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**DEVELOPMENT OF
ALUMINUM BASE ALLOYS**

SECTION III



**ALCOA RESEARCH LABORATORIES
NEW KENSINGTON, PA.**

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ALUMINUM COMPANY OF AMERICA

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ALCOA RESEARCH - LABORATORY



ALCOA

July 25, 1966

Commanding Officer Frankford Arsenal
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Attn: Mr. Harold Markus
SMUFA-1320

REF: CONTRACT NO. DA-36-034-ORD-3559RD
DEVELOPMENT OF ALUMINUM BASE ALLOYS

Dear Mr. Markus:

Enclosed is one (1) copy of Section III of the Final Report of the subject contract covering the period September 29, 1961 to September 30, 1965. Section II of the captioned report has already been completed and distributed; Section I is being assembled into rough draft form for your approval.

Copies of Section III are being distributed according to the report's distribution list.

Very truly yours,

J. P. LYLE, JR., Assistant Chief
Physical Metallurgy Division

JPL/mmk

Enclosure

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DEVELOPMENT OF ALUMINUM-BASE ALLOYS-Section III
(Unclassified)
FINAL REPORT

FOR THE PERIOD SEPTEMBER 29, 1961 to
SEPTEMBER 30, 1965

CONTRACT NO. DA-36-034-ORD-3559RD
MAY 31, 1966

by

A. P. HAARR

ALCOA RESEARCH LABORATORIES
ALUMINUM COMPANY OF AMERICA

REPORT NO. 13-65-AP59-S

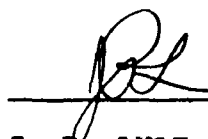
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DA PROJECT NO. 593-32-004

FRANKFORD ARSENAL



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FOREWORD

New highs in the strengths of aluminum alloy products were the object of Contract No. DA-36-034-ORD-3559RD. This contract has been successfully completed. The final report covers all the work done on the contract since its beginning in September 1961, and is divided into three parts:

I. Outline of information on the most promising alloys. The preferred processes and compositions are described.

II. Fabricating Development.

The development of the processes which achieved the desired properties and products is described, and recommendations for further study are made.

III. Alloy Development.

The development of alloy compositions and thermal practices which achieved the desired properties is described, and recommendations for further study are made.

ABSTRACT - SECTION III

The objectives of this alloy development research program were: (1) aluminum alloys with 125,000 psi yield strength, (2) aluminum alloys with yield strengths at least 10% higher than commercial alloys with no sacrifice in resistance to stress corrosion cracking (SCC), and (3) determination of tensile properties at elevated and cryogenic temperatures, impact properties, tear properties, electrical conductivities, hardness, and fatigue strengths. All objectives have been met by APM (Aluminum Powder Metallurgy) extrusions made from prealloyed atomized powders using alloys which combine precipitation and dispersion hardening.

1. A yield strength of 124,000 psi was obtained in Alloy 50 containing Al, 9.8 Zn, 4.0 Mg, 0.8 Cu, 1.1 Mn, 1.0 Fe, 1.3 Ni, 0.01 Cr and 0.01 Ti after solution heat treating for 0.5 hours at 920°F, quenching at 2,000-25,000°F/sec., and aging at 225°F for 96 hours.
2. (a) - Alloy 87 containing Al, 7.6 Zn, 2.5 Mg, 1.1 Cu, 2.2 Fe, 2.3 Ni and 0.2 Cr, solution heat treated 2 hours at 860°F, quenched in cold water after aging for 6 hours at 250°F plus 8 hours at 330°F had a yield strength 11% higher than 7075-T7351 and did not fail in A.I. (alternate immersion) when stressed at 75% of Y.S.

(b) - Alloy 71 containing Al, 9.2 Zn, 3.6 Mg, 0.6 Cu, 0.75 Co and solution heat treated for 2 hours at 860°F, quenched in cold water and after aging 24 hours at 250°F had a yield strength 14% higher than 7178-T651 and did not fail in A.I. when stressed at 25% of Y.S.

(c) - Alloy 71 after aging 24 hours at 250°F plus 3 hours at 330°F had strengths equal to 7178-T651 and the threshold stress in A.I. was at least twice as high as 7178-T651.

The strengths of some APM alloys are higher than commercial alloys from -112°F to 350°F. Fatigue strengths of smooth specimens of those APM alloys are higher than commercial 7075-T6 and fatigue strengths of notched specimens are at least as high. Impact and tear properties are low but may be improved by further changes in composition, fabrication and heat treatment.

When heat treated to maximum strengths, dispersion hardeners raise strengths slightly but the elongation of such alloys is so low that the potential usefulness is very limited. When "overaged" to lower strengths, however, dispersion hardeners make a very important contribution to resistance to SCC.

The structures were studied by light and electron microscopy, X-ray diffraction and electron microprobe.

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INTRODUCTION

The powder metallurgy approach to alloy development has several attractive features. Atomization of alloys from the melt permits the use of higher concentrations of alloy elements than is possible in ingot metallurgy where the cooling rate is slow relative to atomizing cooling rates. Thus compositions which result in such coarse constituents in ingots that properties or fabricability are impaired, and which result in ingot cracking, can be made by atomizing. The structure of atomized alloy powders is very similar to that of ingot except that powder structures are several orders of magnitude finer. This can be carried over into the products made from powder with the result that wrought products made from atomized alloys can have a very fine structure. Powder metallurgy makes possible the fabrication of dispersion hardened alloys and also alloys combining dispersion hardening with precipitation hardening.

Before this contract began, it was known that high strength aluminum alloy extrusions could be made from prealloyed atomized powder. The alloys fell into three classes: (1) dispersion hardened alloys which are characterized by a high liquid solubility and a low solid solubility at room and elevated temperatures; (2) precipitation hardened alloys which are characterized by a high liquid solubility, a high solid solubility at high temperatures and a low solid solubility at room and intermediate temperatures; and (3) alloys combining the characteristics of the dispersion hardened and precipitation hardened systems. Examples of the three classes from ARL work are:

Alloy	T.S.
(1) 4.5 Fe, 7.0 Ni	69,000 psi
(2) 6.0 Zn, 2.7 Mg, 1.6 Cu, .2 Cr	94,000 psi
(3) 5.7 Fe, 5.5 Ni, 5.3 Zn, 2.4 Mg, 1.7 Cu, .2 Cr	112,000 psi

Other examples can be cited from the work of S. G. Roberts (Ref. 1, 6, 7 and 8):

(1) 5.0 Mn, 2.0 Zr, 0.5 Ti, 0.5 V	59,000 psi
(2) 9.8 Zn, 3.2 Mg, 1.98 Cu, 0.2 Cr	114,000 psi
(3) 12.4 Zn, 2.5 Mg, 2.2 Cu, 3.3 Fe	122,000 psi

For the purposes of this investigation, Zn, Mg, and Cu are considered to be the elements which contribute the most to precipitation hardening. The dispersion forming elements include Mn, Fe, Ni, Cr, Ti, V, Zr, Co, Mo, and W.

It had been found in ARL investigations that high strength powder metallurgy alloys of the Al-Zn-Mg-Cu-Cr type sometimes had unusually good resistance to SCC (stress corrosion cracking) even in the short transverse direction when the alloys were heat treated and aged to their highest strengths, but the results were erratic. Roberts raised the question of SCC in alloys of this type because of their structure but reported no test results to support this speculation.

Roberts used extrusions which were too small to permit testing for transverse tensile properties. The extrusions used in ARL investigations prior to this contract were large enough to permit the determination of transverse properties, but low quality of the extrusions frequently vitiated the results. After the development of a method for making high quality extrusions, which is described

in detail in Section II of this report, it was possible to get reliable results in tensile tests and SCC tests in the transverse direction.

OBJECT OF SECTION III

Develop an aluminum alloy with a yield strength of 125,000 psi.

Develop an aluminum alloy with a yield strength at least 10% higher than commercial alloys without a sacrifice in resistance to stress corrosion cracking.

Determine tensile properties at cryogenic and elevated temperatures, impact properties, tear properties, electrical conductivities, hardness, and fatigue properties.

MATERIALS

1. Powders prepared as described in Section II of this report and having the compositions shown in Table I.
2. Two-inch diameter extrusions prepared as described in Section II - Fig. 6 and having the compositions shown in Table II.
3. 0.100 in. sheet prepared by rolling as described in Section II or machined from 2 inch dia. extrusions.

RESULTS AND DISCUSSION

I. Aluminum Alloys With 125,000 psi Yield Strength

A. Selection of Alloys

Various approaches were used in the alloy selection.

Alloys 1-3 were based on earlier work performed at ARL. Mr. S. G.

Roberts reported 0.25 in. dia. extrusions made from atomized powders of the same composition as Alloys 4-6 had very high strengths (Ref. 1). Compositions 7-18 contained two levels of Zn, 8% and 12%, and a fixed level of Mg and Cu to which various amounts of dispersion hardening elements were added. The base levels of Zn, Mg and Cu in these alloys were chosen from results of prior work at ARL.

Quaternary Alloys 19-31 constitute a broad survey of certain phase fields in the Al-Zn-Mg-Cu system (Table III). Some of these alloys are outside the limits of ingot metallurgy. Some of them also served as a base for evaluating the effects of dispersion hardening additions. Many of the earlier alloys lay in the $\alpha + \beta$ and $\alpha + M$ phase fields at 860°F (Ref. 2). The other phase fields investigated are listed in Table III.

Alloys 32-34 and 36-40 were suggested from observed trends. Alloy 35 was raised to a higher Mn level than Alloy 33, so that the Mn would exceed the solid solubility. Alloys 41 and 42 were selected to evaluate the effects of large amounts of Al-Mg-Cr constituents on tensile properties. Alloys 43-59 were selected on the basis of statistical analysis from data generated on Alloys 1-39. A discussion of this and other statistical analyses is found in Appendix A.

It was expected that the effect of omitting dispersion hardeners could be determined by comparing Alloys 60 and 61 with 39 and 50 (or 52) respectively. Alloy 60 is similar to Alloy 39 with a lower Mn level, 1.7% versus 0.77; Alloy 61 is similar to Alloys 50 and 52 without any dispersion hardeners present. However, the comparison was confused by unintentional variations in Zn and Mg.

Alloys 62-74 are modifications of Alloy 32. Alloys 75-84 are modifications of 7178. Alloys 85-87 and 90 are modifications of Alloy 34. Alloys 88 and 89 are the same compositions as 79 and 87 respectively, but the former are mixtures of powders instead of prealloyed powders.

B. Properties of Extrusions

1. Tensile Properties

Table II summarizes the properties of the extrusions. Attention is called to the ultrasonic rating; over 75% of the sections examined exceeded SNT Class A with 95% meeting or exceeding Class A.

The densities of the extrusions, Table II, are probably essentially 100% of theoretical, based on the absence of porosity seen in metallographic examinations. The values in Table II were derived from the measured densities of the powders in Table I by multiplying the density of the powder by 1.014 after it was determined that the density of the extrusion was 1.1 to 1.7% higher than that of powder (Table IV). This difference between extrusions and powders is due to sealed pores in the atomized powder particles which are not filled by the liquid in the determination of density by the pycnometer method. This difference in density could also be due in part to techniques used to measure density of powder and extrusion and also to structural changes in fabrication and heat treatment. In Table IV it is seen that the density of the heat-treated and aged extrusions is about 0.3% less than that of the as-extruded material. This is typical of Al-Zn-Mg-Cu alloys produced in conventional ways (Ref. 3) and

gives further evidence of the soundness and low gas content of the extrusions made from powder by the process described in Section II.

The tensile properties of the alloys are compared in Table II in one or two heat treated conditions: (1) solution heat treated in 2 in. dia. sections for 2 hours at 860°F, quenched in cold water, aged for 24 hours at 250°F or (2) solution heat treated in 1 in. x 1 in. quadrants for 0.5 hours at 920°F, quenched in cold water, aged for 96 hours at 225°F. In general, the second heat treatment resulted in higher strengths. The highest yield strength for Heat Treatment #1 is 112 ksi for Alloy 38; the highest yield strength for Heat Treatment #2 is 117 ksi for Alloys 38 and 70. Incidentally, Alloys 73, 74, 76-78, 80, 81, 84, 88 and 89 were not tested after it became desirable to use available funds in other parts of the program.

The longitudinal tensile properties are generally uniform between the front and back of the extrusions; the greatest difference for Heat Treatment #1 is 5,200 psi. Transverse yield strengths were usually not determined since failure occurred before a 0.2% offset was reached. The strain followers were damaged in some cases due to premature failures, therefore only the tensile strengths were usually measured. The transverse tensile strength is much lower than the longitudinal value and greater variations exist between the front and back. The greatest differences are 63,200 psi for Alloy 66 and 39,100 psi for Alloy 9; these large differences are probably a result of internal defects. The higher property is probably more representative of the potential of the alloy.

The heat treatments reported in Table II do not necessarily develop the highest properties in these alloys. Examples of increases which can be obtained are shown in Table V where it is seen that

combinations of higher solution heat treat temperature, longer aging times, and lower aging temperatures tend to raise tensile strengths; the effectiveness of these treatments depends on alloy composition. Higher solution heat-treat temperatures, however, tend to increase cracking and splitting during quenching. The tensile strength of Alloy 39 was raised to 122 ksi by a solution heat treatment of 2 hours at 920°F followed by aging for 96 hours at 225°F. The time at solution heat treatment temperatures may also affect properties slightly as shown in Table VI, which suggests that highest strengths are obtained with shortest times.

Tensile and yield strengths increase with increasing quench rates as shown in Table VII, Figure 1, and Figure 2. The quench rates are only rough estimates, but the trend is at least qualitatively reliable. The high strength objective of this contract was substantially achieved by Alloy 50 having a tensile strength of 127,500 psi and a yield strength of 124,000 psi when solution heat treated for 0.5 hours at 920°F, quenched at 2,000-25,000°F/sec., and aged for 96 hours at 225°F. The highest Y.S.: density (1.17×10^6 in.) was found in Alloy 52 when solution heat treated for 0.5 hours at 920°F, quenched at approximately 25,000°F/sec., and aged for 96 hours at 225°F.

The compact preheat temperature can have an effect on quench sensitivity as shown in Figure 2 for Alloy 50. A 900°F preheat results in a higher quench sensitivity than a 1000°F preheat. The same trend was observed in Alloy 52.

2. Tensile Properties at Cryogenic and Elevated Temperatures

The ten alloys evaluated at cryogenic and/or elevated temperatures are listed in Table VIII. Only four alloys were tested below room temperature. Properties of 7075-T6 and X2020-T6 extrusions fabricated from ingot are included also for purposes of comparison. The effect of the temperature on tensile strengths is best illustrated in Figure 3. (Alloy 52 is the only APM alloy shown since the other alloys responded in a similar fashion.) The APM alloy has a definite strength advantage up to about 375°F, above which X2020-T6 takes over.

The effect of time at temperature on the tensile properties of Alloy 52 was also investigated; the results are given in Table IX and Figure 4 and 5. Again the APM alloy has the highest strength up to about 375°F at which time X2020-T6 surpasses it. The lack of data for Alloy 52 between 212°F and 400°F leaves some question as to whether this alloy has a curve as illustrated in Figure 3 or one more similar to that of 7075-T6.

3. Notch Toughness and Tear Resistance

The notch toughness and/or tear resistance of Alloys 38, 52, 62, 64 and 71 were determined. The former property was evaluated by use of the Izod impact test on heat treated 2 in. dia. extruded rod machined into test specimens as specified by ASTM Standard E-23-60T. The tear resistance was evaluated by means of a Kahn-Type tear test on 0.10 in. thick sheet. This sheet was produced by either rolling of 1 in. x 4-1/4 in. extruded slab or machining a "sheet type" specimen from a 2 in. dia. extrusion. This test measures the energy

necessary to initiate a crack in the specimen and the energy necessary to propagate this crack to complete failure and is described in Ref. 4.

The Izod impact tests revealed the brittleness of the APM alloys and the impact resistance is closer to that of casting alloys than to extruded material, Table X. The sheet rolled from extrusions was very notch sensitive, the energy required to initiate a crack ranging from 1.2 to 2.4 in.-lb. Once the crack was initiated, it propagated without additional energy being needed until complete failure occurs. This is much lower than the values usually obtained from sheet, and is even lower than values obtained for castings.

The tear resistance of certain step aged 0.10 in. thick sheet machined from 2 in. dia. extrusions compared favorably with commercial alloys, Table XI. The tear strength to yield strength ratios are generally lower than the commercial alloys because of the higher yield strengths obtained for the APM alloys. Alloy 71 looks promising when compared with 7178-T6.

4. Electrical Conductivity

Heat treated slices of 2 in. dia. rod and rolled 1 in. x 4-1/4 in. extrusions were measured using the Magnatest type FM-100 Conductivity meter (Table XII). Conductivities follow patterns generally expected from compositions and thermal practices.

5. Hardness

Hardness tests, both Brinell and Rockwell, were made on APM products to determine the values and to try to correlate a

possible relationship between hardness and tensile strength. The hardness values were higher than those usually obtained for aluminum but the test results were not reproducible. The data are summarized in Appendix B.

6. Fatigue Tests

The fatigue endurance limits of certain alloys were investigated using a rotating beam specimen in both smooth and notched configurations. The results are discussed in Appendix C.

C. Effectiveness of Dispersion Hardening

One of the original objectives of this investigation was to determine the feasibility of obtaining high tensile strengths by combining dispersion hardening with precipitation hardening. That this approach is effective, at least to a limited extent, is seen from the fact that the highest yield strength obtained in the entire investigation was in an alloy containing significant amounts of Mn, Fe, and Ni in addition to Zn, Mg, and Cu. Furthermore, the highest Y.S. to density ratio was obtained in an alloy containing a large amount of Co in addition to Zn, Mg, and Cu.

It is well, however, to make a judgment as to the effectiveness of the combination of dispersion hardening and precipitation hardening by comparing that kind of alloy with precipitation hardened alloys using the results in Table II. The properties for Heat Treatment #1 in Table II have been arranged in groups according to Zn, Mg, and Cu content in Table XIII. It is seen that dispersion hardeners generally tend to raise tensile and yield strengths (at least up to a point) and to lower elongations.

It is also fairly clear that there is a maximum in the yield strength-amount of dispersoid relationship with that maximum depending on the Zn, Mg, and Cu content as well as on the specific dispersoids present. In all cases, however, the alloys containing dispersoids have such low elongations when heat treated to high strengths that the usefulness of the alloys will be very limited.

Another means of comparing the two types of alloys is on the basis of elongation at a given yield strength-to-density ratio. This is done in Table XIV in which it appears that the two types of alloys are about the same at Y.S.:density greater than 0.95×10^6 and that the precipitation alloys tend to be more ductile at Y.S.:density values of 0.95 and lower.

An attempt was made to assess the effects of dispersion hardening elements on tensile properties by various computer analyses of results obtained in this investigation. While these were not very successful in predicting results, they are included in Appendix A for the record. The highest predicted yield strength for any powder metallurgy extrusion was 127,000 psi for Heat Treatment #1. It is interesting to compare this with a predicted maximum of 122,000 psi for 3/4 in. dia. extrusions made from ingot in another investigation. Allowing for the effect of difference in quench rate between 3/4 in. and 2 in. dia. rod, these analyses would indicate an advantage of 8-10 ksi for the powder metallurgy product. However, the very low elongations of all of the aluminum alloy materials in this strength range make these differences academic; in practice these high strengths are not obtained consistently, possibly due to the difficulties

associated with making tensile tests on extremely brittle materials.

The effectiveness of dispersion hardening in alloys which also contain precipitation hardening elements can be judged to some extent from the response of the alloy to factors affecting dispersion hardening. The strength of dispersion hardened alloys based solely on intermetallic compounds having low solid solubility at elevated temperatures, e.g., FeAl_3 , FeAl_6 , FeNiAl_9 , Co_2Al_9 , MnAl_6 , etc., is a function of the volume percent of the dispersed phase and an inverse function of the spacing between the particles of that phase. The interparticle spacing for a given volume percent can be minimized by keeping the times and temperatures at a minimum during preheating, fabrication and heat treatment, and by using finer atomized powders.

The effects of shorter preheat times and lower preheat temperatures were generally opposite to those expected as shown in Table XV. Die quenching, which minimizes times at elevated temperatures by eliminating a separate heat treating operation, also gave unexpected results as shown in Table XVI.

Finer powders gave higher longitudinal strengths than the normal powder in the case of Al-Zn-Mg-Cu alloys given Heat Treatment #2 in Table XVII, but the reverse was true for Al-Zn-Mg alloy and for both types of alloys for Heat Treatment #1. Finer powders (Table XVIII) may give higher transverse strengths than normal powders, but the wide scatter in data shown in Section II - Table VIII requires that this conclusion be treated with reservations.

D. Summary

Higher tensile strengths than ever reported before for Al

alloys have been achieved by combining dispersion hardening and precipitation hardening. These high strengths may not be obtainable with precipitation hardening alone. The extremely low ductility, low impact strength and low tear strength associated with these high tensile strengths and the specialized processes required to achieve them will seriously limit the usefulness of these alloys. Practical considerations probably would favor extrusions made from ingot over extrusions made from powder.

II. Development of Aluminum Alloys With Yield Strength 10% Higher Than Commercial Alloys Without Sacrificing Resistance to Stress Corrosion Cracking

When it became apparent that alloys having yield strengths of 125,000 psi would have very low elongations, the emphasis of the investigation was changed. At the suggestion of Mr. Harold Markus of Frankford Arsenal, it was agreed to try to develop alloys and practices to make extrusions which had 10% higher yield strengths than currently available commercial extrusions, elongations of at least 5%, and resistance to SCC (stress corrosion cracking) at least equal to commercial alloys. This amounted to two targets depending on strength and degree of resistance to stress corrosion cracking, based on 7075-T7351 (the strongest commercial alloy with immunity to stress corrosion cracking) and on 7178-T651.

Alloy	Typical Tensile Properties (of Extrusions, 2-3" Diameter)					
	Longitudinal			Transverse		
	T.S. ksi	Y.S. ksi	El. % in 4D	T.S. ksi	Y.S. ksi	El. % in 4D
7075-T7351	75	66	11	62	56	4
7178-T651	92	84	8	83	74	5

<u>Targets</u>	<u>Longitudinal Tensile Properties</u>			<u>SCC*</u> <u>ksi</u>
	<u>T.S.</u> <u>ksi</u>	<u>Y.S.</u> <u>ksi</u>	<u>El. %</u> <u>in 4D</u>	
1	83	73	5	>44
2	101	92	5	7

* Highest sustained tension stress in short transverse direction at which test specimen does not fail in the 3.5% NaCl alternate immersion test.

The attack on the targets was to be two pronged: (1) longer aging times and higher aging temperatures than were used to develop the highest tensile strengths, (2) alloys with lower amounts of dispersoids.

In the initial tests (Tables XIX and XX), it was found that these alloys responded to extended aging with much higher increases in elongation than were expected.

Systematic aging studies were made on a number of alloys using 2" diameter extrusions. An extensive effort was made to use Rockwell G hardness measurements to follow the aging, but it was found that the relation between hardness and strength was not very clear and that hardness values could not be interpolated accurately from existing hardness-aging time curves. (The hardness values are tabulated in Appendix B for the record.) Tensile property-aging time relationships for Alloys 2, 3, 4, 5, 6, 19, 20, 28, 33, 36, 38, 39, 49, 50, 52, 59, 60, 61, and 71 are tabulated in Tables XXI through XXXIX. Some of the data are plotted in Figures 6 through 11. The results of stress corrosion tests are given in Tables XXI through XLIII and Figures 12 through 34.

A summary of stress-corrosion cracking results is given in Table XLIV in which the alloys and thermal practices are listed in

order of decreasing stress levels.

The following alloys and aging treatments meet the strength and stress corrosion targets.

<u>Alloy</u>	<u>Aging</u>	<u>T.S.</u> <u>ksi</u>	<u>Longitudinal</u> <u>Y.S.</u> <u>ksi</u>	<u>El. %</u> <u>in 4D</u>	<u>SCC</u> <u>Stress</u> <u>ksi</u>	<u>Days to</u> <u>Failure</u>
<u>Target I: 7075-T7351 + 10% With No Failures at 75% Y.S.</u>						
		83	73	5	>48	OK 84
87	6 @ 250 + 8 @ 330	90	81	7	57	OK 84
87	16 @ 330	86	75	7	52	OK 84
79	6 @ 250 + 8 @ 330	86	79	8	54	OK 84
90	6 @ 250 + 8 @ 330	84	78	8	54	OK 84
<u>Target II: 7178-T651 + 10% Strength Improvement, Equal Stress, Corrosion, Resistance</u>						
		101	92	5	7-20	OK 84
71	24 @ 250	108	105	5	22	OK 84
<u>Target III: Better Stress Corrosion Resistance Than 7178-T651</u>						
		92	84	5	7-20	OK 84
71	24 @ 250	108	105	5	22	OK 84
90	24 @ 250	99	93	5	20	OK 28
71	24 @ 250 + 3 @ 330	94	88	7	40	OK 84

(The alloys were all SHT 2 hours at 860°F and immediately quenched in cold water prior to aging.) Target III was not included as one of the original two targets but was considered. A more complete summary is given in Table XLV which lists the composition of these alloys as well as alloys which may meet the targets with adjustments in aging practices.

The susceptibility of APM alloys to exfoliation was evaluated on 1 in. x 4-1/4 in. extruded sections of Alloy 52, S.No. 293690 using an improved accelerated test of acetic acid-sodium chloride intermittent spray at 95°F for a 2 week exposure (Ref. 5). The extrusions were sawed such that surface and mid-plane surfaces would be exposed in the as-extruded (-W) temper, given Heat Treatment #1 (SHT 2 hours at 860°F, C.W.Q., Aged 24 hours at 250°F) and given Heat Treatment #1 with an additional step aging of 4 hours at 330°F. All heat treatments were conducted prior to the sample preparation. Generally, the mid-plane and surface of the specimens were covered with small shallow pits and a mild form of corrosion. There was no indication of exfoliation on any of the panels. Extrusion lines were visible on the panel surface after exposure. Heat Treatment #1 panels resisted the corrosive environment best. The -W temper pieces exhibited slightly more pitting; the step-aged panels had more pits than the as-extruded panels.

III. Structure

The structures of atomized alloy powders and extrusions made from them are fine relative to ingot and ingot extrusions, and the structures of extrusions are coarser than the powders from which they were made (Figures 35-37).

In the early stages of this investigation, large constituent particles which were present in some of the extrusions were analyzed by electron microprobe with the results shown in Table XLVI. It was concluded from the analyses that Fe, Ni, Co, and Mn were desirable elements for dispersion hardening because they

tended to be absent from (or present in relatively slight amounts in) the large constituent particles.

Guinier X-ray diffraction also revealed that the Zn, Mg, Cu, and Mn, were present in the same phases in powder metallurgy extrusions (Table XLVII) that occur in products made from ingot.

After it became apparent that Alloys 34, 87, 52, and 71 had good strengths combined with good resistance to SCC, a somewhat more extensive study was made of the structure.

Extrusions of these alloys all had essentially the same structures when viewed by the light microscope, and Figure 38 showing Alloy 71 in the -T6 condition serves as an example. The two-step aged condition, Figure 39, shows no obvious difference in structure, but may contain a little more precipitate.

The electron microprobe was used to analyze 14 to 15 of the larger particles in extrusions of Alloys 34, 87, 52 and 71, as illustrated by the black phases in Figure 38, Tables XLVIII and XLIX. It was determined that some of the particles were non-metallic, i.e., their composition could not be entirely accounted for in the microprobe analysis. It should be noted that the percentage figures reported for the non-metallic particles cannot be considered to be quantitatively correct because of uncompensated absorption effects and are given only to indicate order of magnitude. The percentage figures for the metallic particles are somewhat more meaningful because approximate absorption corrections were made; quantitative accuracy is still questionable. Sixty percent of the larger particles in Alloy 34 were approximately 40% Zr and 10% Si (probably $ZrSiO_4$) while 29% of the

particles in Alloy 87 had a similar composition. No Zr was reported in the semiquantitative chemical analysis. These particles are probably part of the Zirconite paste wash which was applied to the crucible prior to melting a charge. The particles flaked off or were chipped off during stirring to become part of the atomized product. The higher ZrSiO_4 concentration occurred in the larger charges. The presence of Cr, Fe, Si, and Ni in certain of the large constituent particles indicate more work should be done to minimize growth of these particles. Mn and Co do not occur as large constituent particles and are desirable. The effect of Zn and Mg varies; sufficient data are not available to come to any conclusions at this time.

Alloys 34, 87, 52, and 71 were also analyzed by the Guinier X-ray diffraction technique. Not only were attempts made to identify the phases present but also to determine the formation of additional phases when progressing from the powder to -T6 extrusion and finally after prolonged aging. Only 2 or 3 phases were indicated as being present in the powder, Table L, Al , Mg_2Si and either FeNiAl_9 or Co_2Al_9 , depending on the alloy. After the powder is compacted, extruded and given a -T6 heat treatment, the structure becomes quite complex. Additional phases appear including one or more phases which cannot be identified. Prolonged aging results in an apparent increase in the amount of FeNiAl_9 but no change in the amount of CoAl_9 . Prolonged aging also results in the appearance of an M' precipitate. Other phases stay relatively unchanged.

Examination of the powders by electron microscope indicates the microstructures of Alloys 34 and 87 are somewhat coarser than

that of Alloys 52 and 71, Figures 40 to 43. Alloy 71, Figure 43, appeared to have a less uniform structure in terms of constituent dispersion than the other powders.

The microstructures of Alloys 34 and 37 extrusions are quite similar, Figures 44, 45, 46, and 47. Prolonged aging of both these alloys results in an increase in the large dark particles labeled $MgZn_2$. The gray particles are believed to be $FeNiAl_9$ and the number does not change appreciably. The smaller, more spherical particles are probably the E-phase ($Al_{12}MgCr$) dispersoid. The Mg_2Si precipitate would be present in small quantity and is not easily identified. A very fine, light background precipitate also appears to increase during step aging. This is similar to the θ' phase which occurs in alloys containing Cu, but a positive identification was not made. This could also be the M' or unidentified phase noted in X-ray diffraction.

Alloys 52 and 71 are also similar in composition, but the amount of precipitate present in Alloy 52 is greater than for any of the other alloys, Figures 48, 49, 50 and 51. The differences between the $MgZn_2$ and the $Mg_3Zn_3Al_2$ phases are indistinguishable in the electron micrographs. The Co_2Al_9 dispersoid is believed to be the light gray angular particles. Alloy 71 exhibits noticeable grain (or subgrain) boundary precipitation, especially after step aging. Note the increase in precipitate around the Co_2Al_9 particles.

Small phases within the larger phases are noted in Figures 44 to 51. The compositions of the larger phases could be influenced by these smaller included phases when analyzed by the microprobe.

The microprobe has also been used to investigate tensile specimen fractures of two specimens of Alloy 59 in which low strengths and low elongations had been observed. The origin of failure appeared to be a region containing black inclusions. Test results indicate the black spot inclusions have a high Mg content, a moderate amount of Al and low-to-trace amounts of Zn, Mn, Ni, Fe and Cu. The level of each of these elements, with the exception of Mg, is far less in the dark region than in the surrounding region of the fracture. A thin layer of Mg-rich material, a spinel or possibly MgO, is present in the "black spot" regions. Thus low strengths and elongations can be the result of greater than normal oxidation.

CONCLUSIONS

1. The longitudinal tensile properties of certain APM alloys exceeded 100 ksi and were uniform along the length of the extrusion. The transverse tensile properties were lower than the longitudinal and failure frequently occurred before the yield strength at 0.2% offset was reached.

2. The ductility of the alloys generally decreased as the strength increased.

3. Alloy 50, Al, 9.8% Zn, 4.0% Mg, 0.8% Cu, 1.1% Mn, 1.0% Fe, 1.3% Ni, 0.01% Cr and 0.01% Ti, had the highest strength values with a yield strength of 124,400 psi and a tensile strength of 127,500 psi.

4. Alloy 52 containing 10.0% Zn, 4.0% Mn, 0.9% Cu, 0.4% Mn, 0.02% Ti, 0.01% Cr and 1.5% Co had the highest yield strength to density ratio, 1.174×10^6 in.

5. The extrusion densities are higher than the powder densities due to the inability of the testing fluid to completely fill all voids and crevices.

6. The difference in the densities of the extrusions tested in the -F and -T6 conditions is similar to that of conventional wrought alloys.

7. Compact density and compact preheat temperature affect the tensile properties of a fabricated product from a given alloy.

8. The tensile strengths of an alloy increase with the quench rate. Quench rates are determined by the specimen size and the quenching medium.

9. Alloy composition affects the quench sensitivity of alloys.

10. Compact preheats of 1000°F result in extrusions with less quench sensitivity than 900°F preheats.

11. Elevated and cryogenic tensile tests on selected alloys indicate the properties are superior to conventional alloys up to 350°F. Above this temperature the tensile strength decreases rapidly.

12. Increasing the time at elevated temperatures from 1/2 to 100 hours results in a lowering of strengths and an improvement on the ductility. Comparison with other alloys for similar time at temperatures indicates that Alloy 52 again has superior properties up to about 350°F.

13. The tear strength values, while lower than some commercial alloys, can be improved by prolonged aging of the more ductile alloys.

14. The poor notch sensitivity of these extrusions is indicated by the low Izod impact test values.

15. The conductivity of these alloys varies depending on composition and aging practice.

16. The alloys are generally harder than commercial APM alloys.

17. Attempts to correlate hardness or conductivity data and tensile properties have not been successful.

18. The fatigue endurance limit on smooth specimens of Alloys 52, 62, 64, and 71 are greater than 7075-T6 and the data points generally fall above the upper scatter band limit for 7075-T6.

19. Dispersion hardeners generally tend to raise the tensile and yield strengths and lower the elongation.

20. The alloys respond to prolonged aging by increased ductility and resistance to stress corrosion cracking. The strengths decrease.

21. Alloy 71 responds very well to overaging. The strengths are almost as high as those obtained for Alloy 52, however, the material is much more ductile.

22. Alternate immersion stress corrosion tests have a varied response on the short transverse specimens from extrusions. Alloy content and heat treatments determine the effect.

23. Stress corrosion resistance of alloys given prolonged aging and containing high Fe and Ni (Alloys 34, 87 and 90) resulted in no failures at stress levels significantly greater than typical values of 7075-T73. Heat Treatment #1 resulted in very high strengths with better stress corrosion resistance than 7075-T6 or 7178-T6.

24. Alloys 52 and 71, Co containing series, had stress corrosion resistance better than that obtained for 7075-T73 + 10% after prolonged aging. Although not as good as the Fe-Ni series, the ductility of these alloys is greater.

25. No indication of exfoliation corrosion was present in Alloy 52. The general effect of exfoliation corrosion on APM material is not known.

26. The maximum dispersion strengthening effect was not achieved from the insoluble elements because the constituent particles in the extrusions were coarsened considerably over those in the atomized powder.

27. The electron microprobe indicated that the coarse constituents contained large amounts of Cr, Ti, V, Zr, Mo and W. These alloying elements are therefore considered undesirable in large amounts.

28. Fe, Ni, Co and Mn are desirable elements for dispersion hardeners since they are not present as large constituent particles.

FUTURE WORK

A total of 90 alloys have been partially evaluated. The results have indicated that at least two families of alloys should be given additional testing, namely, Al-Zn-Mg-Co-Cu (Alloys 52 and 71) and Al-Zn-Mg-Cu-Fe-Ni (Alloys 34, 87 and 90). Additional testing has shown that these alloys are indeed promising but many unanswered questions are still present, i.e., alloy limits, purity, fabrication techniques, more complete stress corrosion data in both alternate immersion and atmospheric tests, etc. Also, means of

improving some of the poor properties, i.e., ductility and tear strength, must be made. Both alloy systems should be included as part of an extensive program to obtain a high strength commercial alloy.

The alloys obtained by use of statistical analyses should be produced and fabricated to determine how accurate the model was and also to improve the model.

Other families of alloys could be included for further evaluation, however, the emphasis should be directed toward the alloys discussed in the earlier paragraphs.

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TABLE I

COMPOSITION AND PROPERTIES OF POWDERS

Alloy No.	Series	Sub No.	Material Analyzed	Zn	Mg	Cu	Mn	Fe	Ni	Cr	Ti	V	Zr	Co	Mo	W	Si	Al ₂ O ₃ (a)	Powder Density lb./in. ³ (b)	Powder Size MMD, microns
1			Intended Powder	9.86	3.49	1.02	0.47												.1014	44
1	A	267948	Intended Powder	10.0	3.53	1.04	0.50	0.12		0.00	0.00							0.06		
1	A	277373	Extrusion	9.94	3.53	1.07	0.52	0.08		0.01	0.00							0.05		
2			Intended Powder	12.0	3.50	1.50	0.50												.1038	54
2	A	267949	Intended Powder	12.1	3.48	1.51	0.54	0.13		0.00	0.01							0.08		
3			Intended Powder	12.30	4.05	1.53	0.50												.1038	27
3	A	267970	Intended Powder	12.3	4.03	1.56	0.53	0.13		0.00	0.01							0.08		
4			Intended Powder	9.76	3.24	1.99				0.20									.1027	39
4	A	267971	Intended Powder	9.60	3.19	1.99	0.00	0.16		0.23	0.01							0.05		
5			Intended Powder	10.36	3.08	2.03	1.74			0.20									.1047	37
5	A	267972	Intended Powder	10.3	2.93	2.07	1.80	0.21		0.14	0.00							0.11		
6			Intended Powder	11.25	2.45	2.01				0.20									.1015	39
6	A	267973	Intended Powder	11.2	2.44	2.03	0.01	0.16		0.17	0.01							0.06		
7			Intended Powder	8.0	3.5	1.5			2.5										.1043	26
7	A	267960	Intended Powder	7.92	3.41	1.52	0.01	2.50	2.00									0.02		
8			Intended Powder	8.0	3.5	1.5	1.5	1.63	1.40										.1042	44
8	A	267961	Intended Powder	7.88	3.46	1.50	1.58	1.63	1.40									0.06		
9			Intended Powder	8.0	3.5	1.5				0.5	0.5	0.5	0.5						.1023	38
9	A	267962	Intended Powder	7.88	3.54	1.60	0.01	0.13		0.48	0.38	0.41	0.44					0.07		
10			Intended Powder	8.0	3.5	1.5				2.0	0.8	2.0	1.0						.1050	39
10	A	267963	Intended Powder	7.91	3.54	1.51	0.04	0.15		2.13	0.89	1.73	0.85					0.08		
11			Intended Powder	8.0	3.5	1.5								1.5	1.5	1.5			.1033	37
11	A	267964	Intended Powder	8.03	3.54	1.53	0.01	0.10						1.48	1.19	0.39		0.10		
11	A	277383	Extrusion	7.55	3.54	1.52	0.01	0.09						1.37	1.55	0.48		0.08		
12			Intended Powder	8.0	3.5	1.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			.1046	41
12	A	267965	Intended Powder	7.81	3.53	1.56	0.61	0.51	0.55	0.53	0.44	0.39	0.56					0.09		
13			Intended Powder	12.0	3.5	1.5			2.5										.1081	37
13	A	267966	Intended Powder	11.7	3.43	1.52	0.02	2.43	2.23									0.05		
14			Intended Powder	12.0	3.5	1.5	1.5	1.5	1.5										.1083	35
14	A	267967	Intended Powder	11.8	3.47	1.52	1.65	1.64	1.45									0.07		
15			Intended Powder	12.0	3.5	1.5				0.5	0.5	0.5	0.5						.1054	33
15	A	267968	Intended Powder	11.4	3.40	1.50	0.02	0.14		0.54	0.51	0.46	0.55					0.07		

(Continued)

TABLE I (Cont'd.)

Alloy No.	Ref.	Mat'l. Analysis	Zn	Fe	Mn	Pb	Al	Cr	Ni	Composition, %	V	Zr	Co	Mo	V	P	Powder Density lb./in. ³ (b)	Powder Blow V.D. lb./sq. in.
5		Intended Powder	12.0	3.5	1.5	—	—	2.0	0.8	2.0	2.0	1.0	—	—	—	—	.1080	—
6	1	267969	12.0	3.54	1.52	0.04	0.13	2.18	1.06	1.89	0.98	0.98	—	—	—	—	.1080	—
17		Intended Powder	12.0	3.5	1.5	—	—	—	—	—	—	—	1.5	1.5	1.5	0.54	.1087	41
17	A	267970	11.9	3.46	1.55	0.00	0.10	—	—	—	—	—	1.48	1.10	0.54	0.11	.1080	39
18		Intended Powder	12.0	3.5	1.5	0.5	0.54	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.54	.1080	42
18	A	267971	11.7	3.38	1.52	0.62	0.54	0.56	0.45	0.39	0.54	0.54	0.50	0.50	0.50	0.11	.1080	39
19		Intended Powder	7.6	3.0	1.5	—	—	—	—	—	—	—	—	—	—	—	.1080	42
19	A	267972	7.49	2.97	1.70	0.00	0.17	—	—	—	—	—	—	—	—	—	.1080	42
20		Intended Powder	7.9	3.6	2.3	—	—	—	—	—	—	—	—	—	—	—	.1080	42
20	A	267973	7.74	3.39	2.33	0.00	0.17	—	—	—	—	—	—	—	—	—	.1080	42
21		Intended Powder	8.0	5.6	7.5	—	—	—	—	—	—	—	—	—	—	—	.1080	42
21	A	267974	7.92	5.40	7.44	—	—	—	—	—	—	—	—	—	—	—	.1080	42
22		Intended Powder	8.0	8.5	15.0	—	—	—	—	—	—	—	—	—	—	—	.1080	42
22	A	267975	7.93	8.39	14.9	0.00	0.13	—	—	—	—	—	—	—	—	—	.1080	42
23		Intended Powder	8.0	10.3	20.0	—	—	—	—	—	—	—	—	—	—	—	.1130	34
23	A	267976	7.71	10.1	20.1	0.00	0.12	—	—	—	—	—	—	—	—	—	.1130	34
24		Intended Powder	8.0	7.5	20.0	—	—	—	—	—	—	—	—	—	—	—	.1151	27
24	A	267977	7.76	7.16	20.0	0.00	0.14	—	—	—	—	—	—	—	—	—	.1151	27
25		Intended Powder	—	10.8	2.3	—	—	—	—	—	—	—	—	—	—	—	.0927	39
25	A	267978	—	10.6	2.37	0.00	0.19	—	—	—	—	—	—	—	—	—	.0927	39
26		Intended Powder	3.0	7.5	2.3	—	—	—	—	—	—	—	—	—	—	—	.0944	30
26	A	267979	2.95	7.41	2.33	0.00	0.17	—	—	—	—	—	—	—	—	—	.0944	30
27		Intended Powder	7.0	4.0	2.3	—	—	—	—	—	—	—	—	—	—	—	.1000	38
27	A	267980	6.90	3.93	2.33	0.00	0.14	—	—	—	—	—	—	—	—	—	.1000	38
28		Intended Powder	10.0	4.0	2.3	—	—	—	—	—	—	—	—	—	—	—	.1028	34
28	A	267981	9.77	3.83	2.28	0.00	0.16	—	—	—	—	—	—	—	—	—	.1028	34
29		Intended Powder	14.0	4.4	2.3	—	—	—	—	—	—	—	—	—	—	—	.1054	42
29	A	267982	13.7	4.33	2.33	0.00	0.12	—	—	—	—	—	—	—	—	—	.1054	42
30		Intended Powder	9.0	15.0	—	—	—	—	—	—	—	—	—	—	—	—	.0928	27
30	A	267983	7.90	14.6	0.02	0.00	0.12	—	—	—	—	—	—	—	—	—	.0928	27

(continued)

TABLE 1 (Cont'd.)

Alloy No.	Section	St. No.	Material / Intended	Al	Si	Fe	Mn	P	S	Cu	Cr	Ni	Mo	Co	W	Al-0.5 (b)	Powder Density 1b./in. ³ (b)	Powder Size MMD - microns
31	A	2677964	Intended Powder	3.0	15.0	2.3	0.00	0.13	—	—	—	—	—	—	—	—	.0922	31
32	A	2677964	Intended Powder	6.45	2.70	0.41	—	—	—	—	—	—	—	—	—	—	.1011	44
33	A	2677964	Intended Powder	9.15	3.44	1.17	1.10	—	—	—	—	—	—	—	—	—	.1018	41
34	A	2677964	Intended Powder	8.0	2.5	1.0	—	—	—	—	—	—	—	—	—	—	.1074	44
35	A	2677964	Intended Powder	7.79	2.53	1.03	0.04	3.93	—	—	—	—	—	—	—	—	.1061	24
36	A	2677964	Intended Powder	7.77	2.48	1.03	0.02	3.49	—	—	—	—	—	—	—	—	.1024	45
37	A	2677964	Intended Powder	9.15	3.44	1.17	1.10	—	—	—	—	—	—	—	—	—	.1061	22
38	A	2677964	Intended Powder	11.0	3.7	2.0	1.7	—	—	—	—	—	—	—	—	—	.1112	43
39	A	2677964	Intended Powder	10.7	3.82	2.04	1.66	—	—	—	—	—	—	—	—	—	.1056	39
40	A	2677964	Intended Powder	10.6	4.36	1.97	1.68	—	—	—	—	—	—	—	—	—	.1035	24
41	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
42	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
43	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
44	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
45	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
46	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
47	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
48	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
49	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
50	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
51	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
52	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
53	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
54	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
55	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
56	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
57	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
58	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
59	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
60	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
61	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35
62	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	24
63	A	2677964	Intended Powder	6.5	3.5	—	2.0	4.0	3.32	6.05	—	—	—	—	—	—	.1044	35

(Continued)

TABLE I (Cont'd.)

Alloy No.	Series	S ₁ No.	Material Analyzed	Composition, %											Powder Density lb./in. ³ (b)			Powder Size ISO- microns			
				Zn	Mg	Cu	Mn	Fe	Ni	Cr	Ti	V	Zr	Co	Mo	N	Si		Al ₂ O ₃ (a)		
43			Intended Powder	12.0	4.5	1.0	1.0			0.20								0.35			18
43	A	278105		12.0	4.66	0.90	0.86	0.14	0.01	0.20	0.01						0.09	0.28	.1041		
44			Intended Powder	12.0	4.5	1.0	2.4			0.25								1.00			20
44	A	276106		11.2	4.96	0.90	2.53	0.24	0.03	0.23	0.01						0.24	0.33	.1057		
45			Intended Powder	12.0	4.5	1.0	2.8			0.75								0.40			19
45	A	278107		11.7	4.58	0.90	3.02	0.21	0.01	0.75	0						0.16	0.41	.1067		
46			Intended Powder	12.0	4.5	1.0	1.1			1.0								0.80			23
46	A	278108		11.4	4.61	0.93	0.57	0.13	0.09	1.12	0.01						0.07	0.42	.1054		
47			Intended Powder	10.0	4.0	0.4	2.0	1.5	5.0												27
47	A	278109		9.82	4.20	0.42	2.05	1.57	4.56	0.09	0.01						0.13	0.25	.1086		
48			Intended Powder	15.5	4.7		1.75														23
48	A	278110		15.2	4.92	0.01	1.81	0.19	0.02	0.00	0.01						0.10	0.30	.1064		
49			Intended Powder	15.5	4.7	2.0	1.75														24
49	A	278111		14.8	4.92	1.77	1.71	0.16	0.00	0.00	0.00						0.10	0.28	.1080		
49	C	283272		15.3	4.64	2.02	1.87	0.21	0.00	0.00	0.01						0.08	0.63	.1085		
50			Intended Powder	10.0	4.0	0.9	1.3	0.9	1.5	0.01	0.01										22
50	A	278112		9.80	4.02	0.78	1.10	1.00	1.34	0.01	0.01						0.09	0.81	.1053		
50	C	283273		9.95	4.11	0.72	1.39	1.11	1.44	0.01	0.02						0.06	0.69	.1053		
50	Special	284130		9.7	3.86	0.90	1.26	0.85	1.51		0.01						0.08				23
51			Intended Powder	10.0	4.0	0.9	1.3	0.9	1.5	0.01	0.01			1.5							22
51	A	278113		9.55	4.12	0.75	1.23	1.02	1.37	0.01	0.01			1.34			0.18	0.75	.1059		
52			Intended Powder	10.0	4.0	0.9				0.01	0.01			1.5							22
52	A	278114		9.65	4.14	0.83	0.04	0.13	0.03	0.01	0.01			1.38			0.04	0.73	.1034		22
52	C	283274		9.79	4.01	0.92	0.01	0.14	0.01	0.01	0.02			1.49			0.06	0.75	.1033		24
52	Special	284131		10.1	4.0	0.93		0.1	0.02				0.01	1.49			0.3				24
53			Intended Powder	10.0	4.0		2.4	1.3	4.9	0.04	0.04										25
53	A	278115		9.55	4.13	0.02	2.43	1.40	4.82	0.04	0.04						0.10	0.71	.1085		25
54			Intended Powder	10.0	4.0	1.6	2.9	1.5	1.0	0.05	0.04										23
54	A	278116		9.45	3.98	1.39	2.88	1.61	0.89	0.05	0.04						0.11	0.60	.1070		23
55			Intended Powder	10.0	4.0	1.6	1.0	1.7	2.6	0.07	0.05										23
55	A	278117		9.92	4.18	1.47	0.86	1.85	2.41	0.07	0.05						0.07	0.73	.1071		23

(Continued)

TABLE I (Cont'd.)

Alloy No.	Series	S. No.	Material Analysis	Zn	Fe	Cu	Pb	Cr	Composition, %	Si	Al ₂ O ₃ (a)	Powder Density lb/in. ³ (b)	Powder Size R ₉₀ - microns
56	A	278118	Intended Powder	10.0	1.8	1.9	—	2.6	0.11	0.07	—	—	22
56	A	278118	Powder	9.76	1.67	1.99	0.21	2.50	0.11	0.07	—	.1065	22
57	A	278119	Intended Powder	10.0	2.1	1.9	1.3	2.9	0.00	0.11	—	—	25
57	A	278119	Powder	9.55	1.92	2.00	1.24	2.98	0.00	0.10	—	.1081	25
58	A	278120	Intended Powder	10.0	2.7	2.0	1.3	3.6	0.04	—	—	—	25
58	A	278120	Powder	10.0	2.51	2.18	1.38	3.24	0.04	0.01	—	.1096	25
59	A	277918C	Intended Powder	10.0	1.5	1.5	1.0	4.0	—	—	—	—	26
59	A	277918C	Powder	10.2	1.57	1.62	1.03	4.10	—	—	—	.1068	26
60	A	283674	Intended Powder	11.0	0.7	0.7	—	—	—	—	—	—	33
60	A	283674	Powder	11.6	1.82	0.72	0.13	—	—	—	—	.1035	33
61	A	283675	Intended Powder	10.0	0.9	—	—	—	—	—	—	—	26
61	A	283675	Powder	10.4	0.76	0.00	0.09	—	—	—	—	.1018	26
62	A	283925	Intended Powder	10.0	0.9	—	—	—	0.01	0.02	—	—	42
62	A	283925	Powder	10.0	0.94	—	—	—	0.01	0.03	—	.1022	42
63	A	283926	Intended Powder	10.0	0.9	—	—	—	0.01	0.02	—	—	50
63	A	283926	Powder	10.1	0.94	0.00	0.1	0.07	0.01	0.03	—	.1029	50
64	A	283927	Intended Powder	9.0	0.9	—	—	—	0.01	0.02	—	—	48
64	A	283927	Powder	8.9	0.94	—	—	—	0.01	0.03	—	.1024	48
65	A	283928	Intended Powder	11.0	0.9	—	—	—	0.01	0.02	—	—	43
65	A	283928	Powder	11.1	1.02	—	—	—	0.01	0.03	—	.1038	43
66	A	283929	Intended Powder	10.0	0.9	—	—	—	0.01	0.02	—	—	43
66	A	283929	Powder	10.0	0.94	—	—	—	0.01	0.03	—	.1034	43
67	A	283930	Intended Powder	10.0	0.9	—	—	—	0.01	0.02	—	—	47
67	A	283930	Powder	10.3	0.94	—	—	—	0.01	0.03	—	.1021	47
68	A	283931	Intended Powder	10.0	1.5	—	—	—	0.01	0.02	—	—	37
68	A	283931	Powder	9.9	1.50	0.00	0.1	0.06	0.01	0.03	—	.1033	37
69	A	283932	Intended Powder	10.0	0.5	—	—	—	0.01	0.02	—	—	41
69	A	283932	Powder	9.8	0.65	—	—	—	0.01	0.03	—	.1029	41
70	A	283933	Intended Powder	11.0	1.5	—	—	—	0.01	0.02	—	—	42
70	A	283933	Powder	10.8	1.31	—	—	—	0.01	0.03	—	.1047	42
71	A	283934	Intended Powder	9.0	0.5	—	—	—	0.01	0.02	—	—	40
71	A	283934	Powder	9.2	0.63	—	—	—	0.01	0.03	—	.1016	40
72	A	283935	Intended Powder	10.0	0.9	—	—	—	0.01	0.02	—	—	35
72	A	283935	Powder	10.1	0.93	—	—	—	0.01	0.03	—	.1027	35

(Continued)

TABLE I (Cont'd.)

Alloy No.	Series	S. No.	Material Analyzed	Composition, %										Powder Density lb/in. ³ (b)	Powder Size MMD-microns
				Si	Fe	Mn	Cu	Ni	Cr	Ti	V	Al	Al ₂ O ₃ (a)		
73	A	284202	Powder	10.2	4.10	0.94	--	--	0.01	0.03	--	--	0.29	.1032	41
74	A	284203	Powder	9.8	4.14	1.36	--	--	0.01	0.03	--	--	0.34	.1033	44
75	A	--	Intended	6.8	2.7	2.0	--	1.0	0.3	--	--	--	--	--	31
75	A	307586	Powder	7.06	2.79	2.04	0.01	0.93	4.72	0.01	--	--	0.08	.1056	31
76	--	--	Intended	6.8	2.7	2.0	--	3.0	0.3	--	--	--	--	--	31
76	A	307587	Powder	6.72	2.68	2.08	0.02	3.51	6.74	0.01	--	--	0.05	.1098	31
77	--	--	Intended	6.8	2.7	2.0	1.0	--	0.5	--	--	--	--	--	35
77	A	307588	Powder	7.03	2.71	2.08	1.06	0.16	0.68	0.01	0.01	--	0.07	.1022	35
78	--	--	Intended	6.8	2.7	2.0	3.0	--	1.0	--	--	--	--	--	37
78	A	207589	Powder	7.06	3.11	2.12	2.84	0.21	0.84	0.01	0.01	--	0.1	.1035	37
79	--	--	Intended	6.8	2.7	2.0	1.0	--	0.5	--	--	--	--	--	31
79	A	307590	Powder	6.85	2.76	2.06	1.02	0.15	0.52	0.01	0.01	--	0.2	.1023	31
80	--	--	Intended	6.8	2.7	2.0	3.0	--	1.0	--	--	--	--	--	33
80	A	307591	Powder	7.12	2.72	2.11	2.88	0.14	1.02	0.01	0.01	--	0.05	.1043	33
81	--	--	Intended	6.8	2.7	2.0	1.0	--	0.5	--	--	--	--	--	34
81	A	307592	Powder	6.96	2.74	2.12	1.02	0.16	0.58	0.01	0.01	--	0.05	.1060	34
82	--	--	Intended	6.8	2.7	2.0	3.0	--	1.0	--	--	--	--	--	34
82	A	307593	Powder	6.92	2.68	2.11	2.86	0.13	1.28	0.01	0.01	--	0.05	.1103	34
83	--	--	Intended	6.8	2.7	2.0	1.0	1.0	0.5	--	--	--	--	--	35
83	A	307594	Powder	6.85	2.65	2.06	1.02	1.25	0.43	0.01	0.01	--	0.2	.1065	35
84	--	--	Intended	6.8	2.7	2.0	3.0	3.0	1.0	--	--	--	--	--	29
84	A	307595	Powder	6.74	2.72	2.08	2.88	3.05	1.08	0.01	0.01	--	0.05	.1129	29
85	--	--	Intended	7.8	2.5	1.0	--	2.0	0.2	--	--	--	--	--	33
85	A	307596	Powder	7.58	2.55	1.14	0.02	2.16	0.00	0.01	0.01	--	0.08	.1060	33
86	--	--	Intended	7.8	2.5	1.0	--	4.0	0.2	--	--	--	--	--	36
86	A	307597	Powder	7.55	2.55	1.11	0.02	4.04	0.14	0.01	0.01	--	0.05	.1061	36
87	--	--	Intended	7.8	2.5	1.0	--	2.0	0.2	--	--	--	--	--	37
87	A	307598	Powder	7.58	2.52	1.06	0.02	2.16	0.16	0.01	0.01	--	0.05	.1043	37
88(c)	A	(c)	Intended	6.8	2.7	2.0	1.0	1.0	0.5	--	--	--	--	--	--
88	A	307599	Powder	--	--	--	--	--	--	--	--	--	--	--	--
89(c)	A	--(c)	Intended	7.8	2.5	1.0	--	2.0	0.2	--	--	--	--	--	--
89	A	307600	Powder	--	--	--	--	--	--	--	--	--	--	--	--
90	--	--	Intended	7.8	2.5	1.0	--	1.0	0.2	--	--	--	0.36	--	--
90	A	294013	Powder	7.52	2.44	1.00	0.01	1.08	0.20	0.00	0.00	--	0.02	.1030	44
90	A	294013(c)	Powder	7.74	2.44	1.01	--	0.96	0.20	0.01	--	--	0.06	.1027	41

(a) The HCl technique was modified depending on the alloying elements present.

