENDED ITEMS
6537	12 12827818010	4	4	69400	72300	80600			NO SUSPENDED ITEMS
6538	12 12827818010	2	2	161000	187000	357000	1204000		NO SUSPENDED ITEMS
6539	12 12827818010	2	2	357000	659000	700000			NO SUSPENDED ITEMS
6540	12 12827818010	2	2	14800	19000				NO SUSPENDED ITEMS
6541	12 12827818010	2	2	24700	33100				NO SUSPENDED ITEMS
6542	12 12827818010	2	2	68300	81200				NO SUSPENDED ITEMS
6543	12 12827818010	2	2	203000	290000				NO SUSPENDED ITEMS
6544	12 12827818010	2	2	11600	12700				NO SUSPENDED ITEMS
6545	12 12827818010	2	2	30900	36900				NO SUSPENDED ITEMS
6546	12 12827818010	2	2	87800	93000				NO SUSPENDED ITEMS
6547	12 12827818010	2	2	13500	14600				NO SUSPENDED ITEMS
6548	12 12827818010	2	2	21500	37000				NO SUSPENDED ITEMS
6549	12 12827818010	2	2	75500	115000				NO SUSPENDED ITEMS
6550	12 12827818010	2	2	170000	161800				NO SUSPENDED ITEMS
6551	12 12827818010	2	2	13800	14500				NO SUSPENDED ITEMS
6552	12 12827818010	2	2	25900	28100				NO SUSPENDED ITEMS
6553	12 12827818010	2	2	40900	70000				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE	CYCLES AT SUSPENSION
6557	12 12833011010	2	2	241000	NO SUSPENDED ITEMS
6557	12 12827011010	3	3	11200	NO SUSPENDED ITEMS
6554	12 12827011010	3	3	20200	NO SUSPENDED ITEMS
6555	12 12827011010	3	3	37400	NO SUSPENDED ITEMS
6556	12 12827011010	3	3	51400	NO SUSPENDED ITEMS
6557	12 12827011010	3	3	164600	NO SUSPENDED ITEMS
6558	12 12827011010	3	3	8300	NO SUSPENDED ITEMS
6559	12 12827011010	4	4	16200	NO SUSPENDED ITEMS
6560	12 12827011010	2	2	31100	NO SUSPENDED ITEMS
6561	12 12827011010	3	3	94200	NO SUSPENDED ITEMS
6562	12 12827011010	2	2	8501	NO SUSPENDED ITEMS
6563	12 12827011010	3	3	11900	NO SUSPENDED ITEMS
6564	12 12827011010	3	3	14700	NO SUSPENDED ITEMS
6565	12 12834011010	2	2	17700	NO SUSPENDED ITEMS
6566	12 12834011010	2	2	62400	NO SUSPENDED ITEMS
6567	12 12834011010	2	2	12700	NO SUSPENDED ITEMS
6568	12 12834011010	2	2	43200	NO SUSPENDED ITEMS
6569	12 12834011010	2	2	212500	NO SUSPENDED ITEMS
6570	12 12834011010	2	2	1275000	NO SUSPENDED ITEMS
6571	12 12827011010	2	2	93700	NO SUSPENDED ITEMS
6572	12 12827011010	2	2	378401	NO SUSPENDED ITEMS
6573	12 12827011010	2	2	13960	NO SUSPENDED ITEMS
6574	12 12827011010	2	2	54200	NO SUSPENDED ITEMS
6575	12 12827011010	2	2	113700	NO SUSPENDED ITEMS
6576	12 12827011010	2	2	652000	NO SUSPENDED ITEMS
6577	12 12827011010	2	2	17400	NO SUSPENDED ITEMS
6578	12 12827011010	2	2	24100	NO SUSPENDED ITEMS
6579	12 12827011010	2	2	109400	NO SUSPENDED ITEMS
6580	12 12827011010	4	4	633400	NO SUSPENDED ITEMS
6581	12 12827011010	3	3	22926	NO SUSPENDED ITEMS
6582	12 12827011010	3	3	24750	NO SUSPENDED ITEMS
6583	12 12827011010	3	3	4075000	NO SUSPENDED ITEMS
6584	12 12827011010	4	4	1972000	NO SUSPENDED ITEMS
6585	12 12827011010	2	2	1204000	NO SUSPENDED ITEMS
6586	12 12827011010	2	2	361000	NO SUSPENDED ITEMS
6587	12 12827011010	3	3	1330000	NO SUSPENDED ITEMS
6588	12 12827011010	4	4	644000	NO SUSPENDED ITEMS
6589	12 12827011010	2	2	2093000	NO SUSPENDED ITEMS
6590	12 12827011010	2	2	3800000	NO SUSPENDED ITEMS
6591	12 12827011010	2	2	1422000	NO SUSPENDED ITEMS
6592	12 12827011010	2	2	5471000	NO SUSPENDED ITEMS
6593	12 12827011010	5	5	434	NO SUSPENDED ITEMS
