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WADC TECHNICAL REPORT 56-585

Part II

**EFFECTS OF TEMPERATURE-TIME-STRESS HISTORIES
ON THE MECHANICAL PROPERTIES OF AIRCRAFT
STRUCTURAL METALLIC MATERIALS**

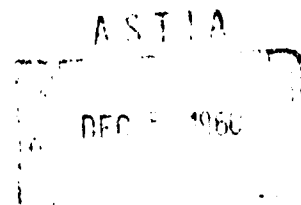
Part II. STRESSED EXPOSURE OF 7075-T6

C. D. Brownfield

D. M. Badger

Northrop Corporation

SEPTEMBER 1960



WRIGHT AIR DEVELOPMENT DIVISION

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PART II. STRESSED EXPOSURE OF 7075-T6

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D. M. Badger*

Northrop Corporation

SEPTEMBER 1960

**Materials Central
Contract No. AF 33(616)-5769
Project No. 7360**

**WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO**

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FOREWORD

This report was prepared by the Norair Division of Northrop Corporation under USAF Contract No. AF 33(616)-5769. This contract is a continuation of a previous contract, AF 33(616)-3028. This contract was initiated under Project No. 7360, "Materials Analysis and Evaluation Techniques", Task No. 73604, "Fatigue and Creep of Materials." The program was administered under the direction of the Materials Central, Directorate of Advanced Systems Technology, Wright Air Development Division, with Mr. K. F. Klinger acting as project engineer.

This report covers work conducted from May 1958 to September 1959.

Norair personnel responsible for this program included Messrs. D. M. Badger, C. D. Brownfield, and J. V. Griffin. The contributions of Metal Control Laboratories of Huntington Park, California, in their capacity as testing subcontractor are gratefully acknowledged. Primary technical personnel on this program at Metal Control Laboratories consisted of Messrs. R. E. Clark and J. W. Vinatieri.

Acknowledgement is also given to the authors of Part I for their constructive suggestions in this study.

This report is identified at Norair as NOR 60-16.

ABSTRACT

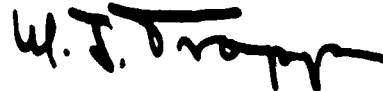
A study has been made on the problem of predicting strength of a hardened metal alloy after subjection to variable thermal and stress environments severe enough to cause permanent loss of properties. Methods have been developed for predicting tensile ultimate, tensile yield, and compressive yield strengths of 7075-T6 aluminum alloy after single or multiple exposures to various conditions of temperature and stress. An analytical expression suitable for automatic computing machine use has also been developed.

The results of tensile and compressive tests on alclad 7075-T6 aluminum alloy showed that stresses large enough to produce inelastic creep strain during thermal exposure cause reduction in residual strength after exposure. The test results have been used to establish the usefulness of the Larson-Miller exposure parameter for correlating residual strength after simple and complex, stressed and unstressed exposures.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:



W. J. TRAPP
Chief, Strength and Dynamics Branch
Metals and Ceramics Laboratory
Materials Control

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NOMENCLATURE

		<u>Units</u>
D	$\frac{F_{ef}-F_1}{F_F-F_1} \Big _{T_F}$, strength deterioration factor describing F_F in terms of its relationship to the strength interval between F_F and F_1 at any temperature T_F .	--
F_F	Strength (F_{tu} , F_{ty} , or F_{cy}) at any temperature T_F with no previous exposure to temperature.	psi
F_{ef}	Strength (F_{tu} , F_{ty} , or F_{cy}) at any temperature T_F after exposure to T_e .	psi
F_1	Strength (F_{tu} , F_{ty} , or F_{cy}) at the given temperature after exposure to a reference exposure condition.	psi
F_{tu}	Tensile ultimate strength	psi
F_{ty}	Tensile yield strength	psi
F_{cy}	Compressive yield strength	psi
R_T	Strength reduction factor combining exposure temperature effects and test temperature effects. Ratio of strength-at-temperature-after-exposure to original-room-temperature-strength.	--
R_e	Strength reduction factor for effect of stress during exposure. Ratio of strength-after-stressed-exposure to strength-after-unstressed-exposure at the same value of θ .	--
R.T.	(Subscript) room temperature	--
T_e	Temperature of exposure	$^{\circ}F$ or $^{\circ}R$
T_F	Temperature of strength test or of design condition after exposure.	$^{\circ}F$
t	Time	hours
θ	Larson-Miller exposure parameter expressing equivalent combinations of exposure temperature and exposure time. $\theta = T (C + \log_{10} t)$	(T in $^{\circ}R$)
θ_{17}	$T(17 + \log_{10} t)$, the specific variation of θ used in this report.	(T in $^{\circ}R$)
θ'	$T(20 + 1.46 \log_{10} t)$, the variation used for 7075-T6 in Part I.	(T in $^{\circ}R$)
ϵ	Inelastic strain remaining after creep exposure.	%

INTRODUCTION

Modern flight vehicles are sometimes subjected to such severe thermal environments that the materials of which they are constructed suffer permanent loss in strength. Typically, these materials are hardened metal alloys which progressively lose strength during periods of exposure to temperatures at which the hardening mechanism is unstable. If stress is also present during the thermal exposure, as is often the case, this can have a further damaging effect on strength. Efficient design for such severe temperatures therefore requires a knowledge of how to predict the residual strength of structural materials after exposure to various histories of temperature and stress.

In the study reported here, empirical methods were established for predicting residual strength of aluminum alloy 7075-T6 in tension and in compression after such exposures. These methods are extensions of the approaches established by Fortney and Avery in Part I on aluminum alloys 7075-T6 and 2024-T3. The choice of 7075-T6 for the present study was made recognizing that this material is finding considerable use in moderate temperature applications and some use for limited times in higher temperature applications. Cost factors often make an aluminum alloy the best choice of materials for severe thermal and stress environments, providing accurate strength data are available. The methods of analysis developed in this study allow the use of the subject material to its practical limit in high temperature design.

In the most general form, these methods are based on curves which attempt to describe the characteristic deterioration or retrogression of strength with exposure, from fully hardened values toward annealed values. For unstressed exposures of 7075-T6 it was found that a single curve could be used to adequately describe characteristic deterioration of all strength properties considered (tensile yield and ultimate, and compressive yield) throughout most of the exposure range. For stressed exposures the same approach was used with modifications. Analytical methods for design use based on these curves are given in a special section presented early in this report.

For many other hardened materials it is considered likely that similar characteristic curves can be generated by applying the methods developed in this study. For materials which respond to thermal exposure in a more complex fashion than 7075-T6 or which have a markedly different response to stress during exposure, these methods would have to be modified, possibly toward a less general type of final curve.

The empirical approach used to define the characteristics of 7075-T6 in this study was as follows: .063 inch Alclad sheet coupons were subjected to a variety of exposure conditions and then tested at selected temperatures to determine residual short-time strength. Stressed exposures were studied by applying tensile stress during exposure with the amount of stress chosen to produce up to 1 percent inelastic strain -- about the practical limit for design based on short-time strength after exposure.

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The scope of the single exposure was:

Temp. range	250-600°F
Time range	1-100 hr
Stress range	0-50,000 psi (tension)*

The scope of multiple exposures was:

Temp. range	275-400°F
Time range	3.5-240 hr
Stress range	to 1 percent accumulated inelastic strain

The variety of multiple exposures included:

- 1-step, 2-step, 3-step, 4-step, and 10-step sequences
- Increasing temperature sequences
- Decreasing temperature sequences
- Mixed sequences
- Stressed sequences to various strain levels
- Stressed sequences with zero-stress soaking periods at start or end

The scope of final test conditions after exposure included:

Several mechanical properties:	F_{tu} , F_{ty} , F_{cy} , percent elongation, hardness
Several test temperatures:	R.T., 200, 300, 400°F
One strain rate:	.01 in./in./min. to yield
then:	.01-.05 in./in./min.

The presentation of information in this report is oriented from the standpoint of design use. Major results are presented first followed by substantiation and detailed descriptions. Illustrative material is grouped together at the end of the report for convenience in following references frequently repeated throughout the report. This places the graphs of final results (Figure 17 through 20) which are most useful for design applications just inside the back cover where they can be found quickly.

*Note: A spot-check of the effect of compressive exposure stress was also included.

Empirical methods for predicting residual strength of two aircraft structural materials after exposures to temperature alone, without stress have been developed in the first phase of this work, reported by Fortney and Avery in WADC Technical Report 56-585, Part I. The subject materials were 2024-T3 and alclad 7075-T6 aluminum alloys, and strengths in tension only were considered. The use of the Larson-Miller time-temperature parameter for predicting the total effect of a sequence of differing unstressed exposures was successfully demonstrated in the aforementioned report. Extension of these methods to the case of stressed exposures and to design mechanical properties other than yield and ultimate strengths in tension was the purpose of the study reported here. Other studies, on alloys other than 7075-T6, have considered effects of prior creep on subsequent strength for creep strains ranging above about 0.5 percent (References 4, 5, and 6). None of these referenced studies were primarily concerned with development of methods for accounting for prior creep exposure effects in practical design cases.

CONCLUSIONS

A number of valuable conclusions can be drawn from the results obtained in the study. The limitations of these conclusions are cited in the text.

1. Stress applied during severe thermal exposure can significantly accelerate deterioration of strength in 7075-T6 (retrogression of strength level toward the level of the annealed state).
2. The degree of strength reduction due to exposure stress is associated with the amount of inelastic strain accumulated during exposure. It is dependent upon the total degree of thermal exposure but is affected only slightly by manner of exposure accumulation for the cases investigated.
3. The Larson-Miller exposure parameter can be used to define equivalent single exposures for determining residual tensile ultimate, tensile yield, and compressive yield strengths after single or multiple stressed or unstressed thermal exposures.
4. The general strength deterioration characteristics of 7075-T6 can be adequately represented on a single curve. Tensile ultimate, tensile yield, and compressive yield strengths and all final test temperatures are reflected in this curve. For stressed exposures, separate curves are required for different degrees of straining during exposure.

Based on these findings, analytical methods for determining allowable strengths in practical design situations have been developed. These are presented in the following section, together with limitations on their usage. Substantiation of both the conclusions and the methods can be found under experimental results.

In practical design situations it is sometimes necessary to predict allowable short-time strength after complex histories of temperatures severe enough to cause partial annealing and of stress severe enough to cause creep. "Short-time" or "static" failures as opposed to "creep" failures are a likelihood for environments in which there is considerable variation in the severity of stress-temperature cycles, and in which the severe stresses are of short duration. Such environments may or may not produce amounts of creep significant from the standpoint of design.

Analytical procedures for assessment of strength under such conditions are presented here. In the approach used, the failure is artificially separated from the spectrum, and thereby the effects of the prior history on the allowable strength remaining may be defined. The prior history is simplified by computing an equivalent exposure value for the temperature spectrum alone and by accounting for the effects of creep separately.

To find equivalent thermal exposures, the Larson-Miller exposure parameter, Θ , is used:

$$\Theta = T(C + \log t) \quad (1)$$

where T is temperature in degrees Rankine, t is time in hours, and C is a constant. For the 7075-T6 data used in this report, the best value of C has been found to be 17, and the parameter becomes:

$$\Theta_{17} = T(17 + \log t) \quad (2)$$

Given an actual spectrum of temperature exposures, the first step in computing the equivalent total exposure for 7075-T6 is to reduce each increment of exposure in the spectrum to a value of Θ_{17} using equation (2). Next, a single reference temperature, T_{ref} is chosen arbitrarily, preferably within the temperature range of the spectrum. The equivalent time at this temperature is computed using equation (2) for each of the previously determined values of Θ_{17} . Adding the results gives the total equivalent time at T_{ref} for the entire spectrum, as shown below:

<u>Given Spectrum</u>	<u>Θ</u>	<u>Find Time at T_{ref}</u>
T_1, t_1	$(\Theta_{17})_1$	Equiv t_1
T_2, t_2	$(\Theta_{17})_2$	Equiv t_2
T_3, t_3	$(\Theta_{17})_3$	Equiv t_3
.	.	.
.	.	.
.	.	.
		Total Equiv. Time

The equivalent total thermal exposure, Θ_{17} is now computed directly from equation (2) using the total equivalent time and the reference temperature.

The evaluation of a spectrum can be considerably simplified by using Figure 21. With this diagram the only calculation required for the above example is addition of the equivalent times at T_{ref} .

Once the equivalent total exposure is known, the assessment of its effect (if any) on strength can be made. It is useful to separately identify the major sources of strength reduction encountered. Strength is reduced as a result of: (1) duration of exposure to a sufficiently high temperature and (2) temperature at the time of failure. Combining these two effects, the residual strength after temperature exposure and at a given test temperature can be expressed as a function of original room temperature strength, as follows:

$$F_{ef} = R_T F_{R.T.} \quad (3)$$

where F_{ef} is residual strength (F_{tu} , F_{ty} , etc.), R_T is a strength reduction factor combining exposure temperature effects and test temperature effects and $F_{R.T.}$ is the original room temperature strength.

Stress during exposure, especially if high enough to cause inelastic strain, is another factor which may affect residual or final strength. It will be seen that stress did have a significant effect on the 7075-T6 material tested in this work. Including this factor, equation (3) above becomes,

$$F_{ef} = R_T R_\epsilon F_{R.T.} \quad (4)$$

where R_ϵ is a strength reduction factor for the effect of strain accumulated during stressed exposures.

Values of R_T , R_ϵ , and $R_T R_\epsilon$ obtained for 7075-T6 are shown in Figures 16 and 17 plotted against exposure value Θ_{17} . These were obtained from a program of single exposure tests and checked at key points by program of sequential exposure tests. F_{tu} , F_{ty} or F_{cy} values may be determined for a variety of exposure conditions and test temperatures using these data and equation (4). The $F_{R.T.}$ value used is the corresponding allowable room temperature F_{tu} , F_{ty} or F_{cy} (see Reference 7). Limitations on the use of these data are discussed at the end of this section.

It can be readily seen that the curves of Figure 17 are not sufficiently general in application to cover all test temperatures and exposure conditions which are practical for this material. A more general strength deterioration factor has been developed for 7075-T6 which relates all three types of strength F_{tu} , F_{ty} , and F_{cy} (and possibly others not tested) at all test temperatures. This factor is shown plotted in Figure 20(a) against exposure value Θ_{17} . In general terms, it represents a relative strength value where 1.0 is the fully hardened strength and zero is a reference (nearly annealed) strength. This strength deterioration factor, D , is:

$$D = \frac{F_{ef} - F_l}{F_f - F_l} \bigg| T_f \quad (5)$$

in which F_{ef} is the strength as tested after a given exposure, F_f is the original (fully hardened) strength, F_1 is the reference (nearly annealed) strength, and T_f is test temperature. For a given value of D , the F_{ef} , F_f and F_1 values must all be the same type of mechanical strength (F_{tu} , F_{ty} , or F_{cy}) and obtained at the same test temperature, T_f .

When Figure 20(a) is used as a design curve, F_{ef} is the unknown residual strength to be determined. Rearranging equation (5) for this purpose gives,

$$F_{ef} = D F_f + (1-D) F_1 \quad \Big| \quad T_f \quad (6)$$

The appropriate value of D is obtained from Figure 20(a) for the particular total exposure value θ_{17} (obtained as before). Appropriate values of F_f and F_1 are chosen from Figure 19.

Notice that F_{ef} here is for the unstressed exposure case if D is taken from Figure 20(a). The same equation applies to stressed exposure cases if appropriate values of D are substituted. These are provided in Figure 20(b) for two stressed exposure cases involving, respectively, 0.2 percent and 1.0 percent inelastic strain accumulated during exposure. The proper value of D from Figure 20(b) is used in equation (6) above with appropriate values of F_f and F_1 from Figure 19 (as in the unstressed case) to find F_{ef} for a stressed exposure case.

No further explicit accounting for the effects of stress during exposure is necessary. For illustration, assume a design which meets the usual aircraft design criteria of 0.2 percent inelastic strain, as substantiated by methods not covered in this report. Then, any effects on residual strength of a spectrum of conditions within the design envelope are covered by use of the D value for 0.2 percent inelastic strain. Limitations are discussed at the end of this section.

For automatic computing purposes, an analytical expression is usually preferable to an empirical curve. Referring to Figure 20(a), an expression which fits the 7075-T6 data for unstressed exposure quite well throughout most of the exposure range and which relates D to θ_{17} is:

$$D = \frac{34,800}{(\theta_{17} - 12,920)^4 + 28,950} - 0.202 \quad (7)$$

$$(13,000 \leq \theta_{17} \leq 17,500)$$

This value of D can be used in place of Figure 20(a) for unstressed exposures and F_{ef} can be found as before.

The added influence of stress during exposure can be taken into account by a simple correction which will suffice for many practical design situations. For example, assume that the design criteria restricts accumulated inelastic strain to 0.2 percent. From Figure 20(b) it can be estimated that for a considerable range of exposure values above $\theta_{17} = 14,500$, the effect of this

degree of inelastic strain is the same as adding a small increment of exposure value, approximately

$$\Delta\theta_{17} = 100$$

The new value of D can then be found using equation (7) above with the corrected value of θ_{17} , in this case $\theta_{17} + 100$, as

$$D = \frac{34,800}{(\theta_{17} - 12,820)^4 + 28,950} - 0.202 \quad (8)$$

$$(14,500 \leq \theta_{17} \leq 17,500)$$

If accumulated inelastic strains significantly larger than 0.2 percent are permitted, a larger correction must be made. To correct for 1.0 percent strain, the appropriate increment of θ_{17} can be estimated from the curves of Figure 20(b) for each mechanical property. In many calculations, an average correction for the three properties will suffice and will simplify the calculations. In this case, for $\theta_{17} \geq 14,500$,

$$\Delta\theta_{17} = 250$$

may be used in equation (7) as in the previous case, and:

$$D = \frac{34,800}{(\theta_{17} - 12,670)^4 + 28,950} - 0.202 \quad (9)$$

$$(14,500 \leq \theta_{17} \leq 17,500)$$

For θ_{17} values between 13000 and 14,500 the appropriate curve should be chosen from Figure 20(b) to suit the design conditions. For automatic computing purposes the chosen curve can be represented either analytically as was done above or as a set of coordinate values.

The effect of inelastic strain beyond 1 percent is not considered since prior creep strains of this magnitude are not likely to be permitted (except in very local areas) in cases where short-time strength is required after creep exposure.

It should be noted that the inelastic strain values of 0.2 percent and 1.0 percent used in this report are the strain accumulated during exposure only. The yield strength tests produce an additional inelastic strain of 0.2 percent. Thus, yield strength curves for 0.2 and 1.0 percent strain during exposure actually represent 0.4 and 1.2 percent total inelastic strain, respectively. The exposure stress was considered separately to provide a consistent treatment of yield and ultimate strength results. For a vehicle designed to criteria restricting inelastic strain to 0.2 percent total from any and all sources, the above methods would be conservative.

The above methods have some limitations and also possibilities of extension. These are outlined below.

Figure 20(b) shows that there is considerable difference between the stressed exposure curves for F_{ty} , F_{tu} , and F_{cy} , for exposures below $\theta_{17} = 14,000$. Here there is a very noticeable Bauschinger-type effect, which has a greater influence on strength than the factor of acceleration of the aging process through straining. In this region, only two exposure conditions were studied and the effect is only approximately defined. However, this effect is usually not taken into consideration in design except when yield strength is reduced (i.e.: when direction of testing is opposite to that of the original straining). The compressive yield curve for 1.0 percent strain can be considered an approximate minimum curve for cases of this type, providing stresses during exposure are no more severe (in causing strain) than used in the 300°F-1 hour condition tested.

Material variation must be considered in applying the results of this study. The curves of Figures 17 and 20 are representative only of the material tested in this investigation and should not therefore be used directly as minimum design curves. There is significant variation in the response of various lots of the subject alloy to exposure in addition to the normal variation in room temperature properties (see pg. 17). A suggested method of reducing strength values obtained from these curves to minimum allowable strengths is by reference to minimum design curves for 7075-T6 such as provided in Reference 7 (Mil Handbook-5). Comparison between equivalent data from this report and from the minimum design curves will indicate necessary adjustments in the curves of Figures 17 and 20. A better solution would be the development of true minimum curves of D versus θ . This could be done using the methods developed in this investigation, and, for the most part, existing data on 7075-T6.

It is felt that justification exists for cautious extension of most of the results to the case of compressive creep exposures. In the compressive creep exposure check test, 0.3 percent compressive creep strain had about the same effect on compressive yield strength as a like amount of tensile creep in the same intermediate exposure range (see Table VIII). It is not certain that like agreement would be obtained for larger amounts of strain. Also, it is probable but not certain that the Bauschinger-type effects noted for exposure values below $\theta_{17} = 14,000$ would be of the same magnitude for straining in compression as in tension. If Figure 20(b) is used to estimate the effect of compressive creep during exposure, the compressive yield curve should be used as the tensile yield curve, and vice-versa. This is to account for the reversal of Bauschinger-type effects.

Investigation of shear and bearing strengths was beyond the scope of this present work. However independent studies (not reported) using 7075-T6 shear and bearing data from Reference 8 have shown promise for application of Figure 20 to these failure modes. Until this is verified, shear and bearing strengths for unstressed exposures can be found from appropriate ratios to tensile values obtained for the given design conditions. It should be noted that these ratios are affected by test temperature and by approximate degree of exposure. Further studies of shear and bearing strengths after stressed and unstressed exposures are planned for further extension of this work.

Care should be exercised in applying the results of the study to conditions outside the scope of the test program. High rates of straining followed by testing in the direction opposite to that of the straining is one possible area for caution. Another such area is that of multiple tensile stressed exposures followed by testing in compression. In tests of this type, compressive yield strength was depressed slightly beyond expected values, most noticeably in the ten part sequence tests. It is not certain whether further strength loss might be caused by increasing numbers of cycles or even whether the effect is real. Care is therefore recommended in extending these results to much more complex sequences followed by compressive loading. For unstressed exposures, and for tensile properties following tensile stressed exposures the results indicate that extension to more complex sequences than those tested should be safe.

EXPERIMENTAL RESULTS

The foregoing conclusions and methods are based on the results of the test program outlined in Tables I and II. The purposes of the various tests are discussed below, then details of the program and the results obtained are presented and reviewed under the following sub-headings, in conjunction with the tables and graphs at the end of this report:

- . Test Materials and Basic Properties
- . Creep Characteristics of Material
- . Tabulated Results
- . Material Response to Thermal Exposure Without Stress
- . Exposure Parameter Re-evaluation
- . Effects of Stress During Single Exposures
- . Effects of Stress During Multiple Exposures
- . Variation of Stress Effects with Degree of Exposure
- . Residual Strength After Single Exposures
- . Accuracy of Prediction of Multiple Exposure Results
- . Generalization of Results

Each test consisted of two principal parts for all exposure conditions, single or sequential:

Exposure of Specimens -- Specimens were subjected to one of the selected temperature-time, or temperature-time-stress exposure conditions or schedules of conditions.

Strength Testing After Exposure -- Standard short-time tensile and compressive tests were performed at room temperature or at one of the selected test temperatures.

The basic tests are the single exposure tests given in Table I. These tests provide data on stressed exposures, and they also form the foundation for examination of multiple exposures. The multiple exposure test program is presented in Table II.

Exposure temperatures, times, and stress levels shown in Table I were chosen to survey the effects of stressed exposure throughout the unstable range of the material from the T-6 condition to the nearly annealed condition. They were also chosen with the possibility in mind of using the Larson-Miller exposure parameter for stressed exposure cases as was done in Part I for unstressed exposure cases. In two cases, combinations of exposure time and temperature were approximately matched in total exposure value by two other combinations; this was done to check the assumed value of the constant C in the Larson-Miller exposure parameter. Values of this parameter using $C = 17$ (determination of which is discussed later) are presented for each exposure condition in the first column.

Exposure stress levels shown were established through creep tests and creep correlation methods. The target inelastic strain values were chosen to cover the range of anticipated practical use in design -- from a lower value

at half of the commonly used 0.2 percent to an upper value of 1.0 percent. Tensile exposure stress was used throughout to study stressed exposure relationships, and a spot-check case of compressive exposure stress was included.

The final test temperatures after exposure were selected to cover the temperature range of practical usage of the alloy with a minimum of tests as assisted by generalizing procedures.

Table II presents the multiple exposure tests. These tests provide data on a wide variety of sequential exposure conditions. The descriptions given in the table identify the main characteristics of the sequences chosen. Increasing and decreasing temperature trends at low, high, and zero stress levels at key values of total exposure are represented, as are some special cases with zero stress in the first or last step. Sequences range from two steps to ten steps.

Exposure temperatures and times were chosen to provide the desired total exposure and also to cause a significant change in properties in each step. The upper and lower limits of time used were 100 hrs. and 3.5 hrs., respectively, and temperatures ranged from 275°F to 400°F. Sequence total exposure values were chosen to approximately match the single exposure cases which had been checked by two different combinations of temperature and time.

Sequential exposure stress levels were established to give the indicated target strain values in the total sequence and also to produce significant strain in each of the stressed exposure steps.

Test temperatures after sequential exposures duplicated those of the single exposure program and were chosen with similar objectives. However, it was found that reductions in the number of final test temperatures could be effected without compromising objectives.

Test Material and Basic Properties

Test material for the entire program was 7075-T6 alclad aluminum alloy. Three .063 inches thick, 48 x 144 inch sheets of this material in the as-supplied T6 temper were used from Northrop Corporation production warehouse stock. All were from the same box of sheets from the material supplier.

The chemical analysis of each of the sheets, shown below, was well within the applicable specification (QQ-A-287) limits. Analyses were performed on a direct reading spectrograph.

PERCENT OF ALLOYING ELEMENTS

Element	QQ-A-287 Limits	Sheet A	Sheet B	Sheet C
Copper	1.2-2.0	1.70	1.60, 1.68	1.63
Magnesium	2.1-2.9	2.76	2.66, 2.58	2.70
Zinc	5.1-6.1	5.40	5.52, 5.48	5.50
Chromium	0.18-0.40	0.22	0.22, 0.21	0.22
Iron	0.70 max	0.10	0.18, 0.19	0.15
Silicon	0.50 max	0.06	0.05, 0.06	0.07
Manganese	0.30 max	0.10	0.09, 0.09	0.08
Titanium	0.20 max	0.02	0.02, 0.03	0.04
Aluminum	Balance	Balance	Balance	Balance

The microstructure of the test material was found to be typical of 7075 in the T-6 condition. Thickness of cladding was approximately 4 percent of the sheet thickness per side. A number of room temperature tensile tests were performed on as-received (unexposed) material from each sheet. All were well within the requirements of QQ-A-287.

Room and elevated temperature tensile and compressive properties of the test material before exposure are presented in Table III. The prefixes A, B, and C in the specimen nomenclature denote sheets A, B, and C which were utilized for the single exposure, tension; the multiple exposure, tension; and the compression program tests, respectively. The room temperature tensile tests performed on sheet A represent a survey of the sheet tensile properties. A total of 36 tensile tests were performed, to determine sheet variation and to provide tests to which nearby specimens exposed and tested could be compared. The latter improved accuracy in evaluating strength reduction factors in cases where strength values were near the original unexposed strength. The survey results are also shown in Figure 11, relating test values to location in the sheet. Variation in sheet A tensile properties was about average. The mean strength level was close to an universal mean for the same alloy and gage.

The average room temperature tensile properties of sheets B and C were approximately the same as sheet A. Room temperature compressive properties were determined only for sheet C. The average compressive yield of sheet C was 8.6 percent higher than its tensile yield, which is about normal.

Elevated temperature tensile and compressive tests in Table III are for unexposed specimens that have been heated to test temperature in a standard time of 12 minutes, from start of heating to start of loading. These data are shown plotted against temperature in Figure 19 (F_T curves).

Creep Characteristics of Material

Some knowledge of the creep characteristics of the material used in this study was needed to establish stress levels which would give the target values of strain during stressed exposure conditions. This need was filled by data from the literature and by check tests on each sheet of material.

Further refinements were required in methods for determining stress levels for succeeding steps in multiple exposure conditions. This was necessary because it was found that the creep strength of the material tended to decrease with progressive softening due to exposure. The strain values achieved during the various stressed single and multiple exposures are recorded in the tables of results. Analysis of creep characteristics is beyond the scope of this report.

Tabulated Results

The results of the experimental program are listed in Tables IV through XVI in the following order:

Table No.	Exposure Condition (Stressed & Unstressed)	Final Test	Nominal Test Temperature
IV	Single Exposure	Tension	R.T.
V	Single Exposure	Tension	200°F
VI	Single Exposure	Tension	300°F
VII	Single Exposure	Tension	400°F
VIII	Single Exposure	Compression	R.T.
IX	Single Exposure	Compression	200°F
X	Single Exposure	Compression	300°F
XI	Single Exposure	Compression	400°F
XII	Sequential Exposures	Tension	R.T.
XIII	Sequential Exposures	Tension	300°F
XIV	Sequential Exposures	Tension	400°F
XV	Sequential Exposures	Compression	R.T.
XVI	Sequential Exposures	Compression	300°F

The single exposure tables describe for each specimen the nominal and actual exposure conditions, the actual temperatures of testing after exposure, and the test results obtained. Actual exposure conditions consist of actual exposure temperature (the average temperature of the entire exposure) and the actual total inelastic strain obtained. The values of Larson-Miller exposure parameter Θ_{17} are also shown.

Similarly, actual test temperatures are distinguished from nominal; it was found that at 400°F very small deviations in test temperature could be significant, also there were a few cases where "room temperature" was significantly above the 68°F to 75°F range.

In addition to the strength values actually obtained in tensile and compressive tests, values corrected to the nominal exposure and test temperatures are provided. This was done as a guide in evaluating the effect of temperature deviations and to give a better basis for comparing results. Correction consisted of adjusting test values by an increment of strength derived from final curves of the test results themselves and appropriate to the error in exposure value (Θ_{17}) or test temperature. This is felt to provide a reasonably accurate correction because of the large amount of data available.

The strength results are also expressed in nondimensional form in the far right hand columns of these tables. The first of these, R_T is the ratio of the test value obtained to the material original unexposed room temperature strength. The second, R_ϵ , is the ratio of stressed exposure test results to the parallel unstressed exposure results, or a reduction factor for the effect of stress alone in the exposure environment.

The sequential exposure tables follow the same general pattern as the single exposure tables, but modifications are made to accommodate the multiple exposure steps. Nominal exposure conditions are shown; actual exposure temperatures are omitted but were used to compute the total exposure value Θ_{17} listed for each specimen. Actual strains accumulated during each exposure step are shown below the nominal conditions. Actual strains accumulated during the entire sequences are also presented. The properties after exposures and strength ratios are treated in the same manner as in the single exposure tables.

Material Response to Thermal Exposure Without Stress

The results of the single exposure tension tests are plotted in Figure 12 together with similar results from Part I to compare the response of the two lots of material to thermal exposure. The form of the Larson-Miller parameter, Θ' , established for 7075-T6 in Part I is used as the abscissa. Values of this form of the parameter are not shown in the tables because another form of the parameter is used for the balance of this report. However, values of Θ' can be readily computed from the equation given in Figure 12. The ordinate is nondimensional strength as established in Part I.

The test data plotted are from Sheet A of the present study and represent the averages of all identical tests. These data are connected with solid line curves, and the data from Part I are shown by dotted line curves.

Comparing the results from the two lots of material, it can be seen that the material from Part I responded to exposure significantly earlier in time (or in Θ') than did the material in Sheet A. Similar disagreement in proportional effect of exposure has been found in comparison of results from comparable exposure and test conditions from various sources (i.e.: Reference 8). This is a factor of material variability that must be considered in applying results of a study of this type of practical situations. Methods of approximately accounting for this variability are discussed under Analytical Methods for Design.

Another difference in results from the two studies is also illustrated in Figure 12. It was originally assumed that the Θ' form of the Larson-Miller parameter used in Part I would also apply to the material used in the present program. This assumption was checked by the tests in which different combinations of exposure time and temperature gave the same value of Θ' . Test data plotted in Figure 12 at these values of Θ' ($\Theta' = 17,400$ and $18,500$) show that imperfect agreement was obtained with the Θ' form of the parameter. Considerably better agreement was obtained when the parameter was modified. This is discussed in the following sub-section.

Exposure Parameter Reevaluation

Reexamination of the Larson-Miller exposure parameter showed that

$$\theta_{17} = T(17 + \log t)$$

provided the best fit for the data from the material in the present study (the change to a single constant is discussed below). The results using the new constant in the parameter are shown in Figure 13. The better agreement for the ultimate strength of Sheet A is immediately apparent (the 376°F-3 hr. data point should be ignored for the moment, since it is from Sheet C and was not shown in the preceding figure). The yield strength curves show similar good agreement for both Sheet A (tension yield points) and Sheet C (compression yield points).

There is thus the indication that the best constant for use in the parameter may change with different lots of material. The degree of change in this case can best be seen by converting the earlier θ' into the single-constant form by dividing by 1.46:

$$\frac{\theta'}{1.46} = T(13.7 + \log t)$$

Thus, the change in constant is effectively from 13.7 to 17. The change to the single constant form of the Larson-Miller parameter in this report is made because this has become the more widely used form.

Effects of Stress During Single Exposures

The effects of stress applied during exposure can be most simply discerned by comparing results for stressed and unstressed exposures having otherwise identical conditions. This may be expressed in ratio form as:

$$R_{\epsilon} = \frac{F_{\text{stressed exposure}}}{F_{\text{unstressed exposure}}}$$

R_{ϵ} is thus a strength reduction factor for the effects of stressed exposure, and the strain subscript ϵ is used because the value of this factor appears to be primarily dependent upon the amount of inelastic strain accumulated during exposure. R_{ϵ} is easily found from the test data because unstressed exposure control specimens were included with each group of three specimens subjected to stressed exposures. The control specimen test results are given in Tables IV through XI just above the associated stressed exposure results. R_{ϵ} is shown in the tables and is obtained by dividing the individual stressed exposure final strength values by the average of the control specimen final strength values.

Study of the ratios in the tables shows that exposure stress (or strain) in general does have an effect on remaining strength of 7075-T6, but this effect is not large. R_{ϵ} ranges from about .85 to 1.05 depending on degree of thermal exposure and degree of strain produced during exposure.

Figure 14 shows the R_e values from the single exposure conditions plotted against inelastic strain. Each individual test result is plotted. Separate plots are made for each strength property measured and for each degree of exposure utilized. Results for all final test temperatures are plotted together. An interesting and useful observation can be made: Final test temperature after exposure has no significant effect on the reduction factor due to stress applied during exposure. This can be confirmed by careful examination of all cases plotted in Figure 14.

In Figure 14, rough scatter bands are indicated by shading to show the basic trends of the results. These scatter bands are drawn arbitrarily in view of the small net effect that precision of establishing these bands has on the final resulting strength. The shading of the bands is stopped just above 1 percent strain because that is the upper limit of the range of interest in this study. However, points with larger strain were considered in drawing the bands.

Included in these bands are key markings (small, black "x" marks) at 0.2 percent strain and at 1.0 percent strain for use in later analysis. These marks are plotted at the approximate mean value of the test data, to the nearest 0.01 value of R_e . A small degree of smoothing of the location of these marks across neighboring exposing conditions was done (up to 0.01 R_e). The scatter of individual test points about the key points is within 3-1/2 percent for most cases.

At the lowest value of exposure, Figure 14(a), no scatter band is established because only large-strain tests were run. Comparing the key points shows that stress during exposure had no appreciable effect on the tensile ultimate strength but it raised the tensile yield strength and depressed the compressive yield strength. This is similar to the Bauschinger effect observed in specimens which have been prestrained in tension (at room temperature) and then tested either in tension or compression (Reference 10). The comparison seems logical since the exposure stress in the 300°F-1 hour case was quite high, and a relatively large part of the resulting strain was probably plastic strain on loading.

