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DETERMINATION OF THE WELDABILILITY AND ELEVATED TEMPERATURE STABILITY OF REFRACTORY METAL ALLOYS.
TOPICAL REPORT NO. 1

EFFECT OF 1000 HOUR THERMAL EXPOSURES ON TENSILE PROPERTIES OF REFRACTORY METAL ALLOYS

BY
G.G. LESSMANN

PREPARED FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SPACE POWER SYSTEMS DIVISION
CONTRACT NAS 3-2540

Astronuclear Laboratory
Westinghouse Electric Corporation

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Contract NAS 3-2540: Determination of the Weldability and Elevated Temperature Stability of Refractory Metal Alloys

Technical Management
NASA-Lewis Research Center
Cleveland, Ohio
Space Power Systems Division
Paul E. Moorhead

Astronuclear Laboratory
Westinghouse Electric Corporation
Pittsburgh 36, Pa.

ABSTRACT

The effect of 100 and 1000 hour aging on the tensile strength of welds and base metal was determined for the columbium and tantalum base alloys following thermal exposure in ultra high vacuum at: 1500°F, 1800°F, 2100°F, and 2400°F. Alloys were tested at 1800°F, 2100°F, 2400°F, and room temperature. Out of ten alloys, three displayed excellent stability (FS-85, C-129Y, and SCb-291) and six responded with modest changes in tensile properties (T-111, T-222, Ta-10W, B-66, Cb-752, and D-43Y). The remaining alloy, D-43, overaged in a classic manner losing strength with a time-temperature dependence during thermal exposure.

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I. INTRODUCTION

This Topical Report describes work accomplished under Contract NAS 3-2540. The overall objective of this program is to determine the weldability and long time elevated temperature stability of promising refractory metal alloys in order to select those most suitable for use in advanced space electric power systems. Alloys included in this program are listed in Table 1. This group includes all the promising alloys commercially available at the inception of this program in mid 1963 and, to this extent, represents the state-of-the-art at that time. Naturally, alloy development has been pursued concurrent with this evaluation and recently introduced alloys offer promise over those evaluated in this program. The ASTAR 811 series of alloys are of particular interest in this respect. These are dispersion strengthened alloys designed specifically for long life (i.e., creep resistant) applications requiring fabricable alloys for containment of liquid metal working fluids. The interested reader will find extensive information on these alloys in References 1, 2, and 3.

The weldability phase of this study has been completed and has been described in detail in quarterly progress reports and technical publications stemming from this investigation (see general references). In chronological sequence it was necessary to complete the weldability study prior to initiation of the thermal stability study. This stems from the fact that thermal stability considerations are most generally associated with weld induced thermal disturbances in the alloy structures. Hence, to assure a judicious weld parameter selection for thermal stability specimens, welding responses of the alloys had to be investigated first.

All of the alloys except W, W-25Re, and Sylvania A were included in the aging study through the 1000 hour exposures. Only three alloys, T-111, T-222, and FS-85 are being aged for longer periods extending pretest exposure to 10,000 hours. Elimination of alloys in the aging study reflects the screening objective of the weldability study in that only the most promising alloys are receiving the longest thermal stability exposure. In addition to the post age tensile results presented in this report, aged alloys are being evaluated for ductility impairment as reflected by bend transition behavior of base metal, electron beam welds, and

TABLE 1 - Alloys Included in the Weldability and Thermal Stability Evaluations

Alloy	Nominal Composition Weight Percent
AS-55	Cb-5W-1Zr-0.2Y-0.06C
B-66	Cb-5Mo-5V-1Zr
C-129Y	Cb-10W-10Hf+Y
Cb-752	Cb-10W-2.5Zr
D-43	Cb-10W-1Zr-0.1C
FS-85	Cb-27Ta-10W-1Zr
SCb-291	Cb-10W-10Ta
D-43+Y	Cb-10W-1Zr-0.1C+Y
T-111	Ta-8W-2Hf
T-222	Ta-9.6W-2.4Hf-0.01C
Ta-10W	Ta-10W
W-25Re	W-25Re
W	Unalloyed
Sylvania "A"*	W-0.5Hf-0.02C

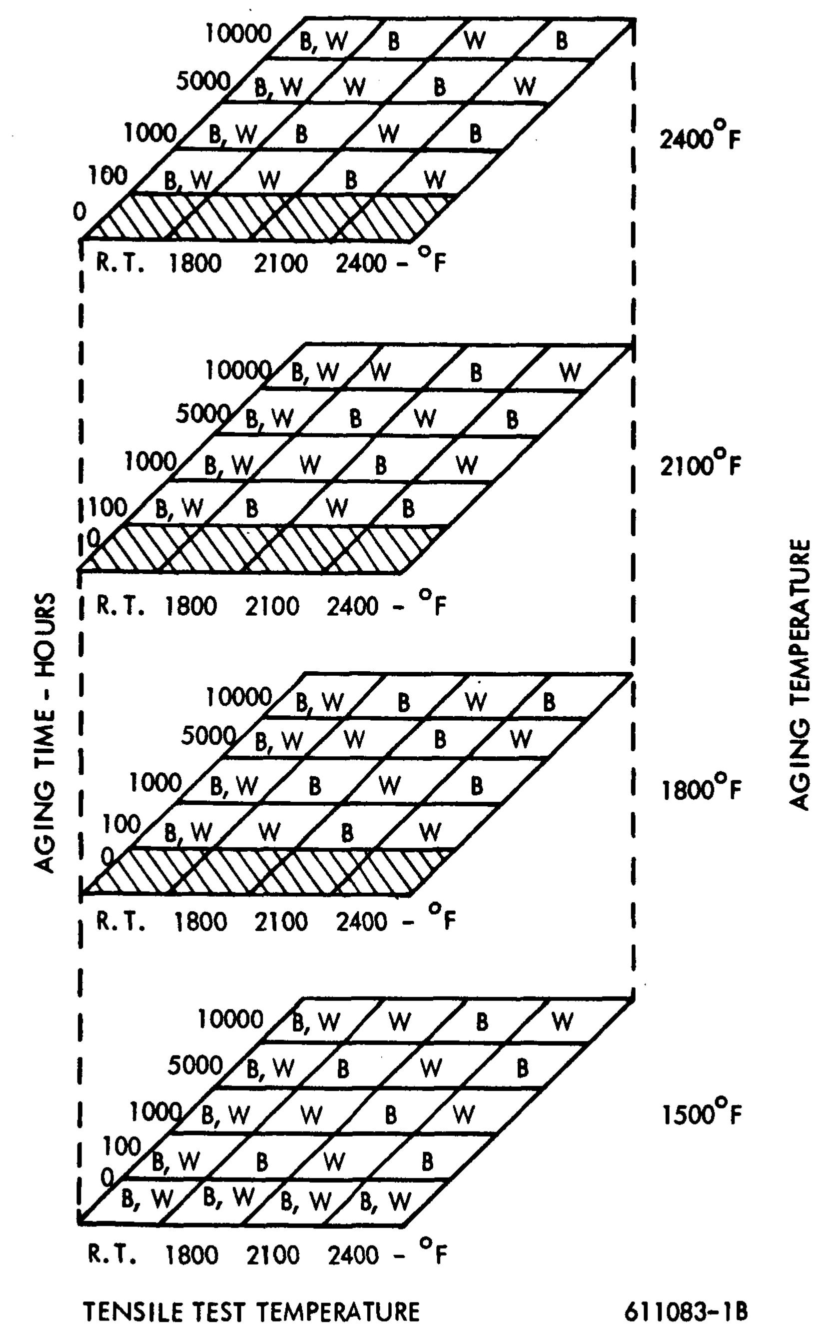
* NOTE: All alloys from arc-cast and/or electron beam melted material except Sylvania "A"

gas tungsten arc welds and also by microstructural examination. Results of these evaluations are the subject for other related reports of this program.

Process and test controls employed throughout this program emphasize the important influence of interstitial elements on the properties of refractory metal alloys. Stringent process and test procedures were employed including continuous monitoring of the TIG welding chamber atmosphere, electron beam welding in a 10^{-6} torr vacuum, aging in furnaces employing hydrocarbon free pumping systems providing pressures less than 10^{-8} torr, and chemical sampling following successive stages of the evaluation for verification of these process controls. The details of the process control development for this evaluation have been previously published. Reports covering this work are listed as general references in Section IV of this report.

II. SUMMARY

The columbium and tantalum alloys were aged for 100 and 1000 hours and tensile tested in accordance with the test schedule shown in Figure 1. Alternate base and weld metal specimens were tested throughout the wide range of aging time-temperature and test temperature combinations providing a thorough screening of the alloys. The alloys were aged in the post weld annealed condition and demonstrated generally excellent stability with only one alloy, D-43, displaying a consistent time-temperature dependent overaging and consequent loss of strength. The loss of strength in D-43 was not suprising based on the apparent optimized pre-aged strength of the particular material employed in this program[4]. FS-85, C-129Y, and SCb-291 displayed excellent stability with little change in tensile properties. T-111 and T-222 had very slight losses in tensile strength except that no change in 2400°F properties was noted. Other alloys displayed particular, but not general, responses. Although indicative of metallurgical structural interactions, most responses were not severe or damaging.



B = BASE METAL SPECIMEN
W = WELD METAL SPECIMEN
\\\ = DUPLICATE CONDITION, NOT RETESTED

FIGURE 1 - Typical Tensile Test Schedule for Aged Specimens

III. TECHNICAL PROGRAM

A. THE EFFECT OF 1000 HOUR HIGH TEMPERATURE AGING ON TENSILE PROPERTIES OF REFRACTORY METAL ALLOYS

Tensile behavior of aged columbium and tantalum based alloys (except AS-55) was evaluated as a portion of the thermal stability evaluation. The tungsten alloys, because of general brittleness and extremely difficult handling, were not included in this study. Further, only the most promising alloys including FS-85, T-111, and T-222 are included in a complete 5000 and 10,000 hour aging response study. Hence, the post 1000 hour age evaluation marks the completion of this investigation for the majority of alloys included in this program. The tensile results, however, represent just one phase of the post-age evaluation. Additional tests for ductility, metallography, and chemical surveillance for all alloys aged 1000 hours are in process and will be covered in subsequent reports.

Gas tungsten arc weld and base metal tensile specimens were tested in the transverse direction. The starting stock for all tensile specimens was recrystallized 0.035 inch sheet. Optimum welding parameters and post weld anneals were used in preparing weld specimens, Table 2. Base metal as well as weld specimens were annealed prior to aging. Selection of parameters was based on optimum as welded or post weld annealed (i.e., if overaged) ductility. For room temperature tensiles a strain rate of 0.005 in/in/min was used through the 0.6% offset yield point, then 0.05 in/in/min to specimen fracture. The 0.05 in/in/min strain rate is used throughout the test at elevated temperatures. Room temperature tensile specimens had two inch gage lengths. Elevated temperature tensile specimens had one inch gage lengths. The gage section of sheet tensile specimens was 0.250 inch wide with an as rolled finish for base metal samples, and ground parallel surfaces for weld specimens. Elevated temperature tests were run at pressures of 10^{-6} torr or less with specimen gage sections wrapped in tantalum foil for additional contamination protection.

Aging was accomplished in ultra high vacuum furnaces which are roughed out and held at vacuum with "oil-free" pumping systems. The vacuum systems employed were designed to

TABLE 2 - Optimized Weld Conditions for 0.035 Inch Sheet

Alloy (1)	Process	Parameters (2)	One Hour Post Weld Anneal Temp., °F (3)	Weld Width Top/Bottom (inches)	BDBTT, °F (4)	
					Long. Bends	Trans. Bends
Ta-10W	TIG	7.5-1/4-118	None	.190/.180	<-320	<-320
	EB	15-1/2-4.5	None	.049/.034	<-320	<-320
T-111	TIG	15-3/8-115	2400°F	.195/.189	<-320	<-320
	EB	15-1/2-3.8	2400°F	.038/.027	<-320	<-320
T-222	TIG	30-1/4-190	2400°F	.180/.159	<-320	<-320
	EB	15-1/2-3.8	2400°F	.039/.026	<-320	<-320
B-66	TIG	15-3/8-86	None	.190/.180	0	+75
	EB	25-3/16-3.2	1900°F	.036/.024	-225	-175
C-129Y	TIG	30-3/8-110	2400°F	.180/.130	-200	-225
	EB	50-1/2-4.1	2200°F	.040/.026	-250	-250
Cb-752	TIG	30-3/8-87	2200°F	.129/.090	-75	0
	EB	15-3/16-3.3	2400°F	.036/.017	-200	-200
D-43	TIG	30-3/8-114	2400°F	.159/.143	+100	0(5)
	EB	50-1/2-4.4	2400°F	.040/.027	-225	-225
D-43Y	TIG	15-3/8-83	2400°F	.165/.150	-175	-250
	EB	50-1/2-4.0	2400°F	.036/.022	-250	<-300
FS-85	TIG	15-3/8-90	2400°F	.204/.195	-175	-175
	EB	50-3/16-4.4	2200°F	.038/.026	-200	-200
SCb-291	TIG	15-1/4-83	2200°F	.160/.150	-275	-275
	EB	50-1/2-4.4	None	.038/.027	<-320	-250

1. As-received alloys were in the R_x condition prior to evaluation, i.e., structurally optimum for high temperature stability and strength.
2. For TIG Welds: Speed (ipm) - Clamp Spacing (in.) - Amperes
   For EB Welds: Speed (ipm) - Clamp Spacing (in.) - Milliamperes (All EB welds with 60~, 0.050 inch longitudinal deflection and 150 KV beam voltage)
3. The post weld anneal was selected for optimum ductility but is also assummed to achieve an overaged structure with respect to internal reactive metal-oxygen reactions thus enhancing compatibility with alkali metals.
4. BDBTT ≈ Bend Ductile Brittle Transition Temperature at 1t Bend Radius Except FS-85 Welds at 2t Bend Radius.
5. Probable Value (Determined Value <-125°F).

hold a vacuum of 10^{-8} torr or better using 500 l/sec. sputter-ion pumps. Actual pressures during aging runs are running at about 10^{-9} torr or lower.

A summary of tensile responses to aging is presented in Table 3. Alloys are grouped in this table based on similarities in behavior. Results are discussed below in the same grouping as presented in Table 3.

Group I - Alloys Demonstrating Little or No Response to Aging

FS-85: Figures 2, 3, 4
C-129Y: Figures 5, 6, 7
SCb-291: Figures 8, 9, 10

As implied, alloys in this group had excellent stability. FS-85 and C-129Y both maintain reasonably high strength, joint efficiency, and consistent elongation. SCb-291, a solid solution alloy, is stable as would be expected even though some reduction of ductility occurs at the highest test temperature, 2400°F, following aging.

Group II - Modest Loss of Strength Under Most Conditions

T-111: Figures 11, 12, 13
T-222: Figures 14, 15, 16

This group is composed of T-111 and T-222 which, because of compositional similarity, behaved much the same. Ultimate strength decreased modestly with aging but this effect diminishes with increasing test temperature so that at 2400°F aging produces no decrease in strength.

Yield strength shows a more pronounced inversion in both alloys. The room temperature yield strength is sharply reduced by aging whereas 2400°F yield strength shows an improvement after aging. Increased elongation is associated only with 2400°F base metal tests, and, hence, not with aging conditions producing lower yield strength.

Group III - Limited, Non-General Responses

Ta-10W: Figures 17, 18, 19

Responses of alloys in this group did not carry through from one test condition to other aging-test combinations. Hence Ta-10W welds, but not base metal, lost strength (ultimate and yield) at room temperature as a function of aging temperature. In elevated temperature tests, however, no aging effect occurred nor was there any effect at all on elongation.

B-66: Figures 20, 21, 22

B-66 demonstrated an unusual ultimate strength response to aging at 2400°F. Room temperature strength decreased from the 2400°F age while 1800°F strength was unchanged but 2100°F and 2400°F strength increased. This was a temperature, not time dependent effect. Room temperature yield strength decreased except for the 1500°F age, but high temperature yield strength increased for all aging conditions. Elongation trends become less consistent with increasing test temperature, particularly for base metal tests.

Cb-752: Figures 23, 24, 25

The room temperature ultimate strength of Cb-752 increased with aging whereas elevated temperature ultimate strength decreased modestly. Room temperature yield strength responded to aging in a complex way whereas 1800°F yield strength followed a classic pattern. Little change occurred in 2100°F and 2400°F tests. As with B-66, base metal elongation became increasingly more variable with increased test temperature.

D-43Y: Figures 26, 27, 28

Insufficient tests were run on D-43Y to identify definite trends. However, base metal tested at room temperature demonstrated a time-temperature dependent aging response.

Group IV - Classic Overaging and Consequent Loss of Strength for Increasing Time-Temperature Exposure

D-43: Figures 29, 30, 31

Only D-43 fit into this category. Ultimate and yield strength of both base and weld are decreased by exposures above 1500°F. Above this temperature strength tends to decrease with a time and temperature dependence such that 2400°F tensile strength after 1000 hours at 2400°F has been reduced by about 20%. This is undoubtedly due to a carbide precipitation reaction. The fact that a significant decrease in strength occurs probably reflects the optimum strength realized in this material through the particular processing employed in this program. Tensile strengths prior to aging were 4000 to 8000 psi higher throughout the elevated temperature range than those generally reported[4]. Consequently the consistent loss of strength, or overaging observed was not unexpected.

TECHNICAL NOTE:

Joint Efficiency represents the ratio comparison of weld and base metal ultimate strength. In this program joint efficiency was obtained using transverse weld tensile tests. Hence, the weld ultimate represents the lowest strength across the weld and "joint efficiency" is simply defined. Transverse tests however do not lend themselves to such a convenient interpretation in terms of yield or elongation measurements because deformation generally occurs locally. Hence, although weld specimens frequently had low elongations as measured across the gage section, they tended to display good local reduction in area indicative of excellent ductility. For this reason weld and base metal elongation had to be treated separately for most of the alloys in the graphical presentation of data and in several cases yield strength was also treated separately. The mode of deformation and fracture and the effect of welds on the deformation behavior frequently presents a more important consideration than either yield or elongation per se. This particular aspect of tensile behavior has been described previously for the alloys evaluated in this program[4,5].

IV. REFERENCES

1. R. W. Buckman and R. C. Goodspeed, "Development of Dispersion Strengthened Tantalum Alloys", Ninth Quarterly Progress Report, Contract NAS 3-2542, Westinghouse Astronuclear Laboratory, NASA-CR-72020, WANL-PR(Q)-010.

2. R. W. Buckman and R. C. Goodspeed, "Development of Dispersion Strengthened Tantalum Alloys", Tenth Quarterly Progress Report, Contract NAS 3-2542, Westinghouse Astronuclear Laboratory, NASA-CR-72093, WANL-PR(Q)-011.

3. R. W. Buckman and R. C. Goodspeed, "Development of Dispersion Strengthened Tantalum Alloys", Eleventh Quarterly Progress Report, Contract NAS 3-2542, Westinghouse Astronuclear Laboratory, NASA-Cr-72094, WANL-PR(Q)-012.

4. G. G. Lessmann and D. R. Stoner, "Determination of the Weldability and Elevated Temperature Stability of Refractory Metal Alloys", Ninth Quarterly Progress Report, Westinghouse Astronuclear Laboratory, WANL-PR(P)-009, NASA-CR-54088.

5. G. G. Lessmann, "The Comparative Weldability of Refractory Metal Alloys", The Welding Journal Research Supplement, Vol. 45 (12), December, 1966.

V. GENERAL REFERENCES

The following references describe in detail the general execution and accomplishments of Contract NAS 3-2540 which preceeded the evaluations described in this report.

Publications

D. R. Stoner and G. G. Lessmann, Measurement and Control of Weld Chamber Atmospheres, The Welding Journal Research Supplement, Vol. 30 (8), August, 1965.

G. G. Lessmann and D. R. Stoner, Welding Refractory Metal Alloys for Space Power System Applications, Presented at the 9th National SAMPE Symposium on Joining of Materials for Aerospace Systems.

D. R. Stoner and G. G. Lessmann, Operation of 10^{-10} Torr Vacuum Heat Treating Furnaces in Routine Processing, Transactions of the 1965 Vacuum Metallurgy Conference of the American Vacuum Society, L. M. Bianchi, Editor.