(b) Density by pycnometer.

(c) Not prealloyed, but mixtures of elemental powders.

Table II

Properties of 2 in. Dia. Extrusions from Alloy Powders

Alloy No.	Ext. S-No.	Composition, % (b)							Powder Size μm - microns	Density lb/in. ³	Loca- tion	Ultra- sonic Rating (G.d)	Heat Treatment #1 (a)			Heat Treatment #2 (h)		
		Zn	Pb	Cu	Fe	Mn	Cr	Ti					T. S. ksi	Y. S. ksi	El. % in 4D	Y. S. ksi	Y. S. ksi	El. % in 4D
1	277373	9.9	3.5	1.1	0.5	-	-	-	44	.1028	Front Back Avg.	A+ A+ A+	106.8 107.2 107.0	104.2 (e)	2.1 2.1 2.1	88.6 83.4 76.0	88.6 (b)	0.0 1.6 0.8
2	277374	12.1	3.5	1.5	0.5	-	-	-	54	.1052	Front Back Avg.	A Failed	105.8 103.6 103.7	103.5 103.1 103.3	2.9 2.9 2.9	75.9 85.1 80.5	75.9 (b)	0.0 0.0 0.0
3	277375	12.3	4.0	1.6	0.5	-	-	-	27	.1052	Front Back Avg.	A+ A+ A+	106.7 105.6 106.2	104.0 103.1 103.6	1.4 0.7 1.1	84.3 90.9 87.8	84.3 (b)	0.0 (s)
4	277376	9.6	3.2	2.0	-	-	0.2	-	39	.1041	Front Back Avg.	A+ A+ A+	103.5 103.2 103.4	100.7 98.6 100.2	2.1 1.4 1.8	72.9 85.5 79.2	72.9 (b)	0.0 0.0 0.0
5	277377	10.3	2.9	2.1	1.8	-	0.1	-	37	.1062	Front Back Avg.	A+ A+ A+	103.8 107.4 105.6	101.0 103.7 102.4	1.4 1.4 1.4	70.6 88.9 80.3	70.6 (b)	0.0 0.0 0.0
6	277378	11.2	2.4	2.0	-	-	0.2	-	39	.1060	Front Back Avg.	A+ A+ A+	104.2 103.7 104.0	99.9 98.9 99.4	4.3 3.6 4.0	87.1 89.0 88.1	87.1 (b)	0.0 1.9 1.0
7	277379	7.9	3.4	1.5	-	2.5	2.0	-	26	.1058	Front Back Avg.	A+ A+ A+	106.4 106.2 106.3	101.6 101.6 101.6	1.4 1.4 1.4	83.1 95.9 88.5	83.1 (b)	0.0 1.9 1.0
8	277380	7.9	3.5	1.5	1.6	1.6	1.4	-	44	.1057	Front Back Avg.	A Split	104.6 107.5 106.1	101.5 102.7 102.1	0.7 2.1 1.4	84.8 89.4 87.1	84.8 (b)	0.0 0.0 0.0
9	277381	7.9	3.5	1.6	-	-	0.5	0.4	38	.1037	Front Back Avg.	A+ A+ A+	98.8 98.5 98.7	93.3 94.3 93.8	2.9 2.1 2.5	(1)41.4 80.5 80.5	(1)41.4 (b)	0.0 0.0 0.0

continued

Table II (Continued)

Alloy No.	Ext. S.No.	Composition, % (b)										Powder Size μm - Microns	Density lb/in. ³	Location	Ultra-sonic Rating (c,d)	Heat Treatment #1 (e)					Heat Treatment #2 (h)				
		Composition, % (b)														Longitudinal (c)					Transverse (e)				
		Zn	Mg	Cu	Fe	Pb	Al	Cr	Ti	Other	T.S. ksi					Y. S. ksi	El. g/in. ³	YS/Density x10 ⁴ in.	T.S. ksi	Y.S. ksi	El. g/in. ³	Y.S./Density x10 ⁴ in.	T.S. ksi	Y.S. ksi	El. g/in. ³
10	277382	7.9	3.5	1.5	-	-	-	2.1	0.9	V-1.7, Zr-0.6	39	.1065	Front Back Avg.	A	83.6 85.4 84.5	83.2 85.4 84.3	0.0 0.0 0.0	0.781 0.802 0.792	62.9 63.2 63.1	(b) (b) (b)	0.0 0.0 0.0				
11	277383	7.6	3.5	1.5	-	-	-	-	-	Co-1.4, Mo-1.6, W-0.5	37	.1047	Front Back Avg.	A+	97.8 97.5 97.7	94.2 95.2 94.7	0.7 0.7 0.7	0.900 0.909 0.904	71.3 80.3 75.8	(b) (b) (b)	0.0 0.0 0.0				
12	277384	7.8	3.5	1.6	0.6	0.5	0.6	0.5	0.4	V-0.4, Zr-0.6, Co-0.5, Mo-0.5, W-0.5	41	.1061	Front Back Avg.	A+	97.4 98.6 98.0	94.1 95.1 94.6	0.7 0.7 0.7	0.887 0.886 0.892	77.5 86.6 82.1	(b) (b) (b)	0.0 0.0 0.0				
13	277385	11.7	3.4	1.5	-	2.4	2.2	-	-	-	37	.1098	Front Back Avg.	A+	104.9 105.8 106.4	103.7 100.7 102.2	0.7 1.4 1.1	0.946 0.919 0.932	75.0 87.2 81.1	(b) (b) (b)	0.0 0.0 0.0				
14	277386	11.8	3.5	1.5	1.6	1.6	1.5	-	-	-	35	.1098	Front Back Avg.	A+	107.0 106.3 106.7	102.7 102.2 102.5	0.7 0.7 0.7	0.935 0.931 0.933	84.4 81.5 83.0	(b) (b) (b)	0.0 0.0 0.0				
15	277387	11.4	3.4	1.5	-	-	0.5	0.5	0.5	V-0.5, Zr-0.6	33	.1069	Front Back Avg.	A+	101.2 95.3 98.3	94.5 94.5 94.5	(e) 1.4 1.4	0.884 0.884 0.884	81.3 88.7 86.0	(b) (b) (b)	0.0 0.0 0.0				
16	277388	12.0	3.5	1.5	-	-	2.2	1.1	-	V-1.9, Zr-1.0	44	.1104	Front Back Avg.	A+	82.4 82.5 83.0	(f) (f) (f)	0.0 0.0 0.0	- - -	57.1 61.9 59.5	(b) (b) (b)	0.0 0.0 0.0				
17	277389	11.9	3.5	1.6	-	-	-	-	-	Co-1.5, Mo-1.1, W-0.5	41	.1082	Front Back Avg.	A+	100.2 101.7 101.0	96.9 97.9 97.4	0.7 0.7 0.7	0.896 0.905 0.900	79.4 81.8 80.6	(b) (b) (b)	0.0 0.0 0.0				
18	277390	11.7	3.4	1.5	0.6	0.5	0.6	0.5	0.5	V-0.4, Zr-0.6, Co-0.5, Mo-0.5, W-0.5	36	.1095	Front Back Avg.	A+	98.2 100.9 99.6	97.5 97.9 97.7	0.0 0.7 0.4	0.890 0.894 0.892	57.1 ⁽¹⁾ 71.8 71.8	(b) (b) (b)	0.0 0.0 0.0				
19	277391	7.5	3.0	1.7	-	-	-	-	-	-	42	.1018	Front Back Avg.	A+	101.9 100.6 101.3	95.9 94.7 95.3	6.4 7.9 7.2	0.942 0.930 0.936	84.1 87.5 85.8	(b) (b) (b)	0.0 1.9 1.0				
																			105.8	101.2	7.1	0.984			

Continued . . .

Table II (Continued)

Alloy No.	Ext. S.No.	Composition, % (b)										Powder Size μm - microns	Density, lb/in ³	Loca- tion	Ultra- sonic Rating (g.d)	Heat Treatment #1 (a)				Heat Treatment #2 (k)				
		Composition, % (b)														Longitudinal (c)		Transverse (c)		Longitudinal				
		Zn	Mn	Cu	Mo	Fe	Ni	Cr	Ti	Other	T. S. ksi					Y. S. ksi	El. % in 4D	YS/Density x10 ⁶ in.	T. S. ksi	Y. S. ksi	El. in 4D	YS/Density x10 ⁶ in.		
20	277392	7.6	3.6	2.3	-	-	-	-	-	-	43	.1021	Front Back Avg.	A+ A+		101.0 99.6 100.3	95.2 94.4 94.8	4.3 3.6 4.0	0.932 0.924 0.928	84.2 90.3 87.3	(b) (b) (b)	0.0 3.7 1.9	108.9 103.3 4.3	1.012
21	277393	7.9	5.6	7.4	-	-	-	-	-	-	42	.1053	Front Back Avg.	A+ A+		98.0 94.5 96.3	93.7 90.6 92.2	1.4 0.7 1.1	0.890 0.860 0.875	85.4 83.2 84.3	(b) (b) (b)	0.0 0.0 0.0		
22	277394	7.9	8.4	14.9	-	-	-	-	-	-	48	.1100	Front Back Avg.	Failed A		93.2 93.7 93.5	{f} {f} {f}	0.7 0.0 0.4	- - -	68.0 70.3 69.2	(b) (b) (b)	0.0 0.0 0.0		
23	277395	7.7	10.1	20.1	-	-	-	-	-	-	34	.1146	Front Back Avg.	None None		72.2 88.2 70.2	{f} {f} {f}	0.0 0.0 0.0	- - -	17.2 13.6 15.4	(b) (b) (b)	0.0 0.0 0.0		
24	277396	7.8	7.2	20.0	-	-	-	-	-	-	27	.1167	Front Back Avg.	A+ A+		79.1 83.6 81.5	{f} {f} {f}	0.0 0.0 0.0	- - -	74.5 82.4 78.5	(b) (b) (b)	0.0 0.0 0.0		
25	277397	-	10.6	2.4	-	-	-	-	-	-	39	.0940	Front Back Avg.	A+ A+		88.7 88.3 87.5	48.0 50.7 49.4	8.6 9.3 9.0	0.511 0.539 0.525	55.2 63.4 59.3	(b) (b) (b)	0.0 5.6 2.8		
26	277398	3.0	7.4	2.3	-	-	-	-	-	-	50	.0957	Front Back Avg.	A+ A+		89.2 87.6 88.4	50.5 49.2 49.9	8.4 7.9 7.2	0.528 0.514 0.521	60.1 60.4 60.3	(b) (b) (b)	5.6 5.6 5.6		
27	277399	6.9	3.9	2.3	-	-	-	-	-	-	39	.1014	Front Back Avg.	A+ A+		99.8 98.9 99.4	94.5 93.2 93.9	2.9 2.9 2.9	0.932 0.919 0.926	76.3 82.8 79.6	(b) (b) (b)	0.0 0.0 0.0		
28	277400	9.8	3.8	2.3	-	-	-	-	-	-	34	.1042	Front Back Avg.	A+ A+		102.7 101.2 102.0	99.9 97.7 98.6	2.9 2.1 2.5	0.959 0.938 0.948	89.0 89.2 89.1	(b) (b) (b)	0.0 1.9 1.0		
29	277401	13.7	4.3	2.3	-	-	-	-	-	-	42	.1069	Front Back Avg.	A+ A+		108.2 106.3 107.3	104.8 101.8 103.3	1.4 1.4 1.4	0.980 0.952 0.966	84.9 90.8 87.9	(b) (b) (b)	0.0 1.9 1.0		

continued . . .

Table II (Continued)

Alloy No.	Ext. S.No.	Composition, % (b)										Powder Size μm electrons	Density lb/in. ³	Loca- tion	Ultra- sonic Rating (G.D.)	Heat Treatment #1 (a)										Heat Treatment #2 (h)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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		Zn	Mn	Cu	Ni	Fe	Al	Cr	Ti	Other	T.S. ksi					Y.S. ksi	El. % in 4D	TS/Density x10 ⁶ lb.	T.S. ksi	Y.S. ksi	El. % in 4D	TS/Density x10 ⁶ lb.	T.S. ksi	Y.S. ksi	El. % in 4D	TS/Density x10 ⁶ lb.	T.S. ksi	Y.S. ksi	El. % in 4D	TS/Density x10 ⁶ lb.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
30	277402	9.9	14.6	-	-	-	-	-	-	-	27	.0941	Front Back Avg.	Split Split	67.9 64.2 66.1	57.1 56.9 57.0	2.1 1.4 1.8	0.607 0.605 0.606	56.9 (b) 55.5 (b) 56.2	0.0 0.0 0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

continued

Table II (Continued)

Alloy No.	Ext. 2-No.	Composition, % (b)							Powder Size μm - sieves	Density lb/in ³	Loca- tion	Ultra- sonic Rating (C.O.)	Heat Treatment #1 (a)				Heat Treatment #2 (κ)			
		Zn	Mg	Cu	Pb	Fe	Al	Cr	Ti	Other			T.S. Y.S. ksi	Y.S. ksi	El. % in 4D	Y.S. ksi	Y.S. ksi	El. % in 4D	Y.S. ksi	Y.S. ksi
40	277428	8.4	5.2	-	1.0	0.7	3.0	-	-	-	42	.1059	Front Back Avg.	A Failed	108.0 102.5 105.3	104.3 99.2 101.7	0.7 0.7 0.7	0.985 0.936 0.960	81.4 84.6 83.0	(g) (h) (g)
41	273040	8.0	4.6	-	-	-	2.9	-	-	-	28	.1027	Front Back Avg.	A+ A+	90.5 93.5 92.0	85.9 89.4 87.7	2.1 2.1 2.1	0.836 0.870 0.854	70.1 86.1 78.1	(f) (f) (f)
42	278041	7.6	3.9	-	-	-	2.0	-	-	-	32	.1022	Front Back Avg.	A+ A+	91.4 90.7 91.1	88.4 (f) (f)	0.7 0.0 0.4	0.885 - -	68.0 81.0 74.5	(e) (f) (f)
43	278241	12.0	4.7	0.9	0.9	-	-	0.20	-	2x-0.2	18	.1058	Front Back Avg.	A+ A+	104.6 103.6 104.1	101.1 99.9 100.5	0.9 1.4 1.2	0.957 0.946 0.952	73.9 86.1 81.0	(f) (f) (f)
44	278242	11.2	5.0	0.9	2.5	-	-	0.23	-	2x-0.9	20	.1072	Front Back Avg.	A+ A+	102.2 96.7 99.5	(f) (f) (f)	0.0 0.0 0.0	- - -	71.3 80.8 76.1	(f) (f) (f)
45	278243	11.7	4.6	0.9	3.0	-	-	0.75	-	2x-0.5	19	.1062	Front Back Avg.	A+ A+	98.5 104.0 101.3	(f) 100.5 101.3	0.0 0.7 0.4	- 0.929 -	76.3 81.7 79.0	(f) (f) (f)
46	278244	11.4	4.6	0.9	0.6	-	-	1.12	-	2x-1.0	23	.1069	Front Back Avg.	A+ A+	98.8 100.2 99.5	94.5 96.7 95.6	0.9 0.7 0.8	0.884 0.804 0.894	83.7 92.0 87.9	(f) (f) (f)
47	278245	9.8	4.2	0.4	2.1	1.6	4.6	-	-	-	27	.1101	Front Back Avg.	A+ A+	82.7 105.1 93.9	(f) (f) (f)	0.0 0.0 0.0	- - -	63.9 82.8 73.4	(f) (f) (f)
48	278246	15.2	4.9	-	1.8	-	-	-	-	-	23	.1078	Front Back Avg.	A+ A+	105.5 105.8 105.7	101.8 102.3 102.1	0.8 0.6 0.7	0.944 0.849 0.947	76.1 91.1 83.7	(f) (f) (f)
49	278247	14.8	4.9	1.8	1.7	-	-	-	-	-	21	.1095	Front Back Avg.	A+ A+	102.9 106.3 104.6	(f) (f) (f)	0.0 0.7 0.4	- 0.941 -	71.6 85.3 78.5	(f) (f) (f)

continued . . .

Table II (Continued)

Alloy No.	Ext. A-E	Composition, % (b)										Powder Size microns	Density lb/in. ³	Loca- tion	Ultra- sonic Rating (c, d)	Heat Treatment #1 (e)				Heat Treatment #2 (k)					
		Composition, % (b)														Heat Treatment #1 (e)				Heat Treatment #2 (k)					
		Zn	Al	Cu	Fe	Mn	Pb	Si	Cr	Other	T. S. ksi					Y. S. ksi	El. % in 4D	IS/Density x10 ⁶ in.	T. S. ksi	Y. S. ksi	El. % in 4D	IS/Density x10 ⁶ in.			
50	278246	9.8	4.0	0.8	1.1	1.0	1.3	0.01	0.01	-	22	.1068	Front Back Avg.	A+ A+	106.8 108.6 107.7	103.3 104.1 103.7	1.1 1.1 1.1	0.937 0.976 0.971	79.5 83.5 86.4	(f) (f) (f)	118.4 115.0 116.7	0.9 0.9 0.9	1.077		
51	278249	9.6	4.1	0.8	1.2	1.0	1.4	0.01	0.01	Co-1.3	22	.1074	Front Back Avg.	A+ A+	107.7 107.9 107.8	104.0 103.6 103.8	0.9 0.9 0.9	0.968 0.965 0.966	82.5 85.1 86.8	(f) (f) (f)	110.4 107.4 108.7	0.4 (g) 0.0 0.0	1.000		
52	278250	9.7	4.1	0.8	-	-	-	0.01	0.01	Co-1.4	22	.1048	Front Back Avg.	A+ A+	105.8 105.8 105.8	102.3 102.8 102.6	1.8 1.5 1.6	0.976 0.981 0.979	91.1 94.1 92.6	89.9 90.3 90.1	0.6 0.4 0.5	108.7 103.8 106.2	2.3 0.0 0.0	0.990	
53	278251	9.6	4.1	-	2.5	1.4	4.8	0.04	0.04	-	25	.1100	Front Back Avg.	A+ A+	95.9 101.7 98.8	(f) (f) (f)	0.0 0.0 0.0	- - -	57.0 86.4 86.4	(f) (f) (f)	99.8 110.3 109.2	(f) (f) (f)	0.0 0.0 0.0	---	
54	278252	9.5	4.0	1.4	2.9	1.6	0.9	0.05	0.04	-	23	.1085	Front Back Avg.	A+ A+	104.6 106.1 105.4	104.1 103.9 104.0	0.1 0.5 0.3	0.959 0.958 0.958	74.8 91.5 83.2	(f) (f) (f)	110.3 107.5 108.9	(f) (f) (f)	0.0 0.0 0.0	---	
55	278253	9.9	4.2	1.5	0.9	1.9	2.4	0.07	0.05	-	23	.1086	Front Back Avg.	A+ A+	105.1 106.9 106.0	101.6 102.4 102.0	0.7 0.6 0.7	0.935 0.943 0.943	69.9 86.8 78.4	(f) (f) (f)	109.2 107.5 111.5	(f) (f) (f)	0.0 0.0 0.0	0.995	
56	278254	9.8	4.3	1.7	2.0	-	2.5	0.11	0.07	-	22	.1080	Front Back Avg.	A+ A+	105.6 106.7 106.2	102.1 101.2 101.7	0.7 1.1 0.9	0.945 0.937 0.942	84.2 94.8 89.5	(f) (f) (f)	108.5 107.5 114.7	(f) (f) (f)	0.0 0.0 0.0	1.010	
57	278255	9.6	4.0	1.9	2.0	1.2	2.6	-	0.10	-	25	.1096	Front Back Avg.	A+ A+	104.9 107.2 106.1	104.3 103.3 103.8	0.4 (g) (g)	0.952 0.942 0.947	82.5 86.4 84.5	(f) (f) (f)	106.8 106.8 106.8	(f) (f) (f)	0.0 0.0 0.0	---	
58	278256	10.0	4.1	2.5	2.2	1.4	3.2	0.04	-	-	25	.1111	Front Back Avg.	A+ A+	102.3 104.6 103.5	(f) (f) (f)	0.0 0.0 0.0	- - -	59.4 85.8 85.8	(f) (f) (f)	106.8 106.8 106.8	(f) (f) (f)	0.0 0.0 0.0	---	
59	278257	10.2	3.9	1.6	1.6	1.0	4.1	-	-	-	26	.1083	Front Back Avg.	A+ A+	96.4 102.1 99.5	(f) (f) (f)	0.0 0.0 0.0	- - -	61.3 74.6 68.0	(f) (f) (f)	83.9 83.9 83.9	(f) (f) (f)	0.0 0.0 0.0	---	
60	283758	11.6	5.5	1.8	0.7	-	-	-	-	-	31	.1049	Front Back Avg.	A+	106.3 - -	104.2 - -	1.9 - -	0.993 - -	84.8 79.9 82.4	(f) (f) (f)	106.8 106.8 106.8	(f) (f) (f)	0.4 (f) 0.2 0.2	---	
61	283759	10.4	4.5	0.9	-	-	-	-	-	-	26	.1032	Front Back Avg.	A+	109.1 108.9 109.0	106.3 106.3 106.3	3.0 3.4 3.2	1.030 1.030 1.030	91.1 91.6 91.4	87.2 87.7 87.4	(g) (g) (g)	106.8 106.8 106.8	(f) (f) (f)	0.9 0.9 0.9	---

continued . . .

Table II (Continued)

Alloy No.	S-J-1	Composition, % (b)								Powder Size microns	Density lb/in. ³	Loca- tion	Ultra- sonic Rating (C, D)	Heat Treatment #1 (a)				Heat Treatment #2 (k)							
		Zn	Pb	Cu	Mn	Fe	Ni	Cr	Ti					Other	Longitudinal (c)		Transverse (c)		Longitudinal						
		T. S.	Y. S.	El. %	YS/Density	T. S.	Y. S.	El. %	YS/Density					T. S.	Y. S.	El. %	YS/Density	T. S.	Y. S.	El. %	YS/Density	T. S.	Y. S.	El. %	YS/Density
		ksi	ksi	in 4D	x10 ⁶ in.	ksi	ksi	in 4D	x10 ⁶ in.					ksi	ksi	in 4D	x10 ⁶ in.	ksi	ksi	in 4D	x10 ⁶ in.	ksi	ksi	in 4D	x10 ⁶ in.
62	307310	10.0	4.0	0.9	-	-	-	.01	.03	Co-0.8	42	.1036	Front	A+	106.6 (b)	2.9	-	95.6	116.2	113.7	2.1	1.097			
													Front		107.2 103.2	2.9	0.996	96.7							
													Back		107.9 (h)	2.6	-	92.7							
													Avg.		107.5 103.5	2.1	0.999	91.1							
															107.4 103.4	2.6	0.998	91.5							
63	307311	10.1	4.0	0.9	-	-	-	.01	.03	Co-2.3	50	.1043	Front	A+	101.6 (h)	0.0	-	73.2	113.7	107.7	0.4	1.030			
													Front		103.6 100.1	0.6	0.960	81.3							
													Back		104.8 (b)	0.8	-	77.9							
													Back		105.7 102.5	0.9	0.983	81.1							
													Avg.		103.9 101.2	0.6	0.971	78.4							
64	307312	8.9	4.1	0.9	-	-	-	.01	.03	Co-1.5	48	.1038	Front	A+	104.8 (h)	1.9	-	91.3	118.0	115.1	1.1	1.090			
													Front		105.5 101.0	2.8	0.973	94.1							
													Back		104.7 (h)	1.8	-	86.9							
													Back		104.3 100.9	1.4	0.972	92.3							
													Avg.		104.8 101.0	2.0	0.973	91.2							
65	307313	11.1	4.1	1.0	-	-	-	.01	.03	Co-1.6	43	.1052	Front	A+	108.1 (b)	1.9	-	84.6	118.7	116.2	0.9	1.104			
													Front		108.2 106.2	1.5	1.000	94.8							
													Back		107.6 (h)	1.2	-	87.3							
													Back		112.4 107.1	1.5	1.018	92.3							
													Avg.		109.3 106.2	1.5	1.010	89.8							
66	307314	10.0	3.6	0.9	-	-	-	.01	.03	Co-1.5	43	.1048	Front	A+	108.3 (h)	2.1	-	96.9	116.9	115.3	2.1	1.061			
													Front		108.5 104.5	2.0	0.997	91.5							
													Back		107.1 (h)	1.9	-	91.1							
													Back		108.0 106.8	2.9	1.010	93.7							
													Avg.		108.2 105.2	2.2	1.004	89.8							
67	307315	10.3	4.7	1.0	-	-	-	.01	.03	Co-1.6	47	.1035	Front	A+	104.8 (h)	1.6	-	87.9	112.4	107.6	1.4	1.040			
													Front		106.2 101.8	1.2	0.984	86.6							
													Back		106.8 (h)	2.9	-	81.7							
													Back		109.6 104.1	2.0	1.002	84.6							
													Avg.		107.3 103.0	1.9	0.996	85.2							

continued . . .

Table II (Continued)

Alloy No.	Ent. Size	Composition, % (b)										Powder Size No. 40 microns	Loca- tion	Ultra- sonic Rating (c, d)	Heat Treatment #1 (a)				Heat Treatment #2 (e)				
		Zn	Al	Cu	Fe	Mn	Si	Cr	Ti	Other	Longitudinal (c)				Transverse (c)		Longitudinal		Transverse				
											T. S. ksi				Y. S. ksi	YS/Density x10 ⁶ in.	T. S. ksi	Y. S. ksi	T. S. ksi	Y. S. ksi	YS/Density x10 ⁶ in.		
66	307319	9.9	3.9	1.5	-	-	-	.01	.03	Co-1.5	37	.1047	Front	A+	104.3 (b)	1.4	-	87.8 (b)	0.3(j)	114.8	110.0	1.6	1.051
													Front		106.5 (b)	1.4	-	86.8 (b)	0.4				
													Back		107.1 (b)	2.1	-	91.5 (b)	0.7				
													Avg.		106.6 (b)	1.5	-	87.3 (b)	0.4				
69	307317	9.8	4.1	0.6	-	-	-	.01	.03	Co-1.5	41	.1043	Front	A+	107.9 (b)	1.9	-	91.9 (b)	0.3(g)	120.8	116.5	1.2	1.117
													Front		108.4 (b)	1.8	-	93.3 (b)	0.4				
													Back		107.3 (b)	1.0	-	88.0 (b)	0.7				
													Avg.		111.9 (b)	1.5	-	84.0 (b)	0.4				
70	307318	10.6	4.6	1.3	-	-	-	.01	.03	Co-2.4	42	.1062	Front	A+	105.9 (b)	1.0	-	77.0 (b)	0	121.3	117.3	0.4	1.104
													Front		108.1 (b)	0.9	-	83.6 (b)	0				
													Back		109.2 (b)	0.6	-	91.0 (b)	0				
													Avg.		110.6 (b)	0.9	-	81.6 (b)	0				
71	307319	9.2	3.6	0.6	-	-	-	.01	.03	Co-0.8	40	.1030	Front	A+	106.9 (b)	3.9	-	94.6 (b)	1.3	115.3	112.0	3.6	1.087
													Front		110.1 (b)	2.3	-	93.3 (b)	0.7				
													Back		107.7 (b)	1.9	-	93.4 (b)	0.9				
													Avg.		110.6 (b)	4.3	-	86.9 (b)	0.2				
72	307320	10.1	4.1	0.9	-	-	-	.01	.03	Co-1.5, Si-0.4	35	.1044	Front	A+	104.9 (b)	1.5	-	94.9 (b)	0.7(j)	116.9	113.4	0.8	1.086
													Front		108.1 (b)	1.7	-	98.0 (b)	1.2				
													Back		105.9 (b)	0.8	-	91.6 (b)	0.6(j)				
													Avg.		110.1 (b)	1.4	-	88.6 (b)	0.3				
															107.2 (b)	1.4	-	93.3 (b)	0.7				
75	293184	7.1	2.8	2.0	-	-	1.0	4.7	0.3	-	31	.1071	Front	A+	101.4 (b)	0.6	-	89.6 (b)	0.7				
													Back		100.2 (b)	0.6	-	87.3 (b)	0.7				
													Avg.		100.8 (b)	0.6	-	88.4 (b)	0.7				
79	293188	6.8	2.8	2.1	1.0	-	-	0.5	-	0.1	24	.1037	Front	A+	97.2 (b)	3.9	-	84.8 (b)	3.4				
													Back		96.3 (b)	2.7	-	85.6 (b)	3.4				
													Avg.		96.8 (b)	3.3	-	85.2 (b)	3.4				

Table II (Continued)

Alloy No.	S.No.	Composition, % (b)										Powder Size MPD - microns	Density, lb/in. ³	Loca- tion	Ultra- sonic Rating (c,d)	Heat Treatment #1 (a)					Heat Treatment #2 (c)				
		Zn	Mg	Cu	Mn	Fe	Ni	Cr	Ti	Other	Longitudinal (c)					Transverse (c)			Longitudinal (c)		Transverse (c)				
											Y.S. ksi					Y.S. ksi	El. in 4D	YS/Density x10 ³ in.	T.S. ksi	Y.S. ksi	El. in 4D	T.S. ksi	Y.S. ksi	El. in 4D	
82	293191	6.9	2.7	2.1	2.9	-	7.1	1.3	-	0.5	2r	34	.1119	Front Back Avg.	A+	92.6 98.3 95.4	(f) (f) -	0 0 0	- - -	82.4 81.7 82.0	(f) (f) -	(g) (g) -			
83	293192	6.8	2.6	2.1	1.0	1.2	4.5	0.4	-	0.1	2r	35	.1080	Front Back Avg.	A+	101.2 99.7 100.4	96.6 95.6 96.1	0.6 0.6 0.6	0.894 0.885 0.890	96.9 86.5 91.7	91.7 (f) -	1.0 (g) -			
85	293194	7.6	2.6	1.1	-	2.2	4.8	0.0	-	-	-	33	.1075	Front Back Avg.	A+	88.5 88.2 88.4	83.7 83.4 83.6	1.7 1.3 1.5	0.779 0.776 0.777	81.5 81.1 81.3	76.0 75.8 75.9	1.3 1.2 1.3			
86	293195	7.6	2.6	1.1	-	4.0	2.1	0.1	-	-	-	36	.1076	Front Back Avg.	A+	107.4 106.8 107.1	101.3 100.9 101.1	1.3 0.7 1.0	0.941 0.938 0.940	88.5 94.9 91.7	(f) 91.0 -	0.3 0.6 0.4			
87	293196	7.6	2.5	1.1	-	2.2	2.3	0.2	-	-	-	37	.1058	Front Back Avg.	A+	104.1 103.7 103.9	99.1 99.3 99.2	1.7 1.0 1.4	0.937 0.928 0.938	97.6 92.2 91.9	91.3 92.2 91.8	1.5 0.7 1.1			
90	294014	7.5	2.4	1.0	-	1.1	1.0	0.2	-	-	-		.1044	Front Back Avg	A+	98.8 99.1 99.0	92.4 93.6 93.0	5.4 5.4 5.4	0.885 0.897 0.891	87.6 86.5 87.0	80.5 80.7 80.6	2.4 2.3 2.4			

(a) Heat Treatment #1 - SHT 2 hrs at 860°F, CWQ, aged 24 hrs at 250°F-2" dia.

(b) Based on analysis of powder or extrusion.

(c) One test per value of heat treated rod to Alloy 59. The tests from 60-90 are for an extruded material.

(d) A+ = met standards higher than Class A. A = met Class A Standards.
Failed = Class A standards not met. Split = rod cracked during CWQ.
None = not measured due to rough surface.

(e) Not measured.

(f) Failed before reaching 0.2% offset.

(g) Not obtained - specimen shattered.

(h) Strain follower not used to avoid breaking it.

(i) Data not included in average.

(j) Failed outside gauge length.

(k) Heat Treatment #2 - SHT 1/2 hr at 920°F, CWQ, aged 96 hrs at 225°F - 1" x 1" quadrants.

(l) S.No. 277645.

(m) S.No. 277646.

TABLE III

COMPOSITIONS IN VARIOUS PHASE FIELDS OF THE
Al-Zn-Mg-Cu SYSTEM AT 860°F (460°C)

Alloy No.	% Zn	% Mg	% Cu	Phase Field*
19	7.6	3.0	1.5	$\alpha + S + T + M$
20	7.9	3.6	2.3	$\alpha + S + T + M$
21	8.0	5.6	7.5	$\alpha + S + T + M$
22	8.0	8.5	15.0	$\alpha + S + T + M$
23	8.0	10.3	20.0	$\alpha + S + T + M$
24	8.0	7.5	20.0	$\alpha + S + Z + M$
25	---	10.8	2.3	$\alpha + S + T$
26	3.0	7.5	2.3	$\alpha + S + T$
27	7.0	4.0	2.3	$\alpha + S + T$
28	10.0	4.0	2.3	$\alpha + M + T$
29	14.0	4.4	2.3	$\alpha + M + T$
30	8.0	15.0	---	$\alpha + T$
31	3.0	15.0	2.3	$\alpha + T$

* Phase identification

α = Al

S = α (Al-Cu-Mg)

T = $\left\{ \begin{array}{l} \alpha(\text{Al-Mg-Cu}) \\ \text{Mg-Zn-Al} \end{array} \right\}$ isomorphous

M = $\left\{ \begin{array}{l} \beta(\text{Zn-Mg}) \text{ or } \text{MgZn}_2 \\ \gamma(\text{Al-Cu-Mg}) \end{array} \right\}$ isomorphous

= $\left\{ \begin{array}{l} \alpha(\text{Zn-Mg}) \\ \beta(\text{Al-Cu-Mg}) \end{array} \right\}$ isomorphous

TABLE IV

COMPARISON OF DENSITY OF POWDERS AND EXTRUSIONS

Alloy No.	S. No.	Location	Powder Density, gm/cc ^(b)	Extrusion Density, gm/cc ^(c)	Difference in Densities, gm/cc (ED-PD)	Variation in Density, % ((ED-PD)/ED)x100
39 (a)	283462	F	2.894	2.9304	.036	1.2
"	"	F	2.894	2.9315	.038	1.3
"	"	B	2.894	2.9298	.036	1.2
"	"	Avg.	2.894	2.9306	.037	1.2
50 (a)	283481	F	2.914	2.9465	.032	1.1
"	"	F	2.914	2.9459	.032	1.1
"	"	B (d)	2.914	2.9481	.034	1.2
"	"	Avg.	2.914	2.9468	.033	1.1
52 (a)	283492	F	2.858	2.8974	.039	1.3
"	"	F	2.858	2.8979	.040	1.4
"	"	B	2.858	2.8975	.038	1.3
"	"	Avg.	2.858	2.8970	.039	1.3
52 (e)	307454	F	2.855	2.9007	.046	1.6
"	"	FM	2.855	2.9005	.046	1.6
"	"	M	2.855	2.9010	.046	1.6
"	"	BM	2.855	2.8998	.045	1.6
"	"	B	2.855	2.8992	.044	1.6
"	"	Avg.	2.855	2.9001	.045	1.6
52 (e)	307455	F	2.855	2.8978	.043	1.5
"	"	B	2.855	2.8977	.043	1.5
"	"	Avg.	2.855	2.8978	.043	1.5
62 (e)	307321	F	2.830	2.8785	.048	1.7
"	"	B	2.830	2.8772	.047	1.6
"	"	Avg.	2.830	2.8778	.048	1.7
64 (e)	307323	F	2.833	2.8770	.044	1.5
"	"	B	2.833	2.8764	.043	1.5
"	"	Avg.	2.833	2.8767	.044	1.5
71 (e)	307330	F	2.813	2.8566	.044	1.5
"	"	FM	2.813	2.8567	.044	1.5
"	"	M	2.813	2.8568	.044	1.5
"	"	BM	2.813	2.8565	.044	1.5
"	"	B	2.813	2.8568	.044	1.5
"	"	Avg.	2.813	2.8567	.044	1.5

(a) Two in. dia. tensile specimens SHT 1/2 hr. at 920°F, CWQ, aged 96 hrs. at 225°F.

(b) By pycnometer method on powders. (PD)

(c) By water displacement method on a, d, and e. (ED)

(d) Two in. dia. broken tensile specimens SHT 2 hrs. at 860°F, CWQ, aged 96 hrs. at 225°F.

(e) One in. x 4-1/4 in. extruded slab in -F temper. Location of specimens in sketch below.

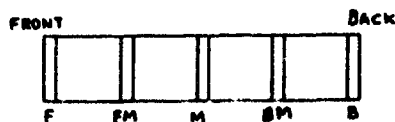


TABLE V
EFFECT OF HEAT TREATMENT CONDITIONS ON LONGITUDINAL TENSILE PROPERTIES (a) OF 2 IN. DIA. EXTRUDED ROD

S. No.	Composition, % (b)					SHT(c)		ARE	T.S.		El. % in SD	TS/Density x10 ⁵ in.
	Zn	Mn	Cu	Pb	Fe	Si	Cr		ksi	ksi		
277557	10.9	4.9	2.0	1.7	—	—	—	96 144 24	225 225 250	122.4 118.9 110.7	(d) 0.7 0.9	1.105 1.107 1.002
277426	8.4	3.6	—	1.0	.8	2.8	—	96 { 6 +48 24	225 200 225 250	118.5 115.8 118.8 112.3	1.0 0.9 (d)	1.081 1.076 1.024
277424	10.7	3.8	2.0	1.7	—	—	—	144 96 24	225 225 250	117.9 118.2 109.4	1.9 1.7 1.4	1.066 1.061 0.993
277401	13.7	4.3	2.3	—	—	—	—	96 144 24	225 200 250	118.1 117.4 108.2	0.8 1.4 1.4	1.062 1.058 0.980
277573	9.9	3.5	1.1	.5	—	—	—	96 144 24	225 200 225 250	112.6 109.5 112.9 109.4 106.8	2.1 2.7 2.7 2.1	1.065 1.064 1.064 1.014
277406	7.8	2.5	1.0	—	3.9	5.3	.2	96 96 24	225 250 250	112.3 (e) 109.7 104.4	0.3 0.4 0.7	— 0.982 0.941

(a) based on one tensile test on front of extrusion.
 (b) based on analysis of powder or extrusion.
 (c) quenched in cold water after solution heat treatment and before aging.
 (d) not obtained - specimen shattered.
 (e) specimen failed before reaching 0.2% offset.

TABLE VI

Alloy No.	Extr. S. No.	Composition, %					Density lb./in. ³	Compact Preheat		SHT (c)		Isentential				YS/Density x10 ⁵ in.
		Fe	Mn	Cu	Ni	Pb		Preheat		Time hr.	Temp. °F	Y.S.		El. % in 4D		
								hr.	°F			ksi	ksi			
36	277645	10.7	3.8	2.0	1.7	—	0.1076	.75	850	.5	920	118.5	115.9	1.1	1.077	
		10.7	3.8	2.0	1.7	—	"	.75	850	1.	920	118.6	115.0	(a)	1.069	
		10.7	3.8	2.0	1.7	—	"	.75	850	2.	920	118.2	115.2	0.3(b)	1.033	
38	277646	8.4	3.6	—	1.0	0.9	0.1071	1.5	850	.5	920	119.6	117.0	1.2	1.092	
		8.4	3.6	—	1.0	0.9	"	1.5	850	1.	920	119.4	116.9	1.3	1.091	
		8.4	3.6	—	1.0	0.9	"	1.5	850	2.	920	119.4	116.9	(a)	1.091	

Note: Each result represents one tensile test.

- (a) Not obtained. Specimen shattered.
(b) Specimen failed outside gage length.
(c) Quarter sections of 2 in. dia. rod fractured at 100,000 lb. load.

Table VII

EFFECT OF COOLING RATE ON TENSILE PROPERTIES

Alloy No.	S. No.	Composition, %						Compact Preheat Temp., °F	Heat Treatment		Specimen Size, in Dia.	Approx. (h) Cooling Rate, °F/Sec.	Longitudinal			Transverse			
		Zn	Mg	Cu	Mn	P	S		SWT T/T (s)	Quench (s)			Age T/T (s)	T.S., ksi	El., % in LD	Y.S./Density x 10 ⁶ in	T.S., ksi	El., % in LD	Y.S., ksi
A	277378	11.2	2.4	2.0	---	---	---	900	2/860	CMQ	2L/250 1x1(c) 2	350	108.4	104.9	4.3	0.990	---	---	
										CMQ		150	104.2	99.9	4.3	0.942	---	---	
B	277392	7.5	3.2	1.7	---	---	---	900	2/860	CMQ	2L/250 1x1 2	350	104.3	98.4	7.1	0.966	---	---	
										CMQ		150	101.9	95.9	6.4	0.942	---	---	
C	277392	7.8	3.6	2.3	---	---	---	900	2/860	CMQ	2L/250 1x1 2	350	104.3	99.9	4.3	0.978	---	---	
										CMQ		150	101.0	95.2	4.3	0.932	---	---	
D	277424	6.4	2.7	0.6	---	---	2.3	900	2/860	CMQ	2L/250 1x1 2	350	97.4	94.2	4.3	0.919	---	---	
										CMQ		150	96.8	92.4	5.7	0.901	---	---	
E	277938	10.6	4.4	2.0	1.7	---	---	550	2/860	CMQ	2L/250 1x1/5/16(d) 2	350/1500(d)	107.0	104.9	0.8	0.991	64.0	(e)	0
										CMQ		150	102.4	99.5	0.9	0.940	70.5	(e)	0
F	277939(f)									CMQ	1x1/5/16(d) 2	350/1500(d)	105.1	102.9	0.8	0.973	88.6	(e)	0
										CMQ		150	102.1	98.0	1.3	0.911	80.4	(e)	0.2
G	277938	8.2	3.3	---	1.1	---	3.0	850	2/860	CMQ	2L/250 1x1/5/16(d) 2	350/1500(d)	113.3	112.7	0.1	1.074	92.3	(e)	0
										CMQ		150	104.7	104.5	0.5	0.946	86.2	(e)	0
H	277937(f)									CMQ	1x1/5/16(d) 2	350/1500(d)	113.6	111.2	0.6	1.060	96.4	(e)	0
										CMQ		150	102.7	100.3	1.3	0.956	93.1	(e)	0
I	277936									CMQ	2L/250 1x1/5/16(d) 2	350/1500(d)	83.5	77.7	2.2	0.741	80.9	77.4	1.4
										CMQ		150	85.6	76.1	5.0	0.725	72.8	70.6	0.8
J	277937(f)									CMQ	1x1/5/16(d) 2	350/1500(d)	85.0	77.0	3.6	0.734	82.2	76.6	1.8
										CMQ		150	82.9	74.4	3.4	0.709	73.9	70.3	1.2
K	277938									CMQ	2L/250 1x1/5/16(d) 2	350/1500(d)	79.0	67.3	5.1	0.612	74.0	66.8	2.0
										CMQ		150	79.8	68.2	6.8	0.650	73.4	64.6	2.6
L	277937(f)									CMQ	1x1/5/16(d) 2	350/1500(d)	78.1	67.2	4.6	0.641	75.8	68.2	2.3
										CMQ		150	77.8	66.6	4.0	0.635	72.4	63.8	2.8
M	277938									CMQ	2L/250 1x1/5/16(d) 2	350/1500(d)	75.1	62.1	5.8	0.592	70.0	62.6	2.5
										CMQ		150	74.8	61.1	5.8	0.582	65.7	58.2	2.0
N	277937(f)									CMQ	1x1/5/16(d) 2	350/1500(d)	74.1	61.2	6.4	0.585	72.0	61.4	2.9
										CMQ		150	73.4	60.1	5.8	0.573	66.5	57.4	2.6
O	243462	10.9	4.9	2.0	1.0	---	---	950	0.5/920	CMQ	96/225 0.250 2	2000	122.5	120.2	0.8	1.133	---	---	---
										CMQ		150	112.8	120.2	0.0	1.053	---	---	---
P										SMQ	0.250 2	23	109.7	111.7	1.2	0.995	---	---	---
										A	0.250 2	0.21	99.6	105.6	1.4	0.870	---	---	---
										A			62.5	48.5	3.3	0.457	---	---	---

Continued

Table VII (continued)

EFFECT OF COOLING RATE ON TENSILE PROPERTIES

Alloy No.	S. No.	Composition, %					Compact Preheat Temp, °F		Heat Treatment		Specimen Size, in Dia.	Approx. Cooling Rate, °F/Sec.	Longitudinal		Transverse	
		Cu	Fe	Mn	P	S	°F	°F	SR	Quench			T.S., ksi	EL, in/in	T.S., ksi	EL, in/in
50	278217	11.0	4.9	1.8	1.7	---	---	---	0.5/920	CAQ 96/225	0.250	25,000	118.1	(e)	---	---
									CAQ	CAQ	0.250	2,000	121.3	(e)	---	---
									CAQ	CAQ	1x1	350	116.5	116.2	0.5	1.061
									CAQ	CAQ	2	150	112.9	(e)	0.0	---
50	283471	15.1	4.6	2.0	1.9	---	---	---	---	CAQ	0.250	2,000	106.7	101.2	0.8	0.724
									CAQ	CAQ	0.250	2,000	120.2	(e)	---	---
									CAQ	CAQ	0.250	25,000	127.5	124.4	(e)	---
									CAQ	CAQ	0.250	2,000	127.5	124.4	(e)	---
50	278218	9.8	4.0	0.8	1.1	0.1	1.0	1.3	0.01	CAQ	0.250	2,000	118.9	115.6	1.0	1.161
									CAQ	CAQ	0.250	500	118.9	115.6	1.0	1.083
									CAQ	CAQ	1x1	350	118.4	115.0	0.9	1.077
									CAQ	CAQ	0.250	23	102.0	94.8	2.0	0.888
50	283481	10.0	4.1	0.9	1.4	0.01	1.1	1.4	0.02	CAQ	0.250	1.7	91.9	81.5	4.0	0.763
									CAQ	CAQ	2	0.21	63.3	45.8	4.3	0.429
									CAQ	CAQ	0.250	150	115.3	109.0	(e)	1.020
									CAQ	CAQ	0.250	2,000	121.9	119.8	1.4	1.122
52	278250	9.7	4.1	0.8	---	0.01	---	---	0.01	CAQ	0.250	2,000	114.4	111.9	2.3	1.048
									CAQ	CAQ	0.250	150	108.2	103.9	1.4	0.973
									CAQ	CAQ	0.250	1.7	99.3	93.5	1.4	0.875
									CAQ	CAQ	2	0.21	63.6	51.6	2.4	0.485
52	278250	9.7	4.1	0.8	---	0.01	---	---	0.01	CAQ	0.250	25,000	124.8	123.0	2.4	1.174
									CAQ	CAQ	0.250	2,000	123.3	121.5	1.8	1.160
									CAQ	CAQ	0.250	500	117.9	114.9	1.4	1.008
									CAQ	CAQ	1x1	350	108.7	103.8	2.2	0.991
52	283491	10.0	4.0	0.9	---	0.01	---	---	0.02	CAQ	0.250	2,000	99.6	92.3	4.6	0.882
									CAQ	CAQ	0.250	1.7	89.4	80.9	6.0	0.773
									CAQ	CAQ	2	0.21	61.5	44.5	6.6	0.425
									CAQ	CAQ	0.250	2,000	124.0	121.6	2.8	1.163
52	283491	10.0	4.0	0.9	---	0.01	---	---	0.02	CAQ	0.250	2,000	115.4	111.2	(e)	1.062
									CAQ	CAQ	0.250	2,000	122.0	119.4	1.8	1.039
									CAQ	CAQ	0.250	150	115.1	111.1	1.9	1.060
									CAQ	CAQ	0.250	23	104.1	102.0	2.2	0.973
59	277931	10.2	3.9	1.6	1.6	---	---	---	---	CAQ	0.250	1.7	96.7	88.6	3.8	0.845
									CAQ	CAQ	2	0.21	61.9	46.0	8.6	0.439
									CAQ	CAQ	1x1/5/16(d)	350/1500(d)	87.8	(e)	0.0	---
									CAQ	CAQ	2	150	90.3	(e)	0	---
60	277931(f)								---	CAQ	1x1/5/16(d)	350/1500(d)	109.2	107.9	(e)	0.996
									CAQ	CAQ	2	150	101.5	102.9	0.3	0.950
									CAQ	CAQ	0.250	2,000	111.1	110.7	0.8	1.055
									CAQ	CAQ	0.250	150	107.9	---	0.3	---
60	283758	11.6	5.5	1.8	0.7	---	---	---	---	CAQ	0.250	2,000	105.5	103.9	0.9	0.990
									CAQ	CAQ	0.250	23	100.6	97.2	1.0	0.927
									CAQ	CAQ	0.250	1.7	58.1	47.2	2.2	0.450
									CAQ	CAQ	2	0.21	---	---	---	---
62	281759	10.4	4.5	0.8	---	---	---	---	---	CAQ	0.250	2,000	119.5	115.9	2.6	1.123
									CAQ	CAQ	0.250	150	114.9	111.0	2.9	1.076
									CAQ	CAQ	0.250	23	109.4	103.7	3.3	1.005
									CAQ	CAQ	0.250	1.7	98.4	91.1	4.6	0.883

NOTE: (a) Time in hours, T = temperature in °F
 (b) CAQ - Cold water spray quenched
 (c) CAQ - Cold water quench
 (d) CAQ - Boiling water quench
 (e) CAQ - Boiling water quench
 (f) CAQ - Boiling water quench
 (g) CAQ - Boiling water quench
 (h) CAQ - Boiling water quench

(d) Longitudinal processed as 1x1 quadrants, approx. cooling rate 350°F/sec.
 Transverse processed as 5/16" thick slices, approx. cooling rate 1500°F/sec.
 (e) Failed before reaching 0.25 offset
 (f) Classified powder - Fine fraction
 (g) Specimen shattered - Not determined
 (h) Approximate cooling rate from 750° to 550°F

Table VIII

TENSILE PROPERTIES OF APM EXTRUSIONS AT CRYOGENIC AND ELEVATED TEMPERATURES

Alloy No.	S-No.	Heat Treat Mo.(a)	-112°F		-180°F		75° (Room Temp.)			1/2 hr. at 212°F			1/2 hr. at 400°F		
			F.S. ksi	Y.S. ksi	F.S. ksi	Y.S. ksi	F.S. ksi	Y.S. ksi	in 4D	F.S. ksi	Y.S. ksi	in 4D	F.S. ksi	Y.S. ksi	in 4D
34	203442	2	-	-	-	-	109.8	109.1	0.0	96.8	(b)	48.4	40.4	17.7	
		-	-	-	-	103.5	(b)	0.0	93.5	(b)	47.7	36.7	14.9		
		AVG	-	-	-	-	106.7	-	0.0	95.4	-	48.1	38.6	16.3	
38	203452	2	-	-	-	-	115.6	111.3	(c)	100.4	97.0	46.4	39.8	21.1	
		-	-	-	-	112.9	112.2	0.0	104.5	100.2	45.6	41.8	22.9		
		AVG	-	-	-	-	114.6	111.8	-	102.5	98.6	46.0	40.8	22.0	
39	203462	2	-	-	-	-	112.2	112.2	0.0	105.7	102.8	56.4	51.9	9.7	
		-	-	-	-	113.4	111.2	0.0	108.6	104.0	55.7	51.4	19.4		
		AVG	-	-	-	-	112.8	111.7	0.0	107.2	103.4	56.1	51.7	14.6	
49	203472	3	-	-	-	-	107.0	104.7	0.0	99.9	95.0	50.8	48.0	22.3	
		2	-	-	-	-	108.2	(b)	0.0	103.3	102.2	55.9	52.1	10.7	
		AVG	-	-	-	-	103.5	(b)	0.0	107.3	106.1	55.6	52.6	13.1	
50	203483	3	-	-	-	-	105.9	-	0.0	105.3	104.2	55.8	52.4	11.9	
		2	-	-	-	-	111.0	107.7	0.6	99.5	97.9	51.6	47.7	10.9	
		AVG	-	-	-	-	114.7	112.7	0.0	106.4	104.0	54.2	52.1	12.0	
52	203493	2	-	-	-	-	114.0	111.1	0.6	104.7	101.5	54.7	51.8	15.4	
		2	-	-	-	-	114.4	111.9	0.3	105.6	102.8	54.5	52.0	13.7	
		AVG	-	-	-	-	116.2	112.5	2.3	105.1	102.1	48.5	47.7	23.4	
52	203494	2	124.6	122.2	2.0	120.2	119.2	2.0	109.8	103.7	4.0	56.3	52.8	16.0	
		2	126.2	126.2	1.0	119.8	117.2	2.0	(e) 106.6	101.2	5.0	53.2	50.9	17.5	
		AVG	125.4	124.2	1.5	120.0	118.2	2.0	116.7 (d) 108.2	102.4	4.5	54.8	51.8	19.0	
61	203759	2	-	-	-	-	114.1	110.1	2.2	105.5	102.9	52.4	50.6	18.3	
		2	-	-	-	-	115.7	111.5	3.5	104.7	102.3	51.3	50.8	21.7	
		AVG	-	-	-	-	114.9	111.0	2.9	105.1	102.6	51.9	50.7	20.0	
62	307310	2	125.2	124.2	2.0	121.2	119.2	2.0	106.1	101.8	7.0	53.1	49.9	22.0	
		2	124.6	124.2	2.0	122.2	120.2	2.0	117.5	(d) 107.4	5.0	53.1	51.5	23.0	
		AVG	124.9	124.2	2.0	121.7	119.7	2.0	116.8	113.7	6.0	53.1	50.7	22.5	
64	307312	2	123.2	122.2	(c)	119.2	117.1	2.0	106.0	101.4	5.0	51.0	47.5	26.0	
		2	122.2	122.2	2.0	118.1	116.1	3.0	118.0	113.1	1.1	50.6	46.0	28.0	
		AVG	122.7	122.2	2.0	118.6	116.6	2.5	117.1	113.1	1.5	50.8	46.8	27.0	
71	307319	2	123.6	123.2	3.0	117.1	116.1	4.0	103.6	99.2	10.0	48.0	46.1	26.0	
		2	125.2	125.2	2.0	118.1	116.1	3.0	113.7	100.4	11.0	47.2	44.2	24.0	
		AVG	124.4	124.2	2.5	117.6	116.1	3.5	114.4	112.0	3.6	47.6	45.2	25.0	
7075-76 (Extrusions)			97.0	91.0	8.0	93.0	86.0	9.0	83.0	78.0	42.0	40.0	18.0		
X2020-76			88.0	81.0	5.0	86.0	79.0	6.0	77.0	72.0	57.0	54.0	8.0		

(a) 81 S.N.T. 1/2 hr. 320°F, CWQ, 96 hrs. at 225°F.
 83 S.N.T. 2 hrs. 860°F, CWQ, 96 hrs. at 225°F.