6594	12 12827011010	5	5	207	NO SUSPENDED ITEMS
6595	12 12827011010	5	5	706	NO SUSPENDED ITEMS
6596	12 12827011010	5	5	236	NO SUSPENDED ITEMS
6597	12 12827011010	5	5	1075	NO SUSPENDED ITEMS
6598	12 12827011010	5	5	274	NO SUSPENDED ITEMS
6599	12 12827011010	5	5	12270	NO SUSPENDED ITEMS
6600	12 12827011010	5	5	7960	NO SUSPENDED ITEMS

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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE NUMBER	SIZE	FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
					194	215	230	274	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6702	71 00050833070	3	3	0	219	264	274	274	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6703	71 00050833080	3	3	0	82000	100000	195000	195000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6704	9 34031804410	3	3	0	9200	10000	12000	12000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6705	9 40032804410	3	3	0	120000	126000	127000	145000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6706	9 40032804410	4	4	0	80200	134000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6707	9 40032804410	2	2	0	202000	236000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6708	9 40032804410	3	3	0	462000	491000	513000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6709	9 40032804410	2	2	0	547000	643000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6710	9 83232804410	2	2	0	181000	463000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6711	9 03031060410	5	5	0	143000	192000	201000	712000	917000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6712	9 03031060410	3	3	0	95000	95000	100000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6713	9 03031060410	3	3	0	78000	102000	120000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6714	50 30022804410	4	4	0	215000	440000	1039000	1276000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6715	50 30022804410	5	5	0	97000	297000	340000	516000	609000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6716	50 30022804410	3	3	0	94000	177000	272000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6717	50 30022804410	4	4	0	74000	172000	192000	377000	140000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6718	51 30022804410	4	4	0	59000	67000	67000	77000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6719	51 30022804410	7	7	0	55000	55000	50000	63000	82000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6720	51 30022804410	4	4	0	65000	76000			64000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6721	51 30022804410	4	4	0	40000	46000	71000	95000		NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6722	51 30022804410	8	8	0	52000	54000	64000	67000	71000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6723	52 30022804410	5	5	0	92000	119000	136000			NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6724	52 30022804410	2	2	0	35000	30000	43000	53000	61000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6725	52 30022804410	2	2	0	68000	104000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6726	52 30022804410	2	2	0	85000	104000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6727	52 30022804410	2	2	0	282000	343000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6728	52 30022804410	