Progress Reports under Contract NAS 3-2540, "Determination of the Weldability and Elevated Temperature Stability of Refractory Metal Alloys" by G. G. Lessmann and D. R. Stoner:

First Quarterly Progress Report	WANL-PR(P)-001
Second Quarterly Progress Report	WANL-PR(P)-002
Third Quarterly Progress Report	WANL-PR(P)-003 NASA-CR-54088
Fourth Quarterly Progress Report	WANL-PR(P)-004 NASA-CR-54166
Fifth Quarterly Progress Report	WANL-PR(P)-005 NASA-CR-54232
Sixth Quarterly Progress Report	WANL-PR(P)-006 NASA-CR-54301
Seventh Quarterly Progress Report	WANL-PR(P)-007 NASA-CR-54434
Eighth Quarterly Progress Report	WANL-PR(P)-008 NASA-CR-54723
Ninth Quarterly Progress Report	WANL-PR(P)-009 NASA-CR-54923
Tenth Quarterly Progress Report	WANL-PR(P)-010 NASA-CR-54975

TABLE 3 - Summary of Tensile Property Responses to Aging (To 1000 Hours)
NOTE: Alloys are Grouped on the Basis of the Effect of Aging on Ultimate Strength. Arrangement is in Approximate Order of Decreasing Tensile Thermal Stability

I. Little or no Response to Aging

FS-85: Good stability without definite response in tensile, yield, or elongation in either weld or base at ambient or elevated temperature.

C-129Y: Like FS-85

SCb-291: Modest decrease in high temperature (2400°F) elongation only after 1000 hour exposure. Otherwise good all around stability.

II. Modest Loss of Strength Under Most Conditions

T-111: T-222: Slight loss of tensile strength with increasing time temperature except no change in 2400°F properties.
Time-temperature loss in room temperature yield strength but stabile elevated temperature yield strength.
Increasing base metal elongation associated with conditions producing decreased strength.

III. Limited, Non-General Responses

Ta-10W: Room temperature weld tensile and yield strengths (but not base metal strength) suffer modest temperature dependent losses. No other instabilities.

B-66: 2400°F age lowers room temperature strength and increases 2100°F and 2400°F strength without changing 1800°F strength Elevated temperature yield increased modestly with room temperature yield strength decreased by higher aging temperatures. Elongation tends to follow strength decreasing with increased strength.

TABLE 3 (Continued) - Summary of Tensile Property Responses to Aging (To 1000 Hours)

Cb-752: Room temperature strength increased for all aging with a modest loss in elevated temperature strength. Yield strength response in room temperature tests imply a complex aging response whereas 1800°F yield strength responded in a classic manner. Base metal elongation did not follow strength changes but instead became more variable with increased test temperature while weld elongation remained largely unchanged.

D-43Y: More limited testing in this system demonstrated a time-temperature dependence of room temperature base metal strength and a modest loss of 2100°F strength with aging time.

IV. Classic Overaging and Consequent Loss of Strength for Increasing Time Temperature Exposures

D-43: Similar response for both ultimate and yield strengths. Elongation only slightly increased with decreasing strength. Weld and base metal similar in strength and aging response.

TABLE 4 – Tensile Properties of Unaged Sheet

Alloy	Test Temp. (°F)	Specimen Type	Pre-Test 1 Hr. Anneal Temp. (°F)	Ultimate Strength psi x 10^{-3}	0.2% Offset Yield Strength psi x 10^{-3}	Elongation (%)	Weld Joint* Efficiency (%)	Fracture Location
Ta-10W	R. T.	Base	None	84.4	71.5	29	--	--
	R. T.	Weld	None	81.4	69.9	9	97	Weld
	1800	Base	None	42.3	24.5	33	--	--
	1800	Weld	None	38.2	23.9	8	90	Weld
	2100	Base	None	33.7	17.6	42	--	--
	2100	Weld	None	29.5	19.7	5	88	Weld
	2400	Base	None	25.3	20.9	67	--	--
	2400	Weld	None	22.8	14.6	4	90	Weld
T-111	R. T.	Base	2400	89.2	83.2	16	--	--
	R. T.	Weld	2400	92.0	82.5	14	102	Weld
	1800	Base	2400	61.3	34.6	14	--	--
	1800	Weld	2400	58.2	32.3	10	95	Weld
	2100	Base	2400	52.2	29.2	20	--	--
	2100	Weld	2400	49.0	30.2	14	94	Weld
	2400	Base	2400	38.9	23.4	32	--	--
	2400	Weld	2400	37.7	23.9	10	97	Weld
T-222	R. T.	Base	2400	88.0	80.1	18	--	--
	R. T.	Weld	2400	90.1	83.2	14	101	Base
	1800	Base	2400	62.8	33.9	10	--	--
	1800	Weld	2400	60.3	36.0	6	96	Weld
	2100	Base	2400	57.3	31.8	14	--	--
	2100	Weld	2400	52.7	32.9	7	88	Weld
	2400	Base	2400	39.9	27.9	20	--	--
	2400	Weld	2400	40.9	28.7	12	102	Weld

*NOTE: Weld specimen surfaces ground flat and parallel to avoid surface contour effects providing a truer metallurgical joint efficiency.

TABLE 4 - Tensile Properties of Unaged Sheet
(Continued)

Alloy	Test Temp. (°F)	Specimen Type	Pre-Test 1 Hr. Anneal Temp. (°F)	Ultimate Strength psi x 10^{-3}	0.2% Offset Yield Strength psi x 10^{-3}	Elongation (%)	Weld Joint* Efficiency (%)	Fracture Location
B-66	R. T.	Base	None	104.73	79.88	22.5	--	--
	R. T.	Weld	None	100.92	81.04	9	97	Weld
	1800	Base	None	66.9	39.0	48	--	--
	1800	Weld	None	61.5	43.5	6	92	Weld
	2100	Base	None	39.7	29.1	69	--	--
	2100	Weld	None	42.3	33.2	13	103	Weld
	2400	Base	None	23.1	21.1	106	--	--
	2400	Weld	None	22.8	20.0	67	99	Base
C-129Y	R. T.	Base	2400	85.97	72.06	26.5	--	--
	R. T.	Weld	2400	74.93	66.54	5.5	87	Weld
	1800	Base	2400	51.7	31.8	27	--	--
	1800	Weld	2400	45.9	30.2	7	89	Weld
	2100	Base	2400	37.6	25.7	26	--	--
	2100	Weld	2400	36.6	28.8	6	98	Weld
	2400	Base	2400	24.7	20.1	84	--	--
	2400	Weld	2400	24.6	20.0	8	100	Weld
Cb-752	R. T.	Base	2200	73.10	55.50	27	--	--
	R. T.	Weld	2200	64.80	48.80	12.5	89	Weld
	1800	Base	2200	47.1	27.1	24	--	--
	1800	Weld	2200	50.6	28.2	13	104	Weld
	2100	Base	2200	34.6	22.6	40	--	--
	2100	Weld	2200	36.6	24.6	36	103	Base
	2400	Base	2200	22.7	15.6	72	--	--
	2400	Weld	2200	23.7	19.7	66	102	Base

*NOTE: Weld specimen surfaces ground flat and parallel to avoid surface contour effects providing a truer metallurgical joint efficiency.

TABLE 4 - Tensile Properties of Unaged Sheet
(Continued)

Alloy	Test Temp. (°F)	Specimen Type	Pre-Test 1 Hr. Anneal Temp. (°F)	Ultimate Strength psi x 10^{-3}	0.2% Offset Yield Strength psi x 10^{-3}	Elongation (%)	Weld Joint* Efficiency (%)	Fracture Location
D-43	R. T.	Base	2400	90.21	62.15	19.5	--	--
	R. T.	Weld	2400	90.26	63.75	18.0	100	Base
	1800	Base	2400	54.9	39.0	14	--	--
	1800	Weld	2400	55.6	42.1	8	101	Weld
	2100	Base	2400	43.3	33.7	16	--	
	2100	Weld	2400	43.6	38.6	9	100	Weld
	2400	Base	2400	32.7	24.7	21	--	
	2400	Weld	2400	32.6	27.7	6	100	Weld
D-43Y	R. T.	Base	2400	62.75	39.57	24.0	--	
	R. T.	Weld	2400	70.03	42.35	22.5	112	Base
	1800	Base	2400	37.3	31.3	27	--	
	1800	Weld	2400	37.5	21.2	20	100	Base
	2100	Base	2400	27.8	15.3		--	
	2100	Weld	2400	26.6	18.7	19	95	Base
	2400	Base	2400	16.9	13.8	38	--	
	2400	Weld	2400	17.7	15.4	18	102	Base
FS-85	R. T.	Base	2400	83.10	67.60	22.5	--	
	R. T.	Weld	2400	78.60	61.90	10	95	Weld
	1800	Base	2400	44.6	21.7	20	--	--
	1800	Weld	2400	40.4	22.1	8	90	Weld
	2100	Base	2400	34.5	21.9	30	--	--
	2100	Weld	2400	33.1	20.6	8	96	Weld
	2400	Base	2400	22.7	15.0	51	--	--
	2400	Weld	2400	23.4	15.4	12	102	Weld

*NOTE: Weld specimen surfaces ground flat and parallel to avoid surface contour effects providing a truer metallurgical joint efficiency.

TABLE 4 - Tensile Properties of Unaged Sheet
(Continued)

Alloy	Test Temp. (°F)	Specimen Type	Pre-Test 1 Hr. Anneal Temp. (°F)	Ultimate Strength psi x 10^{-3}	0.2% Offset Yield Strength psi x 10^{-3}	Elongation (%)	Weld Joint* Efficiency (%)	Fracture Location
SCb-291	R. T.	Base	2200	59.57	47.53	23.5	--	--
	R. T.	Weld	2200	57.20	45.90	9	96	Weld
	1800	Base	2200	20.9	12.3	46	--	--
	1800	Weld	2200	20.4	12.1	15	98	Weld
	2100	Base	2200	14.8	8.0	46	--	--
	2100	Weld	2200	16.0	10.8	43	108	Base
	2400	Base	2200	12.7	7.7	68	--	--
	2400	Weld	2200	12.6	7.5	50	99	Base

* NOTE: Weld specimen surfaces ground flat and parallel to avoid surface contour effects providing a truer metallurgical joint efficiency.

TABLE 5 - Summary of Sheet Tensile Properties for Transverse Base Metal and Gas Tungsten Arc Weld Specimens Aged 100 Hours in Ultra-High Vacuum Between 1500°F and 2400°F (1)

			Tensile Properties: Strength x 10^{-3} psi, Elongation in Percent															
			1500°F Age				1800°F Age				2100°F Age				2400°F Age			
Alloy	Specimen Type	Test Temp. (°F)	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location
B-66	Base	75	104.47	81.85	23.4	--	102.59	72.89	22.0	--	100.6	71.7	22.5	--	97.4	71.85	23.5	--
	Weld	75	100.95	81.2	9.0	HAZ	96.31	79.4	10.0	HAZ	94.6	72.57	11.0	Weld	96.02	72.89	13.5	Weld
	Base	1800	67.5	43.6	31.0	--	--	--	--	--	67.5	43.4	42.0	--	--	--	--	--
	Weld	1800	--	--	--	--	63.3	44.0	6.0	Weld	--	--	--	--	64.8	43.0	8.0	Weld
	Base	2100	--	--	--	--	41.2	35.0	65.0	--	--	--	--	--	48.0	37.6	16.0	--
	Weld	2100	40.5	34.4	10.0	Weld	--	--	--	--	41.2	34.3	13.0	Weld	--	--	--	--
	Base	2400	27.1	26.2	70.0	--	--	--	--	--	26.2	25.3	97.0	--	--	--	--	--
	Weld	2400	--	--	--	--	25.8	24.8	53.0	Base	--	--	--	--	28.7	27.2	14.0	Weld
D-43	Base	75	88.89	60.68	19.5	--	88.97	57.73	20.5	--	86.19	55.09	18.5	--	82.57	57.53	23.5	--
	Weld	75	87.46	60.79	19.0	Base	86.52	64.01	17.5	Base	86.35	55.87	18.5	Base	79.58	55.14	11.5	Weld
	Base	1800	55.6	42.8	14.0	--	--	--	--	--	53.5	41.1	15.0	--	--	--	--	--
	Weld	1800	--	--	--	--	51.5	43.0	12.0	Base	--	--	--	--	48.9	34.1	9.0	Weld
	Base	2100	--	--	--	--	44.8	38.6	16.0	--	--	--	--	--	39.4	33.8	18.0	--
	Weld	2100	44.2	39.6	17.0	Base	--	--	--	--	41.1	35.8	17.0	Base	--	--	--	--
	Base	2400	32.8	28.7	23.0	--	--	--	--	--	31.0	24.9	26.0	--	--	--	--	--
	Weld	2400	--	--	--	--	33.4	29.5	8.0	HAZ	--	--	--	--	28.0	25.0	12.0	Weld
FS-85	Base	75	83.47	61.93	25.5	--	76.94	58.56	9.0	--	81.1	52.09	24.0	--	81.79	61.21	26.0	--
	Weld	75	77.91	62.33	7.0	HAZ	81.76	59.56	25.0	Weld	77.61	51.5	11.0	HAZ	76.81	60.4	9.0	Weld
	Base	1800	44.6	25.0	21.0	--	--	--	--	--	41.8	23.9	27.0	--	--	--	--	--
	Weld	1800	--	--	--	--	39.1	25.8	7.0	HAZ	--	--	--	--	40.0	24.2	7.0	Weld
	Base	2100	--	--	--	--	32.6	21.7	38.0	--	--	--	--	--	33.7	23.0	30.0	--
	Weld	2100	32.6	23.4	8.0	Weld	--	--	--	--	31.5	22.7	9.0	Weld	--	--	--	--
	Base	2400	22.9	17.3	77.0	--	--	--	--	--	23.6	18.3	51.0	--	--	--	--	--
	Weld	2400	--	--	--	--	23.4	18.0	9.0	Weld	--	--	--	--	26.5	20.5	10.0	Weld

NOTES: All data based on welds prepared using optimum welding conditions and post weld anneals. Base metal annealed with same anneal as TIG welds.

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TABLE 5 (Continued) - Summary of Sheet Tensile Properties for Transverse Base Metal and Gas Tungsten Arc Weld Specimens Aged 100 Hours in Ultra-High Vacuum Between 1500°F and 2400°F (1)

Alloy	Specimen Type	Test Temp. (°F)	Tensile Properties: Strength x 10^{-3} psi, Elongation in Percent															
			1500°F Age				1800°F Age				2100°F Age				2400°F Age			
			σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location
Cb-752	Base	75	81.45	59.95	25.5	--	106.38	77.57	27.5	--	80.05	49.68	24.0	--	79.76	57.76	26.5	--
	Weld	75	82.75	60.98	16.0	Weld	61.14	44.46	13.5	Weld	79.13	52.25	13.0	Weld	79.89	59.73	12.0	Weld
	Base	1800	49.1	30.6	31.0	--	--	--	--	--	47.7	28.1	36.0	--	--	--	--	--
	Weld	1800	--	--	--	--	47.5	29.0	24.0	Base	--	--	--	--	49.5	27.8	15.0	Weld
	Base	2100	--	--	--	--	32.8	24.4	67.0	--	--	--	--	--	35.9	24.6	39.0	--
	Weld	2100	35.7	25.7	41.0	Base	--	--	--	--	34.6	24.1	44.0	Base	--	--	--	--
	Base	2400	23.0	20.0	125.0	--	--	--	--	--	23.1	20.7	75.0	--	--	--	--	--
	Weld	2400	--	--	--	--	24.4	20.6	73.0	Base	--	--	--	--	24.9	20.0	55.0	Base
SCb-291	Base	75	58.4	43.66	29.5	--	58.21	42.07	29.0	--	59.73	46.21	25.5	--	58.18	44.06	28.0	--
	Weld	75	56.43	45.42	9.0	Weld	56.36	44.42	10.5	Weld	57.02	46.59	9.5	Weld	52.83	41.41	9.0	Weld
	Base	1800	20.2	13.3	49.0	--	--	--	--	--	20.6	13.2	47.0	--	--	--	--	--
	Weld	1800	--	--	--	--	20.5	14.7	12.0	Weld	--	--	--	--	19.9	12.0	13.0	Weld
	Base	2100	--	--	--	--	16.1	10.2	55.0	--	--	--	--	--	15.4	10.2	56.0	--
	Weld	2100	16.8	12.6	42.0	Base	--	--	--	--	16.0	10.3	44.0	Weld	--	--	--	--
	Base	2400	12.3	8.2	71.0	--	--	--	--	--	13.0	6.5	41.0	--	--	--	--	--
	Weld	2400	--	--	--	--	13.1	9.3	59.0	Base	--	--	--	--	12.6	7.5	50.0	Base
C-129Y	Base	75	87.12	70.04	28.0	--	86.13	67.84	24.0	--	86.91	69.41	27.0	--	86.63	68.75	26.5	--
	Weld	75	76.05	66.13	6.0	Weld	76.77	65.98	7.5	Weld	75.29	65.42	6.0	Weld	76.32	66.78	6.5	Weld
	Base	1800	52.1	31.8	25.0	--	--	--	--	--	49.3	30.7	23.0	--	--	--	--	--
	Weld	1800	--	--	--	--	44.1	30.3	8.0	Weld	--	--	--	--	45.7	30.2	8.0	Weld
	Base	2100	--	--	--	--	37.4	26.2	33.0	--	--	--	--	--	39.4	27.8	19.0	--
	Weld	2100	36.3	27.2	7.0	Weld	--	--	--	--	34.2	24.9	10.0	Weld	--	--	--	--
	Base	2400	24.9	22.6	76.0	--	--	--	--	--	23.6	21.2	92.0	--	--	--	--	--
	Weld	2400	--	--	--	--	24.8	22.0	18.0	Weld	--	--	--	--	25.8	21.8	19.0	Weld

NOTE: All data based on welds prepared using optimum welding conditions and post weld anneals. Base metal annealed with same anneal as TIG welds.

TABLE 5 (Continued) - Summary of Sheet Tensile Properties for Transverse Base Metal and Gas Tungsten Arc Weld Specimens Aged 100 Hours in Ultra-High Vacuum Between 1500°F and 2400°F (1)

			Tensile Properties: Strength x 10^{-3} psi, Elongation in Percent															
			1500°F Age				1800°F Age				2100°F Age				2400°F Age			
Alloy	Specimen Type	Temp. (°F)	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location
D-43Y	Base	75	72.09	42.05	23.0	--	70.86	42.07	26.0	--	69.0	46.55	25.5	--	67.89	42.15	25.0	--
	Weld	75	69.45	44.32	21.0	Base	66.49	42.74	21.5	Base	67.0	45.74	25.5	Base	66.56	42.84	24.5	Base
	Base	1800	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Weld	1800	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Base	2100	25.6	18.6	30.0	--	24.7	17.7	26.0	--	22.6	13.2	14.0	--	25.3	17.6	26.0	--
	Weld	2100	26.4	20.2	16.0	Base	25.7	19.3	19.0	Base	22.9	16.7	19.0	Base	26.4	19.1	18.0	Base
	Base	2400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Weld	2400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
T-111	Base	75	87.08	80.82	20.0	--	86.26	75.48	19.0	--	85.3	74.18	19.0	--	84.18	77.38	19.0	--
	Weld	75	88.52	79.42	12.5	HAZ	88.89	77.21	14.0	HAZ	86.25	76.89	13.0	HAZ	85.6	74.55	18.0	HAZ
	Base	1800	60.2	38.6	15.0	--	--	--	--	--	54.0	30.6	15.0	--	--	--	--	--
	Weld	1800	--	--	--	--	56.5	34.7	12.0	Weld	--	--	--	--	52.7	32.7	9.0	HAZ
	Base	2100	--	--	--	--	51.5	31.4	23.0	--	--	--	--	--	50.9	29.0	23.0	--
	Weld	2100	51.3	31.9	16.0	HAZ	--	--	--	--	45.7	31.3	10.0	Weld	--	--	--	--
	Base	2400	38.7	27.2	45.0	--	--	--	--	--	38.7	25.9	37.0	--	--	--	--	--
	Weld	2400	--	--	--	--	38.7	28.0	11.0	Weld	--	--	--	--	36.2	26.4	7.0	Weld
Ta-10W	Base	75	81.2	71.85	24.5	--	82.5	74.31	25.0	--	94.14	77.9	29.5	--	80.21	70.87	25.5	--
	Weld	75	79.21	68.97	10.0	Weld	67.39	77.2	9.0	Weld	74.88	62.08	10.5	Weld	74.35	64.0	8.5	Weld
	Base	1800	41.9	26.0	36.0	--	--	--	--	--	41.7	24.7	34.0	--	--	--	--	--
	Weld	1800	--	--	--	--	37.9	24.1	8.0	Weld	--	--	--	--	35.6	23.8	7.0	Weld
	Base	2100	--	--	--	--	32.9	21.4	56.0	--	--	--	--	--	32.4	20.2	47.0	--
	Weld	2100	28.2	23.0	5.0	Weld	--	--	--	--	29.7	19.3	9.0	Weld	--	--	--	--
	Base	2400	26.1	17.9	68.0	--	--	--	--	--	26.4	15.8	60.0	--	--	--	--	--
	Weld	2400	--	--	--	--	23.8	18.3	7.0	Weld	--	--	--	--	23.0	17.8	5.0	Weld
T-222	Base	75	83.12	78.17	15.5	--	81.82	71.46	17.5	--	82.82	74.1	16.5	--	81.82	73.7	17.5	--
	Weld	75	82.4	72.7	14.5	Base	81.94	73.07	12.5	Base	82.77	82.77	13.5	Base	81.06	76.45	15.0	Base
	Base	1800	60.0	34.9	13.0	--	--	--	--	--	54.5	32.3	13.0	--	--	--	--	--
	Weld	1800	--	--	--	--	56.8	34.2	11.0	Base	--	--	--	--	55.2	33.8	7.0	Weld
	Base	2100	--	--	--	--	50.8	31.6	17.0	--	--	--	--	--	49.4	30.0	16.0	--
	Weld	2100	54.2	35.3	14.0	HAZ	--	--	--	--	49.7	34.2	10.0	Base	--	--	--	--
	Base	2400	40.2	30.0	26.0	--	--	--	--	--	40.7	31.4	23.0	--	--	--	--	--
	Weld	2400	--	--	--	--	41.4	32.2	8.0	Weld	--	--	--	--	39.2	30.3	14.0	Weld

NOTE: All data based on welds prepared using optimum welding conditions and post weld anneals. Base metal annealed with same anneal as TIG welds.