(b) Failed before reaching 0.2% offset.

(c) Not obtained - specimen shattered.

(d) Not obtained.

(e) Not included in average.

Table IX

THE EFFECT OF TIME AT ELEVATED TEMPERATURE ON LONGITUDINAL TENSILE PROPERTIES OF ALLOY 52

S. No.	Heat Treatment No. (a)	Time at Temp.	212°F			400°F		
			T.S. ksi	Y.S. ksi	El. % in 4D	T.S. ksi	Y.S. ksi	El. % in 4D
283493 (b)	2	1/2	105.1 103.5	102.1 100.6	3.0 3.0	48.5 48.2	47.7 45.6	23.4 19.4
283494 (c)	2	1/2	109.8 106.6 106.2	103.7 101.2 101.9	4.0 5.0 3.8	56.3 53.2 51.6	52.8 50.9 49.2	16.0 19.0 19.4
AVG								
283497 (d)	2	1/2	106.4	103.9	1.14	47.9	43.8	22.1
283497 (d)	2	100	106.1	102.9	5.0 (f)	25.3	22.9	49.3
283497 (d)	1	1/2	97.2	93.9	7.9 (e)	46.2	41.5	22.9
283497 (d)	1	100	97.4	92.9	1.4	23.7	22.1	57.1
7075-T6		1/2 100	83.0 84.0	78.0 79.0	15.0 14.0	42.0 22.0	40.0 20.0	18.0 35.0
X2020-T6		1/2 100	77.0 78.0	72.0 73.0	9.0 9.0	57.0 38.0	54.0 34.0	8.0 15.0

(a) Heat Treatment #1 - SHT 2 hrs. at 860°F, CWQ, Aged 24 hrs. at 250°F.
Heat Treatment #2 - SHT 1/2 hr. at 920°F, CWQ, Aged 96 hrs. at 225°F.

(b) Compact preheat temperature 1000°F, 81% dense green compact.

(c) Compact preheat temperature 1050°F, 81% dense green compact.

(d) Compact preheat temperature 950°F, 74% dense green compact.

(e) Specimen fractured in three places.

(f) Reduced section splintered longitudinally.

Table X

IMPACT AND TEAR PROPERTIES OF APM MATERIAL

Alloy Number	Sample Number	H.T. No. (a)	Izod Impact Energy At Failure ft-lb (b)	Tear Test Unit Propagation Energy in.lb/in. ² (c)	
				Long.	Trans.
52	283492	2	1.0	-	-
	307454	1	-	0	0
	307455	1	-	0	0
	307454	2	-	0	0
	307455	2	-	0	0
62	307321	1	1.1	0	0
	307321	2	-	0	0
64	307323	1	1.1	0	0
	307323	2	-	0	0
71	307330	1	1.3	0	0
	307330	2	-	0	0
7178-T6	Typical	-	-	140 (d)	130 (d)
7075-T6 (e)	Typical	-	4.5	290 (d)	220 (d)
195-T6	Typical	-	2	-	-
356-T6	Typical	-	1	75 (e)	-

(a) H.T. #1, SHT 2 hrs. at 860°F, CWQ, Aged 24 hrs. at 250°F.
H.T. #2, SHT 1/2 hr. at 920°F, CWQ, Aged 96 hrs. at 225°F.

(b) Obtained from 2 in. dia. extrusions.

(c) .10 in. Thick rolled stock from 1" x 4-1/4" extrusions of alloys covered in this contract.

(d) Results of tear tests from 0.063 in. Al sheet.

(e) Unpublished data.

Table XI

COMPARISON OF TEAR TEST PROPERTIES AFTER STEP AGING

Alloy No.	S. No.	Heat Treatment	Test Specimen (b) Thickness in.	Y.S. ksi	Tear Strength ksi	Tear/Yield Ratio	Unit Energy in-lb/in ²	Product Tested
38	283451	#1	0.1000	108.2	20.8	0.19	65	Extrusion
	283451	#1A	0.1000	69.9	28.4	0.41	95	Extrusion
52	283490	#1	0.1002	105.6	29.1	0.28	100	Extrusion
	283490	#1B	0.0987	69.6	32.4	0.47	115	Extrusion
71	283387	#1C	0.1006	88.1	63.2	0.72	230	Extrusion
	293387	#1D	0.1010	71.1	44.4	0.62	120	Extrusion
7075 7075 7172	(c)	-T6	0.1000	74.7	65.0	0.87	300	Extrusion
	(c)	-T6	0.063	75.1	78.1	1.04	290	Sheet
	(c)	-T6	0.063	81.3	61.8	0.76	140	Sheet

Note: (a) Kahn Type Tear Test, Ref. 4

(b) #1 SHT 2 hours at 860°F, C₄₀, Aged 24 Hours at 250°F.

1A Age #2 18 Hrs. at 330°F

1B Age #2 24 Hrs. at 330°F

1C Age #2 3 Hrs. at 330°F

1D Age #2 20 Hrs. at 330°F

-T6 similar to #1 except SHT---870°F

(c) Specific test values from available data. Not to be considered as typical.

Table III

ELECTRICAL CONDUCTIVITY DATA

Alloy	S. No.	SHT (t)		Age (a)				TS ksi	YS ksi	EL, %	Electrical Conductivity, % IACS (c)
		t	T (°F)	t	T	t	T				
38	283451	2	860	24	250	--	---	112	108	1.2	< 25
38	283453	2	860	24	250	--	---	108	105	0.8	< 25
38	283453	2	860	24	250	2	330	97	93	2.1	25.9
38	283453	2	860	24	250	4	330	91	84	3.0	26.7
38	283453	2	860	24	250	8	330	87	80	3.0	27.6
38	283453	2	860	24	250	16	330	82	72	4.0	28.0
38	283451	2	860	24	250	18	330	82	70	4.0	29.3
38	283453	2	860	24	250	32	330	76	64	5.0	29.1
38	283453	2	860	24	250	48	330	73	61	5.5	29.6
38	283453	2	860	24	250	1	350	93	87	2.5	26.3
38	283453	2	860	24	250	2	350	88	82	2.5	27.3
38	283453	2	860	24	250	4	350	84	75	4.0	27.7
38	283453	2	860	24	250	8	350	79	68	4.5	28.5
38	283453	2	860	24	250	12	350	76	64	5.5	28.9
39	283460	2	860	24	250	--	---	107	104	1.3	< 25
39	283460	2	860	24	250	6	330	81	71	1.8	27.8
39	283460	2	860	24	250	32	330	73	62	2.3	28.7
39	283460	2	860	24	250	48	330	74	61	4.0	29.2
39	283460	2	860	24	250	4	350	82	75	1.8	27.3
39	283460	2	860	24	250	8	350	79	68	3.0	28.2
39	283460	2	860	24	250	12	350	77	65	3.5	28.7
49	283471	2	860	24	250	--	---	107	104	1.0	< 25
49	283471	2	860	24	250	16	330	81	77	2.1	28.2
49	283471	2	860	24	250	32	330	75	67	3.0	29.3
49	283471	2	860	24	250	48	330	72	63	3.0	29.8
49	283471	2	860	24	250	4	350	84	78	1.5	27.4
49	283471	2	860	24	250	8	350	71	66	1.4	28.7
49	283471	2	860	24	250	12	350	71	66	2.4	29.3
50	283480	2	860	24	250	--	---	100	96	1.5	< 25
50	283480	2	860	24	250	16	330	85	77	1.6	27.9
50	283480	2	860	24	250	32	330	78	70	2.4	29.0
50	283480	2	860	24	250	48	330	74	66	2.0	29.2
50	283480	2	860	24	250	4	350	85	79	1.9	27.4
50	283480	2	860	24	250	8	350	80	73	2.4	28.2
50	283480	2	860	24	250	12	350	78	69	2.4	28.8
52	307454(b)	2	860	24	250	--	---	100	95	2	28.6
52	307455(b)	2	860	24	250	--	---	103	98	2	28.2
52	283490	2	860	24	250	--	---	109	106	2.9	28.9
52	283496	2	860	24	250	--	---	107	105	2.6	28.2
52	283496	2	860	24	250	2	330	95	93	1.9	31.5
52	283496	2	860	24	250	4	330	94	90	4.2	32.5
52	283496	2	860	24	250	8	330	91	84	6.5	33.8
52	283496	2	860	24	250	16	330	84	76	6.5	34.7
52	283490	2	860	24	250	24	330	79	70	6.0	36.2
52	283496	2	860	24	250	32	330	77	68	6.0	36.0
52	283496	2	860	24	250	48	330	73	64	7.0	36.7
52	283496	2	860	24	250	1	350	95	90	5.0	32.1
52	283496	2	860	24	250	2	350	91	85	5.0	33.1
52	283496	2	860	24	250	4	350	85	77	6.5	34.1
52	283496	2	860	24	250	8	350	80	70	8.0	35.1
52	283496	2	860	24	250	12	350	77	66	8.0	36.1
52	307454(b)	0.5	920	96	225	--	---	96	---	---	27.6
52	307455(b)	0.5	920	96	225	--	---	102	97	2	28.6
62	307321(b)	2	860	24	250	--	---	104	97	3	28.4
62	307321(b)	0.5	920	96	225	--	---	79	---	---	27.3
64	307323(b)	2	860	24	250	--	---	96	90	2	27.4
64	307323(b)	0.5	920	96	225	--	---	83	---	---	26.3
71	307330(b)	2	860	24	250	--	---	100	94	4	29.2
71	293387	2	860	24	250	--	---	108	103	4.5	31.0
71	293387	2	860	24	250	2	300	103	100	5.2	32.1
71	293387	2	860	24	250	4	300	101	98	5.8	32.5
71	293387	2	860	24	250	8	300	99	95	6.5	33.5
71	293387	2	860	24	250	24	300	91	86	7.8	35.4
71	293387	2	860	24	250	48	300	86	79	9.2	36.8
71	293387	2	860	24	250	2	330	97	93	6.0	33.6
71	293387	2	860	24	250	4	330	93	88	8.0	34.6
71	293387	2	860	24	250	8	330	87	81	9.2	36.3
71	293387	2	860	24	250	16	330	82	74	9.5	37.4
71	293387	2	860	24	250	32	330	76	66	11.2	38.7
71	293387	2	860	24	250	48	330	73	62	11.5	39.2
71	307330(b)	0.5	920	96	225	--	---	98	93	3	29.0
7075-T651 (d)(e)		--	---	--	---	--	---	88	80	11	32.0
7178-T651 (d)(e)		--	---	--	---	--	---	92	84	8	32.5

NOTE:

- (a) t = time in hours, T = temperature in °F.
 (b) Data from 1" x 4-1/4" extrusions rolled to sheet. All other tests - 2" diameter.
 (c) Reading taken midway between edge and center.
 (d) Typicals from R. R. Sons 3/23/65, 2 to 3 inch diameter extrusions.
 (e) Typicals from C. F. Babilon 4/5/66, plate and rolled rod.
 (f) Quenched in cold water immediately after SHT

Table XIII

EFFECT OF DISPERSOIDS ON TENSILE PROPERTIES

REF. TABLE II HEAT TREATMENT NO. 1

Alloy	Composition			Zn	Mg	Cu	Longitudinal		
	Dispersoids	Wt. %	Total				T.S., ksi	Y.S., ksi	EL. % in 4D
90	1.1 Fe, 1.0 Ni,	(0.9 Ni/Fe)	2.1	7.5	2.4	1.0	99	93	5.4
87	2.2 Fe, 2.3 Ni,	(1.0 Ni/Fe)	4.5	7.6	2.5	1.1	104	99	1.4
86	4.0 Fe, 2.1 Ni,	(0.5 Ni/Fe)	6.1	7.6	2.6	1.1	107	101	1.0
85	2.2 Fe, 4.8 Ni,	(2.2 Ni/Fe)	7.0	7.6	2.6	1.1	88	84	1.5
34	3.9 Fe, 5.3 Ni,	(1.4 Ni/Fe)	9.2	7.8	2.5	1.1	106	105	0.7
19	-----		0	7.5	3.0	1.7	101	95	7.2
9	0.5 Cr, 0.4 V, 0.4 Zr, 0.4 Ti		1.7	7.9	3.5	1.6	99	94	2.5
11	1.4 Co, 1.6 Mo, 0.5 W,		3.5	7.6	3.5	1.5	98	95	0.7
8	1.6 Mn, 1.6 Fe, 1.4 Ni,		4.3	7.9	3.5	1.5	106	102	1.4
7	2.5 Fe, 2.0 Ni,		4.5	7.9	3.4	1.5	106	102	1.4
12	0.6 Mn, 0.5 Fe, 0.6 Ni, 0.5 Cr, 0.4 Ti,								
	0.4 V, 0.6 Zr, 0.5 Co, 0.5 Mo, 0.5 W		4.8	7.8	3.5	1.6	98	95	0.7
10	2.1 Cr, 0.9 Ti, 1.7 V, 0.9 Zr,		5.6	7.9	3.5	1.5	84	84	0.0
62	0.8 Co,		0.8	10.0	4.0	0.9	107	103	2.6
52	1.4 Co,		1.4	9.7	4.1	0.8	106	103	1.8
63	2.3 Co,		2.3	10.1	4.0	0.9	104	101	0.6
68	1.5 Co,		1.5	9.9	3.9	1.5	106	101	1.6
57	2.0 Mn, 1.2 Fe, 2.6 Ni, 0.1 Ti,		5.5	9.6	4.0	1.9	106	164	0.4
28	-----		0						
58	2.2 Mn, 1.4 Fe, 3.2 Ni,		6.5	9.8	3.8	2.3	102	99	2.5
				10.0	4.1	2.5	104	--	0.0
46	0.6 Mn, 1.1 Cr, 1.0 Zr,		2.4	11.4	4.6	0.9	100	96	0.8
45	3.0 Mn, 0.8 Cr, 0.5 Zr,		4.0	11.7	4.6	0.9	101	100	0.4

Table XIV

COMPARISON OF ALLOY TYPES WITH RESPECT TO ELONGATION

REF: TABLE II, HEAT TREATMENT NO. 1

Y.S./p	Elongation, % (Alloy No.)	
	Precipitation Alloys	Dispersion & Precipitation Alloys
1.03 x 10 ⁶	3.2 (61)	---
1.02	---	3.1 (71)
1.02	---	0 (38)
1.01	2.1 (1)	1.8 (33)
1.01	---	1.6 (69)
1.01	---	1.5 (65)
1.00	---	2.6 (62)
1.00	---	2.2 (66)
1.00	---	1.9 (67)
0.99	1.1 (3)	1.9 (60)
0.99	---	1.4 (36)
0.99	---	1.4 (99)
0.99	---	0.8 (39)
0.99	---	0.8 (70)
0.99	---	0 (35)
0.98	2.9 (2)	1.8 (52)
0.97	1.8 (4)	2.0 (64)
0.97	1.4 (29)	1.6 (68)
0.97	---	1.4 (8)
0.97	---	1.1 (50)
0.97	---	0.9 (51)
0.97	---	0.6 (63)
0.96	---	1.4 (5)
0.96	---	1.4 (7)
0.96	---	0.7 (34)
0.96	---	0.7 (40)
0.96	---	0.3 (54)
0.95	2.5 (28)	1.2 (43)
0.95	---	0.7 (48)
0.95	---	0.7 (55)
0.94	7.2 (19)	1.4 (87)
0.94	4.0 (6)	1.0 (86)
0.94	---	0.9 (56)
0.94	---	0.0 (57)
0.93	4.0 (20)	1.1 (13)
0.93	2.9 (27)	0.7 (14)

TABLE XV

EFFECT OF COMPACT PREHEAT TIME AND TEMPERATURE
LONGITUDINAL TENSILE PROPERTIES (2)

ALLOY (1)	S. No.	COMPACT PREHEAT		HEAT TREATMENT #1			HEAT TREATMENT #2		
		Time Hr.	TEMP. °F.	T.S. ksi	Y.S. ksi	EL. %	T.S. ksi	Y.S. ksi	EL. (%)
36	278038	1.25	750	99.9	97.2	1.2	56.4(d)	(c)	(b)
	278042	21.5	750	103.4	100.4	1.4	113.6	113.3	(b)
	277644	.25	850 (a)	102.1	97.4	1.9	110.5	107.9	(b)
	277645	.75	850 (a)	105.9	102.1	1.4	118.5	115.9	1.1
	277424	12	900	109.4	106.9	1.4	-	-	-
38	278039	2.25	750	106.5	105.0	0.7	117.7	117.2	(b)
	278043	22.25	750	107.9	104.4	1.6	119.5	118.4	(b)
	277646	1.5	850 (a)	111.1	108.4	1.0	119.6	117.0	1.2
	277647	4	850 (a)	109.9	106.9	1.8	117.4	115.7	(b)
	277426	12	900	112.3	109.7	(b)	-	-	-

Notes: (1)

ALLOY	Zn	Mg	Cu	Mn	Fe	Ni
36	10.7	3.8	2.0	1.7	--	--
38	8.4	3.6	-	1.0	0.8	2.8

(2) Each result represents one test

(3) Thermal Treatments:

#1 Pieces 2" dia. x 6.5" long from front of extrusion solution heat treated 2 hrs at 860°F, CWQ, aged immediately 24 hrs. at 250°F (H.T. #1)

#2 Quadrants of 2" dia. rod x 4.75" long were solution heat treated .5 hr at 920°F, CWQ, and aged immediately 96 hrs at 225°F (H.T. #2)

- (4)
- (a) Compact extruded without hot pressing against a blind die
 - (b) Not obtained. Specimen shattered
 - (c) Not obtained. Specimen failed before reaching 0.2% offset
 - (d) Melting occurred during solution heat treatment

Table XVI

EFFECT OF DIE QUENCHING ON TENSILE PROPERTIES

S. No.	Alloy	Composition %				Compact Preheat Hr	Quench	Thermal Treat- ment (a)	Longitudinal		
		Zn	Mg	Cu	Mn	Fe	Ni		T.S. ksi	Y.S. ksi	El. in LD %
278180	36	10.7	3.8	2.0	1.7	---	---	.75 920	Die	A	100.3 95.2 1.0
277424	36	10.7	3.8	2.0	1.7	---	---	12. 900	CWQ	B	109.4 106.9 1.4
278181(b)	38	8.4	3.6	---	1.0	.8	2.8	1.75 920	Die	A	102.8 99.5 0.7
277426	38	8.4	3.6	---	1.0	0.8	2.8	12. 900	CWQ	B	112.3 109.7 (c)

NOTE: Each result represents one tensile test

(a) Thermal treatment to -T6 temper as follows:

A. Pieces from middle of die quenched 2" dia. extrusion was aged 24 hrs. at 250°F

B. Pieces from front of 2" dia. extrusion was solution heat treated 2 hrs. at 860°F, CWQ, and aged 24 hrs. at 250°F

(b) Extruded with 7075 alloy leader

(c) Not obtained. Specimen shattered

Table XVII

EFFECT OF POWDER SIZE ON LONGITUDINAL TENSILE PROPERTIES

Alloy	S. No.	Compact Preheat		Powder Size (φ)	Heat Treatment #1			Heat Treatment #2		
		Time Hr.	Temp. °F.		T.S. ksi	Y.S. ksi	HL %	T.S. ksi	Y.S. ksi	HL %
34	277938	5.5	850 (a)	14	95.4	95.2	0.5	108.1	106.3	(c)
	277939	2.5	850 (a)	5	94.5	92.2	0.6	110.4	109.4	(c)
38	277936	2.75	850 (a)	13	101.5	100.5	0.6	113.1	112.6	(c)
	277937	1.75	850 (a)	6	100.5	97.7	1.1	109.1	105.2	(c)
59	277934	2.00	850 (a)	15	90.9	(b)	0.4	91.9	(b)	(c)
	277935	1.00	850 (a)	6	90.4	(b)	0.4	107.4	(b)	(c)

Notes: (1) Composition:

Alloy	Zn	Mg	Cu	Mn	Fe	Ni
36	10.6	4.4	2.0	1.7	-	-
38	8.2	3.3	-	1.1	1.1	3.0
59	10.2	3.9	1.6	1.6	1.0	4.1

(2) Each result represents one tensile test.

- (3) a. Compact extruded without hot pressing against blind die.
 b. Not obtained. Specimen failed before reaching 0.2% offset.
 c. Not obtained. Specimen shattered.
 d. Thermal treatment as follows:

#1 Pieces 2" dia. x 6.5" long from front of extrusions were solution heat treated 2 hrs at 860°F, CWQ, and aged immediately 24 hrs at 250°F.

#2 Quarter sections of 2" dia. rod x 4.75" long were solution heat treated .5 hr at 920°F, CWQ, and aged immediately 96 hrs at 225°F.

e. Microns, by Fisher SSS.

Table XVIII

EFFECT OF POWDER SIZE ON TRANSVERSE TENSILE PROPERTIES

Alloy	S. No.	Time Hr.	Compact Preheat Temp. ° F.	Powder Size (d)	2" Dia. x 6.5" Long (c)			2" Dia. x .31" Long (c)		
					T.S.	Y.S.	HL	T.S.	Y.S.	HL
					kai	kai	g	kai	kai	g
36	277938	3.5	850 (a)	14	70.5	(b)	0.0	64.0	(b)	0
	277939	2.5	850 (a)	5	80.4	(b)	0.2	88.6	(b)	0
38	277936	2.75	850 (a)	13	86.2	(b)	0.0	92.3	(b)	0
	277937	1.75	850 (a)	6	93.1	(b)	0.0	96.4	(b)	0
59	277934	2.00	850 (a)	15	64.6	(b)	0.0	61.2	(b)	0
	277935	1.00	850 (a)	6	85.0	(b)	0.0	91.5	(b)	0

Notes: (1) See Section II, Table VIII for details
(2) Composition:

Alloy	Zn	Mg	Cu	Mn	Fe	Ni
36	10.6	4.4	2.0	1.7	-	-
38	8.2	3.3	-	1.1	1.1	3.0
59	10.2	3.9	1.6	1.6	1.0	4.1

- (3) (a) Compact extruded without pressing against blind die
(b) Failed before reaching 0.2% offset
(c) Specimens of indicated size solution heat-treated 2 hrs @ 860°F, C&Q, aged immediately for 24 hrs at 250°F.
(d) Microns, by Fisher 5SS.

Table XIX

EFFECT OF HEAT TREATMENT AND AGING ON TENSILE PROPERTIES OF EXTRUSIONS (b)

Longitudinal Properties	Alloy 52 S-No. 282494		Alloy 62 S-No. 307310		Alloy 64 S-No. 307312		Alloy 71 S-No. 307319	
	Front	Back	Front	Back	Front	Back	Front	Back
	Heat Treatment #2 S.H.T. 1/2 hr at 920°F, CWQ, Aged 96 hrs at 225°F		Heat Treatment #3 S.H.T. 2 hrs at 860°F, CWQ, Aged 96 hrs at 225°F		Heat Treatment #4 S.H.T. 2 hrs at 830°F, CWQ, Aged 96 hrs at 225°F (f)		Heat Treatment #5 S.H.T. 2 hrs at 830°F, CWQ, Aged 48 hrs at 250°F	
T.S., ksi	116.6	81.7(c)	116.6	116.8(g)	116.8	117.1(g)	117.1	114.4(g)
Y.S., ksi	112.2	(a)	112.2	113.7	113.7	113.1	113.1	112.0
El., % In LD	1.4	0.0(c)	1.4	2.1	2.1	1.5(g)	1.5	3.6
Y.S./Density, x 10 ⁶ in.	1.072	-	1.072	1.097	1.097	1.090	1.090	1.087
	Heat Treatment #6 S.H.T. 2 hrs at 860°F, CWQ, Aged 96 hrs at 225°F		Heat Treatment #7 S.H.T. 2 hrs at 830°F, CWQ, Aged 96 hrs at 225°F (f)		Heat Treatment #8 S.H.T. 2 hrs at 830°F, CWQ, Aged 48 hrs at 250°F		Heat Treatment #9 S.H.T. 2 hrs at 830°F, CWQ, Aged 24 hrs at 250°F	
T.S., ksi	-	-	112.2(g)	-	112.2	109.6(g)	109.6	114.7
Y.S., ksi	-	-	110.3	-	110.3	107.4	107.4	111.4
El., % In LD	-	-	1.8(g)	-	1.8	1.1(g)	1.1	2.4
Y.S./Density, x 10 ⁶ in.	-	-	1.065	-	1.065	1.035	1.035	1.082
	Heat Treatment #10 S.H.T. 2 hrs at 830°F, CWQ, Aged 96 hrs at 225°F (f)		Heat Treatment #11 S.H.T. 2 hrs at 830°F, CWQ, Aged 48 hrs at 250°F		Heat Treatment #12 S.H.T. 2 hrs at 830°F, CWQ, Aged 24 hrs at 250°F		Heat Treatment #13 S.H.T. 2 hrs at 830°F, CWQ, Aged 6 hrs at 250 + 8 hrs at 330°F	
T.S., ksi	103.2	107.1	91.6(c)	107.1	107.1	106.2	105.9	106.0
Y.S., ksi	103.2	103.4	89.6(c)	104.9	104.9	103.5	103.2	103.4
El., % In LD	0.9	2.9	1.4(bc)	2.9	2.9	2.1	4.0	3.0
Y.S./Density, x 10 ⁶ in.	0.986	0.990	0.865(c)	1.012	1.012	0.997	0.994	0.996
	Heat Treatment #14 S.H.T. 2 hrs at 830°F, CWQ, Aged 48 hrs at 250°F		Heat Treatment #15 S.H.T. 2 hrs at 830°F, CWQ, Aged 24 hrs at 250°F		Heat Treatment #16 S.H.T. 2 hrs at 830°F, CWQ, Aged 6 hrs at 250 + 8 hrs at 330°F		Heat Treatment #17 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F	
T.S., ksi	103.4	104.2	88.9(c)	105.2	105.2	105.2	88.1(c)	105.2
Y.S., ksi	101.0	101.8	(a,c)	103.2	102.5	102.5	(a,c)	102.5
El., % In LD	2.8	3.0	(b,c)	4.1	4.1	3.0	(b,c)	3.7
Y.S./Density, x 10 ⁶ in.	0.965	0.972	-	0.996	0.996	0.987	-	0.987
	Heat Treatment #18 S.H.T. 2 hrs at 830°F, CWQ, Aged 24 hrs at 250°F		Heat Treatment #19 S.H.T. 2 hrs at 830°F, CWQ, Aged 6 hrs at 250 + 8 hrs at 330°F		Heat Treatment #20 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F		Heat Treatment #21 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F	
T.S., ksi	102.7	103.0	103.2	105.4	104.3	102.4	102.7	102.6
Y.S., ksi	100.0	100.5	100.5	102.9	101.7	99.8	99.5	99.6
El., % In LD	2.7	3.0	3.0	3.3	3.2	3.8	2.9	3.4
Y.S./Density, x 10 ⁶ in.	0.955	0.960	0.970	0.993	0.982	0.961	0.958	0.960
	Heat Treatment #22 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 250 + 8 hrs at 330°F		Heat Treatment #23 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F		Heat Treatment #24 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F		Heat Treatment #25 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F	
T.S., ksi	90.5	91.2	91.3	91.8	91.6	91.7	91.8	91.8
Y.S., ksi	87.1	87.6	86.6	87.1	86.8	86.5	86.9	86.7
El., % In LD	5.8	5.6	7.7	6.2	7.0	6.6	7.0	6.8
Y.S./Density, x 10 ⁶ in.	0.832	0.837	0.836	0.841	0.838	0.833	0.837	0.835
	Heat Treatment #26 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F		Heat Treatment #27 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F		Heat Treatment #28 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F		Heat Treatment #29 S.H.T. 2 hrs at 860°F, CWQ, Aged 6 hrs at 225°F + 8 hrs at 350°F	
T.S., ksi	84.2	83.7	83.3	84.7	84.0	84.1	85.1	84.6
Y.S., ksi	78.2	77.4	76.5	78.0	77.2	76.2	77.2	76.7
El., % In LD	7.1	6.8	8.8	9.3	9.0	8.0	7.3	7.6
Y.S./Density, x 10 ⁶ in.	0.747	0.739	0.738	0.753	0.745	0.734	0.744	0.739

(a) Failed before reaching 0.1% offset.
 (b) Failed through gage mark.
 (c) Premature failures - not included in average.
 (d) Average of 3 values.
 (e) Specimen shattered.
 (f) Letters assigned non standard heat treatments for ease in reference.
 (g) Average 2 values.
 (h) Heat treated as quadrants.

TABLE IX
TENSILE PROPERTIES OF ALLOYS CONTAINING DECREASING AMOUNTS OF
IRON AND NICKEL AND GIVEN VARIOUS AGING TREATMENTS

Alloy No. (a)	S.No.	Heat Treatment (M)			Longitudinal (b)			Transverse (b)		
		T _h	T _q	T _h	YS ksi	TS ksi	EL in in.	YS ksi	TS ksi	EL in in.
34	(c)	2	860	24	250	106.5 (d)	0.7 (d)	103.1 (d)	90.7 (d)	0.7 (d)
AVE					106.5 (d)	106.5 (d)	0.7 (d)	103.1 (d)	90.7 (d)	0.7 (d)
87	293196	2	860	24	250	103.6 (e)	0.7 (e)	94.5 (e)	90.5 (e)	0.7 (e)
AVE					103.6 (e)	103.6 (e)	0.7 (e)	94.5 (e)	90.5 (e)	0.7 (e)
90	294014	2	860	24	250	103.7 (e)	0.7 (e)	97.9 (e)	92.2 (e)	0.7 (e)
AVE					103.7 (e)	103.7 (e)	0.7 (e)	97.9 (e)	92.2 (e)	0.7 (e)
79	293188	2	860	24	250	98.8 (e)	0.6 (e)	92.4 (e)	89.2 (e)	0.6 (e)
AVE					98.8 (e)	98.8 (e)	0.6 (e)	92.4 (e)	89.2 (e)	0.6 (e)
34	(e)	2	860	6/250- 8/330		91.1	5.4	86.5	80.7	2.4
AVE					91.1	91.1	5.4	86.5	80.7	2.4
87	293196	2	860	6/250- 8/330		97.2 (d)	5.5 (d)	90.2 (d)	81.6 (d)	4.1 (d)
AVE					97.2 (d)	97.2 (d)	5.5 (d)	90.2 (d)	81.6 (d)	4.1 (d)
90	294014	2	860	6/250- 8/330		88.3 (e)	2.7 (e)	84.1 (e)	75.4 (e)	3.4 (e)
AVE					88.3 (e)	88.3 (e)	2.7 (e)	84.1 (e)	75.4 (e)	3.4 (e)
34	(e)	2	860	6/250- 8/330		88.7 (e)	3.7 (e)	86.7 (e)	77.5 (e)	3.8 (e)
AVE					88.7 (e)	88.7 (e)	3.7 (e)	86.7 (e)	77.5 (e)	3.8 (e)
87	293196	2	860	6/250- 8/330		87.9 (e)	0.7 (e)	79.3 (e)	77.6 (e)	0.2 (e)
AVE					87.9 (e)	87.9 (e)	0.7 (e)	79.3 (e)	77.6 (e)	0.2 (e)
90	294014	2	860	6/250- 8/330		84.4	7.0	84.0	76.0	2.9
AVE					84.4	84.4	7.0	84.0	76.0	2.9
79	293188	2	860	6/250-8/330		84.4	7.9	75.2	70.9	2.9
AVE					84.4	84.4	7.9	75.2	70.9	2.9
34	283440	2	860	16	330	86.4	7.5	79.0	70.1	3.4
AVE					86.4	86.4	7.5	79.0	70.1	3.4
87	292196	2	860	16	330	82.6 (e)	0.7 (e)	86.2 (e)	80.3 (e)	0.2 (e)
AVE					82.6 (e)	82.6 (e)	0.7 (e)	86.2 (e)	80.3 (e)	0.2 (e)
90	294014	2	860	16	330	81.0 (e)	0.7 (e)	76.5 (e)	71.8 (e)	0.2 (e)
AVE					81.0 (e)	81.0 (e)	0.7 (e)	76.5 (e)	71.8 (e)	0.2 (e)
79	293188	2	860	16	330	85.7	7.0	79.9	70.3	3.9
AVE					85.7	85.7	7.0	79.9	70.3	3.9
34	(e)	2	860	46	315	79.1 (e)	0.7 (e)	83.4 (e)	76.8 (e)	0.2 (e)
AVE					79.1 (e)	79.1 (e)	0.7 (e)	83.4 (e)	76.8 (e)	0.2 (e)
87	293196	2	860	46	315	82.1 (e)	0.7 (e)	77.9 (e)	72.5 (e)	0.2 (e)
AVE					82.1 (e)	82.1 (e)	0.7 (e)	77.9 (e)	72.5 (e)	0.2 (e)
90	294014	2	860	46	315	82.9	10.0	77.6	65.9	3.8
AVE					82.9	82.9	10.0	77.6	65.9	3.8
79	293188	2	860	46	315	62.9	10.0	77.9	66.4	3.5
AVE					62.9	62.9	10.0	77.9	66.4	3.5
34	(e)	2	860	46	315	76.7	10.0	77.9	66.4	3.5
AVE					76.7	76.7	10.0	77.9	66.4	3.5
87	293196	2	860	46	315	76.9	9.0	77.9	66.4	3.5
AVE					76.9	76.9	9.0	77.9	66.4	3.5
90	294014	2	860	46	315	76.8	9.0	77.9	66.4	3.5
AVE					76.8	76.8	9.0	77.9	66.4	3.5
79	293188	2	860	46	315	78.4	9.0	77.9	66.4	3.5
AVE					78.4	78.4	9.0	77.9	66.4	3.5

(a) Alloy 34, Al 7.8 Zn, 2.5 Mg, 1.0 Cu, 3.5 Fe, 4.9 Ni, 0.09 Cr
87, Al 7.6 Zn, 2.5 Mg, 1.0 Cu, 3.5 Fe, 4.9 Ni, 0.16 Cr
90, Al 7.5 Zn, 2.5 Mg, 1.0 Cu, 3.5 Fe, 4.9 Ni, 0.20 Cr
79, Al 6.8 Zn, 2.8 Mg, 2.1 Cu, 1.0 Mn, 0.5 Cr, 0.01 Zn

(b) One specimen per test unless noted.

(c) Avg. of 3 or more tests.

(d) Highest value of 3 or more test results.

(e) Lowest value of 3 or more test results.

(f) Failed before reaching 0.2% offset.

(g) Not obtained-specimen shattered.

(h) t = time in hours, T = Temp. in °F

(i) Data from S. No. 283445

TABLE XXI

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 2

S. NO. 277374 (a)

Additional Aging Time at 330°F-Hrs. (b)	Data Source	Longitudinal				Transverse			Unstressed			Stressed to 25% TS			Stressed to 50% TS			Stressed to 75% TS		
		TS, ksi	YS, ksi	El, % In 4D	YS/Density x10 ⁶ In.	TS, ksi	YS, ksi	El, % In 4D	TS, ksi	% Change	TS, ksi	% Change	TS, ksi	% Change	TS, ksi	Days to Failure	% Change	TS, ksi	Days to Failure	% Change
0	(c)	105.6	103.5	2.9	0.984	75.9	(d)	0.0	--	--	--	--	--	--	--	--	--	--	--	--
	(c)	105.6	103.1	2.9	0.980	85.1	(d)	0.0	--	--	--	--	--	--	--	--	--	--	--	--
	(e)	106.0	103.2	3.2	0.981	83.1	(f)	0	--	--	--	--	--	--	--	--	--	--	--	--
	(e)	105.7	102.7	3.2	0.976	73.0	(f)	0 (h)	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	105.8	103.1	3.0	0.980	79.3	--	0	--	--	--	--	--	--	--	--	--	--	--	--
4	(e)	91.5	89.7	4.7	0.853	77.0	(f)	0 (h)	--	--	--	--	--	--	--	--	--	--	--	--
	(e)	91.5	89.7	4.3	0.853	73.7	(f)	0	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	91.6	89.7	4.5	0.853	75.4	--	0	--	--	--	--	--	--	--	--	--	--	--	--
6	Predicted	86	85	5	--	74	--	1	--	--	--	--	--	--	--	--	--	--	--	--
	(g)	--	--	--	--	76.3	(f)	0.4	64.0	-17	41.2	-47	68 Da	-100	13 Da	-100	13 Da	-100	13 Da	-100
	(g)	--	--	--	--	78.1	--	0.6	57.4	-26	59.2	-23	40 Da	-100	11 Da	-100	11 Da	-100	11 Da	-100
	Avg.	--	--	--	--	77.2	--	0.5	60.7	-22	50.2	-35	--	-100	--	--	-100	--	--	-100
8	Predicted	85	81	6	--	73	71	1	54.6	-27	58.5	-22	39.7	-47	13 Da	-100	13 Da	-100	13 Da	-100
	(g)	--	--	--	--	73.9	(f)	0.3 (h)	61.8	-17	60.7	-19	38.9	-48	15 Da	-100	15 Da	-100	15 Da	-100
	(g)	--	--	--	--	75.2	--	0.4	58.2	-22	59.6	-20	--	-47	--	--	--	--	--	-100
	Avg.	--	--	--	--	74.6	--	1.2	--	--	--	--	--	--	--	--	--	--	--	--
16	(e)	79.4	73.2	7.5	0.696	69.8	66.2	1.2	--	--	--	--	--	--	--	--	--	--	--	--
	(e)	79.4	72.5	8.0	0.689	68.1	65.8	1.2	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	79.4	72.8	7.6	0.692	69.0	66.0	1.2	--	--	--	--	--	--	--	--	--	--	--	--
18	Predicted	78	71	8	--	68	65	1	58.0	-17	59.7	-14	55.9	-20	57 Da	-100	57 Da	-100	57 Da	-100
	(g)	--	--	--	--	69.8	67.4	1.1	53.5	-23	56.1	-17	56.6	-19	41 Da	-100	41 Da	-100	41 Da	-100
	(g)	--	--	--	--	69.8	67.5	1.0	55.8	-20	58.9	-16	56.2	-19	--	--	--	--	--	-100
	Avg.	--	--	--	--	69.8	67.5	1.0	--	--	--	--	--	--	--	--	--	--	--	-100
26	Predicted	74	66	9	--	65	62	1	--	--	--	--	--	--	--	--	--	--	--	--
	(g)	--	--	--	--	65.6	63.2	0.9	49.6	-25	54.1	-18	53.4	-19	61 Da	-100	61 Da	-100	61 Da	-100
	(g)	--	--	--	--	67.0	63.2	1.7	57.4	-13	56.6	-15	53.7	-19	46.1	-30	46.1	-30	46.1	-65
	Avg.	--	--	--	--	66.3	63.2	1.3	54.5	-19	55.4	-17	53.6	-19	--	--	--	--	--	-65
40	(e)	70.8	61.4	6.5	0.584	61.5	57.1	1.3	--	--	--	--	--	--	--	--	--	--	--	--
	(e)	71.2	61.7	9.5	0.587	61.6	57.0	1.4	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	71.3	61.6	9.0	0.586	61.6	57.0	1.4	--	--	--	--	--	--	--	--	--	--	--	--

Notes: (a) 12-1 Zn, 3.5 Mg, 1.5 Cu, 0.5 Mn
 (b) 500 hrs. at 330°F, CWG, Aged #1 24 hrs. at 250°F as 2 in. dia. piece.
 (c) Table is original tests
 (d) Strain follower not used to avoid breaking it.
 (e) Step Aged Data
 (f) Failed before reaching 0.2% Offset.
 (g) From stress corrosion data.
 (h) Failed at or outside gage length.

TABLE XXII

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 3

Additional Aging Time at 310°P-Hrs. (b)	Data Source	S.No. 271375 (a)									
		Longitudinal					Transverse				
		YS		El. %		VS/Density x10 ⁶ In.	YS		El. %		TS
		ksi	ksi	In 4D	In 4D		ksi	ksi	In 4D	In 4D	ksi
0	(c)	106.7	104.0	1.4	1.4	0.988	84.2	(d)	(e)		84.2
	(c)	105.6	103.1	0.7	0.7	0.980	90.2	(d)	0.0		90.2
	(f)	107.6	104.1	2.2	0.90	0.990	87.7	86.4	0.9		87.7
	(f)	108.2	104.8	2.3	0.926	0.996	82.8	(h)	0		82.8
	Avg.	107.0	104.0	1.9	0.988		86.4	86.4	0.3		86.4
3	Predicted	102	99	3	3	--	82	81	1		82
	(g)	--	--	--	--	--	77.8	(h)	0.4		77.8
	(g)	--	--	--	--	--	81.6	81.3	0.4		81.6
	(g)	--	--	--	--	--	79.7	--	0.4		79.7
	Avg.	--	--	--	--	--	79.7	--	0.4		79.7
4	(f)	92.8	89.8	3.6	0.854	0.854	51.2	79.8	0.7		51.2
	(f)	92.6	89.7	3.0	0.853	0.853	80.7	78.7	1.0		80.7
	(f)	92.7	89.8	3.3	0.854	0.854	81.0	79.2	0.8		81.0
	Predicted	89	85	4	4	--	77	74	1		77
	(g)	--	--	--	--	--	80.8	77.9	0.7		80.8
7	(g)	--	--	--	--	--	80.2	77.9	0.5		80.2
	(g)	--	--	--	--	--	80.5	77.9	0.6		80.5
	(g)	--	--	--	--	--	69.3	65.2	1.0		69.3
	(g)	--	--	--	--	--	69.7	65.7	0.8 (1)		69.7
	Avg.	--	--	--	--	--	69.6	65.4	0.9		69.6
16	(f)	79.8	73.0	5.8	0.694	0.694	69.3	65.2	1.0		69.3
	(f)	79.8	72.9	5.4	0.693	0.693	69.6	65.4	0.9		69.6
	(f)	79.8	73.0	5.6	0.694	0.694	69.6	65.4	0.9		69.6
	Predicted	79	72	6	6	--	69	65	1		69
	(g)	--	--	--	--	--	72.0	68.1	0.7 (1)		72.0
17	(g)	--	--	--	--	--	71.5	68.2	0.7		71.5
	(g)	--	--	--	--	--	71.8	68.2	0.7		71.8
	(g)	--	--	--	--	--	66	62	1		66
	(g)	--	--	--	--	--	71.3	65.3	2.0		71.3
	Avg.	--	--	--	--	--	69.3	65.7	1.1		69.3
20	(f)	75	67	6	6	--	70.3	65.5	1.6		70.3
	(f)	75	67	6	6	--	66	62	1		66
	(f)	75	67	6	6	--	71.3	65.3	2.0		71.3
	(f)	75	67	6	6	--	69.3	65.7	1.1		69.3
	Avg.	--	--	--	--	--	70.3	65.5	1.6		70.3
40	(f)	71.2	61.4	6.5	0.584	0.584	61.5	57.5	1.2		61.5
	(f)	71.9	61.9	6.5	0.588	0.588	63.6	57.0	1.7		63.6
	(f)	71.6	61.6	6.5	0.586	0.586	62.6	57.2	1.4		62.6
	Predicted	75	67	6	6	--	66	62	1		66
	(g)	--	--	--	--	--	71.3	65.3	2.0		71.3

Notes: (a) 12.3 Zn, 4.0 Mg, 1.6 Cu, 0.5 Mn

(b) SH: 2 hrs. at 860°P, CWG, Age #1 24 hrs. at 250°P as 2 in. dia. pieces.

(c) Original evaluation, Table II

(d) Strain follower not used to avoid breaking it.

(e) Not obtained - specimen shattered.

(f) Step aging tests.

(g) Stress corrosion data from (f)

(h) Failed before reaching of 2% offset.

(i) Specimen failed outside gage length.

TABLE XXIII

THE EFFECT OF STEP AGING OF TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 4

Additional Aging Time at 1300° F.	Data Source	S.No. 277376 (a)									
		Longitudinal					Transverse				
		Yield		El. %		Yield	Yield		El. %		Yield
		ksi	ksi	ksi	ksi	ksi	ksi	ksi	ksi	ksi	ksi
0		103.5	105.7	2.1	2.1	8.967	72.9	(d)	0.0	0.0	77.7
2		101.1	99.6	1.9	1.9	8.963	55.5	(d)	0.0	0.0	77.7
4		102.7	100.8	2.4	2.4	8.966	72.7	(h)	0.1(g)	0.1(g)	77.7
6		105.7	103.9	2.1	2.1	8.968	82.5	(h)	0.1(g)	0.1(g)	77.7
Avg.		103.1	100.4	2.1	2.1	8.964	80.2	--	0.0	0.0	77.7
8		99.7	99.1	5.5	5.5	8.656	77.7	(h)	0.4	0.4	77.7
10		93.7	93.7	6.1	6.1	8.652	72.4	(h)	0.0	0.0	77.7
Avg.		96.6	96.4	5.8	5.8	8.654	75.0	--	0.2	0.2	77.7
12	Predicted	86	86	--	--	--	77	74	1	1	74
14		--	--	--	--	--	71.6	(h)	0.1(g)	0.1(g)	74
16		--	--	--	--	--	73.0	(h)	0.2	0.2	74
Avg.		--	--	--	--	--	72.3	--	0.2	0.2	74
18	Predicted	86	86	6	6	--	72	71	1	1	71
20		--	--	--	--	--	76.6	75.2	0.5	0.5	75.2
22		--	--	--	--	--	76.1	75.2	0.5	0.5	75.2
Avg.		--	--	--	--	--	76.4	75.2	0.6	0.6	75.2
24		86.6	71.4	7.1	7.1	8.686	70.7	67.1	1.2	1.2	67.1
26		41.2	72.3	7.5	7.5	8.695	68.1	66.1	1.1	1.1	66.1
Avg.		63.9	71.6	7.3	7.3	8.690	69.4	66.6	1.2	1.2	66.6
28	Predicted	76	76	--	--	--	68	65	1	1	65
30		--	--	--	--	--	69.7	67.2	0.9	0.9	67.2
32		--	--	--	--	--	69.2	66.7	0.9	0.9	66.7
Avg.		--	--	--	--	--	69.4	67.0	0.8	0.8	67.0
34	Predicted	76	65	7	7	--	65	62	1	1	62
36		--	--	--	--	--	63.4	61.6	0.9(g)	0.9(g)	61.6
38		--	--	--	--	--	70.7	64.1	0.3	0.3	64.1
Avg.		--	--	--	--	--	67.0	63.0	0.6	0.6	63.0
40		73.3	61.6	7.5	7.5	8.691	63.1	57.3	2.0	2.0	57.3
42		73.4	61.1	4.5	4.5	8.694	58.0	57.0	0.2 (g)	0.2 (g)	57.0
Avg.		73.4	61.4	6.0	6.0	8.694	60.6	57.0	1.1	1.1	57.0

Notes: (a) 2.6 Zn, 3.2 Mg, 0.3 Cu, 0.2 Sn.
 (b) 2 hrs. at 1300° F., 24 hrs. at 2500° F. as 2 in. dia. piece.
 (c) Original Evaluation - Table 17.
 (d) Grain follower not used to avoid breaking it.
 (e) Step Aging Data.
 (f) Stress corrosion data.
 (g) Specimen failed at or outside gage mark.
 (h) Specimen failed before reaching 0.2% offset.