2	2	0	64000	109000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6729	52 30022804410	2	2	0	86000	109000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6730	52 30022804410	2	2	0	161000	230000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6731	52 30022804410	2	2	0	226000	476000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6732	52 30022804410	2	2	0	131000	280000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6733	52 30022804410	2	2	0	345000	1030000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6734	52 30022804410	5	5	0	22000	22000	22000	24000	25000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6735	52 30022804410	5	5	0	37000	36000	45000	51000	54000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6736	52 30022804410	2	2	0	68000	104000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6737	52 30022804410	5	5	0	171000	205000	317000	472000	1247000	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6738	52 30022804410	2	2	0	89000	104000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6739	52 30022804410	2	2	0	282000	543000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS
6740	52 30022804410	2	2	0	126000	244000				NO SUSPENDED ITEMS	NO SUSPENDED ITEMS	NO SUSPENDED ITEMS

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COLLECTION

ITEM	OFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILURES	CYCLES AT FAILURE	CYCLES AT SUSPENSION
7001	56	20020800110	2	2	344000	NO SUSPENDED ITEMS
7002	56	30020800410	4	3	51000	NO SUSPENDED ITEMS
7003	56	30020800410	4	3	230700	2848000
7004	56	30020800110	2	2	70000	NO SUSPENDED ITEMS
7005	56	30020800110	3	2	226000	1141000
7006	56	30020800110	2	2	61000	NO SUSPENDED ITEMS
7007	56	30020800110	2	2	345000	NO SUSPENDED ITEMS
7008	56	20020800110	2	2	19000	NO SUSPENDED ITEMS
7009	56	20020800110	2	2	32000	NO SUSPENDED ITEMS
7010	56	20020800110	3	2	57000	NO SUSPENDED ITEMS
7011	56	20020800110	3	2	219000	NO SUSPENDED ITEMS
7012	56	20020800110	2	2	45000	NO SUSPENDED ITEMS
7013	56	20020800110	2	2	191000	NO SUSPENDED ITEMS
7014	56	20020800110	3	3	14000	NO SUSPENDED ITEMS
7015	56	20020800110	3	3	34000	NO SUSPENDED ITEMS
7016	56	20020800110	2	2	45000	NO SUSPENDED ITEMS
7017	56	20020800110	2	2	69000	NO SUSPENDED ITEMS
7018	56	20020800110	2	2	22000	NO SUSPENDED ITEMS
7019	56	20020800110	3	3	34000	NO SUSPENDED ITEMS
7020	56	20020800110	2	2	345000	NO SUSPENDED ITEMS
7021	56	20020800110	2	2	39001	NO SUSPENDED ITEMS
7022	56	20020800110	3	3	394000	NO SUSPENDED ITEMS
7023	56	20020800110	2	2	62000	NO SUSPENDED ITEMS
7024	56	20020800110	3	3	25000	NO SUSPENDED ITEMS
7025	56	20020800110	3	3	68000	NO SUSPENDED ITEMS
7026	56	20020800110	3	3	36000	NO SUSPENDED ITEMS
7027	56	20020800110	2	2	573000	NO SUSPENDED ITEMS
7028	56	20020800110	3	3	25000	NO SUSPENDED ITEMS
7029	56	20020800110	3	3	422000	NO SUSPENDED ITEMS
7030	56	20020800110	3	3	51000	NO SUSPENDED ITEMS
7031	56	20020800110	3	3	450000	NO SUSPENDED ITEMS
7032	56	20020800110	3	3	46000	NO SUSPENDED ITEMS
7033	56	20020800110	3	3	740000	NO SUSPENDED ITEMS
7034	56	20020800110	3	3	27000	NO SUSPENDED ITEMS
7035	56	20020800110	2	2	332000	NO SUSPENDED ITEMS
7036	56	20020800110	3	3	31000	NO SUSPENDED ITEMS
7037	56	20020800110	3	3	203000	NO SUSPENDED ITEMS