At moderate exposure values, Figures 14(c) through 14(g), this pronounced effect has disappeared and the scatter bands for all three properties are depressed, with compressive yield reduced slightly more than the tensile properties. In this area, the predominant effect of strain during exposure seems to be an acceleration of the process of averaging or annealing. However, a small degree of Bauschinger-type effect appears to persist to fairly high exposure values.

At extreme exposure values, Figure 14(h) and 14(i), the effect of stress during exposure on remaining strength is diminished and the R_e values again approach 1.0. In this exposure range, there may be a tendency for ultimate strength to be least affected and compressive yield the most affected.

Effects of Stress During Multiple Exposures

The effect of creep stress during the sequential exposures is presented in Figure 15. The manner of presentation is similar to that of the single exposure results discussed in the previous section, so that visual comparisons may be made at nearly equivalent exposure values (Θ_{17} values). Direct comparisons of single and multiple exposure results are presented later in the report. In comparing the single and multiple exposure curves it is valuable to note that the vertical scale of these plots is a rather expanded one, so that any real differences should be easily detected.

Examination of the curves in Figure 15 shows that of the sequence variables considered. There is little evidence of greater strength reductions than found in comparable single exposure tests. The one sequence in which a noticeably different result was obtained is the D sequence shown in Figure 15(e). In the D exposure sequence, specimens were unstressed until the last fraction of exposure period, at which time an exposure stress which gave a relatively high rate of straining was applied. Reductions in final strength caused by exposure strain in D sequence tests were not as great as in tests at similar values of strain and exposure value Θ_{17} , in which the strain was more uniformly accumulated. The results from these tests indicate that the stressed exposure strength reductions can be affected to some degree by extreme non-uniformity in strain accumulation.

Slightly greater strength reduction than expected was obtained in compression tests after the stressed E sequence (10 Part) exposure, shown in Figure 15(f). It is not certain whether this effect is real since it is small in magnitude especially considering the number of test results defining it and their scatter. The results obtained raise questions as to the effect of further increases in number of steps in sequences. Additional tests would be required to definitely establish the nature of this effect.

The various types of sequential exposures serve to demonstrate that, except for unusual exposure conditions such as the D sequence, (and possibly the case of compression after very complex stressed exposures, as noted above) the results are independent of the type of sequence used. Thus, it may be assumed for a large number of practical problems that if the sequence is sufficiently well mixed to avoid radical situations, consistent results can be expected from all sequences in the range covered by this study.

Variation of Stress With Degree of Exposure

As noted above, the effect of stress during exposure on the subsequent residual strength varies with degree of exposure. Figure 16 shows this variation; the key points for 0.2 percent and 1.0 percent inelastic tensile strain from Figures 14 and 15 are replotted as a function of Θ_{17} to show the trends of the mean values of the scatter bands with exposure.

The curves were drawn through the single exposure key points only (x symbol) for several reasons: (1) to establish a set of single exposure R_E values to be used in later analysis, (2) to provide a basis to which stress

effects in multiple exposure tests could be compared, and (3) to provide a basis for some smoothing of single exposure key values across adjacent exposure conditions. Key points are omitted and dashed lines are used where R_c curves had to be interpolated or extrapolated to obtain values at either 0.2 percent or 1.0 percent strain. Multiple exposure key points (+ symbol) are plotted for comparison with single exposure results.

The maximum effect of exposure stress and the trend of this effect with single exposures are easily discerned from this figure, since the effects of scatter are minimized. It can be seen that for 1 percent accumulated tensile strain during exposure the maximum effect on residual strength is about 8 percent for tensile ultimate, 10 percent for tensile yield and 11 percent for compressive yield. At very early exposures, greater differences between the effects in the three cases are noted, as discussed earlier. For 0.2 percent inelastic strain, the maximum effects are about 3 percent of tensile ultimate, 4 percent of tensile yield, and 2 percent of compressive yield. The differences at 0.2 percent strain are considered smaller than the accuracy of definition of the trends.

It is of interest to note the shapes of the yield curves for 1 percent strain during exposure as compared to that of the ultimate tensile curve. The compressive yield minimum is both lower than that of the tensile yield and occurs earlier. While the tensile yield minimum even occurs later than that of the tensile ultimate. Apparently a small degree of Bauschinger-type effect persists to relatively high exposure values. Possibly, much shorter exposure periods than those investigated, with rapid accumulation of strain during exposure would emphasize this effect. However, it is significant that there was no apparent difference in this effect between 10 hour and 100 hour tests at approximately the same exposure value.

In Figure 16, the multiple exposure results follow much the same pattern as the single exposure results for tensile ultimate and yield strengths. Compressive yield, on the other hand shows a possible tendency toward more strength loss in multiple exposures than in single exposures, most noticeable in the 10 step sequence, as noted in the previous discussion. Comparison of single and multiple scatter bands at equivalent exposures for the compressive yield cases indicates that the difference is slight for the variety of cases covered. The cause of this difference, if a real effect, is not identifiable from these tests. Additional studies are desirable to check the existence of this effect.

The small net error introduced in predicting multiple exposure results for sequences within the scope of this investigation is treated in later discussions of the accuracy of prediction. The D sequence is the one case in which marked difference was obtained. In Figure 16, the D sequence points for tension ultimate and tension yield after 1 percent strain fall quite high, near the 0.2 percent strain curve, at $\sigma_{17} = 15,300$.

Residual Strength After Single Exposure:

In the foregoing discussion, the strength reduction factor for stressed exposure has been based on the strength after unstressed exposures. Strength after unstressed exposure is reduced as a result of: (1) duration of exposure to a sufficiently high temperature and (2) temperature at the time of failure. These effects can be combined and the total strength reduction for unstressed exposure expressed as the ratio:

$$R_T = \frac{\text{Strength at Temperature After Unstressed Exposure}}{\text{R.T. Strength Before Exposure}}$$

For stressed exposure the reduction factor for the effect of stress, R_ϵ is included in the expression for total strength reduction, as:

$$R_T R_\epsilon = \frac{\text{Strength at Temperature After Stressed Exposure}}{\text{R.T. Strength Before Exposure}}$$

Expressed in these terms, stressed and unstressed exposure results can be plotted on the same coordinates, providing curves that are more general than obtained by plotting actual strengths.

Figure 17 shows the F_{tu} , F_{ty} and F_{cy} strength reduction factors R_T and $R_T R_\epsilon$ plotted as a function of exposure value Θ_{17} . Trends of R_T values are indicated by the solid curves. $R_T R_\epsilon$ values for 1.0 percent strain during exposure are shown connected by dashed curves. Each R_T data point represents an individual unstressed exposure test result. These values are also listed in Tables IV through XI. Values of $R_T R_\epsilon$ were obtained by applying R_ϵ values for 1.0 percent strain from Figure 16 to the R_T curves.

Correlation of unstressed exposure results with the Larson-Miller parameter as modified for this study appears good, as was noted previously in discussion of Figure 13. The stressed exposure results indicate that although inelastic strain during exposure does affect strength, it does not impair this correlation. This can be seen by reference to Figures 14 and 16. As noted in previous discussion of these figures, in cases where different combinations of time and temperature gave approximately the same exposure value Θ_{17} , the effect of inelastic strain on final strength was nearly the same.

The general effects of inelastic strain during exposure can be seen by examination of the curves of Figure 17 for all strength properties and final test temperatures. First, it is observed that the effect of up to 1.0 percent inelastic strain on the residual strength of 7075-T6 is not large but is significant. Second, the effect is nearly the same in all cases at a given exposure value except in the lower exposure values. A third observation is that for a large part of the exposure range the stressed exposure results are offset from the unstressed exposure results by approximately a constant increment of exposure. These observations make possible a much simplified, general approach for predicting the effect of stressed exposures presented in this report.

Accuracy of Prediction of Multiple Exposure Results

Use of the single exposure results to predict multiple exposure values for the same total exposure has already been suggested for unstressed exposures in Part I and for stressed exposures in foregoing discussions. Comparison of the accuracy of such predictions is given in Figure 18 for the three strength properties investigated and for unstressed and stressed exposures. The actual results achieved in test after multiple exposures are plotted against values predicted from the single exposure curves for the same calculated total θ_{17} exposure. The solid line at 45 degrees in each chart represents perfect agreement.

Unstressed exposure correlations are shown in Figure 18(a). Individual points reflect averages of all results for each sequence. Coding is provided to identify the different sequences investigated. Agreement between predicted and actual results is in general quite good. One difference can be detected between results from certain exposure sequences. Considering sequences identical except for the temperature direction of the exposure steps, decreasing temperature steps resulted in slightly higher strengths than increasing temperature steps. This can be seen by comparing the open and closed symbols having the same shape. Even with this difference, the agreement between predicted and actual results is good.

The stressed exposure correlations are shown in Figures 18(b) and 18(c) for 0.2 percent and 1.0 percent inelastic strain. In this case the test values for comparison with predicted values were derived by using the key values of R_E (for 0.2 and 1.0 percent strain) for the stressed multiple exposure cases from Figure 15. Each key R_E value was multiplied by the R_T value for the sequence it represented. This removed the scatter of individual test results as was done for Figure 18(a). Also, the R_T values for sequences identical excepting for direction of temperature steps were averaged, removing the difference noted previously for different temperature directions of unstressed exposure sequences. (No distinction in stress effects was noted for this case, see Figures 15(a) and (c)). Since accuracy of the R_T value prediction in Figure 18(a) was good (especially with temperature direction effect averaged), Figures 18(b) and 18(c) clearly indicate any additional inaccuracy due to the effect of stress (or strain) during the various sequences.

The results for the stressed exposures are similar to those found for the unstressed exposures. The correlation between predicted and actual test results is generally very good. The maximum difference is noticed in the case of the D sequence. Another smaller difference can be detected. This is for compressive yield strength after the ten-part E sequence. Both of these results were discussed under "Effects of Stress During Multiple Exposures."

Generalization of Results

It is valuable to generalize the foregoing results in order to simplify and extend application to practical problems. This can be accomplished by finding ways to relate as many variables as possible to each other on a common basis. This has already been partly accomplished by the general correlation of all test results with the form of the Larson-Miller parameter used.

Closer examination of the various curves in Figure 17 shows that all material strengths do not deteriorate to the same degree with prolonged exposure. Room temperature tensile ultimate strength declines to 50 percent of its original strength while room temperature tensile yield and compressive yield strengths decline to about 20 percent. This means that any relationship which exists between the magnitudes of these various strengths must be non-linear and is not entirely obvious from the empirical data. However, these curves have some similarities. It can be seen that in all cases deterioration of properties begins to occur at a common degree of exposure and becomes essentially complete at another common degree of exposure. Similarity can also be seen in the general shapes of the curves. This leads to the supposition that a single general shape of decay curve might be followed by all strength properties in traversing the interval between full-hard strength and full-soft strength.

Attempts were therefore made to plot all properties tested in terms of relative strength between full-hard and full-soft strength, against the exposure parameter Θ_{17} . This was not too successful, due to a rather large degree of scatter which occurred in tests at extreme exposures (see plotted data for 600°F-8 hours in Figure 17(c)). Attempts to approximate the same results by using a more restricted interval have been met with success. The interval between the original strength and the strength remaining after an exposure of $\Theta_{17} = 16,380$ (450°F-10 hr.) was chosen as the reference interval. The strength values for the extremes of this interval (for the three sheets of material used in this study) are shown in Figure 19 as a function of temperature. All other strength values are related to their position in this interval by the expression:

$$D = \frac{F_{ef} - F_1}{F_f - F_1} \bigg|_{T_f}$$

in which D is called the strength deterioration factor, F_{ef} is the strength as tested after a given exposure, F_f is the original (full hardened) strength, F_1 is the strength after the reference exposure (450°F-10 hr.) and T_f is test temperature. For a given value of D, the F_{ef} , F_f , and F_1 values are all the same type of mechanical strength (F_{tu} , F_{ty} , or F_{cy}) and obtained at the same test temperature, T_f .

Values of D for unstressed exposures are computed in Table XIX using data from Tables IV through XVI for F_{ef} values, and Figure 19 for values of F_1 and F_f . F_{ef} values used are average values from each group of specimens tested under identical conditions. The results are plotted in Figure 20(a), where all of the unstressed exposure data from the program are shown together on one curve; all three types of mechanical properties at all final test temperatures after single and multiple exposures are represented. It can be seen that the correlation throughout most of the exposure range is good while that at extreme exposure (nearly fully annealed) is poor. Fortunately, the useful portion of the curve is the region of good correlation.

The same procedure is applied to the stressed exposure cases by relating them to the unstressed exposure results. The F_f and F_l values are unstressed exposure values, while the F_{ef} values are for stressed exposures. Calculations for D are given in Table XIX for 0.2 percent accumulated inelastic strain and for 1.0 percent accumulated inelastic strain during exposure. In these cases, F_{ef} is found by applying the strength reduction factors, R_e from Figure 16 to the same unstressed exposure average values of F_{ef} used for the basic D curve.

The results for the stressed exposure cases are shown in Figure 20(b). Here, the data points are omitted for clarity of presentation. The curves for the different properties are practically the same for most of the unstable (steeply sloping) region of the curve and are shown as a single curve for 0.2 percent and another for 1.0 percent. At the low exposure values, the stressed exposure curves for the three properties separate, particularly the 1 percent strain curves. The magnitude of the effect is considerable below $\theta_{17} = 13,500$. In this region the curves are primarily based on only one exposure condition (300°F-1 hr.) and it is not certain that the same curves would hold for all exposures.

All of the test data developed in this investigation have been successfully normalized by means of the procedures which have been discussed. This raises the question of extension to mechanical properties other than those tested. It should be recognized that the normalizing procedures used in this report are basically empirical, and therefore, the resulting strength deterioration curves apply specifically to those mechanical properties for which data were obtained. However, an analysis of data from reference 8 (the results of which are not shown here) has indicated that the shear and bearing properties of 7075-T6 after various exposure conditions can very likely also be normalized by the same procedures. For unstressed exposures, shear and bearing properties may even follow the same strength deterioration curve (Figure 20(a)). The hardness data obtained in this investigation on the other hand, does not plot directly on the same curve, probably due at least in part to characteristics of hardness magnitude scales.

It is believed that the basic approach used in this work on 7075-T6 can also be used in investigating many other hardening materials which deteriorate in strength during exposure to practical thermal and stress environments. Modifications to the approach will no doubt be required, especially for materials having more complex aging or annealing characteristics than 7075-T6.

TEST PROCEDURES

The procedures used in this program were established and checked prior to use in an attempt to attain the accuracy desired in each part of the exposure and of subsequent tests. The consistency of the results achieved tends to verify the adequacy of the procedures. The important features of these procedures are discussed under the following subheadings:

- . Specimen Identification and Preparation
- . Specimen Exposure Assemblies
- . Specimen Exposures
- . Measurement of Creep Strain
- . Specimen Processing Between Exposure and Strength Testing
- . Hardness Testing
- . Strength Testing

Specimen Identification and Preparation

Three 0.063 gage Alclad 7075-T6 aluminum alloy sheets were used during this investigation. Specimen blanks were marked out on heavy adhesive-backed paper covering the sheet, with the axis of all test specimens transverse to the original rolling direction. These were identified by metal stamping according to the identification system shown in Figure 1. The sheet was sheared into specimen blanks and machined to the dimensions shown in Figure 2. Careful machining practices were used, and microhardness tests on machined surfaces showed that machining caused no overheating of the material.

Specimen details are shown in Figure 2. The tension specimen incorporates pin-joint type loading ends, 0.505 inch reduced test section and 2.0 inch gage length. This same specimen was used for both creep-exposure and tensile testing after exposure. Tensile creep-exposure specimens for the compression test program were essentially extra long tensile specimens with a slight machining allowance on the width so that all edges of the compression specimens could be machined to the required tolerances. The compression test specimen was 0.5 in. wide by 2.75 in. long. Three of these specimens were machined from the reduced section of each creep-exposure specimen.

Specimen Exposure Assemblies

Stressed exposure of tension specimens was accomplished for the most part with three specimens linked in series as shown in Figure 3. Unstressed control specimens were exposed along with the stressed specimens, mounted (by one end only) adjacent to the center stressed specimen. Small aluminum blocks were loosely assembled to cover the reduced section of the upper and lower stressed specimens. The use of these blocks improved temperature stability with no detrimental effects other than a slightly slower heat-up rate. Thermocouples were placed at each end of the reduced section of each specimen until enough temperature data were accumulated to allow reduction of the number of thermocouples to that shown in Figure 3.

Some of the one hour and ten hour stressed exposures of tensile specimens were effected in shorter length creep furnaces one specimen at a time. Thermocouples were located at each end of the reduced section of all such specimens. No temperature stabilization blocks were required.

All thermocouples were attached so as to contact the edge of specimens. This location was checked against thermocouples located in drilled holes in a dummy specimen and found to be an accurate procedure. (Temperature deviation between edge location and hole location was found to be less than 10°F as long as reasonably uniform furnace temperatures existed. For rapid heat-up conditions, the edge thermocouples responded more rapidly to increase in furnace air temperatures than did the thermocouples in holes.)

Stressed exposure of material for compression specimens was accomplished with the creep exposure specimen shown in Figure 2. Unstressed exposure specimens consisted in most cases of 0.625 in. by 3 in. blanks. These were mounted in the center of a second creep exposure specimen which acted as a carrier only. The carrier specimen was mounted (by one end) parallel to the stressed exposure specimen separated by about 0.25 in. In a few cases a long creep-exposure specimen was utilized for unstressed exposure compression specimens, mounted the same as the "carrier" specimen described below.

A total of four thermocouples were used to instrument the ten-inch long reduced section of the stressed exposure specimen. A single thermocouple sufficed for the zero stressed specimens, all of which were in mutual contact.

Specimen Exposures

Most specimen exposures were performed in the type of creep machines shown in Figure 4. Exceptions were some short duration unstressed exposures and the compression creep exposure check test which were exposed in the circulating-air oven.

Creep Furnace Exposures:

Specimen assemblies were installed in the furnace and heated to the desired temperature as rapidly as possible, using caution to avoid temperature overshooting of any of the specimens. Specimens were then loaded by gently adding weights to the weight pan. The time for heat-up, from start of heating to start of loading averaged one-half hour (the creep furnaces were limited in rate at which specimens could be heated with accuracy, especially when utilizing a large proportion of the furnace length).

Thermocouple temperatures were recorded continuously throughout all exposures on multi-channel recorders and checked periodically with a precision potentiometer (the latter readings also recorded). Variation in temperature of a given point throughout the exposure period was within $\pm 5^\circ\text{F}$ from the average temperature, after the first hour of exposure. Usually, for the first hour temperature was less stable, within about $\pm 7.5^\circ\text{F}$ (excepting the 300°F-1 hr exposures, discussed further below). Temperature variation during exposure over specimen 2 inch gage lengths was within 3.5°F. The temperature records obtained

were used to determine specimen average temperatures for the entire exposure period. These are the actual exposure temperatures recorded in Tables of Results along with nominal exposure temperatures. Actual temperatures were up to $\pm 4^{\circ}\text{F}$ from the nominal exposure temperatures.

At the conclusion of the exposure period specimens were unloaded, removed from the furnace, disassembled from all linkage, and allowed to cool on a wood surface.

Procedures for each of the exposures in sequential exposure tests were the same as above except that specimens were usually transferred to a different creep furnace for each part of the sequence. This was done because it was found that rapid heat-up could be obtained more accurately by starting with a cool furnace.

An analysis was made of effect of heat-up time for the various exposure conditions. The conclusion was that the only exposure condition in which this became important was the 300°F -1 hr condition. The check test on the effect of compressive creep exposure (375°F -3 hr) was also short enough to have been in this category, but these exposures were performed in a circulating air oven which provided more rapid heat-up. For the short exposures in the sequential exposure program heat-up times were incorporated approximately into the calculation of total exposure for the sequence (θ value) and so were negligible in the effect on the net accuracy of the sequence.

The 300°F -1 hr exposures were given special attention and, for the tests that were reported, heat-up times were held to 15 minutes, with good temperature stability achieved throughout the exposure period. This heat-up time amounts to a possible error in exposure value of plus 50 units of θ_{17} . The appearance of the strength reduction curves (Figure 17) at this exposure indicates that this error is negligible as to effect on strength level. Similarly, this error has a negligible effect on the determination of the effects of stress during exposure. This can best be seen in Figure 16.

Circulating-Air Oven Exposures:

A few unstressed exposures were performed in the circulating air oven used for elevated temperature strength tests, shown in Figure 6. These were relatively short exposures, from 3 to 10 hours in duration. The specimens for each exposure were bound together and a thermocouple was attached to each end of the group. The heat-up time was 15 minutes or less except for the 600°F -8 hr exposure; one half hr was required for 600°F stabilization. Thermocouple temperatures were determined periodically with a precision potentiometer and recorded by hand.

Compressive Creep Exposure:

The compressive creep exposure check test followed procedures identical with the elevated temperature compression tests. The same specimen was used, supported in the compression test fixture while subjected to a predetermined compressive stress. With each of these were exposed one unstressed compression and one unstressed tension specimen as controls. Compressive creep exposure specimens were undistorted after stressed exposure and no machining was required between exposure and compression test.

Measurement of Creep Strain

Creep strain was measured by using two sets of gage points of the type shown in Figure 5. One had about 2" separation and the other slightly less. The larger set was impressed in the reduced section of the specimens before exposure and the smaller set was impressed within the first set after exposure. The separation between the resulting points at each end of the gage length was measured under a microscope with a Filor eyepiece, at a magnification of 100 power. The sum of the two measurements was equal to the total inelastic strain in the 2 inch gage length plus the original difference in lengths of the two sets of points.

To calibrate this system, it was necessary to know precisely the differences in lengths of the two sets of gage points. To accomplish this, each time a group of specimens for exposure was marked, trial impressions were made on a dummy strip. The differences between sets of points on the test strip was measured precisely under a microscope as before. Variation in creep strain measurement was checked and found to be within approximately $\pm 0.02\%$ strain for the single exposure measurements.

For the long creep exposure specimens, the same procedure was followed in each of the three locations from which a compression specimen was to be machined.

For specimens subjected to multiple exposures, total creep strain accumulated was determined after each exposure step. This was done with succeeding sets of gage marks laterally displaced (up to 0.035 in.) from the original set. It was found that accuracy of creep strain measurement was reduced by the lateral displacement of gage marks. Performance checks indicated that maximum variation of measured sequential exposure strain from the actual was about 0.06%.

Specimen Processing Between Exposure and Strength Testing

Tensile Specimens:

For tensile specimens, steps between exposure and tensile testing consisted of: creep strain measurement, hardness testing (if applicable, see below), and holding at room temperature for a standard delay time. The first two items are discussed elsewhere under test procedures. The standard delay time is explained as follows: Up to 1 1/2 hours were required to complete tensile tests of some groups of specimens exposed together. To minimize differences between specimens as to holding time at room temperature before testing, it was decided to delay start of testing for a standard time of one hour after the end of the exposure period. This step was taken against the possibility of minor changes in strength due to secondary ageing reactions at room temperature after exposure to temperature.

Compression Specimens:

Steps between exposure and compression testing consisted of:

- Creep strain measurement
- Cutting compression test blanks from reduced section of creep exposure specimens
- Hardness testing (if applicable)
- Refrigeration storage of compression test blanks
- Machining of compression specimens from blanks

All of the above steps are explained elsewhere or are self explanatory except the fourth. Refrigeration of compression test blanks was used to avoid long and variable soaking times at room temperature caused by the intermediate machining step. Blanks were refrigerated to below 50°F within an hour after the end of exposure and held from a minimum of 12 hours to a maximum of four weeks before bringing back to room temperature for machining and compression testing. Time at room temperature for machining and compression testing varied from 3 to 8 hours. Total time at room temperature between exposure and compression testing was therefore from 4 to 9 hours for all specimens.

The effect of refrigeration was checked on unexposed control specimens for room temperature test. Two such specimens were refrigerated for about 16 hours while several specimens located near these in the sheet were not. All were compression tested at room temperature. No effect of refrigeration could be discerned in the results (Table 3).

Hardness Testing

All specimens for room temperature strength tests were hardness tested after exposure and before strength testing. Two Rockwell hardness scales were used because of the wide range of hardness of specimens after exposure, the B scale and the H scale. Most specimens were tested on both. Location of hardness tests on tensile specimens was at each end of the reduced section. Compression test blanks were hardness-tested at each end on material subsequently removed in machining of compression specimens.

A number of hardness test results on creep-exposed tensile specimens have been omitted from the results reported. These tests were performed just outside the specimen reduced section, through error, on material which had been subjected to a lower exposure stress than that in the reduced section. These values would not have been completely representative of the material which was subsequently strength tested and so were deleted.

Strength Testing

Tensile Tests:

After exposure, tensile specimens were tested at one of four test temperatures, room temperature, 200°F, 300°F or 400°F, using the equipment shown in Figure 6 for the elevated temperature tensile tests and most of those at room temperature. Properties determined were ultimate tensile strength, 0.2% offset yield strength, and percent elongation. Yield strength values were obtained from autographic stress-strain curves using extensometers over a two inch gage length. Percent elongation was measured over a two inch gage length with dividers.

Specimen temperatures were measured by a thermocouple contacting the specimen edge at the midpoint between ends of the reduced section. In tests to verify this procedure, there was no difference between readings of thermocouples located in holes drilled in the specimen and those at the edge location, nor was there any significant temperature difference from top to bottom of the reduced section. Temperature was read from a precision potentiometer. Readings were recorded at the start of loading and at maximum load. The actual test temperatures given in the tables of results are the averages of these two values, which were never more than 3°F apart.

The maximum time for heating specimens to test temperature was 12 minutes and this was for the 400°F test temperature. Less heat-up time was required for the 200°F and 300°F test temperatures, but a standard heating time of 12 minutes before loading was also used for these. Times from start of loading to the 0.2% offset yield load and to maximum load were obtained on elevated temperature tests, using a stopwatch. Time to yield varied between 20 seconds and one minute. Time from start of loading to ultimate load varied between 45 seconds and 3 1/2 minutes. (At 300°F and 400°F test temperatures maximum time was 2 1/2 minutes.) An exception to this were tests on the nearly annealed material (600°F-8 hr exposures). Some of these required 5 minutes to reach maximum load.

All tension tests were performed with a constant rate of crosshead travel from start of loading to fracture. A few of the first room temperature tensile tests were performed on a Baldwin SR-4 test machine at a strain rate of 0.005 in/in/min up to yield, with the aid of strain pacing. Shortly thereafter the Instron Machine, with a circulating air furnace (Figure 6) became available, and strength testing was changed over to this machine. The strain rate up to yield for tests conducted on the Instron Machine averaged 0.01 in/in/min. Data provided in Reference 11 indicate that a change in strain rate of this magnitude should not significantly affect the results of tensile tests on 7075-T6 at room temperature.

Strain rates up to yield were calculated from readings of time to reach the 0.2% offset yield load. These values varied from the average value quoted above, depending on the strength level of the material and the test temperature. All strain rates fell within 0.008 and 0.012 in/in/min. This degree of variation would be undesirable for tests at 400°F on this alloy; however, nearly all of the 400°F tests fell within 0.008 and 0.01 in/in/min. The few that did not were tests of material in the nearly annealed condition. Actual strain rates up to yield for tests at 400°F are given in the tables of results (see Tables III and XVII).

Strain rate in the specimen reduced section tended to increase after yielding, the usual case when crosshead travel rate is held constant throughout tensile tests. (With specimen yielding the change in stress rate causes a change in distribution of strain between the specimen reduced section and other parts of the linkage between the test machine crossheads.) Actual strain rates from yield to ultimate were not obtained, however all fell between approximately 0.01 in/in/min and 0.05 in/in/min. The latter is the maximum possible rate with the 0.1 in/min crosshead separation rate used. Also, specimens of approximately equal strengths tested at the same test temperature would have had comparable strain rates from yield to ultimate.

Compression Tests:

After single exposures compression specimens were tested at one of four test temperatures, room temperature, 200°F, 300°F or 400°F; and after multiple exposures at room temperature or 300°F. 0.2% offset compressive yield values were obtained from autographic stress-strain curves. Test facilities were the same as for tension tests.

The fixture for supporting compression specimens during tests is shown in detail in Figure 9 and in place in the test machine in Figure 10. Specimens were supported by guide plates having offset vertical grooves. Specimen alignment in the fixture and tightening of guides were by "feel". Strain was measured by a two inch averaging extensometer, using extension arms for elevated temperature tests. Accuracy of compression test procedures was checked by inspection of modulus of elasticity values from a number of compressive and tensile stress-strain curves obtained at room temperature and 300°F.

Specimen temperatures were measured by a thermocouple attached to the edge of one of the specimen guides, at the midpoint between specimen ends, about 0.125 in. from the specimen surface. The test furnace and fixtures were stabilized at the test temperature before installing compression test specimens.

Maximum time for specimens to reach any of the test temperatures was slightly under 12 minutes, so heating time was standardized at 12 minutes for all elevated temperature compression tests. This agreed with the heating time for elevated temperature tension tests. Maximum time from start of loading to the 0.2% offset compressive yield load was 1.2 minutes.

The accuracy of compression specimen heating was checked with a dummy specimen which had thermocouples located in grooves at the top, middle and bottom in addition to the thermocouple on the specimen guide. No significant temperature disagreement occurred between any of the thermocouples when procedures which simulated compression tests were followed.

Compression tests were performed with a constant rate of crosshead travel. Strain rates as determined by stopwatch readings averaged 0.009 in/in/min for all tests. Individual values obtained varied between 0.007 and 0.001 in/in/min with a few exceptions. Part of this variation is probably due to the method of measuring strain rate. All tests at 400°F fell between 0.0075 and 0.0095 in/in/min. Strain rates for 400°F tests and for the exceptions noted above are recorded with the test results (Tables III, XI and XVI).

TEST EQUIPMENT

Equipment used in the experimental portion of this investigation can be conveniently divided into two categories.

Exposure Equipment: Equipment used to provide the desired exposure conditions for specimens prior to testing consisted of:

- . Creep-rupture machines
- . Temperature recording equipment
- . Creep strain measurement equipment

Test Equipment: Equipment used for tensile, compressive and hardness testing of specimens after exposure consisted of:

- . Tension and compression test equipment
- . Compression test fixture
- . Load-strain recording equipment
- . Hardness tester

Creep-Rupture Machines

Stressed and unstressed exposure of specimens was carried out on several creep rupture machines. Six of these on which most of the exposures were performed were of the type shown in Figure 4. These are Arcweld M-3 creep frames with cylindrical wire-wound resistance furnaces, 32 inches long by 2.5 inches inside diameter. Specimen loading is by weights acting on a lever. Furnaces are controlled by Wheelco 407 current proportioning, indicating controller in conjunction with a chromel-alumel thermocouple mounted on a specimen in the center of the furnace.

Three Arcweld XJ creep frames were also used. These had 22 inch long by 4.5 inch inside diameter wire-wound resistance furnaces. Function of the XJ units is similar to the M-3 units previously discussed. Furnace control is by Brown Electronik electropulse proportioning recording controller.

Temperature Recording Equipment

Specimen exposure temperatures were continuously recorded on one of two Brown Electronik 12-channel recorders. These recorders have a rated accuracy of 0.25 percent of full scale temperature range. The scale used was zero to 1200°F. Specimen temperatures were periodically checked with a Leeds and Northrup model 8662 precision potentiometer. Thermocouples used throughout all tests were made of special close tolerance 24 gage chromel and alumel wires joined by flash welding. Thermocouples were within $\pm 1^\circ\text{F}$ accuracy in the temperature range of usage.

Creep Strain Measurement Equipment

Apparatus for measurement of creep strain consisted of two sets of gage points, one of approximately 2 inch separation, the other slightly less than

2 inches. One of these is shown in Figure 5. The points used in these gage marking devices are Rockwell Diamond Point Indenters. Actual measurement of the separation of the two sets of points at each end of the 2 inch gage length was accomplished with a Bausch & Lomb bench microscope with Filor eyepiece at a magnification of 100 or 125 power.

Tension and Compression Test Equipment

Two test machines were utilized for tension tests. A few of the first room temperature tensile tests were performed on a Baldwin SR-4 hydraulic universal testing machine, with a 50,000 pound maximum capacity. This machine is equipped with a Baldwin strain pacer operated from the extensometer differential transformer. The remainder of the tension tests and all compression tests were performed on an Instron TTC-M1 test machine, shown in Figure 6. Tests on the Instron machine were run at a constant rate of crosshead travel. A stopwatch was used to measure time from start of loading to the .2 percent offset yield load and maximum load. For elevated temperature tests, a circulating air electric-resistance oven manufactured by Missimers Inc. was employed (shown in Figures 6 and 7). This oven has a working chamber 15 inches wide by 12 inches high and 22 inches deep.

Furnace temperature was controlled by a Brown Elektronik electropulse proportioning recording controller, in conjunction with a chromel-alumel thermocouple located in the furnace working zone.

Compression Test Fixture

The compression test fixture consisted of a pair of adjustable specimen guides, a loading system and a base for the specimen. Details of the fixture are shown in Figure 9. The compression test assembly is shown in Figure 10.

In this fixture, specimen guides have vertical grooves offset from each other. This has been indicated as a generally acceptable specimen supporting arrangement in Reference 9. The specimen is loaded at the top by an unattached blade which is supported by the guides and protrudes slightly at the top of the guides, where it contacts a loading ram. The blade thickness is a slight undersize of the specimen to avoid binding in the guides. Load is transmitted through a 5/8 inch diameter ball in the ram assembly to assist in alignment of loading.

Material used in the frame, guides and loading ram is A-286 alloy, with Stellite No. 1 hard facing in highly loaded areas. The loading blade is hardened tool steel. The ball is a standard ball bearing which is replaced upon any sign of plastic deformation.

Load-Strain Recording Equipment

A Baldwin PS-5M microformer extensometer was used to measure strain in all tensile tests. This extensometer is an averaging, separable type. For tests at room temperature, 200°F and 300°F, it was attached directly to the specimen with opposing conical points, over a 2 inch gage length. For tension tests at 400°F extension arms from a different extensometer were used with the PS-5M. These were also attached to the specimen with opposing conical points

over a 2 inch gage length, with the arms extending outside the furnace. The installation for tests up to 300°F is shown in Figure 7, and for 400°F tests in Figure 8.

During compression tests strain was measured with a Baldwin SR1E resistance wire strain gage type compressometer. This is also a strain averaging instrument, and was used over a 2 inch gage length. For tests at room temperature the compressometer was attached directly to specimen edges by spring loaded knife edges. For elevated temperature tests, a set of extension arms were used which gripped the specimen edges in a similar fashion and extended outside the furnace. The SR1E was actuated by the relative motion of the extension arms, unmagnified by any lever system. The elevated temperature compression test assembly is shown in Figure 10.

Load-strain curves were obtained on the Instron machine X-Y recorder. Load was recorded on the Y axis as measured by the test machine SR-4 load cell. Strain was recorded on the X axis either from the extensometer differential transformer signal or the compressometer signal after conversion by an SR-4 converter.

Hardness Tester

A Rockwell hardness tester, Wilson model 4JR was used with 1/16 inch diameter and 1/8 inch diameter indenters to obtain Rockwell B and H scale hardness readings. Hardness test accuracy was periodically checked by hardness tests on calibrated test blocks.