Table XXIV

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING: RESISTANCE OF ALLOY 5

S. No. 277377 (4)

Additional Aging Time at 330°F, Hrs(b)	Data Source	Longitudinal				Transverse				Unstressed		Stressed		Stressed 50% T.S.		Stressed 75% T.S.	
		T.S. ksi	Y.S. ksi	El. %	in LD	T.S. ksi	Y.S. ksi	El. %	in LD	T.S. ksi	Change %	T.S. ksi	Change %	T.S. ksi	Days to Failure	T.S. ksi	Days to Failure
0	(c)	103.8	101.0	1.4	0.951	70.6	(d)	0.0	0.0	---	---	---	---	---	---	---	---
	(c)	107.4	103.7	1.4	0.976	69.9	(d)	0.0	0.0	---	---	---	---	---	---	---	---
	(e)	107.3	103.7	1.4	0.976	74.8	(d)	0	0	---	---	---	---	---	---	---	---
	(e)	106.8	100.6	3.0	0.947	5.6	(h)	0	0	---	---	---	---	---	---	---	---
	Avg.	106.3	102.2	1.6	0.962	77.7	---	---	---	---	---	---	---	---	---	---	---
4	(e)	93.5	86.0	3.1(g)	0.810	70.5	(d)	0	0	---	---	---	---	---	---	---	---
	(e)	96.1	88.8	4.0	0.836	74.9	(d)	0	0	---	---	---	---	---	---	---	---
	Avg.	94.8	87.4	3.6	0.823	72.7	---	---	---	---	---	---	---	---	---	---	---
16	(e)	85.2	72.8	6.0	0.685	56.1	66.1	0.4	0.4	---	---	---	---	---	---	---	---
	(e)	84.5	72.6	3.5(g)	0.584	67.5	57.8	0.8	0.8	---	---	---	---	---	---	---	---
	Avg.	84.8	72.7	4.8	0.685	66.8	66.0	0.6	0.6	---	---	---	---	---	---	---	---
17	Predicted	84	72	5	---	66	65	<1	<1	---	---	---	---	---	---	---	---
	(f)	---	---	---	---	67.0	(h)	0.7	0.7	54.6	-19	40.6	-40	22.9	3 days	---	-100
	Avg.	---	---	---	---	67.6	67.5	0.4(g)	0.6	49.8	-26	38.9	-42	47.4	9 days	---	-100
25	Predicted	81	67	5	---	64	62	1	1	---	---	---	---	---	---	---	---
	(f)	---	---	---	---	64.4	63.4	0.7(g)	0.8	51.6	-21	39.6	-39	51.9	44 days	---	-100
	Avg.	---	---	---	---	65.5	63.6	0.8	0.8	55.3	-15	52.5	-19	41.2	11 days	---	-100
40	(e)	76.8	61.8	7.0	0.582	61.8	57.1	1.5	1.5	---	---	---	---	---	---	---	---
	(e)	77.8	62.3	7.0	0.587	59.5	56.6	1.3	1.3	---	---	---	---	---	---	---	---
	Avg.	77.3	62.0	7.0	0.584	60.6	56.8	1.4	1.4	---	---	---	---	---	---	---	---

NOTE: (a) Al, 10.3 Zn, 2.9 Mg, 2.1 Cu, 1.8 Mn, 0.1 Cr
 (b) SHT 2 hrs at 840°F, OAO, Age #1 24 hrs at 250°F as 2 in. dia. pieces
 (c) Original evaluation - Table II
 (d) Strain follower not used to avoid breaking it
 (e) Step aging data
 (f) Stress corrosion data
 (g) Specimen failed outside gage length
 (h) Specimen failed before reaching 0.2% offset

Table XXV

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 6

S. No. 277378 (a)

Additional Aging Time at 250°F, Hrs(b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed 25% T.S.		Stressed 50% T.S.		Stressed 75% T.S.	
		T.S. ksi	Y.S. ksi	El. % in 10 ⁶ in	T.S. ksi	Y.S. ksi	El. % in 10 ⁶ in	T.S. ksi	% Change	T.S. ksi	% Change	T.S. ksi, or Days to Failure	% Change	T.S. ksi, or Days to Failure	% Change
0	(c)	104.2	99.9	4.3	87.1	(d)	0.0	---	---	---	---	---	---	---	---
	(c)	103.7	98.9	3.6	89.0	85.7	1.2	---	---	---	---	---	---	---	---
	(e)	106.3	100.6	7.0	83.9	82.8	0.2(g)	---	---	---	---	---	---	---	---
	(e)	---	---	---	84.2	83.2	0.4(g)	---	---	---	---	---	---	---	---
	Avg.	104.7	99.8	5.0	86.0	83.9	0.6	---	---	---	---	---	---	---	---
4	(e)	93.1	89.0	7.0	78.0	76.6	0.2(g)	---	---	---	---	---	---	---	---
	(e)	---	---	---	79.6	77.9	0.4(g)	---	---	---	---	---	---	---	---
	Avg.	93.1	89.0	7.0	78.8	77.2	0.3	---	---	---	---	---	---	---	---
6	Predicted	90	85	8	76	74	1	---	---	---	---	---	---	---	---
	(f)	---	---	---	78.8	76.3	1.4	67.9	-14	---	---	30 days	-100	6 days	-100
	(f)	---	---	---	79.1	76.4	1.8	67.7	-14	---	---	18 days	-100	5 days	-100
	Avg.	---	---	---	79.0	76.4	1.6	67.8	-14	---	---	---	-100	---	-100
16	(e)	80.8	73.0	10.5	70.2	65.8	2.0	---	---	---	---	---	---	---	---
	(e)	---	---	---	69.8	65.8	2.8	---	---	---	---	---	---	---	---
	Avg.	80.8	73.0	10.5	70.0	65.8	2.4	---	---	---	---	---	---	---	---
	Predicted	80	72	10	69	65	2	---	---	---	---	---	---	---	---
17	(f)	---	---	---	68.8	67.1	1.7	63.3	-10	---	---	47 days	-100	23 days	-100
	(f)	---	---	---	71.5	67.1	2.6(g)	61.5	-12	---	---	60 days	-100	23 days	-100
	(f)	---	---	---	70.2	67.1	2.2	62.4	-11	---	---	---	-100	---	-100
	Avg.	---	---	---	---	---	---	---	---	---	---	---	-100	---	-100
24	Predicted	77	69	12	68	62	3	---	---	---	---	---	---	---	---
	(f)	---	---	---	69.9	64.6	2.1(g)	61.3	-12	---	---	---	-21	11 days	-100
	(f)	---	---	---	68.7	64.2	1.9(g)	61.1	-12	---	---	54.6	-100	20 days	-100
	Avg.	---	---	---	69.3	64.4	2.0	61.2	-12	---	---	40 days	-60	---	-100
40	(e)	75.6	65.9	10.5	66.8	60.0	3.7	---	---	---	---	---	---	---	---
	(e)	---	---	---	67.4	59.5	3.9	---	---	---	---	---	---	---	---
	Avg.	75.6	65.9	10.5	67.1	59.8	3.8	---	---	---	---	---	---	---	---

NOTE: (a) Al, 11.2 Zn, 2.4 Mg, 2.0 Cu, 0.2 Cr
 (b) 5HT 2 hrs at 860°F, O₂, Age #1 24 hrs at 250°F as 2 in dia. piece
 (c) Original evaluation - Table II
 (d) Strain follower not used to avoid breaking it
 (e) Step aging data
 (f) Stress corrosion data
 (g) Specimen failed outside gage length

Table XVI

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 19

S. No. 277391 (a)

Additional Aging Time at 350°F, hrs (b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed		Stressed 50% T.S.		Stressed 75% T.S.	
		Y.S. ksi	El., in	Y.S./Density $\times 10^6$ in	Y.S. ksi	El., in	Y.S. ksi	Y.S. ksi	% Change	Y.S. ksi	% Change	Y.S., ksi, or Days to Failure	% Change	Y.S., ksi, or Days to Failure	% Change
0	(c)	101.9	95.9	6.4	84.1	(d)	0.0	---	---	---	---	---	---	---	---
	(c)	100.6	94.7	7.9	87.5	(d)	1.9	---	---	---	---	---	---	---	---
	(e)	102.4	97.0	7.0	86.6	78.0	2.2	---	---	---	---	---	---	---	---
	(e)	102.2	96.9	7.0	85.9	78.5	0.2	---	---	---	---	---	---	---	---
	Avg.	101.8	96.1	7.1	86.0	78.2	1.1	---	---	---	---	---	---	---	---
4	(e)	93.3	88.4	9.0	84.0	77.5	3.1(g)	---	---	---	---	---	---	---	---
	(e)	93.4	88.4	9.5	83.3	77.5	3.3	---	---	---	---	---	---	---	---
	Avg.	93.4	88.4	9.2	83.6	77.5	3.2	---	---	---	---	---	---	---	---
	Predicted	88	83	10	81	74	4	---	---	---	---	---	---	---	---
	(f)	---	---	---	79.4	74.0	2.8	72.5	-10	67.7	-16	60 days	-100	24 days	-100
12	(f)	---	---	---	81.3	74.4	4.2	71.6	-11	67.9	-16	44 days	-100	32 days	-100
	(f)	---	---	---	80.4	74.2	3.5	72.0	-10	67.8	-16	---	-100	---	-100
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	85	79	10	78	71	5	---	---	---	---	---	---	---	---
	(f)	---	---	---	76.3	72.0	2.9	70.1	-9	68.6	-11	54 days	-100	34 days	-100
16	(e)	82.0	74.5	10.5	76.4	67.4	6.6	---	---	---	---	---	---	---	---
	(e)	83.1	75.9	10.5	74.8	66.5	3.5(g)	---	---	---	---	---	---	---	---
	Avg.	82.6	75.2	10.5	75.6	67.0	5.0	---	---	---	---	---	---	---	---
	Predicted	81	73	11	74	65	6	---	---	---	---	---	---	---	---
	(f)	---	---	---	76.3	67.9	5.2	66.3	-13	60.7	-20	34.9	-54	44 days	-100
19	(f)	---	---	---	76.0	67.9	4.2	67.1	-12	64.8	-15	49.8	-35	50 days	-100
	(f)	---	---	---	76.2	67.9	4.7	66.7	-12	62.8	-18	42.4	-44	---	-100
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	78	70	11	72	62	7	---	---	---	---	---	---	---	---
	(f)	---	---	---	74.6	65.2	5.7	64.8	-12	60.6	-18	42.7	-42	57 days	-100
25	(f)	---	---	---	73.4	65.6	3.9	65.1	-12	59.5	-20	46.0	-38	47 days	-100
	(f)	---	---	---	74.0	65.4	4.8	65.0	-12	60.0	-19	44.4	-40	---	-100
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	75.2	65.2	12.0	70.7	59.1	8.4	---	---	---	---	---	---	---	---
	(e)	74.1	63.8	12.5	70.7	59.1	9.2	---	---	---	---	---	---	---	---
40	(e)	74.6	64.5	12.2	70.7	59.1	8.8	---	---	---	---	---	---	---	---
	(e)	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	(f)	---	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTE: (a) Al, 7-5 Zn, 3-0 Mg, 1-7 Cu

(b) SHT 2 hrs at 660°F, CAG, Age #1 24 hrs at 250°F as 2 in dia. pieces

(c) Original evaluation - Table II

(d) Strain follower not used to avoid breaking it

(e) Step aging data

(f) Stress corrosion data

(g) Specimen failed outside gage length

Table XXV

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 20

S. No. 277392 (a)

Additional Aging Time at 300°F, Hrs(b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed 25% T.S.		Stressed 50% T.S.		Stressed 75% T.S.	
		T.S. ksi	El., % in 10 in	Y.S./Density x 10 ⁶ in	T.S. ksi	Y.S. ksi	El., % in 10 in	T.S. ksi	% Change	T.S. ksi	% Change	T.S., ksi, or Days to Failure	% Change	T.S., ksi, or Days to Failure	% Change
0	(c)	101.0	95.2	4.3	84.2	(d)	0.0	---	---	---	---	---	---	---	---
	(c)	99.6	94.4	3.6	90.3	(d)	3.7	---	---	---	---	---	---	---	---
	(e)	102.4	97.2	6.5	86.6	79.5	2.2	---	---	---	---	---	---	---	---
	(e)	102.4	97.1	6.5	85.3	79.5	1.2	---	---	---	---	---	---	---	---
	Avg.	101.4	96.0	5.2	86.6	79.5	1.8	---	---	---	---	---	---	---	---
4	(e)	95.0	90.1	7.0	81.6	78.3	1.1	---	---	---	---	---	---	---	---
	(e)	95.4	90.1	7.0	83.6	77.9	1.6	---	---	---	---	---	---	---	---
	(e)	95.2	90.1	7.0	82.6	78.1	1.3	---	---	---	---	---	---	---	---
	Avg.	95.2	90.1	7.0	82.6	78.1	1.3	---	---	---	---	---	---	---	---
8	Predicted	91	85	8	80	74	2	---	---	---	---	---	---	---	---
	(f)	---	---	---	79.5	76.4	1.2	---	---	---	---	---	---	---	---
	(f)	---	---	---	79.4	76.4	1.0	---	---	---	---	---	---	---	---
	Avg.	---	---	---	79.4	76.4	1.1	---	---	---	---	---	---	---	---
13	Predicted	87	81	8	78	71	3	---	---	---	---	---	---	---	---
	(f)	---	---	---	80	73.2	3.9	---	---	---	---	---	---	---	---
	(f)	---	---	---	77.1	73.2	1.6	---	---	---	---	---	---	---	---
	Avg.	---	---	---	78.9	73.2	2.8	---	---	---	---	---	---	---	---
16	(e)	85.5	78.6	8.0	76.4	69.3	2.9	---	---	---	---	---	---	---	---
	(e)	85.3	78.3	9.0	77.2	69.5	3.0	---	---	---	---	---	---	---	---
	(e)	85.4	78.4	8.5	76.8	69.4	3.0	---	---	---	---	---	---	---	---
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---
28	Predicted	81	72	9	73	65	4	---	---	---	---	---	---	---	---
	(f)	---	---	---	74.4	66.7	3.1	---	---	---	---	---	---	---	---
	(f)	---	---	---	75.0	66.7	3.1	---	---	---	---	---	---	---	---
	Avg.	---	---	---	74.7	66.7	3.1	---	---	---	---	---	---	---	---
40	(e)	77.8	68.5	10.0	71.4	62.1	4.6	---	---	---	---	---	---	---	---
	(e)	76.6	66.9	10.5	71.2	62.1	3.7	---	---	---	---	---	---	---	---
	(f)	---	---	---	72.8	63.9	4.4	---	---	---	---	---	---	---	---
	(f)	---	---	---	72.8	63.4	4.4	---	---	---	---	---	---	---	---
	Avg.	77.2	67.7	10.2	72.0	62.9	4.3	---	---	---	---	---	---	---	---

NOTE: (a) Al, 7.0 Zn, 3.6 Mg, 2.3 Cu
 (b) SHT 2 hrs at 860°F, CQ, Age #1 24 hrs at 250°F as 2 in dia. piece
 (c) Original data - Table II
 (d) Strain follower not used to avoid breaking it
 (e) Step aging data
 (f) Stress corrosion data

Table XXVIII

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 28

S. No. 277400 (a)

Additional Aging Time at 330°C-Hrs. (b)	Data Source	Longitudinal			Transverse			Unstressed			Stressed 25% TS			Stressed 50% TS			Stressed 75% TS		
		TS ksi	YS ksi	El. % In. 4D	YS/Density x10 ⁶ In.	TS ksi	YS ksi	El. % In. 4D	TS ksi	% Change	TS, ksi or Days to Failure	% Change	TS, ksi or Days to Failure	% Change	TS, ksi or Days to Failure	% Change	TS, ksi or Days to Failure	% Change	TS, ksi or Days to Failure
0	(c)	102.7	99.9	2.9	0.959	89.0	(d)	0.0	--	--	--	--	--	--	--	--	--	--	--
	(e)	101.2	97.7	2.1	0.938	89.2	(d)	1.9	--	--	--	--	--	--	--	--	--	--	--
	(e)	103.8	100.2	2.8	0.962	87.4	83.1	1.3	--	--	--	--	--	--	--	--	--	--	--
	(e)	103.5	99.9	3.1	0.959	85.6	81.5	1.1	--	--	--	--	--	--	--	--	--	--	--
	Avg.	102.8	99.4	2.7	0.954	87.6	82.3	1.1	--	--	--	--	--	--	--	--	--	--	--
1	Predicted	101	97	3	--	85	81	1	68.8	-20	50.6	-41	1 Da	-100	1 Da	-100	1 Da	-100	-100
	(f)	--	--	--	--	84.8	81.3	0.9(g)	71.2	-17	55.1	-24	1 Da	-100	1 Da	-100	1 Da	-100	-100
	(f)	--	--	--	--	85.8	81.4	1.0	70.0	-18	57.8	-32	--	--	--	--	--	--	-100
	Avg.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	(e)	93.1	89.7	5.0	0.861	81.7	78.8	1.3	--	--	--	--	--	--	--	--	--	--	--
	(e)	93.2	90.1	3.8	0.865	80.6	78.3	0.9	--	--	--	--	--	--	--	--	--	--	--
	Avg.	93.2	89.9	4.4	0.863	81.2	78.6	1.1	--	--	--	--	--	--	--	--	--	--	--
8	Predicted	87	83	5	--	77	74	1	63.0	-21	62.0	-23	--	--	--	--	--	--	--
	(f)	--	--	--	--	79.8	76.2	1.4	59.5	-26	64.9	-19	37 Da	-100	11 Da	-100	11 Da	-100	-100
	(f)	--	--	--	--	80.4	76.9	1.4	61.2	-24	63.4	-21	--	--	--	--	--	--	-100
	Avg.	--	--	--	--	80.1	76.6	1.4	--	--	--	--	--	--	--	--	--	--	--
16	(e)	81.5	75.0	6.5	0.720	72.3	67.9	0.9	--	--	--	--	--	--	--	--	--	--	--
	(e)	82.4	75.6	5.5	0.726	72.9	68.3	1.9	--	--	--	--	--	--	--	--	--	--	--
	Avg.	82.0	75.3	6.0	0.723	72.6	68.1	1.4	--	--	--	--	--	--	--	--	--	--	--
22	Predicted	79	71	6	--	70	65	1	57.6	-20	58.8	-19	--	--	--	--	--	--	--
	(f)	--	--	--	--	73.0	68.2	2.5	57.1	-21	56.3	-22	57.1	-21	32 Da	-100	29 Da	-100	-100
	(f)	--	--	--	--	71.5	68.2	1.5	57.4	-21	57.6	-20	42.7	-41	29 Da	-100	26 Da	-100	-100
	Avg.	--	--	--	--	72.2	68.2	2.0	--	--	--	--	49.9	-31	--	--	--	--	-100
32	Predicted	76	67	7	--	67	62	1	53.6	-21	56.2	-17	--	--	--	--	--	--	--
	(f)	--	--	--	--	65.1	63.2	0.9	53.6	-21	56.2	-18	54.1	-20	26 Da	-100	19 Da	-100	-100
	(f)	--	--	--	--	71.1	64.5	2.8	53.9	-21	55.7	-21	53.4	-21	49 Da	-100	49 Da	-100	-100
	Avg.	--	--	--	--	68.0	63.8	1.8	53.8	-21	56.0	-18	53.8	-21	--	--	--	--	--
40	(e)	74.7	65.7	8.5	0.631	66.0	60.9	1.6(g)	--	--	--	--	--	--	--	--	--	--	--
	(e)	73.5	64.4	8.0	0.618	65.2	60.0	1.7	--	--	--	--	--	--	--	--	--	--	--
	Avg.	74.1	65.0	8.2	0.624	65.6	60.4	1.6	--	--	--	--	--	--	--	--	--	--	--

Notes: (a) Al-2.8 Zn, 3.6 Mg, 2.3 Cu.

(b) SHT 2 hrs. at 860°C, CMQ, Age #1, 24 hrs. at 350°C as 2 in. dia. piece.

(c) Original Data - Table II, Section III

(d) Strain follower not used to avoid breaking it.

(e) Step Aging Data.

(f) Stress corrosion data.

(g) Specimen failed through gage mark.

Table XXIX

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE ON ALLOY 33

S. No. 277405 (a)

Additional Aging Time at 300°F, Hrs(b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed		Stressed 50% T.S.		Stressed 75% T.S.	
		T.S., ksi	Y.S., ksi	El., % in 10 ² in	T.S., ksi	Y.S., ksi	El., % in 10 ² in	T.S., ksi	Change %	T.S., ksi	Change %	T.S., ksi, or Days to Failure	Change %	T.S., ksi, or Days to Failure	Change %
0	(c)	107.7	124.0	2.1	81.8	(d)	(e)	---	---	---	---	---	---	---	---
	(c)	108.2	104.4	1.4	82.9	(d)	0.0	---	---	---	---	---	---	---	---
	(f)	109.6	105.1	2.7	74.4	(h)	0	---	---	---	---	---	---	---	---
	Avg.	108.5	104.5	2.2	79.0	---	0	---	---	---	---	---	---	---	---
4	(f)	96.5	90.6	5.3	75.0	(h)	0	---	---	---	---	---	---	---	---
	(f)	56.3	89.8	4.9	67.1	(h)	0	---	---	---	---	---	---	---	---
	Avg.	56.4	90.2	5.1	71.0	---	0	---	---	---	---	---	---	---	---
	Predicted	87	79	7	71	---	<1	---	---	---	---	---	---	---	---
12	(g)	---	---	---	70.1	(h)	1.2	60.4	-13	57.0	-18	75 days	-100	11 days	-100
	(g)	---	---	---	68.9	(h)	0.3(d)	63.9	-8	60.2	-13	58.1	-16	11 days	-100
	Avg.	---	---	---	69.5	---	0.8	62.2	-11	58.6	-16	---	-58	---	-100
	(f)	85.8	76.4	7.0	70.0	69.2	1.2	---	---	---	---	---	---	---	---
16	(f)	85.5	75.2	7.5	69.8	68.3	0.7	---	---	---	---	---	---	---	---
	Avg.	85.6	76.2	7.2	69.9	68.7	1.0	---	---	---	---	---	---	---	---
	Predicted	81	71	7	67	65	1	---	---	---	---	---	---	---	---
	(g)	---	---	---	69.6	66.0	2.1	62.0	-10	60.2	-13	59.9	-13	24 days	-100
26	(g)	---	---	---	68.4	66.4	1.3	62.7	-9	58.9	-15	54.9	-22	21 days	-100
	Avg.	---	---	---	69.0	66.2	1.7	62.4	-10	59.6	-14	57.0	-17	---	-100
	Predicted	79	67	7	64	62	1	---	---	---	---	---	---	---	---
	(g)	---	---	---	64.1	62.3	0.5	57.5	-11	56.7	-12	59.4	-8	41 days	-100
35	(g)	---	---	---	64.6	62.7	1.0	58.9	-9	57.5	-11	59.6	-7	35 days	-100
	Avg.	---	---	---	64.4	62.5	0.8	58.2	-10	57.1	-11	59.5	-8	---	-100
	Predicted	77.6	65.2	7.0	62.6	60.9	1.2	---	---	---	---	---	---	---	---
	(f)	77.3	65.2	8.0	61.8	59.8	1.2	---	---	---	---	---	---	---	---
40	Avg.	77.4	65.2	7.5	62.2	60.4	1.2	---	---	---	---	---	---	---	---
	(f)	---	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTE: (a) Al, 9.0 Zn, 3.5 Mg, 1.2 Cu, 1.1 Mn
 (b) SHF 2 hrs at 860°F, CaQ, Age #1 24 hrs at 250°F as 2 in dia. pieces
 (c) Original evaluation - Table II
 (d) Strain follower not used to avoid breaking it
 (e) Not determined - Specimen shattered
 (f) Step aging data
 (g) Stress corrosion data
 (h) Failed before reaching 0.2% offset
 (i) Failed outside of at gage length

Table III
THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY X6
S. No. 277938 (a)

Additional Aging Time at 350°F, Hrs.(b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed 25% T.S.		Stressed 50% T.S.		Stressed 75% T.S.		
		T.S. ksi	E.L., in	T.S./Density $\times 10^6$ in	T.S. ksi	E.L., in	T.S. ksi	Change ksi	T.S. ksi	Change ksi	T.S. ksi	Change %	Days to Failure	Change %	Days to Failure	Change %
0	(c)	95.4	95.2	0.5	---	---	---	---	---	---	---	---	---	---	---	---
	(d)	105.2	101.0	1.3	74.8	(e)	0.0	---	---	---	---	---	---	---	---	---
	(d)	104.1	101.4	0.7	55.6(f)	(e)	0(f)	---	---	---	---	---	---	---	---	---
	(g)	104.7	100.4	1.1(1)	85.2	(e)	0	---	---	---	---	---	---	---	---	---
	(g)	---	---	---	66.3	(e)	0	---	---	---	---	---	---	---	---	---
4	Avg.	102.4	99.5	0.9	70.5	---	0	---	---	---	---	---	---	---	---	---
	(g)	92.0	87.7	1.4	79.1	(e)	0(1)	---	---	---	---	---	---	---	---	---
	(g)	---	---	---	68.7	(e)	0	---	---	---	---	---	---	---	---	---
	Avg.	92.0	87.7	1.4	73.9	---	0	---	---	---	---	---	---	---	---	---
	(g)	84.1	74.8	3.0	70.0	69.4	0.1(1)	---	---	---	---	---	---	---	---	---
16	(g)	---	---	---	70.1	69.8	0.6	---	---	---	---	---	---	---	---	---
	(g)	84.1	74.8	3.0	70.0	69.6	0.4	---	---	---	---	---	---	---	---	---
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	80	70	3	68	65	1	---	---	---	---	---	---	---	---	---
	(h)	---	---	---	68.6	66.4	0.8	55.7	-20	50.9	48.7	-30	7 days	-100	---	---
28	(h)	---	---	---	69.9	66.3	1.2	49.8	-28	46.5	48.5	-30	7 days	-100	---	---
	(h)	---	---	---	69.2	66.4	1.0	52.8	-24	48.7	48.6	-30	7 days	-100	---	---
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	79	67	3	67	62	1	---	---	---	---	---	---	---	---	---
	(h)	---	---	---	65.4	63.4	0.9	52.3	-21	53.4	51.7	-22	21 days	-100	---	---
36	(h)	---	---	---	67.8	64.2	1.4	51.9	-22	54.2	52.2	-19	69 days	-100	---	---
	(h)	---	---	---	66.6	63.8	1.2	52.1	-22	53.8	52.0	-22	69 days	-100	---	---
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	78.0	66.2	3.2(1)	65.2	61.5	0.9	---	---	---	---	---	---	---	---	---
	(g)	---	---	---	67.4	62.0	1.6	---	---	---	---	---	---	---	---	---
40	(g)	78.0	66.2	3.2	66.3	61.8	1.2	---	---	---	---	---	---	---	---	---
	(g)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Avg.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Predicted	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	(g)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTE: (a) Al, 10.6 Zn, 4.4 Mg, 2.0 Cu, 1.7 Mn-14 microns
(b) SHT 2 hrs at 860°F, OAG, Age #1 24 hrs at 250°F 2 in. dia. pieces
(c) Table VII, Section II
(d) Table II, Section III
(e) Failed before reaching 0.2% offset
(f) Specimen contained discontinuity
(g) Step aging data
(h) Stress corrosion data
(i) Specimen failed at or outside of gage marks

Table XXII
THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 36 (a)

Age 62 (b)	S. No.	Longitudinal				Transverse				Unstressed			Stressed 25% YS			Stressed 50% YS			Stressed 75% YS		
		YS ksi	El. % in. in.	YS/Density x10 ⁶ in.	TS ksi	YS ksi	El. % in. in.	TS ksi	YS ksi	TS ksi	% Change	Days to Failure	% Change	Days to Failure	% Change	Days to Failure	% Change	Days to Failure	Days to Failure	% Change	Days to Failure
--	283453	108.4	1.6	0.990	95.5	95.1	0.6	95.5	95.1	95.5	--	--	--	--	--	--	--	--	--	--	--
	108.4	105.4	1.6	0.994	91.9	91.9	0	91.9	91.9	91.9	--	--	--	--	--	--	--	--	--	--	--
	Avg.	108.4	1.6	0.992	93.7	95.1	0.3	93.7	95.1	93.7	--	--	--	--	--	--	--	--	--	--	--
2	283451	111.4	1.2	1.021	95.6	95.6	(d)	95.6	95.6	95.6	-37	17 Da	-100	2 Da	-100	1 Da	-100	1 Da	-100	-100	-100
	111.4	106.3	1.2	1.022	98.0	97.6	(d)	98.0	97.6	98.0	-32	6 Da	-100	1 Da	-100	1 Da	-100	1 Da	-100	-100	-100
	Avg.	111.6	1.2	1.021	96.8	96.6	(d)	96.8	96.6	96.8	-35	--	-100	--	-100	--	-100	--	-100	--	-100
4	283453	97.4	2.1	0.876	86.0	84.0	0.7	86.0	84.0	86.0	--	--	--	--	--	--	--	--	--	--	--
	97.4	92.7	2.2	0.875	86.7	86.6	0.6	86.7	86.6	86.7	--	--	--	--	--	--	--	--	--	--	--
	Avg.	97.4	2.1	0.875	86.3	86.3	0.6	86.3	86.3	86.3	--	--	--	--	--	--	--	--	--	--	--
8	283453	84.2	1.4	0.766	85.0	80.1	1.2	85.0	80.1	85.0	--	--	--	--	--	--	--	--	--	--	--
	84.2	81.5	1.3	0.765	84.1	79.7	0.8	84.1	79.7	84.1	--	--	--	--	--	--	--	--	--	--	--
	Avg.	84.2	1.4	0.765	84.6	79.9	1.0	84.6	79.9	84.6	--	--	--	--	--	--	--	--	--	--	--
16	283453	87.4	2.5	0.756	82.1	76.4	2.0	82.1	76.4	82.1	--	--	--	--	--	--	--	--	--	--	--
	87.4	83.3	2.3	0.756	79.7	75.2	1.3	79.7	75.2	79.7	--	--	--	--	--	--	--	--	--	--	--
	Avg.	87.4	2.5	0.757	80.9	75.8	1.6	80.9	75.8	80.9	--	--	--	--	--	--	--	--	--	--	--
24	283453	81.5	5.0	0.682	74.4	69.5	1.6	74.4	69.5	74.4	--	--	--	--	--	--	--	--	--	--	--
	81.5	72.3	4.0	0.682	76.8	70.1	1.9	76.8	70.1	76.8	--	--	--	--	--	--	--	--	--	--	--
	Avg.	81.5	4.5	0.682	75.5	69.8	1.8	75.5	69.8	75.5	--	--	--	--	--	--	--	--	--	--	--
32	283453	61.5	4.0	0.659	75.9	65.2	3.1	75.9	65.2	75.9	-13	66.0	-13	66.5	-12	26 Da	-100	26 Da	-100	-100	-100
	61.5	69.9	4.0	0.659	75.2	65.6	2.8	75.2	65.6	75.2	-14	67.3	-13	65.7	-13	84 Da	-100	84 Da	-100	-100	-100
	Avg.	61.5	4.0	0.659	75.6	65.4	3.0	75.6	65.4	75.6	-13	66.6	-12	66.1	-13	--	--	--	--	--	--
48	283453	73.2	5.0	0.579	69.3	59.4	3.1	69.3	59.4	69.3	--	--	--	--	--	--	--	--	--	--	--
	73.2	61.7	5.0	0.575	68.9	59.4	2.8	68.9	59.4	68.9	--	--	--	--	--	--	--	--	--	--	--
	Avg.	73.2	5.0	0.577	69.1	59.4	3.0	69.1	59.4	69.1	--	--	--	--	--	--	--	--	--	--	--
1	283453	91.3	2.4	0.824	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	91.3	86.4	2.6	0.819	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	91.3	2.5	0.821	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	283453	88.4	1.5	0.776	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	88.4	84.1	3.2	0.763	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	88.4	2.5	0.770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	283453	75.2	4.0	0.709	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	75.2	73.2	4.0	0.709	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	75.2	4.0	0.709	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	283453	76.7	4.0	0.643	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	76.7	67.7	5.0	0.639	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	76.7	4.5	0.642	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	283453	76.1	5.0	0.606	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	76.1	64.2	5.0	0.606	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Avg.	76.1	5.5	0.606	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

(a) Al, 8.5 Zn, 3.5 Mg, 1.1 Mn, 1.2 Fe, 3.0 Ni.
(b) All specimens SHT 2 hrs. at 660°F, CWQ, Age #1 24 hrs. at 250°F.
(c) Not obtained, specimen shattered.
(d) Failed before reaching 0.2% offset.

Table XXXIII

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES OF ALLOYS 39, 49 AND 50

Age #2 (d) t	Alloy 39				Alloy 49				Alloy 50			
	T.S. ksi	Y.S. ksi	El, % in 1/2	Y.S./Density x 10 ⁶ in	T.S. ksi	Y.S. ksi	El, % in 1/2	Y.S./Density x 10 ⁶ in	T.S. ksi	Y.S. ksi	El, % in 1/2	Y.S./Density x 10 ⁶ in
--	---	106.9	103.5	1.3	0.975	106.4	102.5	1.1	98.4	97.0	1.4	0.908
---	---	97.0(e)	(f)	0(e)	---	107.9	104.9	1.0	101.7	96.0	1.6	0.899
Avg.	---	106.9	103.5	1.3	0.975	107.2	103.7	1.0	100.0	96.5	1.5	0.904
16	330	81.8	72.6	2.3	0.684	81.2	76.0	1.6	85.0	76.7	1.7	0.718
---	---	79.5	68.8	1.4	0.648	81.6	78.0	2.6	84.3	77.6	1.5	0.727
Avg.	---	80.6	70.7	1.8	0.666	81.4	77.0	2.1	84.6	77.2	1.6	0.723
32	330	68.2	58.2	2.9	0.549	74.1	67.3	3.1	79.0	70.5	2.7	0.660
---	---	77.1	65.3	1.7	0.615	75.2	66.4	3.0	77.2	69.7	2.1	0.653
Avg.	---	72.6	61.8	2.3	0.582	74.6	66.8	3.0	78.1	70.1	2.4	0.656
48	330	73.9	60.8	4.4	0.573	72.3	62.7	2.7	72.1	66.2	1.3	0.620
---	---	73.4	60.7	3.5	0.572	71.8	63.4	3.3	76.5	66.0	2.7	0.618
Avg.	---	73.6	60.8	4.0	0.573	72.0	63.0	3.0	74.3	66.1	2.0	0.619
4	350	84.3	75.7	2.4	0.713	83.9	77.7	1.7	84.7	78.3	1.8	0.733
---	---	79.0	74.9	1.1	0.706	83.4	78.7	1.3	84.7	78.9	2.0	0.739
Avg.	---	81.6	75.3	1.8	0.710	83.6	78.2	1.5	84.7	78.6	1.9	0.736
8	350	76.3	67.2	2.8	0.633	77.1	70.6	2.5	80.5	73.0	2.5	0.683
---	---	80.2	69.3	3.1	0.653	65.0	60.8	0.3	80.0	72.3	2.2	0.677
Avg.	---	79.2	68.2	3.0	0.643	71.0	65.7	1.4	80.2	72.6	2.4	0.680
12	350	77.2	64.7	3.4	0.615	73.5	65.8	3.2	77.9	69.2	2.8	0.648
---	---	77.4	65.3	3.6	0.610	69.2	66.0	1.5	78.2	68.8	2.1	0.644
Avg.	---	77.3	65.0	3.5	0.612	71.4	65.9	2.4	78.0	69.0	2.4	0.646

NOTE: (a) Al, 10.9 Zn, 4.9 Mg, 2.0 Cu, 1.8 Mn
 (b) Al, 15.3 Zn, 4.6 Mg, 2.0 Cu, 1.9 Mn
 (c) Al, 10.0 Zn, 4.1 Mg, 0.9 Cu, 1.4 Mn, 1.1 Fe, 1.4 Ni, 0.01 Cr, 0.02 Ti
 (d) All specimens SHT 2 hrs @ 860°F, CwQ, Age #1 24 hrs @ 250°F
 (e) Not included in average
 (f) Failed before reaching 0.2% offset

Table XXIV
THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 52 (a)

Age, hr.	S. No.	Longitudinal				Transverse				Unstressed		Stressed 25% YS		Stressed 50% YS		Stressed 75% YS	
		TS, ksi	YS, ksi	El., % in. in. in.	YS/Density, 1000 in.	TS, ksi	YS, ksi	El., % in. in. in.	YS/Density, 1000 in.	TS, ksi	% Change	TS, ksi	% Change	TS, ksi	% Change	TS, ksi	% Change
2	330	107.7	105.7	2.7	1.010	92.4	89.0	1.1	1.1	--	--	--	--	--	--	--	--
	Avg.	106.5	104.8	2.6	1.001	90.2	89.0	0.6	0.6	--	--	--	--	--	--	--	--
4	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
6	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
8	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
10	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
12	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
14	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
16	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
18	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
20	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
22	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
24	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
26	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
28	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
30	330	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100
	Avg.	106.6	105.2	2.6	1.005	89.8	89.6	(d)	(d)	49.6	-45	64.8	-26	12 Da	-100	6 Da	-100

(a) All specimens were aged at 800°F. for 24 hrs. at 250°F. (b) All specimens were aged at 800°F. for 24 hrs. at 250°F. (c) Failed before reaching 0.2% offset. (d) Specimen failed at approx. 0.2% offset.

Table XXXV

THE EFFECT OF STEP AGING ON TENSILE
PROPERTIES OF ALLOY 59.S. No. 277934 (a)

Additional Aging Time At 330 F-Hrs. (b)	Data Source	Longitudinal			Transverse		
		T.S. ksi	Y.S. ksi	EL, % in 4D	Y.S./Density x 10 ⁶ in.	T.S. ksi	Y.S. ksi
0	(c)	90.9	(d)	0.4	-	-	-
	(e)	96.2	(f)	0.0	-	73.8 (g)	(d)
	(e)	89.7	(f)	0.0	-	50.1	(d)
	(h)	84.4	(d)	0.0	-	70.8	(d)
	(h)	90.5	(d)	0.0	-	63.5	(d)
	Avg.	90.3	-	0.0	-	64.6	-
4	(h)	90.2	89.8	0.5 (i)	0.829	52.2	(d)
	(h)	91.8	90.1	0.5 (i)	0.832	62.3	(d)
	Avg.	91.0	90.0	0.5	0.831	57.2	-
	(h)	83.4	78.4	1.2 (i)	0.724	67.9	(d)
16	(h)	82.7	78.9	1.0	0.729	64.2	(d)
	Avg.	83.0	78.6	1.1	0.726	66.0	-
	(h)	76.5	71.3	1.3 (i)	0.658	63.4	(d)
	(h)	74.1	69.0	0.6 (i)	0.637	60.4	(d)
40	Avg.	75.3	70.2	1.0	0.648	61.9	-

- (a) Al, 10.2 Zn, 3.9 Mg, 1.6 Cu, 1.6 Mn, 1.0 Fe, 4.1 Ni, 15 Microns
(b) SHT 2 Hrs, at 860°F. CWQ, Ag: #1 24 Hrs at 250°F. as 2 in. Dia. Piece
(c) Table VII, Section I
(d) Failed before reaching 0.2% offset
(e) Table VIII, Section II
(f) Strain follower not used to avoid breaking it
(g) Specimen contains discontinuity
(h) Step aging data
(i) Specimen failed at or outside gage mark

Table XXVII

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 60

S. No. 283758 (a)

Additional Aging Time at 330°F-Hrs. (b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed 25% TS		Stressed 50% TS		Stressed 75% TS	
		TS ksi	YS ksi	El. % In 4D	TS ksi	YS ksi	El. % In 4D	TS ksi	Change %	TS ksi	Change %	TS ksi	Change %	TS ksi	Days to Failure
0	(c)	106.3	104.2	1.9	84.8	84.6	0.4(r)	--	--	--	--	--	--	--	--
	(c)	--	--	--	79.9	(e)	0	--	--	--	--	--	--	--	--
	Avg.	106.3	104.2	1.9	82.4	84.8	0.2	--	--	--	--	--	--	--	--
4	(c)	95.9	93.7	2.3	77.4	(e)	0	--	--	--	--	--	--	--	--
	(c)	--	--	--	80.2	(e)	0	--	--	--	--	--	--	--	--
	Avg.	95.9	93.7	2.3	78.8	--	0	--	--	--	--	--	--	--	--
16	(c)	82.8	80.3	2.2	62.6	(e)	0	--	--	--	--	--	--	--	--
	(c)	--	--	--	69.9	(e)	0	--	--	--	--	--	--	--	--
	Avg.	82.8	80.3	2.2	66.2	--	0	--	--	--	--	--	--	--	--
40	(c)	74.8	70.7	5.2	68.1	64.6	0.8	--	--	--	--	--	--	--	--
	(c)	--	--	--	66.4	64.2	0.3(r)	--	--	--	--	--	--	--	--
	(c)	--	--	--	68.4	65.3	0.6	46.5	-32	40.8	-41	50.1	-27	6 Da	-100
	(d)	--	--	--	68.9	65.6	0.9	43.4	-37	47.3	-31	40.4	-41	5 Da	-100
	Avg.	74.8	70.7	5.2	68.0	64.9	0.6	45.0	-35	44.0	-36	45.2	-34	--	--

Notes: (a) Al, 11.6 Zn, 5.5 Mg, 1.8 Cu, 0.7 Mn.

(b) SHT 2 hrs. at 860°F, CWQ, Age #1 24 hrs. at 250°F as 2 in. dia. piece.

(c) Step Aging Data.

(d) Stress Corrosion Data.

(e) Failed before reaching 0.2% offset.

(f) Specimen failed at or outside gage mark.

Table XXVIII

THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 61

S. No. 283/59 (a)

Additional Aging Time at 250°F, Hrs (b)	Data Source	Longitudinal			Transverse			Unstressed		Stressed 25% T.S.		Stressed 50% T.S.		Stressed 75% T.S.	
		T.S. ksi	Y.S. ksi	El., % in 10 in	T.S. ksi	Y.S. ksi	El., % in 10 in	T.S. ksi	Change	T.S. ksi	Change	T.S., ksi, or Days to Failure	Change	Days to Failure	Change
0	(c)	109.1	106.3	3.0	91.1	87.2	0.9	---	---	---	---	---	---	---	---
	(c)	108.9	106.3	3.4	91.6	87.7	(e)	---	---	---	---	---	---	---	---
	Avg.	109.0	106.3	3.2	91.4	87.4	0.9	---	---	---	---	---	---	---	---
4	(c)	93.9	91.3	5.5	80.5	80.1	C.1(f)	---	---	---	---	---	---	---	---
	(c)	94.4	91.6	5.5	83.1	80.4	1.1	---	---	---	---	---	---	---	---
	Avg.	94.2	91.4	5.5	81.8	80.2	C.6	---	---	---	---	---	---	---	---
8	Predicted	88	83	7	78	74	1	---	---	---	---	---	---	---	---
	(c)	---	---	---	81.5	75.2	1.1(f)	59.4	-27	50.9	-38	35 days	-100	7 days	-100
	Avg.	---	---	---	81.7	77.2	0.8(f)	60.0	-22	48.5	-41	21 days	-100	6 days	-100
16	(c)	82.6	76.6	9.0	74.0	68.4	2.0	---	---	---	---	---	---	---	---
	(c)	83.0	77.0	7.5	73.8	68.4	1.4(f)	---	---	---	---	---	---	---	---
	Avg.	82.8	76.8	8.2	73.9	68.4	1.7	---	---	---	---	---	---	---	---
22	Predicted	80	72	9	71	55	2	---	---	---	---	---	---	---	---
	(d)	---	---	---	70.7	68.3	0.7	62.9	-14	56.0	-23	58.7	-19	35 days	-100
	Avg.	---	---	---	74.9	68.3	2.7	62.4	-14	60.6	-17	56.4	-23	24 days	-100
30	(c)	---	---	---	72.8	68.3	1.7	62.6	-14	58.3	-20	57.6	-21	---	---
	(d)	---	---	---	69	62	2	---	---	---	---	---	---	---	---
	Avg.	---	---	---	71.1	64.6	2.4	60.5	-15	54.4	-23	49.6	-30	35 days	-100
40	(c)	74.1	65.5	10.0	71.0	64.9	2.3	60.8	-14	57.3	-19	49.3	-31	24 days	-100
	(c)	74.3	65.5	11.0	71.0	64.8	2.4	60.6	-15	55.8	-21	49.4	-30	---	---
	Avg.	74.2	65.5	10.5	69.0	59.5	4.3	---	---	---	---	---	---	---	---

NOTE: (a) Al, 10.4 Zn, 4.5 Mg, 0.8 Cu
 (b) SH 2 hrs at 860°F, CQ, Age #1 24 hrs at 250°F
 (c) Step aging data

(c) Stress corrosion data
 (e) Not determined, specimen shattered
 (f) Specimen failed at or outside gage length

Table XXXIX
THE EFFECT OF STEP AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING RESISTANCE OF ALLOY 71
S. No. 293387

Age, (b)	Longitudinal				Transverse				Unstressed				Stressed 25%YS				Stressed 50%YS				Stressed 75%YS			
	TS ksi	YS ksi	El. % in./in.	YS/Density x10 ⁶ in.	TS ksi	YS ksi	El. % in./in.		TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change
--	109.0	103.9	4.0	1.005	93.2	89.0	2.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	107.1	102.9	5.0	0.995	94.0	89.0	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	106.0	103.4	4.5	1.000	93.6	89.0	1.5		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	107.1	105.0	4.8	1.015	92.0	87.8	1.0		58.1	-37	53.5	-42	18 Da	-100	13 Da	-100	22 Da	-100	7 Da	-100	13 Da	-100	7 Da	-100
AVG.	107.7	105.0	4.6	1.015	92.0	87.8	1.0		61.9	-33	56.1	-35	22 Da	-100	7 Da	-100	22 Da	-100	7 Da	-100	22 Da	-100	7 Da	-100
2	103.2	100.3	4.5	0.970	91.9	87.1	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	102.2	99.8	6.0	0.965	87.8	85.5	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	102.8	100.0	5.2	0.967	89.8	86.3	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	101.2	98.3	5.5	0.951	88.6	85.6	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	101.4	97.8	6.0	0.946	90.3	85.4	2.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	101.3	98.0	5.8	0.948	89.4	85.5	1.5		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	99.3	95.2	6.5	0.921	87.7	84.0	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	98.4	94.0	6.5	0.909	85.8	83.2	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	98.8	94.6	6.5	0.915	86.8	83.6	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	91.4	86.2	8.0	0.834	80.2	77.2	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	91.0	85.9	7.8	0.831	80.3	77.4	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	91.2	86.0	7.8	0.832	80.2	77.2	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
48	85.5	79.2	9.0	0.766	79.9	72.1	5.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	85.5	79.2	9.5	0.766	79.8	72.3	4.5		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	85.5	79.2	9.5	0.766	79.8	72.3	4.5		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	97.1	93.4	7.0	0.903	86.4	82.1	2.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	96.1	92.2	6.0	0.892	81.7	78.1	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	96.6	92.8	6.0	0.896	84.0	82.1	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	93.5	88.1	7.0	0.852	82.5	79.9	2.0		76.0	-10	75.2	-11	60.3	-28	31 Da	-100	60.3	-28	31 Da	-100	60.3	-28	31 Da	-100
AVG.	93.5	88.1	7.0	0.852	84.0	79.4	3.0		76.3	-9	71.8	-15	51.0	-39	31 Da	-100	51.0	-39	31 Da	-100	51.0	-39	31 Da	-100
	93.5	88.1	7.0	0.852	84.0	79.4	3.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	92.9	88.6	8.0	0.857	83.1	79.9	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	92.5	87.7	8.0	0.848	83.9	79.5	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	92.7	88.2	8.0	0.853	83.5	79.7	1.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	87.3	81.3	9.0	0.786	80.2	73.4	4.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	86.9	80.6	9.5	0.781	79.1	73.8	4.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	87.1	81.0	9.2	0.783	79.6	73.6	4.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	87.2	80.1	8.9	0.775	76.6	72.0	2.0		71.3	-8	71.3	-8	70.7	-8	45 Da	-100	70.7	-8	45 Da	-100	70.7	-8	45 Da	-100
AVG.	87.2	80.1	8.9	0.775	77.3	71.1	4.0		71.4	-7	71.6	-7	69.7	-10	54 Da	-100	69.7	-10	54 Da	-100	69.7	-10	54 Da	-100
	87.2	80.1	8.9	0.775	77.3	71.1	4.0		71.4	-7	71.6	-7	70.2	-9	54 Da	-100	70.2	-9	54 Da	-100	70.2	-9	54 Da	-100
16	82.2	74.6	9.0	0.721	76.7	67.5	5.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	81.7	73.8	10.0	0.714	73.4	67.6	3.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	82.0	74.2	9.5	0.718	75.0	67.6	4.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20	80.9	71.1	7.6	0.688	75.5	63.5	8.0		65.7	-12	66.4	-11	65.2	-13	56.2	-25	65.2	-13	56.2	-25	65.2	-13	56.2	-25
AVG.	80.9	71.1	7.6	0.688	74.6	63.6	6.5		66.2	-11	66.4	-11	65.1	-13	56.2	-25	65.1	-13	56.2	-25	65.1	-13	56.2	-25
	80.9	71.1	7.6	0.688	74.6	63.6	6.5		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	76.4	66.7	11.0	0.645	68.9	61.0	4.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	75.6	65.7	11.5	0.635	72.1	61.5	6.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	76.1	66.2	11.2	0.640	70.5	61.2	5.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
48	72.8	62.1	12.0	0.601	70.9	57.8	6.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AVG.	72.7	62.1	11.0	0.601	70.5	57.8	6.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	72.8	62.1	11.5	0.601	70.7	57.8	6.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

(a) Al-9.3 Zn, 3.6 Mg, 0.5 Cu, 0.02 Cr, 0.02 Ti, 0.7 Co.
(b) All specimens SHF 2 hrs. at 860°F, CVD, Age #1 24 hrs. at 250°F.
(c) Failed before reaching 0.2% offset.
(d) Not obtained, specimen shattered.
(e) Premature failure - Disregard

Table XL
THE EFFECT OF PROLONGED AGING AND QUENCHING RATES ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING OF ALLOY 24 (1)

Specimen	Age (h)	S. No.	Longitudinal			Transverse			Stress Value Used	Unstressed		Stressed 25%		Stressed 50%		Stressed 75%	
			TS ksi	YS ksi	El. In.	TS ksi	YS ksi	El. In.		TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change
			TS ksi	YS ksi	El. In.	TS ksi	YS ksi	El. In.		TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change
24-250	203441	203441	97.2(f)	101.9	0.7(f)	101.9	100.6	0.7(f)	--	50.4(h)	-50(h)	54.8(h)	-46(h)	1 Da	-100	1 Da	--
24-250	106.1(f)	106.1(f)	106.1(f)	101.9(f)	0.7(f)	100.6	100.6	0.7(f)	--	55.4(h)	-45(h)	52.6(h)	-48(h)	1 Da	-100	1 Da	--
24-250	101.6(f)	101.6(f)	101.6(f)	101.9(f)	0.7(f)	101.2	101.2	0.7(f)	101.2	52.9(h)	-48(h)	50.0(h)	-51(h)	1 Da	-100	1 Da	--
24-250	104.4(g)	104.4(g)	104.4(g)	102.5(g)	0.7(g)	99.4	99.4	0.7(g)	--	57.5	-43	69.5	-31	2 Da	-100	2 Da	-100
24-250	106.6(g)	106.6(g)	106.6(g)	106.5(g)	0.7(g)	101.3	101.3	0.7(g)	--	67.3	-33	66.2	-34	2 Da	-100	2 Da	-100
24-250	105.5(g)	105.5(g)	105.5(g)	104.5(g)	0.7(g)	100.4	100.4	0.7(g)	100.4	62.4	-38	67.8	-32	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	98.8	98.8	--	--	51.1	-49	53.2	-46	2 Da	-100	2 Da	-100
24-250	--	--	--	--	--	100.2	100.2	--	99.5	37.8	-62	57.8	-42	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	99.5	99.5	--	--	75.2	-22	62.2	-36	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	103.1	103.1	--	--	57.0	-41	63.3	-35	3 Da	-100	3 Da	-100
24-250	--	--	--	--	--	90.8	90.8	--	--	66.1	-32	62.8	-35	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	97.0	97.0	--	97.0	66.1	-32	62.8	-35	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	64.2	64.2	--	--	50.0	-41	57.7	-31	2 Da	-100	2 Da	-100
24-250	--	--	--	--	--	84.1	84.1	--	84.2	51.2	-39	65.5	-28	2 Da	-100	2 Da	-100
24-250	--	--	--	--	--	84.2	84.2	--	84.2	50.6	-40	59.1	-30	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	96.4	96.4	--	--	54.2	-43	61.7	-35	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	88.3	88.3	--	--	65.6	-27	77.8	-13	3 Da	-100	3 Da	-100
24-250	--	--	--	--	--	90.4	90.4	--	89.4	72.9	-18	74.4	-15	1 Da	-100	1 Da	-100
24-250	--	--	--	--	--	69.4	69.4	--	--	77.2	-14	74.6	-17	31 Da	-100	31 Da	-100
24-250	--	--	--	--	--	84.6	84.6	--	90.3	68.0	-27	60.1	-11	68.5	-26	61 Da	-100
24-250	--	--	--	--	--	86.4	86.4	--	--	71.6	-20	77.4	-14	70.6	-22	31 Da	-100
24-250	--	--	--	--	--	85.5	85.5	--	--	67.6	-22	69.5	-19	63.5	-26	59.5	-31
24-250	--	--	--	--	--	87.0	87.0	--	--	63.6	-26	64.6	-25	55.9	-35	55.9	-35
24-250	--	--	--	--	--	86.2	86.2	--	82.0	65.6	-24	67.0	-22	65.5	-24	57.7	-33
24-250	--	--	--	--	--	84.8	84.8	--	--	70.1	-18	73.1	-14	72.8	-15	64.3	-25
24-250	--	--	--	--	--	85.8	85.8	--	81.0	45.9	-46	66.7	-17	66.7	-18	9 Da	-100
24-250	--	--	--	--	--	85.3	85.3	--	81.0	58.0	-32	72.1	-15	69.8	-18	--	-62
24-250	--	--	--	--	--	84.4	84.4	--	--	73.5	-12	74.5	-14	67.8	-19	70.6	-15
24-250	--	--	--	--	--	81.9	81.9	--	80.0	71.9	-14	73.1	-12	71.0	-15	71.8	-14
24-250	--	--	--	--	--	83.2	83.2	--	80.0	72.7	-13	72.3	-13	69.4	-17	71.8	-14
24-250	--	--	--	--	--	83.4	83.4	--	--	64.8	-22	65.6	-21	67.4	-19	70.5	-15
24-250	--	--	--	--	--	82.2	82.2	--	--	70.8	-14	70.6	-15	72.3	-13	68.2	-18
24-250	--	--	--	--	--	82.8	82.8	--	79.2	67.8	-18	68.1	-16	69.8	-16	69.2	-16
24-250	--	--	--	--	--	85.5	85.5	--	--	67.1	-22	71.4	-16	69.0	-19	--	-45
24-250	--	--	--	--	--	82.7	82.7	--	0.7	0.753	--	--	--	--	--	--	--
24-250	--	--	--	--	--	82.7	82.7	--	0.7	0.753	--	--	--	--	--	--	--

(Continued)

Table XL (continued)

THE EFFECT OF PROLONGED AGING AND QUENCHING RATES ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING OF ALLOY 34 (1)

Quench Age (a) t, hr	S. No.	Longitudinal			Transverse			Stress		Unstressed		Stressed 25%		Stressed 50%		Stressed 75%	
		TS ksi	YS ksi	El., % In 10 in.	TS ksi	YS ksi	El., % In 10 in.	Value Used	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS ksi	% Change
CMQ 16 330	283440	82.6(f)	76.2(f)	0.7(f)	86.2	80.3	1.1	--	--	69.7	-18	72.0	-16	68.4	-20	62 Da	-100
CMQ 16 330		83.0(f)	75.7(f)	0.7(f)	85.2	80.5	0.6	--	--	71.4	-16	72.4	-15	70.5	-18	9 Da	-100
CMQ 16 330		82.8(f)	76.0(f)	0.7(f)	85.2	80.4	0.8	85.2	--	70.6	-17	72.4	-15	69.4	-19	--	-100
CMQ 6.225-8/350 283443		--	--	--	83.3	75.6	1.7	--	--	70.1	-14	69.1	-15	68.9	-14	72.5	-11
CMQ 6.225-8/350 Avg.		--	--	--	80.1	75.6	1.4	81.7	--	71.3	-13	71.0	-13	70.0	-14	71.3	-13
CMQ 48 315	283444	79.1(f)	73.1(f)	0.7(f)	83.4	76.8	2.0	--	--	67.2	-18	75.0	-9	68.5	-16	68.6	-16
CMQ 48 315		82.1(f)	73.0(f)	0.7(f)	86.5	76.0	1.2	--	--	72.0	-12	72.6	-11	69.1	-16	67.8	-17
CMQ 48 315		--	--	--	--	--	--	--	--	72.4	-12	--	--	--	--	--	--
CMQ 48 315		80.6(f)	73.0(f)	0.7(f)	82.0	76.4	1.6	82.0	--	71.0	-13	73.8	-10	68.8	-14	68.2	-17
CMQ 48 315	283440	--	--	--	79.7	74.8	0.9	--	--	66.2	-15	64.5	-20	64.7	-19	66.0	-18
CMQ 48 315		--	--	--	80.5	75.6	0.9	--	--	67.1	-16	65.2	-19	65.1	-19	63.3	-21
CMQ 48 315		--	--	--	80.1	75.2	0.9	75.2	--	67.6	-16	65.5	-19	64.7	-19	64.3	-19
CMQ 48 315	283444	--	--	--	74.6	71.0	0.7	--	--	66.5	-17	64.9	-19	66.6	-17	65.8	-18
CMQ 48 315		--	--	--	80.6	71.1	2.2	--	--	64.6	-19	64.8	-20	65.4	-19	65.5	-19
CMQ 48 315		--	--	--	77.6	71.0	1.4	71.0	--	65.1	-19	64.8	-20	66.0	-18	65.6	-19
CMQ 48 315	283446	--	--	--	72.5	72.7	0.6	--	--	62.6	-18	63.2	-18	64.6	-16	63.4	-17
CMQ 48 315		--	--	--	76.2	72.7	1.2	--	--	63.8	-17	62.5	-19	61.8	-20	64.6	-16
CMQ 48 315		--	--	--	76.8	72.7	1.0	72.7	--	63.3	-18	62.5	-18	63.2	-18	64.0	-17
CMQ 48 315	283447	--	--	--	74.6	70.1	0.5	--	--	63.2	-17	66.3	-13	64.8	-15	59.1	-23
CMQ 48 315		--	--	--	78.7	71.1	0.8	--	--	64.1	-16	64.5	-12	67.1	-12	67.5	-25
CMQ 48 315		--	--	--	76.6	70.6	0.6	70.6	--	63.7	-17	65.1	-14	66.1	-14	68.3	-24
CMQ 48 315 Overall Avg.		50.6	73.0	0.7	78.6	73.2	1.1	--	--	67.1	-16	66.4	-15	65.8	-17	64.2	-19
CMQ 32 330	283440	--	--	--	75.6	72.5	1.0	--	--	77.7	-1	65.0	-17	67.3	-14	61.8	-21
CMQ 32 330		--	--	--	81.2	73.6	1.6	--	--	77.7	-1	70.3	-10	68.8	-13	63.1	-23
CMQ 32 330		--	--	--	78.4	73.2	1.3	78.4	--	77.7	-1	67.6	-14	68.0	-13	61.0	-22
CMQ 8 350	283440	--	--	--	78.2	71.7	0.9	--	--	68.4	-13	63.9	-18	70.1	-11	65 Da	-100
CMQ 8 350		--	--	--	78.2	71.7	1.1	--	--	69.3	-12	69.0	-12	69.3	-11	63.6	-19
CMQ 8 350		--	--	--	78.2	71.7	1.0	78.2	--	68.8	-12	66.4	-15	69.7	-11	--	-60
BMQ 24 250	283443	--	--	--	76.6	72.5	0.9	--	--	60.7	-21	60.7	-21	69.0	-10	3 Da	-100
BMQ 24 250		--	--	--	75.0	73.4	1.1	--	--	56.1	-24	68.6	-11	65.9	-14	3 Da	-100
BMQ 24 250		--	--	--	--	--	--	--	--	--	--	--	--	64.6	-16	--	-100
BMQ 24 250		--	--	--	76.8	73.0	1.0	76.8	--	59.4	-23	64.6	-16	66.5	-13	--	-100
BMQ 24 250	283440	--	--	--	75.7	69.5	1.0	--	--	58.3	-24	58.8	-23	59.0	-23	24 Da	-100
BMQ 24 250		--	--	--	77.1	69.3	0.9	--	--	63.5	-17	63.1	-17	65.0	-15	28 Da	-100
BMQ 24 250		--	--	--	76.4	69.6	1.0	76.4	--	60.9	-20	61.0	-20	62.0	-19	--	-100
BMQ 24 250	283444	--	--	--	72.6	72.4	0.9	--	--	58.0	-21	62.8	-15	62.4	-15	53.7	-27
BMQ 24 250		--	--	--	71.8	72.2	0.9	--	--	64.5	-11	63.1	-16	57.9	-21	27.4	-22
BMQ 24 250		--	--	--	73.7	72.3	0.9	73.7	--	61.7	-16	63.0	-15	60.2	-15	55.6	-25
BMQ 24 250 Overall Avg.		--	--	--	75.6	71.6	0.9	--	--	60.5	-20	62.8	-17	63.4	-16	--	-75
BMQ 8 330	283443	--	--	--	68.2	61.2	1.5	--	--	58.5	-14	59.1	-13	55.7	-18	57.1	-16
BMQ 8 330		--	--	--	68.3	62.4	0.9	--	--	59.7	-12	60.3	-12	56.4	-18	55.9	-17
BMQ 8 330		--	--	--	68.2	61.8	1.2	68.2	--	59.1	-13	59.7	-13	56.0	-18	55.8	-17

(a) All samples CMT 2 hrs at 860°F

(b) Failed before reaching 0.2% offset

(c) Avg. of 3 or more values

(d) Not obtained

(e) Does not include data from 28 day AI test

(f) S. No. 283445 data

(g) S. No. 277406 data

(h) Data for 28 day AI test

(i) AI 7.6 Zn, 2.5 Mg, 1.0 Cu, 3.5 Fe, 4.9 Ni, 0.09 Cr.