7038	56	20020800110	3	3	4000	NO SUSPENDED ITEMS
7039	56	20020800110	3	3	44000	NO SUSPENDED ITEMS
7040	56	20020800110	3	3	35000	NO SUSPENDED ITEMS
7041	56	20020800110	3	3	467000	NO SUSPENDED ITEMS

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ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION		
7127	44 16020821010	3	3	10000	24000	43000	•	•	NO SUSPENSION ITEMS
7128	44 16020821010	3	3	212000	234000	1361000	•	•	NO SUSPENSION ITEMS
7129	44 16020821010	3	3	14000	15000	15000	•	•	NO SUSPENSION ITEMS
7130	45 16020821010	4	3	217000	493000	573000	•	•	NO SUSPENSION ITEMS
7131	45 16020821010	3	3	24000	27000	32000	•	•	NO SUSPENSION ITEMS
7132	45 16020821010	3	3	307000	451000	404000	•	•	NO SUSPENSION ITEMS
7133	45 16020821010	3	3	34000	34000	37000	•	•	NO SUSPENSION ITEMS
7134	45 16020821010	2	2	300000	350000	350000	•	•	NO SUSPENSION ITEMS
7135	46 17020821010	4	4	16000	19000	25000	•	•	NO SUSPENSION ITEMS
7136	46 16020821010	3	3	180000	350000	1080000	•	•	NO SUSPENSION ITEMS
7137	46 16020821010	4	4	11000	15000	17000	•	•	NO SUSPENSION ITEMS
7138	46 17020821010	4	4	26000	27000	29000	•	•	NO SUSPENSION ITEMS
7139	46 17020821010	4	4	24000	24000	29000	•	•	NO SUSPENSION ITEMS
7140	47 16020821010	3	3	41000	43000	44000	•	•	NO SUSPENSION ITEMS
7141	47 16020821010	3	3	590000	540000	771000	•	•	NO SUSPENSION ITEMS
7142	47 16020821010	3	3	41000	54000	75000	•	•	NO SUSPENSION ITEMS
7143	47 16020821010	4	4	45000	76000	89000	•	•	NO SUSPENSION ITEMS
7144	53 26020831110	2	2	31000	34000	36000	•	•	NO SUSPENSION ITEMS
7145	53 26020831110	4	4	31000	36000	42000	•	•	NO SUSPENSION ITEMS
7146	53 26020831110	4	4	22000	23000	28000	•	•	NO SUSPENSION ITEMS
7147	53 31022831410	2	2	11000	34000	36000	•	•	NO SUSPENSION ITEMS
7148	53 26020831110	5	5	94000	98000	170000	3520000	•	NO SUSPENSION ITEMS
7149	53 26020831410	4	4	129000	190000	235000	•	•	NO SUSPENSION ITEMS
7150	53 31022831410	4	4	48000	110000	114000	•	•	NO SUSPENSION ITEMS
7151	53 26020831410	2	2	745000	791000	791000	•	•	NO SUSPENSION ITEMS
7152	53 31022831410	3	3	277000	330000	625000	•	•	NO SUSPENSION ITEMS
7200	43 16020821010	3	3	1091000	1702000	2720000	•	•	NO SUSPENSION ITEMS
7201	47 16020821010	3	3	1304000	1722000	1775000	•	•	NO SUSPENSION ITEMS
7202	47 16020821010	3	3	1551000	3502000	3925000	10300000	•	NO SUSPENSION ITEMS
7203	53 26020831110	3	3	585000	1190000	3925000	•	•	NO SUSPENSION ITEMS
7400	31 00050089011	2	2	31500	40300	40300	•	•	NO SUSPENSION ITEMS
7401	31 00050087011	3	3	850370	915250	934050	•	•	NO SUSPENSION ITEMS
7402	32 00052081011	3	3	441100	547300	590000	•	•	NO SUSPENSION ITEMS
7403	31 00054083010	3	3	36400	50000	69200	•	•	NO SUSPENSION ITEMS
7404	31 00053089010	4	4	73000	84100	104400	•	•	NO SUSPENSION ITEMS
7405	31 00053083010	3	3	39400	59000	181500	•	•	NO SUSPENSION ITEMS
7406	31 00059081010	2	2	19830	20490	20490	•	•	NO SUSPENSION ITEMS
7407	31 00059081010	2	2	103900	109800	109800	•	•	NO SUSPENSION ITEMS
7408	31 00053087010	2	2	1440000	1440100	1440100	•	•	NO SUSPENSION ITEMS
7409	31 00053081010	3	3	1559000	1699100	1731400	•	•	NO SUSPENSION ITEMS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION		
7610	32	00050081010	3	3	513000	686700	919400	112508	1181920	NO SUSPENDED ITEMS