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TABLE 1
SINGLE EXPOSURE CONDITIONS TESTED

Qty Exposure $\times 10^{-3}$	EXPOSURE CONDITIONS				FINAL TEST TEMPERATURE	
	Temp. °F	Time hrs	Stress (tensile) ksi	Target Strain %	Tension °F	Compression °F
12.92	300	1	0	0	R.T., 300	R.T., 300
12.92	300	1	50	1.0	R.T., 300	R.T., 300
13.49	250	100	0	0	R.T., 300, 400	R.T., 300, 400
13.49	250	100	35-36	0.1	R.T., 300, 400	R.T., 300
13.49	250	100	40	1.0	R.T., 300, 400	R.T., 300
14.44	300	100	0	0	R.T., 200, 300, 400	R.T., 300
14.44	300	100	20	0.1	R.T., 300	R.T.
14.44	300	100	32	0.3	R.T., 200, 300, 400	R.T.
14.44	300	100	34-35	1.0	R.T., 200, 300, 400	R.T., 300
14.58	350	10	0	0	R.T., 300	R.T., 200, 300, 400
14.58	350	10	20	0.1	R.T., 300	R.T., 300
14.58	350	10	29	0.3	R.T., 300	R.T., 300
14.58	350	10	30-32	1.0	R.T., 300	R.T., 300, 400
14.89	350	24	0	0	R.T., 300	
14.89	350	24	24	0.3	R.T., 300	
14.89	350	24	27	1.0	R.T., 300	
15.31	350	80	0	0	R.T., 300	R.T., 300
15.31	350	80	13	0.1	R.T., 300	R.T., 300
15.31	350	80	19	0.3	R.T., 300	R.T., 300
15.31	350	80	21	1.0	R.T., 300	R.T., 300
15.48	400	10	0	0	R.T., 200, 300, 400	R.T., 200, 300, 400
15.48	400	10	13	0.1	R.T., 200, 300, 400	R.T., 300
15.48	400	10	17	0.3	R.T., 200, 300, 400	R.T., 300
15.48	400	10	19-20	1.0	R.T., 200, 300, 400	R.T., 300, 400
16.38	450	10	0	0	R.T., 200, 300, 400	R.T., 200, 300, 400
16.38	450	10	10	0.1		R.T.
16.38	450	10	13	1.0	R.T., 200, 300	R.T., 300
17.28	500	10	0	0	R.T., 300	R.T., 200, 300, 400
17.28	500	10	9	1.0	R.T., 300	R.T., 300
18.98	600	8	0	0	R.T., 200, 300, 400	
(Compressive)						
14.59	375	3	0	0	R.T.	R.T.
14.59	375	3	28	-0.3		R.T.

TABLE II
SEQUENTIAL EXPOSURE CONDITIONS TESTED -- STRESSED EXPOSURE⁽¹⁾

SEQUENCE ¹		EXPOSURE CONDITIONS						FINAL TEST TEMPERATURES	
Code	Description	Total $\theta_{10^{-3}}$ Exposure	Step No.	Temp. °F	Time hrs	Stress (tensile) ksi	Target Strain	Tension	Compression
								°F	°F
A-1	Decreasing temp. trend, high stress	.	1	350	3.5	31.0	.		
		.	2	315	20	32.5	.		
		14.6	3	275	100	35.0	1.0	R.T., 300, 400	R.T., 300
A-2	Same as A-1 sequence except lower exposure stresses.						0.25	R.T., 300, 400	R.T., 300
A'-1	Inverse of A-1.	.	1	275	100	34.5	.		
	Increasing temp. trend, high stress	.	2	315	20	32.5	.		
		14.6	3	350	3.5	31.5	1.0	R.T.	
A'-2	Same as A'-1 sequence except lower exposure stresses.						0.25	R.T.	
B-12	Two steps of B-14	.	1	300	100	29.5	.		
		15.0	2	350	24	21.0	0.50	R.T., 300, 400	
B-13	Three steps of B-14	.	1	300	100	29.5	.		
	Increasing temp. trend.	.	2	350	24	21.0	.		
		15.3	3	400	3.5	19.0	0.75	R.T., 300, 400	R.T., 300
B'-13	Inverse of B-13	.	1	400	3.5	21.0	.		
	Decreasing temp. trend.	.	2	350	24	20.0	.		
		15.3	3	300	100	19.0	0.75	R.T., 300	
B-14	Mixed temp. trend, high stress	.	1	300	100	29.5	.		
		.	2	350	24	21.0	.		
		.	3	400	3.5	19.0	.		
		15.4	4	350	24	20.0	1.0	R.T., 300, 400	R.T., 300
B-24	Same as B-14 sequence except lower exposure stresses.						0.25	R.T., 300	R.T.
B-13a	Modified B-13	.	1	300	100	29.5	.		
	zero-stress last step	.	2	350	24	22.0	.		
		15.3	3	400	3.5	0	0.50	R.T.	
B-14a	Modified B-14	.	1	300	100	29.5	.		
	zero-stress last step	.	2	350	24	21.0	.		
		.	3	400	3.5	19.0	.		
		15.4	4	350	24	0	0.75	R.T., 300	R.T.
D	Zero-stress first step	.	1	350	72	0	.		
	High stress last step	15.3	2	375	3.5	25.0	1.00	R.T., 300	R.T.
E-1	Complex 10 part mixed sequence	.	1	350	10	24.0	.		
		.	2	325	40	0	.		
		.	3	375	3.5	22.5	.		
		.	4	300	90	24.0	.		
		.	5	350	10	22.0	.		
		.	6	325	40	19.0	.		
		.	7	375	3.5	0	.		
		.	8	300	100	21.5	.		
		.	9	325	40	16.0	.		
		15.4	10	375	3.5	0	0.80	R.T., 300	R.T.
E-2	Same as E-1 sequence except lower exposure stresses						0.25	R.T.	
E-3	Same as E-1 and E-2 sequences except lowest exposure stresses.						0.15	R.T.	

(1) Note: An equivalent unstressed sequential exposure program was provided by zero stress control specimens included with each exposure in this table.

TABLE III
TENSILE AND COMPRESSIVE STRENGTHS -- UNEXPOSED

TENSION										COMPRESSION						
IDENTIFICATION			HARDNESS		PROPERTIES AT TEMPERATURE			CORRECTED PROPERTIES (1)		IDENTIFICATION			PROPERTIES AT TEMPERATURE		CORRECTED PROPERTIES (1)	
Federal Test Spec. No.	Test Temp. °F	Specimen No.	Rockwell Hardness	Brinell Hardness	Actual Test Temp. °F	F _u psi	F _y psi	Elong. in/in	F _u psi	F _y psi	Federal Test Spec. No.	Test Temp. °F	Specimen No.	Actual Test Temp. °F	F _{cy} psi	F _{cy} psi
			H _R	B _H		psi	psi	%	psi	psi					psi	psi
R.T.	71	A130			80	67,200	77,800	11.0	67,200	77,800	R.T.	211	C1107(3)	91	73,000	73,300
R.T.	102	A130(4)			75	67,200	77,800	10.5	67,200	77,800	R.T.	211	C1108	91	72,300	72,600
R.T.	71	A210			75	67,200	77,800	11.5	67,200	77,800	R.T.	211	C1108(2)	91	73,200	73,500
R.T.	71	A211			75	67,900	78,000	11.5	67,900	78,000	R.T.	211	C3307	82	73,500	73,700
R.T.	71	A230			80	67,200	77,300	12.0	67,500	77,500	R.T.	211	C3304(2)	82	74,900	75,100
R.T.	71	A236			80	67,200	77,300	11.5	67,500	77,500	R.T.	211	C3308	82	75,400	75,600
R.T.	71	A310			80	67,700	78,100	11.5	68,000	78,300	Average 74,300					
R.T.	71	A330			80	67,900	78,500	11.5	68,200	78,800						
R.T.	71	A350			80	67,300	77,400	10.5	67,600	77,500						
R.T.	71	A410			80	67,200	77,850	11.0	67,500	78,000						
R.T.	71	A430			80	67,900	78,600	11.0	68,200	78,800						
R.T.	71	A450			80	67,400	77,400	13.0	67,700	77,600						
R.T.	71	A520			70	69,200	77,800	14.0	69,200	77,800						
R.T.	71	A540			70	68,100	77,000	11.0	68,100	77,000						
R.T.	71	A560			67	70,200	80,400	12.5	70,000	80,500						
R.T.	71	A620			67	69,700	78,600	11.5	69,500	78,500						
R.T.	71	A640			67	65,500	77,600	12.5	65,300	77,500						
R.T.	71	A660			70	70,100	79,300	13.0	70,100	79,300						
R.T.	71	A710			60	68,500	78,900	11.5	68,800	79,100						
R.T.	71	A730			80	68,000	78,700	10.5	68,300	78,900						
R.T.	71	A750			80	67,200	77,100	10.5	67,500	77,300						
R.T.	71	A810			80	68,900	79,700	11.0	69,200	79,900						
R.T.	71	A830			80	69,100	78,700	11.0	69,400	78,900						
R.T.	71	A850			80	67,600	77,900	11.5	67,900	78,100						
R.T.	71	A920			75	67,700	77,400	11.5	67,700	77,400						
R.T.	71	A940			75	65,800	76,700	11.5	65,800	76,700						
R.T.	71	A941			75	67,500	78,100	10.5	67,500	78,100						
R.T.	71	A960			75	68,000	78,900	10.5	68,000	78,900						
R.T.	71	A1020			75	67,100	77,700	10.0	67,100	77,700						
R.T.	71	A1060			75	68,400	79,300	10.0	68,400	79,300						
R.T.	71	A1110			80	68,800	78,300	12.5	69,100	78,500						
R.T.	71	A1130			80	69,100	78,300	10.5	69,400	78,500						
R.T.	71	A1150			80	68,400	77,900	11.5	68,700	78,100						
R.T.	71	A1210			80	68,700	78,200	10.5	69,000	78,400						
R.T.	71	A1230			80	69,100	78,600	12.0	69,400	78,800						
R.T.	102	A1246(4)			75	70,800	77,700	10.7	70,800	77,700						
						Average			68,300	78,300						
R.T.	120	B131	115.5	80.0	74	66,800	75,600	10.5	66,800	75,600						
R.T.	120	B150	116.0	80.0	74	67,600	77,100	11.0	67,600	77,100						
R.T.	102	B166 (4)			77	71,200	81,100	11.5	71,200	81,100						
R.T.	120	B321	116.0	81.0	74	66,500	76,200	11.0	66,500	76,200						
R.T.	120	B360	117.0	81.0	74	67,000	76,700	10.5	67,000	76,700						
R.T.	102	B1266(4)			77	72,900	80,500	11.0	72,900	80,500						
						Average			67,000	76,400						
R.T.	158	C117			73	68,300	76,100	14.0	68,300	76,300						
R.T.	211	C210 (5)			91	68,000			68,000							
R.T.	211	C331 (5)			82	68,200	76,300	13.5	68,500	76,600						
R.T.	158	C636			73	67,900	75,100	12.5	67,900	75,100						
						Average			68,400	76,100						
200	71	A355			204	64,500	69,200	12.5	64,800	69,700	200	223	C725-1	202	69,100	69,200
200	71	A431			200	65,000	69,700	13.0	65,000	69,700	200	223	C725-2	202	72,500	72,600
200	71	A420			200	65,100	70,400	12.0	65,100	70,400	200	223	C725-3	203	71,700	71,800
						Average			65,000	69,900	200	223	C725-3	203	60,000	69,100
						Average			65,000	69,900	Average 70,700					
300	71	A130			298	57,600	58,900	14.0	57,600	58,700	300	223	C725-4	300	63,700	63,700
300	71	A256			302	56,700	57,600	20.0	56,900	57,800	300	223	C725-5	300	63,600	63,600
300	72	A720			298	56,900	56,500	21.0	56,700	56,300	300	223	C725-6	300	62,000	62,000
						Average			57,000	58,300	Average 63,300					
300	120	B230			299	54,300	56,400	18.5	54,300	56,300						
300	120	B420			299	54,400	56,100	18.0	54,300	56,000						
300	120	B460			300	54,600	56,300	11.5	54,600	56,300						
						Average			54,400	56,200						
300	224	C7217			300	56,500	58,300	16.5	56,500	58,300						
300	224	C7218			302	55,900	57,500	19.0	56,200	57,800						
						Average			56,400	58,100						
400	71	A277 (3)			405	41,800	43,700	14.0	42,700	43,600	400	223	C725-7(3)	400	47,300	47,300
400	71	A266 (3)			198	44,000	45,000	13.5	43,700	44,600	400	223	C725-8(3)	400	46,300	46,300
400	71	A610 (3)			197	42,200	43,100	15.5	41,900	43,100	400	223	C725-9(3)	400	46,700	46,700
						Average			42,000	43,600	Average 47,300					
400	234	B212 (3)			401	42,700	43,600	13.5	42,800	43,700						
400	234	B425 (3)			401	42,700	44,100	16.5	42,800	44,500						
400	234	B461 (3)			401	42,400	44,100	13.5	42,500	44,500						
						Average			42,700	44,200						
400	224	C7227 (3)			402	43,200	44,300	16.0	43,200	44,400						
400	224	C7228 (3)			199	42,400	44,200	16.0	42,400	44,400						
						Average			42,800	44,400						

- (1) Properties corrected to nominal test temperature.
- (2) Specimens refrigerated prior to test.
- (3) Strain rates were 0.008 to 0.009 in/in/min for tests at 400°F; 0.01 in/in/min for spec. C1107.
- (4) Strengths omitted from average, sheet acceptance tests taken from sheet corners.
- (5) Tensile test performed on a creep specimen. (See Figure 2)

TABLE IV
ROOM TEMP. TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES(1)			STRENGTH RATIO	
Temp.	Time	T_{90} (17-18°C)	Stress	Total Strain	Specimen No.	Temp.	Time	Total Strain	Specimen Group No.	Rockwell Hardness	Actual Test Temp.	F_{ty}	F_{tu}	F_{su}	Yield	Ult. Yield
°C	hr	T_{90} (17-18°C)	ksi	%	No.	°C	hr	%	No.	R _H	°C	psi	psi	psi	psi	psi
300	1	12.92	0	0	A1216	300	1	0	54	117.0	78	67,100	77,300	67,200	67,200	0.974
300	1	12.92	0	0	A1214	300	1	0	54		72	67,000	77,300	67,000	67,300	0.971
300	1	12.92	50.0	1.00	A1213	300	1	1.70	54		72	70,800	77,400	70,800	77,400	1.055
300	1	12.92	50.0	1.00	A1111	300	1	1.50	54		75	69,500	76,900	69,500	76,900	1.032
300	1	12.92	50.0	1.00	A1215	300	1	1.30	54		76	70,500	77,000	70,500	77,100	1.052
250	100	13.49	0	0	A734	250	100	0	25	115.5	77	68,000	77,600	68,100	77,700	0.997
250	100	13.49	0	0	A736	250	100	0	30	116.0	76	68,300	78,700	68,400	78,700	0.997
250	100	13.49	35.0	0.10	A735	250	100	0.09	30		76	66,700	77,600	66,800	77,700	0.975
250	100	13.49	35.0	0.10	A736	250	100	0.13	30		76	67,300	77,800	67,400	78,000	0.984
250	100	13.49	47.5	1.00	A731	250	100	1.02	29		77	67,800	76,500	67,900	76,700	0.991
250	100	13.49	47.5	1.00	A732	250	100	0.80	29		77	67,300	77,200	67,400	77,400	0.986
300	100	14.44	0	0	A734	300	100	0	35	115.0	72	60,400	72,100	60,900	72,600	0.893
300	100	14.44	0	0	A735	300	100	0	35		72	61,100	72,600	61,600	72,100	0.876
300	100	14.44	0	0	A736	300	100	0	37	115.0	72	61,400	73,500	61,100	73,200	0.892
300	100	14.44	20.0	0.10	A731	300	100	0.13	35	115.0	72	59,900	71,200	59,900	71,200	0.983
300	100	14.44	20.0	0.10	A732	300	100	0.12	35		72	58,300	71,300	59,000	72,000	0.969
300	100	14.44	20.0	0.10	A733	300	100	0.15	35	115.0	72	60,500	71,300	61,000	72,200	1.008
300	100	14.44	20.0	0.10	A734	300	100	0.095	31		74	61,200	72,700	60,500	72,000	0.995
300	100	14.44	20.0	0.10	A735	300	100	0.085	31		74	60,500	72,000	60,500	72,000	0.995
300	100	14.44	20.0	0.10	A736	300	100	0.095	31		74	60,500	72,000	60,500	72,000	0.995
300	100	14.44	32.0	0.35	A731	300	100	0.50	39	115.0	80	57,000	67,500	57,100	67,700	0.938
300	100	14.44	32.0	0.35	A732	300	100	0.40	39		80	57,400	68,800	56,900	68,500	0.914
300	100	14.44	32.0	0.35	A733	300	100	0.30	39	115.0	80	60,100	71,300	59,200	70,500	0.927
300	100	14.44	35.0	1.00	A734	300	100	1.37	37		75	56,100	68,200	56,100	68,200	0.920
300	100	14.44	35.0	1.00	A735	300	100	0.72	37		75	57,800	68,900	57,400	68,900	0.941
300	100	14.44	35.0	1.00	A736	300	100	0.99	37	115.0	75	56,000	68,500	56,100	68,600	0.921

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE IV (Continued)
ROOM TEMP. TENSILE STRENGTH AFTER SINGLE EXPOSURES

INITIAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1)				STRENGTH FACTOR			
Temp.	Time	σ_{17}	Stress	Total	Specimen	Actual	Rockwell	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}	F_{17}
σ_{17}	hr	σ_{17}	ksi	Strain	No.	Temp.	R_{17}	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
350	10	14.58	0	0	55	76	75.0	57,900	57,900	57,900	57,900	57,900	57,900	57,900	57,900	57,900	57,900	57,900	57,900
350	10	14.58	0	0	60	72	75.0	56,900	56,900	56,900	56,900	56,900	56,900	56,900	56,900	56,900	56,900	56,900	56,900
350	10	14.58	0	0	61	72	75.0	58,300	58,300	58,300	58,300	58,300	58,300	58,300	58,300	58,300	58,300	58,300	58,300
350	10	14.58	20.0	0.10	61	72		55,700	55,700	55,700	55,700	55,700	55,700	55,700	55,700	55,700	55,700	55,700	55,700
350	10	14.58	20.0	0.10	61	72		56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000
350	10	14.58	20.0	0.10	61	72		56,200	56,200	56,200	56,200	56,200	56,200	56,200	56,200	56,200	56,200	56,200	56,200
350	10	14.58	29.0	0.35	60	72		54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900
350	10	14.58	29.0	0.35	60	72		54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900	54,900
350	10	14.58	29.0	0.35	60	72		53,600	53,600	53,600	53,600	53,600	53,600	53,600	53,600	53,600	53,600	53,600	53,600
350	10	14.58	31.5	1.00	65	76		54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000
350	10	14.58	31.5	1.00	65	76		54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000
350	10	14.58	31.5	1.00	65	76		55,900	55,900	55,900	55,900	55,900	55,900	55,900	55,900	55,900	55,900	55,900	55,900
350	24	14.89	0	0	121	78	65.0	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000
350	24	14.89	0	0	121	78	65.0	52,100	52,100	52,100	52,100	52,100	52,100	52,100	52,100	52,100	52,100	52,100	52,100
350	24	14.89	0	0	123	78	69.5	50,600	50,600	50,600	50,600	50,600	50,600	50,600	50,600	50,600	50,600	50,600	50,600
350	24	14.89	0	0	123	78	69.5	52,400	52,400	52,400	52,400	52,400	52,400	52,400	52,400	52,400	52,400	52,400	52,400
350	24	14.89	24.0	0.40	121	78		46,300	46,300	46,300	46,300	46,300	46,300	46,300	46,300	46,300	46,300	46,300	46,300
350	24	14.89	24.0	0.35	121	78		48,100	48,100	48,100	48,100	48,100	48,100	48,100	48,100	48,100	48,100	48,100	48,100
350	24	14.89	24.0	0.35	121	78		47,600	47,600	47,600	47,600	47,600	47,600	47,600	47,600	47,600	47,600	47,600	47,600
350	24	14.89	27.0	1.00	123	78	67.0	48,400	48,400	48,400	48,400	48,400	48,400	48,400	48,400	48,400	48,400	48,400	48,400
350	24	14.89	27.0	1.00	123	78	67.0	46,100	46,100	46,100	46,100	46,100	46,100	46,100	46,100	46,100	46,100	46,100	46,100
350	80	15.11	0	0	63	71	63.0	40,600	40,600	40,600	40,600	40,600	40,600	40,600	40,600	40,600	40,600	40,600	40,600
350	80	15.11	0	0	63	71	63.0	40,900	40,900	40,900	40,900	40,900	40,900	40,900	40,900	40,900	40,900	40,900	40,900
350	80	15.11	0	0	79	74	60.0	38,600	38,600	38,600	38,600	38,600	38,600	38,600	38,600	38,600	38,600	38,600	38,600
350	80	15.11	13.0	0.10	79	74		37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600
350	80	15.11	13.0	0.10	79	74		37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600	37,600
350	80	15.11	13.0	0.10	79	74		37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900
350	80	15.11	19.0	0.35	80	74		36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300
350	80	15.11	19.0	0.35	80	74		35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600
350	80	15.11	19.0	0.35	80	74		35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600	35,600
350	80	15.11	20.9	1.00	80	74	49.5	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900	37,900
350	80	15.11	21.0	1.00	63	71		36,400	36,400	36,400	36,400	36,400	36,400	36,400	36,400	36,400	36,400	36,400	36,400
350	80	15.11	21.0	1.00	63	71		35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700
350	80	15.11	21.0	1.00	63	71		35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700	35,700

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TABLE V
300°F TENSILE STRENGTH AFTER SINGLE EXPOSURES

INITIAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1)				STRENGTH RATIOS			
Temp.	Time	ϕ_{17}	Stress	Total Strain	Specimen No.	Temp.	Time	Total Strain	Specimen Group No.	Actual Test Temp. ϕ_T	F_{ty}	F_{tu}	F_{ty}	F_{tu}	E_T	Yield	E_T	Yield	
$^{\circ}F$	hr	$\times 10^{-3}$	ksi	%		$^{\circ}F$	hr	%		$^{\circ}F$	psi	psi	psi	psi					
300	100	14.44	0	0	A435	302	100	0	83	200	57,700	62,000	58,300	62,200	0.855	0.785			
300	100	14.44	0	0	A436	302	100	0	83	200	57,400	62,100	58,000	62,300	0.850	0.792			
300	100	14.44	0	0	A517	302	100	0	95	203	58,000	63,000	58,700	63,400	0.848	0.815			
300	100	14.44	32.0	0.35	A514	301	100	0.45	95	203	56,200	60,500	56,600	60,800			0.970	0.972	
300	100	14.44	32.0	0.35	A515	302	100	0.46	95	203	53,400	59,600	54,200	60,000			0.929	0.958	
300	100	14.44	32.0	0.35	A516	302	100	0.40	95	203	54,700	60,300	55,500	60,700			0.951	0.969	
300	100	14.44	35.0	1.00	A432	300	100	2.45	83	203	51,600	56,000	51,700	56,200			0.882	0.897	
300	100	14.44	35.0	1.00	A433	301	100	3.00	83	201	51,400	55,600	51,800	55,800			0.882	0.897	
300	100	14.44	35.0	1.00	A434	300	100	2.95	83	200	50,800	55,500	51,800	56,000			0.886	0.911	
400	10	15.48	0	0	A1254	401	10	0	81	203	37,000	45,100	37,200	45,500	0.542	0.575			
400	10	15.48	0	0	A1165	399	10	0	76	201	39,800	48,600	39,700	48,500	0.578	0.623			
400	10	15.48	0	0	A537	402	10	0	132	200	36,100	45,300	36,400	45,600	0.530	0.590			
400	10	15.48	13.0	0.10	A1251	402	10	—	81	200	43,400	44,300	43,700	44,600			1.172	0.982	
400	10	15.48	13.0	0.10	A1252	400	10	—	81	203	35,400	44,700	35,500	44,900			0.952	0.945	
400	10	15.48	13.0	0.10	A1253	402	10	0.10	81	204	35,400	44,000	35,900	44,400			0.965	0.985	
400	10	15.48	17.5	0.35	A535	403	10	0.30	132	202	34,200	44,000	34,800	44,700			0.955	0.980	
400	10	15.48	17.5	0.35	A536	403	10	0.30	132	200	35,200	44,800	35,700	45,300			0.981	0.993	
400	10	15.48	17.5	0.35	A536	400	10	0.30	132	200	35,700	45,200	35,700	45,200			0.981	0.993	
400	10	15.48	20.0	1.00	A1162	398	10	0.70	76	204	35,900	46,000	35,700	45,900			0.899	0.925	
400	10	15.48	20.0	1.00	A1163	399	10	0.75	76	204	37,100	45,200	37,000	46,300			0.922	0.954	
400	10	15.48	20.0	1.00	A1164	398	10	0.75	76	202	36,400	45,900	36,100	45,700			0.909	0.921	
450	10	16.38	0	0	A990	449	10	0	74	204	24,500	37,900	24,500	38,100	0.353	0.490			
450	10	16.38	0	0	A1090	449	10	0	74	203	24,600	37,700	24,600	37,800	0.360	0.485			
450	10	16.38	13.0	1.00	A1054	451	10	1.25	74	204	23,200	36,800	23,300	37,100			0.949	0.978	
450	10	16.38	13.0	1.00	A1055	449	10	1.25	74	203	23,400	37,000	23,400	37,100			0.933	0.979	
450	10	16.38	13.0	1.00	A1056	451	10	1.25	74	200	23,000	36,800	23,000	36,800			0.937	0.970	
600	8	18.98	0	0	A120	600	8	0	231	202	15,300	36,600	15,300	36,600	0.225	0.465			
600	8	18.98	0	0	A622	600	8	0	231	200	15,200	36,300	15,200	36,300	0.227	0.475			
600	8	18.98	0	0	A623	600	8	0	231	201	15,000	36,400	15,000	36,400	0.224	0.475			

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VI
300°F TENSILE STRENGTH AFTER SINGLE EXPOSURE

INITIAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1)				STRENGTH RATIOS			
Temp. °F	Time hr	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Actual Test Temp. °F	F _{ty} psi	F _{tu} psi	elong. in. 2 in.	F _{ty} psi	F _{tu} psi	Yield %	Ult. %	F _{ty} %	F _{tu} %		
350	1	12.92	0	0	Al013	299	1	0	302	56,000	58,500	20.0	56,000	58,500	0.856	0.773	0.856	0.773	
350	1	12.92	0	0	Al014	299	1	0	302	55,400	57,700	21.5	55,400	57,500	0.829	0.743	0.829	0.743	
350	1	12.92	50.0	1.00	Al010	299	1	1.20	301	59,000	59,000	12.0	59,100	59,100	0.856	0.773	0.856	0.773	
350	1	12.92	50.0	1.00	Al011	298	1	1.10	302	58,800	58,800	17.0	59,000	59,000	0.856	0.773	0.856	0.773	
350	1	12.92	50.0	1.00	Al012	302	1	1.65	301	59,000	59,000	17.5	59,200	59,200	0.856	0.773	0.856	0.773	
250	100	13.49	0	0	A74C	251	100	0	300	56,000	57,100	13.0	56,000	57,100	0.825	0.726	0.825	0.726	
250	100	13.49	0	0	A84C	251	100	0	300	56,100	57,500	17.0	56,100	57,500	0.825	0.726	0.825	0.726	
250	100	13.49	35.0	0.10	A644	251	100	0.15	303	56,800	58,300	17.5	57,100	58,300	0.856	0.773	0.856	0.773	
250	100	13.49	35.0	0.10	A645	251	100	0.15	301	56,800	57,800	19.5	56,900	57,800	0.856	0.773	0.856	0.773	
250	100	13.49	35.0	0.10	A646	253	100	0.15	299	55,600	56,900	16.0	55,600	56,900	0.856	0.773	0.856	0.773	
250	100	13.49	47.3	1.00	A841	250	100	1.10	299	54,300	56,200	17.5	54,300	56,200	0.856	0.773	0.856	0.773	
250	100	13.49	47.3	1.00	A842	250	100	1.11	300	54,400	56,000	19.5	54,400	56,000	0.856	0.773	0.856	0.773	
250	100	13.49	47.3	1.00	A843	250	100	1.00	299	54,400	55,900	12.5	54,300	55,900	0.856	0.773	0.856	0.773	
350	100	14.44	0	0	A345	301	100	0	302	51,600	52,100	11.5	51,900	52,100	0.856	0.773	0.856	0.773	
350	100	14.44	0	0	A513	302	100	0	301	51,200	52,500	9.0	51,700	52,500	0.856	0.773	0.856	0.773	
350	100	14.44	0	0	A333	300	100	0	302	51,800	52,800	19.0	52,100	52,800	0.856	0.773	0.856	0.773	
350	100	14.44	20.0	0.10	A510	302	100	0.05	300	51,300	52,400	14.0	51,300	52,400	0.856	0.773	0.856	0.773	
350	100	14.44	20.0	0.10	A511	302	100	0.05	300	47,500	48,500	13.5	47,500	48,500	0.856	0.773	0.856	0.773	
350	100	14.44	20.0	0.10	A512	302	100	0	299	47,500	48,700	13.5	47,500	48,700	0.856	0.773	0.856	0.773	
350	100	14.44	32.0	0.35	A335	300	100	0.50	302	48,800	49,400	15.0	48,800	49,400	0.856	0.773	0.856	0.773	
350	100	14.44	32.0	0.35	A336	301	100	0.60	302	48,200	48,800	13.5	48,500	49,100	0.856	0.773	0.856	0.773	
350	100	14.44	32.0	0.35	A344	301	100	0.95	302	48,700	49,200	16.0	48,700	49,200	0.856	0.773	0.856	0.773	
350	100	14.44	35.0	1.00	A134	300	100	0.95	299	47,900	48,100	17.0	47,900	48,100	0.856	0.773	0.856	0.773	
350	100	14.44	35.0	1.00	A131	300	100	1.70	300	47,900	48,500	13.5	47,900	48,500	0.856	0.773	0.856	0.773	
350	100	14.44	35.0	1.00	A142	299	100	1.05	299	47,700	48,000	23.0	47,500	47,800	0.856	0.773	0.856	0.773	
350	10	14.58	0	0	Al015	352	10	0	300	48,400	49,000	13.5	48,400	49,000	0.856	0.773	0.856	0.773	
350	10	14.58	0	0	A922	350	10	0	300	47,400	47,700	17.5	47,400	47,700	0.856	0.773	0.856	0.773	
350	10	14.58	0	0	A912	352	10	0	300	48,200	49,000	13.0	48,400	49,200	0.856	0.773	0.856	0.773	
350	10	14.58	20.0	0.10	A921	349	10	0.10	300	46,800	47,300	16.0	46,700	47,200	0.856	0.773	0.856	0.773	
350	10	14.58	20.0	0.10	A923	350	10	0.10	300	46,600	46,900	14.5	46,600	46,900	0.856	0.773	0.856	0.773	
350	10	14.58	20.0	0.10	A924	350	10	0.10	300	45,700	46,500	16.5	45,700	46,500	0.856	0.773	0.856	0.773	
350	10	14.58	29.0	0.35	A915	351	10	0.35	302	47,600	47,900	17.0	47,600	48,100	0.856	0.773	0.856	0.773	
350	10	14.58	29.0	0.35	A917	351	10	0.45	310	46,700	46,800	11.0	46,800	46,900	0.856	0.773	0.856	0.773	
350	10	14.58	29.0	0.35	A847	351	10	0.40	300	47,000	47,300	10.5	47,100	47,300	0.856	0.773	0.856	0.773	
350	10	14.58	31.5	1.00	A910	354	10	1.80	298	44,500	44,700	14.0	44,500	44,700	0.856	0.773	0.856	0.773	
350	10	14.58	31.5	1.00	A911	351	10	2.05	300	43,600	43,600	12.0	43,700	43,700	0.856	0.773	0.856	0.773	
350	10	14.58	31.5	1.00	A913	351	10	1.50	300	44,300	44,600	15.5	44,400	44,700	0.856	0.773	0.856	0.773	

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VI (Continued)
300°F TENSILE STRENGTH AFTER SINGLE EXPOSURE

ACTUAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1)				SINGLE EXPOSURE			
Temp., °F	Time, hr	Temp., °F	Time, hr	Specimen No.	Temp., °F	Time, hr	Total Strain, %	Actual Test, %	F _y , psi	F _u , psi	Elong. in 2 in., %	F _y , psi	F _u , psi	Yield, %	UT, %	Temp., °F	Time, hr	Temp., °F	Time, hr
350	2	350	2	A760	350	2	0	299	44,900	46,300	12.5	44,800	46,200	0.005	0.006	350	2	350	2
350	2	350	2	B232	350	2	0	300	44,300	45,100	13.5	44,200	45,100	0.004	0.005	350	2	350	2
350	2	350	2	A857	350	2	0	301	43,300	44,100	16.5	43,200	44,000	0.004	0.005	350	2	350	2
350	2	350	2	B233	350	2	0	300	43,500	44,600	17.5	43,400	44,800	0.005	0.006	350	2	350	2
350	2	350	2	A761	350	2	0.25	300	43,500	44,700	16.0	43,400	44,400	0.005	0.006	350	2	350	2
350	2	350	2	B231	350	2	0.35	300	43,400	42,500	16.0	43,300	43,500	0.005	0.006	350	2	350	2
350	2	350	2	A855	350	2	0.25	300	42,500	43,600	17.5	42,400	43,500	0.005	0.006	350	2	350	2
350	2	350	2	B234	350	2	1.00	300	40,200	41,000	14.0	40,100	41,000	0.005	0.006	350	2	350	2
350	2	350	2	A856	350	2	1.75	300	38,700	39,500	12.0	38,600	39,500	0.005	0.006	350	2	350	2
350	2	350	2	B235	350	2	0.90	301	40,900	41,500	11.0	40,800	41,400	0.005	0.006	350	2	350	2
350	2	350	2	A858	350	2	0.90	300	34,900	36,600	22.0	34,800	36,500	0.005	0.006	350	2	350	2
350	2	350	2	B236	350	2	0	297	35,500	36,900	21.5	35,400	36,800	0.005	0.006	350	2	350	2
350	2	350	2	A762	350	2	0.10	300	36,100	37,500	20.5	36,000	37,400	0.005	0.006	350	2	350	2
350	2	350	2	A763	350	2	0.10	301	35,000	36,100	25.0	34,900	36,000	0.005	0.006	350	2	350	2
350	2	350	2	A764	350	2	0.10	301	35,300	36,400	24.0	35,200	36,300	0.005	0.006	350	2	350	2
350	2	350	2	A765	350	2	0.10	302	34,100	35,700	18.5	34,000	35,600	0.005	0.006	350	2	350	2
350	2	350	2	A766	350	2	0.30	302	34,000	35,600	16.5	33,900	35,500	0.005	0.006	350	2	350	2
350	2	350	2	A767	350	2	0.30	302	34,800	36,000	23.5	34,700	36,000	0.005	0.006	350	2	350	2
350	2	350	2	A768	350	2	0.90	301	32,500	34,400	16.0	32,400	34,700	0.005	0.006	350	2	350	2
350	2	350	2	A769	350	2	1.15	302	31,900	34,200	23.0	31,800	34,500	0.005	0.006	350	2	350	2
350	2	350	2	A770	350	2	0.85	300	32,300	34,200	17.0	32,200	34,200	0.005	0.006	350	2	350	2
350	2	350	2	A771	350	2	0	302	34,100	35,400	20.5	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A772	350	2	0	303	33,400	35,300	20.5	33,300	35,400	0.005	0.006	350	2	350	2
350	2	350	2	A773	350	2	0	302	34,100	35,400	17.0	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A774	350	2	0	300	33,900	35,400	25.0	33,800	35,500	0.005	0.006	350	2	350	2
350	2	350	2	A775	350	2	0.10	299	33,900	35,400	19.0	33,800	35,300	0.005	0.006	350	2	350	2
350	2	350	2	A776	350	2	0.10	299	33,300	35,100	21.5	33,200	35,200	0.005	0.006	350	2	350	2
350	2	350	2	A777	350	2	0.30	300	32,800	34,300	18.5	32,700	34,200	0.005	0.006	350	2	350	2
350	2	350	2	A778	350	2	0.30	302	32,500	34,100	19.5	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A779	350	2	0.35	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A780	350	2	0.85	299	31,500	33,400	23.0	31,400	33,200	0.005	0.006	350	2	350	2
350	2	350	2	A781	350	2	1.10	302	31,500	33,100	19.5	31,400	33,000	0.005	0.006	350	2	350	2
350	2	350	2	A782	350	2	0.90	300	31,900	33,500	24.0	31,800	33,400	0.005	0.006	350	2	350	2
350	2	350	2	A783	350	2	0	300	34,100	35,400	20.5	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A784	350	2	0	303	33,400	35,300	20.5	33,300	35,400	0.005	0.006	350	2	350	2
350	2	350	2	A785	350	2	0	302	34,100	35,400	17.0	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A786	350	2	0	300	33,900	35,400	25.0	33,800	35,500	0.005	0.006	350	2	350	2
350	2	350	2	A787	350	2	0.10	299	33,900	35,400	19.0	33,800	35,300	0.005	0.006	350	2	350	2
350	2	350	2	A788	350	2	0.10	299	33,300	35,100	21.5	33,200	35,200	0.005	0.006	350	2	350	2
350	2	350	2	A789	350	2	0.30	300	32,800	34,300	18.5	32,700	34,200	0.005	0.006	350	2	350	2
350	2	350	2	A790	350	2	0.30	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A791	350	2	0.35	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A792	350	2	0.85	299	31,500	33,400	23.0	31,400	33,200	0.005	0.006	350	2	350	2
350	2	350	2	A793	350	2	1.10	302	31,500	33,100	19.5	31,400	33,000	0.005	0.006	350	2	350	2
350	2	350	2	A794	350	2	0.90	300	31,900	33,500	24.0	31,800	33,400	0.005	0.006	350	2	350	2
350	2	350	2	A795	350	2	0	300	34,100	35,400	20.5	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A796	350	2	0	303	33,400	35,300	20.5	33,300	35,400	0.005	0.006	350	2	350	2
350	2	350	2	A797	350	2	0	302	34,100	35,400	17.0	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A798	350	2	0	300	33,900	35,400	25.0	33,800	35,500	0.005	0.006	350	2	350	2
350	2	350	2	A799	350	2	0.10	299	33,900	35,400	19.0	33,800	35,300	0.005	0.006	350	2	350	2
350	2	350	2	A800	350	2	0.10	299	33,300	35,100	21.5	33,200	35,200	0.005	0.006	350	2	350	2
350	2	350	2	A801	350	2	0.30	300	32,800	34,300	18.5	32,700	34,200	0.005	0.006	350	2	350	2
350	2	350	2	A802	350	2	0.30	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A803	350	2	0.35	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A804	350	2	0.85	299	31,500	33,400	23.0	31,400	33,200	0.005	0.006	350	2	350	2
350	2	350	2	A805	350	2	1.10	302	31,500	33,100	19.5	31,400	33,000	0.005	0.006	350	2	350	2
350	2	350	2	A806	350	2	0.90	300	31,900	33,500	24.0	31,800	33,400	0.005	0.006	350	2	350	2
350	2	350	2	A807	350	2	0	300	34,100	35,400	20.5	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A808	350	2	0	303	33,400	35,300	20.5	33,300	35,400	0.005	0.006	350	2	350	2
350	2	350	2	A809	350	2	0	302	34,100	35,400	17.0	34,000	35,700	0.005	0.006	350	2	350	2
350	2	350	2	A810	350	2	0	300	33,900	35,400	25.0	33,800	35,500	0.005	0.006	350	2	350	2
350	2	350	2	A811	350	2	0.10	299	33,900	35,400	19.0	33,800	35,300	0.005	0.006	350	2	350	2
350	2	350	2	A812	350	2	0.10	299	33,300	35,100	21.5	33,200	35,200	0.005	0.006	350	2	350	2
350	2	350	2	A813	350	2	0.30	300	32,800	34,300	18.5	32,700	34,200	0.005	0.006	350	2	350	2
350	2	350	2	A814	350	2	0.30	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A815	350	2	0.35	302	32,500	34,100	19.0	32,400	34,000	0.005	0.006	350	2	350	2
350	2	350	2	A816	350	2	0.85	299	31,500	33,400	23.0	31,400	33,200	0.005	0.006	350	2	350	2
350	2	350	2	A817	350	2	1.10	302	31,500	33,100	19.5	31,400	33,000	0.005	0.006	350	2	350	2
350	2	350	2	A818	350	2													

TABLE VI (Continued)

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TABLE VII
400°F TENSILE STRENGTH AFTER SINGLE EXPOSURES

ACTUAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES				
Temp.	Time	Stress	Total		Specimen	Temp.	Time	Total	Specimen	Actual	F _{ty}	F _{tu}	Strain	Rate	F _{ty}	F _{tu}	F _{ty}	F _{tu}	F _{ty}
°F	hr	ksi	Strain	%	No.	°F	hr	%	No.	°F	ksi	ksi	in/in	in/in/min	ksi	ksi	ksi	ksi	ksi
288	18	13.45	0	0	A933	252	100	0	92	398	41,200	42,900	15.0	0.0090	41,000	42,700	41,000	42,700	41,000
288	18	13.45	0	0	A934	252	100	0	52	403	42,100	43,100	15.5	0.0092	42,100	43,100	42,100	43,100	42,100
288	18	13.45	0	0	A951	252	100	0	97	400	42,100	43,600	14.5	0.0095	42,100	43,600	42,100	43,600	42,100
288	18	13.45	0.10	0.10	A952	250	100	0.10	97	400	42,800	43,000	11.0	0.0095	42,800	43,000	42,800	43,000	42,800
288	18	13.45	0.10	0.10	A953	252	100	0.10	97	400	41,900	42,800	17.0	0.0093	41,900	42,800	41,900	42,800	41,900
288	18	13.45	0.10	0.10	A954	251	100	0.10	97	401	42,000	42,800	15.5	0.0100	42,000	42,800	42,000	42,800	42,000
288	18	13.45	1.00	1.30	A955	252	100	1.30	92	402	41,600	41,600	7.5	0.0090	41,600	41,600	41,600	41,600	41,600
288	18	13.45	1.00	1.55	A956	252	100	1.55	92	399	40,700	40,700	5.5	0.0095	40,700	40,700	40,700	40,700	40,700
288	18	13.45	1.00	1.00	A957	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A958	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A959	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A960	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A961	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A962	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A963	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A964	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A965	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A966	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A967	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A968	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A969	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A970	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A971	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A972	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A973	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A974	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A975	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A976	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A977	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A978	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A979	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A980	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A981	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A982	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A983	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A984	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A985	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A986	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A987	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A988	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A989	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A990	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A991	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A992	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A993	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A994	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A995	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A996	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A997	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A998	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A999	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300
288	18	13.45	1.00	1.00	A1000	252	100	1.00	92	402	42,300	42,400	13.0	0.0090	42,300	42,400	42,300	42,400	42,300

U. Properties corrected to nominal exposure conditions and nominal test temperature.

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TABLE VII (Continued)
400° F TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (1)					STRENGTH RATIO		
Temp.	Time	Q ₁	Q ₂	Q ₃	Temp.	Time	Specimen No.	Temp.	Time	Specimen No.	Temp.	Time	Temp.	Time	Temp.	Time	Temp.	Time	Temp.	Yield	Ult.	Ratio
°F	hr	24.98	18.98	15.98	°F	hr	°F	hr	°F	hr	°F	hr	°F	hr	°F	hr	°F	hr	°F	psi	psi	psi
600	8	24.98	0	0	600	8	0	0	600	8	0	0	600	8	0	0	600	8	0	0.201	0.213	
600	8	18.98	0	0	600	8	0	0	600	8	0	0	600	8	0	0	600	8	0	0.204	0.219	
600	8	15.98	0	0	600	8	0	0	600	8	0	0	600	8	0	0	600	8	0	0.207	0.221	

TABLE VIII
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

ACTUAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1) STRENGTH RATIOS			
Temp. of Specimen	Time hr	Stress $\times 10^{-3}$ ksi	Total Strain %	Specimen No.	Temp. of Specimen	Time hr	Total Strain %	Specimen Group No.	Rockwell Hardness R _H	Actual Test Temp. of Specimen	F _{cy} psi	F _{cy} psi	R _p	R _e	
300	1	12.92	0	C335T	298	1	0	173	117.0	80.0	75	73,000	73,500	0.989	
300	1	12.92	0	C335N	298	1	0	173	116.5	79.5	75	73,300	73,600	0.993	
300	1	12.92	1.0	C336T	299	1	1.49	173	117.0	80.0	75	71,200	71,500	0.971	
300	1	12.92	1.0	C336N	299	1	1.35	173	116.5	80.5	75	70,700	70,900	0.953	
300	1	12.92	1.0	C3363	301	1	1.60	173	116.5	80.5	75	71,700	72,500	0.971	
250	100	13.49	0	C232T	253	100	0	168	117.0	82.5	75	75,500	75,500	1.016	
250	100	13.49	0	C232N	253	100	0	168	117.0	82.0	75	75,200	75,200	1.012	
250	100	13.49	0	C233T	251	100	0	172	117.0	82.5	75	74,600	74,800	1.007	
250	100	13.49	0	C233N	251	100	0	172	117.0	82.0	75	75,500	75,500	1.016	
250	100	13.49	0	C233B	251	100	0	172	117.0	82.0	75	75,700	75,700	1.019	
250	100	13.49	0.1	C234T	251	100	0.03	172	117.0	82.0	75	75,700	76,700	1.025	
250	100	13.49	0.1	C234N	251	100	0.13	172	117.0	81.5	75	75,500	75,500	0.999	
250	100	13.49	1.0	C231T	253	100	0.81	168	117.5	80.0	75	72,500	72,600	0.954	
250	100	13.49	1.0	C231N	253	100	0.84	168	117.0	80.0	75	72,300	72,300	0.950	
250	100	13.49	1.0	C231B	253	100	0.86	168	117.5	81.0	75	73,100	73,100	0.970	
300	100	14.44	0	C324N	300	100	0	180	116.0	77.0	75	67,300	67,300	0.969	
300	100	14.44	0	C324B	300	100	0	180	116.0	77.0	75	68,900	68,900	0.927	
300	100	14.44	0	C422B	301	100	0	179	116.0	77.5	75	66,500	67,000	0.902	
300	100	14.44	0	C423B	301	100	0	179	116.0	77.0	75	67,300	67,800	0.913	
300	100	14.44	0	C326T	302	100	0	184	116.0	77.0	75	66,400	66,900	0.900	
300	100	14.44	0	C326N	302	100	0	184	116.0	75.5	75	65,600	66,300	0.892	
300	100	14.44	0.1	C323T	300	100	0.03	180	116.0	74.5	75	67,800	67,800	0.975	
300	100	14.44	0.1	C323N	300	100	0.03	180	115.5	76.0	75	66,800	66,800	0.982	
300	100	14.44	0.1	C323B	300	100	0.02	180	116.0	76.0	75	67,500	67,500	0.995	
300	100	14.44	0.35	C321T	301	100	0.41	179	115.5	74.5	75	62,900	63,200	0.938	
300	100	14.44	0.35	C321N	301	100	0.37	179	115.5	75.5	75	63,300	63,600	0.944	
300	100	14.44	0.35	C321B	301	100	0.34	179	115.5	75.0	75	63,300	63,600	0.944	
300	100	14.44	1.0	C327T	302	100	0.75	184	115.0	72.5	75	59,700	60,300	0.905	
300	100	14.44	1.0	C327N	301	100	0.75	184	115.5	73.0	75	60,600	60,900	0.914	
300	100	14.44	1.0	C327B	301	100	0.71	184	115.5	74.0	75	65,000	65,300	0.980	

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VII (Continued)
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

ACTUAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE					MECHANICAL PROPERTIES (1. STRAIN RATE)				
Temp.	Time	Stress	Total		Specimen	Temp.	Time	Total	Specimen	Rockwell	Actual	F _y	F _u	R _t					
°F	hr	ksi	Strain	%	No.	°F	hr	%	No.	BH	Test Temp.	psi	psi	%					
350	10	14.58	0	0	C412T	350	10	0	180	115.0	75	52,500	52,500	6.855					
350	10	14.58	0	0	C412K	350	10	0	166	115.0	75	52,500	52,500	6.855					
350	10	14.58	0	0	C413T	352	10	0	177	106.5	75	50,500	50,500	6.821					
350	10	14.58	0	0	C413K	352	10	0	177	106.5	75	50,500	50,500	6.821					
350	10	14.58	0	0	C222B	351	10	0	161	115.0	75	51,400	51,400	6.850					
350	10	14.58	0	0	C224T	351	10	0	161	115.5	75	50,500	50,500	6.811					
350	10	14.58	0.1	0.1	C411K	350	10	0.07	166	115.0	75	50,300	50,300	6.811					
350	10	14.58	0.1	0.1	C411B	350	10	0.09	166	115.0	75	51,900	51,900	6.811					
350	10	14.58	0.35	0.35	C414T	352	10	0.31	177	106.0	75	56,500	56,500	6.811					
350	10	14.58	0.35	0.35	C414K	352	10	0.28	177	105.5	75	56,500	56,500	6.811					
350	10	14.58	0.35	0.35	C414B	351	10	0.34	177	105.5	75	57,800	57,800	6.811					
350	10	14.58	1.0	1.0	C223T	350	10	0.77	161	114.5	75	55,500	55,500	6.811					
350	10	14.58	1.0	1.0	C223K	350	10	0.75	161	115.0	75	55,000	55,000	6.811					
350	10	14.58	1.0	1.0	C223B	350	10	0.64	161	114.5	75	55,000	55,000	6.811					
350	10	14.58	1.0	1.0	C314T	351	80	0	169	112.0	75	44,900	44,900	6.811					
350	10	14.58	0	0	C314B	351	80	0	159	111.5	75	44,000	44,000	6.811					
350	10	14.58	0	0	C314K	350	80	0	185	112.0	82	44,700	44,700	6.811					
350	10	14.58	0	0	C315T	350	80	0	165	112.0	75	44,100	44,100	6.811					
350	10	14.58	0	0	C315K	350	80	0	165	112.5	75	44,000	44,000	6.811					
350	10	14.58	0.1	0.1	C315T	351	80	0.10	169	111.5	75	44,900	44,900	6.811					
350	10	14.58	0.1	0.1	C315K	351	80	0.08	159	111.5	75	44,500	44,500	6.811					
350	10	14.58	0.1	0.1	C315B	351	80	0.07	169	111.5	75	43,700	43,700	6.811					
350	10	14.58	0.35	0.35	C313T*	350	80	0.33	185	110.0	82	43,700	43,700	6.811					
350	10	14.58	0.35	0.35	C313K	349	80	0.35	185	111.5	82	42,500	42,500	6.811					
350	10	14.58	0.35	0.35	C313B	350	80	0.32	185	111.0	82	43,400	43,400	6.811					
350	10	14.58	1.0	1.0	C317T	350	80	0.62	165	111.0	75	41,200	41,200	6.811					
350	10	14.58	1.0	1.0	C317K	349	80	0.66	165	111.0	75	41,000	41,000	6.811					
350	10	14.58	1.0	1.0	C317B	349	80	0.70	165	111.0	75	41,900	41,900	6.811					
400	10	15.48	0	0	C442T	400	10	0	167	110.5	75	40,600	40,600	6.811					
400	10	15.48	0	0	C422K	400	10	0	167	111.0	75	40,800	40,800	6.811					
400	10	15.48	0	0	C423T	400	10	0	178	111.5	75	40,200	40,200	6.811					
400	10	15.48	0	0	C214K	402	10	0	163	110.5	75	40,000	40,000	6.811					
400	10	15.48	0	0	C214B	402	10	0	163	110.5	75	39,100	39,100	6.811					

* Strain rate for specimen C313T was 0.0063 in./in./min (rest were 0.007 - 0.011)

ROOM TEMP. COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

ACTUAL EXPOSURE CONDITIONS										PROPERTIES AFTER EXPOSURE										CLASSIFIED PROPERTIES/STRENGTH RATIOS	
Temp.	Time	Gr.	Stress	Total	Specimen	Temp.	Time	Total	Specimen	Rockwell	Actual	Fcy	R _H	R _H	Fcy	R _H	R _H				
°F	hr	ksi	ksi	Strain	No.	°F	hr	Strain	No.	Hardness	Test Temp.	psi	psi	psi	psi	psi	psi				
400	10	15.6	13.0	0.1	C-217	401	10	0.11	167	110.0	75	40,900	53.0	53.0	40,900	53.0	53.0				
400	10	15.6	13.0	0.1	C-218	400	10	0.07	167	111.0	75	40,900	53.0	53.0	40,900	53.0	53.0				
400	10	15.6	13.0	0.1	C-219	400	10	0.09	167	110.0	75	40,900	53.0	53.0	40,900	53.0	53.0				
400	10	15.6	17.5	0.35	C-220	401	10	0.26	178	110.0	75	38,900	55.0	55.0	38,900	55.0	55.0				
400	10	15.6	17.5	0.35	C-221	400	10	0.24	178	110.5	75	38,900	55.5	55.5	38,900	55.5	55.5				
400	10	15.6	17.5	0.35	C-222	400	10	0.22	178	111.0	75	39,100	56.0	56.0	39,100	56.0	56.0				
400	10	15.6	19.5	1.0	C-223	402	10	0.60	163	109.5	75	38,200	49.5	49.5	38,200	49.5	49.5				
400	10	15.6	19.5	1.0	C-224	401	10	0.76	163	109.0	75	37,100	49.0	49.0	37,100	49.0	49.0				
400	10	15.6	19.5	1.0	C-225	402	10	0.95	163	109.0	75	37,100	49.0	49.0	37,100	49.0	49.0				
500	10	16.38	0	0	C-124	500	10	0	184	105.5	81	27,900	34.0	34.0	27,900	34.0	34.0				
500	10	16.38	0	0	C-125	501	10	0	171	105.5	75	28,200	37.0	37.0	28,200	37.0	37.0				
500	10	16.38	0	0	C-126	501	10	0	171	105.5	75	28,200	38.0	38.0	28,200	38.0	38.0				
500	10	16.38	0	0	C-127	501	10	0	171	105.5	75	28,200	39.0	39.0	28,200	39.0	39.0				
500	10	16.38	10.5	0.1	C-128	500	10	0.14	184	104.5	81	28,800	34.5	34.5	28,800	34.5	34.5				
500	10	16.38	10.5	0.1	C-129	500	10	0.13	184	105.0	81	29,200	34.0	34.0	29,200	34.0	34.0				
500	10	16.38	10.5	0.1	C-130	500	10	0.12	184	104.5	81	28,400	33.0	33.0	28,400	33.0	33.0				
500	10	16.38	13.0	1.0	C-131	501	10	1.04	171	104.0	75	25,200	29.0	29.0	25,200	29.0	29.0				
500	10	16.38	13.0	1.0	C-132	500	10	0.87	171	104.5	75	27,400	29.0	29.0	27,400	29.0	29.0				
500	10	16.38	13.0	1.0	C-133	501	10	0.68	171	104.5	75	25,800	34.0	34.0	25,800	34.0	34.0				
500	10	17.28	0	0	C-6167	501	10	0	174	98.5	75	20,500	98.5	98.5	20,500	98.5	98.5				
500	10	17.28	0	0	C-6154	501	10	0	174	98.5	75	21,000	98.5	98.5	21,000	98.5	98.5				
500	10	17.28	8.70	1.0	C-6177	502	10	1.15	174	98.5	75	19,400	98.5	98.5	19,400	98.5	98.5				
500	10	17.28	8.70	1.0	C-6174	501	10	1.22	174	98.0	75	19,200	98.0	98.0	19,200	98.0	98.0				
500	10	17.28	8.70	1.0	C-6178	500	10	1.24	174	98.0	75	19,300	98.0	98.0	19,300	98.0	98.0				
COMPRESSION EXPOSURE STRESS CHECK TEST:																					
377	3	14.63	0	0	C-6107	377	3	0	216		90	59,400			59,400						
377	3	14.63	0	0	C-5104	378	3	0	216		90	59,100			59,500						
377	3	14.63	0	0	C-6108	378	3	0	216		90	57,500			57,900						
377	3	14.63	28.5	-0.3	C-6104	376	3	-0.32	216		90	56,300			56,100						
377	3	14.63	28.5	-0.3	C-5107	376	3	-0.26	216		90	58,900			58,500						
377	3	14.63	28.5	-0.3	C-5108	376	3	-0.26	216		90	57,800			57,800						

TABLE IX
200°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURES

WADC TR 56-585 Pt II

NOMINAL EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE			CORRECTED (1) PROPERTIES		
Temp. °F	Time hr	Stress psi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Actual Test Temp. °F	F _{cy} psi	F _{cy} psi	F _{cy} psi	R _q	R _e
35C	10	14.58	0	C1137	352	10	0	202	50,900	51,500	51,500	0.828	
35C	10	14.58	0	C1138	352	10	0	201	58,900	59,500	59,500	0.801	
35C	10	14.58	0	C1139	352	10	0	202	50,400	57,000	57,000	0.727	
40C	10	15.48	0	C1167	400	10	0	200	40,900	40,900	40,900	0.556	
40C	10	15.48	0	C1168	400	10	0	200	41,200	41,200	41,200	0.555	
40C	10	15.48	0	C1169	400	10	0	200	40,400	40,400	40,400	0.543	
450	10	16.38	0	C5337	451	10	0	200	27,600	27,600	27,600	0.371	
450	10	16.38	0	C5338	451	10	0	200	27,500	27,500	27,500	0.370	
450	10	16.38	0	C5339	451	10	0	200	27,000	27,000	27,000	0.363	
500	10	17.22	0	C626M	501	10	0	201	23,700	23,700	23,700	0.319	
500	10	17.22	0	C626N	501	10	0	203	21,700	21,700	21,700	0.292	

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

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TABLE X
300°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (1) AFTER EXPOSURE				
Temp. °F	Time hr	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F _{cy} psi	Actual Test Temp. °F	F _{cy} psi	Actual Test Temp. °F	F _{cy} psi	Actual Test Temp. °F	F _{cy} psi	Actual Test Temp. °F	F _{cy} psi	Actual Test Temp. °F
300	1	12.92	0	C310B	299	1	0	228	300	51,100	300	51,100	300	51,100	300	51,100	300	51,100	300
300	1	12.92	0	C310B	299	1	0	228	302	50,900	302	50,900	302	50,900	302	50,900	302	50,900	302
300	1	12.92	50.0	C310T	300	1	0.86	228	300	59,400	300	59,400	300	59,400	300	59,400	300	59,400	300
300	1	12.92	50.0	C316M	300	1	1.24	228	301	57,400	301	57,400	301	57,400	301	57,400	301	57,400	301
300	1	12.92	50.0	C316B	300	1	2.01	228	300	57,400	300	57,400	300	57,400	300	57,400	300	57,400	300
250	100	13.49	0	C337E	252	100	0	217	301	51,300	301	51,300	301	51,300	301	51,300	301	51,300	301
250	100	13.49	0	C337B	252	100	0	217	301	52,100	301	52,100	301	52,100	301	52,100	301	52,100	301
250	100	13.49	0	C337B	252	100	0	192	299	51,300	299	51,300	299	51,300	299	51,300	299	51,300	299
250	100	13.49	0	C336B	250	100	0	192	299	52,500	299	52,500	299	52,500	299	52,500	299	52,500	299
250	100	13.49	0	C337T	250	100	0	240	302	59,400	302	59,400	302	59,400	302	59,400	302	59,400	302
250	100	13.49	0	C337M	250	100	0	240	300	50,400	300	50,400	300	50,400	300	50,400	300	50,400	300
250	100	13.49	36.0	C631T	251	100	0.14	240	302	59,400	302	59,400	302	59,400	302	59,400	302	59,400	302
250	100	13.49	36.0	C631M	250	100	0.13	240	302	60,300	302	60,300	302	60,300	302	60,300	302	60,300	302
250	100	13.49	36.0	C631B	250	100	0.09	240	301	60,400	301	60,400	301	60,400	301	60,400	301	60,400	301
250	100	13.49	47.3	C535T	252	100	0.94	217	300	58,100	300	58,100	300	58,100	300	58,100	300	58,100	300
250	100	13.49	47.3	C535M	252	100	0.89	217	301	58,900	301	58,900	301	58,900	301	58,900	301	58,900	301
250	100	13.49	47.3	C535B	252	100	0.91	217	300	57,000	300	57,000	300	57,000	300	57,000	300	57,000	300
300	100	14.44	0	C625M	301	100	0	218	301	55,800	301	55,800	301	55,800	301	55,800	301	55,800	301
300	100	14.44	0	C625B	301	100	0	218	301	56,300	301	56,300	301	56,300	301	56,300	301	56,300	301
300	100	14.44	35.0	C521T	302	100	1.33	218	300	49,400	300	49,400	300	49,400	300	49,400	300	49,400	300
300	100	14.44	35.0	C521M	301	100	1.27	218	300	49,000	300	49,000	300	49,000	300	49,000	300	49,000	300
300	100	14.44	35.0	C521B	301	100	1.20	218	299	47,300	299	47,300	299	47,300	299	47,300	299	47,300	299

(1) Properties corrected to nominal exposure conditions and nominal test temperatures.

TABLE X (Continued)
300°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

INITIAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE					CORRELATION PROPERTIES (15-MINUTE RATIOS)				
Temp. °F	Time hr	σ (1740 kgf) x10 ⁻³	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F _{cy} psi	F _{cy} psi	R _y	R _e	F _{cy} psi	F _{cy} psi	R _y	R _e	
350	10	14.58	0	0	C1202	350	10	0	199	300	55,600	55,600	0.702		55,600	55,600	0.702		
350	10	14.58	0	0	C2203	351	10	0	200	303	54,100	54,100	0.734		54,100	54,100	0.734		
350	10	14.58	0	0	C2168	352	10	0	227	300	52,800	52,800	0.711		52,800	52,800	0.711		
350	10	14.58	0	0	C2169	352	10	0	227	299	50,800	51,300	0.690		50,800	51,300	0.690		
350	10	14.58	0	0	C4135	351	10	0	201	302	55,100	55,500	0.727		55,100	55,500	0.727		
350	10	14.58	20.0	0.10	C4167	351	10	0.13	201	299	53,200	53,500		0.884	53,200	53,500		0.884	
350	10	14.58	20.0	0.10	C4168	350	10	0.09	201	300	53,700	53,700		0.920	53,700	53,700		0.920	
350	10	14.58	20.0	0.10	C4169	351	10	0.09	201	303	51,400	51,900		0.954	51,400	51,900		0.954	
350	10	14.58	29.0	0.35	C4177	352	10	0.31	227	300	49,500	50,100		0.963	49,500	50,100		0.963	
350	10	14.58	29.0	0.35	C4178	351	10	0.42	227	300	49,800	50,200		0.884	49,800	50,200		0.884	
350	10	14.58	29.0	0.35	C4179	352	10	0.37	227	300	49,200	49,700		0.955	49,200	49,700		0.955	
350	10	14.58	31.5	1.00	C1217	351	10	1.38	199	300	44,800	44,900		0.820	44,800	44,900		0.820	
350	10	14.58	31.5	1.00	C1218	349	10	0.75	199	298	50,500	50,000		0.919	50,500	50,000		0.919	
350	10	14.58	31.5	1.00	C1219	348	10	0.73	199	302	50,300	50,000		0.919	50,300	50,000		0.919	
350	80	15.31	0	0	C6208	350	80	0	219	300	38,200	38,200	0.514		38,200	38,200	0.514		
350	80	15.31	0	0	C1107	350	80	0	196	302	37,700	37,800	0.509		37,700	37,800	0.509		
350	80	15.31	0	0	C1108	351	80	0	197	303	36,900	37,200	0.501		36,900	37,200	0.501		
350	80	15.31	13.0	0.10	C4107	350	80	0.05	197	300	37,500	37,500		0.994	37,500	37,500		0.994	
350	80	15.31	13.0	0.10	C4108	350	80	0.05	197	300	37,100	37,100		0.983	37,100	37,100		0.983	
350	80	15.31	13.0	0.10	C4109	350	80	0.06	197	303	37,500	37,700		0.999	37,500	37,700		0.999	
350	80	15.31	19.0	0.35	C1111	350	80	0.35	196	300	37,800	37,800		1.002	37,800	37,800		1.002	
350	80	15.31	19.0	0.35	C1114	350	80	0.27	196	300	36,500	36,500		0.927	36,500	36,500		0.927	
350	80	15.31	19.0	0.35	C1118	350	80	0.27	196	301	36,900	37,000		0.981	36,900	37,000		0.981	
350	80	15.31	21.5	1.00	C6208	350	80	0.79	219	304	34,500	34,500	0.917		34,500	34,500	0.917		
350	80	15.31	21.5	1.00	C6209	350	80	0.71	219	300	35,600	35,600	0.944		35,600	35,600	0.944		
400	10	15.48	0	0	C1208	400	10	0	202	303	38,700	38,800	0.522		38,700	38,800	0.522		
400	10	15.48	0	0	C4377	400	10	0	203	300	36,200	36,200	0.487		36,200	36,200	0.487		
400	10	15.48	0	0	C4378	400	10	0	203	301	35,300	35,400	0.475		35,300	35,400	0.475		
400	10	15.48	0	0	C4379	400	10	0	204	300	36,500	36,500	0.491		36,500	36,500	0.491		
400	10	15.48	0	0	C5278	400	10	0	204	300	35,700	35,700	0.480		35,700	35,700	0.480		
400	10	15.48	13.0	0.10	C4357	399	10	0.09	204	301	35,400	35,300		0.927	35,400	35,300		0.927	
400	10	15.48	13.0	0.10	C4308	399	10	0.17	204	300	35,900	35,700		0.978	35,900	35,700		0.978	
400	10	15.48	13.0	0.10	C4309	400	10	0.07	204	299	35,600	35,500		0.973	35,600	35,500		0.973	
400	10	15.48	17.5	0.35	C4357	400	10	0.29	203	300	34,700	34,700		0.931	34,700	34,700		0.931	
400	10	15.48	17.5	0.35	C4368	399	10	0.29	203	299	34,200	34,000		0.931	34,200	34,000		0.931	
400	10	15.48	17.5	0.35	C4369	400	10	0.23	203	300	34,500	34,500		0.931	34,500	34,500		0.931	
400	10	15.48	20.0	1.00	C2207	400	10	0.42	202	301	33,200	33,200		0.912	33,200	33,200		0.912	
400	10	15.48	20.0	1.00	C2208	399	10	0.59	202	300	34,400	33,800		0.925	34,400	33,800		0.925	
400	10	15.48	20.0	1.00	C2209	398	10	0.54	202	300	34,100	34,000		0.941	34,100	34,000		0.941	

TABLE X (Continued)
300°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

INITIAL EXPOSURE CONDITIONS						ACTUAL EXPOSURE CONDITIONS						PROPERTIES AFTER EXPOSURE			CORRECTED PROPERTIES (1)			STRENGTH RATIOS	
Temp. °F	Time hr	Temp °F (17.2 deg C)	Stress ksi	Total Strain %		Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.		Actual Test Temp. °F	F _{cy} psi	F _{cy} psi				F _r	F _o
-50	10	16.34	0	0		C1237	450	10	0	205		301	26,300	26,400				0.355	
-50	10	16.34	0	0		C1238	450	10	0	205		301	26,100	26,100				0.351	
-50	10	16.34	0	0		C1239	450	10	0	205		301	26,400	26,400				0.355	
-50	10	16.34	13.0	1.00		C1227	449	10	0.94	205		300	24,400	24,400				0.528	
-50	10	16.34	13.0	1.00		C1228	448	10	0.62	205		299	24,500	24,400				0.522	
-50	10	16.34	13.0	1.00		C1229	448	10	0.59	205		301	24,800	24,700				0.515	
500	10	17.28	0	0		C6307	499	10	0	202		302	20,000	20,000				0.259	
500	10	17.28	0	0		C6308	499	10	0	202		300	19,300	19,300				0.250	
500	10	17.28	0	0		C6147	498	10	0	206		301	20,300	20,300				0.273	
500	10	17.28	0	0		C6148	498	10	0	206		300	19,500	19,500				0.262	
500	10	17.28	0	0		C6149	498	10	0	206		301	20,300	20,300				0.273	
500	10	17.28	6.7	1.00		C5307	500	10	0.79	202		301	19,200	19,200				0.97	
500	10	17.28	6.7	1.00		C5308	498	10	0.74	202		301	19,900	19,900				1.01	
500	10	17.28	6.7	1.00		C5309	498	10	0.75	202		301	19,500	19,500				0.992	
500	10	17.28	6.7	1.00		C6137	497	10	1.11	206		301	20,200	20,200				1.010	
500	10	17.28	6.7	1.00		C6138	498	10	1.08	206		301	20,100	20,100				1.005	
500	10	17.28	6.7	1.00		C6139	499	10	1.15	206		302	19,500	19,500				0.975	

TABLE XI
400°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

POSITIVE EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE				CORRECTED (1) PROPERTIES STRENGTH RATIOS			
Temp. °F	Time hr	σ_T (10 ³ psi)	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F _{cy} psi	Strain Rate in/in/min	F _{cy} psi	R _T	R _ε		
25C	100	13.49	0	0	C334T	252	100	0	209	400	46,500	0.0085	46,500	0.625			
25C	100	13.49	0	0	C334M	251	100	0	209	400	47,500	0.0090	47,500	0.639			
25C	100	13.49	0	0	C334B	251	100	0	209	402	46,100	0.0085	46,100	0.617			
35C	10	14.58	0	0	C112T	352	10	0	207	398	42,400	0.0085	42,400	0.571			
35C	10	14.58	0	0	C112M	352	10	0	207	402	41,000	0.0085	41,300	0.555			
35C	10	14.58	0	0	C112B	352	10	0	207	400	40,600	0.0083	40,800	0.549			
35C	10	14.58	31.5	1.00	C111T	352	10	0.73	207	400	38,200	0.0075	38,400	0.925			
35C	10	14.58	31.5	1.00	C111M	351	10	0.96	207	399	36,700	0.0085	36,700	0.884			
35C	10	14.58	31.5	1.00	C111B	351	10	1.04	207	399	36,600	0.0090	36,600	0.881			
40C	10	15.48	0	0	C115T	400	10	0	208	400	30,000	0.0067	30,000	0.404			
40C	10	15.48	0	0	C115M	400	10	0	208	399	30,300	0.0092	30,200	0.406			
40C	10	15.48	0	0	C115B	400	10	0	208	400	29,100	0.0085	29,100	0.392			
40C	10	15.48	20.0	1.00	C114T	400	10	0.79	208	400	28,100	0.0090	28,100	0.946			
40C	10	15.48	20.0	1.00	C114M	399	10	0.81	208	400	27,700	0.0080	27,500	0.929			
40C	10	15.48	20.0	1.00	C114B	399	10	1.06	208	400	26,300	0.0093	26,200	0.882			
45C	10	16.38	0	0	C334T	451	10	0	217	400	21,300	0.0075	21,300	0.287			
45C	10	16.38	0	0	C334M	451	10	0	217	400	21,800	0.0078	21,800	0.293			
45C	10	16.38	0	0	C334B	451	10	0	217	401	21,600	0.0075	21,700	0.292			
50C	10	17.28	0	0	C611T	502	10	0	213	402	18,100	0.0085	18,100	0.244			
50C	10	17.28	0	0	C611M	501	10	0	213	400	17,400	0.0095	17,400	0.234			
50C	10	17.28	0	0	C611B	500	10	0	213	400	17,100	0.0090	17,100	0.230			

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE XII
ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	INITIAL EXPOSURE CONDITIONS AND RESULTING STRAIN *				PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (2)				STRENGTH RATIOS		
		Step 1	Step 2	Step 3	Step 4	Total ϵ_{17} Exposure $\times 10^{-3}$	Specimen Group No.	Actual Test Temp.	F_{ty}	F_{tu}	elong. in 2 in.	F_{ty}	F_{tu}	R_t Yield	R_t Ult.	R_t Ult.	
		ksi	ksi	ksi	ksi	(1)		$^{\circ}F$	psi	psi	%	psi	psi				
A-1	A544	3507 3.5 hr 31.0 ksi	3197 20 hr 32.5 ksi	2757 100 hr 35.0 ksi		14.57	105	75.0	61,000	71,700	9.5	51,000	71,700	0.855	0.932		
						14.58	105	70	55,100	56,900	9.5	55,100	56,900		0.910	0.932	
						14.58	105	70	55,000	56,700	10.0	55,000	56,700		0.908	0.935	
A-2	A765	3507 3.5 hr 21.0 ksi	3197 20 hr 22.0 ksi	2757 100 hr 23.0 ksi		14.56	116	80.0	59,700	71,300	9.5	59,700	71,300	0.885	0.922		
						14.56	116	79.0	60,000	71,600	11.0	60,000	71,500	0.890	0.928		
						14.50	116	70	59,900	71,300	10.5	59,900	71,200		0.995	0.995	
						14.53	116	70	58,900	70,400	10.0	58,900	70,100		0.982	0.981	
A-3	A1120	3507 3.5 hr 34.5 ksi	3197 20 hr 32.5 ksi	2757 100 hr 31.5 ksi		14.62	115	74.0	55,700	67,800	11.0	55,700	67,800	0.805	0.853		
						14.59	129	76.0	58,300	69,700	11.0	58,400	69,800	0.846	0.891		
						14.59	129	76.0	59,600	70,400	10.0	59,500	70,500	0.866	0.897		
						14.60	115	72	51,400	63,600	10.0	51,400	63,600		0.922	0.940	
A-4	A1121	3507 3.5 hr 34.5 ksi	3197 20 hr 32.5 ksi	2757 100 hr 31.5 ksi		14.62	115	74.0	55,700	67,800	11.0	55,700	67,800	0.805	0.853		
						14.59	129	76.0	58,300	69,700	11.0	58,400	69,800	0.846	0.891		
						14.59	129	76.0	59,600	70,400	10.0	59,500	70,500	0.866	0.897		
						14.60	115	72	51,400	63,600	10.0	51,400	63,600		0.922	0.940	

* Specimen isostatic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures ($\pm 4^{\circ}F$ from nominal) were used to compute ϵ_{17} .