Table XLI
THE EFFECT OF PROLONGED AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING OF ALLOY 79
S. No. 283188 (b)

Age (a) t	Longitudinal				Transverse		Stressed Value, ksi	Unstressed		Stressed 25% YS		Stressed 50% YS		Stressed 75% YS	
	TS ksi	YS ksi	El, % In 4D	YS/Density x100 in.	TS ksi	YS ksi		TS ksi	% Change	TS ksi	% Change	TS ksi	% Change	TS, ksi or Days to Failure	% Change
24	97.2(d) 96.3(e) 96.9(c)	88.6(d) 87.3(e) 86.0(c)	5.5(d) 2.7(e) 3.7(c)	0.656(d) 0.842(e) 0.849(c)	80.2(d) 84.1(e) 86.7(c)	81.6(d) 75.4(e) 77.5(c)	-- -- 75.5	74.9 75.1 75.0	-12 -12 -12	61.1 59.9 63.5	-28 -22 -25	84 Da 48.6 --	-100 -43 -72	52 Da 52 Da --	-100 -100 -100
6	86.4	77.0	7.5	0.743	79.3	71.1	--	71.3	-10	72.7	-8	70.9	-10	70.6	-11
8	-- 86.4	-- 77.0	-- 7.5	-- 0.743	78.7 79.0	70.1 70.6	-- 70.6	71.3 71.3	-8 -10	72.9 72.8	-8 -8	70.6 70.5	-11 -10	72.5 71.6	-8 -9
16	80.2	66.5	9.0	0.661	74.4	64.5	--	68.0	-9	69.3	-8	68.0	-9	66.5	-11
Avg.	-- 80.2	-- 66.5	-- 9.0	-- 0.661	75.8 75.1	64.5 64.5	-- 64.5	68.1 68.0	-9 -9	69.4 69.4	-8 -8	64.5 66.2	-14 -12	63.9 65.2	-15 -13
	78.4	66.2	9.0	0.638	71.7	61.5	--	62.8	-14	63.6	-13	62.0	-15	65.9	-10
Avg.	-- 78.4	-- 66.2	-- 9.0	-- 0.638	74.6 73.2	61.7 61.6	-- 61.6	63.2 63.0	-14 -14	63.7 63.6	-13 -13	63.7 62.8	-13 -14	60.4 63.2	-17 -14

- Notes: (a) SHT 2 hrs. at 860°F, CWQ, Aged as noted.
(b) AL 6.6 Zn, 2.8 Mg, 2.1 Cu, 1.0 Mn, 0.5 Cr, 0.1 Zr.
(c) Avg. of 3 or more test values.
(d) Highest test value.
(e) Lowest test value.

Table XLII

THE EFFECT OF PROLONGED AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING OF ALLOY 87

S. No. 283196 (b)

S. NO. 203178 (U)

Age (a)	Longitudinal				Transverse		El. % In 4D	Stress Value Used, ksi	Unstressed		Stressed 25% Y.S.		Stressed 50% Y.S.		Stressed 75% Y.S.	
	TS ksi	YS ksi	El. % In 4D	YS/Density x 10 ⁶	TS ksi	YS ksi			TS, ksi	% Change	TS, ksi or Days to Failure	% Change	TS, ksi or Days to Failure	% Change		
24	106.6(d)	99.3(d)	5.1(d)	0.938(d)	97.6(d)	92.2(d)	1.5(d)	--	60.6	-33	58.5	-35	82 Da	-100	1 Da	-100
	103.7(e)	96.8(e)	1.0(e)	0.934(e)	87.9(e)	86.9(e)	0.7(e)	--	58.5	-35	55.2	-39	58	-35	1 Da	-100
Avg.	104.8(c)	99.1(c)	2.6(c)	0.937(c)	92.5(c)	89.5(c)	1.1(c)	87.2	59.6	-34	56.8	-37	--	-68	--	-100
6	90.1	80.7	7.0	0.763	83.9	75.6	2.7	--	67.5	-20	70.0	-17	68.7	-18	59.8	-29
8	--	--	--	--	84.0	76.0	2.9	--	67.5	-20	70.8	-16	67.1	-20	50.6	-40
Avg.	90.1	80.7	7.0	0.763	84.0	75.8	2.8	75.8	67.5	-20	70.4	-16	67.9	-19	55.2	-34
16	85.7	74.6	7.0	0.705	77.5	70.3	2.7	--	62.7	-20	66.6	-15	63.5	-19	66.2	-16
	--	--	--	--	79.9	70.1	3.9	--	65.2	-17	65.8	-16	67.6	-14	64.4	-18
Avg.	85.7	74.6	7.0	0.705	78.7	70.2	3.3	70.2	64.0	-19	66.2	-16	65.6	-17	65.3	-17
48	82.9	69.5	10.0	0.657	77.6	65.9	3.8	--	60.5	-22	60.2	-23	62.4	-20	61.0	-22
	--	--	--	--	77.9	66.4	3.5	--	60.9	-22	61.1	-21	61.0	-22	61.8	-21
Avg.	82.9	69.5	10.0	0.657	77.8	66.2	3.6	66.2	60.7	-22	60.6	-22	61.7	-21	61.4	-21

Notes: (a) SHT 2 hrs. at 860, CWQ, Aged as noted.

(b) Al, 7.6 Zn, 2.5 Mg. 1.1 Cu, 2.2 Fe, 2.3 Ni, 0.16 Cr.

(c) Avg. of 3 or more test values.

(d) Highest test value.

(e) Lowest test value.

Table XLVII:
THE EFFECT OF PROLONGED AGING ON TENSILE PROPERTIES AND STRESS CORROSION CRACKING OF ALLOY 9C
S. No. 294014

[illegible]

(a) Exposed to 3/25 NaCr Al test for 20 days
(b) Exposed to 3/25 NaCr Al test for 24 days
(c) All samples SRT 2 hrs. at 600°F, CWQ. Aged as noted
(d) Al, 7.5 Zn, 2.4 Mg, 1.0 Cu, 1.1 Fe, 1.0 Ni, 0.2 Cr

Table XLIV

STRESS CORROSION CRACKING RESISTANCE OF APM ALLOYS EXPOSED TO

3% NaCl: ALTERNATE IMMERSION TEST BATH

SCC (Stress-Failure Time) (1)														
Alloy No.	S. No.	Age #2 (a, b) Time At 300° F. Hrs.	Longitudinal		Transverse		75% (1)		50% (1)		25% (1)			
			T.S. ksi	Y.S. ksi	EL, % in LD	T.S. ksi	Y.S. ksi	Stress ksi	Time Days	Stress ksi	Time Days	Stress ksi	Time Days	
34	283412	-D-	110	109	0	102	(g)	<1	---	---	51	1,1	26	OK28(2)
	283493	-D-	116	112	0	102	98	<1	---	---	51	1,2	26	9,OK28
	283411	0	106(c)	106(c)	<1(c)	101	(g)	(h)	---	---	50	1,1,1	25	OK28(3)
	283414	0	106(c)	103(c)	<1(c)	100	(g)	(h)	75	1,1	50	1,2	25	OK84(2)
34	283411	0	106(c)	103(c)	<1(c)	100	(g)	(h)	75	1,1	50	2,2	25	OK84(2)
52	283492	0	106(c)	103(c)	2(c)	98	(g)	(h)	---	---	49	1,1,1	24	OK84(3)
	283452	-D-	116	111	<1	98	(g)	0	---	---	49	1,1	24	5,5
	283451	0	112	108	1	97	97	(h)	74	1,1	48	1,2	24	6,17
	283483	-D-	115	113	0	97	(g)	(h)	---	---	48	2,2	24	1,5
34	283413	0	106(c)	103(c)	<1(c)	97	(g)	(h)	74	1,2,2	48	1,3	24	OK84(2)
	293496	0	105	99	3	92	90	1	68	1,1	45	82,OK84	22	OK84(2)
	293490	0	109	106	3	90	90	(h)	68	5,6	45	12,15	22	OK84(2)
	283411	-A-	88(c)	83(c)	<1(c)	90	88	1	68	31,61	45	OK84(2)	22	OK84(2)
34	283413	-F-	(d)	(d)	(d)	89	(g)	(h)	67	3,3	44	OK84(2)	22	OK84(2)
	293487	0	108	105	5	92	88	1	66	7,13	44	18,22	22	OK84(2)
	277400	1	101(e)	97(e)	3(e)	86	81	1	64	<1, <1	43	<1, <1	22	OK84(2)
	283410	-B-	83(c)	76(c)	<1(c)	85	80	1	64	9,62	42	OK84(2)	21	OK84(2)
34	283410	0	106(c)	104(c)	<1(c)	84	(g)	(b)	63	1,2	42	2,2	21	OK84(2)
	283418	-A-	88(c)	83(c)	<1(c)	86	82	1	62	OK84(2)	41	OK84(2)	20	OK84(2)
	283459	2	88(e)	83(e)	7(e)	82	76	1	62	6,7	41	21,35	20	OK84(2)
	283413	-C-	(d)	(d)	(d)	82	76	1	62	OK84(2)	41	OK84(2)	20	OK84(2)
34	283411	-C-	81(c)	73(c)	<1(c)	82	76	2	62	OK84(2)	41	OK84(2)	20	OK84(2)
	294011	0	99	93	5	87	81	2	61	2,3,3	40	5,5,16	20	OK28(3)
	283410	-A-	(d)	(d)	(d)	85	81	1	61	9,OK84	40	OK84(2)	20	OK84(2)
	283490	4	94	89	1	84	80	1	60	25,33	40	OK84(2)	20	OK84(2)
34	283411	-A-	88(c)	83(c)	<1(c)	83	80	1	60	OK84(2)	40	OK84(2)	20	OK84(2)
	277375	3	102(e)	99(e)	3(e)	80	(g)	<1	60	2,3	40	24,27	20	OK84(2)
	277375	7	89(e)	85(e)	4(e)	80	78	<1	60	9,9	40	29,53	20	OK84(2)
	277400	8	87(e)	83(e)	5(e)	80	77	1	60	11,11	40	37	20	OK84(2)
28	277391	8	88(e)	83(e)	10(e)	80	74	1	60	24,32	40	44,60	20	OK84(2)
	294011	-C-	77	68	9	64	64	3	60(k)	OK84(3)	40(k)	OK84(3)	20(k)	OK84(3)
	293487	3	94	88	7	84	79	3	59	31,31	40	OK84(2)	20	OK84(2)
	283417	-A-	88(c)	83(c)	<1(c)	83	79	1	59	OK84(2)	40	OK84(2)	20	OK84(2)
20	277392	8	91(e)	85(e)	8(e)	79	76	1	59	7,9	40	24,35	20	OK84(2)
	277378	5	90(e)	85(e)	8(e)	79	76	2	59	5,6	40	18,30	20	OK84(2)

(Continued)

Table CLV Continued

STRESS COR. STOP CRACKING PREVENTION OF APM ABOVE EXP. 10.

DATE: 10/10/2011

Allot No.	S. No.	Age of (a, b) Year	Longitudinal			T.R. Averages			75% (a)			50% (a)			25% (a)		
			7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg	7.5 kg
1	27735	13	67(e)	51(e)	5(e)	71	76	59	59	51, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
2	27736	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
3	27737	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
4	27738	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
5	27739	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
6	27740	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
7	27741	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
8	27742	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
9	27743	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
10	27744	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
11	27745	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
12	27746	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
13	27747	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
14	27748	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
15	27749	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
16	27750	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
17	27751	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
18	27752	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
19	27753	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
20	27754	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
21	27755	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
22	27756	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
23	27757	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
24	27758	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
25	27759	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
26	27760	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
27	27761	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
28	27762	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
29	27763	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
30	27764	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
31	27765	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
32	27766	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
33	27767	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
34	27768	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
35	27769	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
36	27770	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
37	27771	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
38	27772	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
39	27773	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
40	27774	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
41	27775	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
42	27776	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
43	27777	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
44	27778	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
45	27779	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
46	27780	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
47	27781	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
48	27782	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
49	27783	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
50	27784	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
51	27785	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
52	27786	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
53	27787	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
54	27788	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
55	27789	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
56	27790	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
57	27791	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
58	27792	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
59	27793	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
60	27794	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
61	27795	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
62	27796	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
63	27797	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
64	27798	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
65	27799	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
66	27800	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
67	27801	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
68	27802	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
69	27803	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
70	27804	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
71	27805	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
72	27806	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
73	27807	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
74	27808	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
75	27809	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
76	27810	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
77	27811	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
78	27812	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
79	27813	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
80	27814	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
81	27815	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
82	27816	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OKBU(2)
83	27817	13	51	51	5	64	76	58	58	52, 52	45, 47	19	OKBU(2)	20	OKBU(2)	20	OK

(Continued)

Table XLIV (Continued)

STRESS CORROSION CRACKING RESISTANCE OF APM ALLOYS EXPOSED TO

3% NaCl: ALTERNATE IMMERSION TEST BATH

Alloy No.	S. No.	Age #2 (a, b) hrs	Longitudinal		Transverse		75% (d)		SCC (Stress-Failure Time) (e)	
			T.S. ksi	EL, S in	T.S. ksi	EL, S in	Stress ksi	Time hrs	Stress ksi	Time hrs
36	217936	36	79(e)	3(e)	67	64	50	21, 69	34	ORBU(2)
4	277376	27	76(e)	7(e)	67	63	50	9, 11	34	ORBU(2)
67	293196	-C-	83	20	78	66	50	ORBU	33	ORBU(2)
2	277376	28	77(e)	8(e)	66	65	50	61, ORBU	33	ORBU(2)
90	293024	-A-	81	6	77	71	49(m)	73, 75, ORBU	33(m)	ORBU(3)
36	293024	16	82	4	76	65	49	26, 84	32	ORBU(2)
90	293024	-B-	78	10	71	65	49	ORBU(3)	32	ORBU(2)
5	277377	28	83(e)	5(e)	67	64	49	11, 14	32	ORBU(2)
36	277377	36	78(e)	4(e)	67	65	49	11, 34	32	ORBU(2)
90	293024	0	83	5	87	81	48(m)	9, 16, 21	32(n)	ORBU(3)
71	293187	20	81	6	75	64	48	ORBU(2)	32	ORBU(2)
79	293188	-B-	80	9	75	64	48	(2)	32	ORBU(2)
90	293024	-C-	77	9	69	64	48	3(2)	32	ORBU(2)
31	277206	35	79(e)	7(e)	64	62	48	22, 41	32	ORBU(2)
52	283496	24	79	6	71	63	47	ORBU(2)	32	ORBU(2)
79	293188	-C-	76	9	73	62	46	ORBU(2)	31	ORBU(2)
49	283472	-	120	4.1	51	(g)	--	-----	26	4, 6
7178-T652 (1)			92	8	63	74	56	1 to 12	37	1 to 13
7075-T652 (1)			88	11	75	65	49	1 to 12	32	1 to 13
7075-T652 (1)			75	11	62	54	42	ORBU	28	ORBU

(a) All specimens SNT 2 Hrs at 860°F, OR, Age #1, 24 Hrs at 250°F, Age #2, as noted (exceptions are listed (b)).

(b) Heat Treatment Used

- A- Age #1, 1 Hrs at 250°F, Age #2 6 Hrs at 150°F.
- B- Age #1, 1 Hrs at 150°F.
- C- Age #1, 1 Hrs at 150°F.
- D- Age #1, 1 Hrs at 150°F.
- E- SNT 2 Hrs at 860°F, OR, Age #1 24 Hrs at 250°F.
- F- Age #1, 6 Hrs at 150°F.
- G- Age #1, 6 Hrs at 150°F.
- H- Age #1, 6 Hrs at 250°F, Age #2, 6 Hrs at 150°F.
- I- Age #1, 12 Hrs at 150°F.
- J- OR, Age #1, 24 Hrs at 250°F.
- K- OR, Age #1, 6 Hrs at 150°F.
- L- No Age #2

(c) Tensile properties were determined on another extrusion.

(d) Not determined.

(e) Predicted values from available data.

(f) Each value represents one specimen except for run cuts where number of specimen are given in parentheses.

(g) Called before reaching 0.2% offset.

(h) Specimen fractured.

(i) Typical from 0.2% to 0.25% to 0.3% A. extrusion.

(j) Stress levels except when noted.

(k) Stress levels used, 175, 615, and 335, respectively.

(l) Stress levels used, 425, 535, and 275, respectively.

(m) Stress levels used, 495, 645, and 245, respectively.

(n) Stress levels used, 615, 615, and 245, respectively.

Table XLV

A. P. M. ALLOYS MEETING STRESS CORROSION AND STRENGTH TARGETS

Alloy	Composition, %			Other	Aging (a)	Longitudinal			SCC	
	Zn	Mg	Cu			T.S. ksi	Y.S. El., ksi in 4D	(b) Stress to Failure ksi	Days to Failure	
<u>Target I: 7075-T7351 + 10% with no failures at 75% Y.S.</u>						83	73	5	>48	O K 84
<u>A. Meets Target</u>										
87	7.6	2.5	1.1	2.2 Fe, 2.3 Ni, .2 Cr.	6 @ 250 + 8 @ 330	90	81	7	57	O K 84
87	7.6	2.5	1.1	2.2 Fe, 2.3 Ni, .2 Cr.	16 @ 330	86	75	7	52	O K 84
77	6.8	2.8	2.1	1.0 Mn, .5 Cu, .1 Zr.	6 @ 250 + 8 @ 330	86	79	8	54	O K 84
90	7.5	2.4	1.0	1.1 Fe, 1.0 Ni, .2 Cr.	6 @ 250 + 8 @ 330	84	78	8	54	O K 84
<u>B. May Meet Target After Changes in Aging Practices</u>										
71	9.3	3.6	.5	.7 Co, .02 Cr, .02 Ti.	24 @ 250 + 8 @ 330	87	80	9	60	45,54
52	10.0	4.0	.9	1.5 Co, .01 Cr, .02 Ti	24 @ 250 + 4 @ 330	94	89	4	54	33,33
34	7.8	2.5	1.0	3.5 Fe, 4.9 Ni, .09 Cr	6 @ 250 + 8 @ 330	88	83	<1	61	O K 84
<u>Target II: 7178-T651 + 10% Strength Improvement, Equal Stress Corrosion Resistance</u>						101	92	5	7-20	O K 84
<u>A. Meets Target</u>										
71	9.3	3.6	.5	.7 Co, .02 Cr, .02 Ti	24 @ 250	108	105	5	22	O K 84
<u>B. May Meet Target After Changes in Aging Practices</u>										
52	10.0	4.0	.9	1.5 Co, .01 Cr, .02 Ti	24 @ 250	106	103	2	45	12,15
87	7.6	2.5	1.1	2.2 Fe, 2.3 Ni, .2 Cr.	24 @ 250	105	99	3	45	82, OK84
52	10.0	4.0	.9	1.5 Co, .01 Cr, .02 Ti	24 @ 250	109	106	3	49	1,1
<u>Target III: Better Stress Corrosion Resistance than 7178-T651</u>						92	84	5	7-20	O K 84
<u>A. Meets Target</u>										
71	9.3	3.6	.5	.7 Co, .02 Cr, .02 Ti	24 @ 250	108	105	5	22	O K 84
90	7.5	2.4	1.0	1.1 Fe, 1.0 Ni, .2 Cr	24 @ 250	99	93	5	20	O K 28
71	9.3	3.6	.5	.7 Co, .02 Cr, .02 Ti	24 @ 250 + 3 @ 330	94	88	7	40	O K 84
<u>B. May Meet Target After Changes in Aging Practices</u>										
52	10.0	4.0	.9	1.5 Co, .01 Cr, .02 Ti	24 @ 250	106	103	2	24	O K 84
87	7.6	2.5	1.1	.02 Mn, 2.2 Fe, 2.3 Ni, .2 Cr.	24 @ 250	105	99	3	22	O K 84
52	10.0	4.0	.9	1.5 Co, .01 Cr, .02 Ti	24 @ 250 + 4 @ 330	94	89	4	40	O K 84
3	12.3	4.0	1.6	.5 Mn	24 @ 250 + 3 @ 330	102	99	3	20	O K 84
79	6.5	2.7	2.1	1.0 Mn, .5 Cr.	24 @ 250	97	88	4	20	O K 84

(a) All Specimens SH1 & Hru at 860°F, Cold water quenched, aged as noted.

(b) Exposed in 3% NaCl AI bath at room temperature. Stressed in short transverse direction.

TABLE XLVI

ELECTRON MICROPROBE SEMI-QUANTITATIVE ANALYSIS OF LARGE CONSTITUENT PARTICLES

Alloy No.	S. No.	(e)	Alloying Elements	Constituent Composition, %									
				Zn	Mg	Cu	Mn	Fe	Ni	Cr	Ti	V	Al
14	277386		A	10	5	2	2	6	10	3(d)	—	—	57
15	277387		B	2	3	0	—	—	—	1	18	7	55
16	277388		C	1	0	0	—	—	—	7	12	17	59
17(b)	277389		D	16	9	4	—	—	—	—	—	—	47
17(c)	277389		D	3	3	0	—	—	—	—	—	—	51
18	277390		E	1	0	0	0	0	0	1	15	6	56

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Note: Accuracy $\pm 10\%$ of indicated value for amounts above 10%, $\pm 20\%$ of indicated value for amounts below 10%.

(a) Base composition, Al-12% Zn-3.5% Mg-1.5% Cu to which were added

A - 1.5% each Mn, Fe, Ni
 B - 0.5% each Cr, Ti, V, Zr
 C - 2.0% Cr-0.8% Ti-2.0% V-1.0% Zr
 D - 1.5% each Co, Mo, W
 E - 0.5% each Mn, Fe, Ni, Cr, Ti, V, Zr, Co, Mo, W

(b) Light colored particle.

(c) Dark colored particles.

(d) Not an alloying element. Presence unexplained.

(e) Extrusions SHT 2 hrs at 860°F, CMQ, Aged 24 hrs at 250°F.

TABLE XLVII
PHASES PRESENT IN AL-Zn-Mg-Cu-Mn ALLOYS IN -76 TEMPER

Alloy No.	Composition, %					Phase (s)			
	Zn	Mg	Cu	Mn	Si	α (Al-Mn)	Al-Mg-Mn	α (Al-Cu-Fe)	Type
1	9.84	3.53	1.07	.52	.03	.05	M.	W.	M.
33	8.95	3.47	1.18	1.13	.15	.10	M.S.	Tr.	M.S.
35	9.01	3.41	1.16	2.53	.19	.11	S.	Tr.	M.S.
36	10.7	3.82	2.04	1.66	.13	.10	M.W.	V.W.	M.W.

(a) Phases

- α (Al-Mn)
- α (Al-Mg-Mn)
- α (Al-Cu-Fe) type
- M
- W
- Tr
- MnAl₆
- Al₁₀Mg₂Mn
- May contain some Mn
- Mg/Zn₂
- Al₂Mg₃Zn₃

Diffraction line intensity relative to that from other alloys.

- S.
- M.S.
- M.
- M.W.
- W.
- V.W.
- Tr.
- Strong
- Medium strong
- Medium
- Medium weak
- Weak
- Very weak
- Trace

ELECTRON MICROPROBE SEMI-QUANTITATIVE ANALYSIS

OF LARGE CONSTITUENT PARTICLES IN ALLOYS 34 AND 87

(a) Alloy 34, Al 7.77 Zn, 2.48 Mg, 1.03 Cu, 0.02 Mn, 3.49 Fe, 4.94 Ni, 0.09 Cr, 0.01 Ti, 0.07 Si, 0.59 Al₂O₃
Alloy 87, Al 7.58 Zn, 2.52 Mg, 1.06 Cu, 0.02 Mn, 2.16 Fe, 2.26 Ni, 0.16 Cr, 0.01 Ti, 0.01 V, 0.01 Co, 0.05 Si, 0.63 Al₂O₃

Table XLIX

ELECTRON MICROPROBE SEMI-QUANTITATIVE ANALYSIS
OF LARGE CONSTITUENT PARTICLES IN ALLOYS 52 AND 71

Alloy (a)	Particles Particular Type	Constituent Composition %											Remarks		
		Al	Mg	Zn	Fe	Mn	Cr	Cu	Pb	Ti	Si	Co		Ca (b)	K (c)
52	2,5,7,9-15	Nonmetallic	-	-	-	-	-	-	-	40	10	-	-	-	Probably Zr SiO ₄
	1	Nonmetallic	-	-	-	7	-	-	-	-	-	-	-	-	-
	3	Nonmetallic	20	10	-	1	-	-	-	-	-	-	-	-	-
	4	Nonmetallic	10	-	-	3	-	-	-	-	10	-	-	-	-
	8	Nonmetallic	25	-	-	2	-	-	-	-	10	-	L	L	-
	16B (c)	Nonmetallic	-	-	-	72	-	-	-	-	-	-	M	-	-
	16A (c)	Metallic	56	-	2	42	-	-	-	2	-	-	-	-	Fe ₃ O ₄ FeAl ₃ Fe
	16C (c)	Metallic	-	-	-	>95	-	-	-	2	-	-	-	-	-
71	3,C,E,H	Nonmetallic	-	-	-	-	-	-	-	40	10	-	-	-	Zr SiO ₄
	2	Nonmetallic	10	5	-	-	-	-	-	-	-	-	-	-	-
	5	Nonmetallic	7	5	-	<4	-	-	-	-	15	-	-	-	-
	A	Nonmetallic	12	20	2	1	-	-	-	-	3	-	-	-	-
	B	Nonmetallic	-	1	1	-	-	-	-	-	30	-	-	-	-
	D	Nonmetallic	15	-	1	<1	-	-	-	-	10	-	-	-	-
	G	Nonmetallic	15	15	2	<1	-	-	-	-	3	-	-	-	-
	I	Nonmetallic	15	15	2	<1	-	<1	-	-	4	-	-	-	-
	J	Nonmetallic	30	2	1	<1	-	-	-	-	4	-	-	-	-
	1	Metallic	55	-	10	20	2	13	-	-	-	-	-	-	-
	4	Metallic	59	4	5	30	-	2	-	-	-	-	-	-	-
	F	Metallic	55	10	7	25	-	3	-	-	-	-	-	-	-
															<1

(a) Alloy 52, Al, 9.99 Zn, 4.01 Mg, 0.92 Cu, 0.01 Mn, 0.14 Fe, 0.01 Ni, 0.01 Cr, 0.02 Ti, 1.49 Co, 0.06 Si, 0.75 Al₂O₃

Alloy 71 Al, 9.2 Zn, 3.62 Mg, 0.63 Cu, 0.02 Cr, 0.03 Ti, 0.75 Co, 0.26 Al₂O₃

(b) Since per cent standards are not readily available for these elements, L for Low and M for Moderate were used.

(c) Particle 16 is very large and is composed of three phases--a dark nonmetallic phase (16B--Fe₃O₄) one side, a light metallic phase (16A--FeAl₃) on the other side and a small amount of a second metallic phase (16C--Metallic Fe) in the center.

Table L
IDENTIFICATION OF PHASES IN POWDERS AND EXTRUDED SECTIONS

Alloy	S. No. (a)	Product	Age (b) t/T Hrs/°F	Phases									
				Al	Mg ₂ Si	FeNiAl ₉	MgZn ₂	Al ₁₂ Mg ₂ Cr	Co ₂ Al ₉	Mg ₃ Zn ₃ Al ₂	(e)	M'ppt	
34	283269	Powder	----	✓	✓	(c) ✓	---	---	---	---	---	---	
	283441	2" Ø Extrusion	24/250	✓	✓	(c) ✓	✓	✓	---	---	✓	---	
	283441	2" Ø Extrusion	48/315	✓	✓	(c)(d) ✓	✓	✓	---	---	✓	✓	
87	307598	Powder	----	✓	✓	(c) ✓	---	---	---	---	---	---	
	293196	2" Ø Extrusion	24/250	✓	✓	(c) ✓	✓	✓	---	---	✓	---	
	293196	2" Ø Extrusion	48/315	✓	✓	(c)(d) ✓	✓	✓	---	---	✓	✓	
52	283274	Powder	----	✓	✓	---	---	---	✓	---	---	---	
	283490	2" Ø Extrusion	24/250	✓	✓	---	✓	---	✓	✓	---	---	
	283490	2" Ø Extrusion	24/250 + 20/330	✓	✓	---	✓	---	✓	✓	---	✓	
71	283303	Powder	----	✓	✓	---	---	---	✓	---	---	---	
	293387	2" Ø Extrusion	24/250	✓	✓	---	✓	---	✓	✓	---	---	
	293387	2" Ø Extrusion	24/250 + 20/330	✓	✓	---	✓	---	✓	✓	---	✓	
(a) Alloy				Zn	Mg	Si	Cr	Ti	Co	V	Sn		
34				7.77	2.46	0.02	0.09	0.01	---	---	0.01	0.07	
87				7.58	2.52	0.02	0.16	0.01	0.01	0.01	0.05		
52				9.99	4.01	0.01	0.01	0.02	1.49	---	0.06		
71				9.29	3.58	---	0.02	0.02	0.68	---	---		

(b) Powders were as atomized, extrusions were SHT 2 Hrs at 860°F, CWQ, aged as noted.

(c) FeNiAl₉ finer in powder, amount increased in extrusion.

(d) The amount of FeNiAl₉ increases in extrusion.

(e) Four lines unidentified.

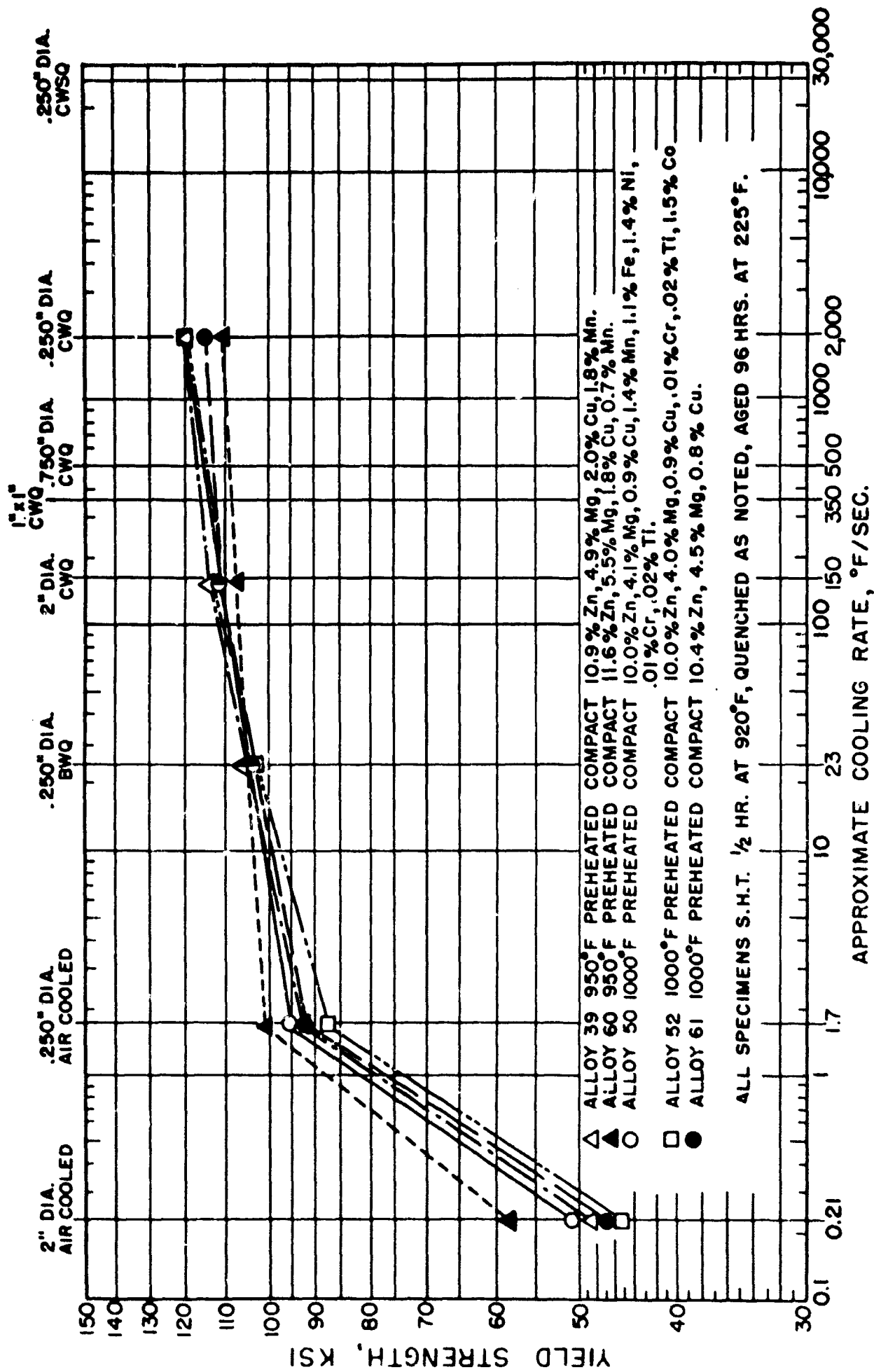


FIGURE 1

THE EFFECT OF COOLING RATE ON YIELD STRENGTHS OF EXTRUSIONS

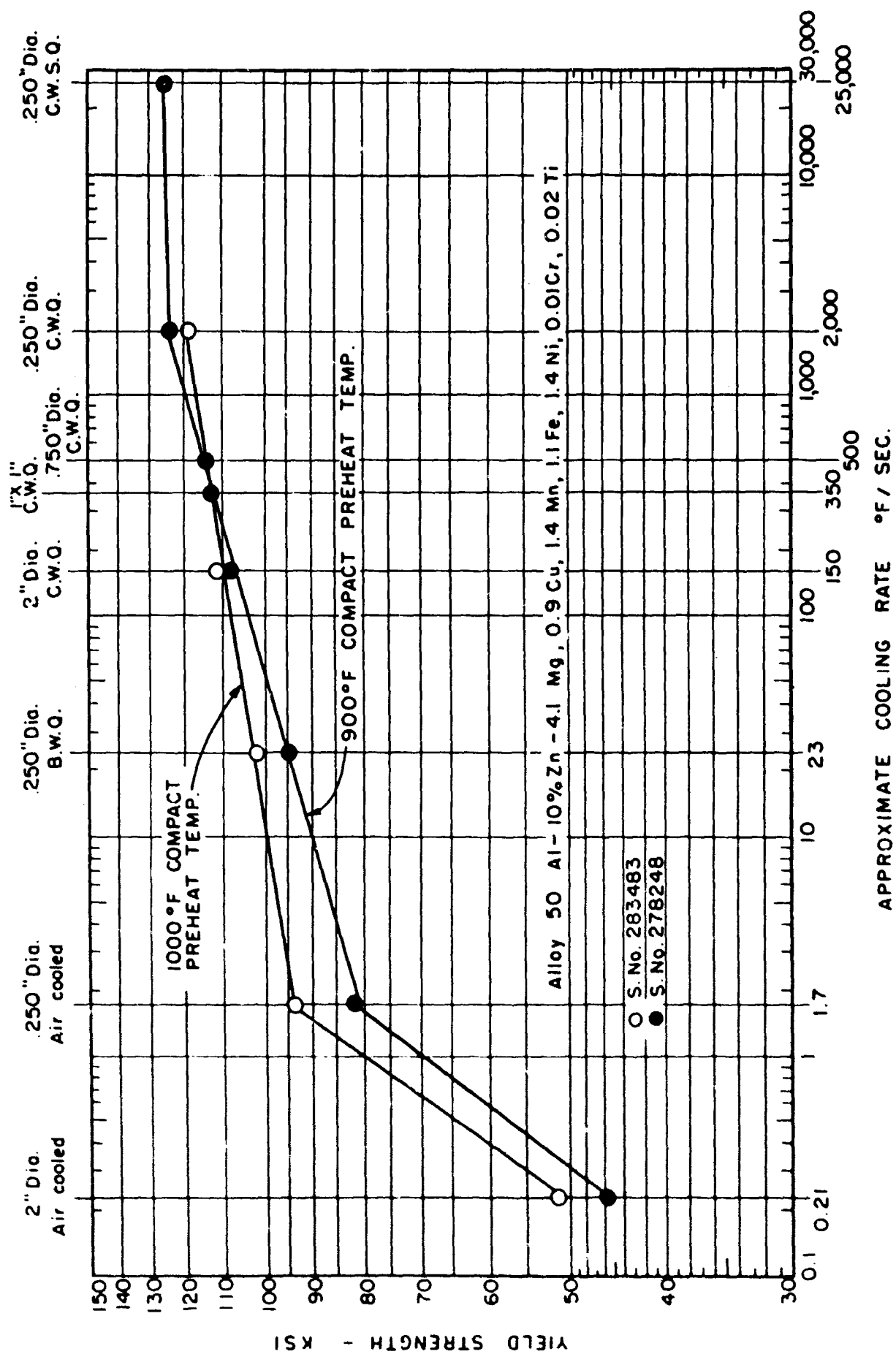


FIGURE 2
 THE EFFECT OF COMPACT PREHEAT TEMPERATURE AND COOLING RATE ON ROOM TEMPERATURE LONGITUDINAL YIELD STRENGTH

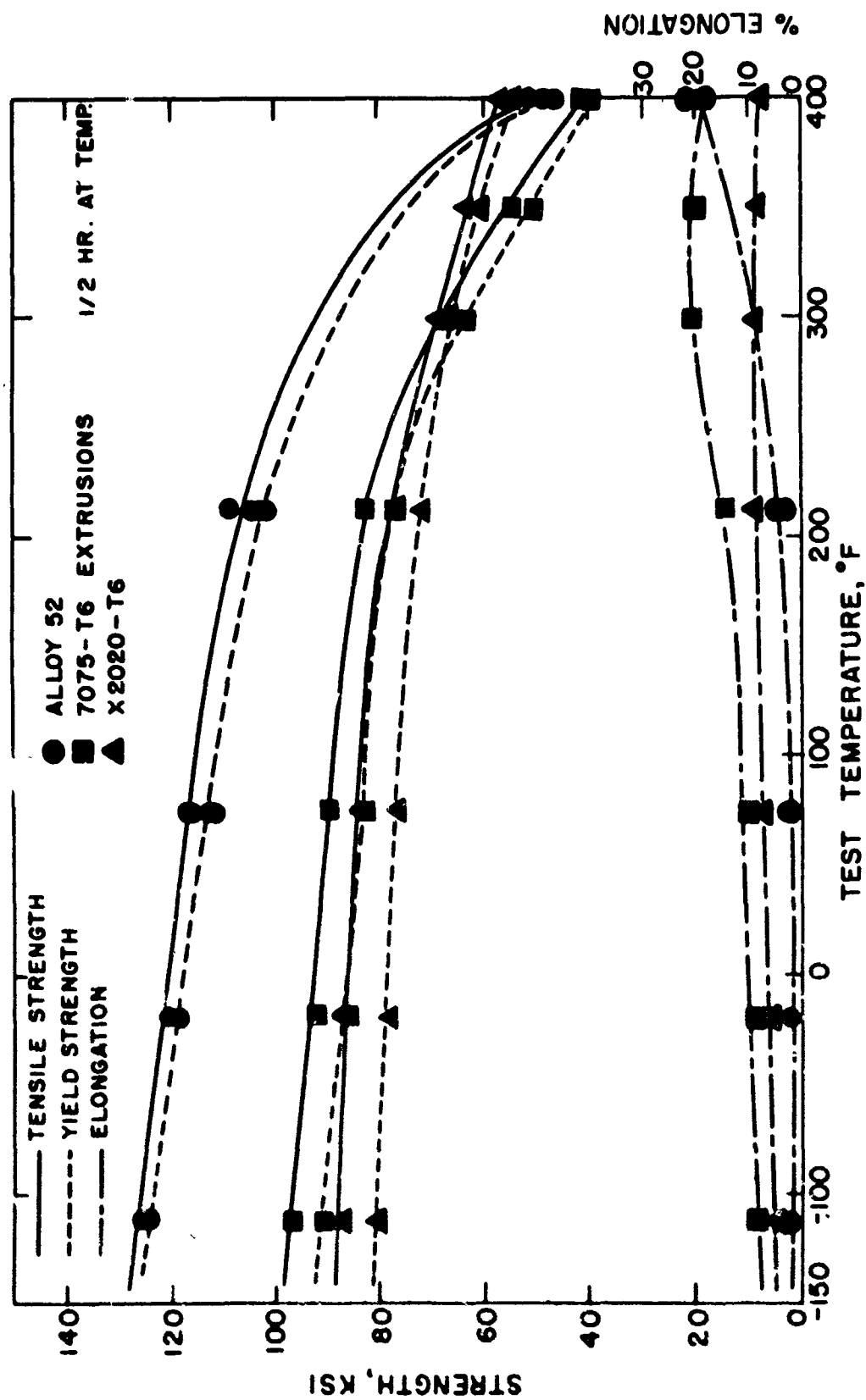
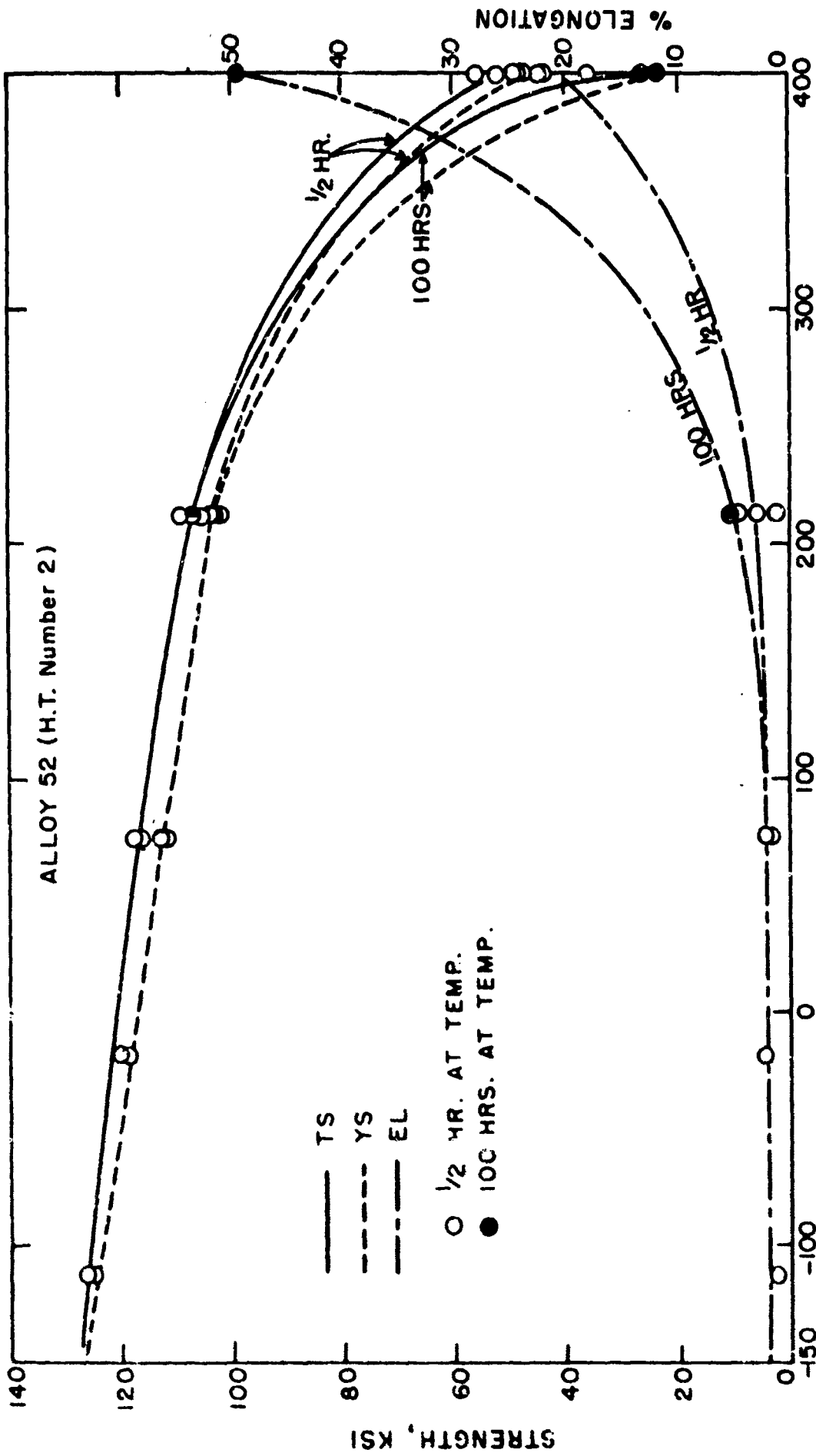


FIGURE 3
LONGITUDINAL TENSILE PROPERTIES OF ALLOYS AT
CRYOGENIC AND ELEVATED TEMPERATURES



THE EFFECT OF TIME AT TEMPERATURE ON LONGITUDINAL TENSILE PROPERTIES

FIGURE 4

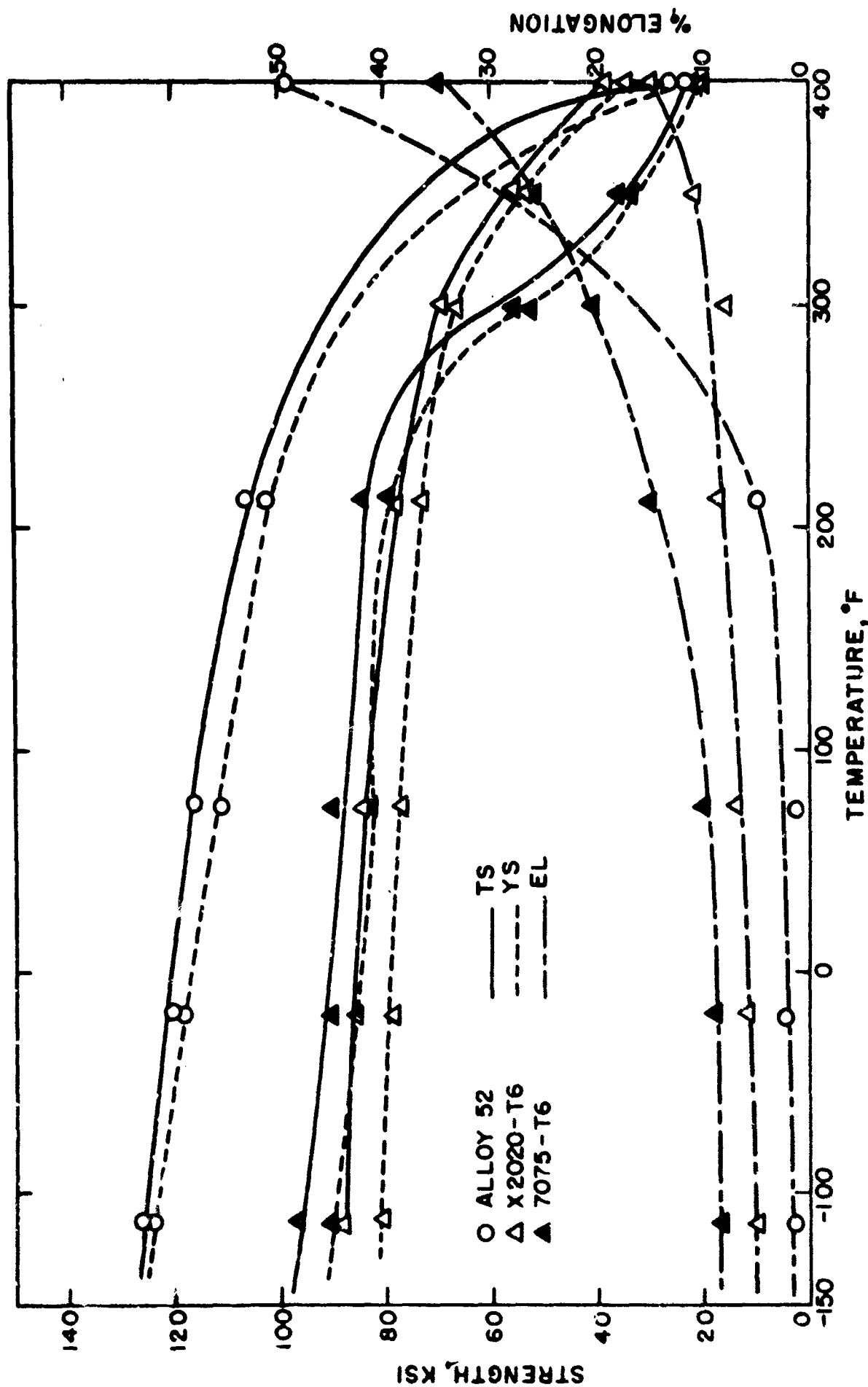


FIGURE 5

LONGITUDINAL TENSILE PROPERTIES AFTER 100 HOURS AT TEMPERATURE

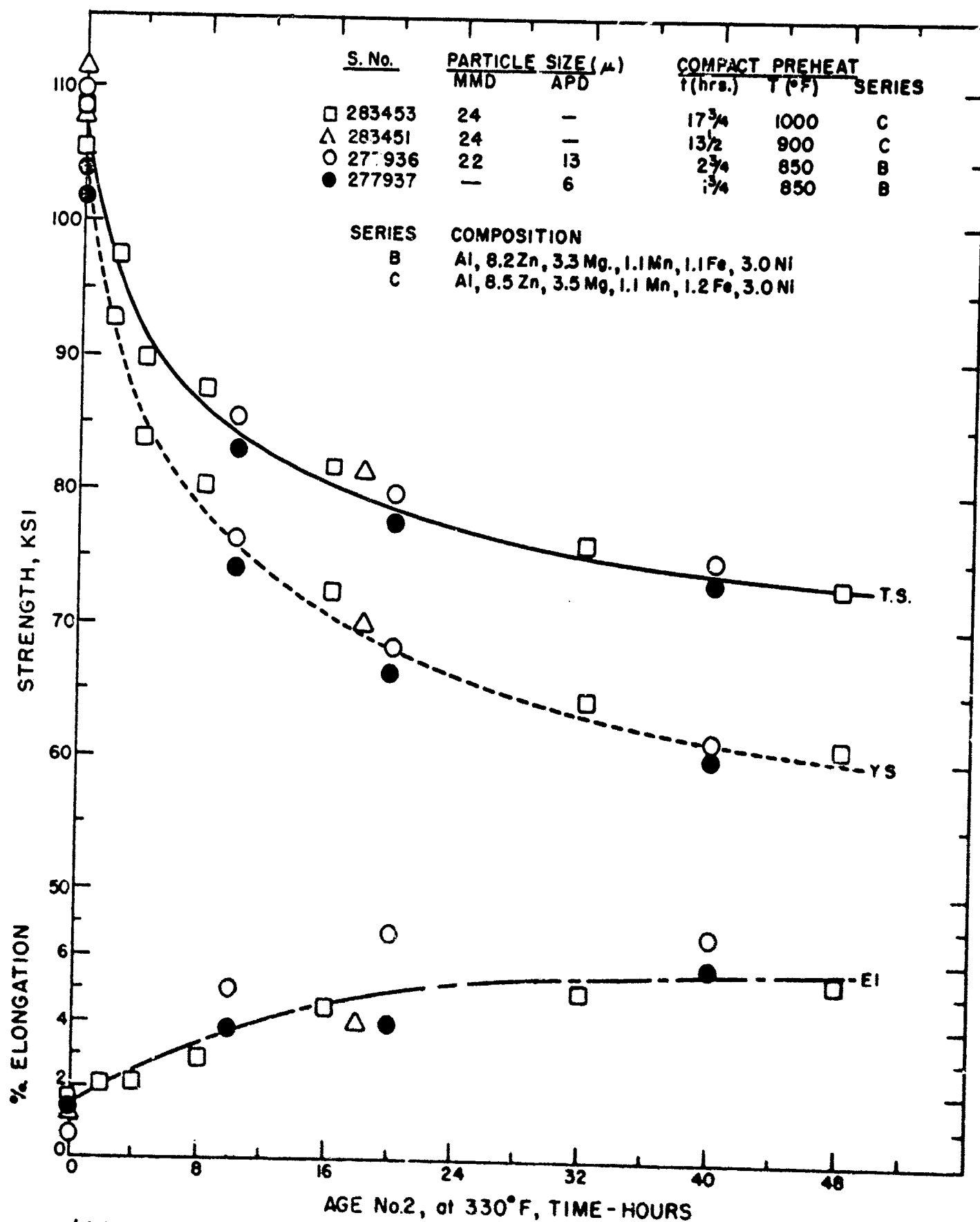
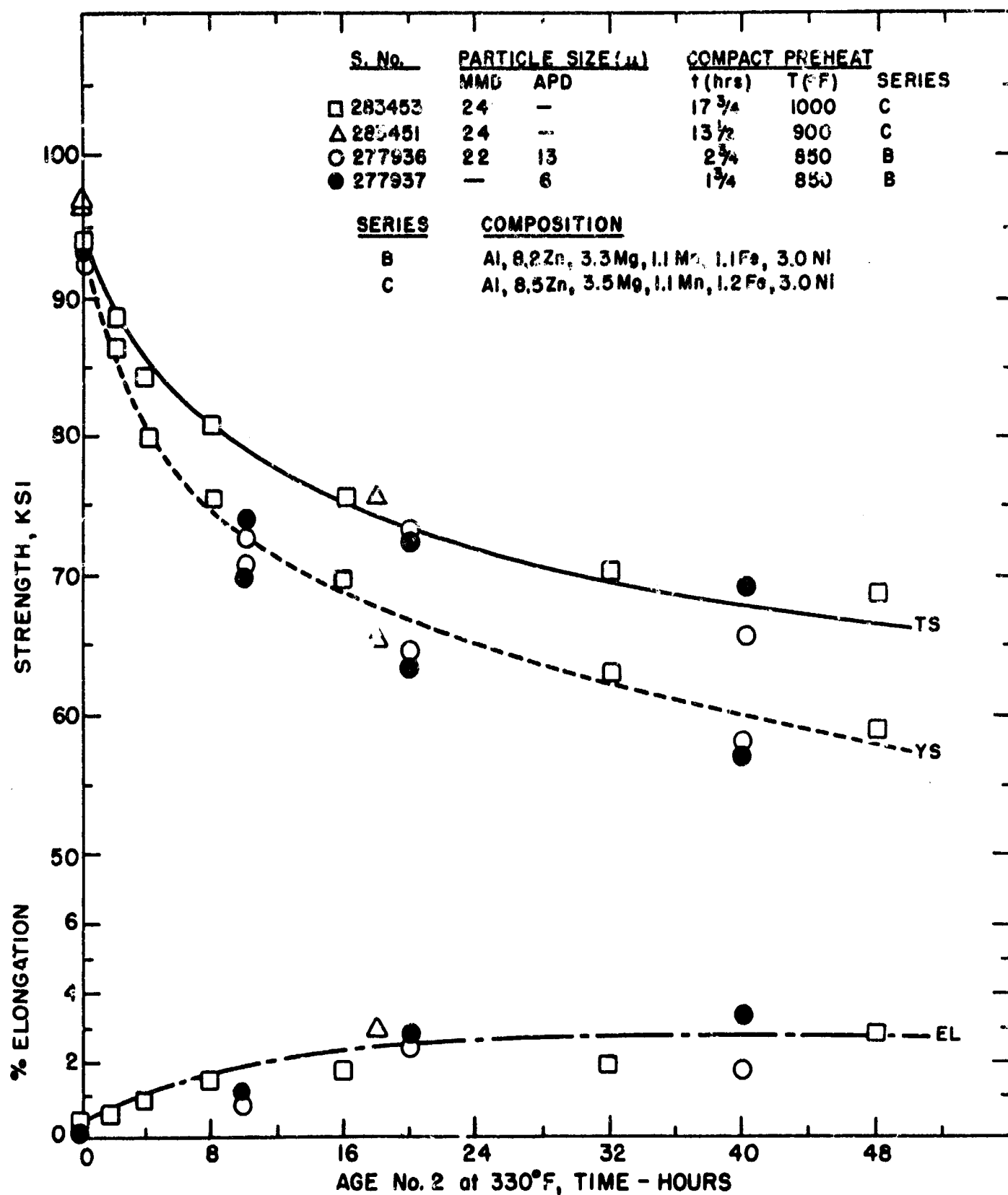