TABLE 6 - Summary of Sheet Tensile Properties for Transverse Base Metal and Gas Tungsten Arc Weld Specimens Aged 1000 Hours in Ultra-High Vacuum Between 1500°F and 2400°F (1)

Alloy	Specimen Type	Temp. (°F)	Tensile Properties: Strength x 10^{-3} psi, Elongation in percent															
			1500°F Age				1800°F Age				2100°F Age				2400°F Age			
			σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location
B-66	Base	75	101.5	82.4	21.5	--	102.5	77.9	21.5	--	103.0	74.8	22.5	--	97.6	74.1	20.5	--
	Weld	75	102.4	82.6	12.0	HAZ	101.6	78.4	13.0	Weld	97.0	73.4	12.5	Weld	97.1	73.8	16.0	Weld
	Base	1800	--	--	--	--	65.0	39.9	41.0	--	--	--	--	--	62.7	40.9	--	--
	Weld	1800	65.3	47.4	6.0	Weld	--	--	--	--	65.2	43.2	9.0	Weld	--	--	20.0	--
	Base	2100	40.0	35.4	58.0	--	--	--	--	--	44.3	35.0	56.0	--	--	--	--	--
	Weld	2100	--	--	--	--	40.3	33.8	49.0	Base	--	--	--	--	--	--	--	--
	Base	2400	--	--	--	--	24.4	23.4	109.0	--	--	--	--	--	45.8	37.8	6.0	Weld
	Weld	2400	26.0	24.2	44.0	HAZ	--	--	--	--	27.9	25.3	19.0	Weld	28.8	27.3	31.0	--
D-43	Base	75	91.0	62.5	19.5	--	88.9	53.5	17.0	--	85.4	57.7	21.0	--	76.6	52.2	22.0	--
	Weld	75	89.8	61.8	18.0	Base	87.1	56.2	18.0	Base	83.1	54.2	19.0	Base	74.3	48.0	14.0	Weld
	Base	1800	--	--	--	--	49.7	41.1	15.0	--	--	--	--	--	44.8	31.9	16.0	--
	Weld	1800	56.3	44.3	13.0	Weld	--	--	--	--	47.5	37.3	14.0	Base	--	--	--	--
	Base	2100	44.1	39.3	16.0	--	--	--	--	--	38.9	33.5	29.0	--	--	--	--	--
	Weld	2100	--	--	--	--	42.0	37.2	18.0	Base	--	--	--	--	32.4	25.4	14.0	Weld
	Base	2400	--	--	--	--	32.9	28.6	21.0	--	--	--	--	--	25.5	20.6	28.0	--
	Weld	2400	32.3	28.5	7.0	Weld	--	--	--	--	29.2	24.7	13.0	HAZ	--	--	--	--
FS-85	Base	75	76.6	56.3	24.5	--	81.5	60.3	26.0	--	81.9	59.1	26.0	--	80.9	61.3	25.0	--
	Weld	75	79.9	62.3	10.0	Weld	55.1	BF*	0.05	Base	76.5	62.3	8.0	Weld	77.6	60.1	11.5	HAZ
	Base	1800	--	--	--	--	41.8	24.8	24.0	--	--	--	--	--	43.3	23.6	18.0	--
	Weld	1800	41.4	25.4	8.0	HAZ	--	--	--	--	39.4	25.4	9.0	HAZ	--	--	--	--
	Base	2100	33.0	21.2	35.0	--	--	--	--	--	30.1	20.6	52.0	--	--	--	--	--
	Weld	2100	--	--	--	--	31.2	22.0	8.0	Weld	--	--	--	--	32.4	21.1	9.0	HAZ
	Base	2400	--	--	--	--	22.8	17.3	55.0	--	--	--	--	--	24.1	17.8	47.0	--
	Weld	2400	23.2	17.1	10.0	Weld	--	--	--	--	24.0	17.9	12.0	Weld	--	--	--	--
Cb-752	Base	75	81.9	59.6	23.5	--	80.1	58.4	25.5	--	80.8	59.5	30.0	--	79.8	57.1	24.0	--
	Weld	75	84.3	57.1	18.0	Weld	80.6	60.3	14.0	Weld	82.4	61.0	16.0	Weld	78.8	50.6	13.0	Weld
	Base	1800	--	--	--	--	45.5	27.9	31.0	--	--	--	--	--	47.0	25.3	18.0	--
	Weld	1800	47.0	29.0	23.0	Base	--	--	--	--	46.7	26.7	23.0	Weld	--	--	--	--
	Base	2100	34.2	24.4	58.0	--	--	--	--	--	34.2	24.0	61.0	--	--	--	--	--
	Weld	2100	--	--	--	--	33.2	22.8	47.0	Base	--	--	--	--	34.9	23.8	23.0	HAZ
	Base	2400	--	--	--	--	22.3	19.1	122.0	--	--	--	--	--	25.5	19.7	54.0	--
	Weld	2400	23.9	19.4	62.0	Base	--	--	--	--	23.3	20.1	73.0	Base	--	--	--	--

NOTE: All data based on welds prepared using optimum welding conditions and post weld anneals. Base metal annealed with same anneal as TIG welds.

* Brittle Fracture

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TABLE 6 (Continued) - Summary of Sheet Tensile Properties for Transverse Base Metal and Gas Tungsten Arc Weld Specimens Aged 1000 Hours in Ultra-High Vacuum Between 1500°F and 2400°F (1)

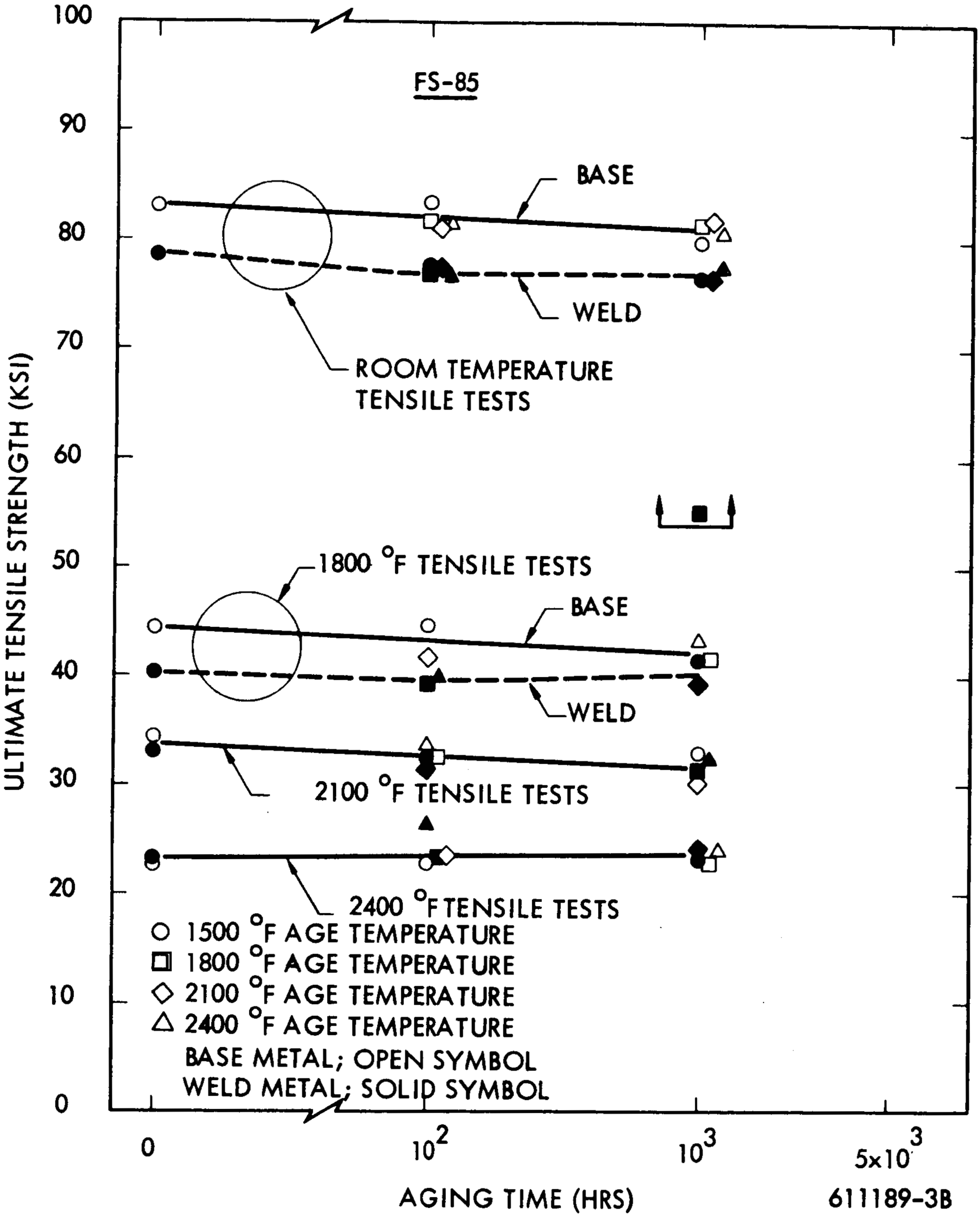
Alloy	Specimen Type	Test Temp. (°F)	Tensile Properties: Strength x 10^{-3} psi, Elongation in percent															
			1500°F Age				1800°F Age				2100°F Age				2400°F Age			
			σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location	σ_u	σ_y	Elong.	Failure Location
SCb-291	Base	75	60.6	45.0	30.0	--	60.2	46.8	24.5	--	59.8	44.9	29.0	--	60.5	47.7	23.0	--
	Weld	75	56.7	45.4	10.5	Weld	54.1	42.4	8.0	Weld	55.2	43.6	8.5	Weld	52.2	38.8	9.5	Weld
	Base	1800	--	--	--	--	20.2	11.8	50.0	--	--	--	--	--	17.9	10.7	29.0	--
	Weld	1800	20.9	14.3	12.0	Weld	--	--	--	--	20.4	11.7	14.0	Weld	--	--	--	--
	Base	2100	16.0	10.2	44.0	--	--	--	--	--	15.7	10.0	57.0	--	--	--	--	--
	Weld	2100	--	--	--	--	15.9	9.8	23.0	Weld	--	--	--	--	14.7	9.3	30.0	Weld
	Base	2400	--	--	--	--	13.5	8.9	32.0	--	--	--	--	--	12.4	8.0	45.0	--
	Weld	2400	12.3	8.7	35.0	Weld	--	--	--	--	13.2	8.5	43.0	Base	--	--	--	--
C-129Y	Base	75	86.4	69.9	26.5	--	86.9	68.6	28.5	--	86.8	68.1	27.0	--	86.2	66.7	27.0	--
	Weld	75	76.5	67.0	7.0	Weld	77.4	67.4	6.5	Weld	75.5	65.6	6.0	Weld	75.2	64.6	7.0	HAZ
	Base	1800	--	--	--	--	49.4	29.8	25.0	--	--	--	--	--	50.9	28.3	23.0	--
	Weld	1800	45.7	29.9	8.0	Weld	--	--	--	--	43.8	29.3	9.0	Weld	--	--	--	--
	Base	2100	35.8	26.0	35.0	--	--	--	--	--	35.9	25.3	39.0	--	38.8	26.2	19.0	--
	Weld	2100	--	--	--	--	35.3	24.8	10.0	Weld	--	--	--	--	--	--	--	--
	Base	2400	--	--	--	--	24.3	22.2	71.0	--	--	--	--	--	--	--	--	--
	Weld	2400	24.2	20.8	23.0	Weld	--	--	--	--	23.9	21.2	53.0	Base	25.5	21.8	19.0	Weld
D-43Y	Base	75	69.2	42.0	30.5	--	68.4	41.4	25.0	--	67.2	48.2	29.5	--	66.5	41.7	28.0	--
	Weld	75	68.6	42.0	23.0	Base	68.5	41.0	23.0	Base	68.8	47.2	22.5	Base	68.4	43.6	17.0	Base
	Base	1800	--	--	--	--	--	--	--	--	--	--	--	--	34.8	16.8	33.0	--
	Weld	1800	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Base	2100	24.5	17.7	28.0	--	22.3	14.1	36.0	--	22.2	15.8	33.0	--	--	--	--	--
	Weld	2100	25.4	19.2	25.0	Base	23.4	18.9	25.0	Base	22.8	16.5	25.0	Base	26.1	17.7	27.0	Base
	Base	2400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Weld	2400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
T-111	Base	75	87.4	77.3	19.5	--	86.7	73.7	17.0	--	84.2	72.7	19.0	--	83.4	75.3	18.0	--
	Weld	75	87.0	76.9	11.5	HAZ	86.0	75.2	10.5	Weld	82.8	71.6	10.0	Weld	84.3	74.2	14.0	HAZ
	Base	1800	--	--	--	--	54.9	33.4	15.0	--	--	--	--	--	54.8	31.0	15.0	--
	Weld	1800	55.3	38.5	9.0	Weld	--	--	--	--	49.8	31.9	8.0	HAZ	--	--	--	--
	Base	2100	49.9	30.4	27.0	--	--	--	--	--	47.9	28.6	27.0	--	--	--	--	--
	Weld	2100	--	--	--	--	47.8	30.3	12.0	HAZ	--	--	--	--	45.1	27.7	12.0	HAZ
	Base	2400	--	--	--	--	39.1	26.8	42.0	--	--	--	--	--	37.9	25.6	38.0	--
	Weld	2400	37.6	28.2	9.0	Weld	--	--	--	--	36.3	27.1	7.0	Weld	--	--	--	--

NOTE: All data based on welds prepared using optimum welding conditions and post weld anneals. Base metal annealed with same anneal as TIG welds.

TABLE 6 (Continued) - Summary of Sheet Tensile Properties for Transverse Base Metal and Gas Tungsten Arc Weld Specimens Aged 1000 Hours in Ultra-High Vacuum Between 1500°F and 2400°F (1)

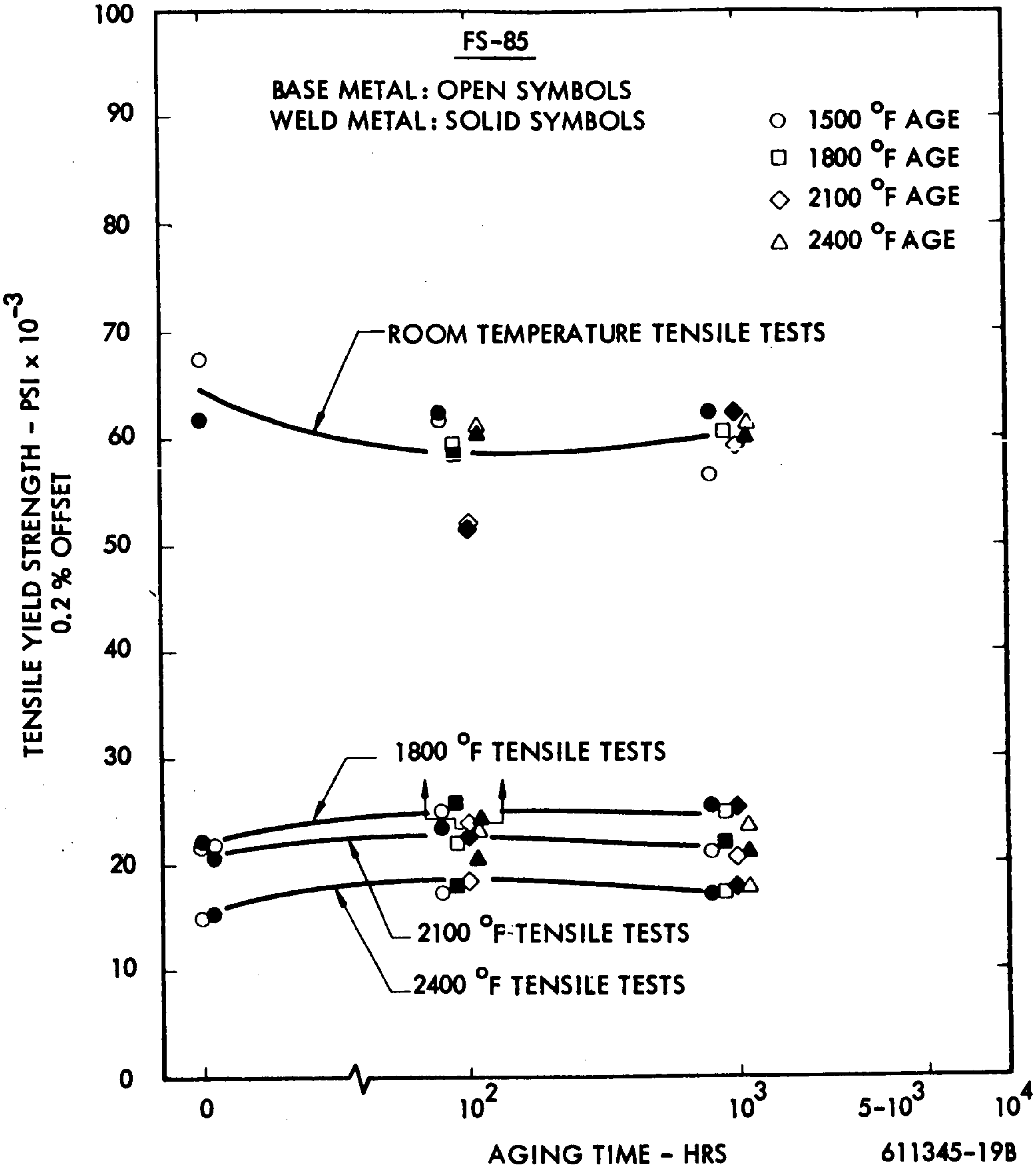
			Tensile Properties: Strength x 10^{-3} psi, Elongation in Percent															
			1500°F Age				1800°F Age				2100°F Age				2400°F Age			
Alloy	Specimen Type	Temp. (°F)	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location	σu	σy	Elong.	Failure Location
Ta-10W	Base	75	83.4	69.2	28.0	--	80.5	67.6	25.5	--	82.7	69.5	27.0	--	78.1	67.0	25.5	--
	Weld	75	80.9	71.0	7.0	Weld	78.5	67.7	10.5	Weld	74.6	63.9	8.5	Weld	75.6	63.1	12.0	Weld
	Base	1800	--	--	--	--	41.4	25.0	37.0	--	--	--	--	--	37.2	20.1	39.0	--
	Weld	1800	37.5	24.2	7.0	Weld	--	--	--	--	39.0	25.4	11.0	Weld	--	--	--	--
	Base	2100	32.8	20.0	50.0	--	--	--	--	--	33.2	20.5	47.0	--	--	--	--	--
	Weld	2100	--	--	--	--	32.2	21.6	11.0	Weld	--	--	--	--	27.4	19.4	9.0	Weld
	Base	2400	--	--	--	--	26.6	17.5	60.0	--	--	--	--	--	26.6	16.4	42.0	--
	Weld	2400	22.8	17.1	5.0	Weld	--	--	--	--	23.8	17.1	8.0	Weld	--	--	--	--
T-222	Base	75	83.4	72.4	16.0	--	82.1	72.2	17.0	--	83.2	71.1	14.0	--	82.0	70.8	16.5	--
	Weld	75	82.0	72.8	18.0	Base	84.4	75.2	11.5	Weld	83.4	72.0	14.0	Base	81.3	68.8	16.0	Base
	Base	1800	--	--	--	--	51.8	31.9	13.0	--	--	--	--	--	54.3	31.9	13.0	--
	Weld	1800	60.5	35.3	10.0	HAZ	--	--	--	--	53.8	33.8	10.0	HAZ	--	--	--	--
	Base	2100	53.8	32.4	15.0	--	--	--	--	--	47.4	31.2	18.0	--	--	--	--	--
	Weld	2100	--	--	--	--	51.4	33.8	12.0	Base	--	--	--	--	47.7	30.5	13.0	HAZ
	Base	2400	--	--	--	--	39.9	31.2	27.0	--	--	--	--	--	38.4	28.1	24.0	--
	Weld	2400	41.7	32.0	10.0	HAZ	--	--	--	--	41.2	32.2	12.0	HAZ	--	--	--	--

NOTES: All data based on welds prepared using optimum welding conditions and post weld anneals. Base metal annealed with same anneal as TIG welds.



NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 2 - Effect of Aging on the Tensile Strength of FS-85



NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED
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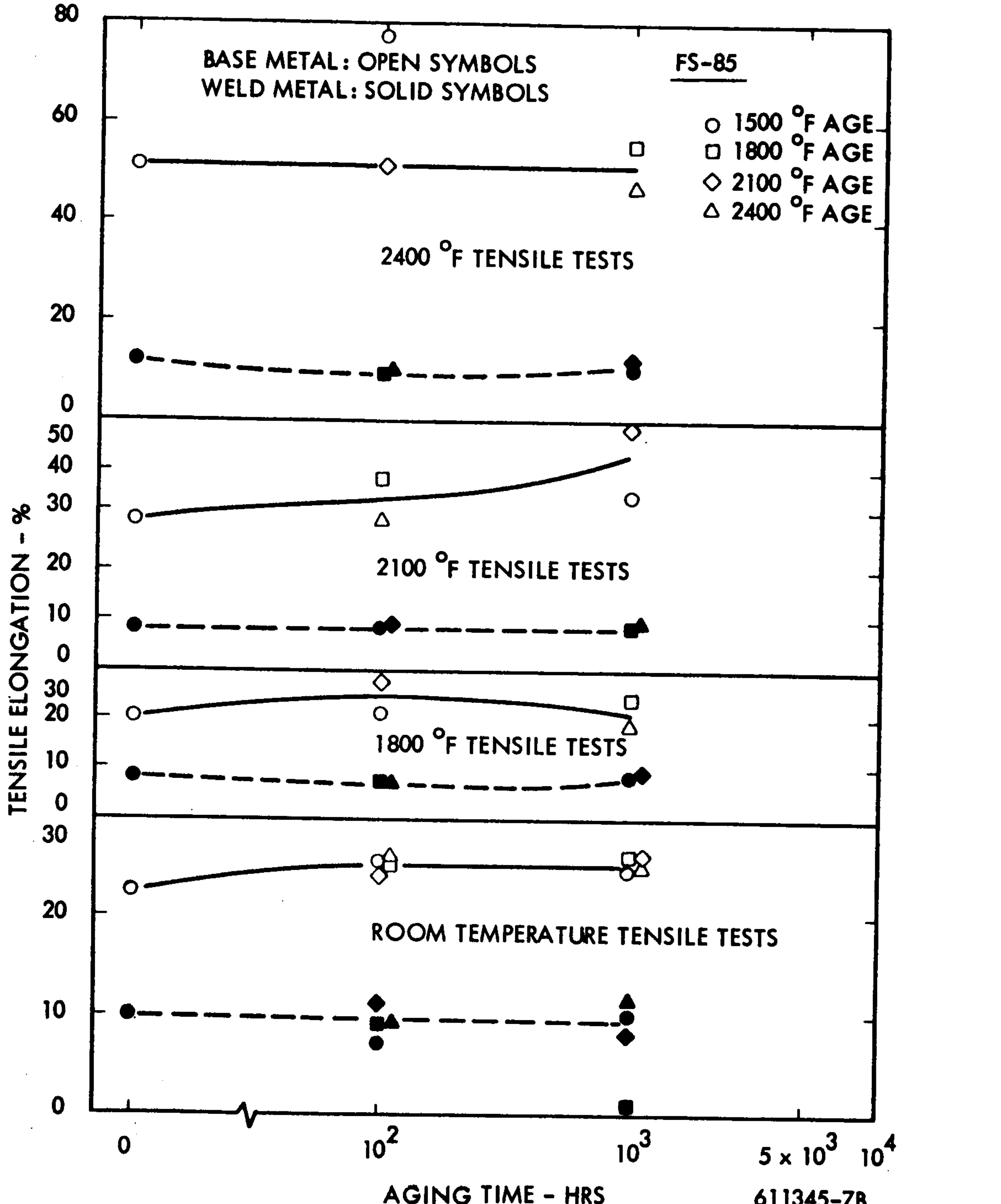
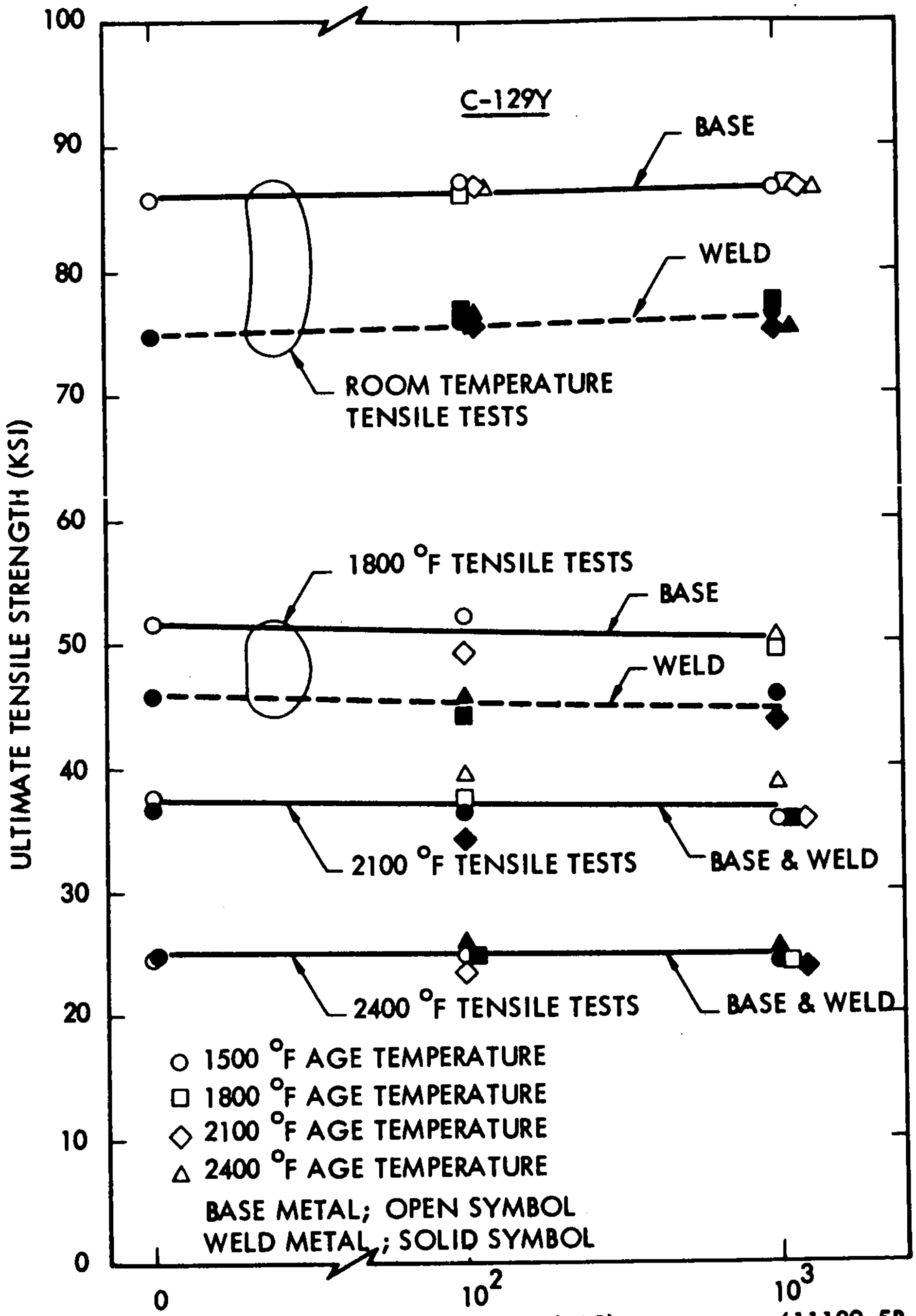
FIGURE 3 - Effect of Aging on the Yield Strength of FS-85



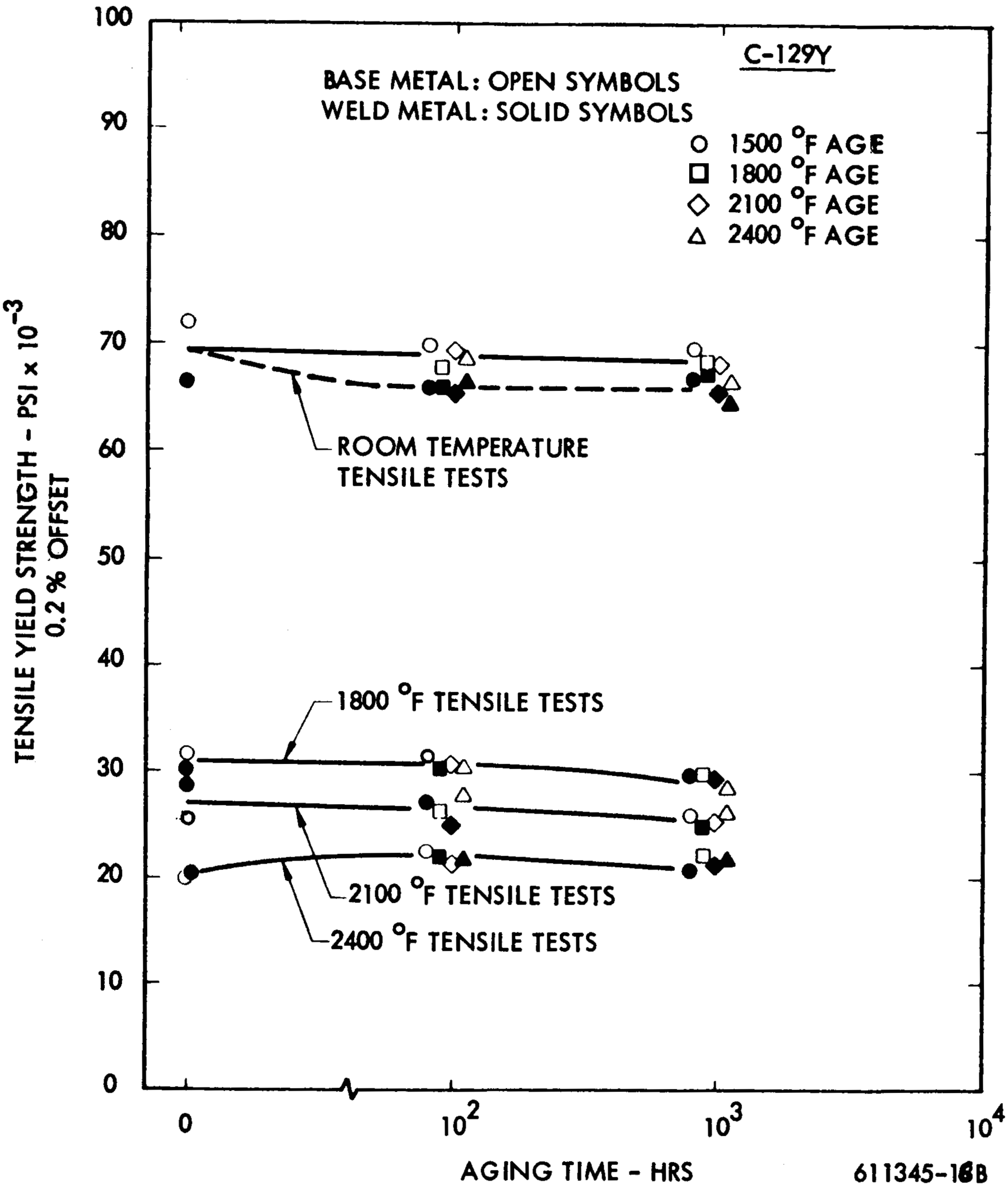
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 4 - Effect of Aging on the Elongation of FS-85



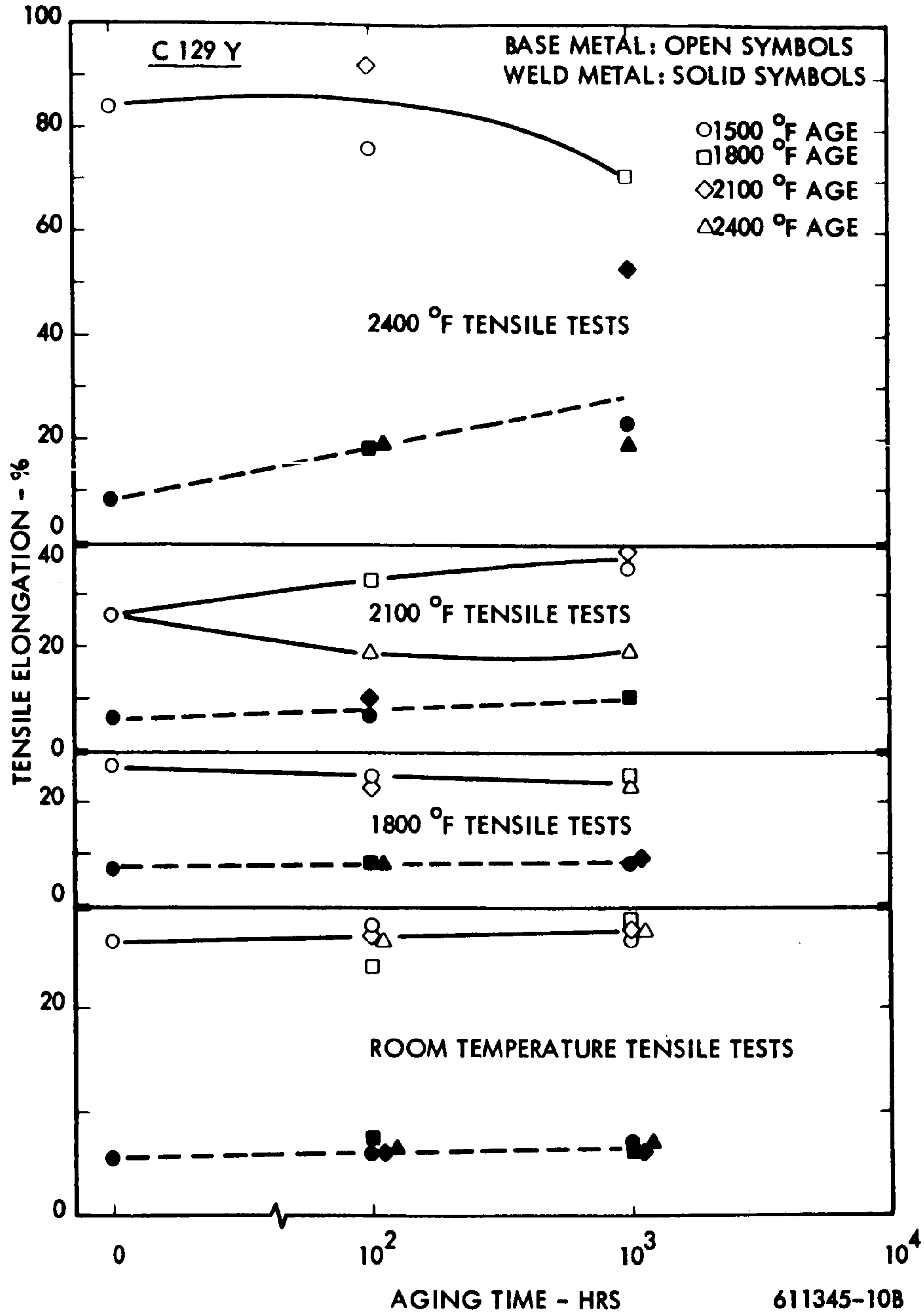
NOTE: OPTIMUM WELD PARAMETERS, SAMPLES ANNEALED 1 HOUR AT 2400 °F PRIOR TO AGING & TESTING

FIGURE 5 - Effect of Aging on the Tensile Strength of C-129Y



NOTE : OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 6 - Effect of Aging on the Yield Strength of C-129Y