(2) Corrected to nominal test temperature.

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TABLE XII (Continued)

**GENERAL SPECIFIC CONDITIONS AND
TERMS OF SALE :**

TABLE XII (Continued)
ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

EXPOSURE CONDITIONS AND RESULTING STRAIN						PROPERTIES AFTER EXPOSURE						CORRELATED PROPERTIES (2)				STRENGTH RATIOS		
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total 0.7 Exposure Strain E10 ⁻³ (1)	Specimen Group No.	Reichell Hardness	Actual Test Temp.	F _{ty}	F _{tu}	elong- in 2in.	F _{ty}	F _{tu}	psi	psi	R _t yield	R _t ult.
D	E120 E126 E275 E226 E227	3407	3407															
		70 hr	3 hr															
		0	25.0															
		hr	hr															
			05	05			15.31	2.6	112.0	61.0	74	44,100	58,700	0.5	44,100	58,700	.659	.770
			0	0			15.31	2.6	113.0	62.0	74	44,300	58,900	0.0	44,300	58,900	.660	.771
			05	0			15.31	2.6	112.0	61.0	74	44,100	58,700	0.0	44,100	58,700		
			0	0			15.31	2.6	113.0	62.0	74	44,300	58,900	0.0	44,300	58,900		
		05	0			15.31	2.6	112.0	61.0	74	44,100	58,700	0.0	44,100	58,700	.659	.770	
		0	0			15.31	2.6	113.0	62.0	74	44,300	58,900	0.0	44,300	58,900	.660	.771	
		05	0			15.31	2.6	112.0	61.0	74	44,100	58,700	0.0	44,100	58,700			
		0	0			15.31	2.6	113.0	62.0	74	44,300	58,900	0.0	44,300	58,900			

TABLE XII (Continued)
ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE													PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES			
Sequence Number	Ex.	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Total Exposure Time (hr)	Specimen Group No.	Rockwell Hardness	Temp °F	Actual Temp °F	F _u	F _u along in 2 in.	F _u	F _u along in 2 in.
1-1		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
1-2		2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
1-3		2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066
1-4		2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085
1-5		2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104
1-6		2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123
1-7		2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142
1-8		2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161
1-9		2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180
1-10		2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199
1-11		2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218
1-12		2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237
1-13		2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256
1-14		2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275
1-15		2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294
1-16		2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313
1-17		2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332
1-18		2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351
1-19		2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370
1-20		2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389
1-21		2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408
1-22		2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427
1-23		2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446
1-24		2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465
1-25		2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484
1-26		2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503
1-27		2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522
1-28		2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541
1-29		2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560
1-30		2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579
1-31		2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598
1-32		2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617
1-33		2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636
1-34		2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655
1-35		2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674
1-36		2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693
1-37		2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712
1-38		2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731
1-39		2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750
1-40		2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769
1-41		2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788
1-42		2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807
1-43		2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826
1-44		2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845
1-45		2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864
1-46		2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883
1-47		2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902
1-48		2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921
1-49		2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940
1-50		2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959

TABLE XIII
300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

ANIMAL EXPOSURE CONDITIONS AND RESULTING STRAIN *						PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (2)		STRENGTH RATIOS						
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total 0.17 Exposure X10 ⁻³ (1)	%	Specimen Group No.	Actual Test Temp.	F _{ty}	F _{tu}	along in 2 hr.	F _{ty}	F _{tu}	R _T Yield	R _T Ult.	Yield	Ult.
									°F	psi	psi	%	psi	psi				
A-1		350°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		31,500	32,500	34,500														
		psi	psi	psi														
	AI025	0.05	0.05	0.05	0.05	14.60	0	110	303	50,200	50,300	11.0	50,500	50,600	0.752	0.551		
A-2		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI023	0.10	0.25	0.50	0.50	14.50	0.85	110	302	47,300	47,500	11.0	47,500	47,700		0.943	0.943	0.943
A-3		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI024	0.20	0.30	0.60	0.60	14.58	1.05	110	302	46,500	46,800	16.0	46,700	47,000		0.925	0.925	0.925
B-1		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI025	0.05	0.70	0.30	0.30	14.58		110	303	45,500	45,800	13.5	45,800	46,100		0.907	0.907	0.911
B-2		350°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI026	0	0	0	0	14.57	0	135	300	50,500	52,400	9.5	50,600	52,400	0.746	0.570	0.570	0.570
B-3		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI027	0.10	0.05	0.10	0.10	14.56	0.25	135	299	48,900	50,800	12.5	48,800	50,700		0.964	0.964	0.970
B-4		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI028	0.10	0.05	0.10	0.10	14.55	0.25	135	300	48,700	50,200	15.0	48,700	50,200		0.962	0.962	0.960
B-5		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI029	0.10	0.05	0.10	0.10	14.58	0.25	135	299	49,700	50,600	9.0	49,600	50,500		0.981	0.981	0.955
B-6		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI030	0	0	0	0	14.96	0	119	300	42,100	43,200	18.0	42,100	43,200	0.607	0.550	0.550	0.550
B-7		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI031	0	0	0	0	14.96	0	119	302	42,100	43,000	13.5	42,600	43,200	0.614	0.550	0.550	0.550
B-8		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI032	0.30	0.15	0.15	0.15	14.97	0.45	119	300	38,700	39,900	17.5	38,700	39,900		0.915	0.915	0.924
B-9		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI033	0.30	0.15	0.15	0.15	14.95	0.45	119	300	39,600	41,200	18.0	39,600	41,200		0.916	0.916	0.954
B-10		315°F	315°F	275°F														
		3.5 hr	20 hr	100 hr														
		27,500	28,000	29,000														
		psi	psi	psi														
	AI034	0.30	0.10	0.10	0.10	14.95	0.40	119	300	39,400	41,000	22.0	39,400	41,000		0.931	0.931	0.949

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions.
(Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures ($\pm 1.0^\circ$ from nominal) were used to compute 0.17.

(2) Corrected to nominal test temperatures.

TABLE XIII (Continued)
300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

INITIAL EXPOSURE CONDITIONS AND RESULTING STRAIN										PROPERTIES AFTER EXPOSURE					OBSERVED PROPERTY 25 (4)		
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total 9.7 Exposure in 10 ⁻³	Specimen Group No.	Actual Test Temp.	Fly	F _{tu}	Elong. in 2 in.	Fly	F _{tu}	Elong.	Fly	F _{tu}	Elong.
						(1)		°F	psi	psi		psi	psi		psi	psi	
B-13	B112	300°F 100 hr 29,500 psi	350°F 24 hr 21,000 psi	400°F 3.5 hr 19,000 psi		15.34	144	299	34,900	36,700	20.5	34,900	36,600	0.526	34,900	36,600	0.526
	B113	0	0	0		15.34	144	300	34,600	36,700	22.5	34,600	36,700	0.475	34,600	36,700	0.475
	B121	0	0	0		15.34	144	300	34,700	36,600	20.5	34,700	36,600	0.513	34,700	36,600	0.513
	B110	0.25	0.16	0.33		15.34	144	299	34,200	34,000	20.0	34,200	34,900	0.475	34,200	34,900	0.475
	B111	0.29	0.05	0.34		15.34	144	300	34,100	34,000	18.5	34,100	34,600	0.475	34,100	34,600	0.475
B-15	B122	0.24	0.12	0.20		15.29	144	299	33,500	35,500	18.5	33,500	35,500	0.475	33,500	35,500	0.475
	B125	0	0	0		15.27	142	300	36,900	38,200	17.5	36,900	38,400	0.513	36,900	38,400	0.513
	B126	0	0	0		15.27	142	300	37,100	38,200	21.0	37,100	38,300	0.505	37,100	38,300	0.505
	B127	0	0	0		15.27	142	300	37,300	38,200	13.5	37,300	38,200	0.533	37,300	38,200	0.533
	B115	0.25	0.15	0.05		15.28	142	298	34,900	36,500	12.0	34,900	36,300	0.475	34,900	36,300	0.475
B-14	B116	0.20	0.15	0.05		15.25	142	300	35,500	36,700	11.5	35,500	36,700	0.475	35,500	36,700	0.475
	B117	0.25	0.10	0.05		15.25	142	300	35,900	37,500	13.5	35,900	37,500	0.475	35,900	37,500	0.475
	B146	0	0	0		15.35	145	300	34,800	36,100	22.0	34,800	36,100	0.526	34,800	36,100	0.526
	B145	0	0	0		15.35	145	300	34,600	35,800	18.0	34,600	35,800	0.513	34,600	35,800	0.513
	B147	0.30	0.20	0.15		15.35	145	300	31,800	33,300	13.5	31,800	33,300	0.475	31,800	33,300	0.475
B-24	B146	0.30	0.20	0.25		15.35	145	299	31,600	33,200	17.5	31,600	33,200	0.475	31,600	33,200	0.475
	B147	0.30	0.15	0.20		15.33	145	300	32,500	34,100	20.5	32,500	34,100	0.475	32,500	34,100	0.475
	B150	0	0	0		15.40	148	301	34,200	35,500	20.5	34,200	35,600	0.513	34,200	35,600	0.513
	B151	0	0	0		15.40	148	302	33,900	35,300	21.0	33,900	35,300	0.506	33,900	35,300	0.506
	B152	0.07	0.10	0.06		15.37	148	304	33,500	34,400	17.5	33,500	34,800	0.475	33,500	34,800	0.475
B-25	B152	0.06	0.09	0.05		15.37	148	299	32,900	34,700	22.0	32,900	34,600	0.475	32,900	34,600	0.475
	B153	0.07	0.07	0.06		15.37	148	300	33,700	35,200	21.0	33,700	35,200	0.475	33,700	35,200	0.475
	B153	0.07	0.07	0.06		15.37	148	300	33,700	35,200	21.0	33,700	35,200	0.475	33,700	35,200	0.475

TABLE XIII (Continued)
300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

TENSILE EXPOSURE CONDITIONS AND RESULTING STRAIN *						PROPERTIES AFTER EXPOSURE					CORRELATED PROPERTIES (2)						
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total @ 17 Exposure X10 ⁻³ (1)	%	Specimen Group No.	Actual Test Temp.	F _y psi	F _{tu} psi	elong- in 2 in.	F _y psi	F _{tu} psi	Yield Ult.	Brk Ult.	% Elong
B-11a	B544	300°F 100 hr 27,500 psi	350°F 24 hr 21,000 psi	400°F 3.5 hr 19,000 psi	350°F 24 hr 0	15.38	0	149	300	33,900	35,100	17.5	33,900	35,100	0.506	0.450	
						15.40	0.57	149	300	32,400	33,800	17.0	32,400	33,800		0.535	0.500
						15.39	0.68	149	301	31,900	33,200	22.0	31,900	33,300		0.521	0.500
						15.55	0.56	149	300	33,400	34,500	18.5	33,400	34,500		0.485	0.475
D	B223	375°F 70 hr 25,000 psi				15.27	0	156	302	37,500	38,800	18.0	37,500	38,900	0.561	0.510	
						15.27	0	156	301	37,300	38,600	19.5	37,300	38,700	0.558	0.507	
						15.27	1.55	156	301	36,700	37,300	27.0	36,800	37,400		0.982	0.975
						15.27	2.26	156	301	36,300	37,300	14.5	36,400	37,400		0.971	0.965
						15.27	1.53	156	302	36,500	37,200	13.0	36,700	37,500		0.975	0.962

TABLE XIII (Continued)
300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

INITIAL EXPOSURE CONDITIONS AND RESULTING STRAIN *													PROPERTIES AFTER EXPOSURE					CORRECTED (2) PROPERTIES			STRENGTH RATIOS			
Sequence	Specimen No.	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Total Elong. Exposure Strain (1) %	Specimen Group %	Actual Test Temp. of	F _y psi	F _u psi	elc. g. of 2 in.	F _y psi	F _u psi	F _y psi	F _u psi	F _y psi	F _u psi	
B-2	B341	350°F 10 hr 21.0 C ksi	325°F 36 hr C ksi	375°F 3 hr 22.5 C ksi	375°F 3 hr 22.5 C ksi	300°F 90 hr 22.0 C ksi	325°F 10 hr 22.0 C ksi	325°F 36 hr 19.0 C ksi	375°F 3 hr 21.5 C ksi	300°F 100 hr 21.5 C ksi	325°F 36 hr 16.0 C ksi	375°F	15.39	152	300	300	300	25.5	300	300	300	300	300	300
	B345	0	0	0	0	0	0	0	0	0	0	15.39	152	300	300	300	28.0	300	300	300	300	300	300	
	B341	0.15	0	0.20	0.15	0.10	0.05	0	0.14	0.08	0	15.39	0.87	152	300	32,000	33,400	14.5	32,000	33,400	300	300	300	
	B342	0.15	0	0.10	0.20	0.10	0.05	0	0.13	0.02	0	15.39	0.75	152	300	31,700	33,400	15.5	31,700	33,400	300	300	300	
	B343	0.15	0	0.10	0.10	0.10	0	0.11	0.04	0	15.38	0.60	152	300	32,100	33,900	15.5	32,100	33,900	300	300	300		

TABLE XIV
400°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *						PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (2)			STRENGTH RATIOS			
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total 0.7 Exposure Time (1)	Specimen Group No.	Actual Test Temp. °F	P_{ty} psi	P_{tu} psi	elong. in 2 in.	Strain Rate in/in/min	P_{ty} psi	P_{tu} psi	R_p Yield	R_t Yield	Ult.
A-1	A1094	350°F 3.5 hr ksi	315°F 20 hr ksi	275°F 100 hr ksi		14.57	113	400	38,600	38,600	7.0	0.0078	38,600	38,600	0.574	0.465	
		31.5	32.5	34.5													
		0%	0%	0%													
		0.10	0.25	0.70													
		0.05	0.25	0.75													
A-2	A936	350°F 3.5 hr ksi	315°F 20 hr ksi	275°F 100 hr ksi		14.55	136	397	38,400	40,000	7.5	0.0093	38,100	39,700	0.563	0.511	
		27.5	28.0	29.0													
		0	0	0													
		0.10	0.10	0.05													
		0.15	0.10	0													
B-2	A1232	300°F 100 hr ksi	350°F 24 hr ksi			14.96	127	402	33,200	34,000	11.5	0.0093	33,300	34,100	0.480	0.433	
		29.5	31.0														
		0	0														
		0.25	0.10														
		0.20	0.10														
A1235	A1235	300°F 100 hr ksi	350°F 24 hr ksi			14.96	127	401	31,800	32,300	16.0	0.0098	31,900	32,400		0.952	0.947
		29.5	31.0														
		0	0														
		0.25	0.10														
		0.20	0.10														

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions.
(Values derived by subtraction of cumulative strain readings obtained at the end of each step, are
only approximate.)

(1) Actual exposure temperatures ($\pm 10^\circ$ from nominal) were used to compute 0.7.

(2) Corrected to nominal test temperatures.

TABLE XIV (Continued)
400°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Case	Nominal Exposure Conditions 1" Insulating Strain					Properties After Exposure					Corrected Properties (2)					Strength Ratios				
	Specimen No.	Step 1	Step 2	Step 3	Step 4															
	Temp. °F	Time hr	Temp. °F	Time hr	Temp. °F	Total Q17 Exposure (1)	Specimen Group No.	Actual Temp. °F	F _{ty} psi	F _{tu} psi	Strain in 2 in. Rate %	F _{ty} psi	F _{tu} psi	Elong. %	F _{ty} psi	F _{tu} psi	Elong. %	F _{ty} psi	F _{tu} psi	Elong. %
B-3	M26	0	0	0	0	15.25	125	399	29,100	29,700	25.0	29,300	29,700	25.0	29,300	29,700	25.0	29,300	29,700	25.0
	M27	0	0	0	0	15.25	125	399	29,800	29,900	23.0	29,700	29,900	23.0	29,700	29,900	23.0	29,700	29,900	23.0
	M28	0	0	0	0	15.30	131	400	28,600	28,100	11.5	28,600	28,100	11.5	28,600	28,100	11.5	28,600	28,100	11.5
	M29	0	0	0	0	15.30	131	400	28,800	28,100	14.5	28,800	28,100	14.5	28,800	28,100	14.5	28,800	28,100	14.5
	M30	0	0	0	0	15.30	131	400	28,600	28,200	16.5	28,600	28,200	16.5	28,600	28,200	16.5	28,600	28,200	16.5
	M31	0.25	0.25	0.15	0.15	15.27	131	400	27,500	27,600	10.5	27,500	27,600	10.5	27,500	27,600	10.5	27,500	27,600	10.5
	M32	0.25	0.25	0.20	0.20	15.28	131	400	26,700	27,300	14.5	26,700	27,300	14.5	26,700	27,300	14.5	26,700	27,300	14.5
	M33	0.25	0.25	0.30	0.30	15.30	131	400	26,800	27,100	15.0	26,800	27,100	15.0	26,800	27,100	15.0	26,800	27,100	15.0
	M34	0.25	0.25	0.35	0.35	15.25	125	395	26,200	26,200	20.0	26,200	26,200	20.0	26,200	26,200	20.0	26,200	26,200	20.0
	M35	0.25	0.25	0.30	0.30	15.28	125	398	27,500	27,500	10.0	27,500	27,500	10.0	27,500	27,500	10.0	27,500	27,500	10.0
	M36	0.25	0.25	0.30	0.30	15.25	125	400	26,000	26,000	15.5	26,000	26,000	15.5	26,000	26,000	15.5	26,000	26,000	15.5
	M37	0.25	0.25	0.20	0.20	15.25	125	400	26,000	26,000	15.5	26,000	26,000	15.5	26,000	26,000	15.5	26,000	26,000	15.5
B-4	B33C	0	0	0	0	15.43	139	400	25,200	25,200	12.0	25,200	25,200	12.0	25,200	25,200	12.0	25,200	25,200	12.0
	B33A	0	0	0	0	15.43	139	400	26,200	26,900	14.5	26,200	26,900	14.5	26,200	26,900	14.5	26,200	26,900	14.5
	B33B	0.25	0.25	0.45	0.45	15.43	139	404	26,100	27,200	9.5	26,100	27,200	9.5	26,100	27,200	9.5	26,100	27,200	9.5
	B33D	0.25	0.25	0.40	0.40	15.41	139	397	26,200	26,900	9.0	26,200	26,900	9.0	26,200	26,900	9.0	26,200	26,900	9.0

TABLE XV
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	MINIMAL EXPOSURE CONDITIONS AND RESULTING STRAIN *				Total Q17 Exposure $\times 10^{-3}$ (1)	Total Strain %	Specimen Group No.	PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (2)		Final R_c
		Step 1	Step 2	Step 3	Step 4				Rockwell Hardness R_H	Actual Test Temp. of R_H	F_{cy} psi	F_{cy} psi			
A-1	CS22T	350 ⁰ 3.5 hr	315 ⁰ 20 hr	275 ⁰ 100 hr				176	115.5	76.5	64,700	64,700	0.4871	0.4871	
		31.5 ksi	33.5 ksi	34.5 ksi		14.58	0	176	116.0	76.5	66,500	66,500			
	CS22B	0	0	0		14.58	0	176	115.0	72.5	60,500	60,500	0.4871	0.4871	
	CS21T	0.23	0.26	0.35		14.58	0.84	176	115.0	73.0	58,400	58,400			
	CS21B	0.26	0.37	0.45		14.57	1.28	176	115.0	72.5	59,300	59,300	0.4871	0.4871	
	CS21B	0.27	0.31	0.42		14.58	1.00	176	115.0	72.5	59,300	59,300			
A-2	CS23T	350 ⁰ 3.5 hr	315 ⁰ 20 hr	275 ⁰ 100 hr				181	116.0	76.0	65,700	65,700	0.4871	0.4871	
		27.5 ksi	28.0 ksi	28.5 ksi		14.58	0	181	116.0	76.0	67,200	67,200			
	CS23B	0	0	0		14.57	0.22	181	115.5	75.0	63,700	63,700	0.4871	0.4871	
	CS24T	0.12	0.05	0.05		14.57	0.20	181	115.5	75.5	65,100	65,100			
	CS24B	0.15	0.02	0.03		14.56	0.23	181	115.5	75.5	65,100	65,100	0.4871	0.4871	
	CS24B	0.10	0.03	0.10		14.55	0.23	181	115.5	75.5	65,100	65,100			
B-13	CS12T	300 ⁰ 100 hr	350 ⁰ 2 hr	400 ⁰ 3.5 hr				175	111.5	62.0	43,800	43,800	0.4530	0.4530	
		28.5 ksi	21.5 ksi	19.5 ksi		15.33	0	175	111.5	61.5	42,700	42,700			
	CS12B	0	0	0		15.33	0	175	109.5	56.5	40,500	40,500	0.4530	0.4530	
	CS11T	0.26	0.13	0.19		15.34	0.58	175	110.0	57.0	40,100	40,100			
	CS11B	0.26	0.13	0.24		15.31	0.63	175	110.0	56.0	39,900	39,900	0.4530	0.4530	
	CS11B	0.24	0.17	0.22		15.30	0.63	175	110.0	56.0	39,900	39,900			
B-14	CA32T	300 ⁰ 100 hr	350 ⁰ 2 hr	400 ⁰ 3.5 hr				182	111.0	59.5	42,300	42,300	0.4572	0.4572	
		28.5 ksi	21.5 ksi	19.5 ksi		15.42	0	182	111.0	59.0	42,500	42,500			
	CA32B	0	0	0		15.42	0	182	109.5	55.0	39,300	39,300	0.4572	0.4572	
	CA31T	0.25	0.11	0.24		15.40	0.77	182	109.5	54.0	38,700	38,700			
	CA31B	0.20	0.18	0.22		15.40	0.77	182	109.5	54.0	38,700	38,700	0.4572	0.4572	
	CA31B	0.16	0.15	0.24		15.40	0.74	182	109.0	55.5	39,800	39,800			

* Specimens isostatic strains during each step. These are listed below minimal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures ($\pm 4^\circ\text{F}$ from minimal) were used to compute θ_{17} .

(2) Corrected to minimal test temperatures.

TABLE XV (Continued)
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	NORMAL EXPOSURE CONDITIONS AND RESULTING STRAIN *				Total Exp. Exposure, $\frac{1}{2}$ (1)	Total Strain $\frac{1}{2}$	Specimen Group No.	PROPERTIES AFTER EXPOSURE			CORRECTED PROPERTIES (2)		STRENGTH RATIO
		Step 1	Step 2	Step 3	Step 4				Rockwell Hardness R_H	Actual Test Temp., $^{\circ}F$	R_H	F_{cy}	F_{su}	
B-2		350 $\frac{1}{2}$ 100 hr	350 $\frac{1}{2}$ 24 hr	400 $\frac{1}{2}$ 3.5 hr	350 $\frac{1}{2}$ 24 hr									
		21.0 ksi	19.5 ksi	14.5 ksi	11.5 ksi									
	C4322	0	0	0	0	15.43	0	184	111.0	59.0	82	42,700	42,700	0.974
	C4323	0	0	0	0	15.43	0	184	111.0	59.5	82	42,700	42,700	0.974
	C4324	0.05	0.09	0.05	0.03	15.44	0.20	184	111.0	55.5	82	42,700	42,700	0.965
B-3		300 $\frac{1}{2}$ 100 hr	350 $\frac{1}{2}$ 24 hr	400 $\frac{1}{2}$ 3.5 hr	350 $\frac{1}{2}$ 24 hr									
		29.5 ksi	21.5 ksi	19.5 ksi	19.5 ksi									
	C4327	0	0	0	0	15.40	0	187	110.5	59.0	82	42,600	42,600	0.975
	C4328	0	0	0	0	15.40	0	187	110.0	59.0	82	42,400	42,400	0.972
	C4329	0.22	0.07	0.27	0	15.40	0.54	187	110.0	55.0	82	39,800	39,800	0.927
D		350 $\frac{1}{2}$ 70 hr	375 $\frac{1}{2}$ 3 hr											
		0 ksi	22.5 ksi											
	C4327	0	0	0	0	15.35	0	210	111.0	57.5	91	43,100	43,200	0.981
	C4328	0	0	0	0	15.35	0.30	210	111.0	58.0	91	42,400	42,500	0.972
	C4329	0	0.35	0.35	0	15.35	0.30	210	110.0	56.5	91	41,300	41,400	0.966
	C4330	0	0.36	0.36	0	15.34	0.36	210	110.5	56.0	91	41,300	41,400	0.966
	C4331	0	0.36	0.36	0	15.34	0.36	210	110.5	57.0	91	42,200	42,300	0.987

TABLE XV (Continued)
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	NORMAL EXPOSURE CONDITIONS AND RESULTING STRAIN										PROPERTIES AFTER EXPOSURE				Addl. Expt. No.	Specimen No.
		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Total Exp. Strain, %	Specimen Group No.	Modulus of Elasticity, E , psi	Actual Test Stress, f_c , psi		
A-1	14097	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497	12497
at 12 hrs. at 22.4 ksi, 24 hrs. at 0 ksi																	

TABLE XVI
300°F COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Nominal Exposure Conditions and Resulting Strain *				Total ϵ_{17} Exposure $\times 10^{-3}$ (1)	Total Strain ϵ	Specimen Group No.	Properties After Exposure		Corrected Properties (2)	Strength Ratio
		Step 1	Step 2	Step 3	Step 4				Actual Test Temp. of	P_{cy} psi		
A-1	C5277	350°F 3.5 hr 31.5 ksi	315°F 20 hr 33.5 ksi	275°F 100 hr 34.5 ksi								
		0	0	0		14.56	0	188	300	54,100	54,100	.723
		0.22	0.22	0.32		14.56	0	188	300	53,700	53,700	.723
		0.21	0.23	0.28		14.57	0.76	188	300	47,900	47,900	.883
		0.21	0.25	0.28		14.55	0.72	188	300	47,300	47,300	.878
A-2	C5248	350°F 3.5 hr 27.5 ksi	315°F 20 hr 28.0 ksi	275°F 100 hr 28.5 ksi		14.56	0.74	188	300	48,600	48,600	.902
		0	0	0								
		0.11	0.11	0.03		14.56	0	189	303	52,700	52,700	.713
		0.11	0.11	0.05		14.55	0.25	189	302	53,700	53,900	.725
		0.17	0.04	0.07		14.56	0.27	189	302	52,200	52,400	.980
A-3	C5238	300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi		14.56	0.28	189	303	50,800	51,000	.954
		0	0	0								
		0.28	0.13	0.29								
		0.30	0.14	0.35								
						15.32	0	190	300	38,000	38,000	.511
A-4	C5337 (3)	300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi		15.32	0	190	300	37,500	37,500	.505
		0	0	0		15.30	0.70	190	301	33,700	33,800	.895
		0.28	0.13	0.29		15.31	0.70	190	303	33,900	34,100	.903
		0.30	0.14	0.35								
						15.43	0	191	302	36,200	36,300	.489
A-5	C4377	300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi		15.43	0	191	300	36,700	36,600	.493
		0	0	0		15.42	0.84	191	300	33,400	33,400	.916
		0.21	0.15	0.24		15.40	0.84	191	301	32,600	32,700	.887
		0.22	0.15	0.23		15.41	0.82	191	303	32,900	32,400	.889
		0.21	0.14	0.24								

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures ($\pm 1^\circ\text{F}$ from nominal) were used to compute ϵ_{17} .

(2) Corrected to nominal test temperatures.

(3) Strain rates for specimens C5337 and C5338 were 0.013 and 0.015 in./in./min respectively. (rest were 0.007 - 0.011)

TABLE XVII
TENSION CONTROL TESTS FOR COMPRESSION PROGRAM

TENSILE EXPOSURE CONDITIONS				ACTUAL EXPOSURE CONDITIONS				PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES		STRENGTH RATIOS	
Temp.	Time	σ_{17}	Specimen	Temp.	Time	Specimen	Rockwell	Actual	F_{ty}	F_{tu}	elong.	F_{ty}	F_{tu}	R_t	Ultimate
$^{\circ}F$	hr	$T(17^{\circ}C)$	No.	$^{\circ}F$	hr	Grp. No.	R_H	Test σ_f	psi	psi	%	psi	psi	Yield	
300	1	12.92	C3371 *	298	1	173	116.5	75	68,300	77,500	9.0	58,300	77,500	0.999	1.016
300	1	12.52	C3375 *	298	1	173	117.0	75	68,900	78,200	9.5	58,900	78,200	1.007	1.028
290	100	13.49	C2357 *	251	100	172	117.0	75	57,500	75,900	11.0	57,500	75,900	0.987	0.997
290	100	13.49	C2358 *	251	100	172	117.0	75	57,100	75,000	11.0	57,100	75,000	0.981	0.999
300	100	14.44	C3227 *	301	100	179	116.0	75	51,500	71,100	9.5	51,800	71,100	0.904	0.938
300	100	14.44	C3228 *	301	100	179	115.0	75	60,700	71,100	9.5	51,000	71,100	0.892	0.958
390	10	14.58	C4137 *	352	10	177	106.0	75	58,500	70,500	10.5	55,200	70,500	0.855	0.935
390	10	14.58	C4138 *	352	10	177	106.0	75	57,200	68,500	10.5	57,900	68,100	0.842	0.908
390	10	14.58	C7267 *	352	10	225	---	301	49,700	50,300	17.0	50,000	50,300	0.731	0.665
390	10	14.58	C7268 *	352	10	225	---	300	49,000	49,800	16.0	49,300	49,100	0.721	0.658
377	3	14.63	C6307 *	377	3	216	---	90	54,700	66,800	9.5	55,300	67,300	0.810	0.880
377	3	14.63	C5207 *	378	3	216	---	90	57,200	59,000	11.0	58,000	59,700	0.950	0.920
377	3	14.63	C6208 *	378	3	216	---	90	57,000	58,700	11.0	57,700	59,300	0.840	0.910
390	80	15.31	C5127 *	390	80	185	112.0	82	40,400	55,700	9.5	40,700	55,100	0.591	0.737
390	80	15.31	C5128 *	390	80	185	112.0	82	40,100	54,900	10.5	40,100	55,300	0.582	0.727
400	10	15.48	C4257 *	400	10	178	111.0	75	39,100	54,100	9.5	39,100	54,100	0.572	0.715
400	10	15.48	C4258 *	400	10	178	111.5	75	39,400	54,900	9.5	39,400	54,900	0.572	0.721
500	10	17.28	C6157 *	501	10	174	98.5	75	19,700	35,300	11.5	19,700	35,300	0.288	0.516
500	10	17.28	C6158 *	501	10	174	98.5	75	19,300	35,600	12.5	19,300	35,600	0.282	0.530
500	10	17.28	C7237 *	502	10	226	---	300	18,500	25,500	35.0	18,500	25,500	0.270	0.335
500	10	17.28	C7238 *	502	10	226	---	301	18,200	25,200	35.0	18,200	25,300	0.260	0.334
500	10	17.28	C7237 *	502	10	226	---	400	16,200(1)	17,100	47.0	16,200	17,100	0.237	0.225
500	10	17.28	C7238 *	502	10	226	---	400	16,400(1)	17,200	48.0	16,400	17,200	0.230	0.226

* Specimens pulled with flat grips.

(1) Strain rate = 0.012 in/in/min

TABLE XVIII
ORIGINAL STRENGTH AND STRENGTH AFTER REFERENCE EXPOSURE

Test Temp. °F	Sheet	ORIGINAL STRENGTH			STRENGTH AFTER REFERENCE EXPOSURE (2)						CHANGE IN STRENGTH		
		F _f (1)			F _l (1)						F _f - F _l		
		Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Comp. Yield
		psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
E.T.	A	68,300	78,300	-	25,800	43,600	-	42,500	34,700	-	42,500	34,700	-
	B	67,000	76,400	-	26,000	44,400	-	41,000	32,000	-	41,000	32,000	-
	C	68,400	76,100	74,300	-	-	28,300	-	-	46,000	-	-	46,000
200	A	65,000	69,900	-	24,500	38,000	-	40,500	31,900	-	40,500	31,900	-
	B	-	-	-	-	-	-	-	-	-	-	-	-
	C	-	-	70,700	-	-	27,400	-	-	43,300	-	-	43,300
300	A	57,000	58,300	-	24,500	28,400	-	32,500	29,900	-	32,500	29,900	-
	B	54,400	56,200	-	24,400	28,500	-	30,000	27,700	-	30,000	27,700	-
	C	56,400	58,100	63,100	-	-	26,300	-	-	36,800	-	-	36,800
400	A	42,000	43,600	-	20,300	20,400	-	21,700	23,200	-	21,700	23,200	-
	B	42,700	44,200	-	20,700	21,200	-	22,000	23,000	-	22,000	23,000	-
	C	43,100	44,400	47,500	-	-	21,600	-	-	25,900	-	-	25,900

(1) Average Strength Values. Refer to Tables III through XI

(2) Reference Exposure = 450°F - 10 hr.