7611	49	00050087020	41	41	88400	109560	109542	130768	1310096	NO SUSPENDED ITEMS
					121552	122080	123088	141376	1424440	
					132912	137296	138560	152752	1531680	
					144608	148144	150016	159400	1600640	
					154000	155200	158320	164824	1677440	
					162352	165824	166328	177552	1787520	
					179104	176608	177408	190192	2147520	
					183376	189328	190128			
					245552					
7612	64	00050081020	3	3	2901	4239	4284			NO SUSPENDED ITEMS
7613	64	00050081020	2	2	1889	3430				NO SUSPENDED ITEMS
7721	31	00050081010	2	2	2110	2160				NO SUSPENDED ITEMS
7722	64	00050081021	2	2	1738	1998				NO SUSPENDED ITEMS
7723	64	00050081021	2	2	896	1272				NO SUSPENDED ITEMS
7761	31	00050080911	3	3	1219200	1545300	4600000	2052900		NO SUSPENDED ITEMS
7762	31	00050080910	4	4	379600	1744400	1857100			NO SUSPENDED ITEMS
7763	39	00050080909	2	2	147000	4140000				NO SUSPENDED ITEMS
7764	39	00050080909	2	2	562000	4950000				NO SUSPENDED ITEMS
7821	32	00050080911	2	2	1160	1230				NO SUSPENDED ITEMS
7822	31	00050080910	2	2	796	1012				NO SUSPENDED ITEMS
7823	31	00050080910	2	2	725	1384				NO SUSPENDED ITEMS
8000	31	00050081011	3	3	481300	971400	1460000			NO SUSPENDED ITEMS
8001	31	00050091010	3	3	130000	193100	216800	43000	440000	NO SUSPENDED ITEMS
8002	36	0515071010	7	7	36000	40000	41000			NO SUSPENDED ITEMS
					45000	46000				
8003	36	05150821010	4	4	41000	47000	51000	72000		NO SUSPENDED ITEMS
8004	36	05150821010	3	3	22800	25000	34000	113000		NO SUSPENDED ITEMS
9004	36	05150811010	4	4	53000	57000	84000			NO SUSPENDED ITEMS
9006	36	05150911010	4	4	25000	24000	32000	51000		NO SUSPENDED ITEMS
9121	31	00053081010	3	3	895400	1468160	2194000			NO SUSPENDED ITEMS
9122	36	05150821010	2	2	1461000	2454000				NO SUSPENDED ITEMS
9123	36	05150811010	2	2	2089000	2954000				NO SUSPENDED ITEMS
9130	70	00050087020	2	2	315000	323000				NO SUSPENDED ITEMS
9151	70	00050087020	2	2	540000	65000				NO SUSPENDED ITEMS
9400	31	00050087011	3	3	136200	162700	247700			NO SUSPENDED ITEMS
9501	31	00050087011	3	3	396800	424800	450200			NO SUSPENDED ITEMS
9502	31	00050091011	3	3	13437	26318	27585			NO SUSPENDED ITEMS
9603	31	00050080911	3	3	73500	273300	792000			NO SUSPENDED ITEMS
9604	31	00050080911	3	3	11700</					

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAIL	CYCLES AT FAILURE	CYCLES AT SUSPENSION
8305	31 00050087011	2	2	39700	NO SUSPENDED ITEMS
8306	31 00050087011	2	2	39600	NO SUSPENDED ITEMS
8307	32 00050087011	2	2	41000	NO SUSPENDED ITEMS
8308	32 00050087011	2	2	31600	NO SUSPENDED ITEMS
8309	32 00050087011	5	5	22000	NO SUSPENDED ITEMS
8310	32 00050087011	2	2	19400	NO SUSPENDED ITEMS
8311	32 00050087011	2	2	13000	NO SUSPENDED ITEMS
8312	31 00050087010	2	2	15770	NO SUSPENDED ITEMS
8313	31 00050087010	3	3	13000	NO SUSPENDED ITEMS
8314	31 00050087010	3	3	587200	NO SUSPENDED ITEMS
8315	31 00050087010	2	2	273906	NO SUSPENDED ITEMS
8316	31 00050087010	2	2	25100	NO SUSPENDED ITEMS
8317	32 00050087010	2	2	29400	NO SUSPENDED ITEMS
8318	32 00050087010	2	2	1511400	NO SUSPENDED ITEMS
8319	32 00050087010	2	2	48100	NO SUSPENDED ITEMS
8320	31 00050087010	2	2	56100	NO SUSPENDED ITEMS
8321	31 00050087010	3	3	424000	NO SUSPENDED ITEMS
8322	33 00020087010	2	2	865400	NO SUSPENDED ITEMS