NOTE: OPTIMUM WELD PARAMETERS, SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING & TESTING

FIGURE 7 - Effect of Aging on the Elongation of C-129Y

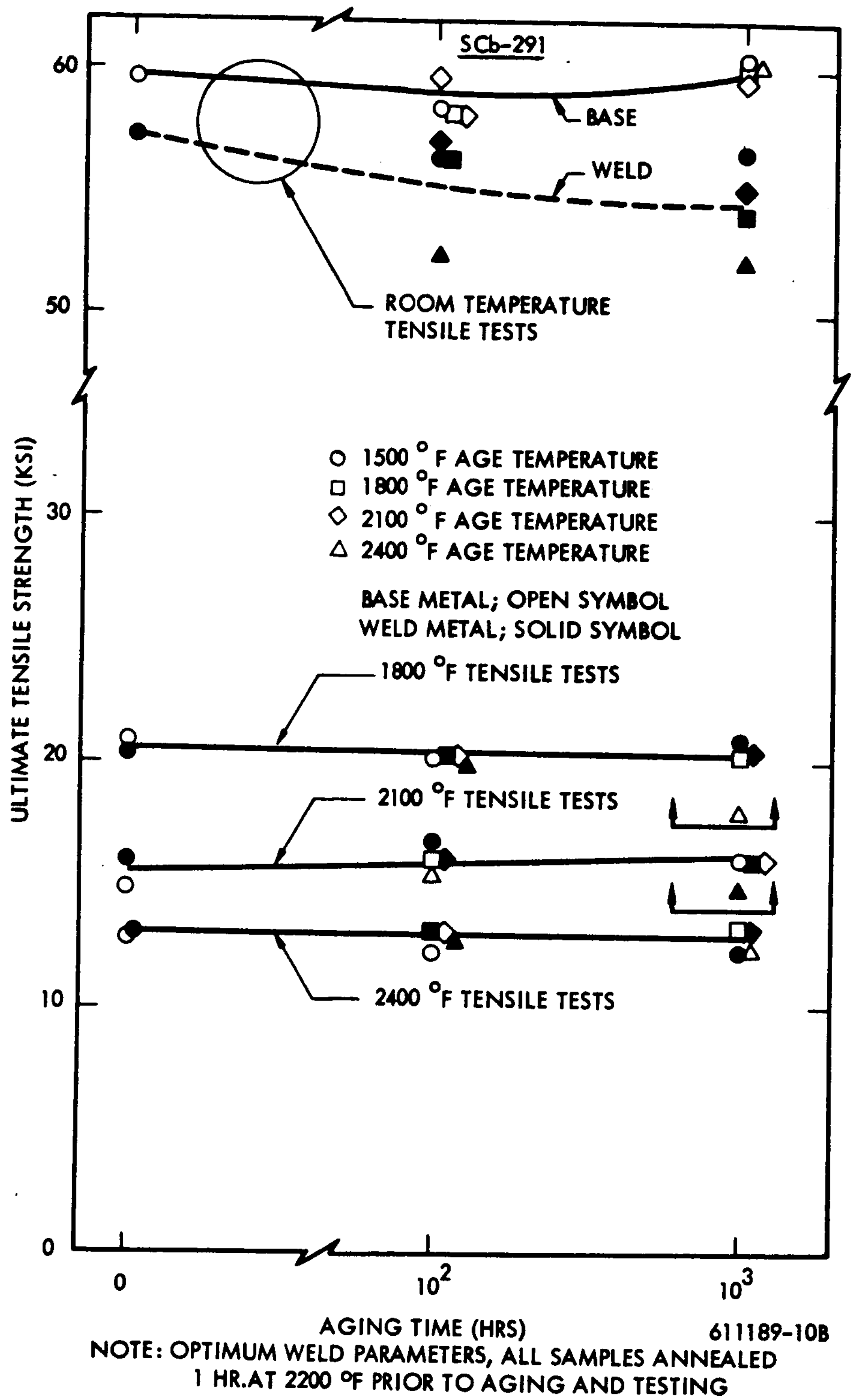
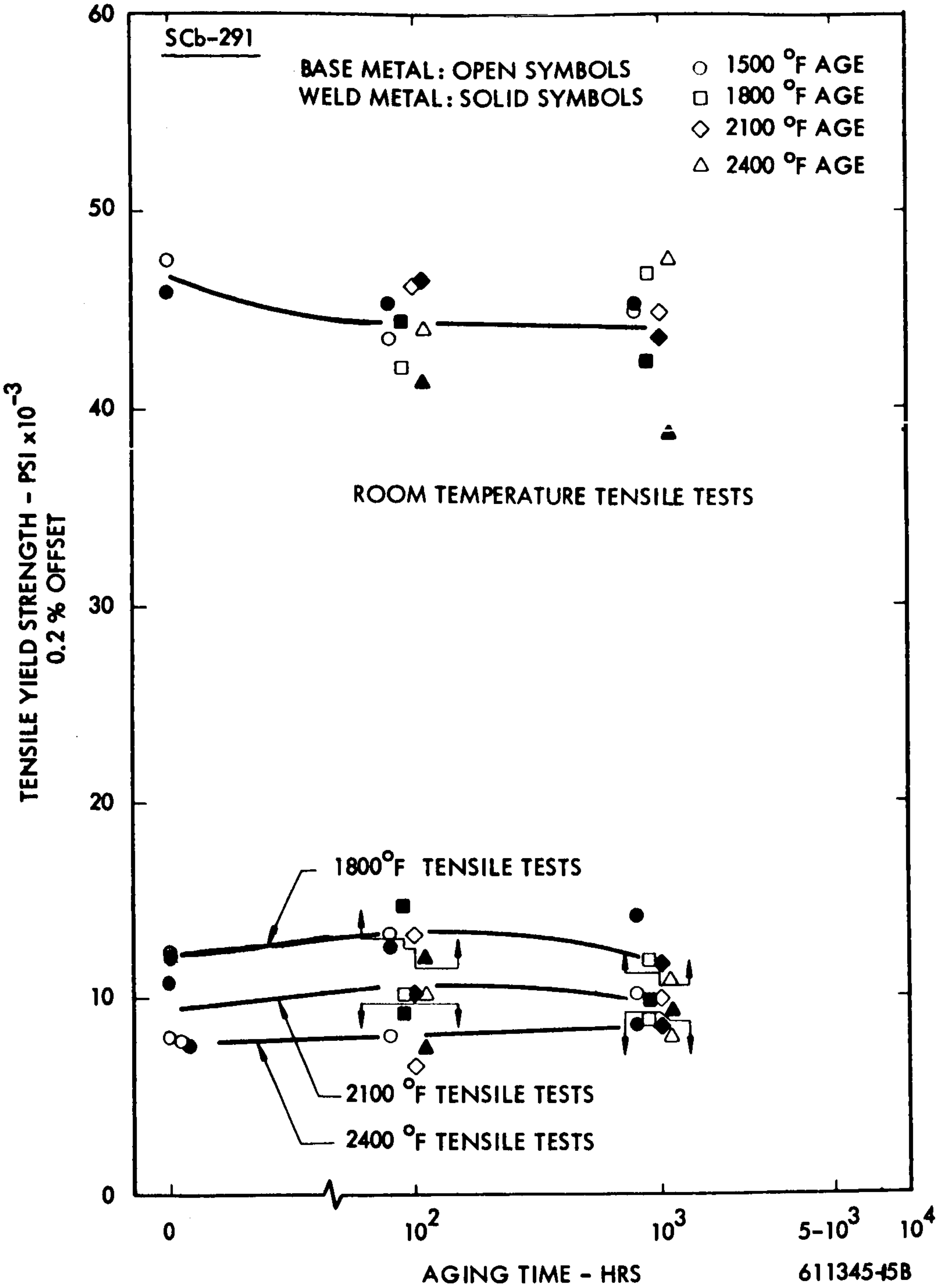
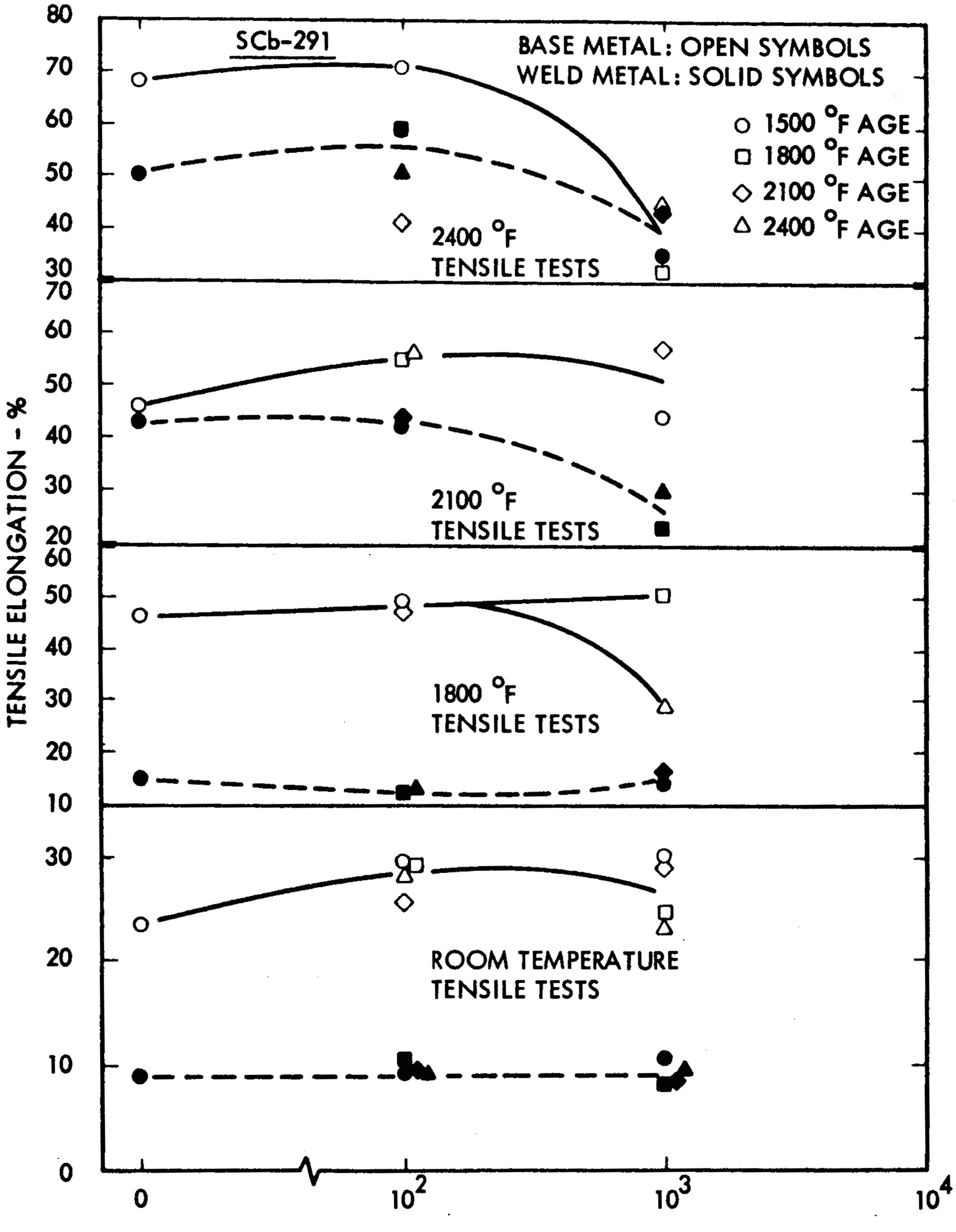


FIGURE 8 - Effect of Aging on the Tensile Strength of SCb-291



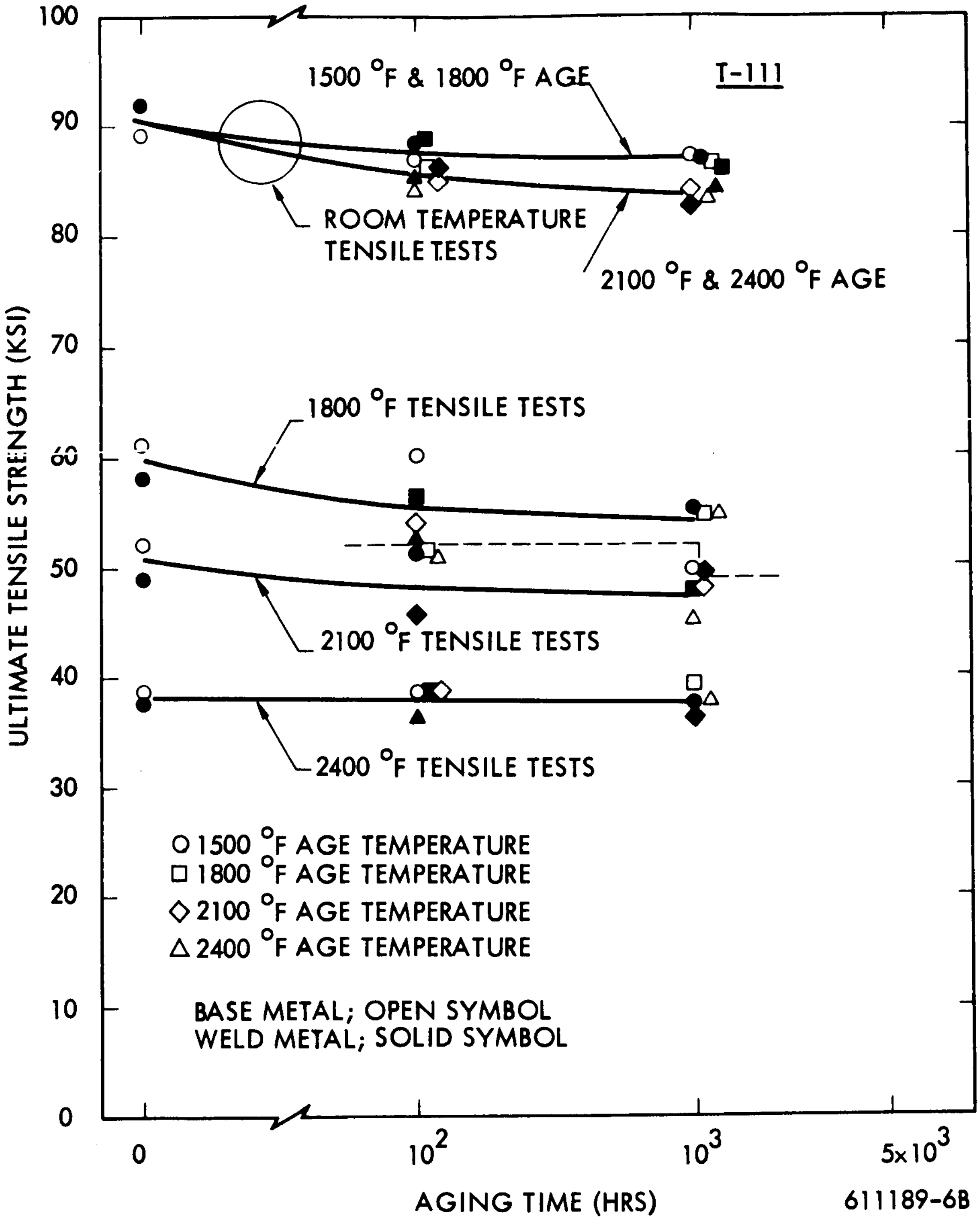
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2200 °F PRIOR TO AGING AND TESTING

FIGURE 9 - Effect of Aging on the Yield Strength of SCb-291



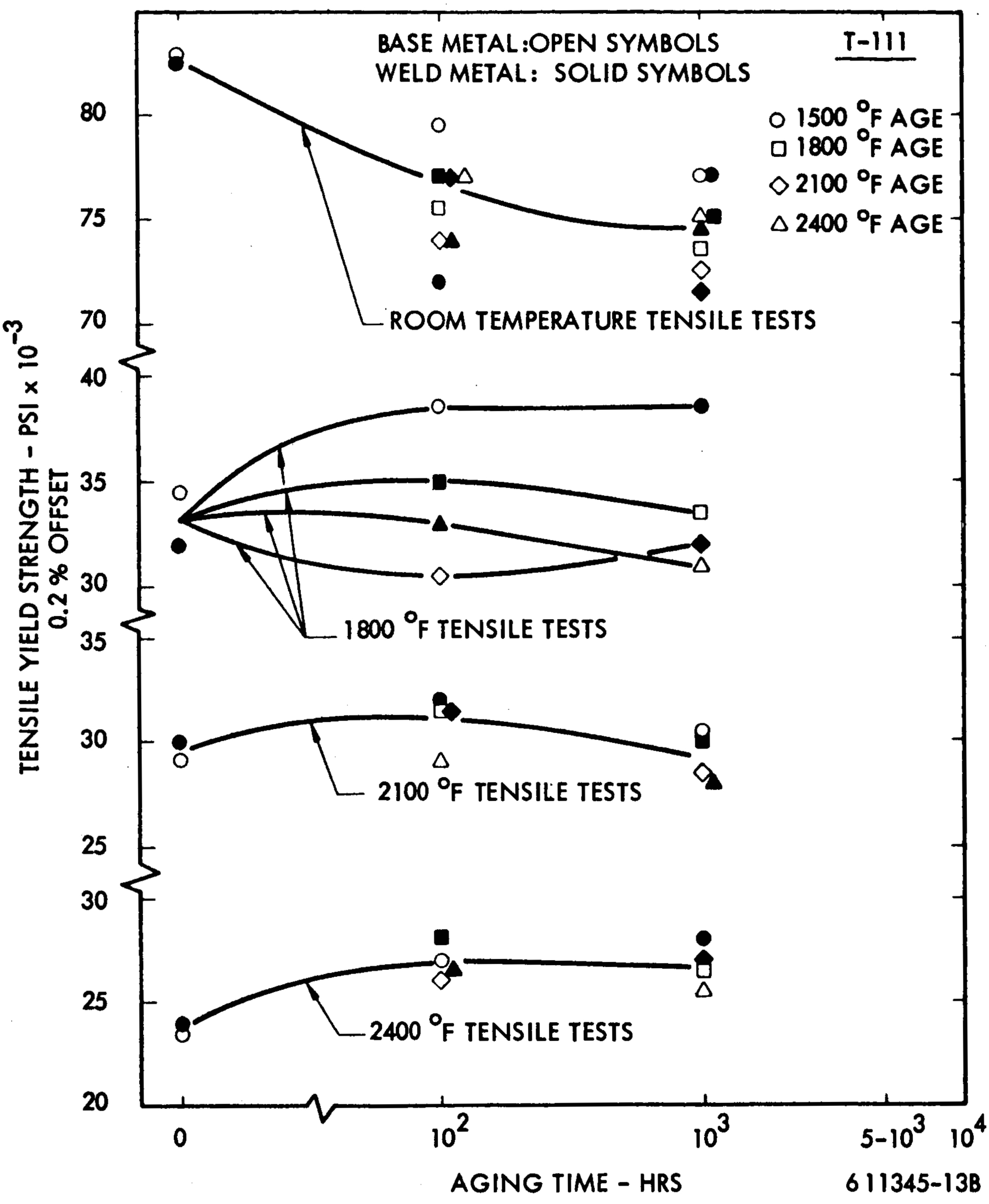
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2200 °F PRIOR TO AGING AND TESTING

FIGURE 10 - Effect of Aging on the Elongation of SCb-291



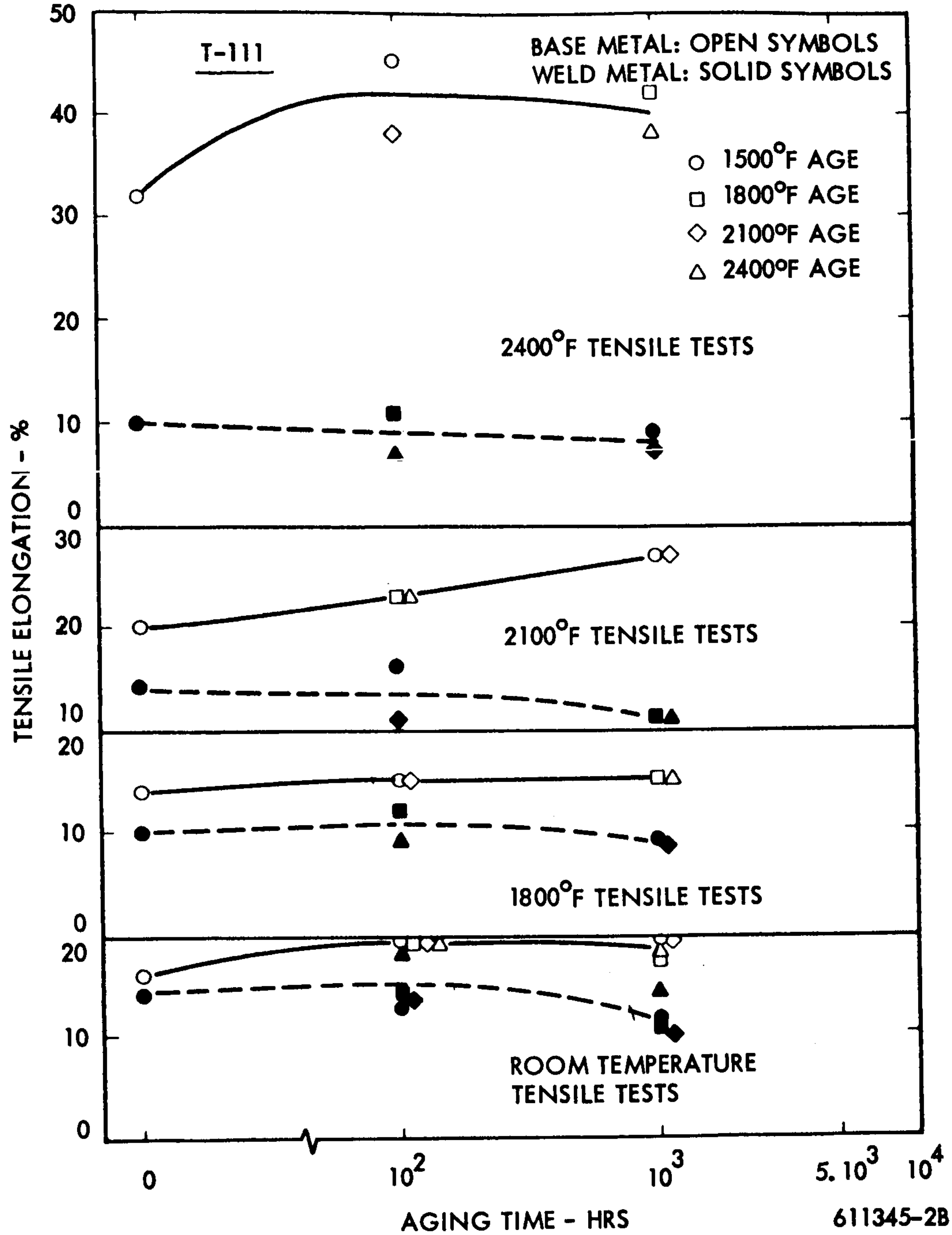
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED
1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 11 - Effect of Aging on the Tensile Strength of T-111