TABLE XIX
STRENGTH DETERIORATION FACTOR FOR SINGLE EXPOSURE - UNSTRESSED AND STRESSED

EXPOSURE CONDITIONS			STRENGTH AT TEMPERATURE AFTER EXPOSURE				STRENGTH DETERIORATION FACTOR FOR UNSTRESSED EXPOSURE				STRENGTH DETERIORATION FACTOR FOR STRESSED EXPOSURE 0.25 INELASTIC STRAIN				STRENGTH DETERIORATION FACTOR FOR STRESSED EXPOSURE 1.0% INELASTIC STRAIN			
			P_{ef} (1)				$D = \frac{P_{ef} - P_1}{P_f - P_1}$ (2)				$D = \frac{P_{ef} - P_1}{P_f - P_1}$ (3)				$D = \frac{P_{ef} - P_1}{P_f - P_1}$ (4)			
Temp. °F	Time hr	ϕ_{17} (17.7 log t)	Test Temp. °F	Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield
300	1	12.92	R.T.	67,100	77,200	73,700	0.972	0.968	0.966	1.003	1.013	0.986	1.003	1.013	1.025	0.990	0.982	0.982
300	1	12.92		55,900	58,300	61,100	0.966	1.000	0.945	1.001	1.039	0.945	1.001	1.039	1.035	1.039	0.945	1.035
250	100	13.49	R.T.	68,300	77,200	75,300	1.000	0.968	1.021	1.000	0.968	1.005	1.000	0.968	0.984	0.924	0.923	0.923
250	100	13.49		56,000	57,400	60,400	0.969	0.969	0.932	0.969	0.969	0.932	0.969	0.969	0.952	0.931	0.931	0.931
250	100	13.49		41,900	43,200	47,400	0.995	0.982	0.996	0.995	0.982	0.978	0.995	0.982	0.976	0.942	0.942	0.942
300	100	14.44	R.T.	60,100	71,900	67,100	0.807	0.815	0.843	0.807	0.815	0.814	0.807	0.815	0.708	0.671	0.682	0.682
300	100	14.44		58,300	62,600	66,000	0.834	0.771	0.818	0.834	0.771	0.818	0.834	0.771	0.734	0.613	0.613	0.613
300	100	14.44		51,900	52,700	56,400	0.812	0.843	0.818	0.812	0.843	0.818	0.812	0.843	0.731	0.689	0.689	0.689
300	100	14.44		39,100	39,700	43,500	0.866	0.831	0.868	0.866	0.831	0.868	0.866	0.831	0.740	0.712	0.712	0.712
350	10	14.58	R.T.	57,800	68,900	61,300	0.752	0.729	0.717	0.752	0.729	0.691	0.752	0.729	0.658	0.590	0.590	0.590
350	10	14.58		44,200	45,200	49,300	0.736	0.736	0.736	0.736	0.736	0.709	0.736	0.736	0.626	0.545	0.545	0.545
350	10	14.58		48,700	48,700	54,400	0.729	0.678	0.763	0.729	0.678	0.763	0.729	0.678	0.626	0.545	0.545	0.545
350	10	14.58		44,200	45,200	49,300	0.736	0.736	0.736	0.736	0.736	0.709	0.736	0.736	0.626	0.545	0.545	0.545
350	24	14.89	R.T.	49,400	62,600	61,300	0.555	0.561	0.561	0.555	0.561	0.561	0.555	0.561	0.451	0.403	0.403	0.403
350	24	14.89		44,200	45,200	49,300	0.606	0.561	0.561	0.606	0.561	0.561	0.606	0.561	0.451	0.403	0.403	0.403
350	60	15.31	R.T.	40,800	56,500	44,500	0.352	0.371	0.352	0.352	0.371	0.352	0.352	0.371	0.266	0.258	0.258	0.258
350	60	15.31		35,600	36,900	37,700	0.341	0.284	0.310	0.341	0.284	0.310	0.341	0.284	0.266	0.258	0.258	0.258
400	10	15.48	R.T.	39,300	55,300	40,300	0.318	0.337	0.260	0.318	0.337	0.260	0.318	0.337	0.234	0.221	0.221	0.221
400	10	15.48		37,800	47,000	40,800	0.328	0.282	0.309	0.328	0.282	0.309	0.328	0.282	0.234	0.221	0.221	0.221
400	10	15.48		34,100	35,600	36,900	0.295	0.240	0.277	0.295	0.240	0.277	0.295	0.240	0.201	0.189	0.189	0.189
400	10	15.48		27,800	28,100	29,800	0.345	0.331	0.316	0.345	0.331	0.316	0.345	0.331	0.230	0.239	0.239	0.239
450	10	16.38	R.T.	25,800	43,600	28,300	0	0	0	0	0	0	0	0	0.031	0.026	0.026	0.026
450	10	16.38		24,500	34,000	27,400	0	0	0	0	0	0	0	0	0.030	0.035	0.035	0.035
450	10	16.38		24,500	28,400	26,300	0	0	0	0	0	0	0	0	0.030	0.035	0.035	0.035
450	10	16.38		20,300	20,400	21,600	0	0	0	0	0	0	0	0	0.030	0.035	0.035	0.035
500	10	17.28	R.T.	19,200	34,500	20,600	0.155	0.144	0.163	0.155	0.144	0.163	0.155	0.144	0.178	0.166	0.166	0.166
500	10	17.28		18,700	25,400	22,700	0.178	0.100	0.108	0.178	0.100	0.108	0.178	0.100	0.178	0.166	0.166	0.166
500	10	17.28		18,700	25,400	22,700	0.178	0.100	0.108	0.178	0.100	0.108	0.178	0.100	0.178	0.166	0.166	0.166
600	8	18.98	R.T.	15,500	37,000	27,000	0.242	0.190	0.190	0.242	0.190	0.190	0.242	0.190	0.242	0.242	0.242	0.242
600	8	18.98		15,500	34,600	27,000	0.227	0.043	0.043	0.227	0.043	0.043	0.227	0.043	0.242	0.242	0.242	0.242
600	8	18.98		14,900	27,000	27,000	0.295	0.093	0.093	0.295	0.093	0.093	0.295	0.093	0.242	0.242	0.242	0.242
600	8	18.98		13,700	16,800	16,800	0.304	0.155	0.155	0.304	0.155	0.155	0.304	0.155	0.242	0.242	0.242	0.242

(1) Average strength values - refer to Tables IV through XII. Tensile data are from Sheet A tests only.

(2) Refer to columns 5 through 7 for P_{ef} and to Table VIII for P_1 and $P_f - P_1$.

(3) P_{ef} for stressed exposure is P_{ef} for unstressed exposure multiplied by appropriate K_f from Figure 16.

TABLE XX
STRENGTH DETERIORATION FACTOR FOR MULTIPLE EXPOSURES - UNSTRESSED

STRENGTH AT TEMPERATURE AFTER EXPOSURE			STRENGTH DETERIORATION FACTOR FOR UNSTRESSED EXPOSURE		
(2)			D = $\frac{F_{ef} - F_1}{F_f - F_1}$ (3)		
Sequence	Total ϕ_{17} 10 ⁻³ (1)	Test Temp. Of	Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi
A-1	14.60	R. T. 300	61,000	71,700	65,600
	14.60	400	50,500	50,600	53,900
	14.60		33,600	38,600	-
A-2	14.60	R. T. 300	59,900	71,500	66,000
	14.60	400	50,600	52,400	53,500
	14.60		38,100	39,700	-
A ¹ -1	14.60	R. T.	57,500	69,100	-
A ¹ -2	14.60	R. T.	59,900	70,300	-
B-12	15.00	R. T. 300	46,800	60,400	-
	15.00	400	42,400	43,200	-
	15.00		33,500	34,200	-
B-13	15.30	R. T. 300	41,400	56,800	43,300
	15.30	400	34,700	36,600	37,800
	15.30		28,900	29,400	-
B ¹ -13	15.30	R. T. 300	43,900	58,200	-
	15.30		37,100	38,200	-
			0.828	0.809	0.810
			0.800	0.742	0.750
			0.843	0.784	-
			0.802	0.804	0.819
			0.803	0.802	0.739
			0.820	0.831	-
			0.745	0.734	-
			0.802	0.769	-
			0.495	0.484	-
			0.550	0.494	-
			0.608	0.594	-
			0.376	0.388	0.326
			0.343	0.292	0.313
			-	-	-
			0.437	0.431	-
			0.423	0.350	-

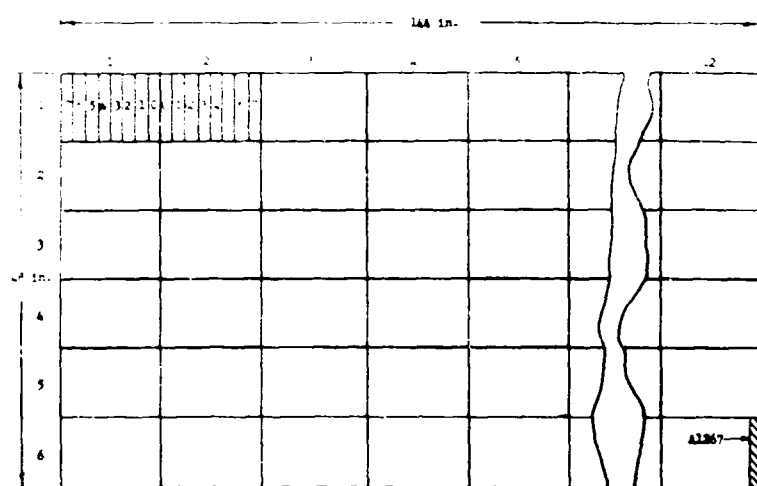
(1) Average values of ϕ , carried to 3 significant figures only.

(2) Averages of individual strength values from Tables XII through XVI. Tensile specimens for A sequences and B-12 sequence were taken from sheet A. Rest of tensile specimens (above) were from Sheet B.

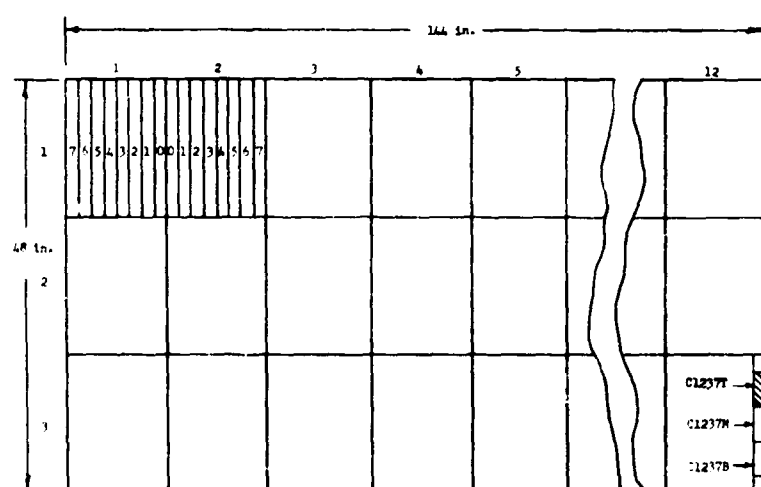
(3) Refer to Table XVIII for values of F_1 and $F_f - F_1$.

TABLE XX (Continued)
STRENGTH DETERIORATION FACTOR FOR MULTIPLE EXPOSURES - UNSTRESSED

STRENGTH AT TEMPERATURE AFTER EXPOSURE				F _{ef} (2)		STRENGTH DETERIORATION FACTOR FOR UNSTRESSED EXPOSURE	
Sequence	Total Φ_{17} 10-3 (1)	Test Temp. of	Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	D = $\frac{F_{ef} - F_1}{F_f - F_1}$ (3)	
						Tensile Yield	Tensile Ultimate Comp. Yield
B-14	15.40	R. T.	37,900	53,400	42,400	0.290	0.281
	15.40	300	34,700	36,000	36,500	0.343	0.270
	15.40	400	25,700	26,100	-	0.245	0.213
B-24	15.40	R. T.	37,900	53,000	42,800	0.290	0.269
	15.40	300	34,100	35,500	-	0.323	0.253
B-13a	15.30	R. T.	41,100	56,200	-	0.368	0.369
B-14a	15.40	R. T.	39,600	54,300	42,500	0.332	0.309
	15.40	300	33,900	35,100	-	0.317	0.238
D	15.30	R. T.	44,200	58,800	42,900	0.444	0.450
	15.30	300	37,500	38,800	-	0.437	0.372
E-1	15.40	R. T.	38,900	54,300	42,400	0.315	0.309
	15.40	300	34,300	36,100	-	0.330	0.274
E-2	15.40	R. T.	39,900	54,600	-	0.339	0.319
E-3	15.40	R. T.	38,700	53,900	-	0.310	0.257



(a) Tension Specimen Identification, Sheets A and B



(b) Compression Specimen Identification, Sheet C

Parent Sheet (A, B, or C)	Horizontal Location (Column)	Vertical Location (Row)	Panel Spec. (D-7)	T, H, or B (Sheet C only)
C	12	3	7	T

(c) Specimen Numbering Code

FIGURE 1 IDENTIFICATION OF TENSION AND COMPRESSION SPECIMENS

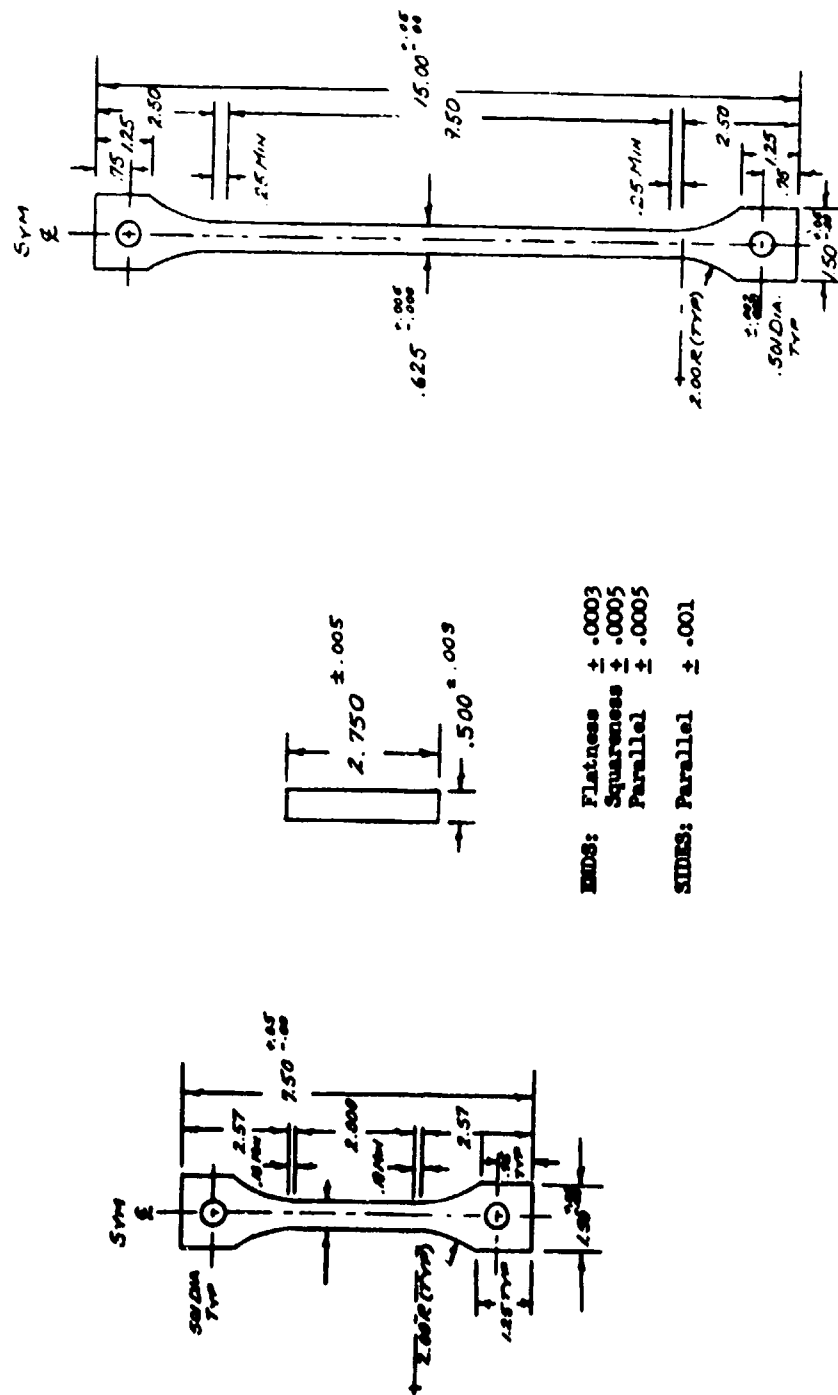


FIGURE 2 TEST SPECIMEN DETAILS

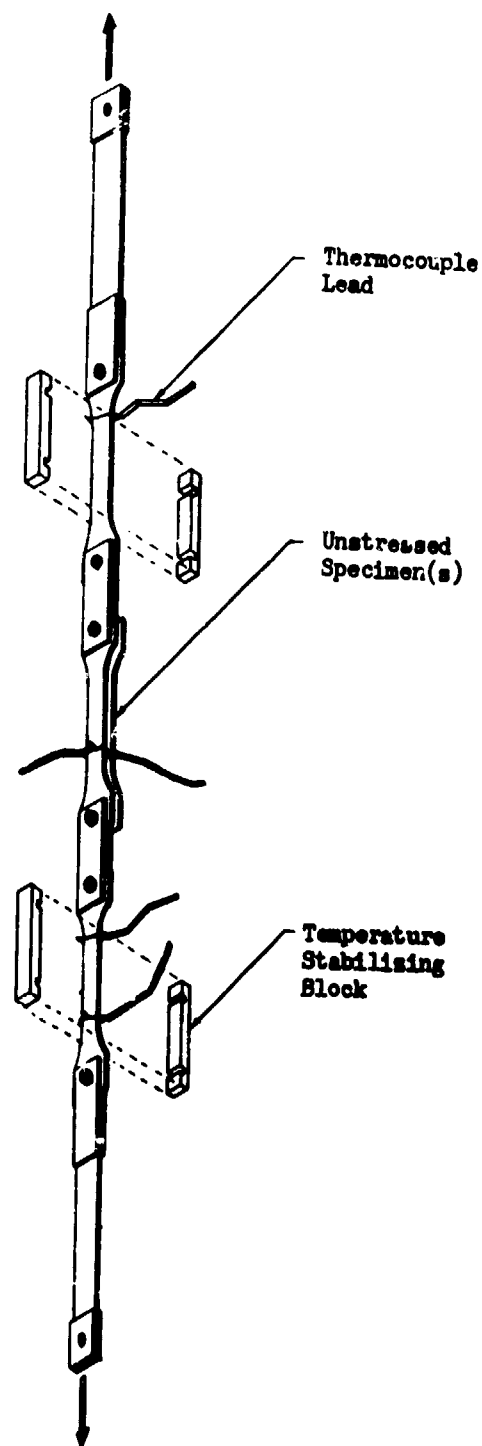


FIGURE 3 TENSION SPECIMEN EXPOSURE ASSEMBLY

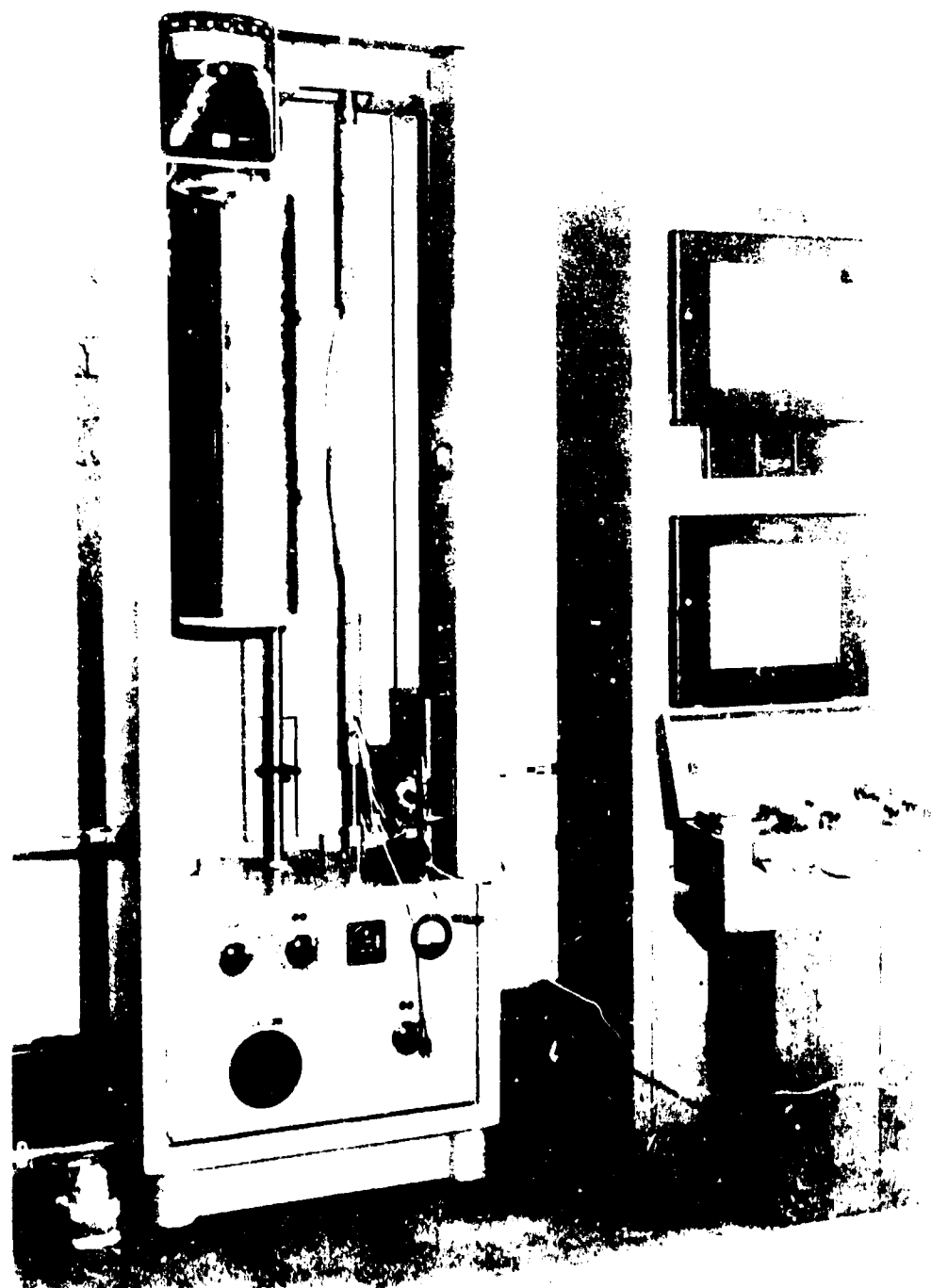
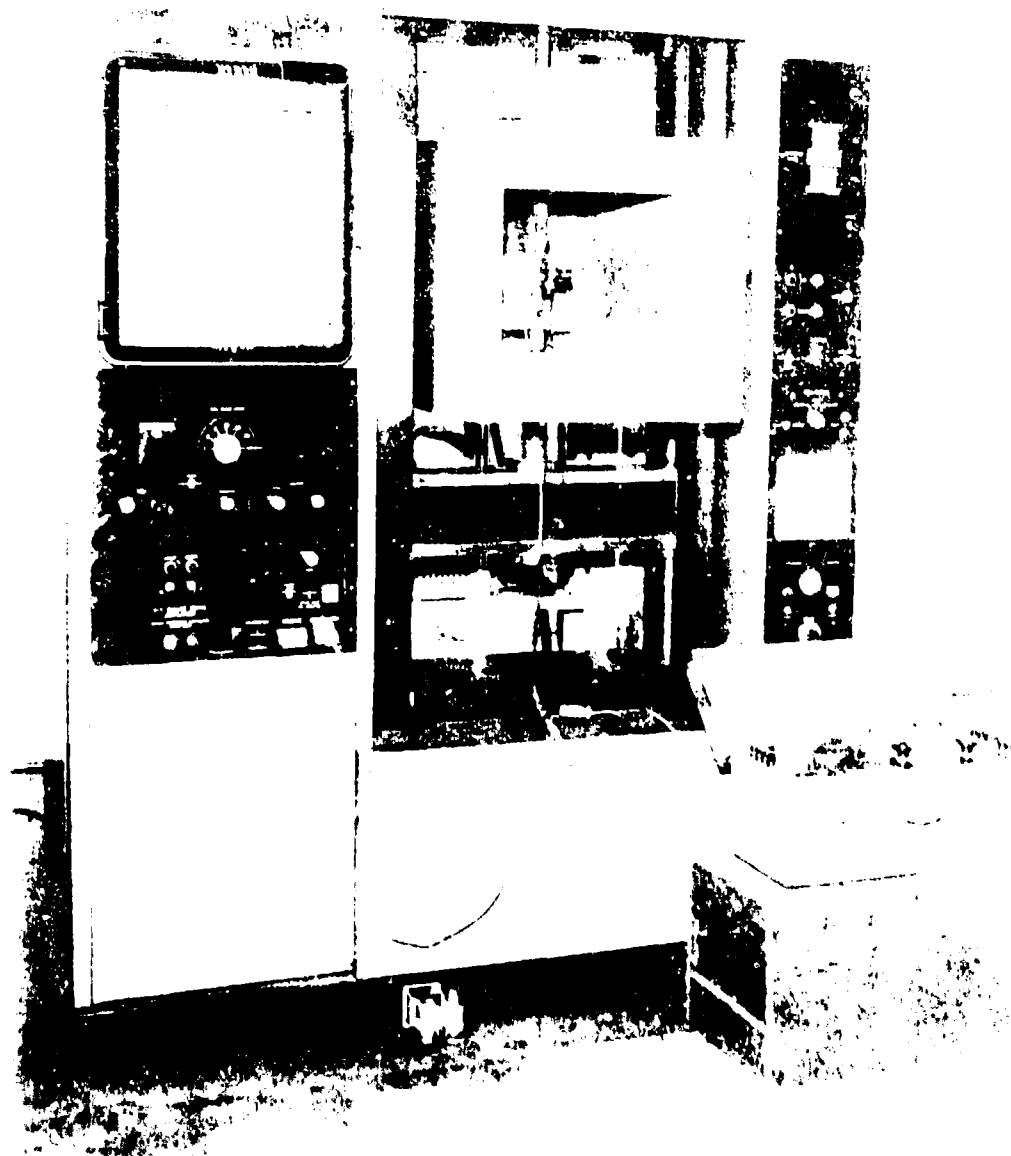
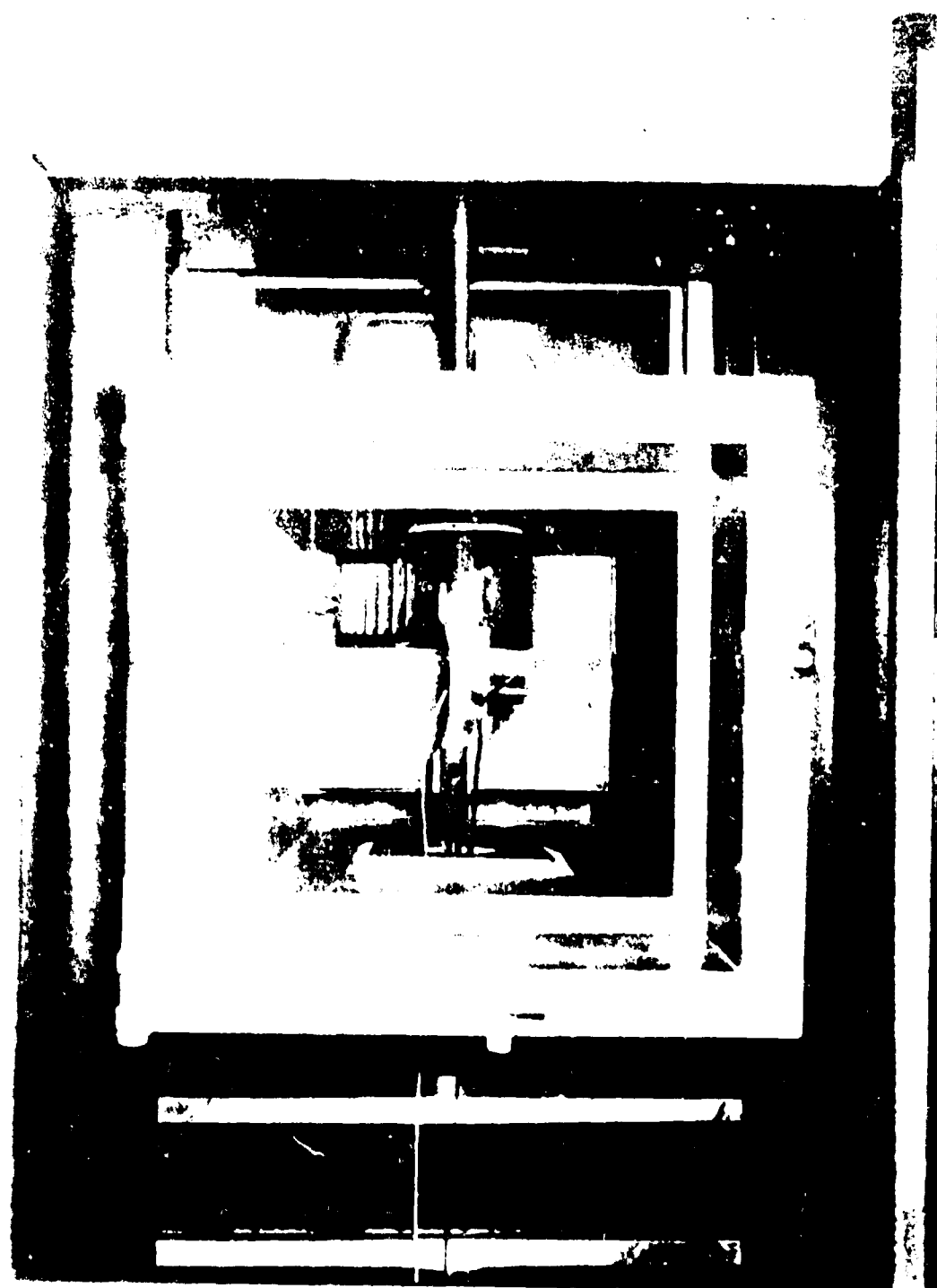


FIG. 1. X-RAY SPECTROMETER WITH SCATTERING
ANGLE MONITOR.

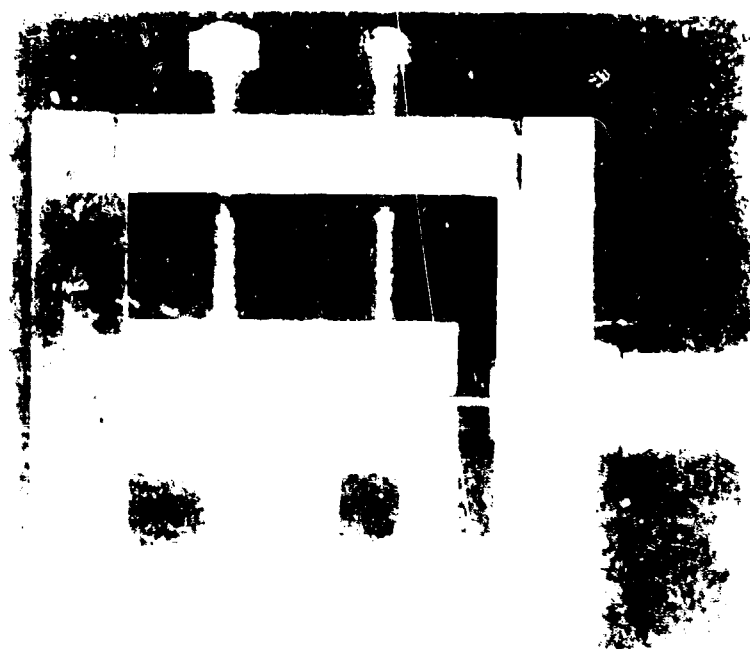






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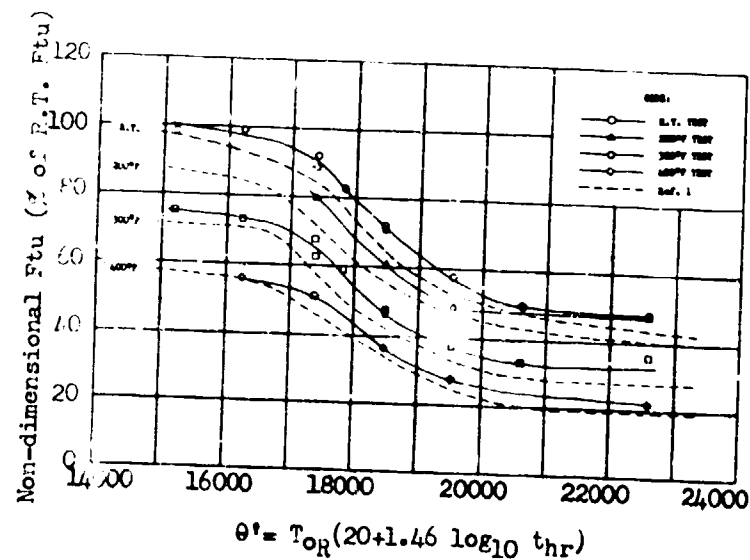




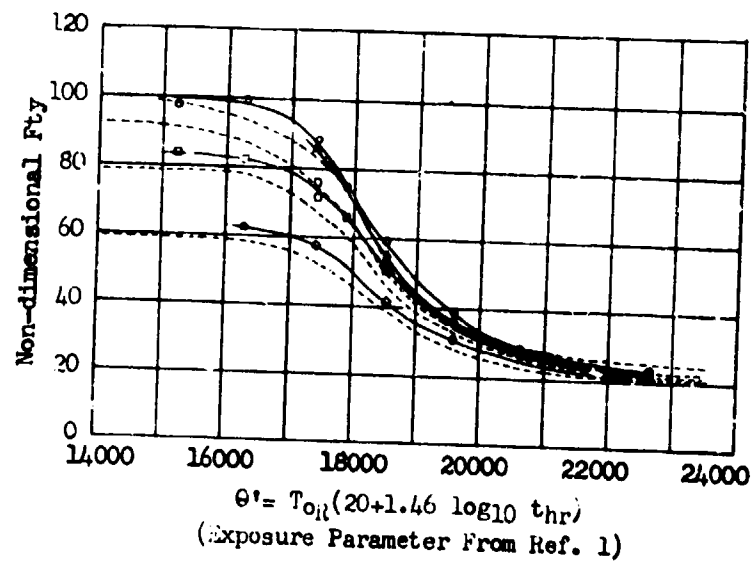
Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult
68.7	78.5	68.0	78.3	69.2	77.8	68.8	79.1	67.7	77.4	69.1	78.5	68.0	78.5
67.9	78.0	67.5	78.0	69.5	78.5	69.2	79.9	67.1	77.7	69.0	78.4		
		68.2	78.8			68.3	78.9			69.4	78.5		
		68.2	78.8			69.4	78.9			69.4	78.8		
68.0	78.1			68.1	77.0			65.8	76.7				
67.5	77.5			65.3	77.5			67.5	78.1				
		67.6	77.5			67.5	77.3			68.7	78.1		
		67.7	77.6			67.9	78.1						
67.2	78.5			70.0	80.5			68.0	78.9			Yld 70.8	
78.5	77.5			70.1	79.3			68.4	79.3			Ult 77.7	

Sheet A F_{ty} F_{tu}
 (Above) Maximum 70,800 psi 80,500 psi
 Minimum 65,300 76,700
 Average 68,300 78,300
 Approx. universal average 67,000 77,000
 for 0.063 in. 7075-T6 Alclad