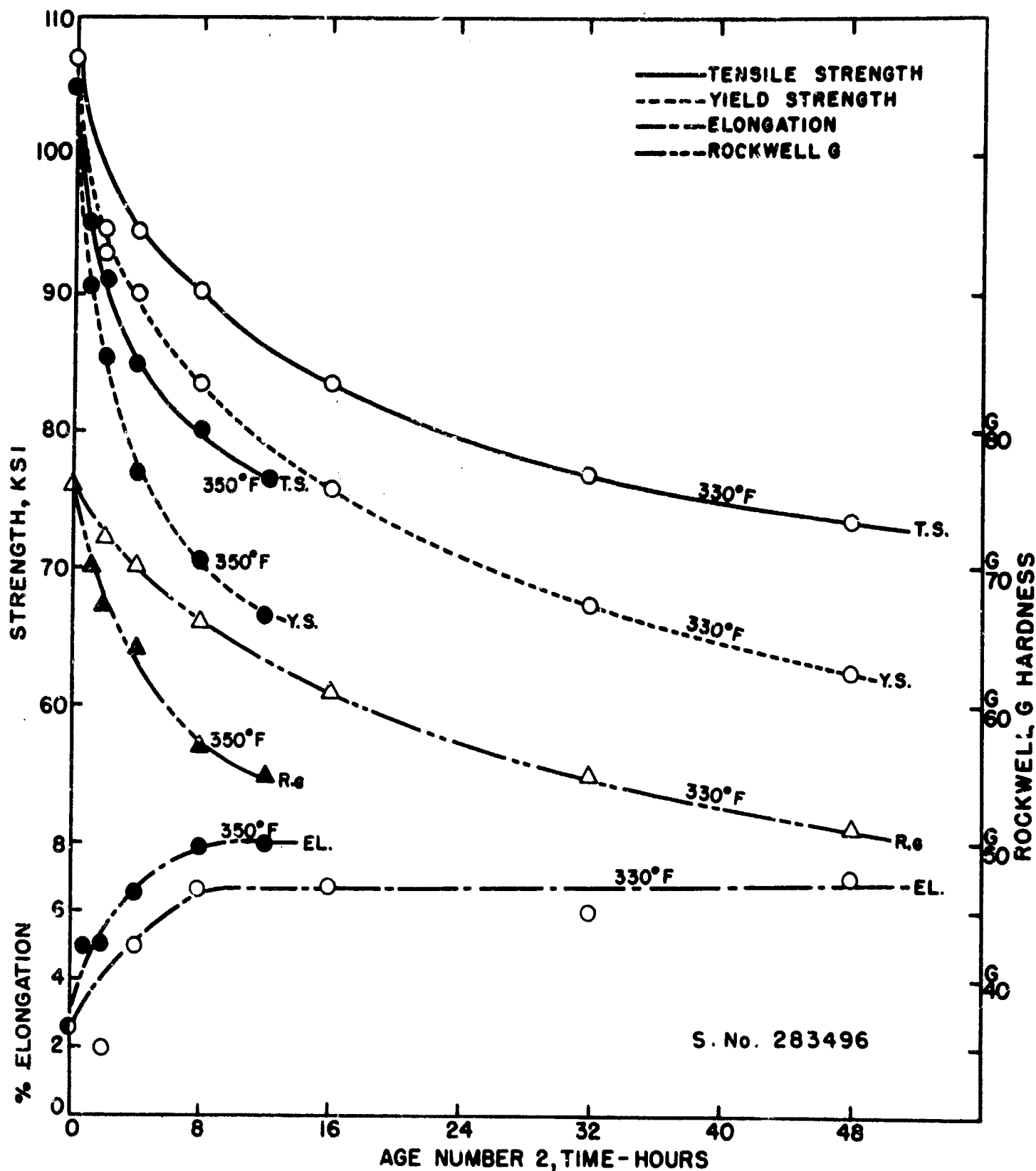
FIGURE 6
THE EFFECT OF STEP AGING ON ALLOY 38 - LONGITUDINAL



(All specimens SHT 2 hours at 860°F, CWQ, Age number 1 24 hours at 250°F)

FIGURE 7

THE EFFECT OF STEP AGING ON ALLOY 38 - TRANSVERSE



(All specimens SHT 2 hours at 860°F, CWQ, Age number 1, 24 hours at 250°F)

FIGURE 8
THE EFFECT OF STEP AGING ON ALLOY 52 - LONGITUDINAL

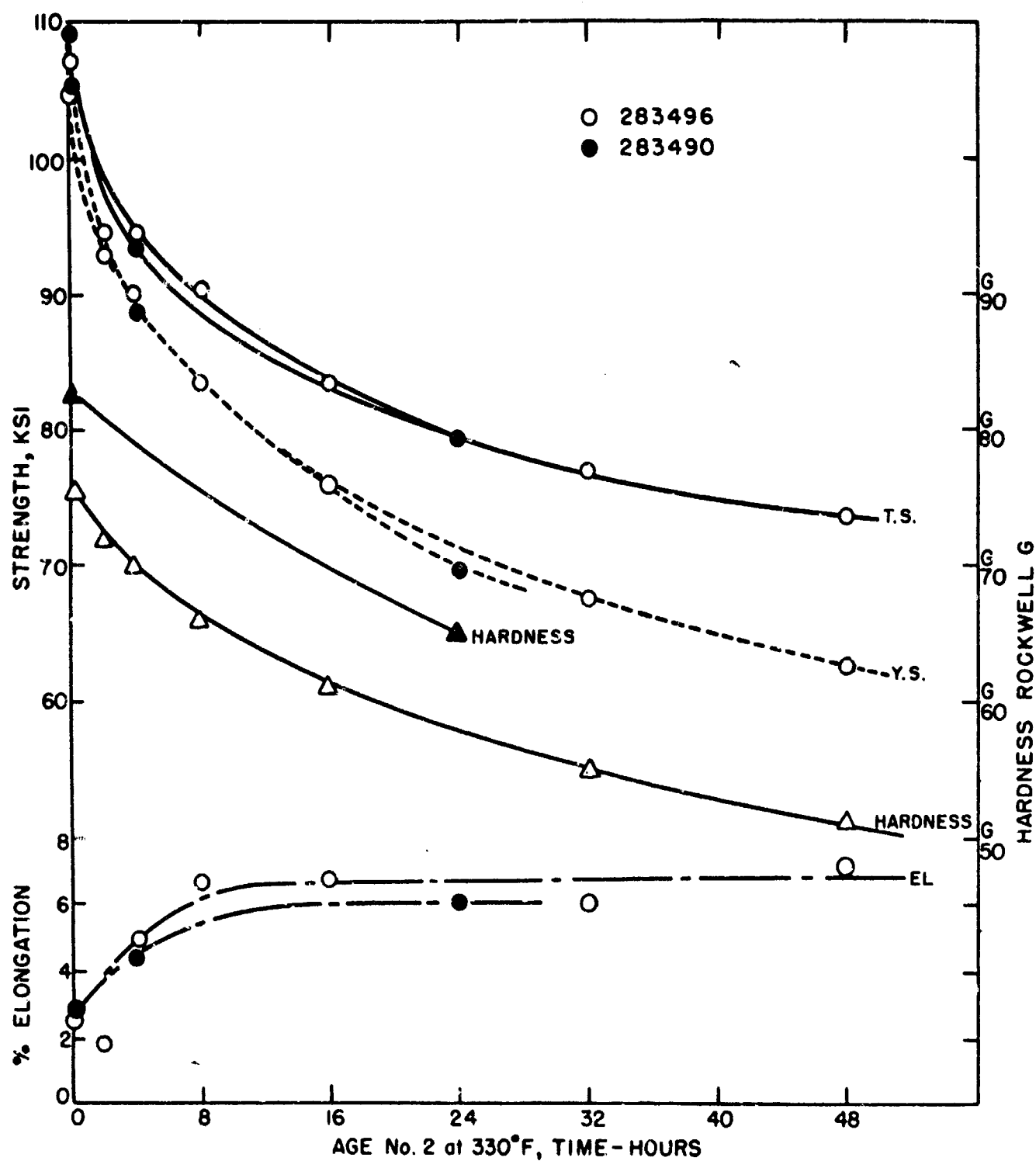
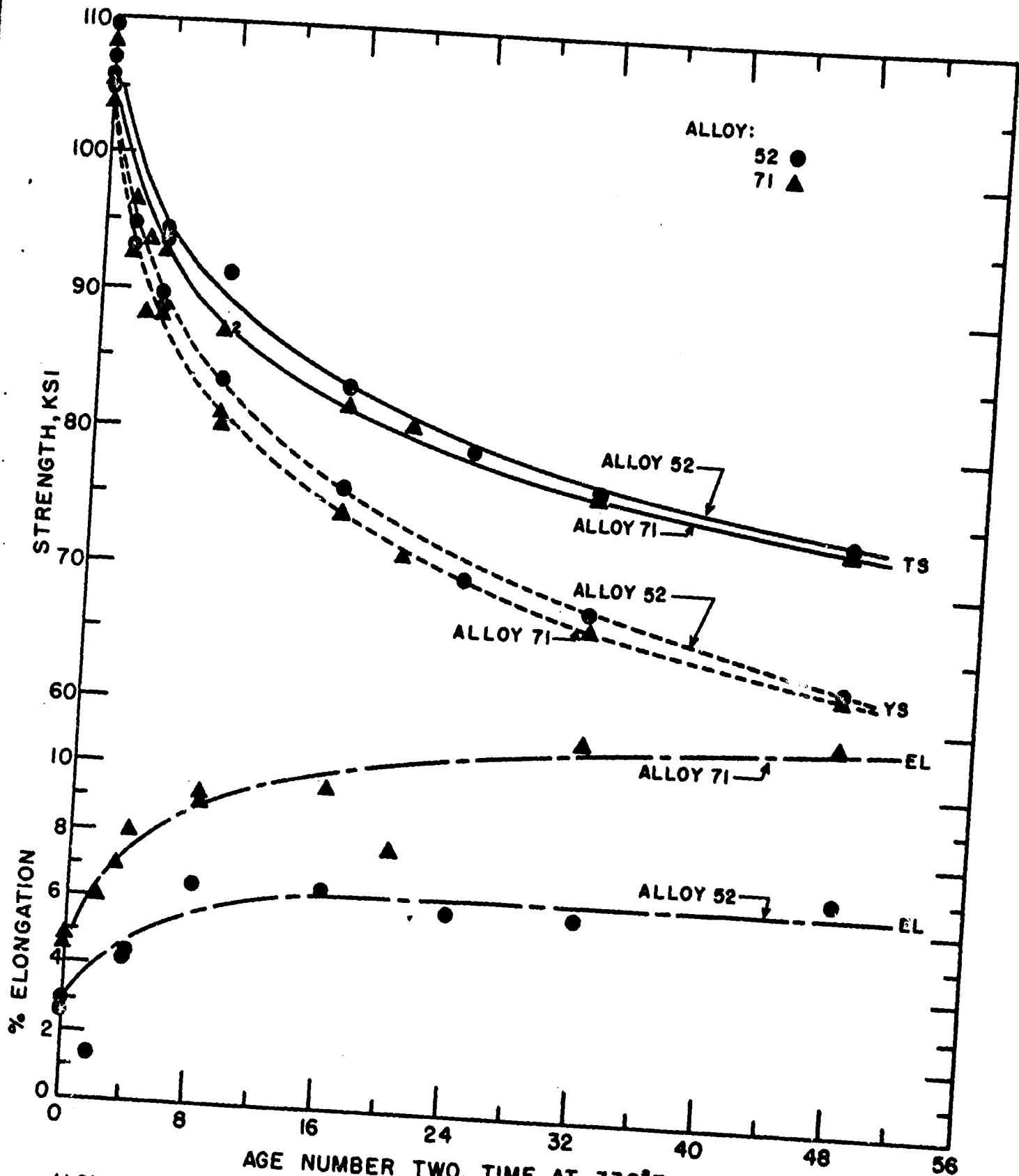
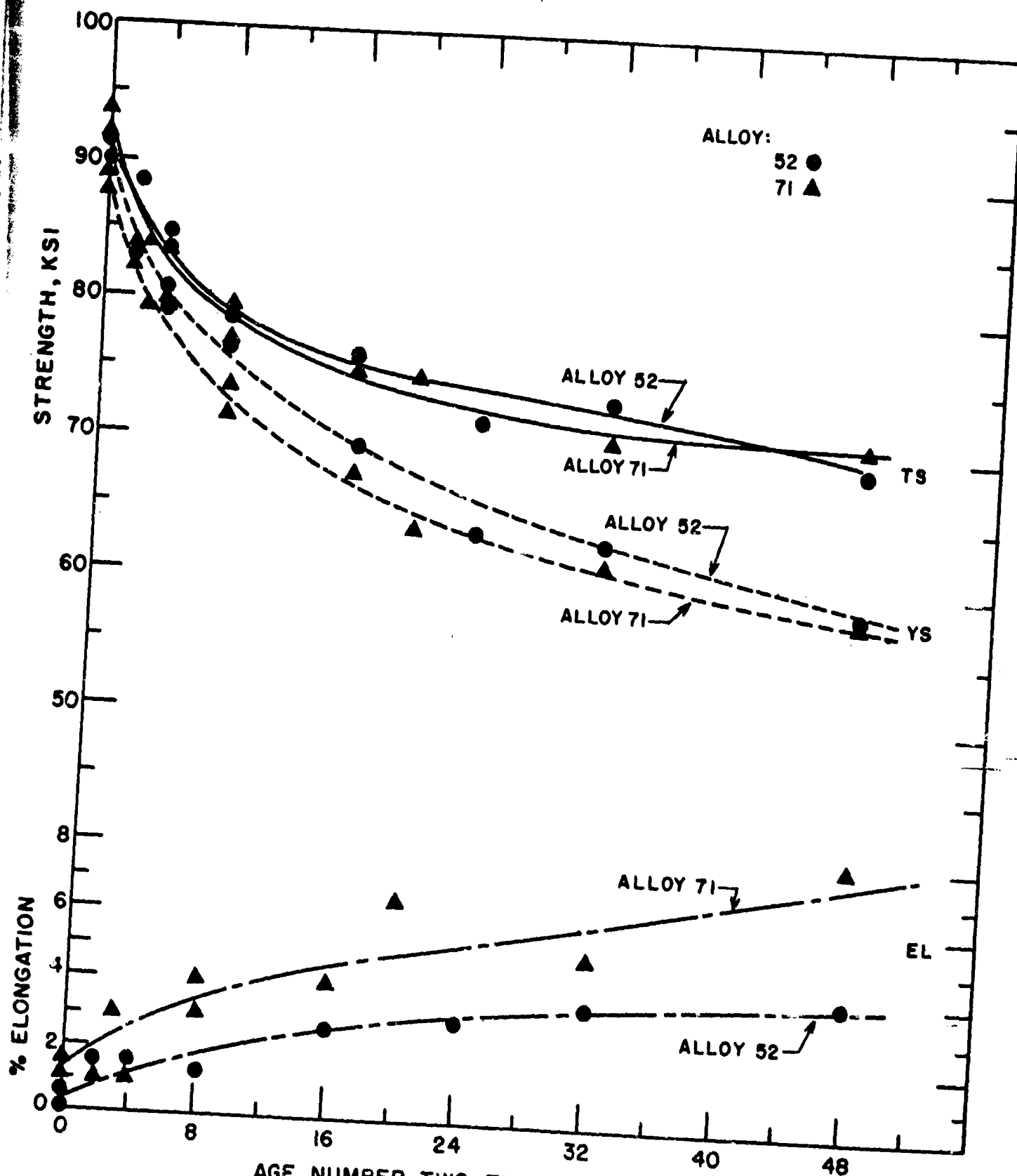


FIGURE 9
THE REPRODUCIBILITY OF STEP AGING ON ALLOY 52 - LONGITUDINAL



(LONGITUDINAL PROPERTIES: ALL SPECIMENS SHT 2 HRS AT 860°F, CWQ, AGE NUMBER ONE, 24 HRS AT 250°F.)

FIGURE 10
THE EFFECT OF STEP AGING ON ALLOYS 52 AND 71 -
LONGITUDINAL



(TRANSVERSE PROPERTIES: ALL SPECIMENS SHT 2 HRS AT 860°F, CWQ, AGE NUMBER ONE, 24 HRS AT 250°F)

FIGURE 11
THE EFFECT OF STEP AGING ON ALLOYS 52 AND 71 -
TRANSVERSE

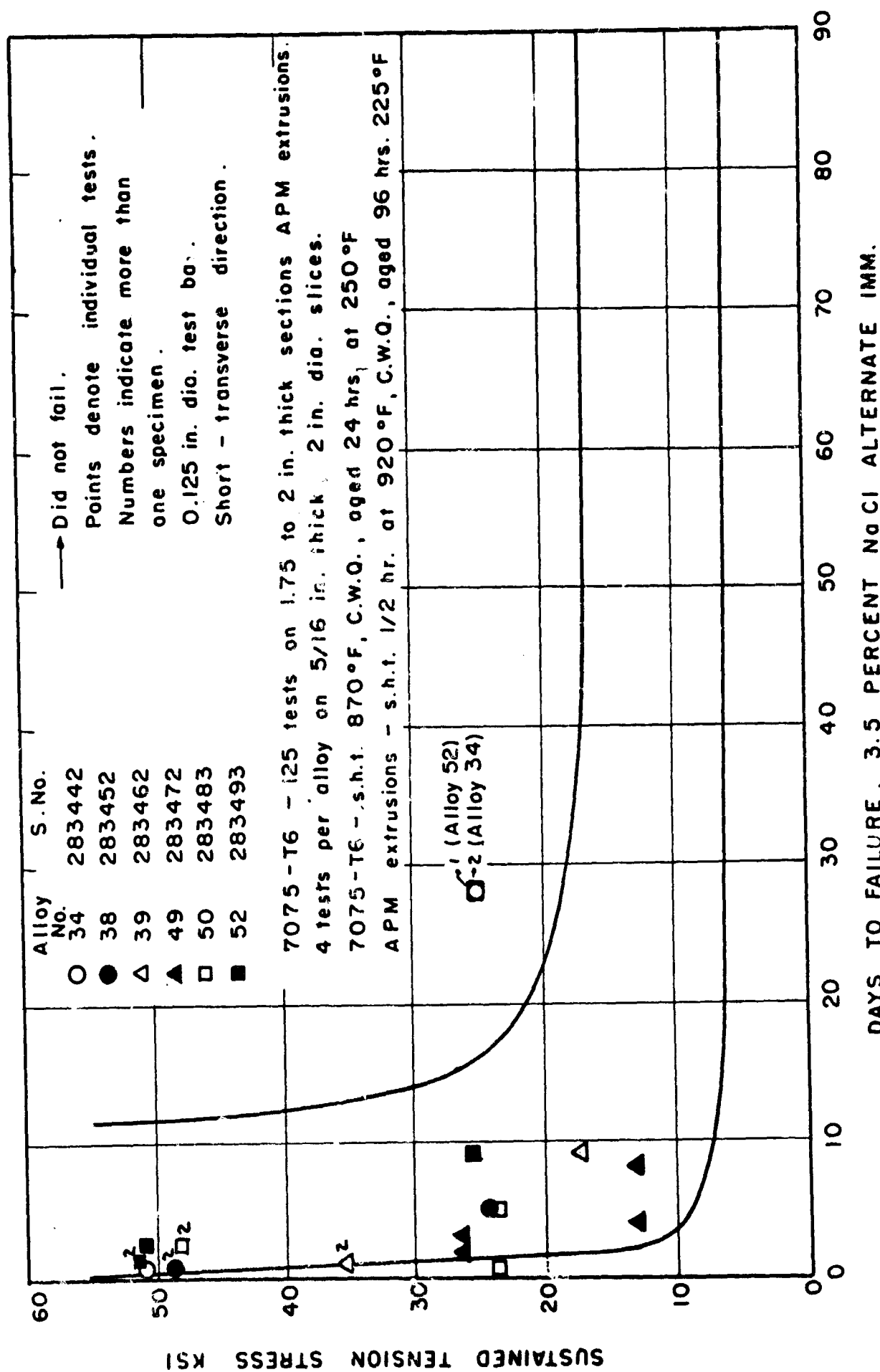
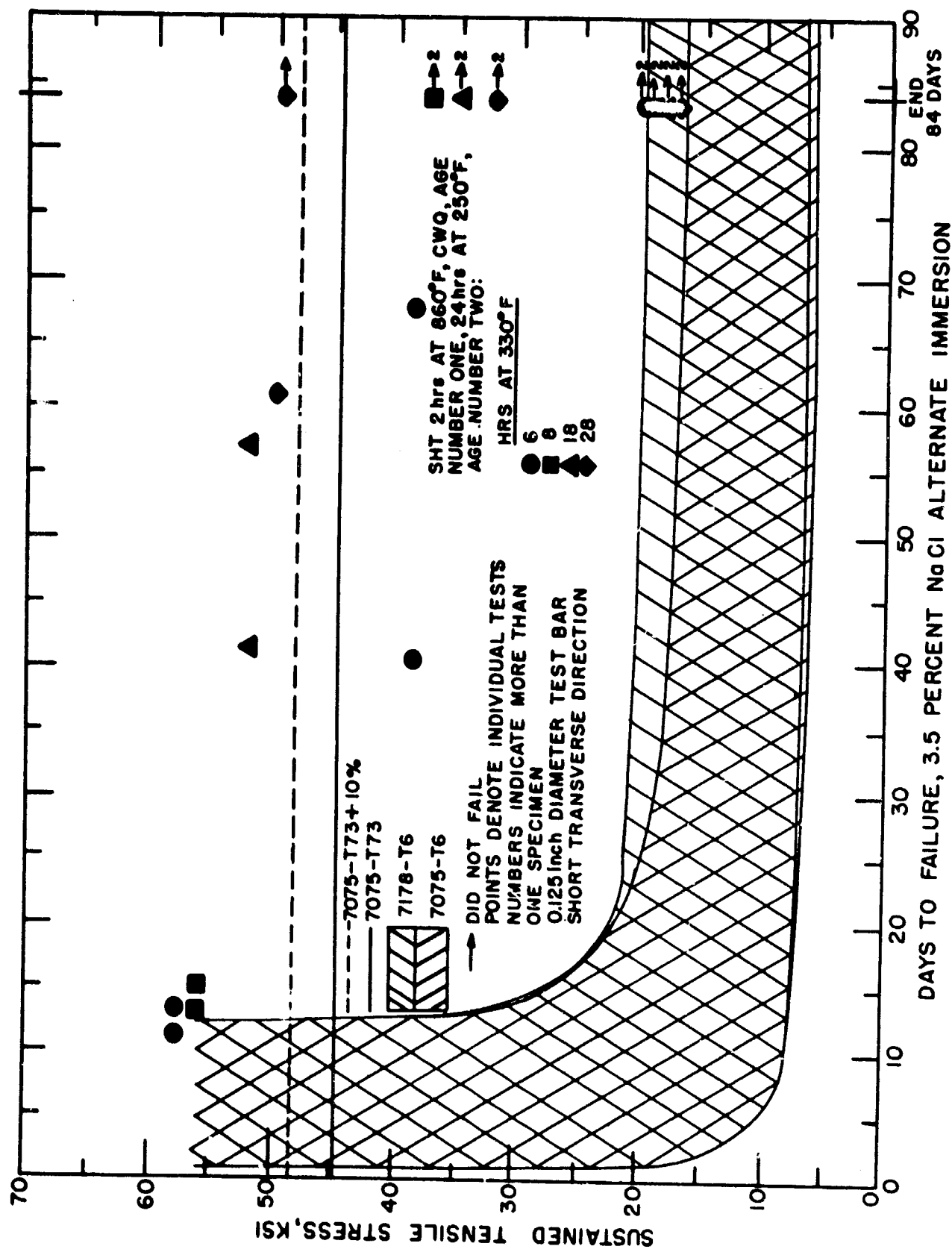


FIGURE 12

COMPARISON OF RELATIVE RESISTANCE TO STRESS-CORROSION CRACKING OF ALUMINUM
 POWDER METALLURGY EXTRUSIONS AND 7075-T6 EXTRUDED SECTIONS



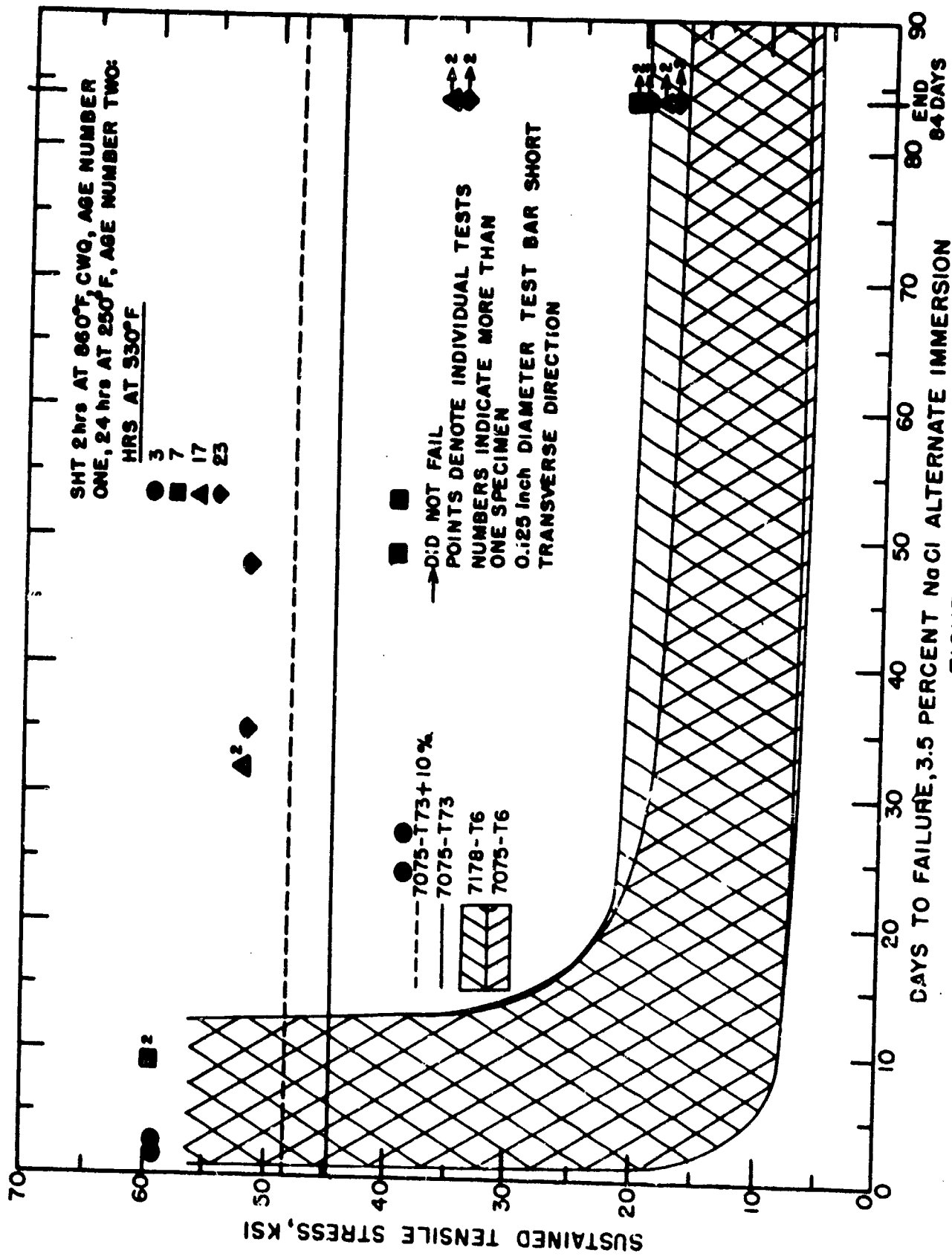


FIGURE 14
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 3

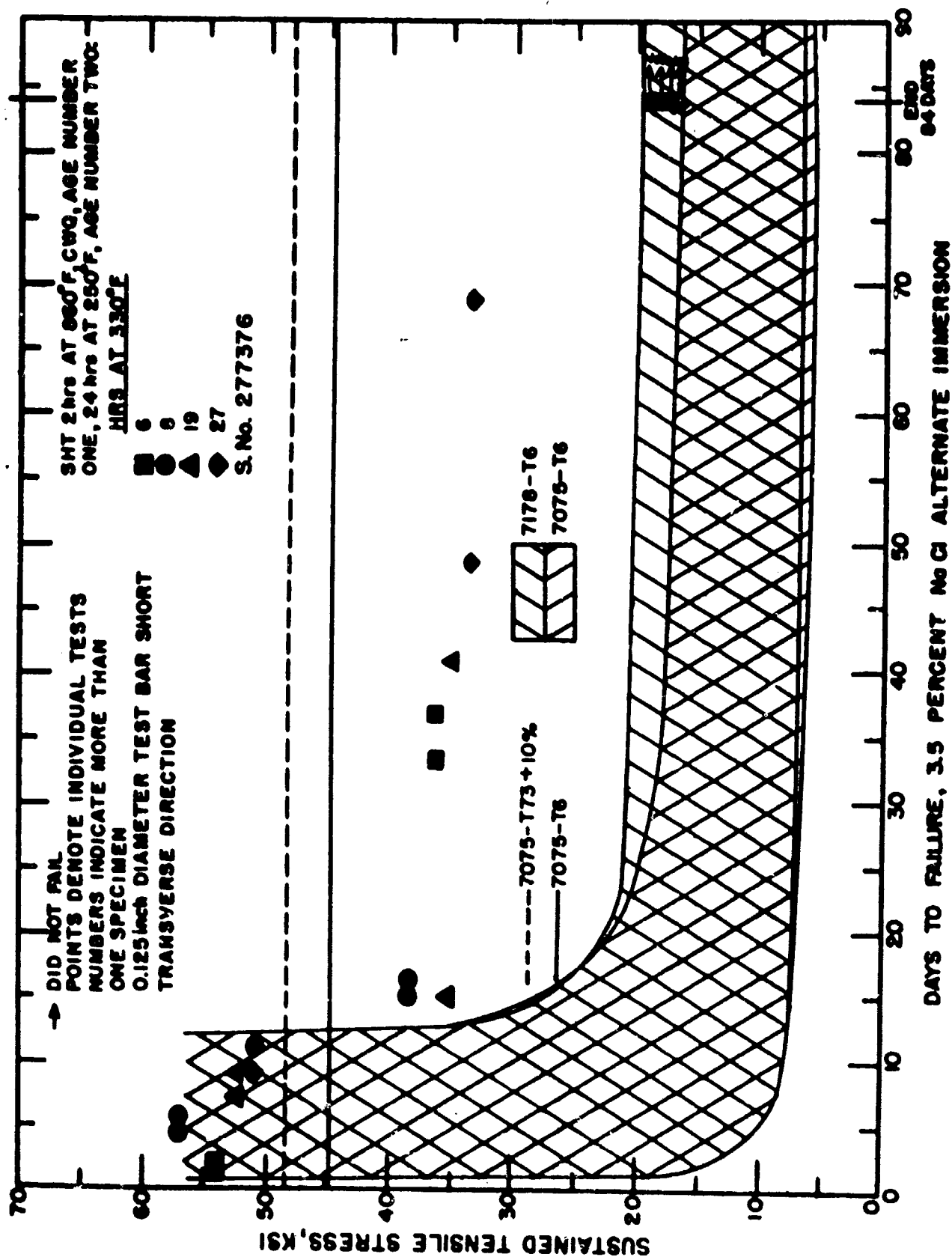


FIGURE 15
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 4

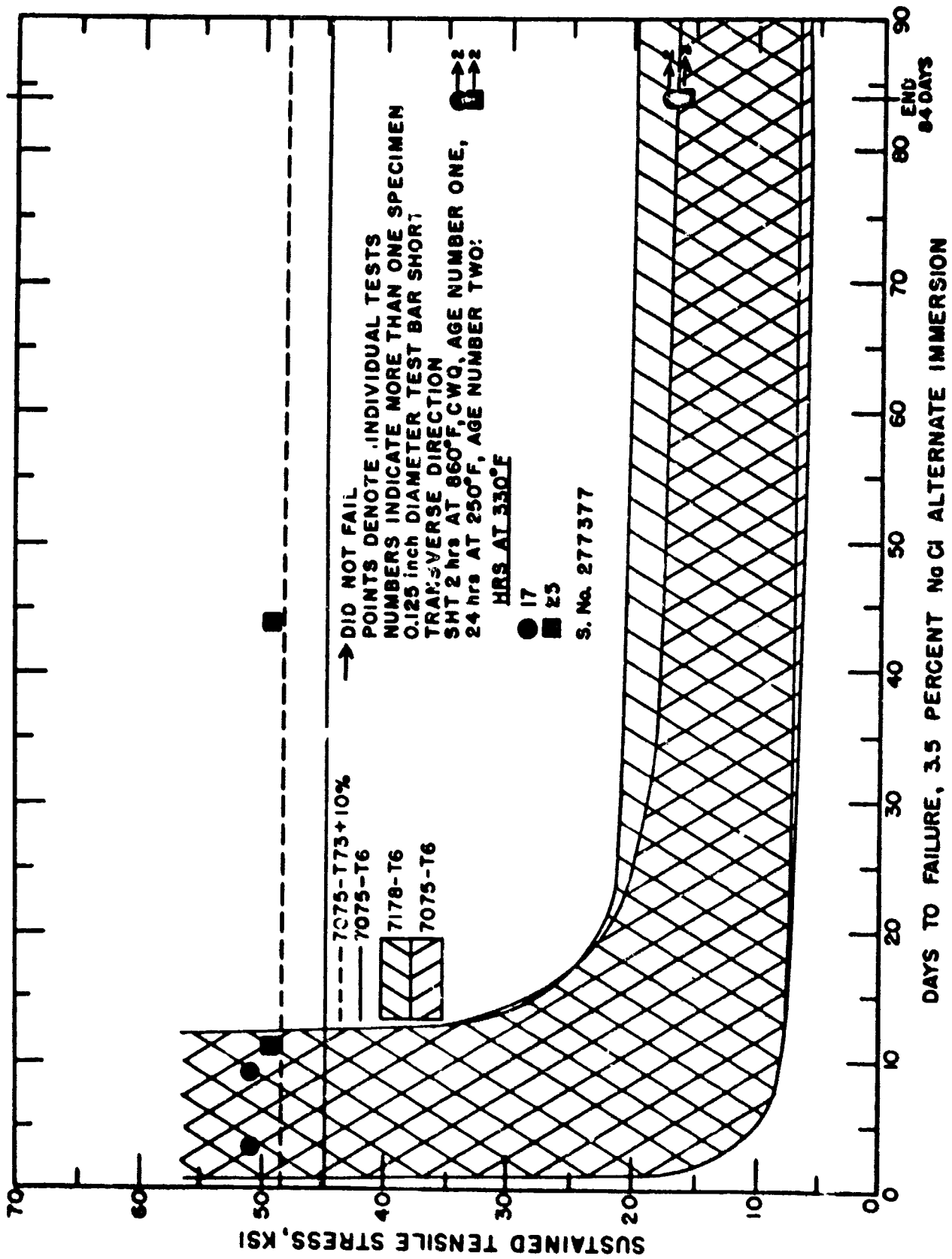


FIGURE 16
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 5

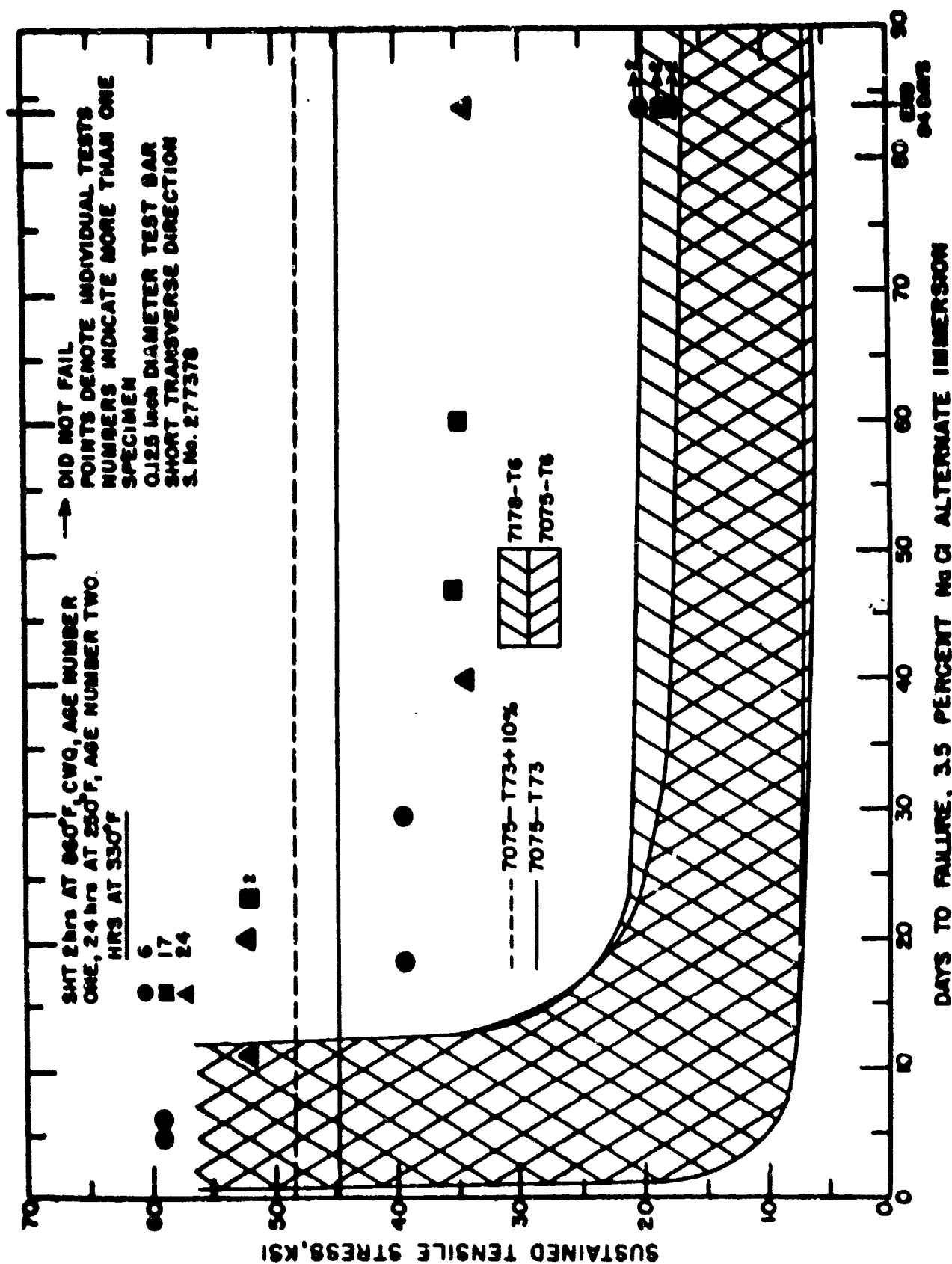


FIGURE 17
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 6

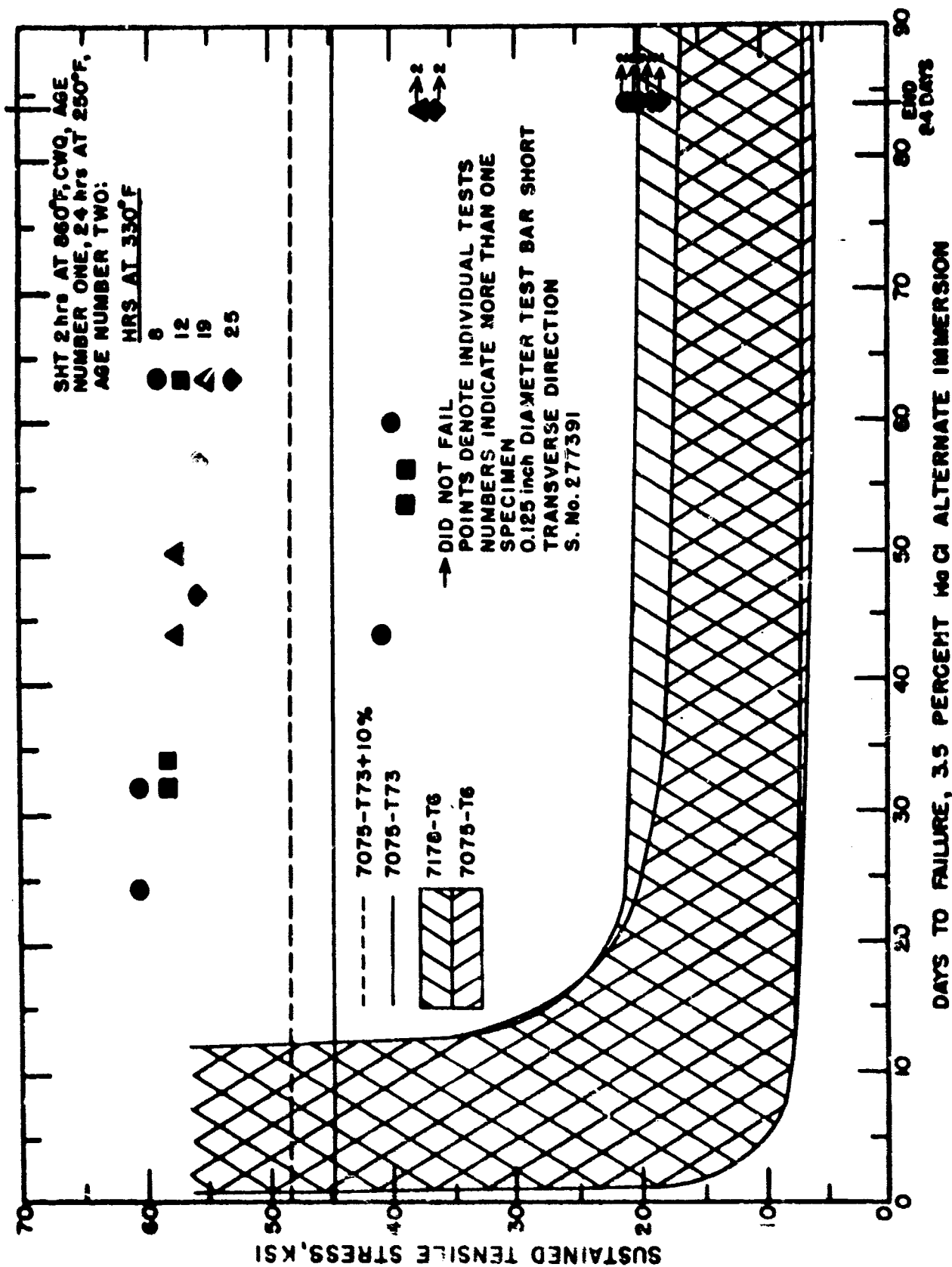


FIGURE 18
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS CORROSION CRACKING FOR ALLOY 19

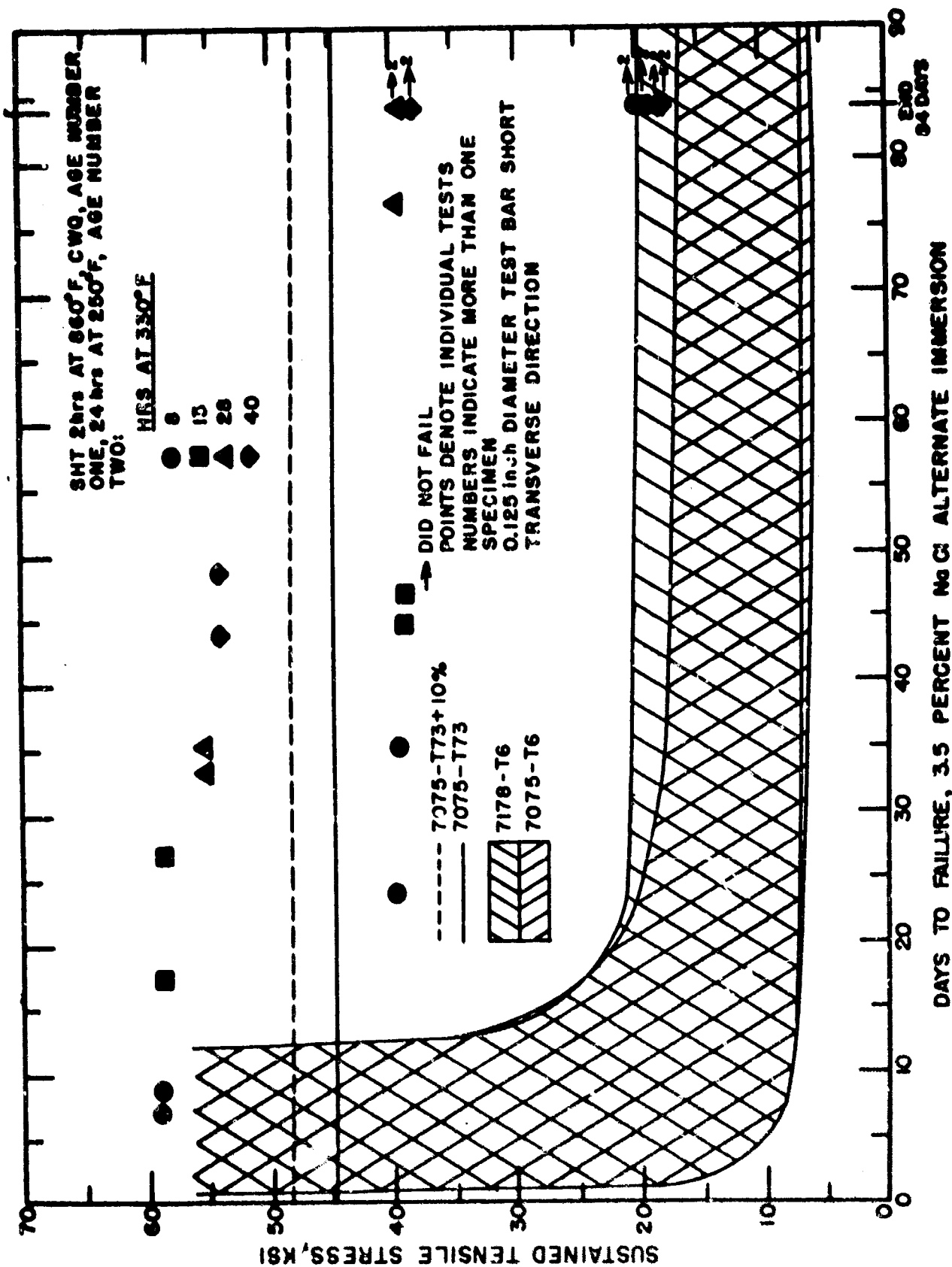


FIGURE 19
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 20

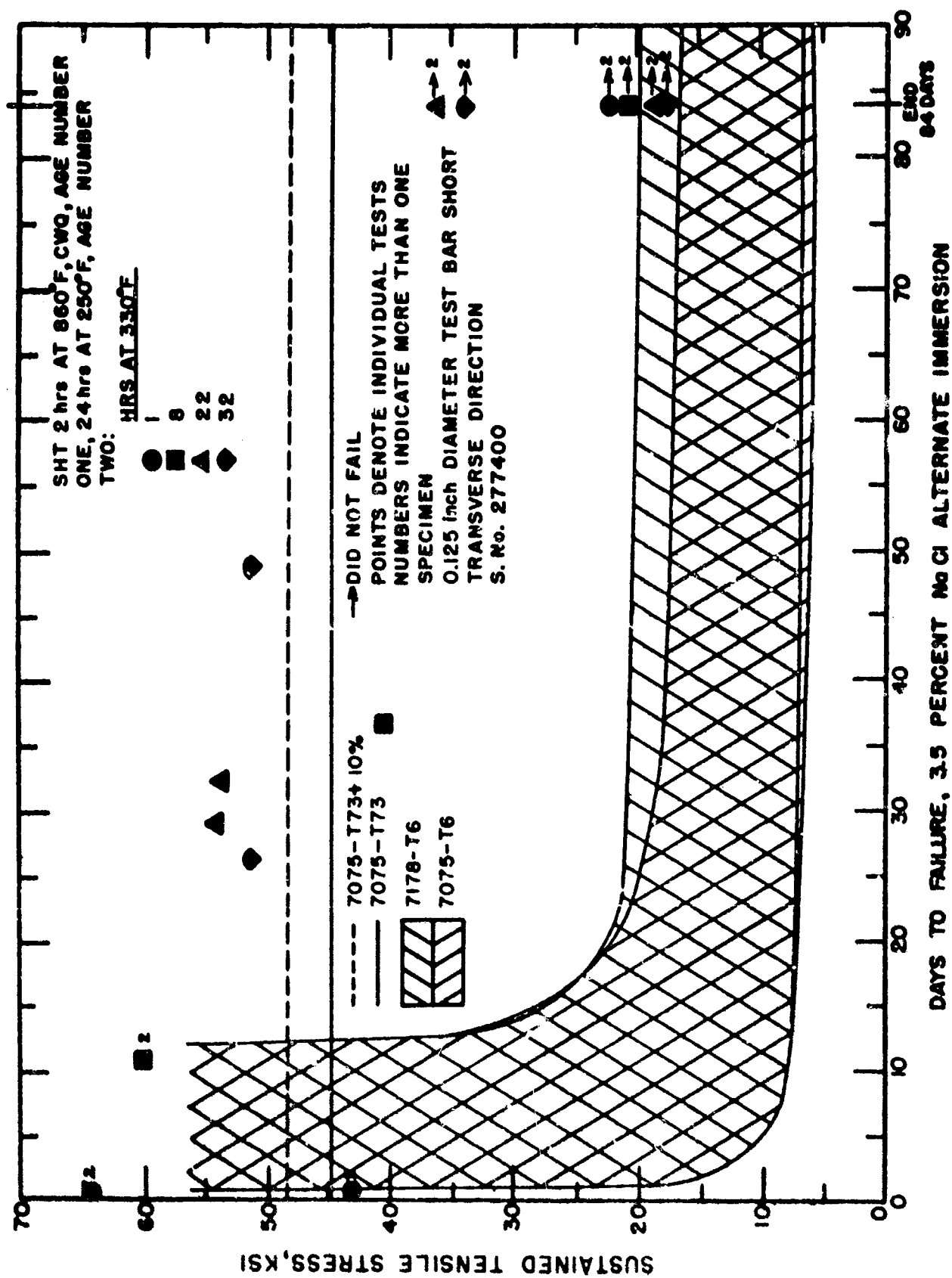


FIGURE 20
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 28

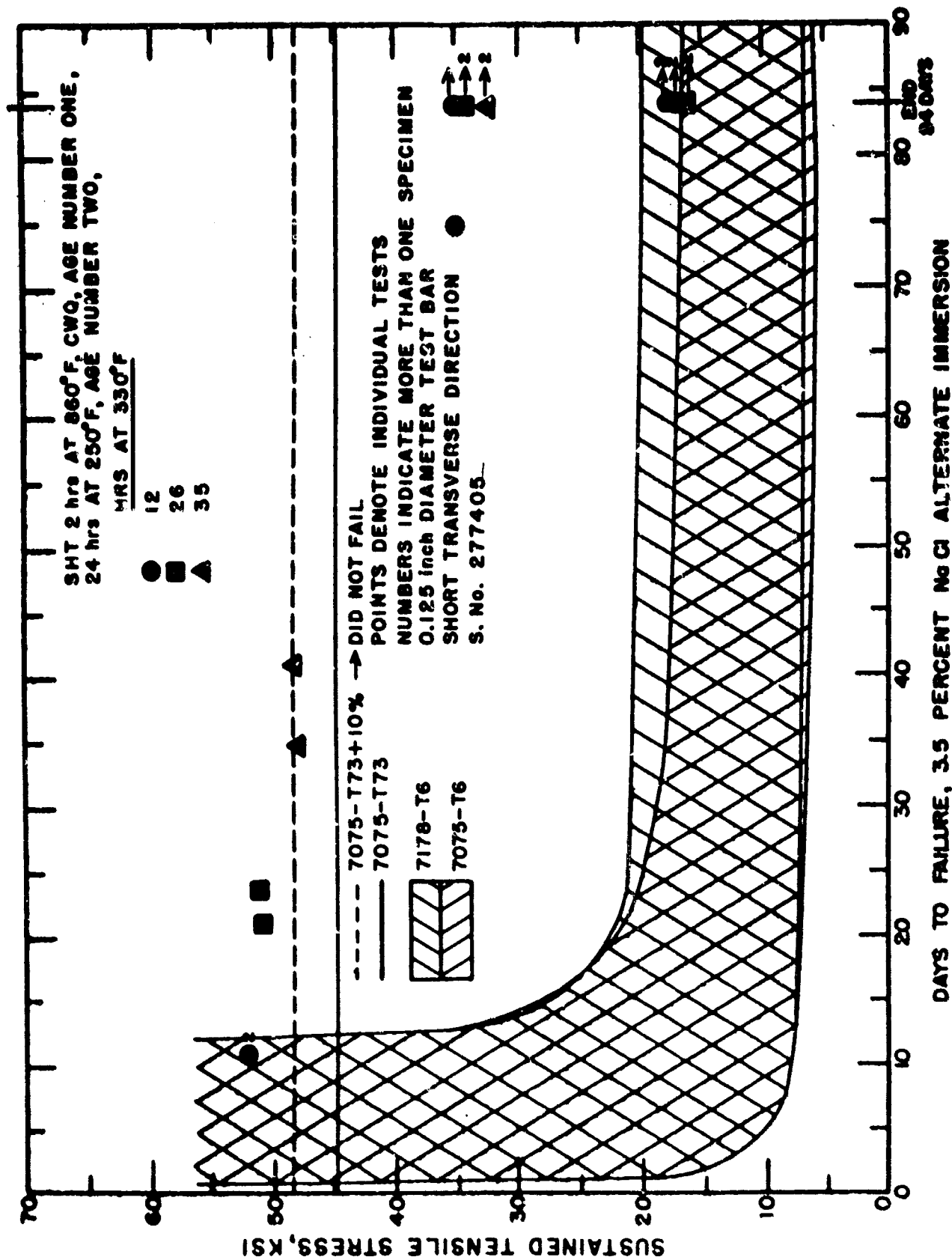


FIGURE 21
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 33

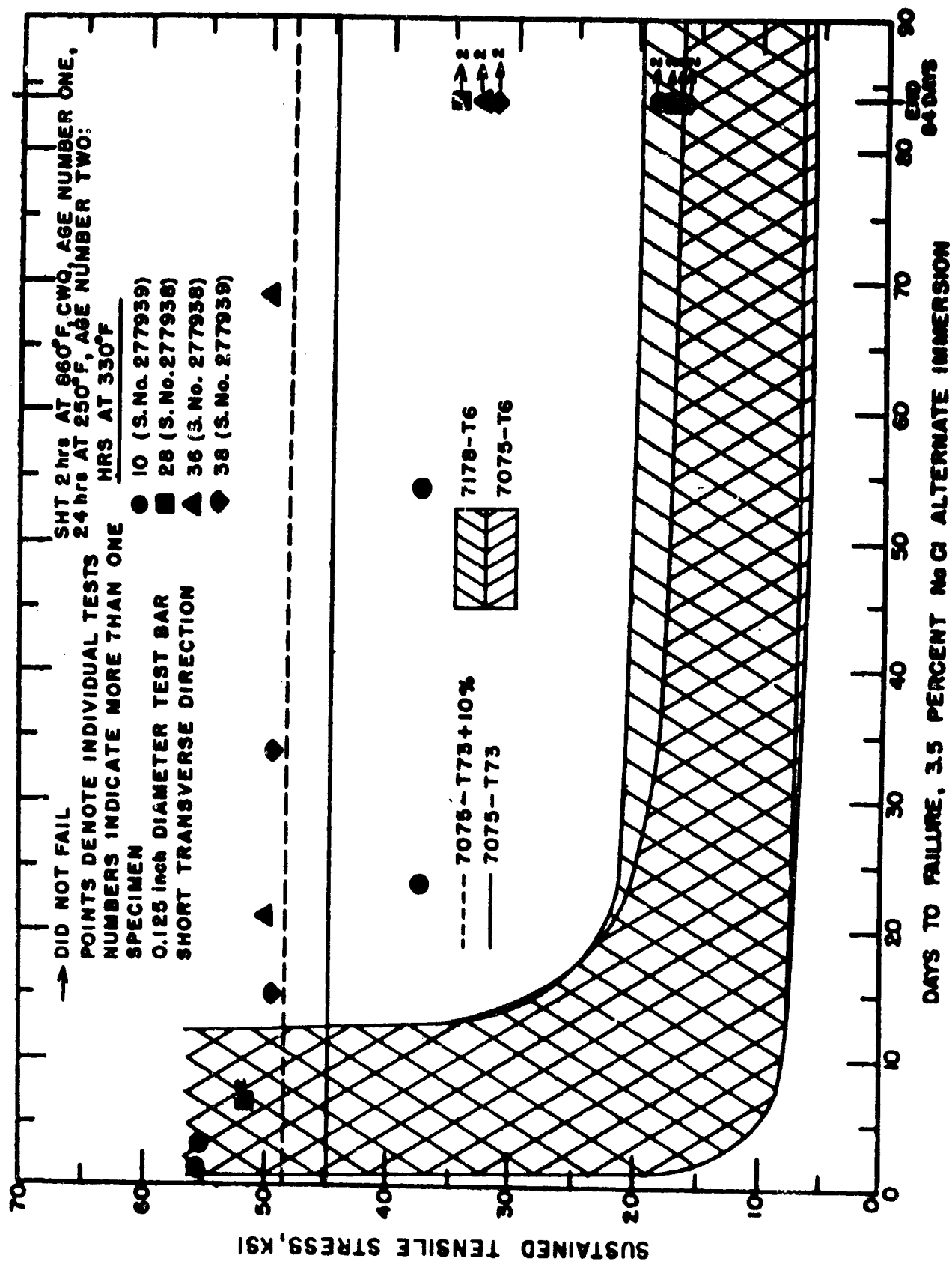


FIGURE 22
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 36

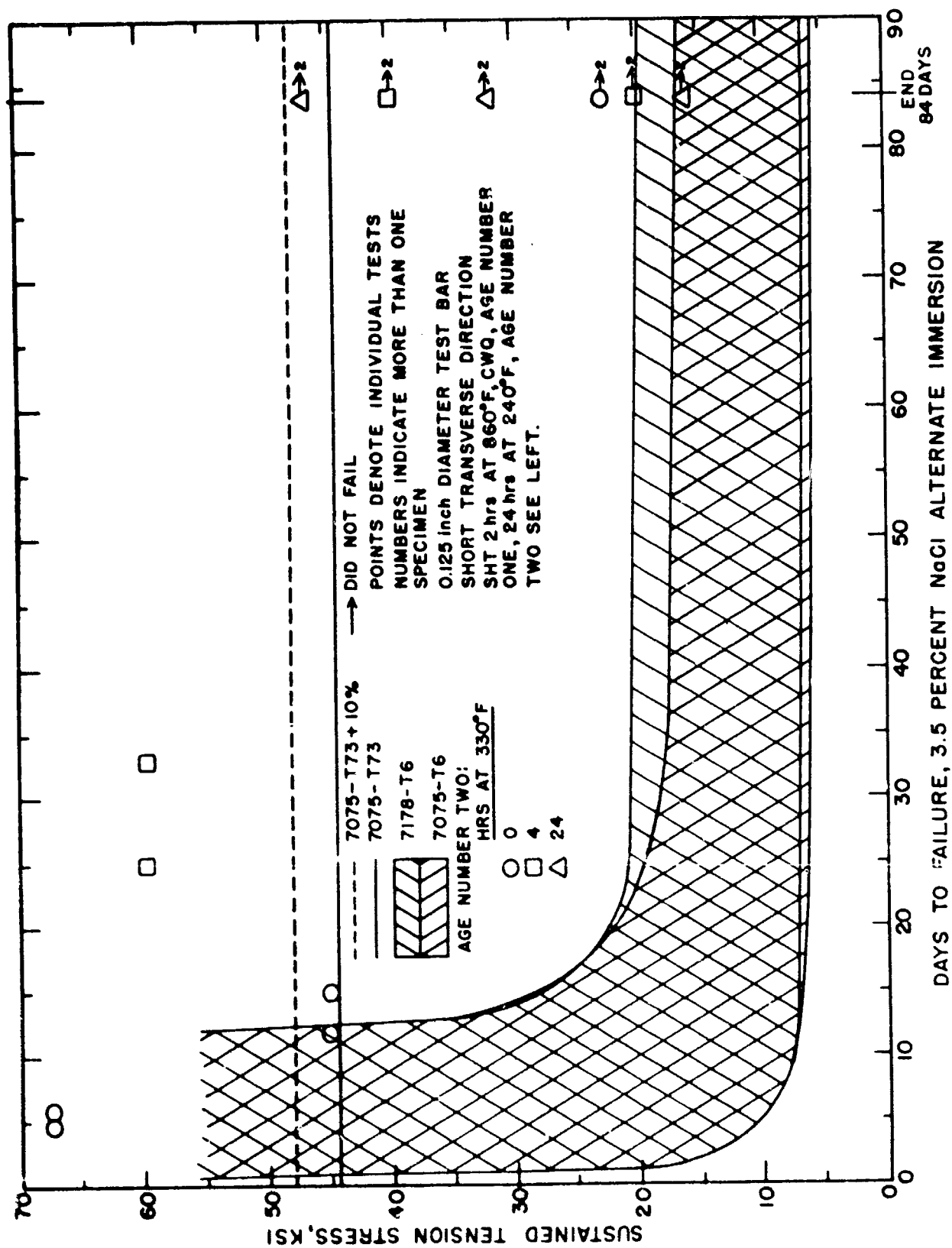


FIGURE 23

COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS CORROSION CRACKING FOR ALLOY 52.