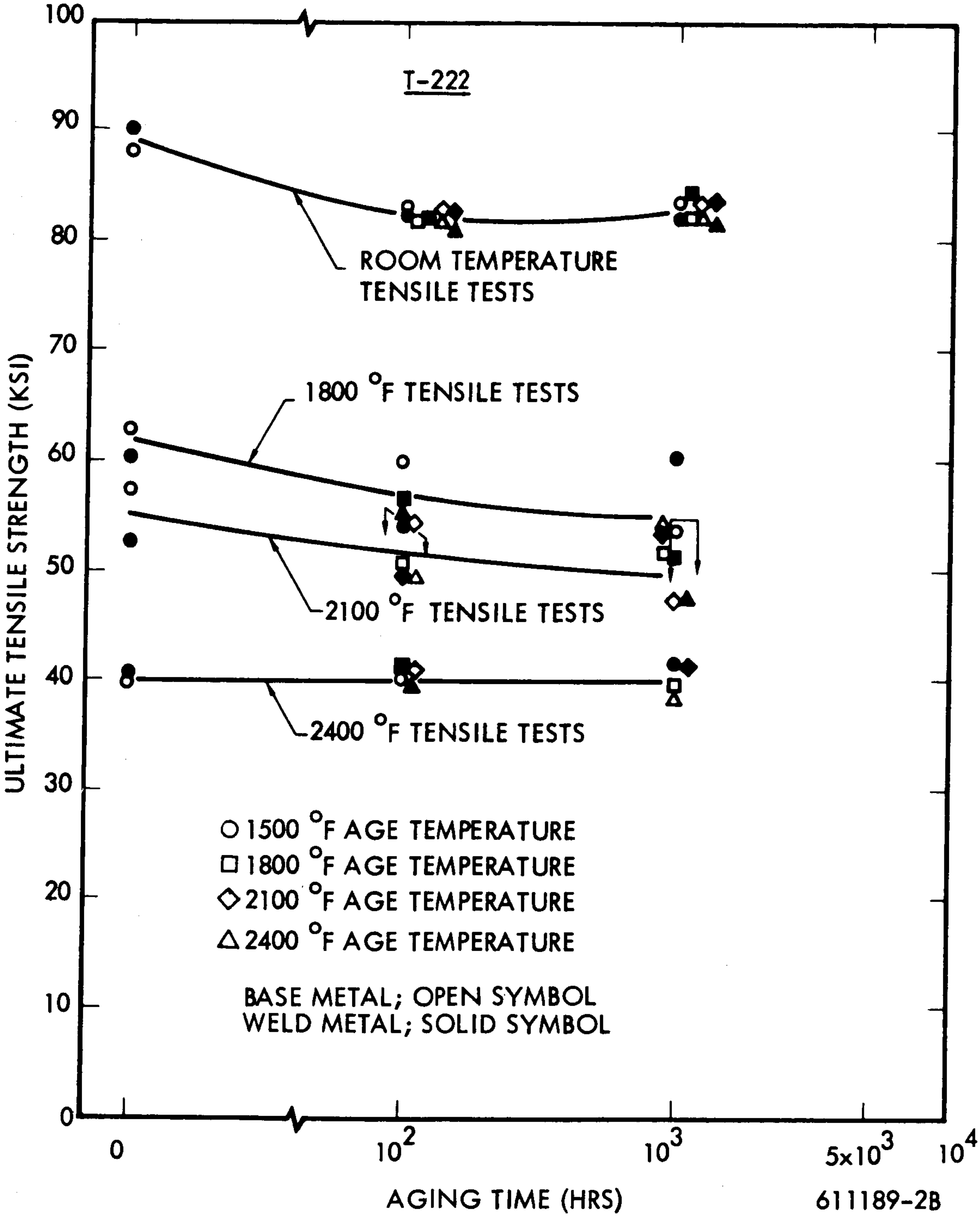
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400°F PRIOR TO AGING AND TESTING

FIGURE 12 - Effect of Aging on the Yield Strength of T-111



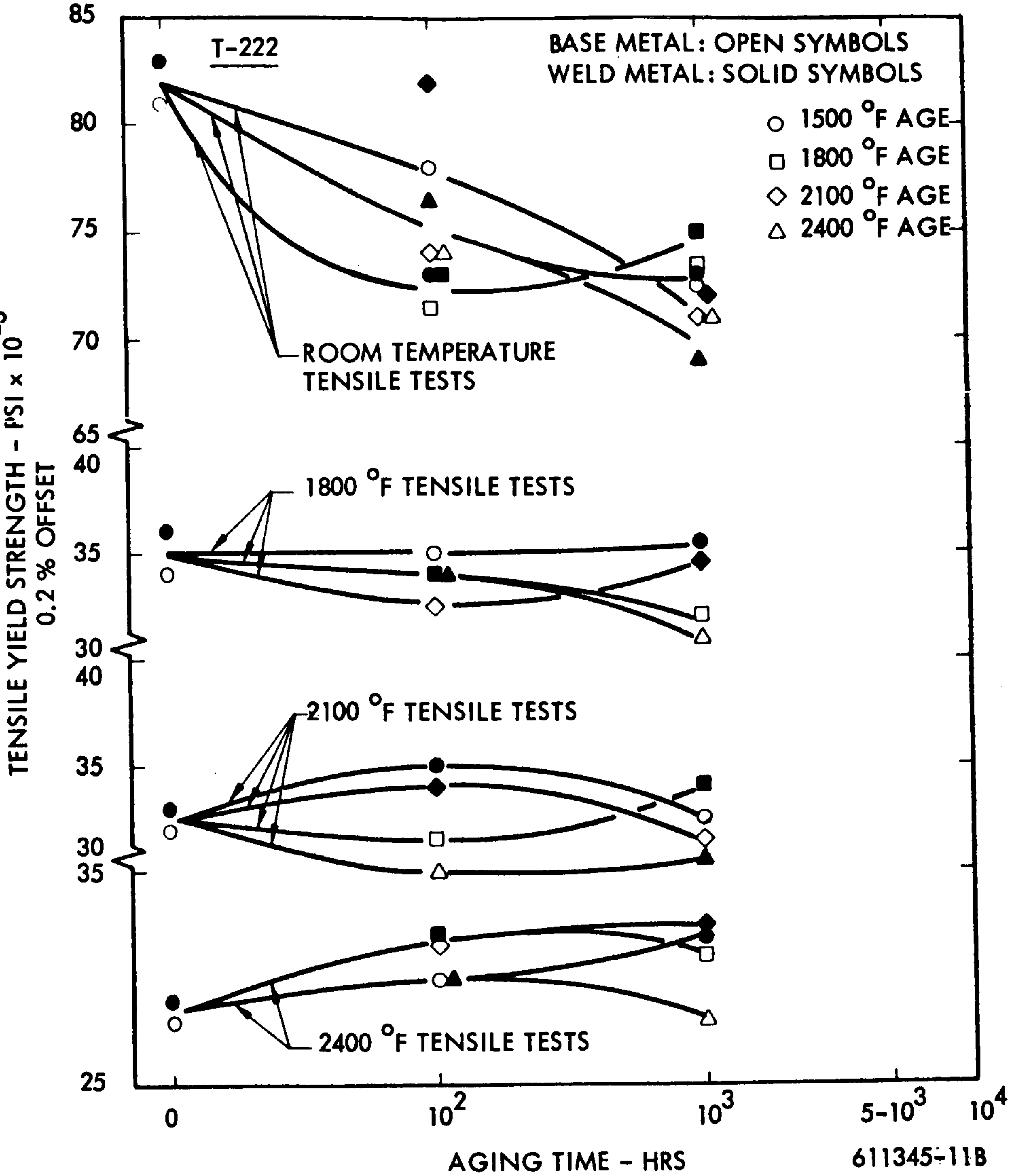
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 13 - Effect of Aging on the Elongation of T-111



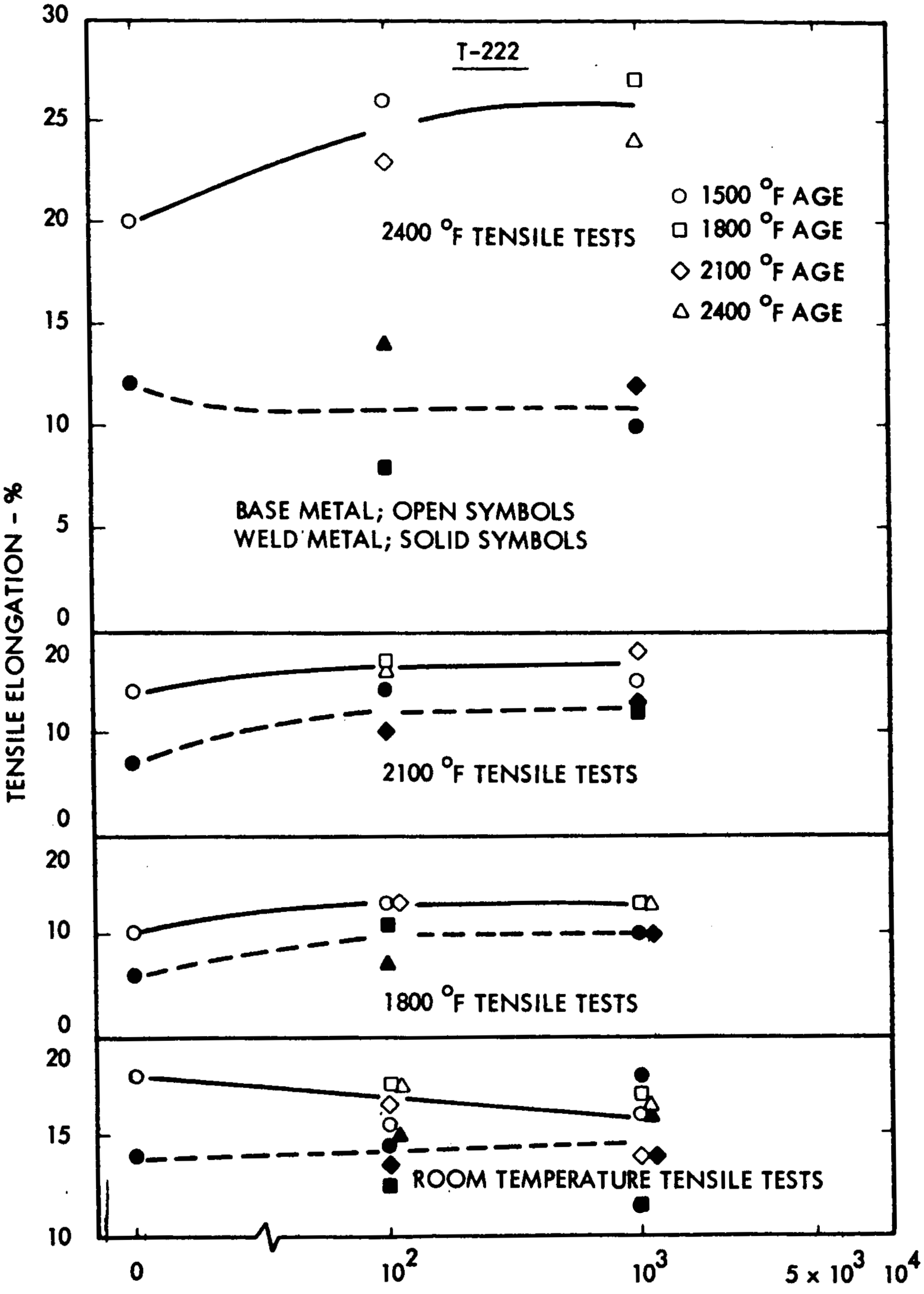
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 14 - Effect of Aging on the Tensile Strength of T-222



NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 15 - Effect of Aging on the Yield Strength of T-222



NOTE: OPTIMUM WELD PARAMETERS, SAMPLES ANNEALED
1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 16 - Effect of Aging on the Elongation of T-222

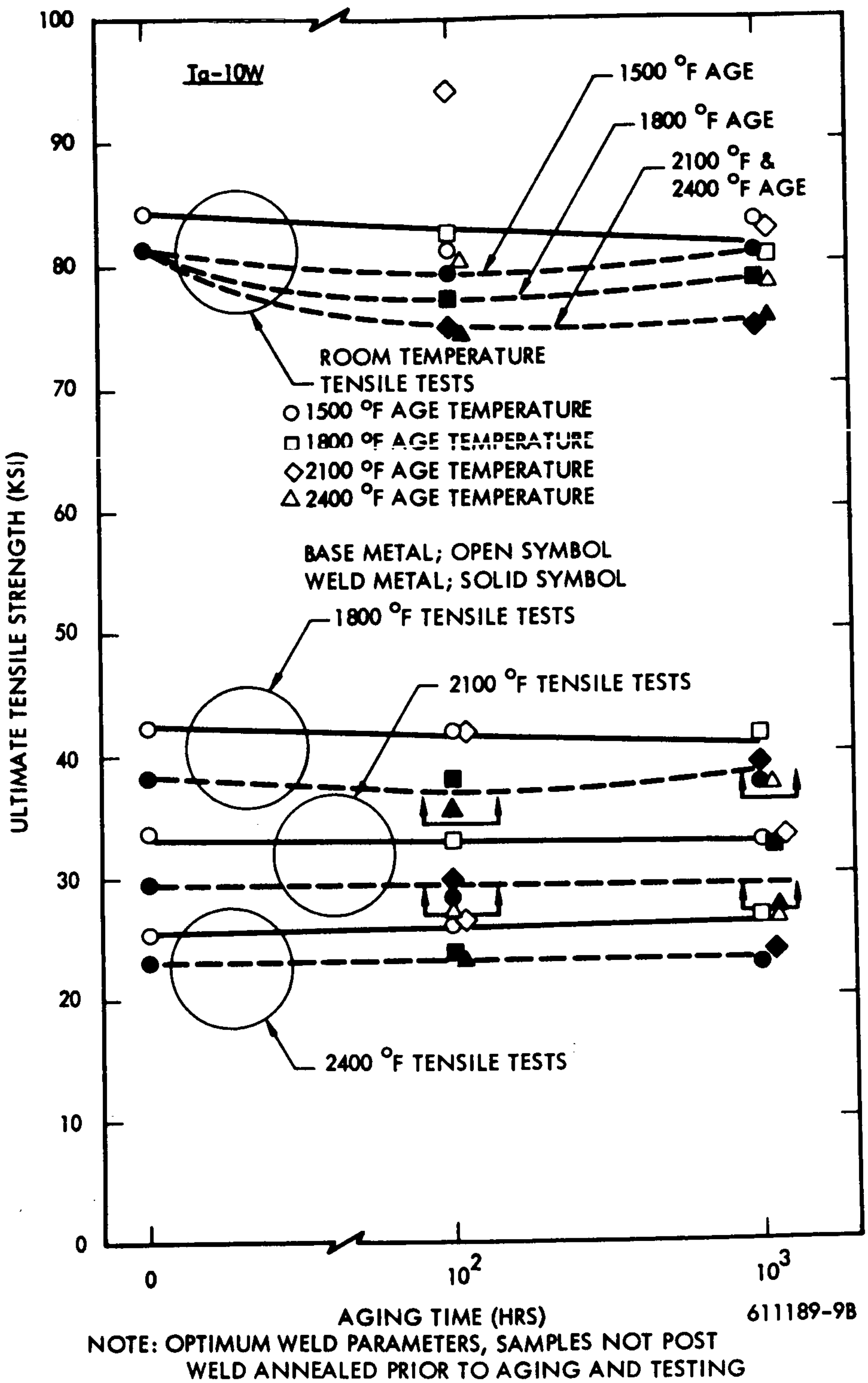
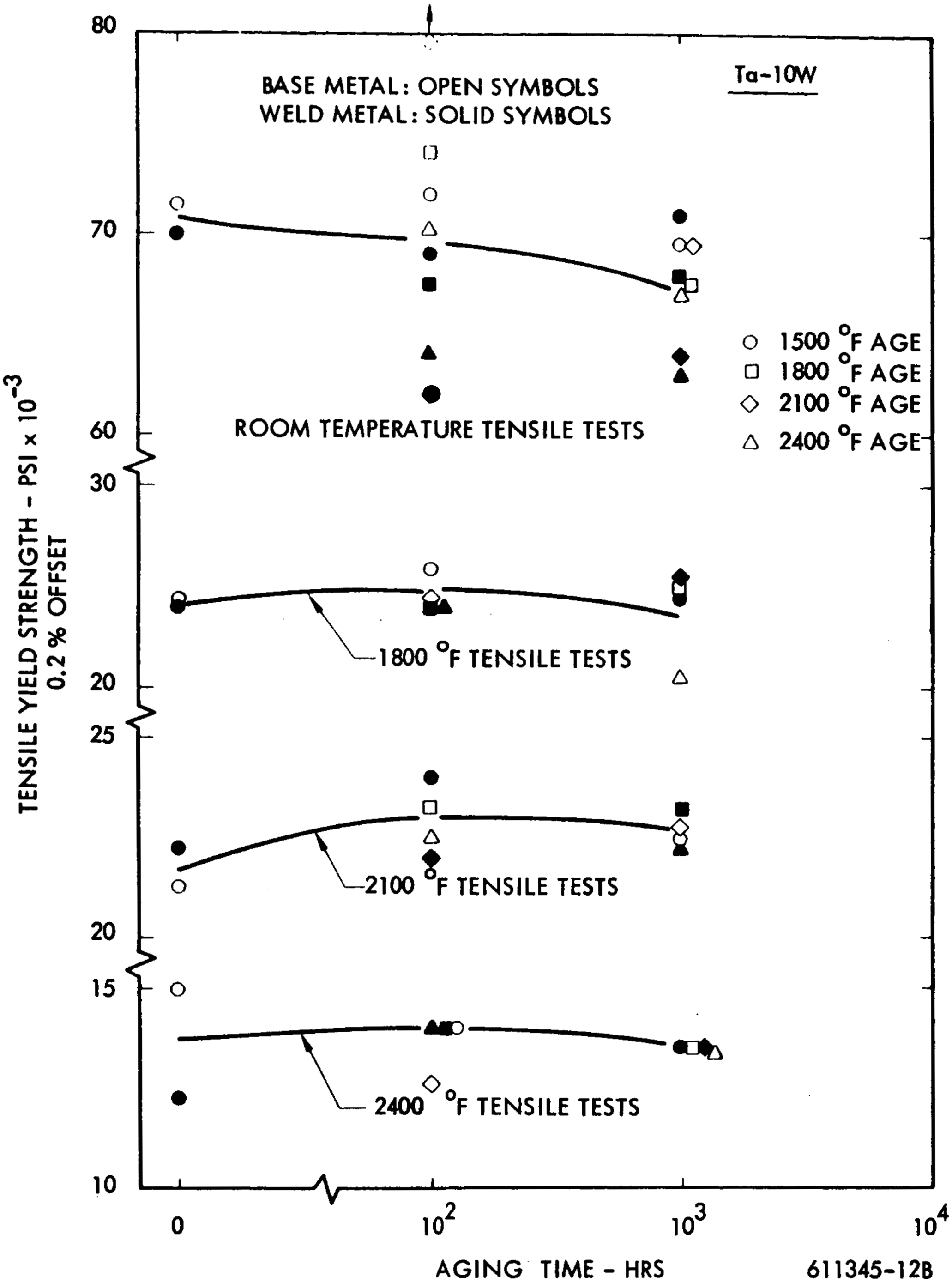
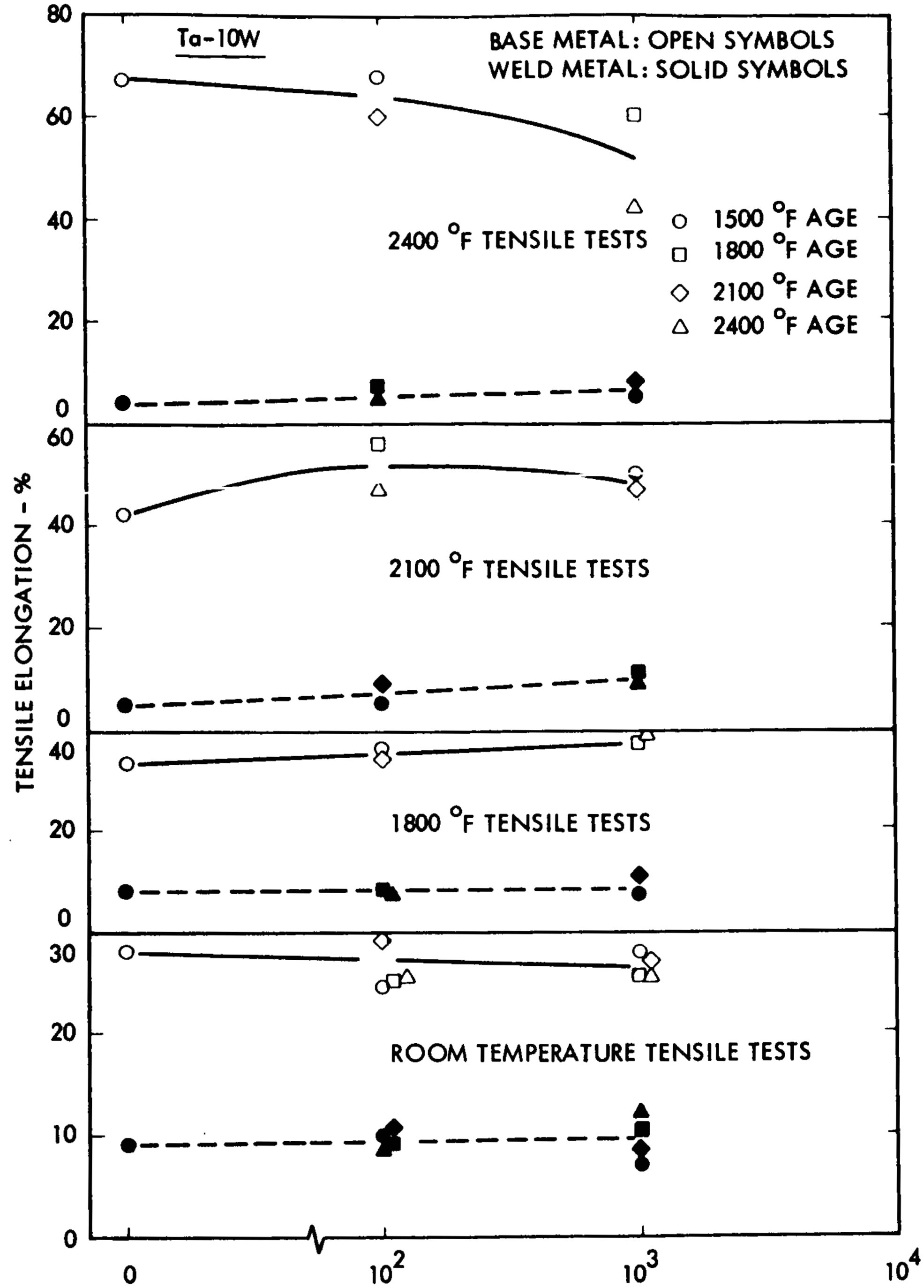