FIGURE 11 TENSILE STRENGTH VARIATION THROUGHOUT ONE SHEET OF TEST MATERIAL



(a) Ultimate Strength



(b) Yield Strength

FIGURE 12 COMPARISON OF STRENGTH AFTER UNSTRESSED EXPOSURE FOR TWO LOTS OF 7075-T6

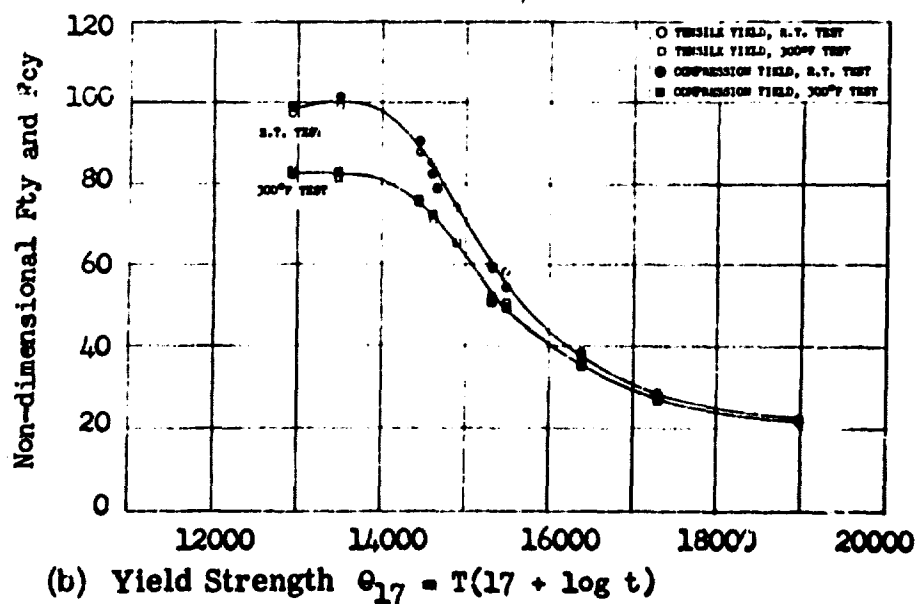
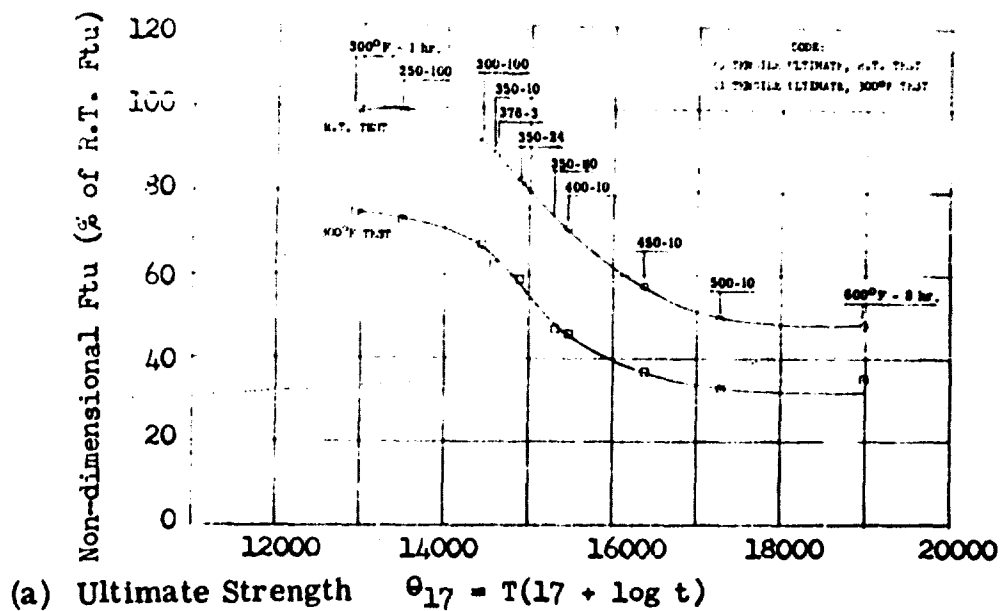
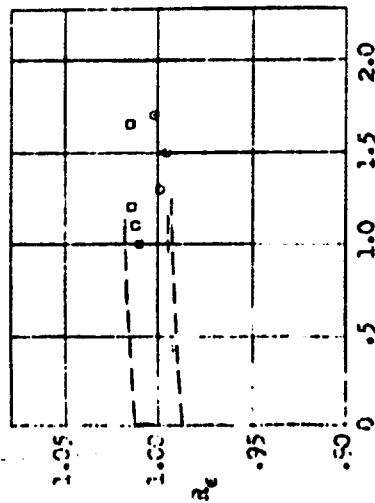


FIGURE 13 CORRELATION OF STRENGTH REDUCTION AFTER EXPOSURE WITH EXPOSURE PARAMETER Θ_{17}

$R_t = \frac{\text{Strength After Stressed Exposure}}{\text{Strength After Unstressed Exposure}}$

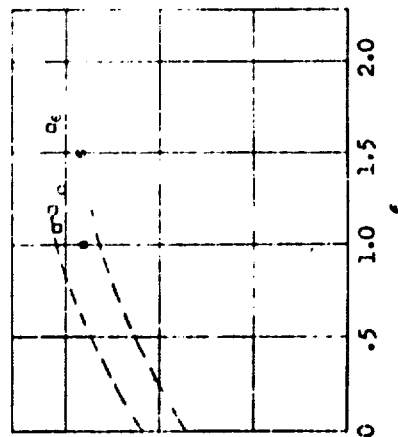
CODE: O Test at 12,920
 Δ " " 13,490
 □ " " 13,990
 ◇ " " 14,490

TENSILE ULTIMATE

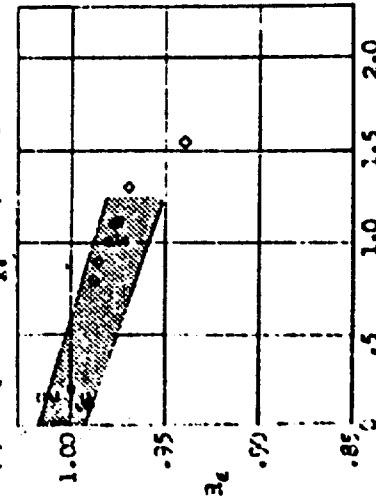
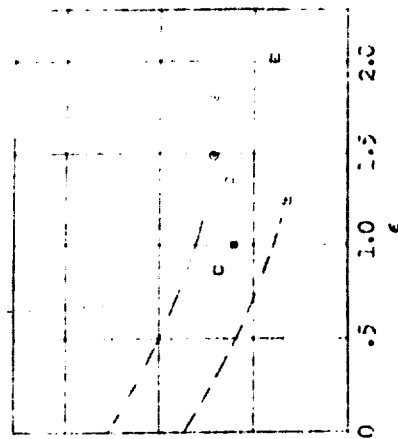


ε = % Total Inelastic Strain
 (a) Exposure 0.17 = 12,920 (300°F - 1 hr)

TENSILE YIELD



COMPRESSIVE YIELD



ε = % Total Inelastic Strain
 (b) Exposure 0.17 = 13,490 (250°F - 100 hr)

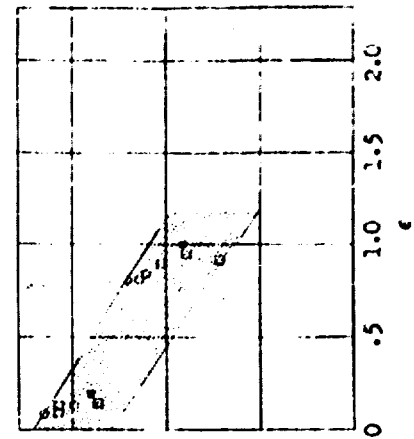
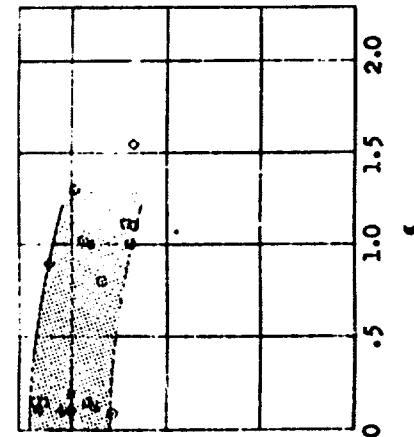


FIGURE 14 EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE

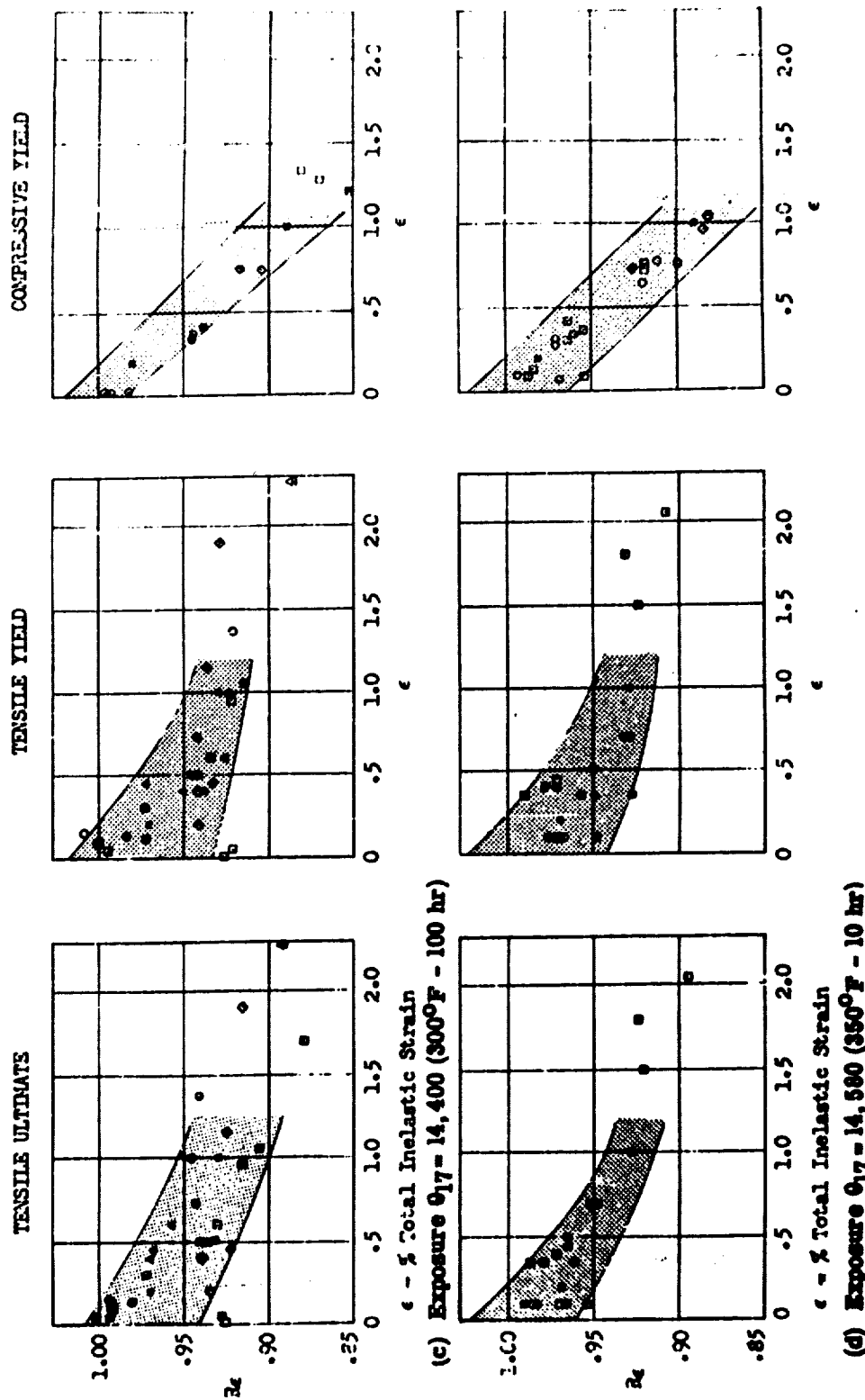


FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH --
SINGLE EXPOSURE

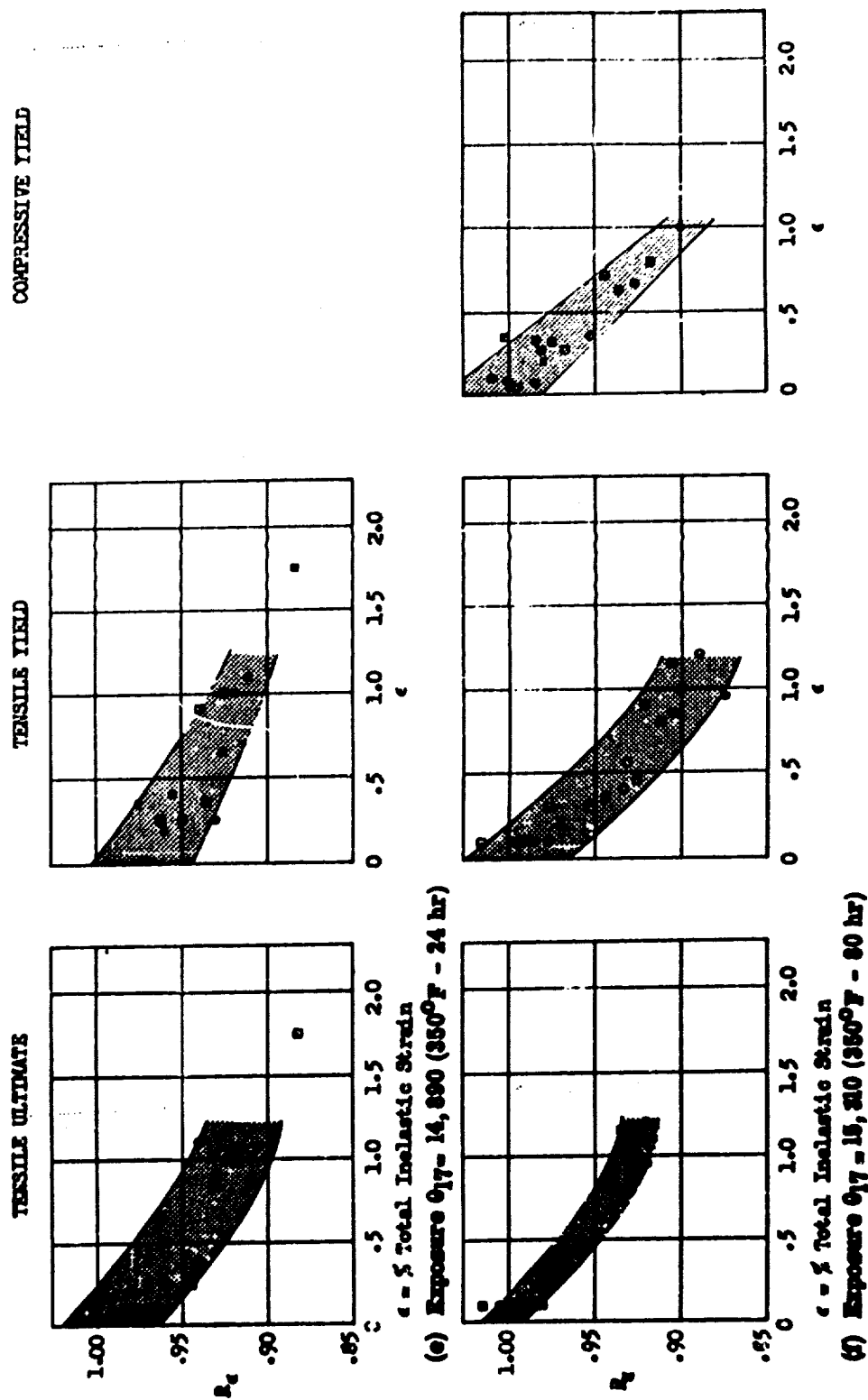
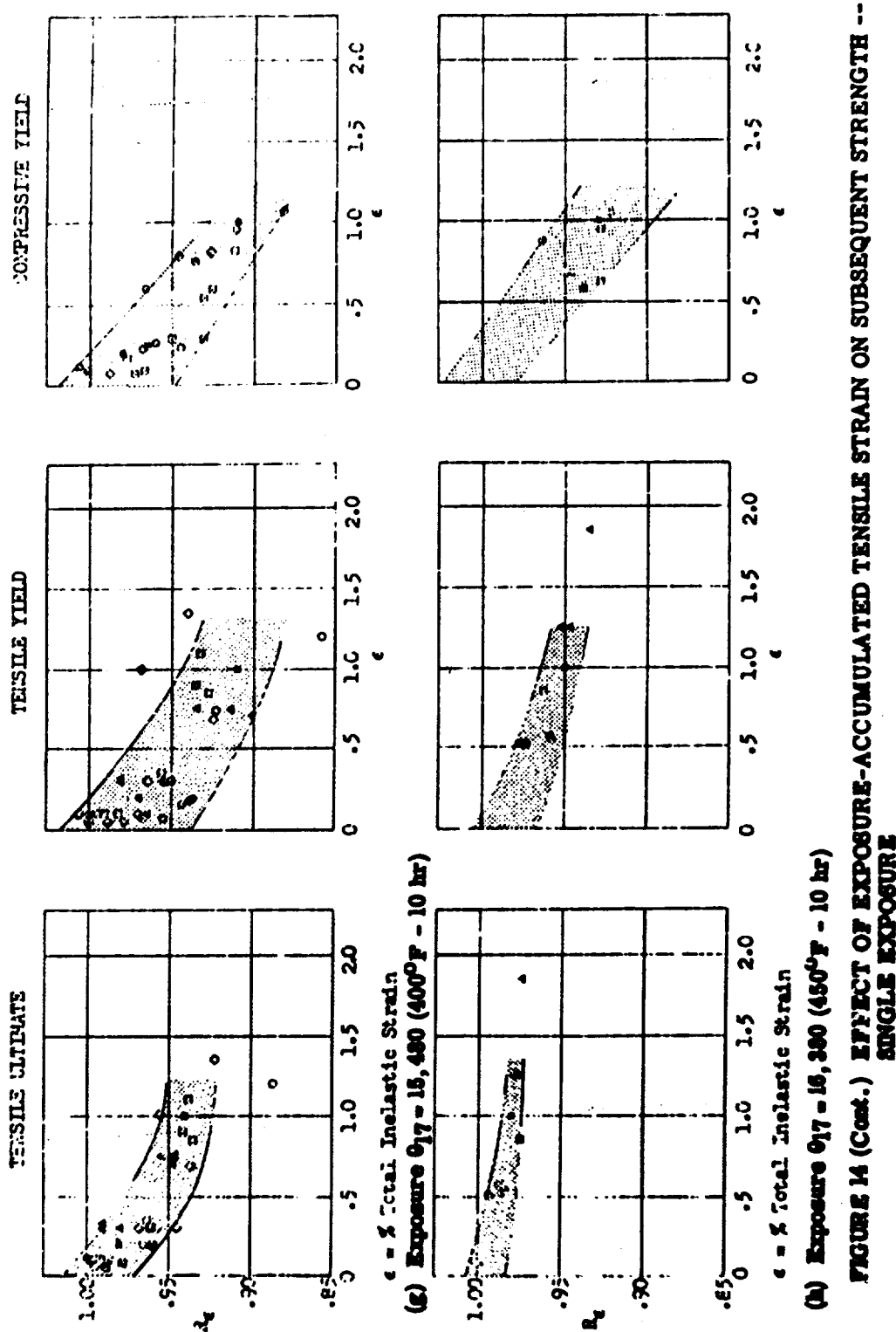


FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE



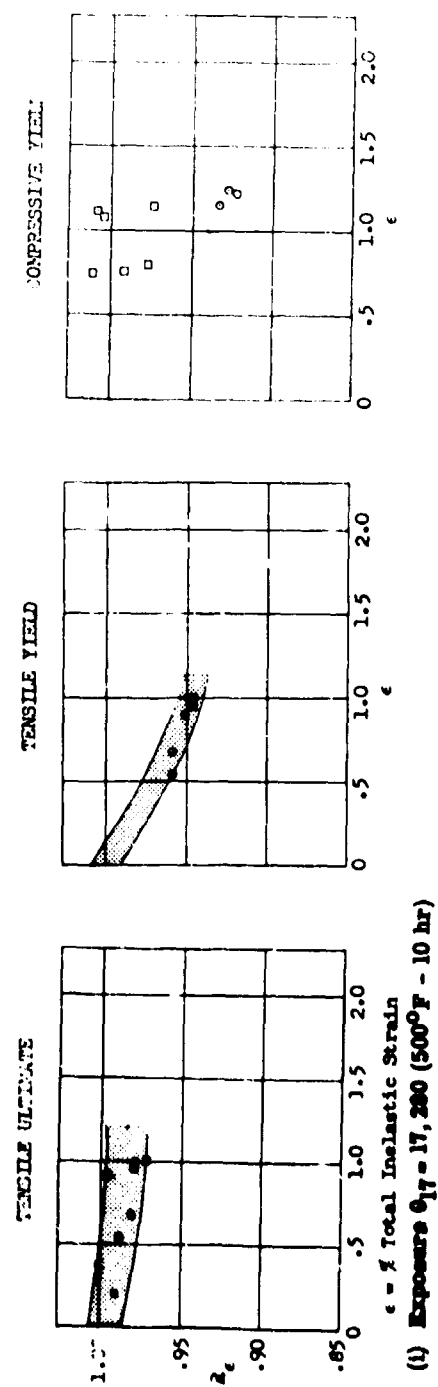


FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE

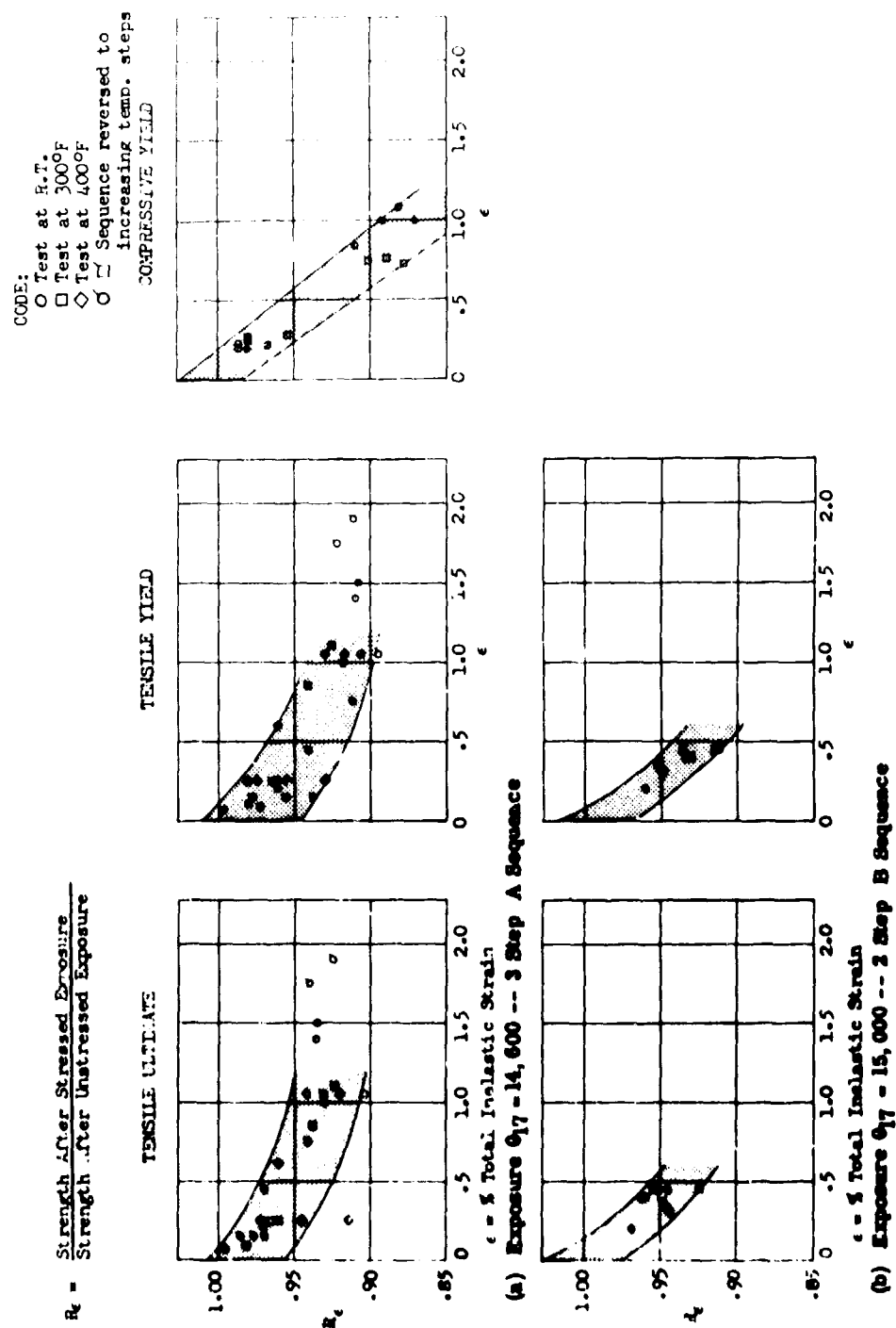


FIGURE 15 EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- MULTIPLE EXPOSURE

CODE:
 O Test at R.T.
 □ Test at 300°F
 ◇ Test at 400°F
 ✓ Sequence reversed to decreasing temp. steps
 ⊠ Final step unstressed

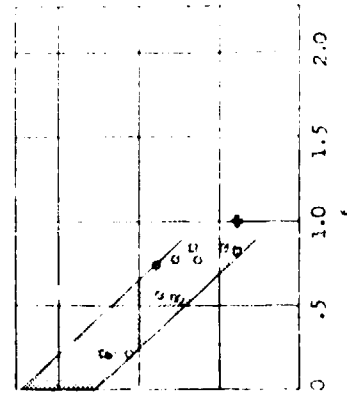
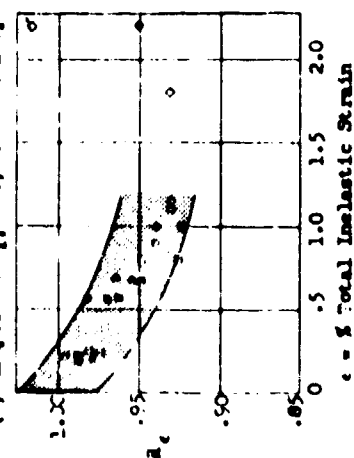
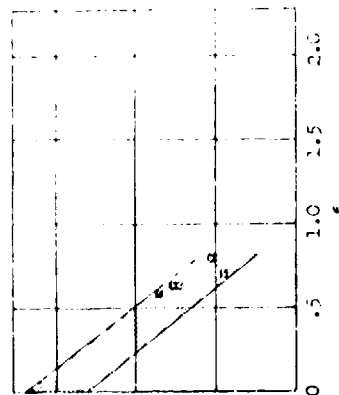
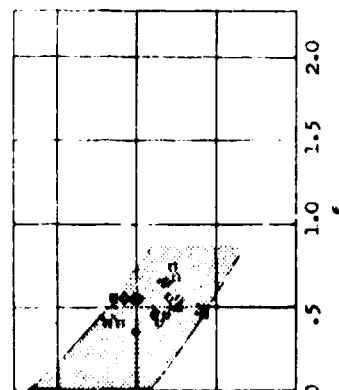
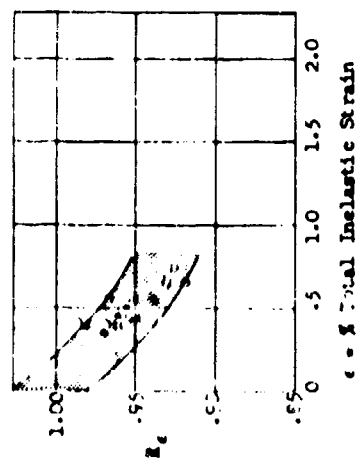


FIGURE 15 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- MULTIPLE EXPOSURE

CODE:
 O Test at R.T.
 □ Test at 300°F
 ◇ Test at 400°F

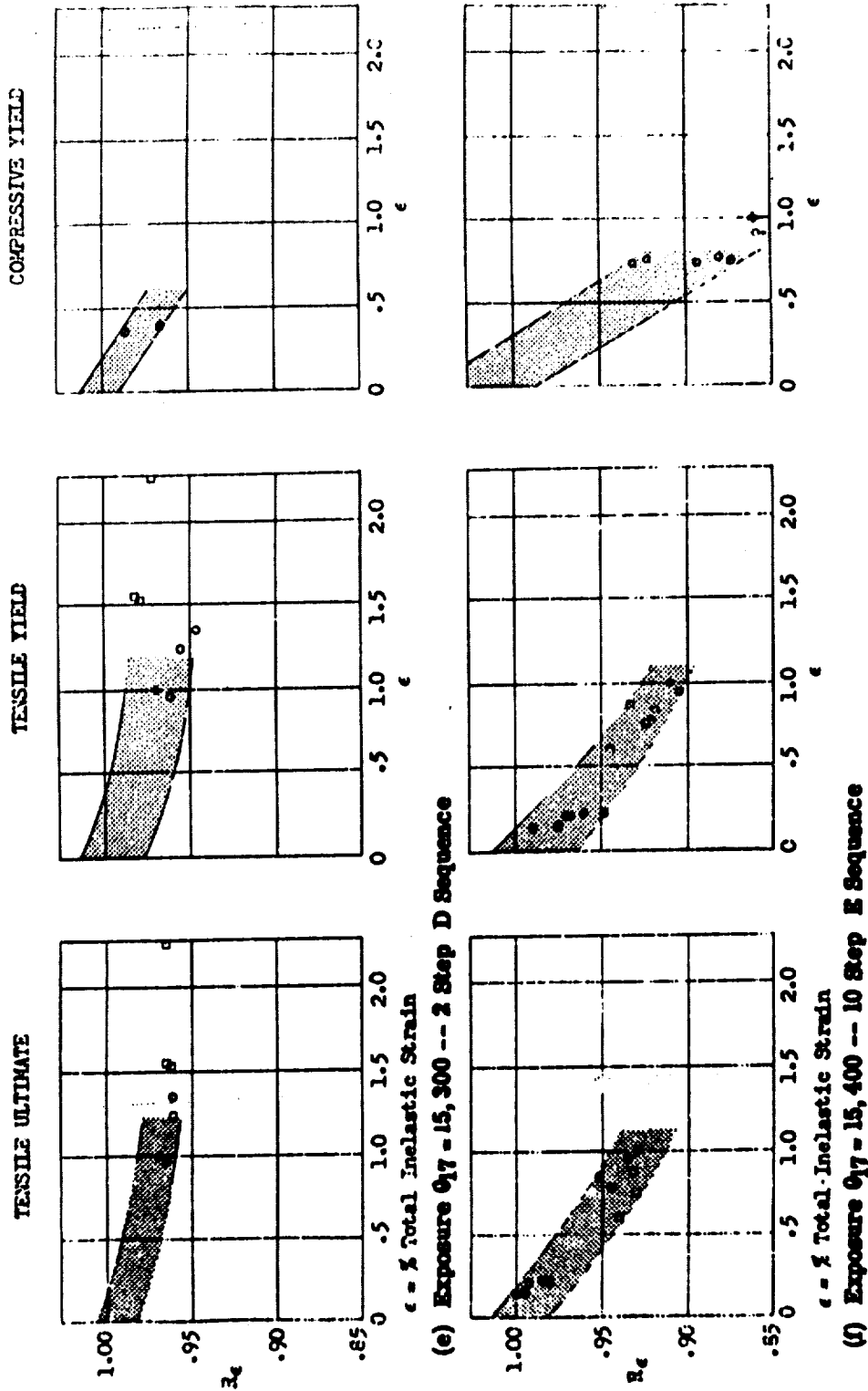


FIGURE 15 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH --- MULTIPLE EXPOSURE

CODE:

- × Single Exposure
- + Multiple Exposure
- ◊ Multiple Exposure (D Sequence, 1 % inelastic strain)

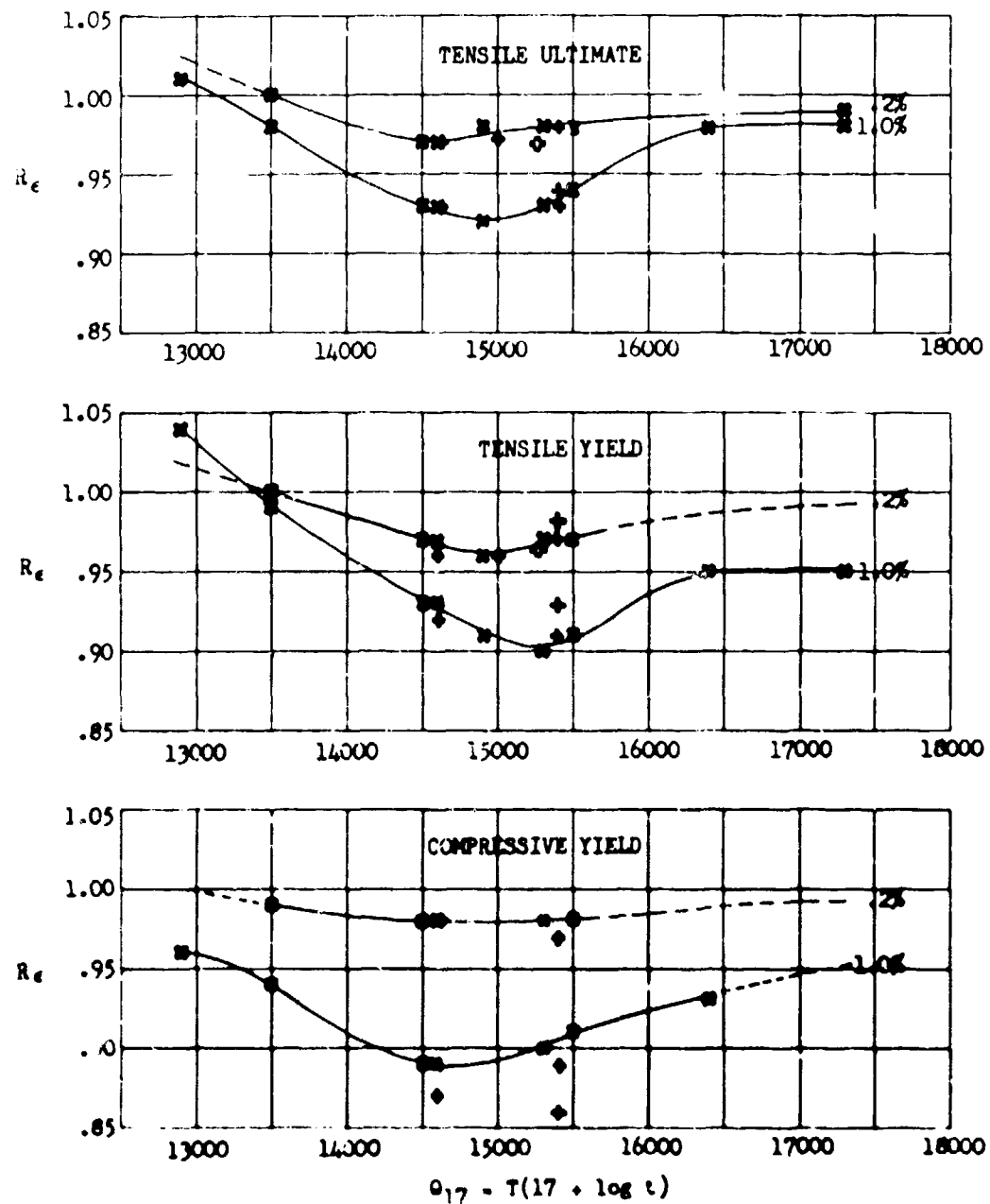
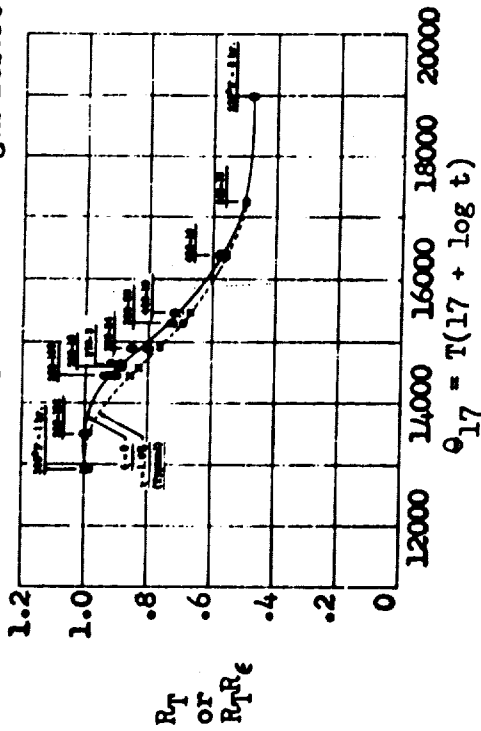


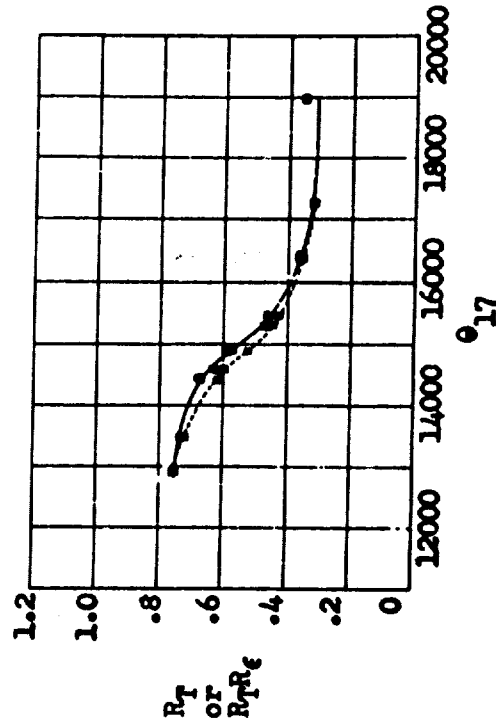
FIGURE 16 VARIATION OF STRESSED EXPOSURE EFFECTS WITH DEGREE OF EXPOSURE

R_T = $\frac{\text{Strength at Temperature After Unstressed Exposure}}{\text{Room Temperature Strength Before Exposure}}$

$R_T R_\epsilon$ = $\frac{\text{Strength at Temperature After Stressed Exposure}}{\text{Room Temperature Strength Before Exposure}}$

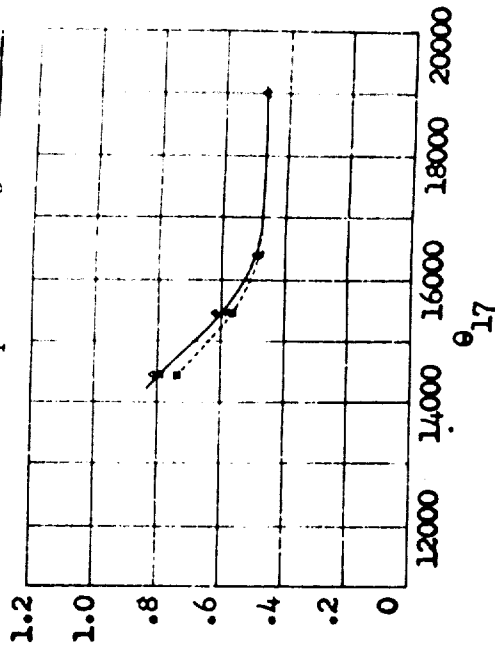


(a) Tensile Ultimate Strength at R.T.