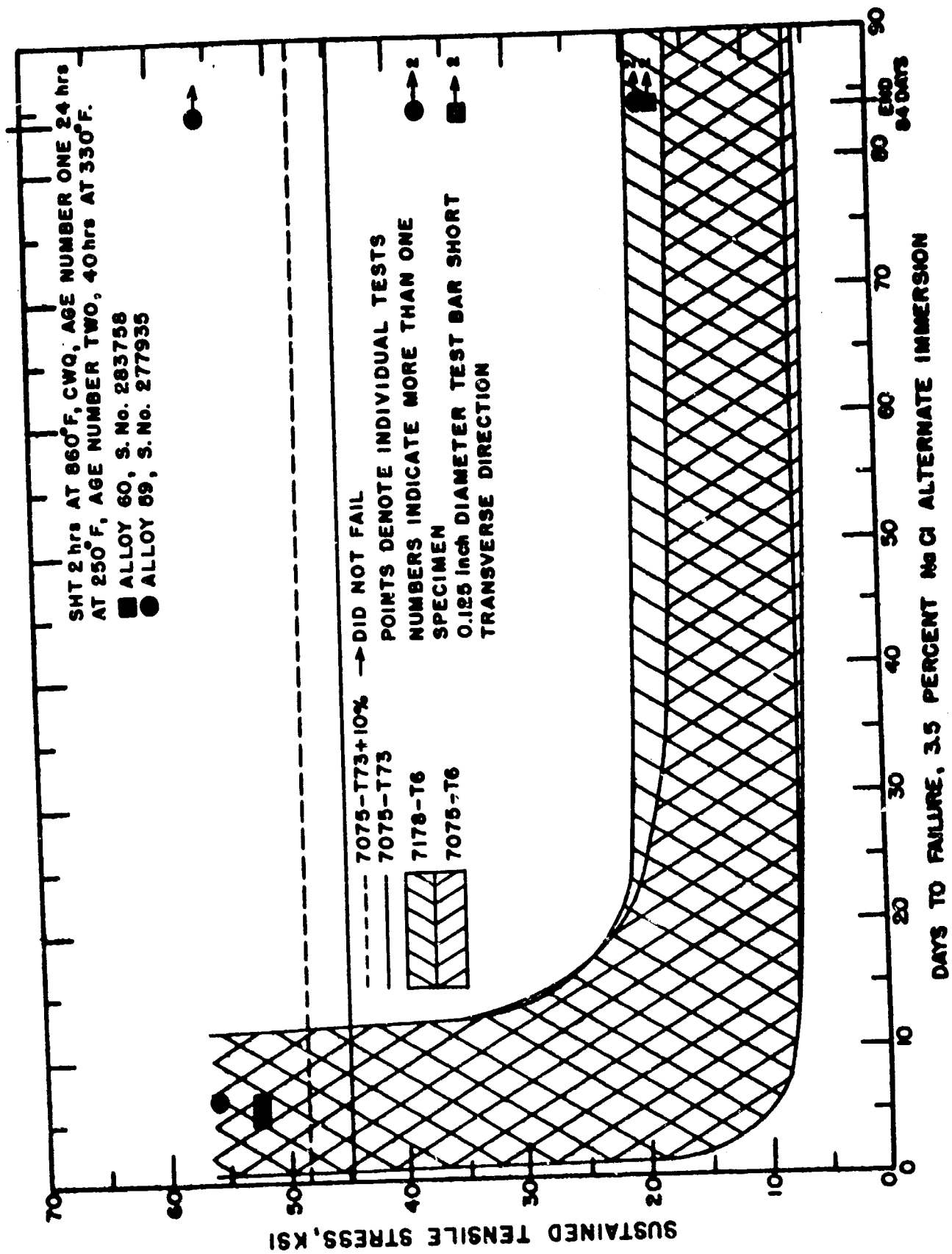


FIGURE 24
 COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
 CORROSION CRACKING FOR ALLOYS 59 AND 60

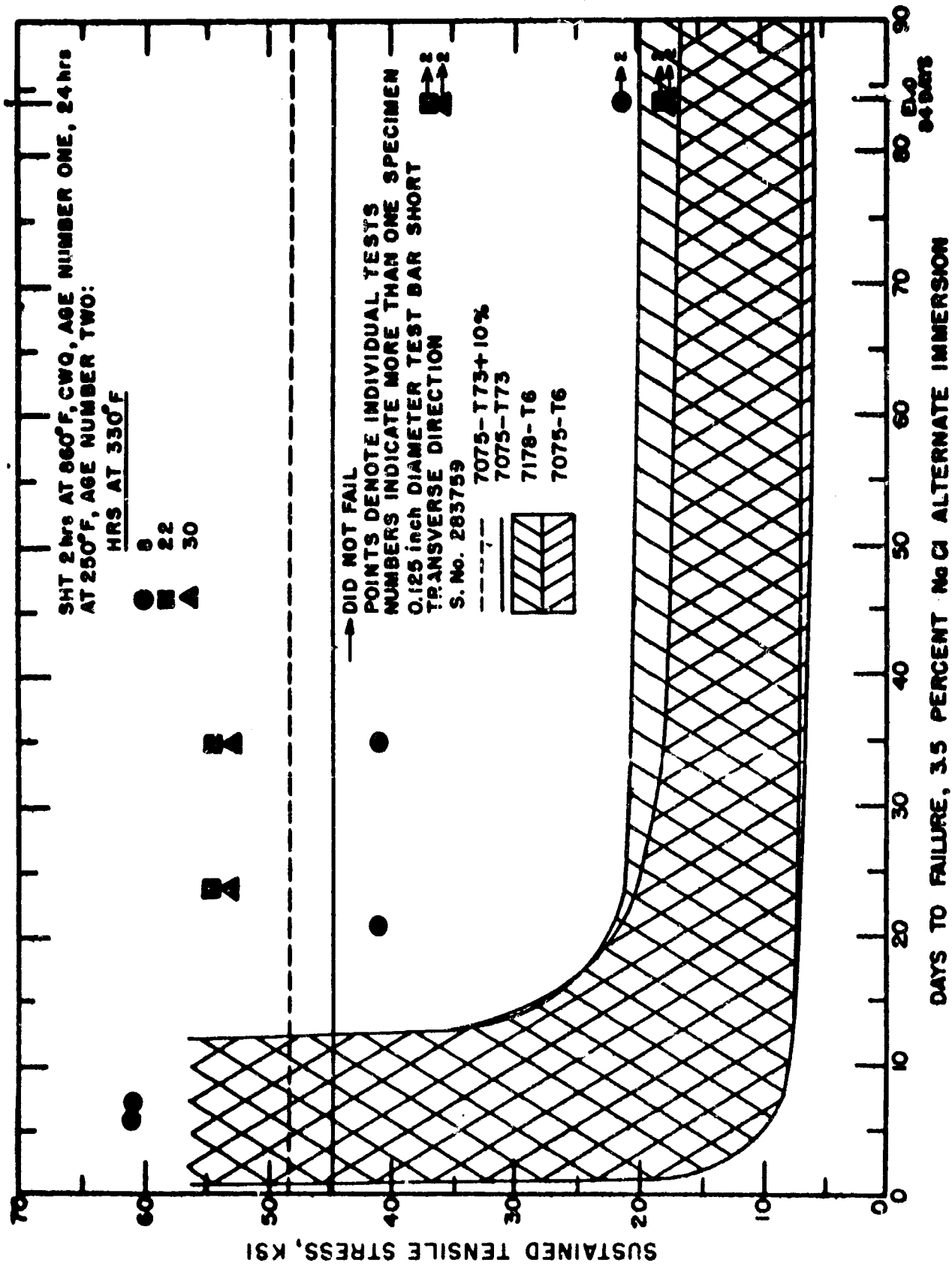


FIGURE 25
COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
CORROSION CRACKING FOR ALLOY 61

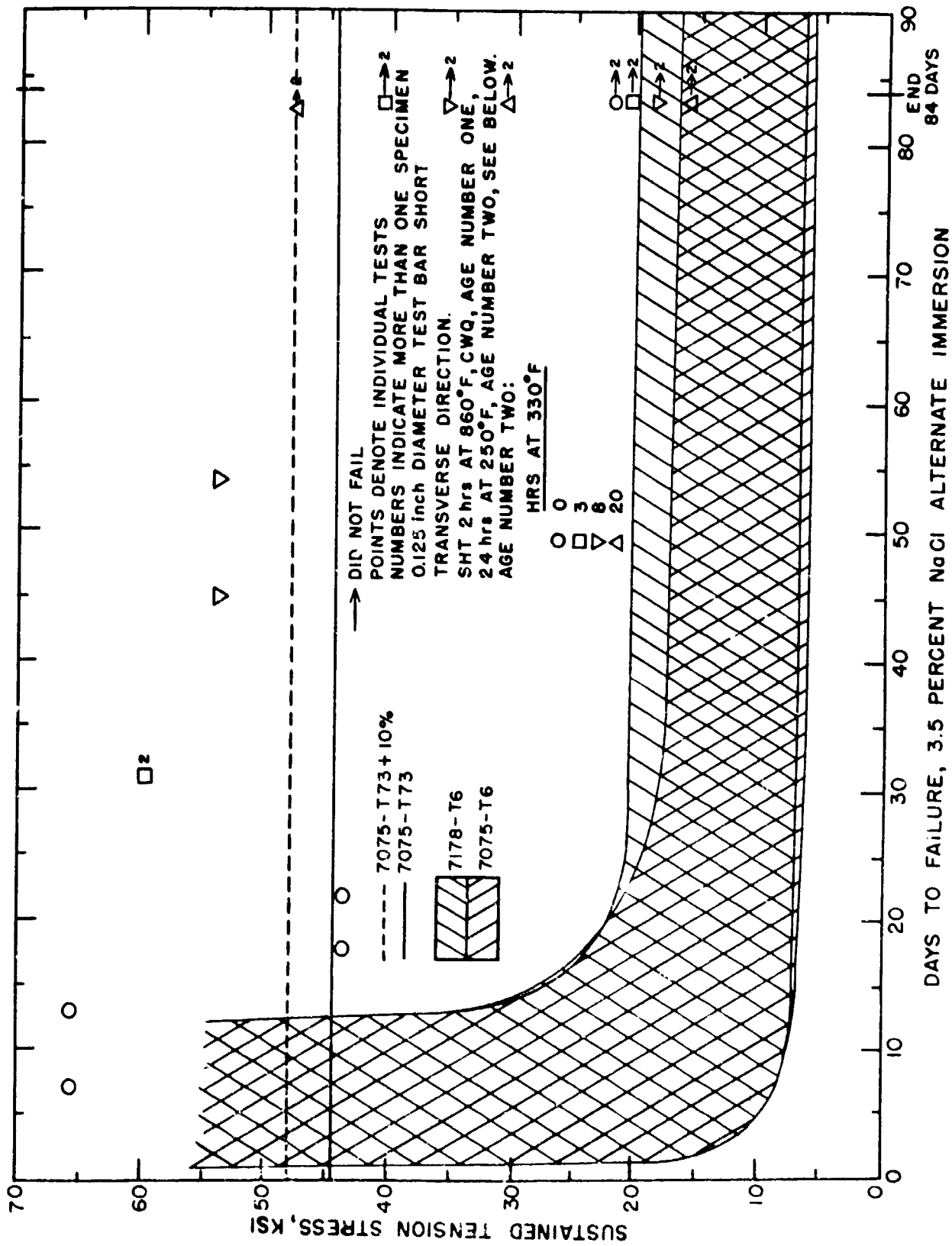


FIGURE 26
 COMPARISON OF AGE NUMBER TWO ON RELATIVE RESISTANCE TO STRESS
 CORROSION CRACKING FOR ALLOY 71.

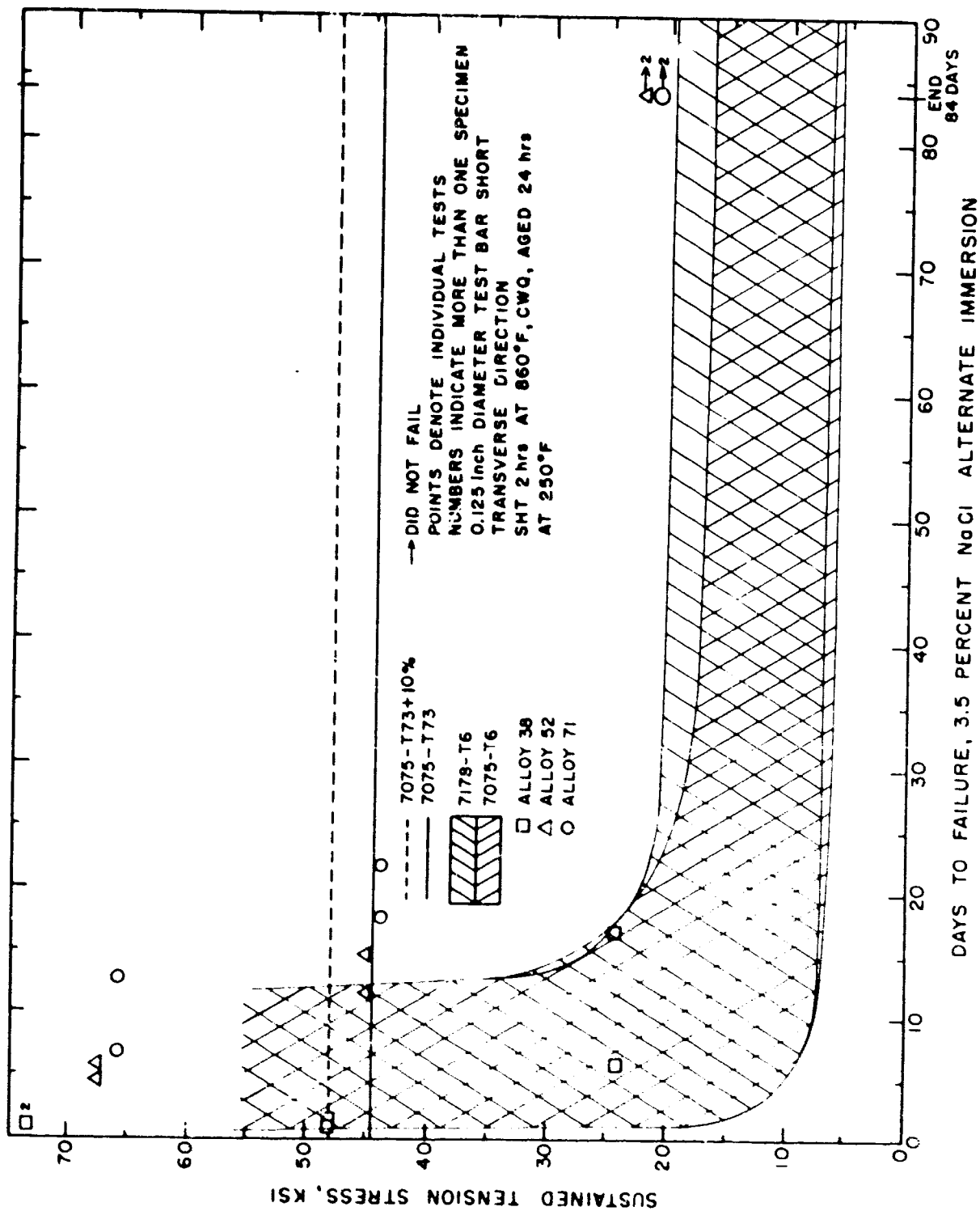
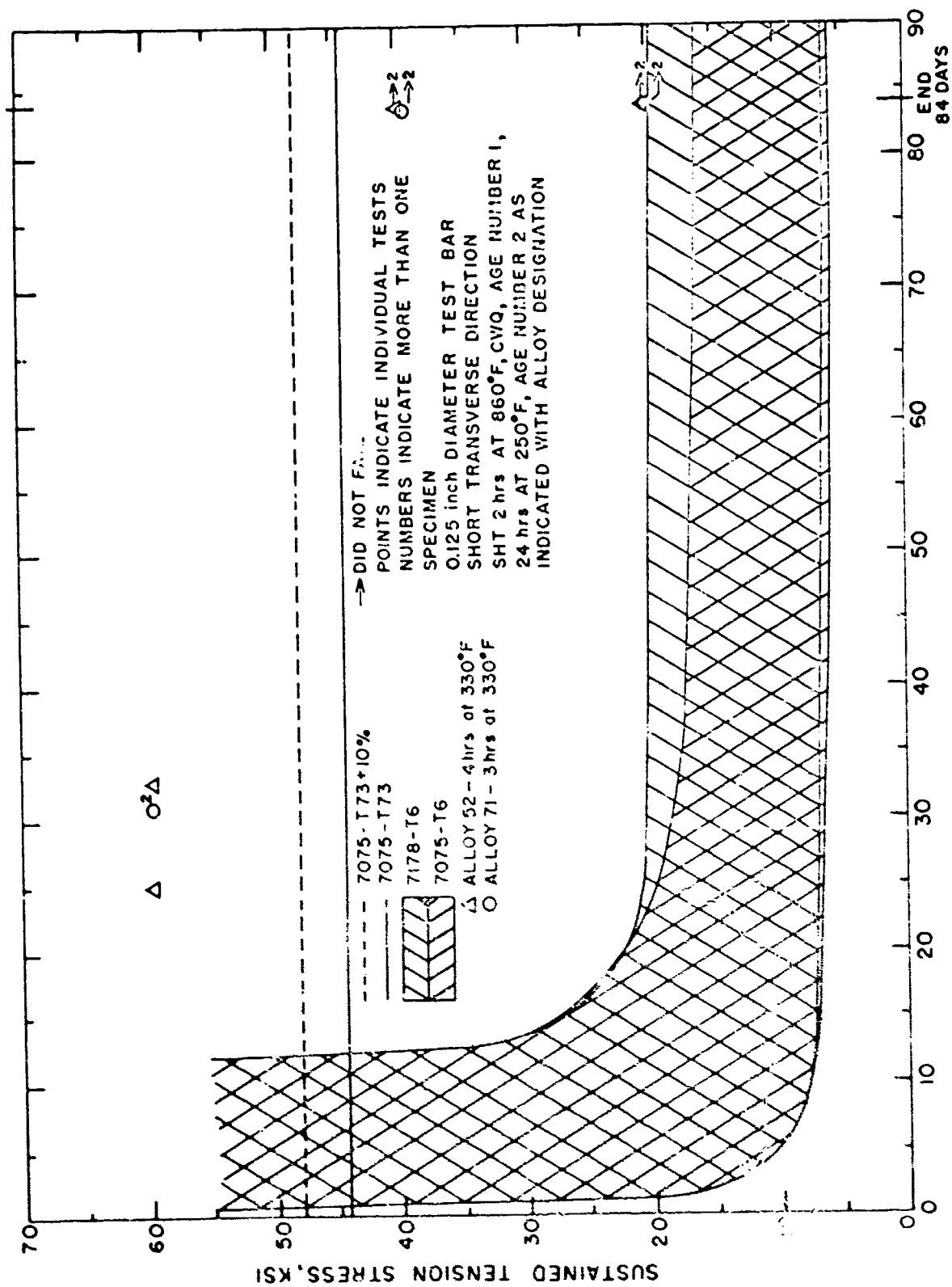


FIGURE 27

RELATIVE RESISTANCE OF APM ALLOYS 38, 52 AND 71 TO STRESS CORROSION CRACKING
FOR TENSILE STRENGTHS OF APPROXIMATELY 10% GREATER THAN 7178-T6



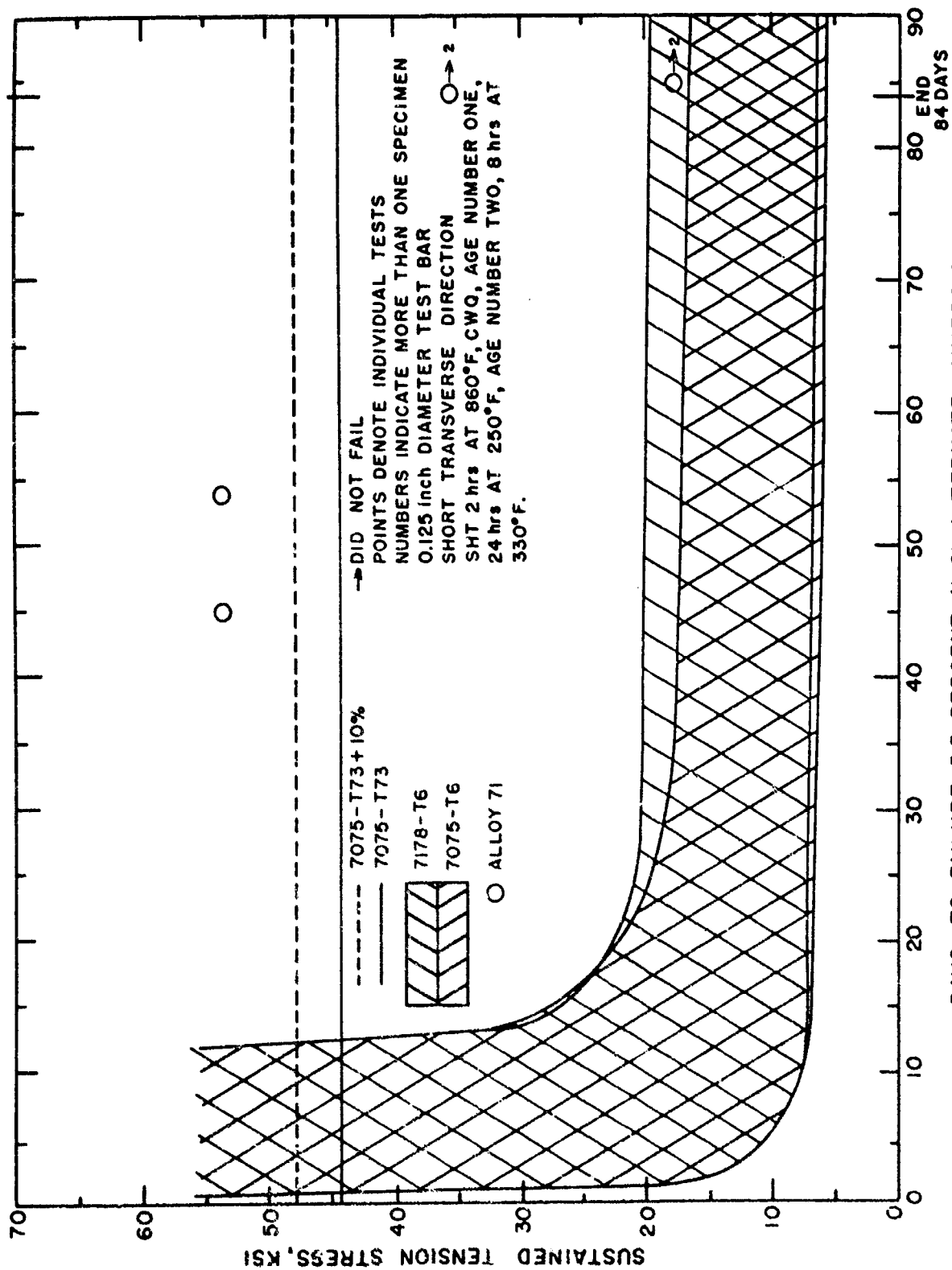


FIGURE 29

RELATIVE RESISTANCE OF APM ALLOY 71 TO STRESS CORROSION CRACKING
 FOR TENSILE STRENGTHS GREATER THAN 7075-T73 BUT LESS THAN 7075-T6

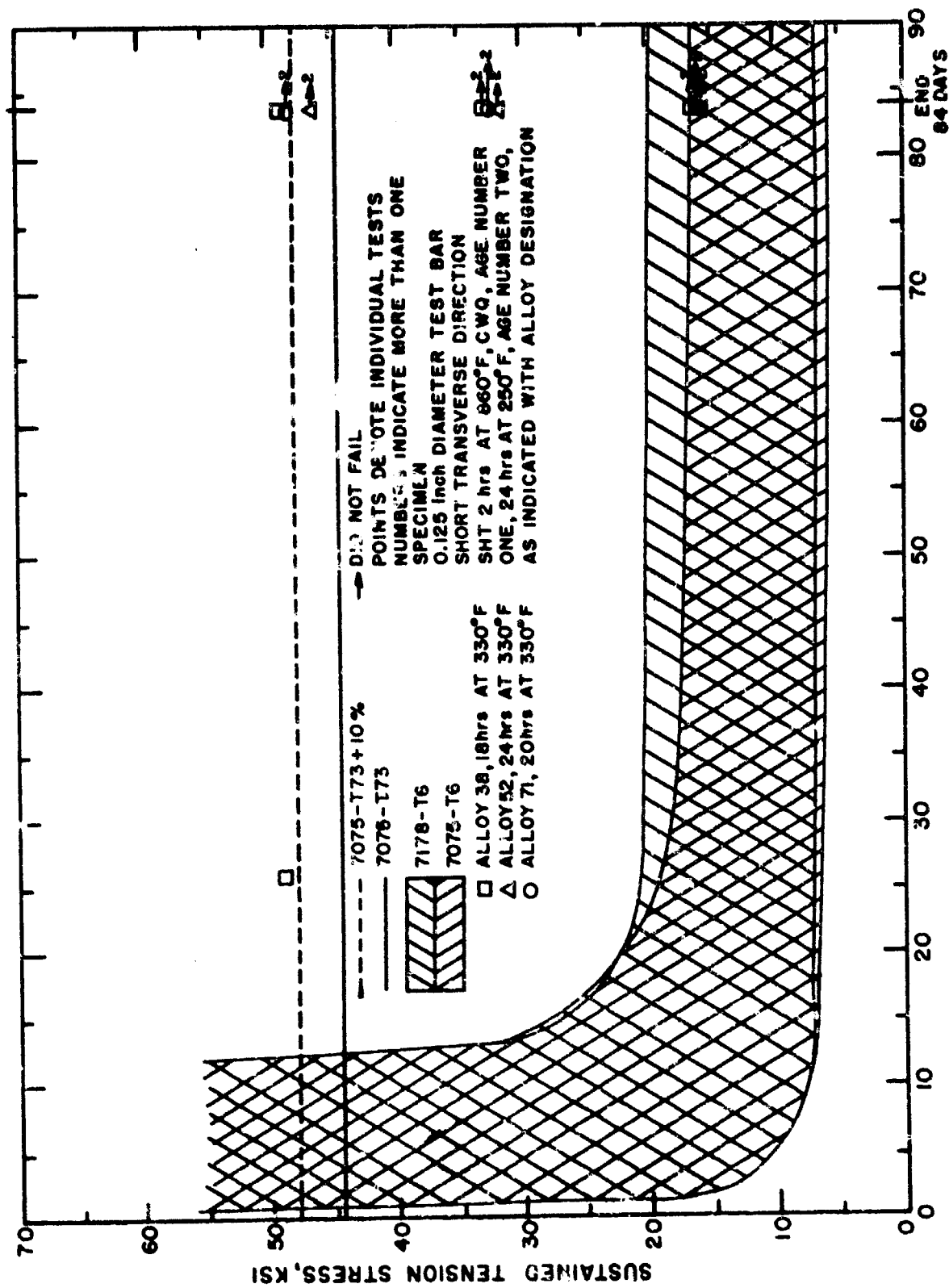


FIGURE 31
COMPARISON OF RELATIVE RESISTANCE TO STRESS CORROSION CRACKING
OF APM ALLOY 34, 79, 87 AND 90 EXTRUSIONS

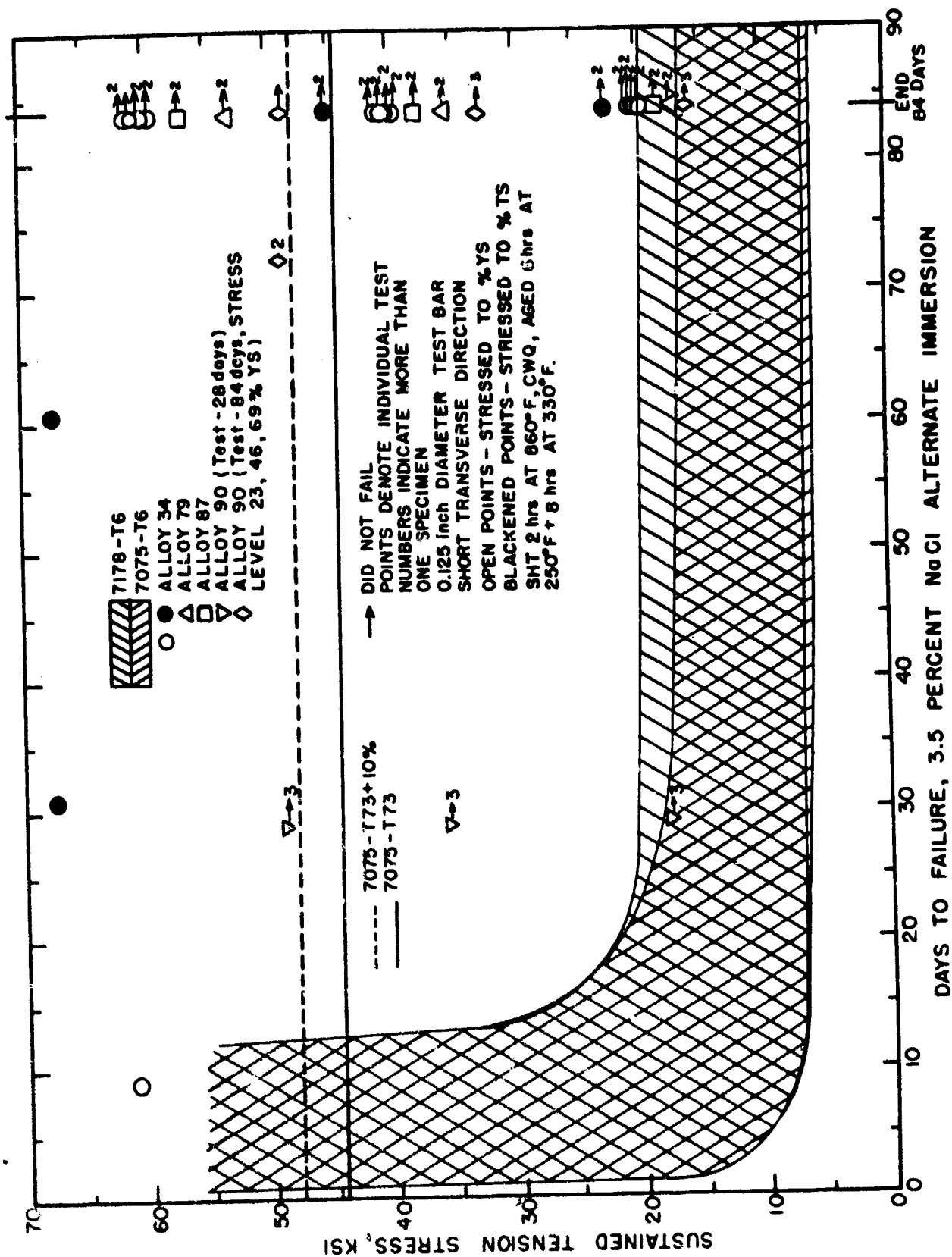


FIGURE 32
COMPARISON OF RELATIVE RESISTANCE TO STRESS CORROSION CRACKING
OF APM ALLOY 34, 79, 87 AND 90 EXTRUSIONS

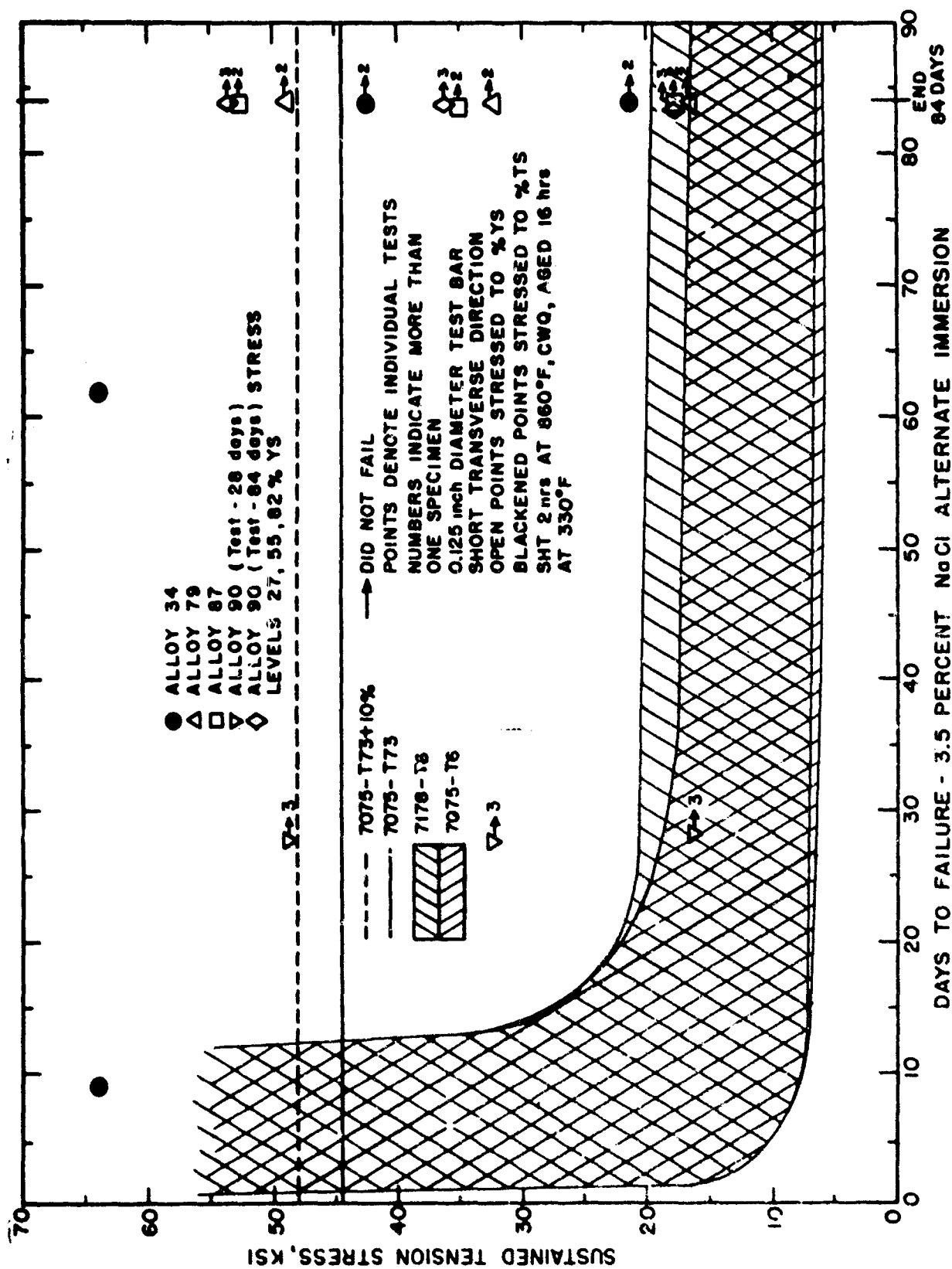


FIGURE 33
COMPARISON OF RELATIVE RESISTANCE TO STRESS CORROSION CRACKING
OF APM ALLOY 34, 79, 87 AND 90 EXTRUSIONS

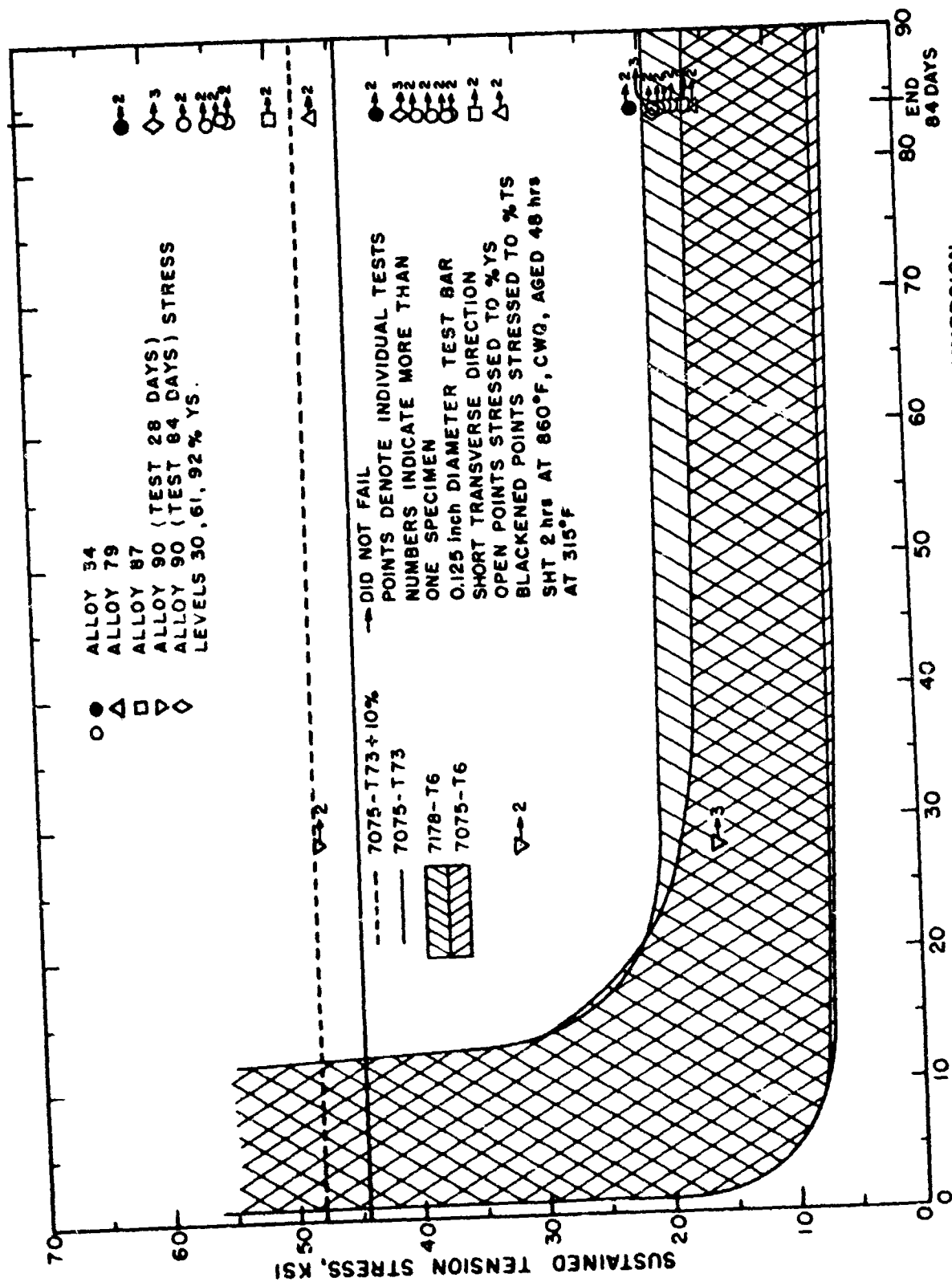
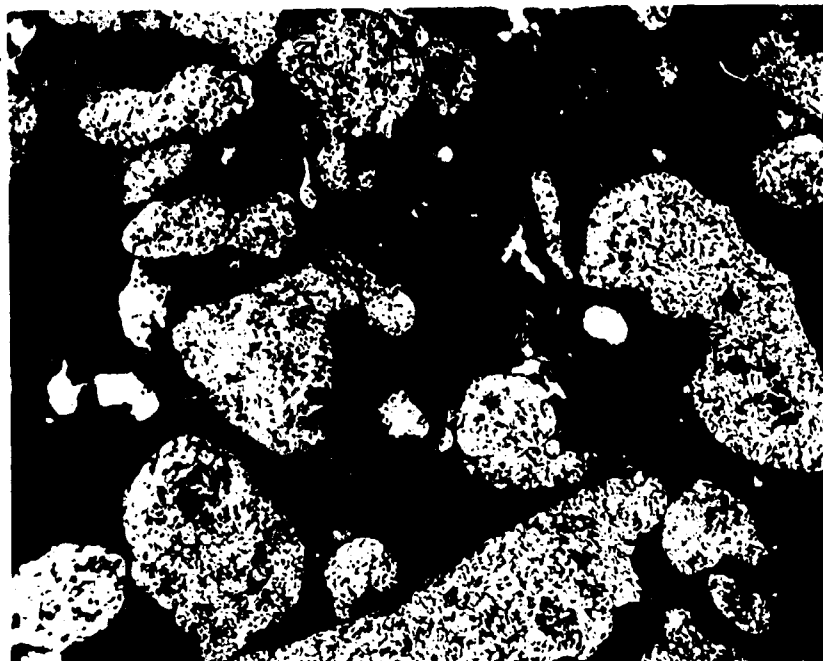


FIGURE 34
COMPARISON OF RELATIVE RESISTANCE TO STRESS CORROSION CRACKING
OF APM ALLOY 34, 79, 87 AND 90 EXTRUSIONS



POWDER
KELLER'S ETCH

500X

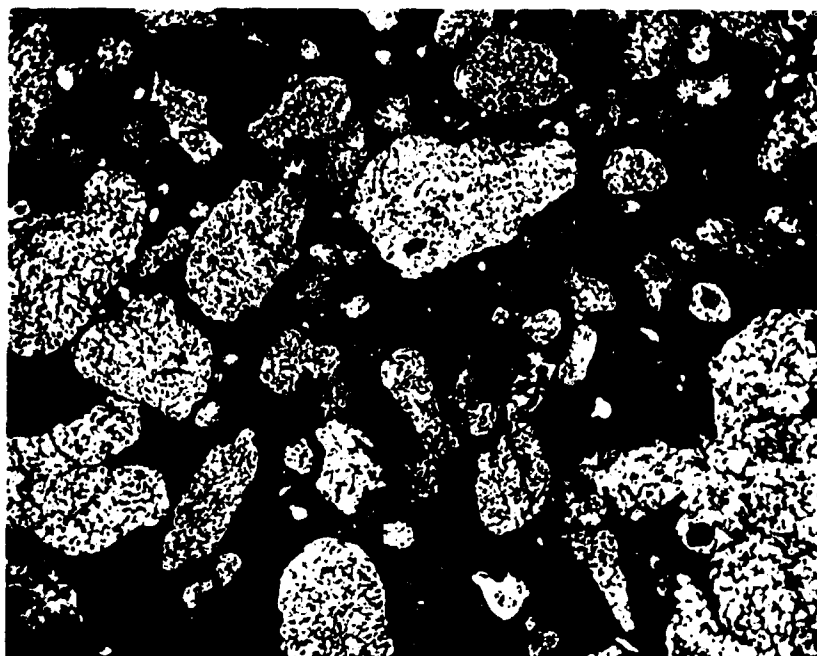


EXTRUSION IN -T6 TEMPER
KELLER'S ETCH

500X
LONG

131452J
1352972

FIGURE 35: ALLOY 38. Al-8.4 Zn - 3.6 Mg - 1.0 Mn - 0.8 Fe - 2.8 Ni



POWDER
KELLER'S ETCH

500X

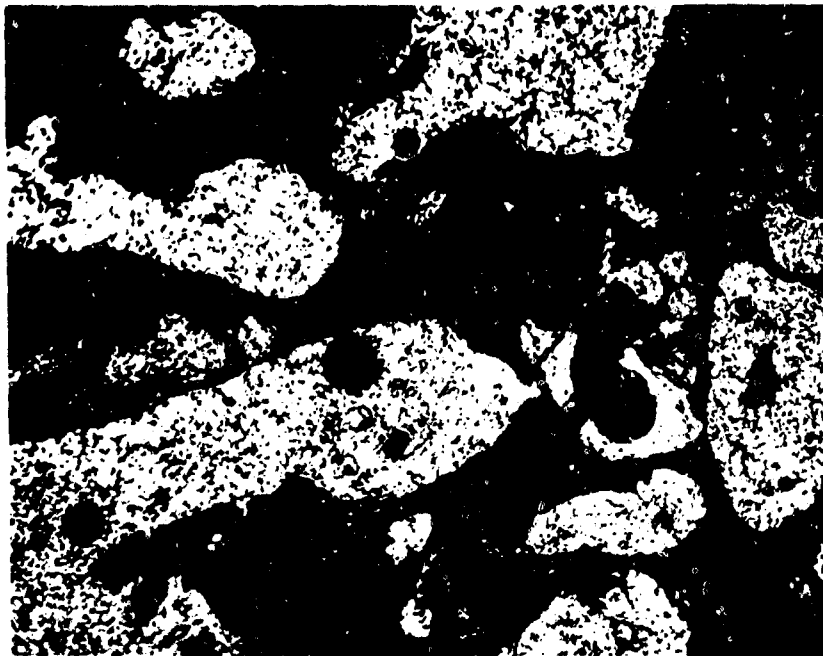


EXTRUSION IN -T6 TEMPER
KELLER'S ETCH

500X
LONG

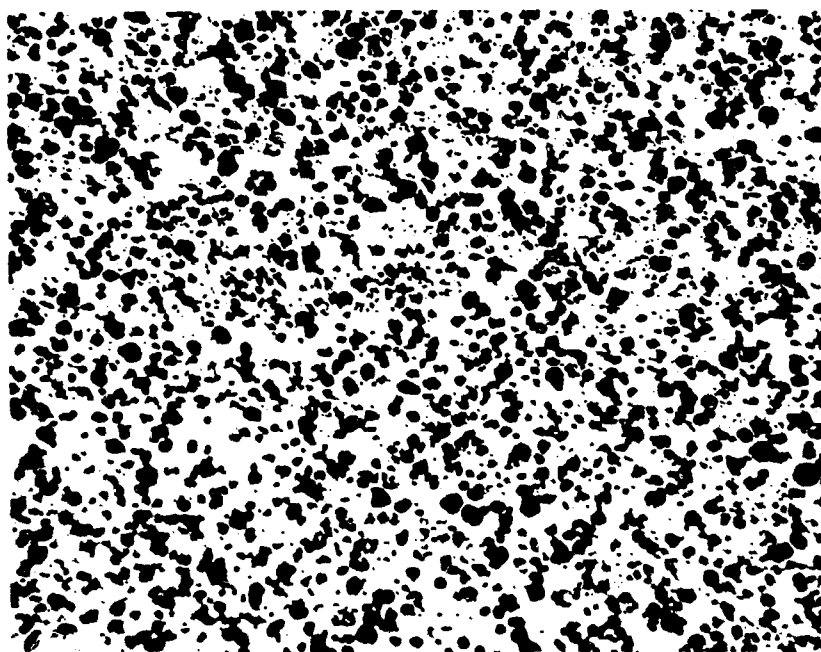
FIGURE 36: ALLOY 15. Al-11.4 Zn-3.4 Mg-1.5 Cu-.5 Cr-.5 Ti-.5 V-.6 Zr

135201J
135202J



POWDER
KELLER'S ETCH

500X

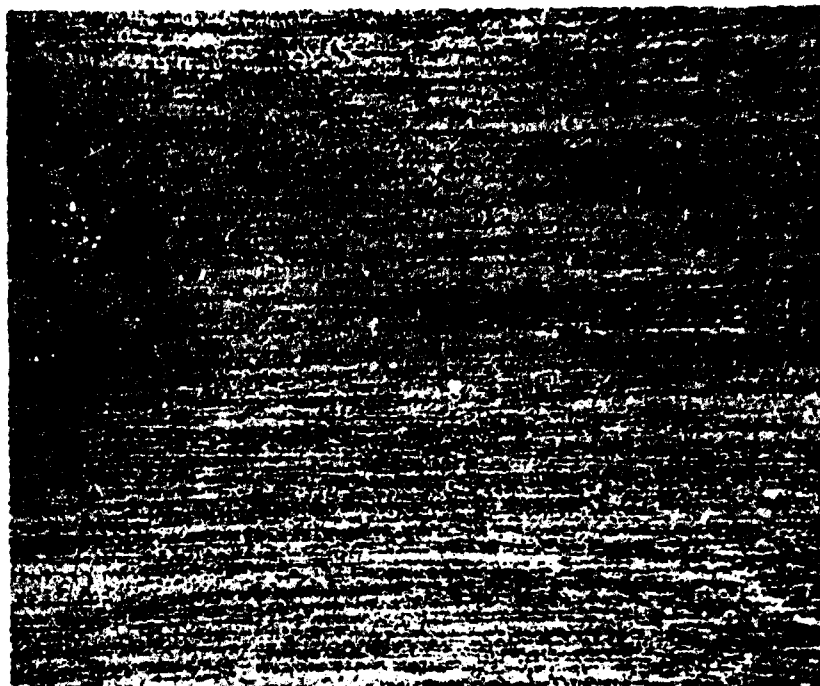


EXTRUSION IN -T6 TEMPER
KELLER'S ETCH

500X
LONG

FIGURE 37: ALLOY 22. Al - 7.9 Zn - 8.4 Mg - 14.9 Cu

1352967
1352968

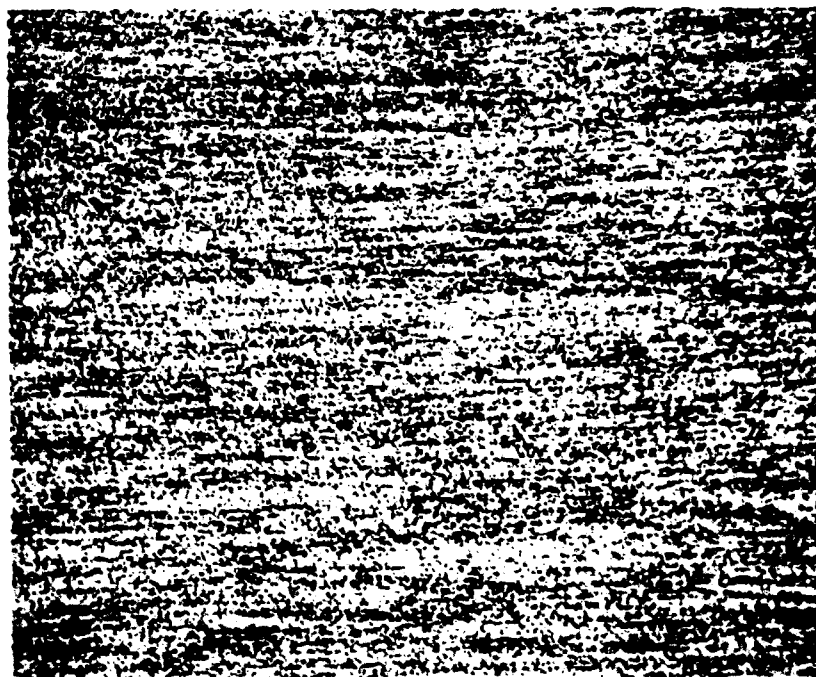


Extrusion in -T6 Temper
Keller's Etch

500X

Figure 38

Alloy 71. Al - 9.3 Zn - 3.6 Mg - 0.5 Cu - 0.7 Co.