8323	32 00050087010	2	2	44900	NO SUSPENDED ITEMS
8324	32 00050087010	2	2	12410	NO SUSPENDED ITEMS
8325	32 00050087010	2	2	13000	NO SUSPENDED ITEMS
8326	31 00020087010	3	3	172000	NO SUSPENDED ITEMS
8327	33 00020087010	3	3	456000	NO SUSPENDED ITEMS
8328	33 00020087010	6	6	130000	NO SUSPENDED ITEMS
8329	34 00050087011	3	3	173000	NO SUSPENDED ITEMS
8330	34 00050087011	6	6	35000	NO SUSPENDED ITEMS
8331	34 00050087011	6	6	37700	NO SUSPENDED ITEMS
8332	34 00050087011	6	6	29700	NO SUSPENDED ITEMS
8333	34 00050087011	6	6	32400	NO SUSPENDED ITEMS
8334	34 00050087011	6	6	50700	NO SUSPENDED ITEMS
8335	34 00050087011	6	6	38100	NO SUSPENDED ITEMS
8336	35 16050087010	4	4	94000	NO SUSPENDED ITEMS
8337	35 16050087010	4	4	98000	NO SUSPENDED ITEMS
8338	35 16050087010	4	4	27000	NO SUSPENDED ITEMS
8339	35 16050087010	4	4	20000	NO SUSPENDED ITEMS
8340	35 16050087010	4	4	17000	NO SUSPENDED ITEMS
8341	35 16050087010	4	4	15000	NO SUSPENDED ITEMS
8342	35 16050087010	4	4	39000	NO SUSPENDED ITEMS
8343	35 16050087010	4	4	35000	NO SUSPENDED ITEMS
8344	35 16050087010	4	4	14000	NO SUSPENDED ITEMS
8345	35 16050087010	5	5	14000	NO SUSPENDED ITEMS
8346	35 16050087010	5	5	25000	NO SUSPENDED ITEMS
8347	35 16050087010	4	4	24000	NO SUSPENDED ITEMS
8348	35 16050087010	4	4	22000	NO SUSPENDED ITEMS
8349	35 16050087010	4	4	34000	NO SUSPENDED ITEMS
8350	35 16050087010	4	4	30000	NO SUSPENDED ITEMS
8351	35 16050087010	4	4	168000	NO SUSPENDED ITEMS
8352	35 16050087010	4	4	304000	NO SUSPENDED ITEMS
8353	35 16050087010	4	4	441000	NO SUSPENDED ITEMS
8354	35 16050087010	4	4	240000	NO SUSPENDED ITEMS
8355	35 16050087010	4	4	225000	NO SUSPENDED ITEMS
8356	35 16050087010	4	4	11000	NO SUSPENDED ITEMS
8357	35 16050087010	4	4	12000	NO SUSPENDED ITEMS
8358	35 16050087010	4	4	45000	NO SUSPENDED ITEMS
8359	35 16050087010	4	4	45000	NO SUSPENDED ITEMS
8360	35 16050087010	4	4	138000	NO SUSPENDED ITEMS
8361	35 16050087010	4	4	265000	NO SUSPENDED ITEMS
8362	35 16050087010	4	4	355000	NO SUSPENDED ITEMS
8363	35 16050087010	4	4	110000	NO SUSPENDED ITEMS
8364	35 16050087010	4	4	114000	NO SUSPENDED ITEMS
8365	35 16050087010	4	4	372000	NO SUSPENDED ITEMS
8366	35 16050087010	2	2	409000	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	OFF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION			
A343	35 16050083010	3	3	81000	84000	88000	244000	NO	SUSPENDED	ITEMS	
A344	35 16050083010	4	4	229000	750000	240000		NO	SUSPENDED	ITEMS	
A345	35 16050083010	2	2	33000	56000			NO	SUSPENDED	ITEMS	
A346	35 16050083010	2	2	103000	198000			NO	SUSPENDED	ITEMS	
A347	35 16050083010	2	2	68000	114000			NO	SUSPENDED	ITEMS	
A348	35 16050083010	4	4	18000	28000	26000	39000	NO	SUSPENDED	ITEMS	
A349	35 16050083010	4	4	59000	109000	104000	108000	NO	SUSPENDED	ITEMS	
A350	35 16050083010	4	4	92000	141000	162000	648000	NO	SUSPENDED	ITEMS	
A351	35 16050083010	4	4	39000	41000	55000	60000	NO	SUSPENDED	ITEMS	
A352	35 16050083010	4	4	141000	141000	277000	315000	NO	SUSPENDED	ITEMS	
A353	35 16050083010	3	3	240000	901300	949000		NO	SUSPENDED	ITEMS	
A354	35 16050083010	4	4	189000	192300	221000	242000	NO	SUSPENDED	ITEMS	
A355	38 16020073010	5	5	22000	28000	29000	45000	NO	SUSPENDED	ITEMS	500000
A356	38 16020073010	5	5	475000	497000	514000	637000	NO	SUSPENDED	ITEMS	39450000