FIGURE 17 - Effect of Aging on the Tensile Strength of Ta-10W



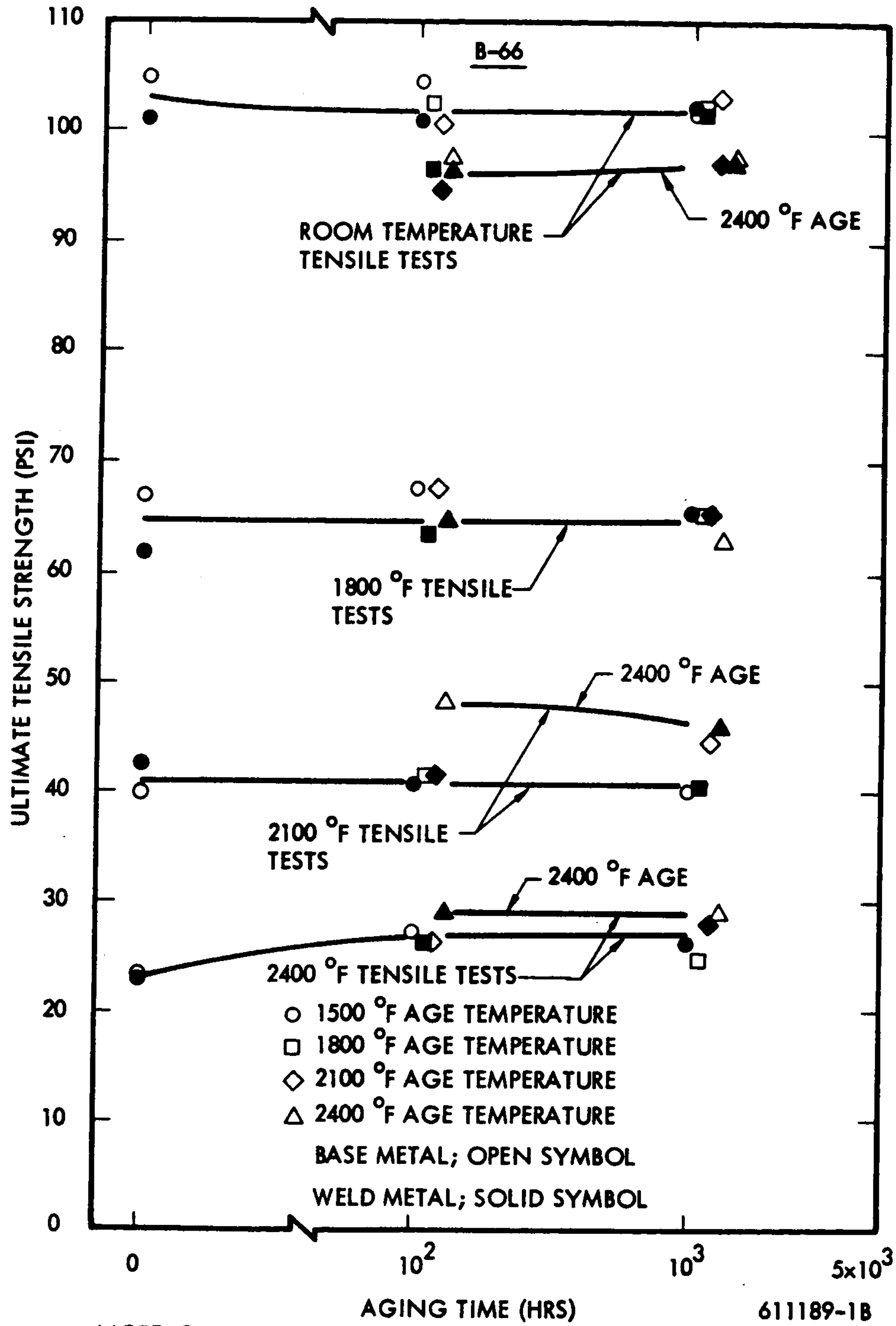
NOTE: OPTIMUM WELD PARAMETERS, SAMPLES WERE NOT ANNEALED PRIOR TO AGING AND TESTING

FIGURE 18 - Effect of Aging on the Yield Strength of Ta-10W



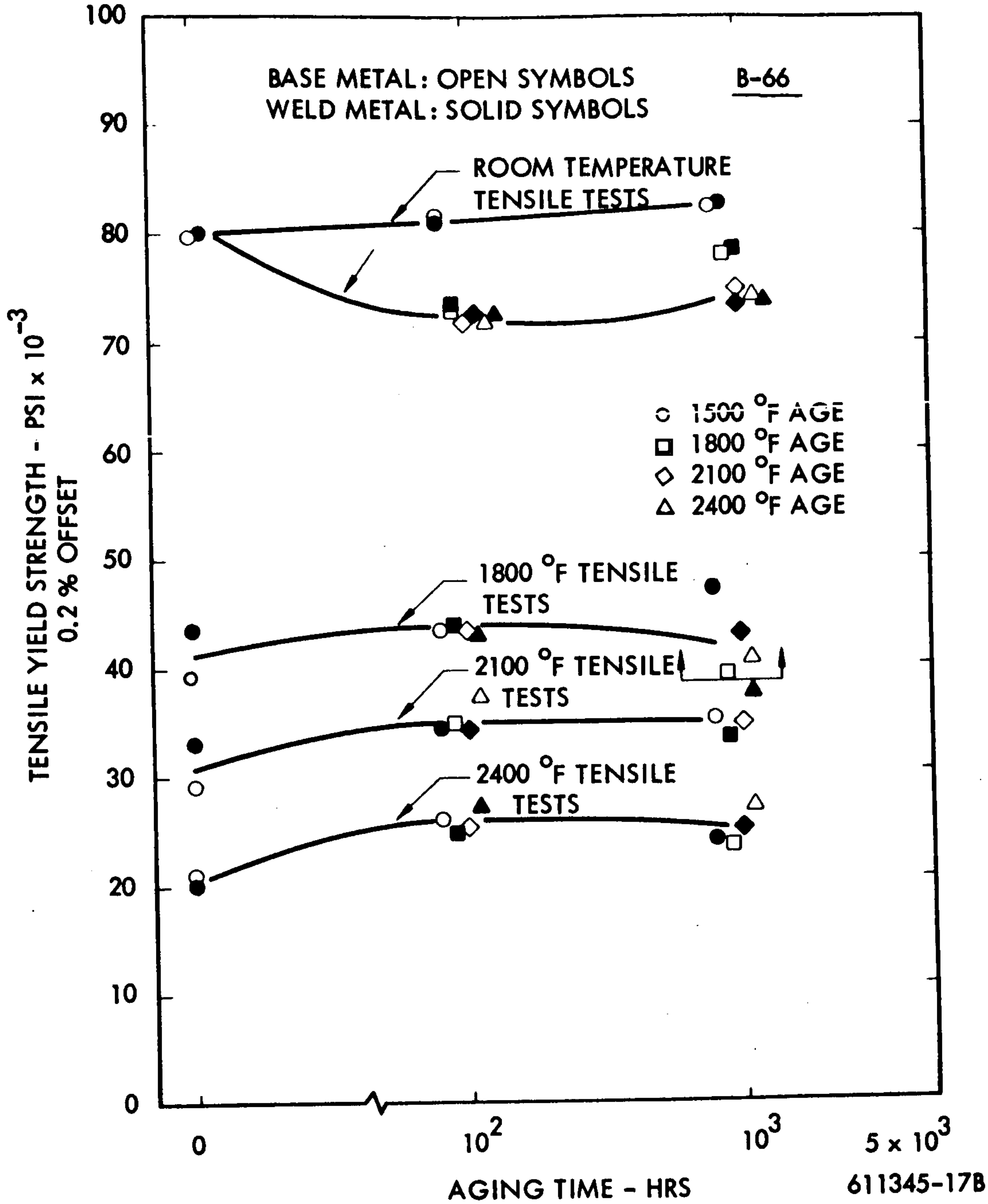
NOTE: OPTIMUM WELD PARAMETERS, SAMPLES NOT POST WELD ANNEALED PRIOR TO AGING AND TESTING

FIGURE 19 - Effect of Aging on the Elongation of Ta-10W



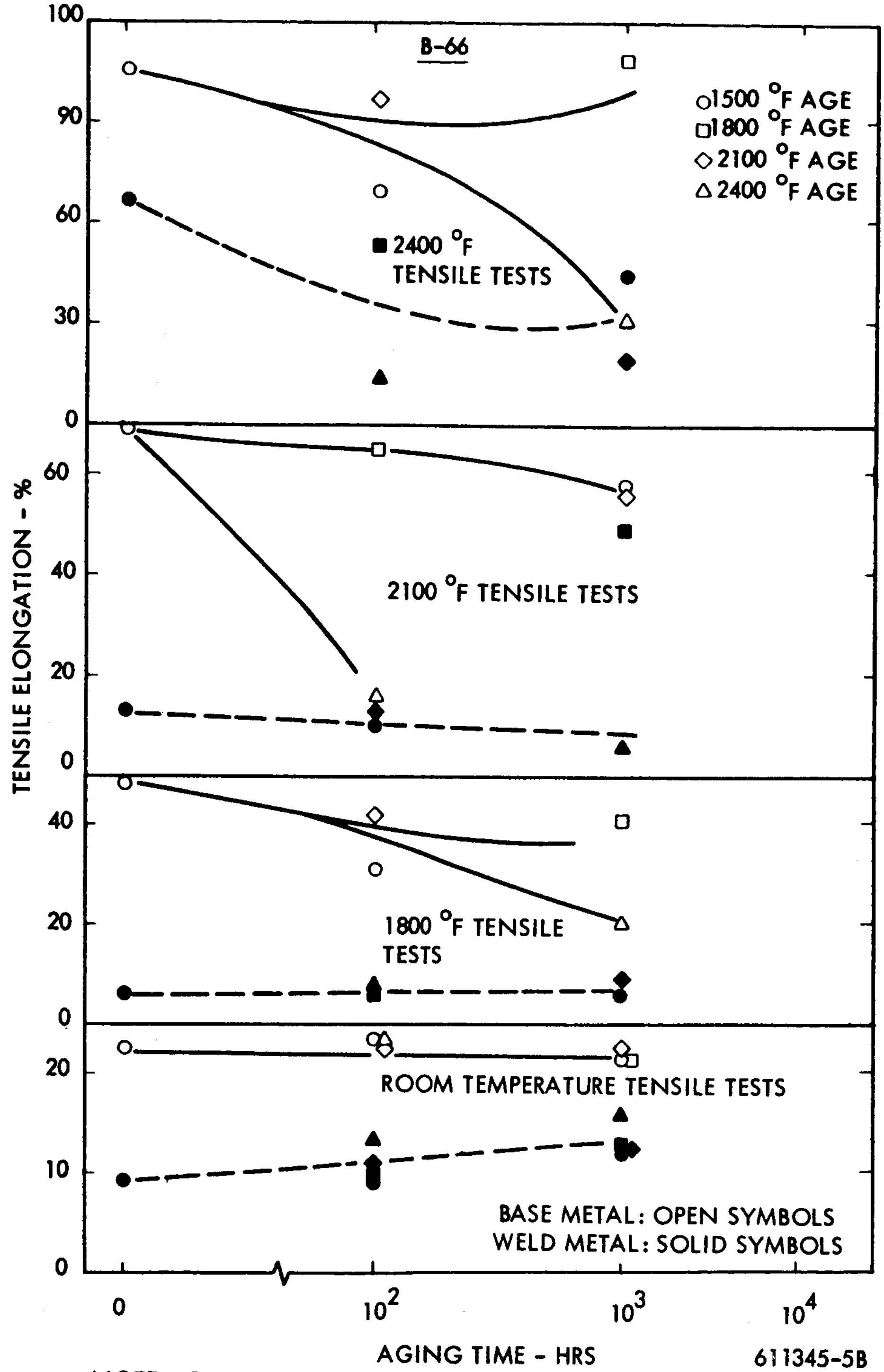
NOTE: OPTIMUM WELD PARAMETERS, SAMPLES NOT POST WELD ANNEALED PRIOR TO AGING & TESTING

FIGURE 20 - Effect of Aging on the Tensile Strength of B-66



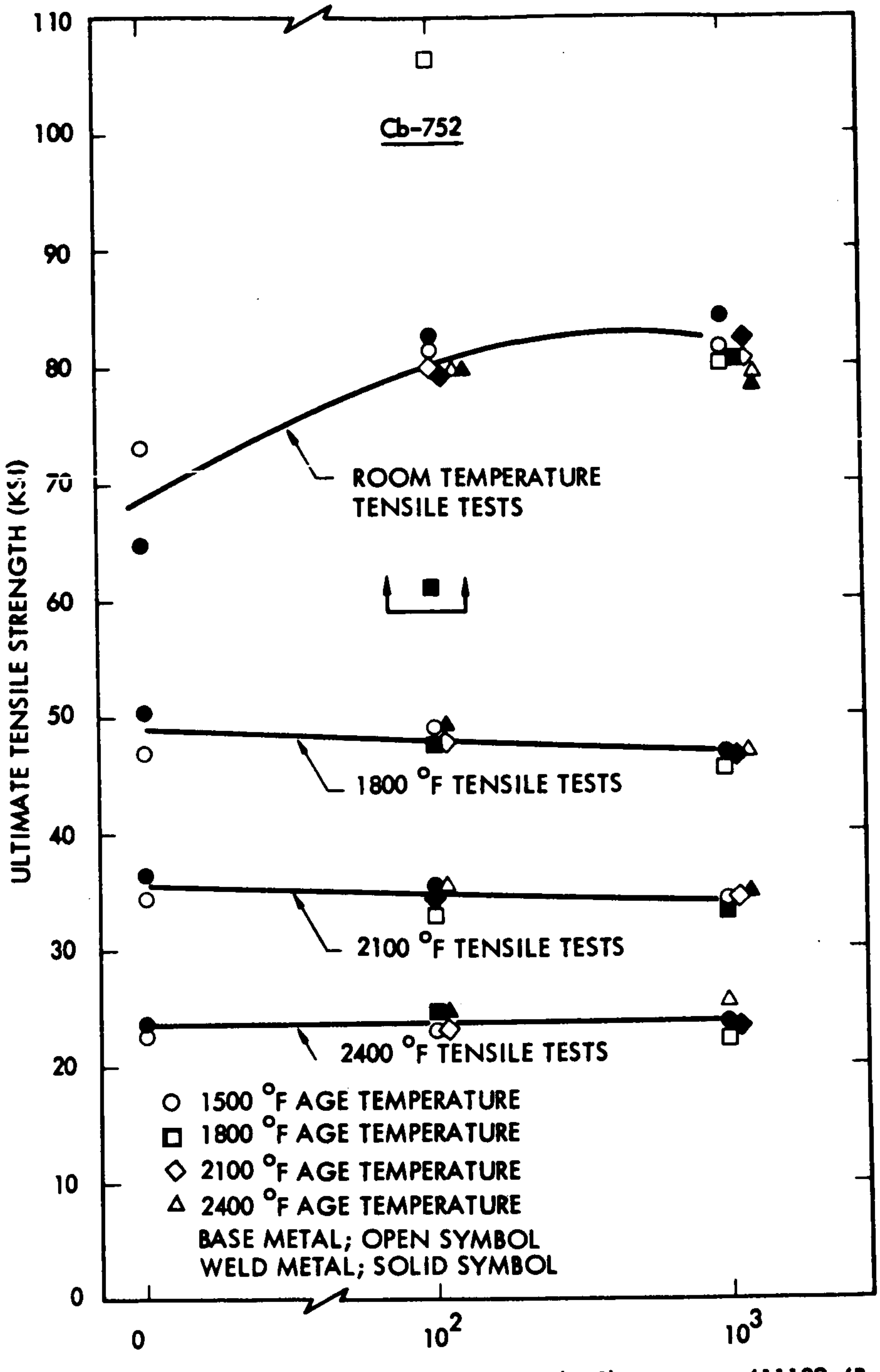
NOTE: OPTIMUM WELD PARAMETERS, SAMPLES WERE NOT ANNEALED PRIOR TO AGING AND TESTING

FIGURE 21 - Effect of Aging on the Yield Strength of B-66



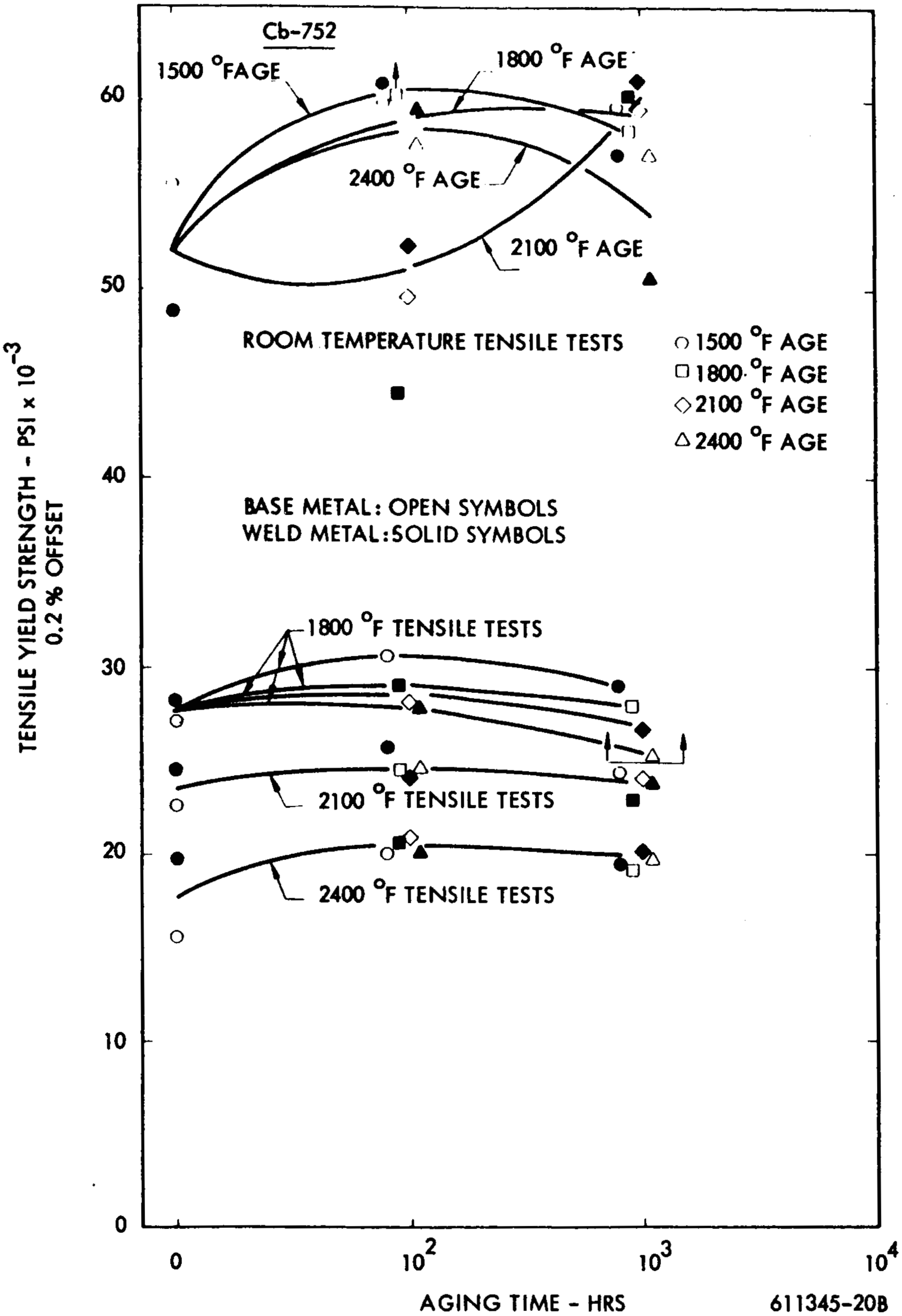
NOTE : OPTIMUM WELD PARAMETERS, SAMPLES NOT POST WELD ANNEALED PRIOR TO AGING & TESTING