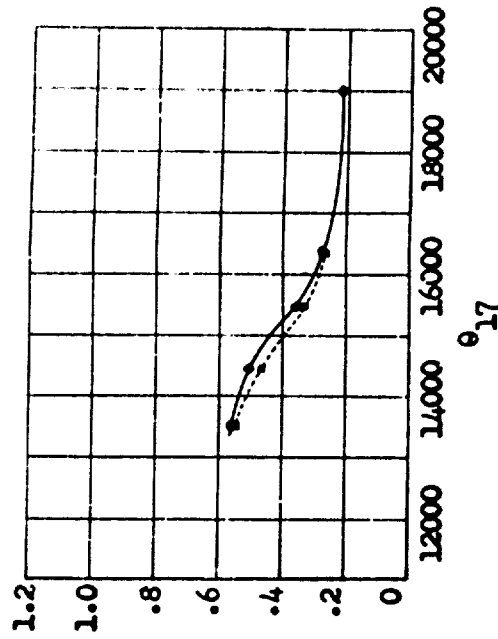


(c) Tensile Ultimate Strength at 300°F

$R_T R_\epsilon$ for $\epsilon = 1.0\%$ - - -
 R_T for $\epsilon = 0$ - - -



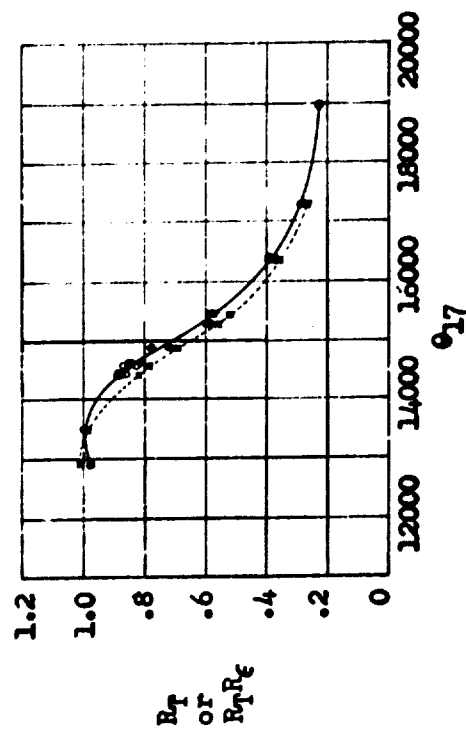
(b) Tensile Ultimate Strength at 200°F



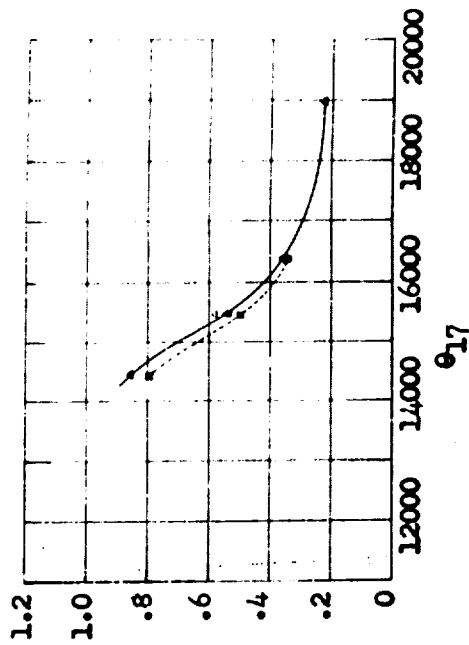
(d) Tensile Ultimate Strength at 400°F

FIGURE 17 STRENGTH REDUCTION AFTER UNSTRESSED AND STRESSED SINGLE EXPOSURE

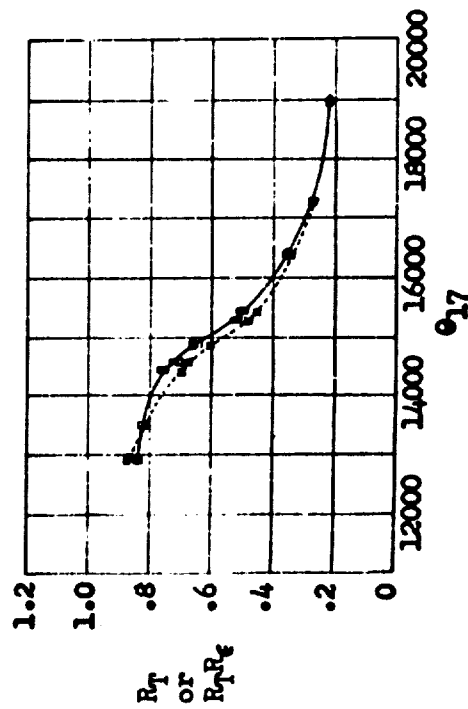
Best Available Copy



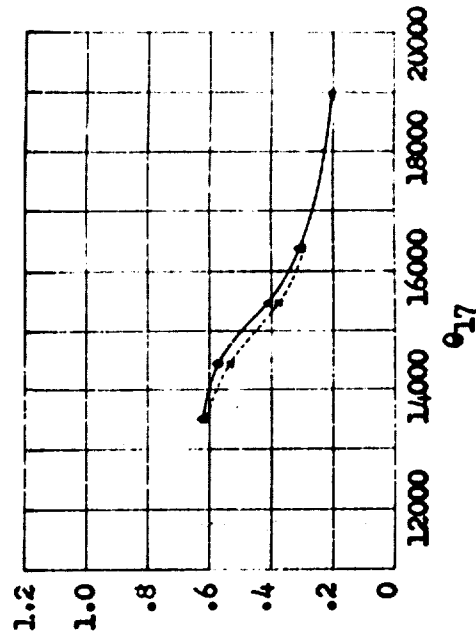
(e) Tensile Yield Strength at R.T.



(f) Tensile Yield Strength at 200°F

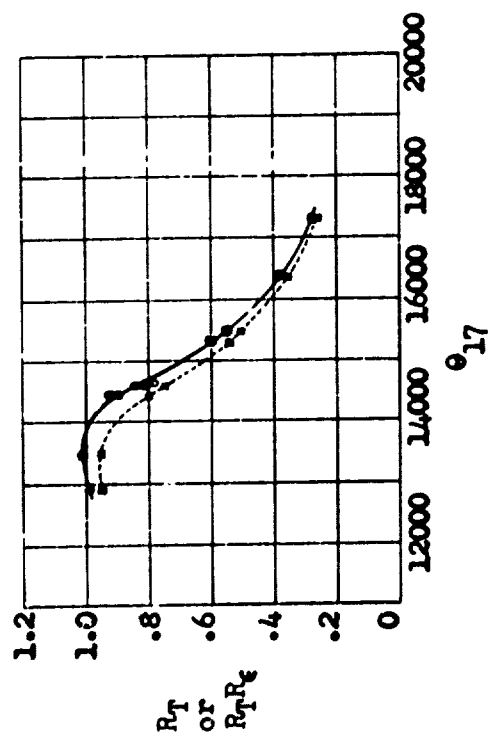


(g) Tensile Yield Strength at 300°F

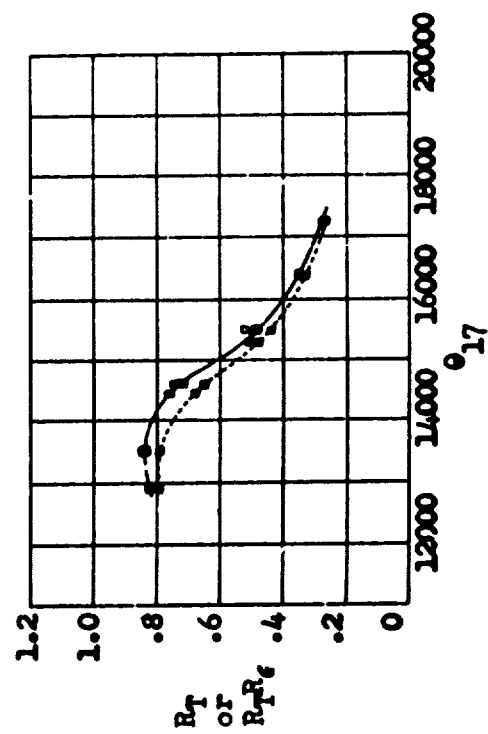


(h) Tensile Yield Strength at 400°F

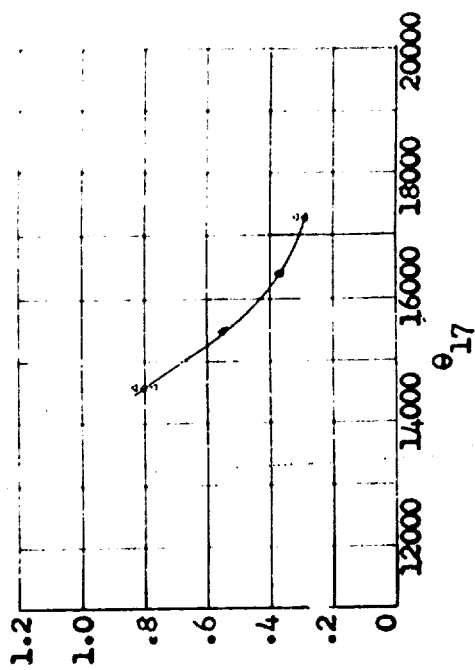
FIGURE 17 (Cont.) STRENGTH REDUCTION AFTER UNSTRESSED AND STRESSED SINGLE EXPOSURE



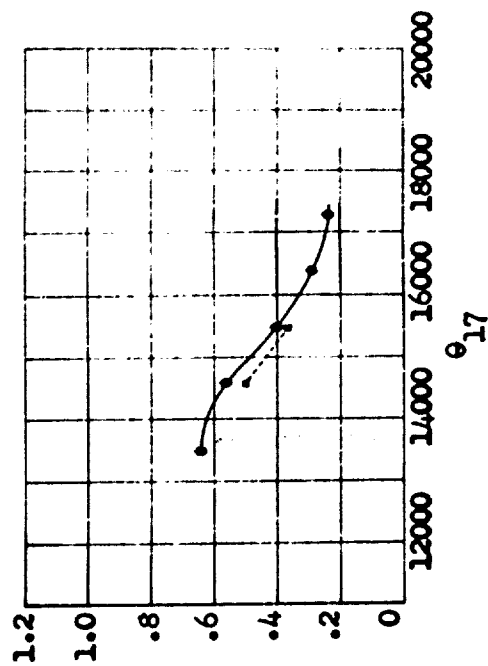
(i) Compressive Yield Strength at R. T.



(k) Compressive Yield Strength at 300°F



(j) Compressive Yield Strength at 200°F



(l) Compressive Yield Strength at 400°F

FIGURE 17 (Cont.) STRENGTH REDUCTION AFTER UNSTRESSED AND STRESSED SINGLE EXPOSURE

CODE: Sequence

 Open Symbols - Steps Decreasing in Temp.

 Closed Symbols - Steps Increasing in Temp.

 Crossed Symbols - Complex Sequences

 Sequence

 ○ A & A' (5 Step)

 ● A' (3 Step)

 ▲ B (2 Step)

 □ B' (3 Step)

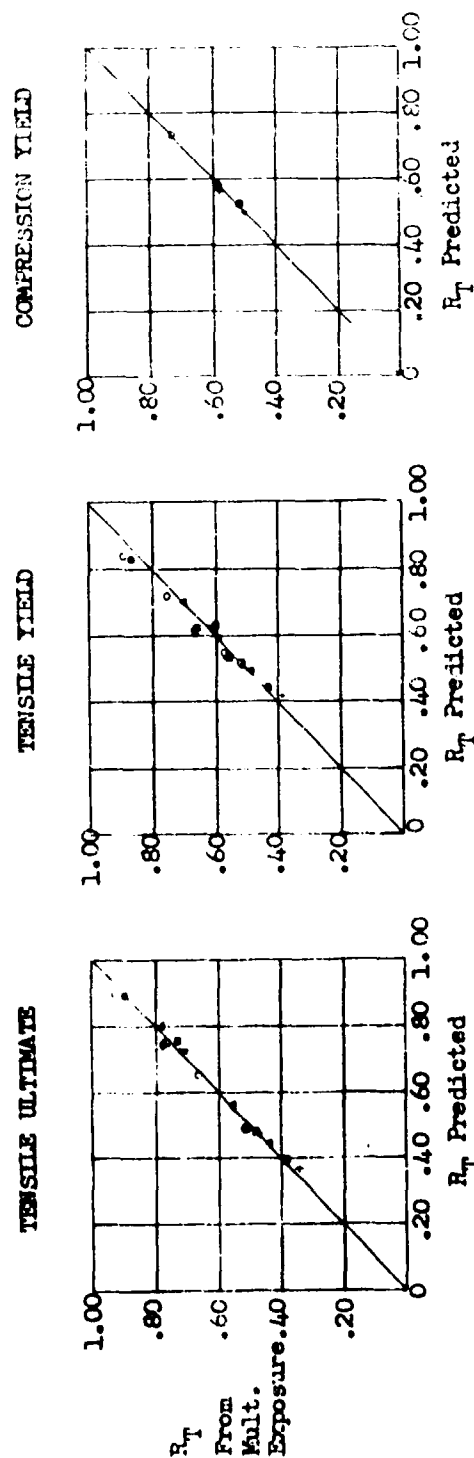
 ■ B (3 Step)

 ● B & B' (3 Step)

 ◆ D (2 Step)

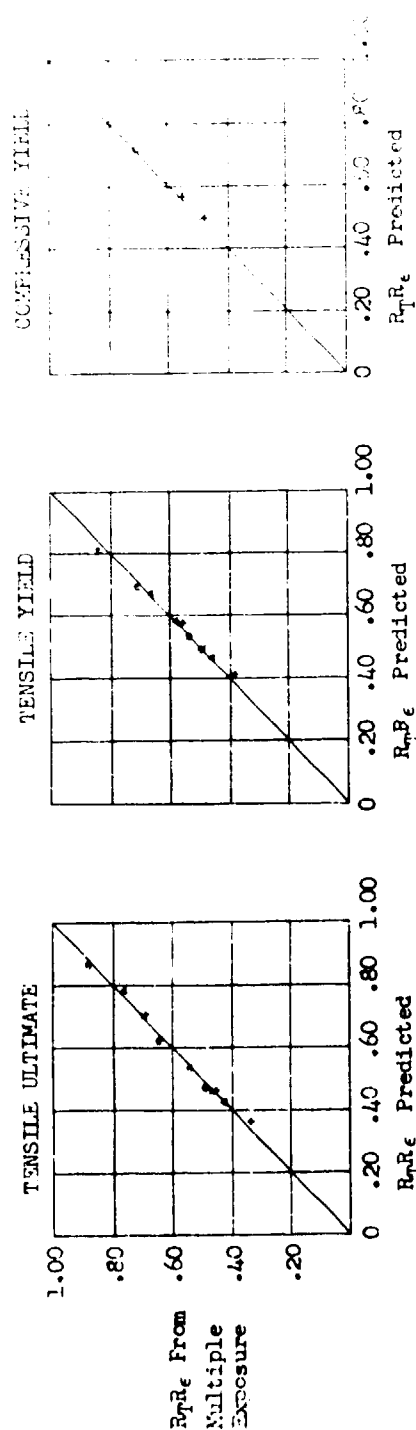
 + B (4 Step)

 x E (10 Step)

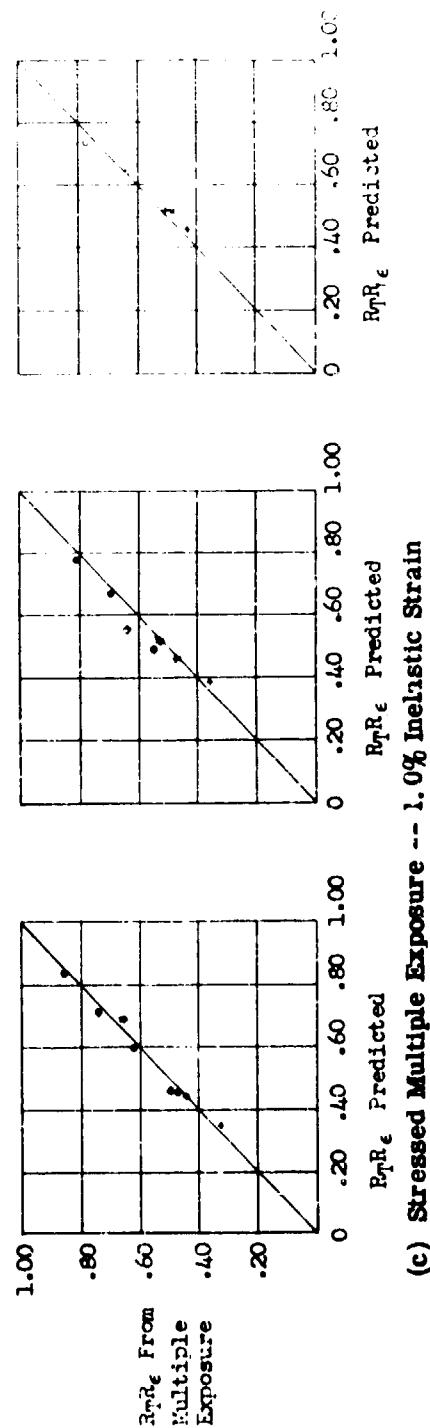


(a) Unstressed Multiple Exposure

FIGURE 13 COMPARISON OF STRENGTH AFTER MULTIPLE EXPOSURE WITH STRENGTH PREDICTED FROM SINGLE EXPOSURE CURVES

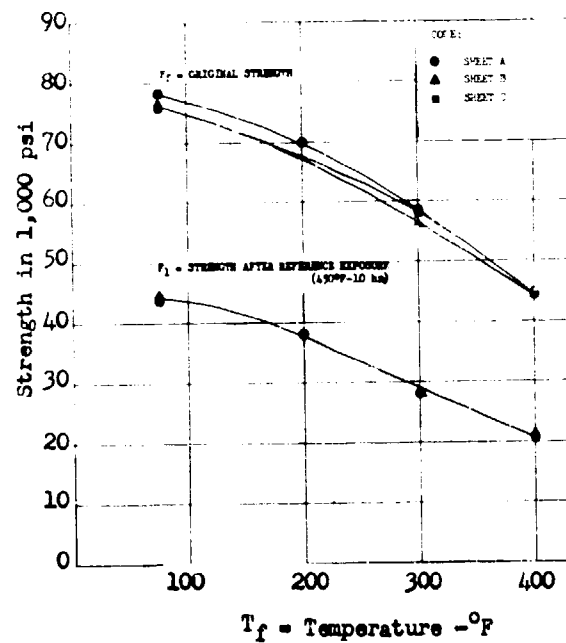


(b) Stressed Multiple Exposure --- 0.2% Inelastic Strain

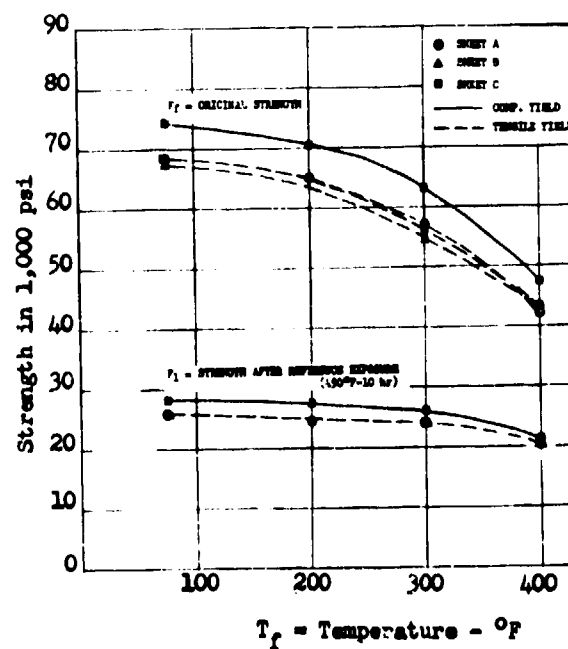


(c) Stressed Multiple Exposure --- 1.0% Inelastic Strain

FIGURE 18 (Cont.) COMPARISON OF STRENGTH AFTER MULTIPLE EXPOSURE WITH STRENGTH PREDICTED FROM SINGLE EXPOSURE CURVES

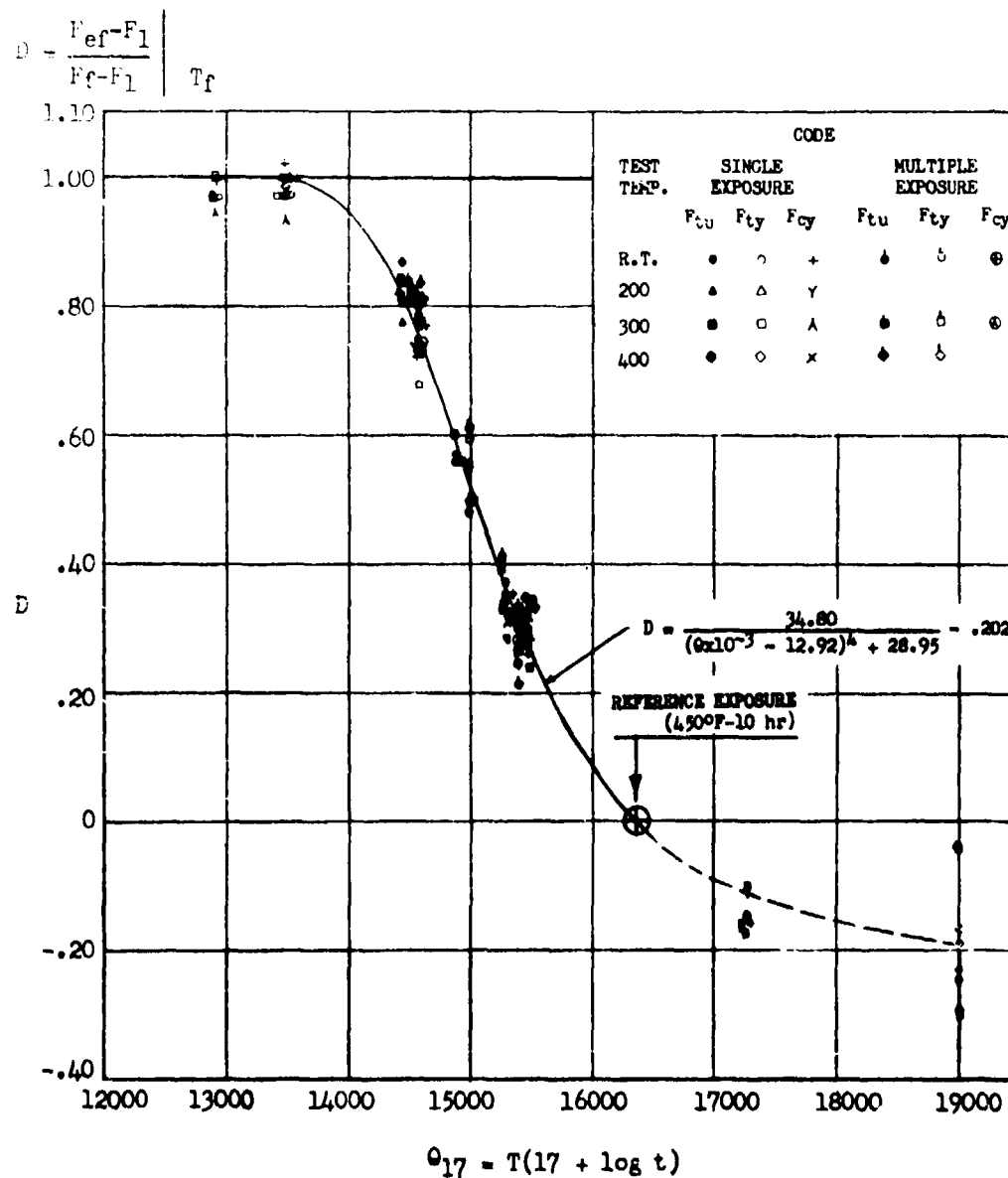


(a) Ultimate Tensile Strength



(b) Yield Strength

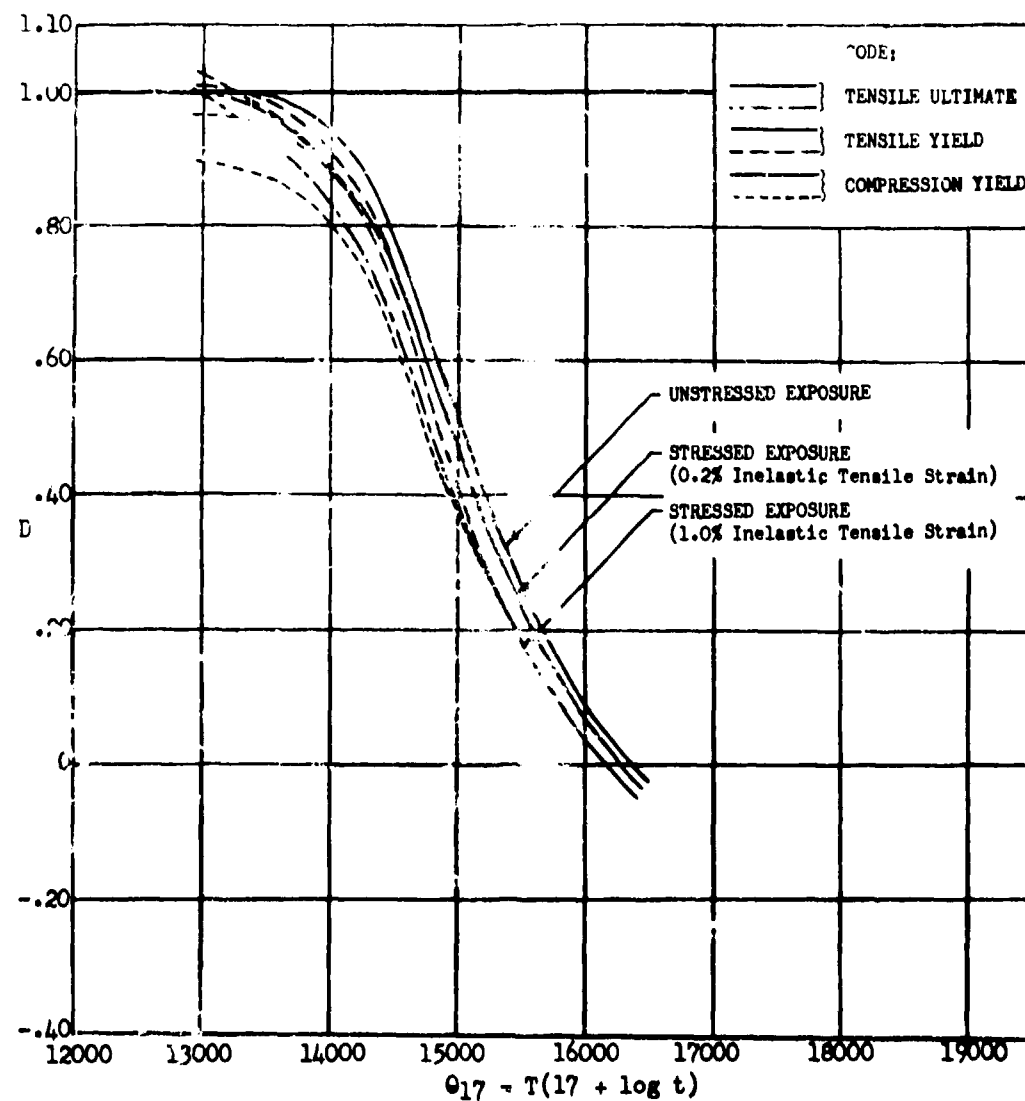
FIGURE 19 STRENGTH OF 7075-T6 AT TEMPERATURE BEFORE AND AFTER REFERENCE EXPOSURE



(a) Unstressed Exposures

FIGURE 20 STRENGTH DETERIORATION CHARACTERISTICS OF 7075-T6 AT ALL TEST TEMPERATURES

$$D = \frac{F_{ef} - F_l}{F_f - F_l} \left| T_f \right.$$



(b) Stressed Exposures

FIGURE 20 (Cont.) STRENGTH DETERIORATION CHARACTERISTICS OF 7075-T6 AT ALL TEST TEMPERATURES

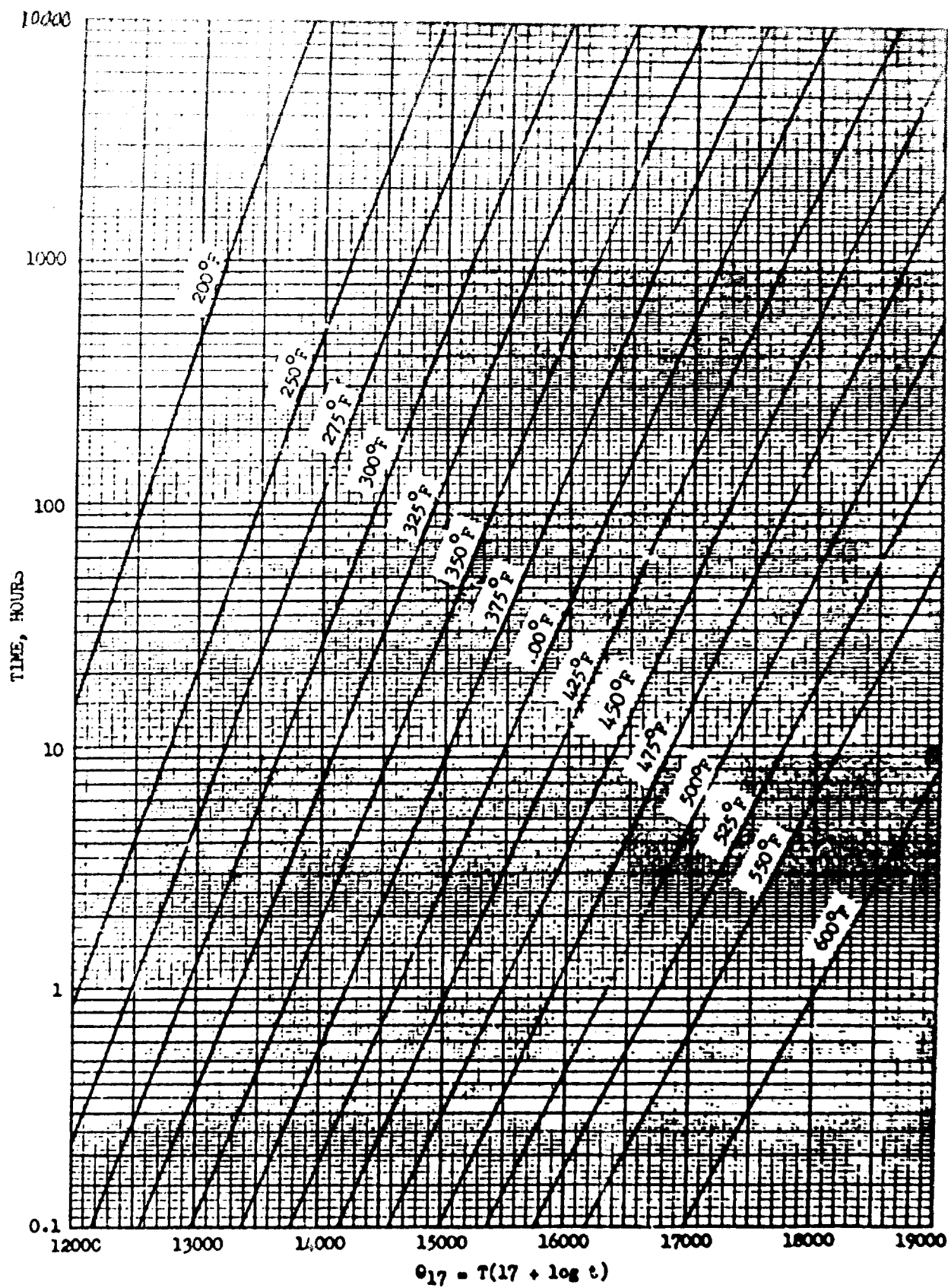


FIGURE 21 LARSON-MILLER PARAMETER DIAGRAM

WADC TR 56-585 Pt II