A357	38 16020073010	5	5	61000	64000	69000	91000	NO	SUSPENDED	ITEMS	990000
A421	31 00058083011	3	3	136	234	642		NO	SUSPENDED	ITEMS	
A422	32 00058083011	3	3	3200	5120	6010		NO	SUSPENDED	ITEMS	
A423	32 00058083011	3	3	1290	1600	2970		NO	SUSPENDED	ITEMS	
A424	31 00058083010	3	3	670	680	1010		NO	SUSPENDED	ITEMS	
A425	32 00058083010	2	2	8090	9900			NO	SUSPENDED	ITEMS	
A426	32 00058083010	2	2	2510	3870			NO	SUSPENDED	ITEMS	
A427	35 16050083010	2	2	6000	7000			NO	SUSPENDED	ITEMS	
A461	33 00020083010	3	3	499000	4434000	6350000		NO	SUSPENDED	ITEMS	
A462	34 00059083011	3	3	740000	1178000	1339500		NO	SUSPENDED	ITEMS	
A463	34 00059083010	2	2	826000	1370000			NO	SUSPENDED	ITEMS	
A621	31 00059083011	5	5	648	790	807	845	NO	SUSPENDED	ITEMS	9000
21	1 04010800010	5	5	10800	12400	12960	14250	NO	SUSPENDED	ITEMS	172800

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NOTE: See Appendix II for a bibliography of reference sources from which all fatigue data were collected.

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13. ABSTRACT		
The application of reliability analysis methods to the estimation of probable aircraft structural fatigue performance was investigated. Use was made of order statistics to establish the means of assessing the fatigue performance reliability of a fleet or number of fatigue-exposed details. A reliability analysis plan for application to aluminum alloy structural fatigue performance was developed and compared with the current, fixed scatter-factor procedure for determining the safe life of a structural detail. Both the two-parameter Weibull distribution and the log-normal distribution with empirically defined shape parameter were utilized to make the reliability plan tractable as compared to a distribution-free approach. Maximum-likelihood estimators, including one which considers only the first two-ordered failures, were employed to examine the many variables that might influence fatigue scatter, to qualify fatigue data that represented aluminum structural scatter and to establish shape-parameter values that typified structural fatigue scatter. The sampling distributions of these estimates were required to work the problem and were calculated by means of existing theory or Monte-Carlo simulation. More than 2,000 groups of fatigue performance data were collected, analyzed, and used to demonstrate the feasibility of establishing a shape-parameter value. Based on this estimate, scatter factors have been generated to account for the penalty of limited input information, the degree of desired reliability, and the size of the exposed fleet. Using these factors, the possible effects of the reliability analysis on structural weight, payload, or range were explored for a jet-engined military tanker/transport-type airplane.		

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	ROLE	WT	ROLE	WT	ROLE	WT
a. Fatigue-Life Variability						
b. Aircraft Structural Fatigue Performance						
c. Reliability Analysis						
d. Statistical Analysis						
e. Order Statistics						
f. Estimation Theory						
g. Scatter Factor						
h. Safe Life						

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