Extrusion in -T6 + 20 hrs at 330°F Temper
Keller's Etch

500X

Figure 39

Alloy 71. Al - 9.3 Zn - 3.6 Mg - 0.5 Cu - 0.7 Co.



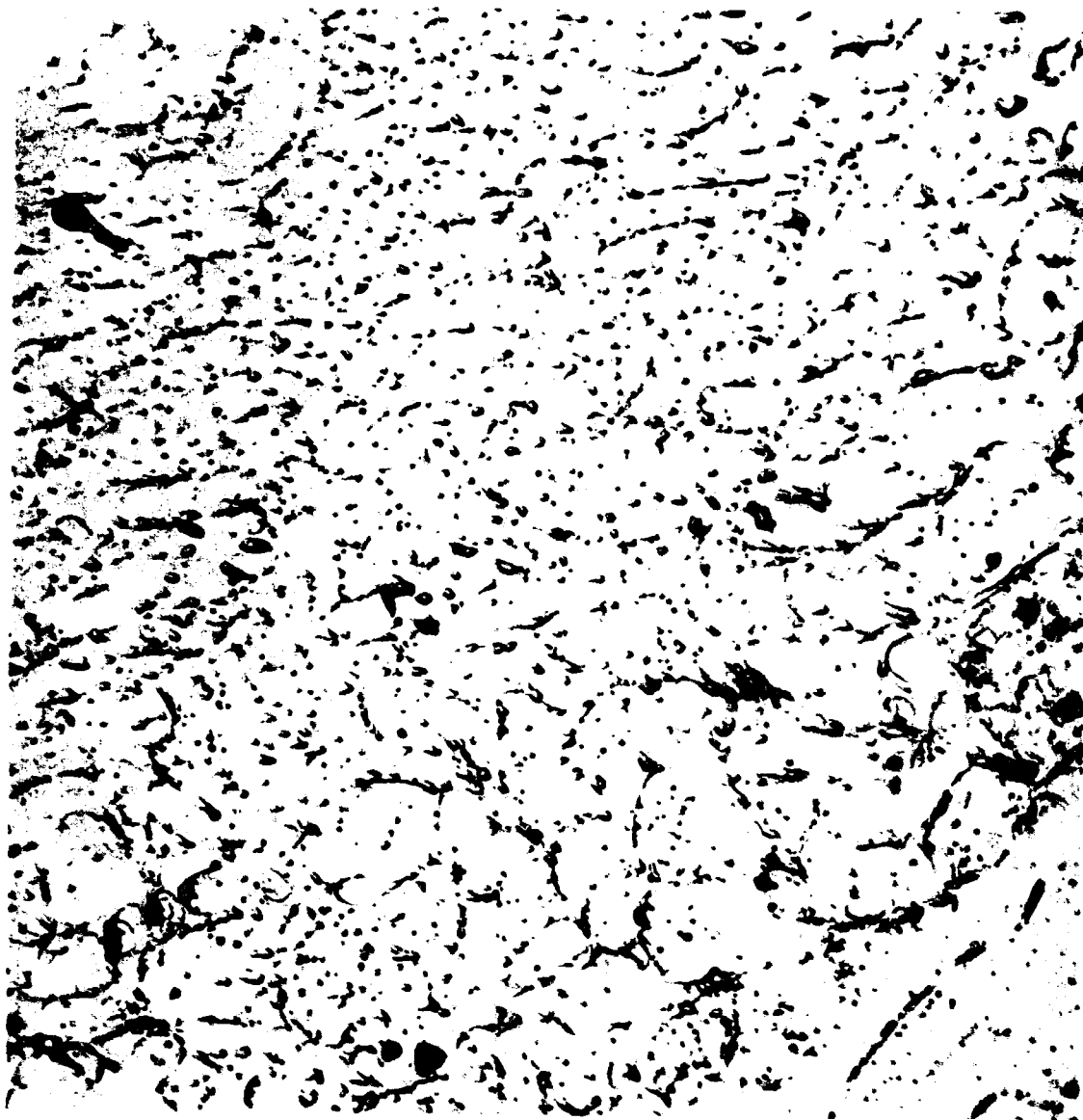
S-283269

Carbon Replica

20,000X

Figure 40

Electron micrograph showing the structure
of Alloy 34 powder.



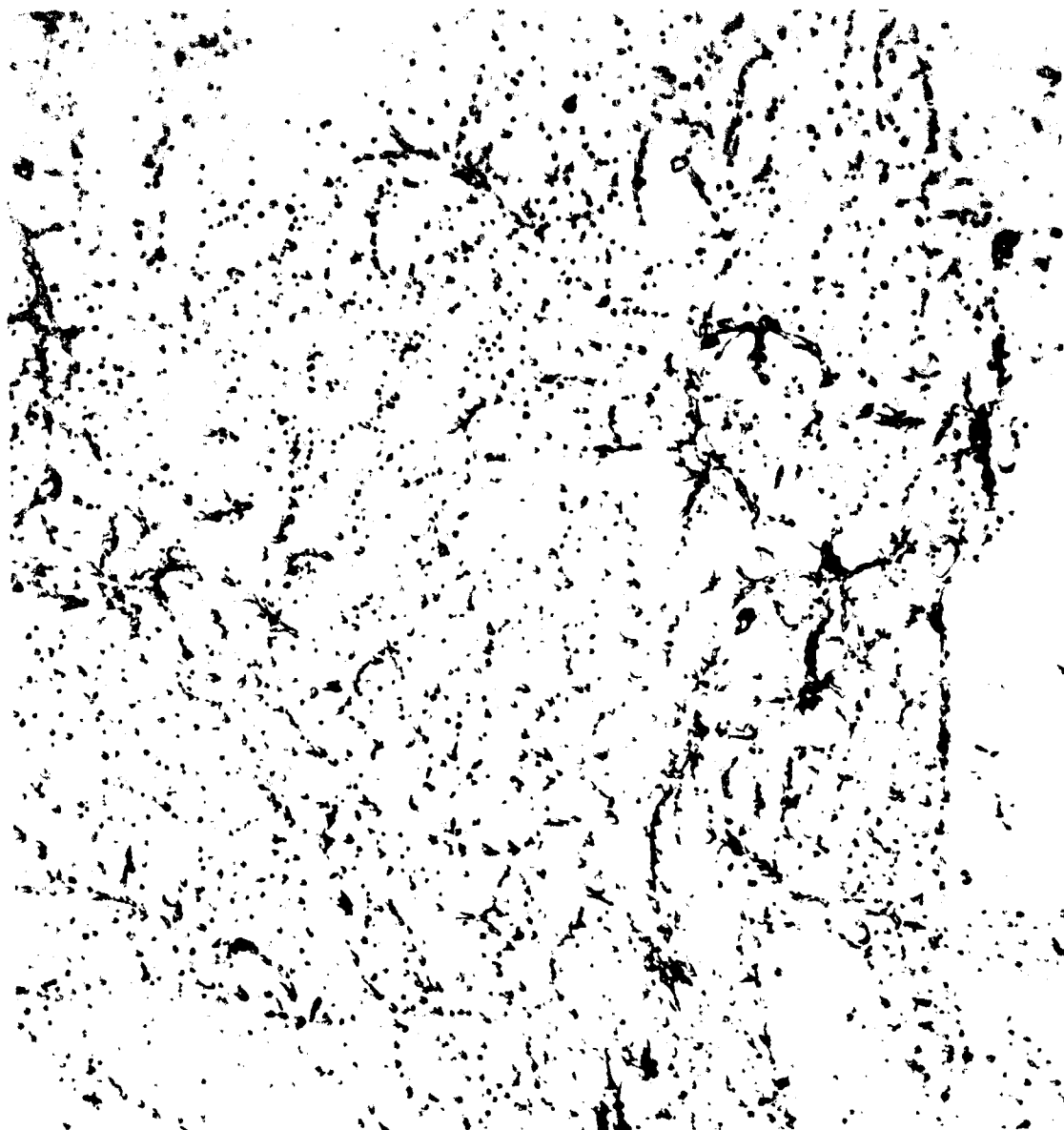
S-307598

Carbon Replica

20,000X

Figure 41

Electron micrograph showing the structure
of Alloy 87 powder.



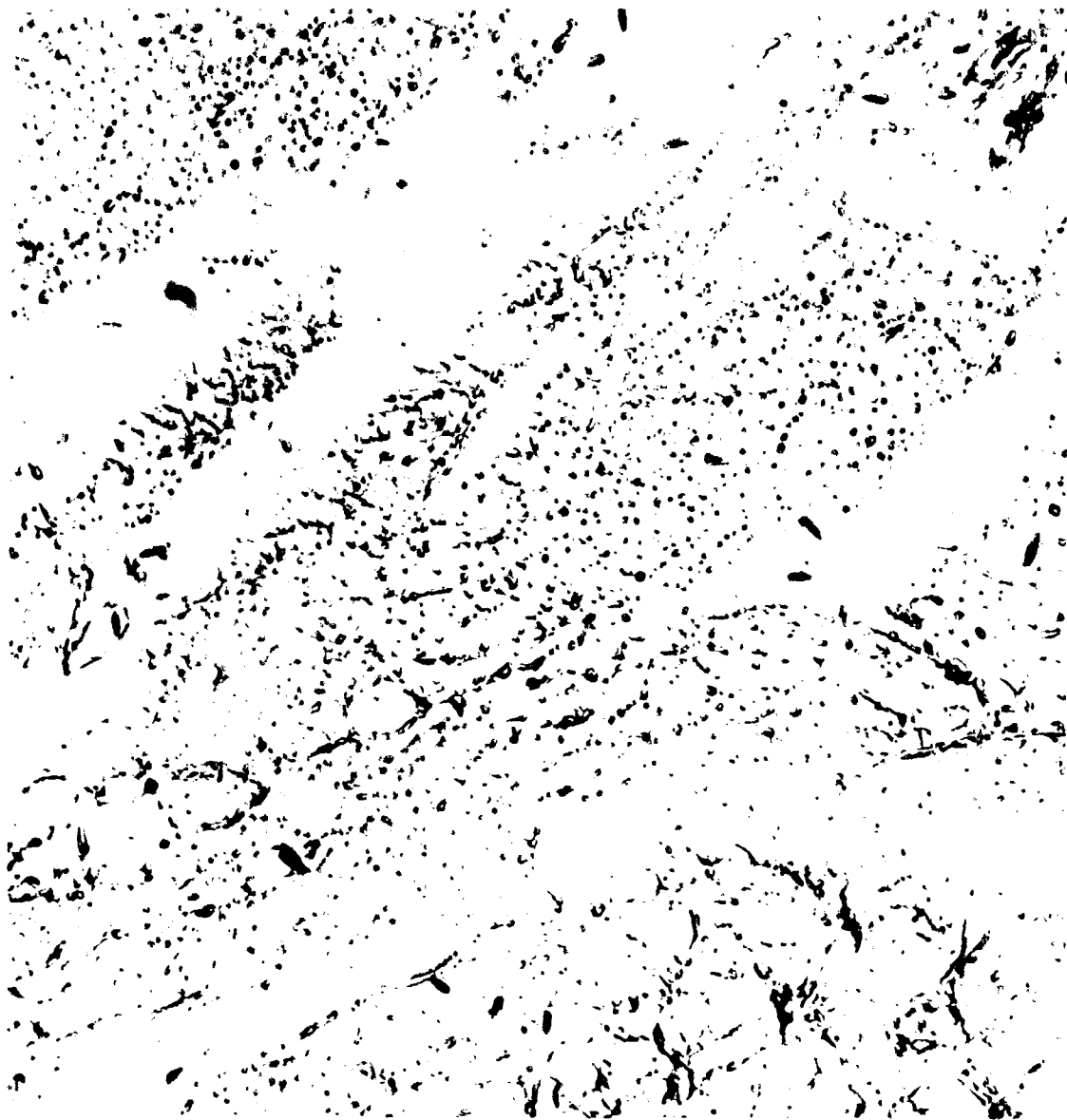
S-283274

Carbon Replica

20,000X

Figure 42

Electron micrograph showing the structure
of Alloy 52 powder.



S-293303

Carbon Replica

20,000X

Electron micrograph showing the structure of Alloy 71 powder. Particles in this powder were slightly less uniformly dispersed than in the other powders.

Figure 43



S-283441-A

Oxide Replica

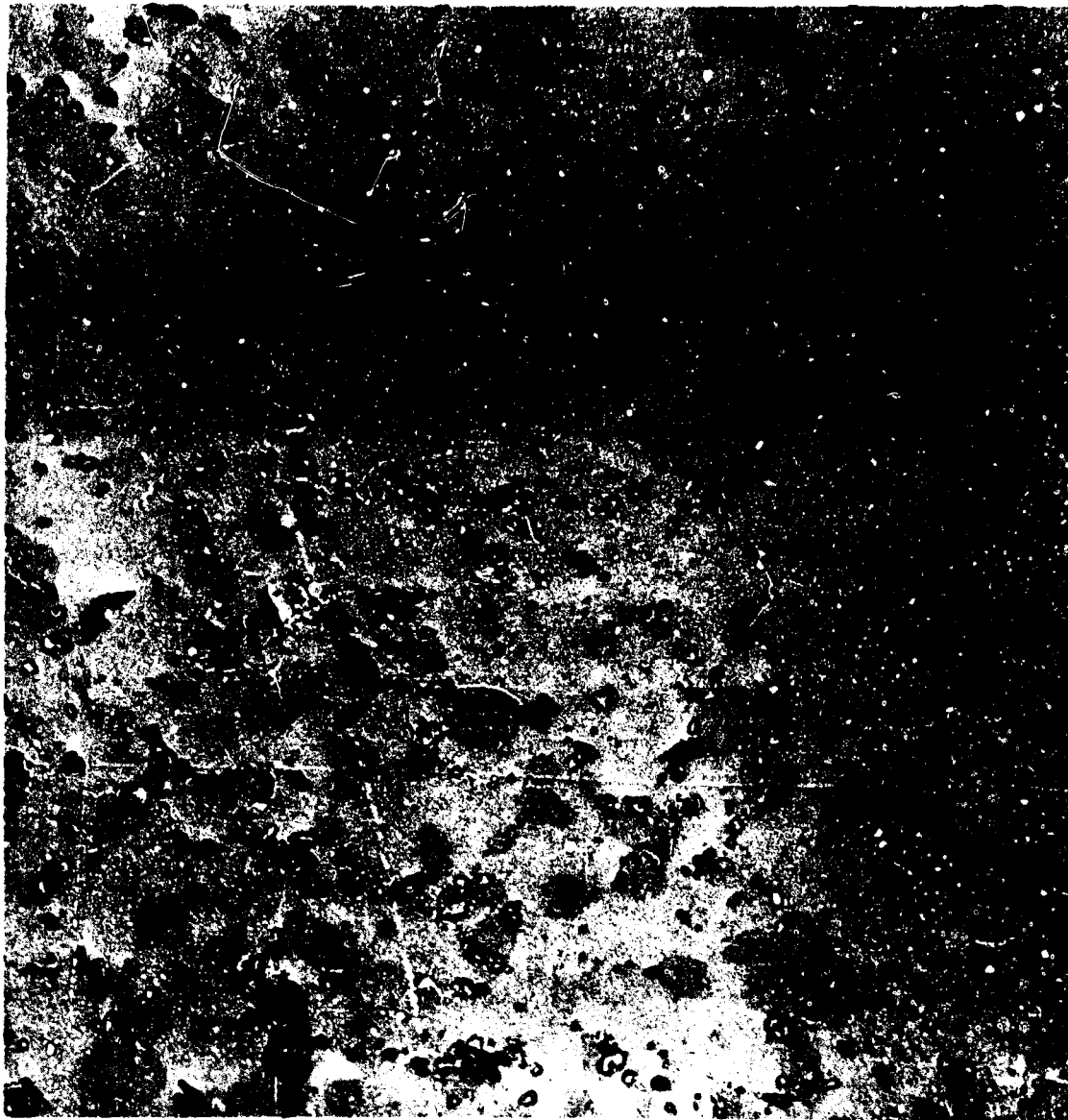
10,000X

Alloy 34-T6

Powder Extrusion

Figure 44

Shows the structure (longitudinal section)
of the extrusion made from Alloy 34 powder.
Extrusion has been S.H.T. 2 hrs at 860°F,
C.W.Q., Aged 24 hrs at 250°F.



S-283441-B

Oxide Replica

10,000X

Alloy 34

Prolonged Age

Powder Extrusion

Shows the structure (longitudinal section) of the extrusion made from Alloy 34 powder. Extrusion has been S.H.T. 2 hrs at 860°F, C.W.Q., Aged 48 hrs at 315°F.

Figure 45



S-293196-A

Oxide Replica

10,000X

Alloy 87-T6

Powder Extrusion

Shows the structure (longitudinal section) of the extrusion formed from Alloy 87 powder. The extrusion had been S.H.T. 2 hrs at 860°F, C.W.Q. Aged 24 hrs at 250°F.

Figure 46



S-293196-B

Oxide Replica

10,000X

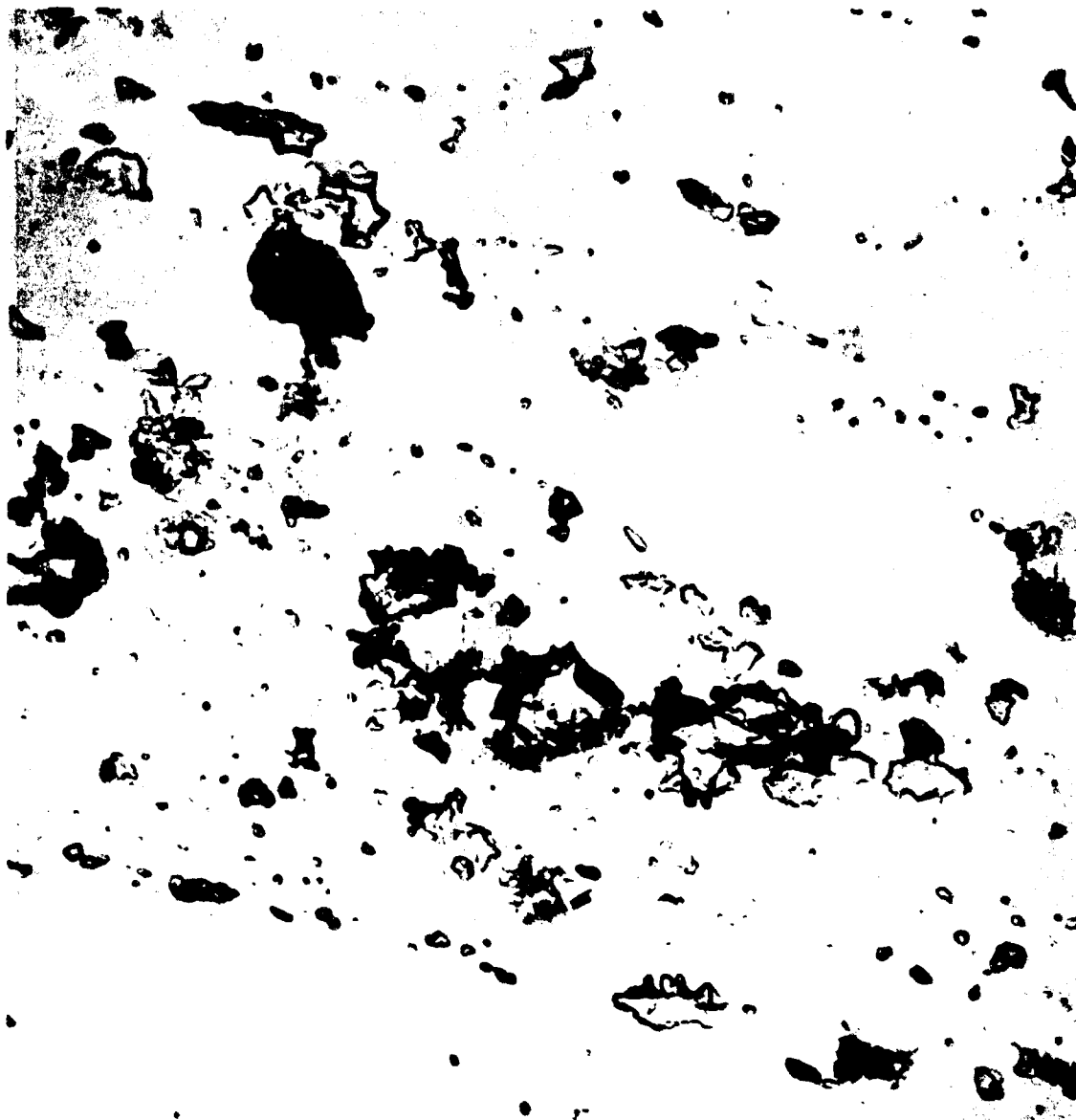
Alloy 87

Prolonged Age

Powder Extrusion

Figure 47

Shows the structure of Alloy 87 powder extrusion that had been S.H.T. 2 hrs at 860°F, C.W.Q. and Aged 48 hrs at 315°F. Probable identification of dispersoid and precipitate phases is noted.



S-283490-A

Oxide Replica

10,000X

Alloy 52-T6

Powder Extrusion

Figure 48

Shows the structure of the extruded section made from the Alloy 52 powder that was S.H.T. 2 hrs at 860°F, C.W.Q. and Aged 24 hrs at 250°F. Note the large amount of (Mg-Zn) precipitate relative to other sections of similar temper.



S-283490-C

Oxide Replica

10,000X

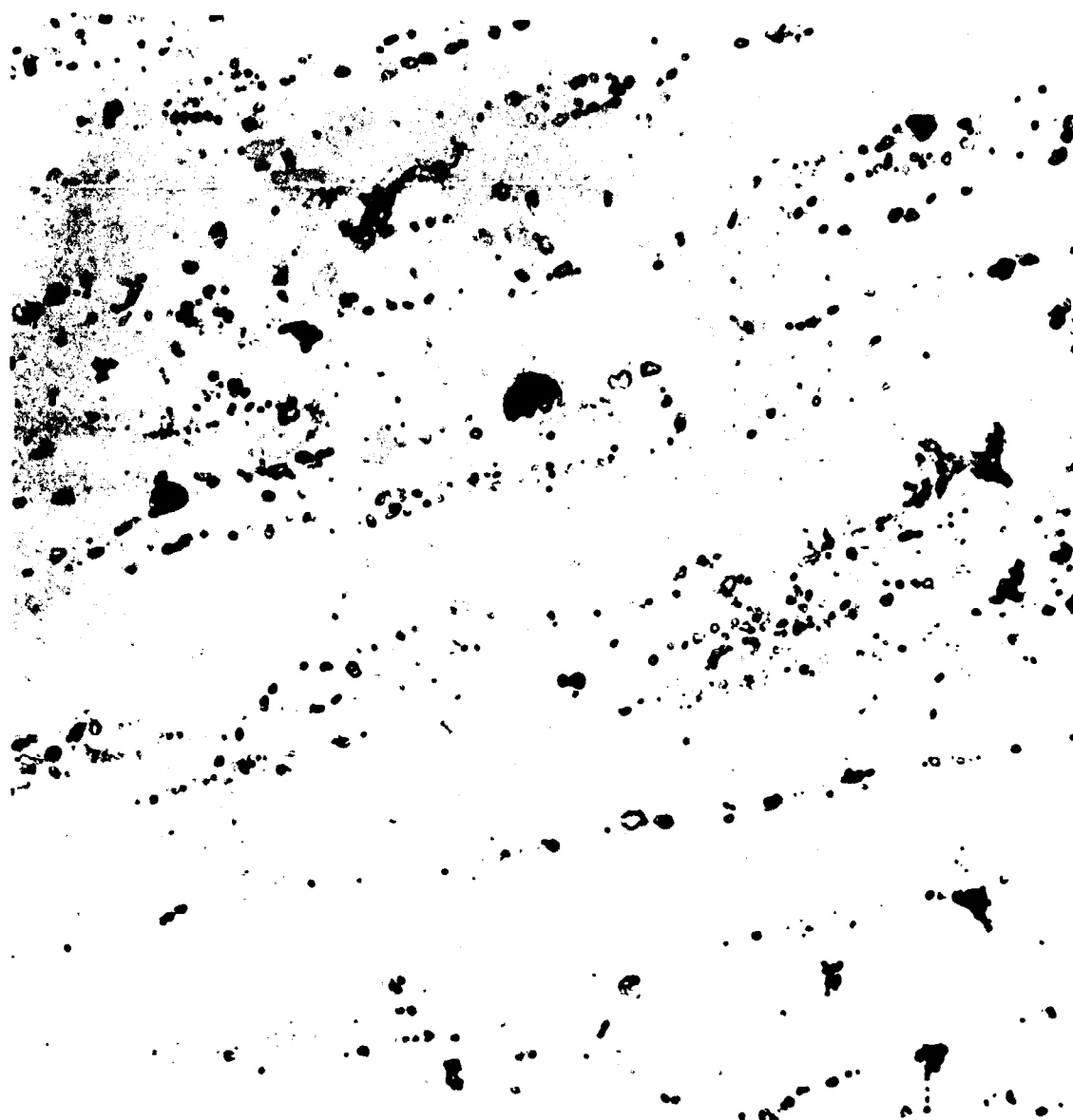
Alloy 52

Step Aged

Powder Extrusion

Figure 49

Shows the structure of Alloy 52 powder extrusion that had been step-aged 24 hrs at 250° + 20 hrs at 330°F after solution heat treatment.



S-293387-A

Oxide Replica

10,000X

Alloy 71-T6

Powder Extrusion

Figure 50

Shows the structure (longitudinal section) of the extrusion made from Alloy 71 powder. The extrusion was S.H.T. 2 hrs at 860°F, C.W.Q. and Aged 24 hrs at 250°F.



S-293387-C

Oxide Replica

10,000X

Alloy 71

Step Aged

Powder Extrusion

Figure 51

Extrusion from Alloy 71 powder that had been step-aged 24 hrs at 250°F + 20 hrs at 330°F after S.H.T. Note increased amount of grain boundary precipitation.

APPENDIX A

Statistical Analyses of Alloy Compositions

Attempts at mathematically selecting compositions resulting in a certain strength have been conducted at times during the course of this contract. The initial evaluation was made on data compiled before the contract began. Two alloy groups were investigated, the Al-Zn-Mg-Cu-Mn-Cr and the Al-Zn-Mg-Cu-Fe-Ni-Mn-Cr series. Equations were obtained from the data and the predicted optimum tensile strength for each group was calculated. The predicted optimum tensile values, the resulting actual tensile values and the equations are listed in Appendix A, Table I. The predicted and actual values are not in close agreement, especially for the latter series. More data are required.

The statistical analyses of the initial 39 alloys resulted in the selection of the compositions of Alloys 43 through 59. These data were obtained using several applicable statistical tools. According to the evaluation, V, Zr, Co, Mo and W appear to have no significant effect on tensile strength. When these elements appeared, they were generally all present and the apparent lack of effect could have been an inability to extract information from the combined groups. The ranges worth investigating were Zn, 8 to 11%; Mg, 3 to 6%; Cu, 1 to 2.5%; Mn, 1 to 2%; Fe, 0 to 1.5%; Ni, 2 to 5%; Cr, 0 to 0.1%; and Ti, 0 to 0.1%. The analyses also indicated the "best" composition, which was atomized as Alloy 59. The results are listed below.

Alloy	Zn	Mg	Cu	Mn	Fe	Ni	Cr	Ti	Predicted	Actual	
									T.S. ksi	T.S., ksi H.T.#1	H.T.#2
--	10.0	4.0	1.5	1.5	1.0	4.0	0.0	0.0	123.0	--	--
59	10.2	3.9	1.6	1.6	1.0	4.1	-	-	--	99.3	83.9

The values are much lower than the predicted values; the reasons for this large difference are not known.

An evaluation of the Al-Zn-Mg-Cu-Mn and the Al-Zn-Mg-Cu-Mn-Fe-Ni alloys was made to determine if a higher strength alloy could be statistically selected. Alloys 1 to 3, 33, 35, 36, 39, 48 and 49 were used for the former group; these same alloys being given Heat Treatments #1 and #2 and evaluated by the optimum point equation. The resulting composition selected to give the highest predicted properties was compared to alloys with similar compositions and heat treatments along with actual properties and is given in Appendix A, Table II. The actual and predicted properties for compositions given Heat Treatment #1 were good. The composition required to give the optimum properties has already been studied. The multiple regression model was used to analyze all alloys having a yield strength of 90,000 psi or higher. The equation obtained is

$$\begin{aligned}
 \frac{Y.S., ksi}{10} = & 5.932 + .5029 Zn - .0215 Zn^2 + .7205 Mg \\
 & - .0930 Mg^2 - .0962 Cu + .0046 Cu^2 + .5335 Mn \\
 & - .1426 Mn^2 - .1826 Fe + .1622 Fe^2 + .1031 Ni \\
 & - .0437 Ni^2 - .4624 Cr - .0639 Ti - .1903 \\
 & (V+Zr+Mo+W) + .0485 Co - .0015 (Cr+Ti)^2 \\
 & + .0082 [Mg \times (Cu+Fe+Mn)] - .0154 (Mg \times Mn) \\
 & - .0010 (Mg \times Zn) - .00008 (Al \times Mg \times Cu) \\
 & - .0011 (Al \times Cu \times Fe)
 \end{aligned}$$

Higher strengths were suggested if the Fe were raised, the Cu were eliminated or maintained at a low level and using Zn ~ 11.7,

Mg = 3.87, Mn = 1.87, and Ni = 1.18. All other alloying additions with the exception of perhaps Co are detrimental. A sample of the predicted yield strengths for several alloys follows:

Composition, %						Predicted Yield, ksi
<u>Zn</u>	<u>Mg</u>	<u>Cu</u>	<u>Mn</u>	<u>Fe</u>	<u>Ni</u>	
11.7	3.87	0.0	1.87	4.0	1.18	127.2
11.7	3.87	0.6	1.87	4.0	1.18	127.0
11.7	3.87	0.0	1.87	3.0	1.18	117.4
11.7	3.87	0.6	1.87	3.0	1.18	117.3

Between the initiation of this survey and the reporting of the results, the object of this contract was changed. This resulted in no alloys being made to obtain the high strengths predicted. Comparisons with existing data are not feasible since the Fe content is high and the ratio of 3 to 4 Fe to 1 Ni has not been investigated.

In conjunction with the revised objective, an optimum point program was conducted on Alloys 52 and 62 to 72. Each heat treatment, Nos. 1 through 3, was evaluated separately to give the highest elongation and the yield strength. The results are given in Appendix A, Table III. Also included are data for Alloy 71 which has a similar composition. The agreement between the predicted and actual yield strengths is quite good; the agreement between the elongations leaves much to be desired. Regression analysis was obtained also, the predicted elongation and yield strength for two alloys calculated from the equation. These results are given in Appendix A, Table IV. An alloy with a higher elongation is possible by lowering the Zn, Mg and Co and setting the Cu at

1.3%. Alloys 19 and 20 have a somewhat similar composition and were included for comparison. The elongation model predictions appear quite reasonable but the yield strength predictions may be high. In comparing the results of the optimum point program and the regression analysis, it is interesting to note that though the indicated alloys differ, the general conclusions of lower Zn and lower Co result from both approaches.

Selection of alloys by statistical methods as a means of obtaining desired properties is possible. The chances of obtaining a reliable value depend on the phases present in the samples and the logical selection of composition.

APPENDIX A

Table I

INITIAL STATISTICAL SELECTION OF COMPOSITION TO GIVE HIGH TENSILE PROPERTIES

Alloy	S. No.	Composition, %						Tensile Strength, ksi		Equation	
		Zn	Mg	Cu	Mn	Cr	Fe	Ni	Actual Avg.		Predicted
--		9.2	3.4	1.2	1.1	0.0	--	--	--	117.5	1
33	277405	9.0	3.5	1.2	1.1	--	--	--	108.0	--	
--		6.5	2.7	0.6	0.0	0.1	0.0	2.0	--	116.2	2
32	277404	6.6	2.7	0.6	--	0.1	--	2.3	97.0	--	

Equation (1)

117.5

$$TS = 1 + (.075 Zn - .685)^2 + (.218 Mg - .750)^2 + (.370 Cu - .434)^2 + (.321 Mn - .354)^2 + (.416 Cr - .078)^2$$

Equation (2)

116.2

$$TS = 1 + (.083 Zn - .537)^2 + (.052 Mn - .141)^2 + (.169 Cu - .103)^2 + (.027 Ni - .053)^2 + (.029 Mn)^2 + (1.42 Cr - .144)^2$$

APPENDIX A

Table II

SUMMARY OF HIGH STRENGTH STATISTICAL ANALYSES PROGRAMS (a)

Alloy	Composition, %							H.T. No.	Avg. Tensile Properties, ksi			
	Zn	Mg	Cu	Mn	Fe	Ni	Cr		Actual		Predicted	
									T.S.	Y.S.	T.S.	Y.S.
36(b)	10.7	3.8	2.0	1.7	--	--	--	1	--	106.0	--	105.3
--	10.88	4.9	2.0	1.71	--	--	--	1	--	--	108.3	--
39	10.9	4.9	2.0	1.7	--	--	--	1	110.0	--	--	--
--	8.4	3.6	0.006	0.99	0.80	2.81	0.0	2	--	--	109.6	--
38	8.4	3.6	0.0	1.00	0.80	2.80	0.0	2	119.6	--	--	--

-149-

(a) Optimum point analysis.

(b) Predicted alloy had same composition as Alloy 36.

APPENDIX A

Table III

SUMMARY OF RESULTS ON OPTIMUM POINT PROGRAMS OF HIGH ELONGATION ALLOYS

Heat Treatment	Composition, %			Yield Strength, ksi		Elongation, %	
	Zn	Mg	Cu	Predicted	Actual Avg. (b)	Predicted	Actual Avg. (b)
1	9.43	NE (3.6-4.7) (a)	0.72	103.2	105.0	2.57	3.1
2	9.29	NE (3.6-4.7)	NE (0.6-1.5)	112.1	112.0	2.13	3.7
3	9.37	4.10	0.55	109.8	111.4	1.80	2.4
(b)	9.2	3.6	0.6	--	--	--	--

(a) NE = Negligible effect in range studied.

(b) Alloy 71 has a similar composition and actual properties to the predicted optimums.

H.T.#1	YS =	104.03	$1 + (.0017) (Zn-11.10)^2 + (.0438) (Cu-1.008)^2$
	EL =	2.568	$1 + (.0209) (Zn-9.43)^2 + (.1186) (Cu-.725)^2$
H.T.#2	YS =	112.09	$1 + (.0021) (Cu-1.31)^2$
	EL =	2.133	$1 + (.2827) (Zn-9.29)^2 + (.9181) (Co-.88)^2$
H.T.#3	YS =	109.79	$1 + (.0074) (Mg-4.1)^2 + (.0389) (Cu-.60)^2$
	EL =	1.803	$1 + (.1564) (Zn-9.37)^2 + (.0369) (Cu-.551)^2 + (.4999) (Co-.737)^2$

APPENDIX A

Table IV

SUMMARY OF RESULTS OF REGRESSION ANALYSES ON HEAT TREATMENT #1 HIGH ELONGATION ALLOYS

Alloy	Composition, %			Yield Strength, ksi		Elongation, %	
	Zn	Mg	Co	Predicted	Actual Avg.	Predicted	Actual Avg.
--	8.0	3.0	1.3	0.5	107.7	--	6.6
--	9.0	3.0	1.3	0.5	107.1	--	5.8
19	7.5	3.0	1.7	0.0	--	95.3	7.2
20	7.8	3.6	2.3	0.0	--	94.8	4.0

$$YS = 284.91 - 20.53 Zn - 39.30 Mg - 17.37 Cu + .17 Co \\ + 1.17 Zn^2 + 4.61 Mg^2 + 6.52 Cu^2 - .28 Co^2$$

$$EL = 60.70 - 4.89 Zn - 15.81 Mg + 1.13 Cu - 2.06 Co \\ + .24 Zn^2 + 1.92 Mg^2 + .42 Cu^2 + .30 Co^2$$

APPENDIX B

Hardness Value

The heat treated APM alloys have hardnesses much higher than usually associated with aluminum, Table I. During the step aging evaluation, a possible correlation between the strength and hardness was sought. A number of alloys were given Heat Treatment #1 with Age #2 at 330°F or 350°F, the hardness values being taken at predetermined intervals, Tables II and III. The results of these and also earlier tests were evaluated graphically. The poor reproducibility of several lots of Alloy 52 is seen in Figure 1. The excellent strength reproducibility is contrasted to the poor hardness reproducibility in the main text in Figure 9, also for Alloy 52. Work was discontinued.

Appendix B

Table I

HARDNESS VALUES OF SELECTED APM ALLOYS

<u>Alloy Number</u>	<u>Sample Number</u>	<u>H.T. No. (a)</u>	<u>Test Piece (b)</u>	<u>Rockwell Hardness</u>	<u>Brinell Hardness (c)</u>
34	283442	2	A	G-79	(189)
	283449	2	B	----	230 (e)
	283449	3	B	----	229 (e)
38	283454	2	A	G-80	(192)
	283459	2	B	----	208 (e)
	283459	3	B	----	210 (e)
39	283463	1	A	G-71	(167)
	283467	2	A	G-80	(192)
49	283471	2	A	G-84	(210)
	283472	2	A	G-79	(189)
50	284130	F	C	B-56	(90)
	284130	2	C	G-86	(220)
	283484	2	A	G-84	(210)
52	307454	1	E	----	190 (e)
	307454	1	F	----	189 (e)
	307455	1	E	----	188 (e)
	307455	1	F	----	186 (e)
	307454	2	E	----	195 (e)
	307454	2	F	----	204 (e)
	307455	2	E	----	182 (e)
	307455	2	F	----	190 (e)
	283497	2	A	G-73	(172)
	284131	2	D	G-87	226 (d)
	284131	2	D	----	213 (e)
	284131	3	D	G-84	204 (e)
	284131	3	D	----	219 (f)
62	307321	1	E	----	186 (e)
	307321	1	F	----	181 (e)
	307321	2	E	----	190 (e)
	307321	2	F	----	188 (e)
64	307323	1	E	----	176 (e)
	307323	1	F	----	186 (e)
	307323	2	E	----	176 (e)
	307323	2	F	----	192 (e)
71	307330	1	E	----	191 (e)
	307330	1	F	----	192 (e)
	307330	2	E	----	185 (e)
	307330	2	F	----	190 (e)

(a) Heat Treatment

F - As Fabricated.

#1 - SHT 2 hrs. at 860°F, CWQ, Aged 24 hrs. at 250°F.

#2 - SHT 1/2 hr. at 920°F, CWQ, Aged 96 hrs. at 225°F.

#3 - SHT 2 hrs. at 860°F, CWQ, Aged 96 hrs. at 225°F.

(b) Test Pieces

A - Broken tensile specimens from 2 in. dia. extruded rod.

B - Rolled plate from hot press forged compacts.

C - Slices from hot compacted billets.

D - Section of rolled plate from 1" x 4-1/4" extrusion 1/2" thick.

E - Section of rolled sheet from 1" x 4-1/4" extrusion 1/10" thick.

F - Section of rolled plate from 1" x 4-1/4" extrusion 1/4" thick.

(c) Values in parenthesis are converted from Rockwell to Brinell Hardness values using a 500 kg load and a 10 mm ball.

Source: ASM Metals Handbook, 1948 Edition, p. 101

(d) 1500 kg load and 10 mm ball.

(e) 500 kg load and 10 mm ball.

(f) 3000 kg load and 10 mm ball.

APPENDIX B

Table II

ROCKWELL C HARDNESS VALUES OF SELECTED ALLOYS AFTER PROLONGED AGING AT 330°F

Alloy/S. No.

Additional Aging Time (a) at 330°F, Hours	5	7	8	14	33	38	39	40	49	50	51	52	54	57	66
2	277177	277379	277380	277386	277405	283452	283464	277428	283470	283482	278249	283492	278252	278255	307144
4	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
6	73	76	78	77	73	75	77	75	76	77	77	73	80	80	77
8	71	74	75	75	71	72	74	74	74	75	75	70	78	79	71
10	68	72	74	73	69	70	74	73	72	73	74	69	76	77	69
12	66	70	71	71	67	69	73	72	70	70	71	66	75	76	67
14	65	69	70	69	65	67	72	70	68	69	71	65	74	75	65
16	62	68	70	68	63	66	71	70	66	68	70	62	73	73	63
18	62	67	70	67	63	66	70	69	66	69	68	64	73	73	63
20	61	67	70	66	63	66	70	69	66	69	68	63	73	73	63
22	61	66	69	66	62	64	69	69	64	65	67	62	72	72	62
24	60	65	68	65	60	63	67	68	63	64	67	61	71	70	59
26	57	65	67	64	59	61	67	67	62	63	66	58	69	70	59
28	56	63	65	63	57	61	65	66	61	63	64	57	68	69	58
30	54	62	64	62	56	60	64	65	60	62	65	55	66	68	57
32	53	61	63	61	55	61	64	65	60	61	64	55	66	69	56
34	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
36	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
38	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
40	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
42	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
44	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
46	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
48	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56
50	53	61	63	61	55	61	64	65	60	61	64	55	67	69	56

NOTE: (a) S.P.T. 2 hrs. at 860°F, C.W.Q., Age #1 - 24 hrs. at 250°F

C - Center
M - Midway

APPENDIX B

Table III

ROCKWELL C HARDNESS VALUES OF SELECTED ALLOYS AFTER PROLONGED AGING AT 350°F

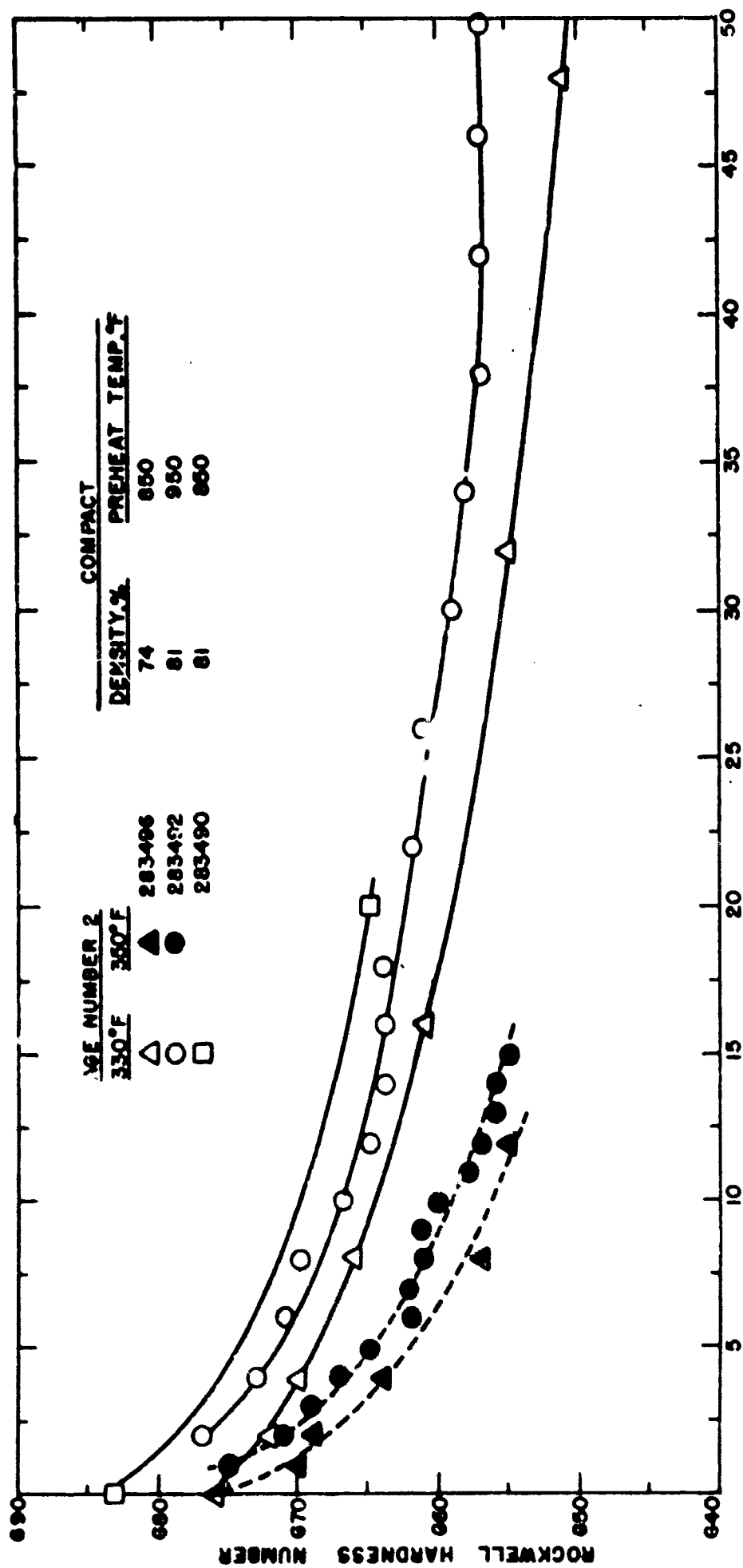
Alloy/S. No.

Additional Aging Time
at 350°F, Hours (a)

	5	7	8	11	33	38	39	40	49	50	51	52	54	57	66
1	277377	277379	277380	277386	277405	283452	283464	277428	283470	283482	278219	283492	278252	278255	307314
2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
3	70	71	75	74	70	72	76	75	74	75	76	71	78	79	71
4	69	70	72	73	68	69	75	71	72	73	73	69	76	77	71
5	66	67	70	69	66	67	72	69	69	70	70	66	74	75	68
6	64	66	69	71	64	66	71	69	68	69	71	64	75	74	65
7	61	63	67	68	62	63	65	69	66	68	69	65	73	72	64
8	59	60	66	67	61	62	65	68	67	68	68	62	71	72	63
9	59	60	66	68	59	61	67	68	65	66	67	60	69	70	62
10	58	60	64	64	58	63	64	67	64	65	65	61	69	70	59
11	58	59	64	63	57	62	66	67	63	64	64	59	68	70	58
12	56	58	63	62	56	61	65	67	61	63	64	57	68	69	57
13	55	57	63	62	56	60	65	67	60	63	64	56	68	70	55
14	54	57	63	60	54	59	64	66	61	62	64	55	68	68	55
15	54	57	62	60	54	59	62	64	60	61	62	55	67	68	54

NOTE: (a) S.H.T. 2 hrs. at 860°F, C.M.Q., Age #1 - 24 hrs. at 250°F

C = Center
M = Midway

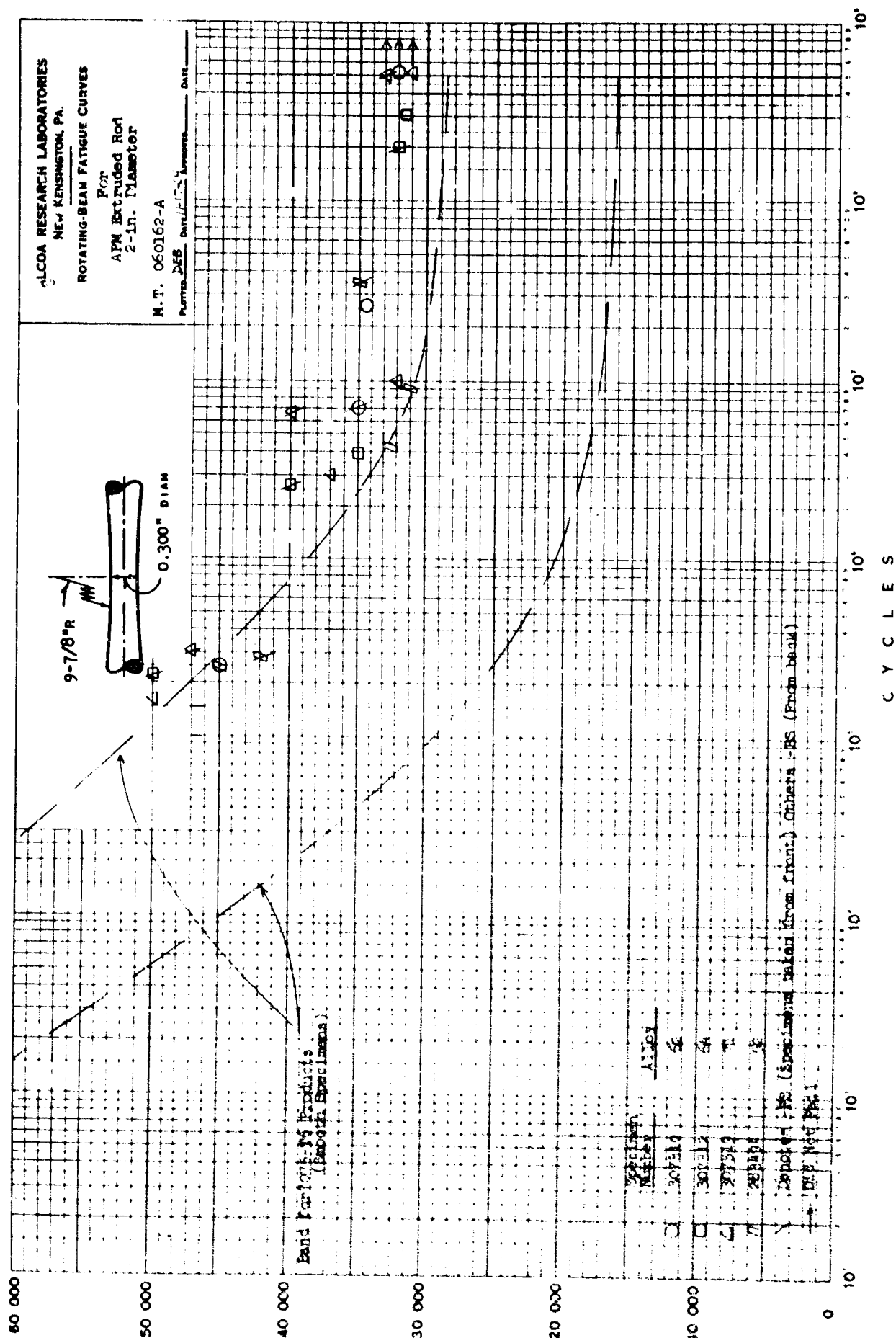


THE EFFECT OF PROLONGED AGING ON HARDNESS OF ALLOY 52

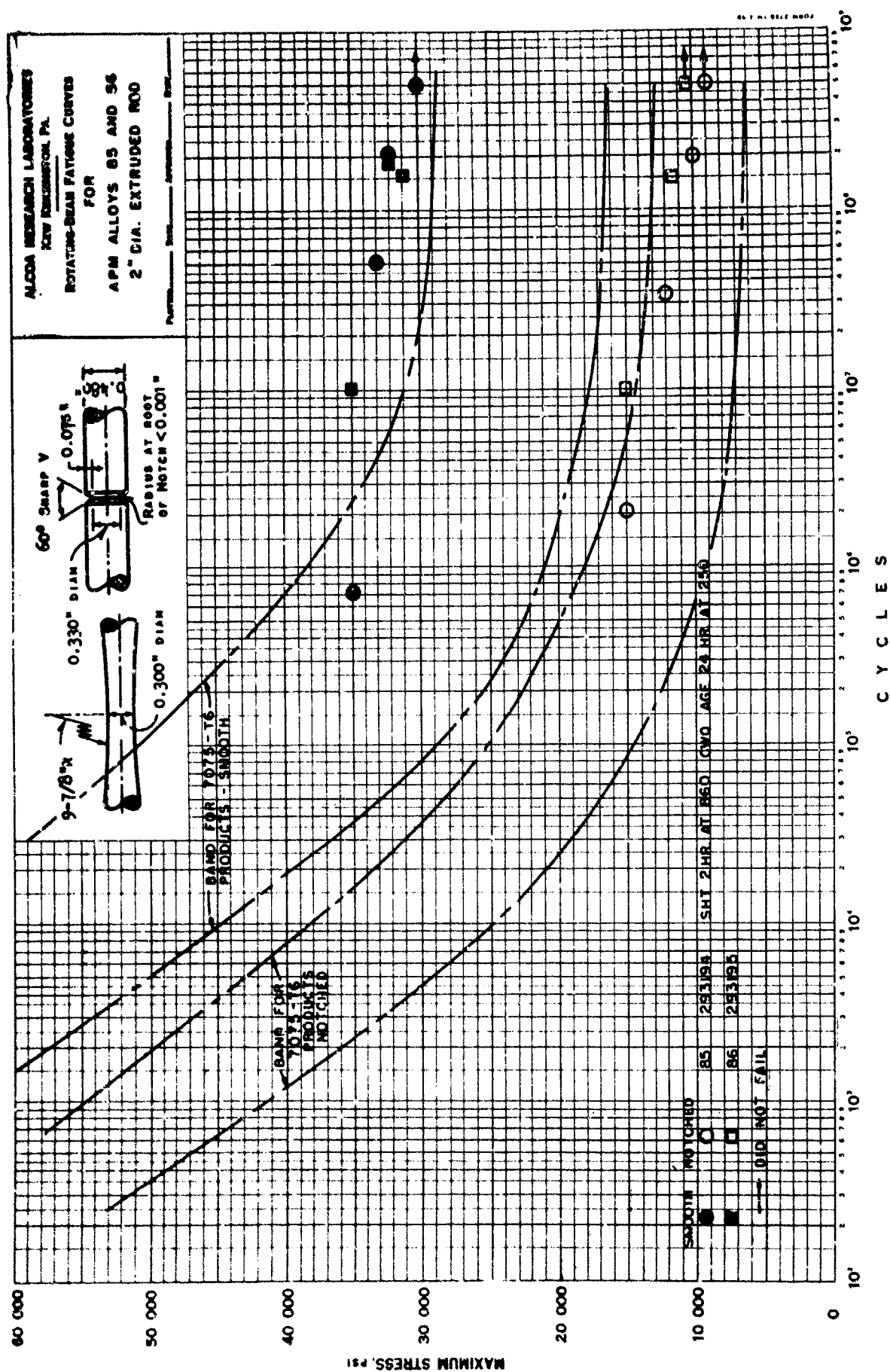
APPENDIX C

Fatigue limits were determined on smooth (unnotched) specimens machined from extruded stock of Alloys 52, 62, 64 and 71. The specimens were given Heat Treatment #1. The results are compared with the 7075-T6 product scatter band, Figure 1. The fatigue limits of these alloys generally fall above the 7075-T6 band with a few falling on or just below the upper limit of the band. The fatigue limit for Alloy 62 is approximately 32 ksi, for Alloy 64 approximately 31 ksi, and for Alloy 71 approximately 32 ± 1 ksi. No fatigue limit was determined for Alloy 52 because of testing difficulties.

Additional tests were made outside the contract but are included in this report. Smooth (unnotched) and notched specimens of Alloy 71 extrusions were given Heat Treatment #1 and also step aged, Figure 2. The notched specimens are at least as good as notched 7075-T6. The smooth specimens are better than 7075 smooth specimens. Step aging does not appear to improve or have an adverse effect on the fatigue endurance limit. Alloys 85 and 86 also show similar fatigue endurance limits in the smooth and notched configurations, Figure 3.



APPENDIX C
FIGURE 1



APPENDIX C
FIGURE 3