FIGURE 22 - Effect of Aging on the Elongation of B-66



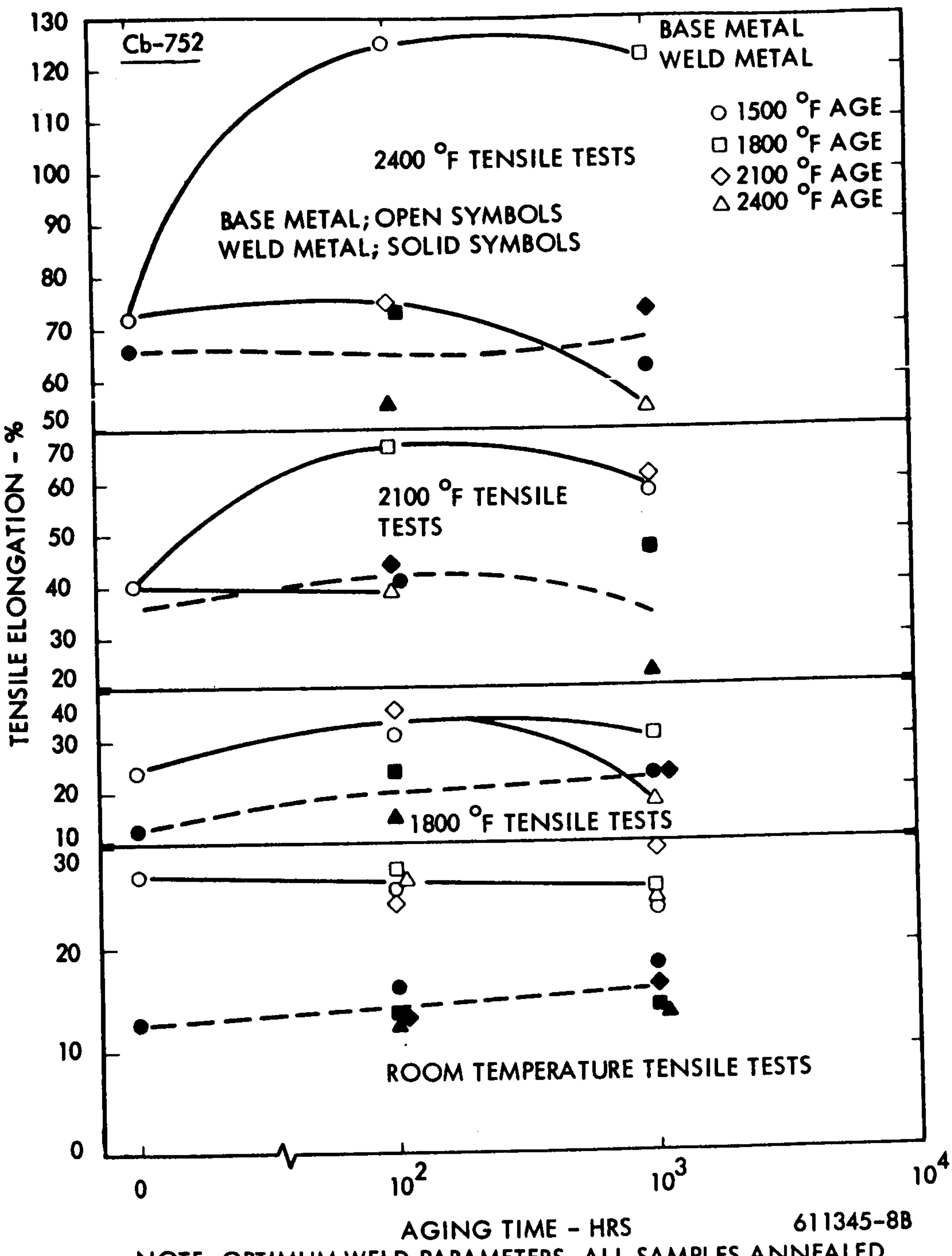
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2200 °F PRIOR TO AGING AND TESTING

FIGURE 23 - Effect of Aging on the Tensile Strength of Cb-752



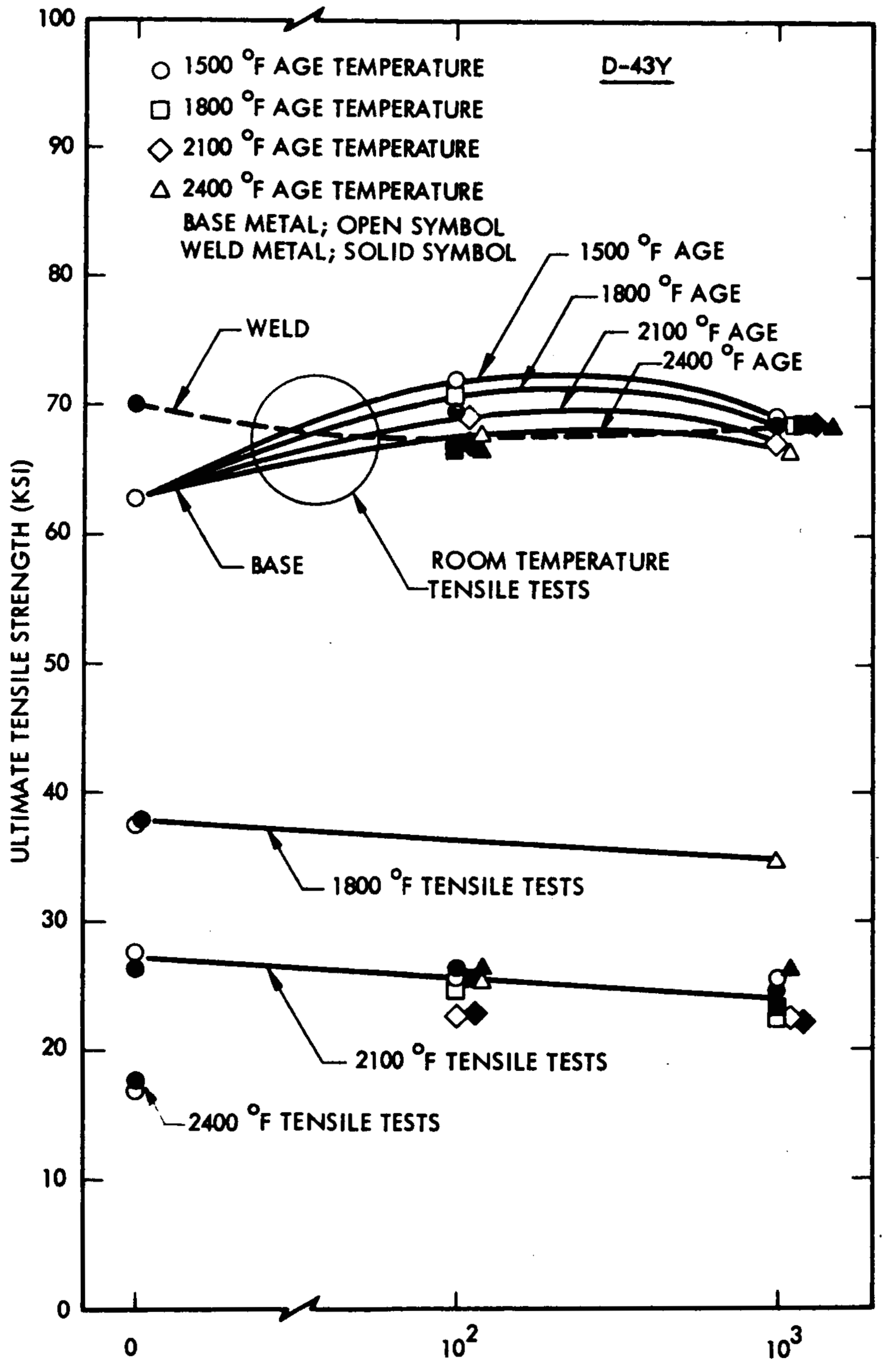
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR AT 2200 °F PRIOR TO AGING AND TESTING

FIGURE 24 - Effect of Aging on the Yield Strength of Cb-752



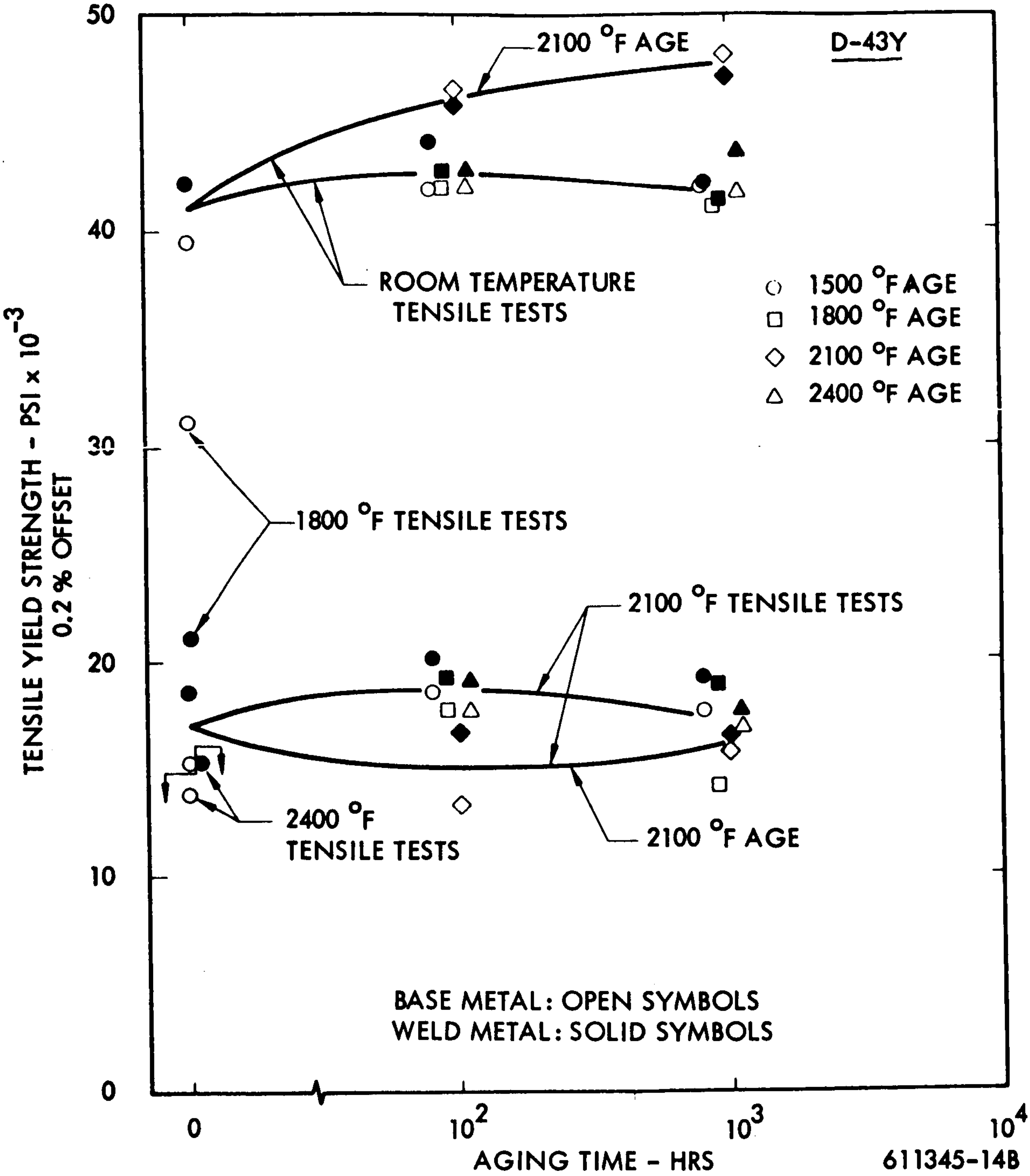
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2200 °F PRIOR TO AGING AND TESTING

FIGURE 25 - Effect of Aging on the Elongation of Cb-752



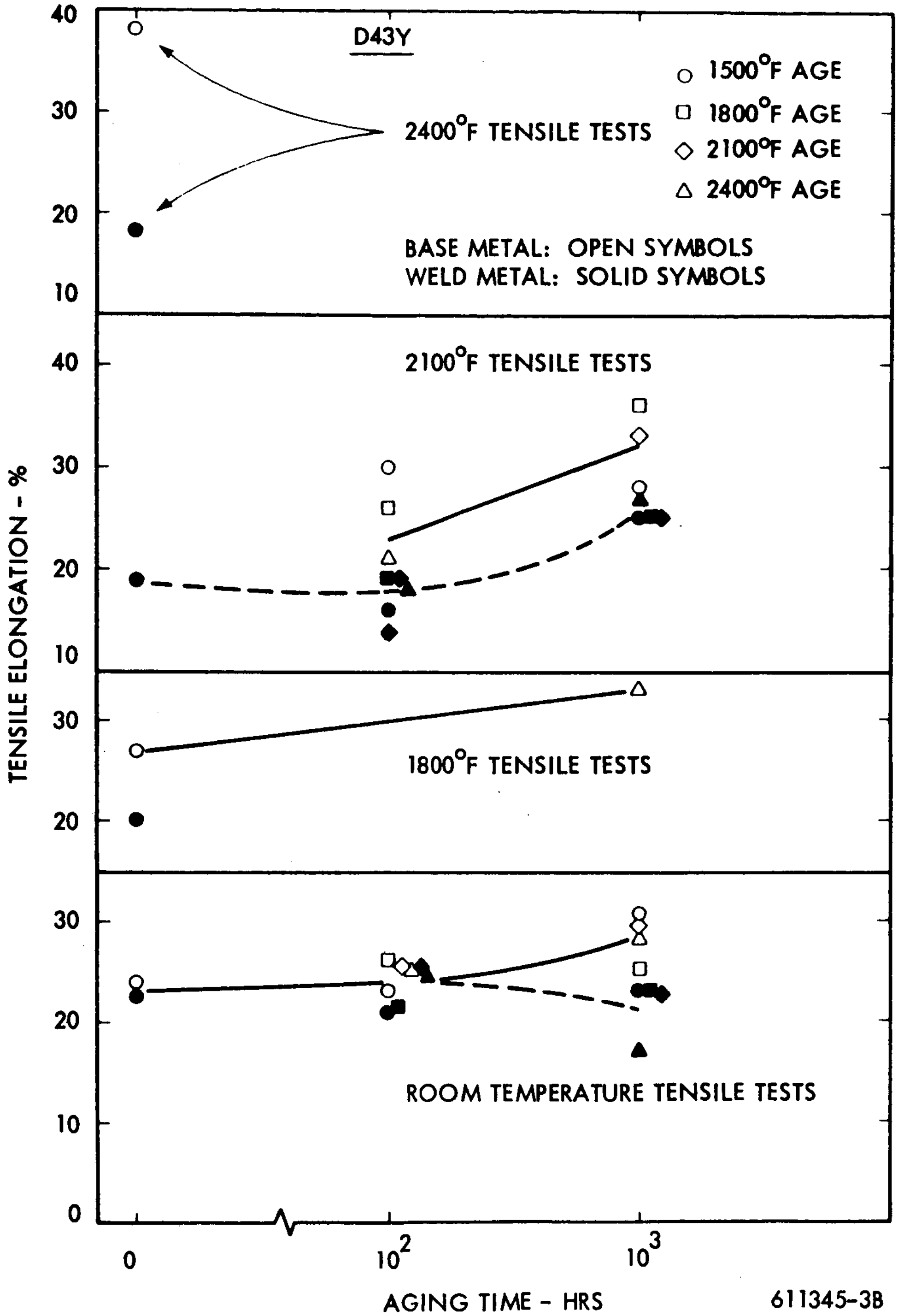
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 26 - Effect of Aging on the Tensile Strength of D-43Y



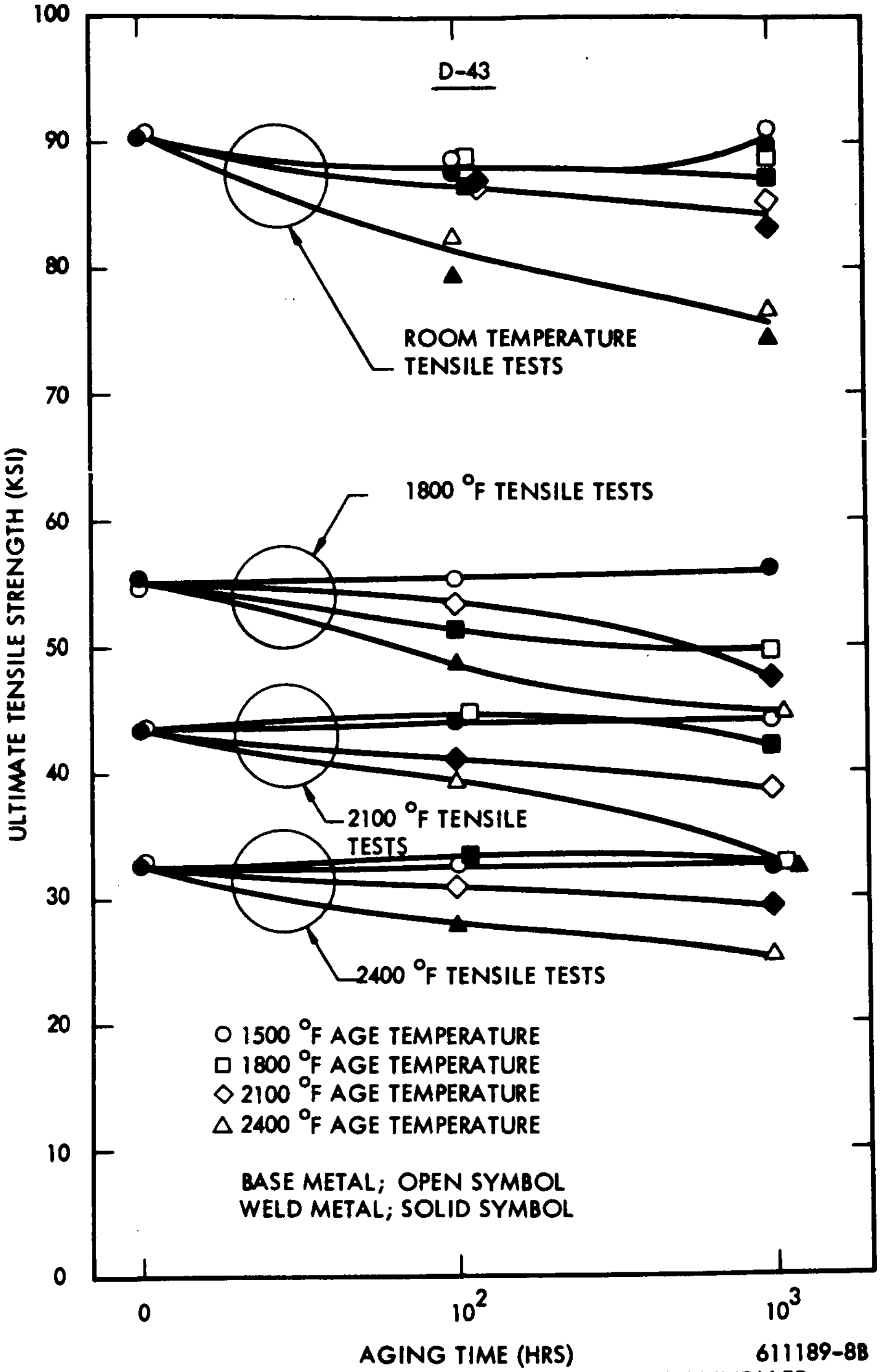
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 27 - Effect of Aging on the Yield Strength of D-43Y



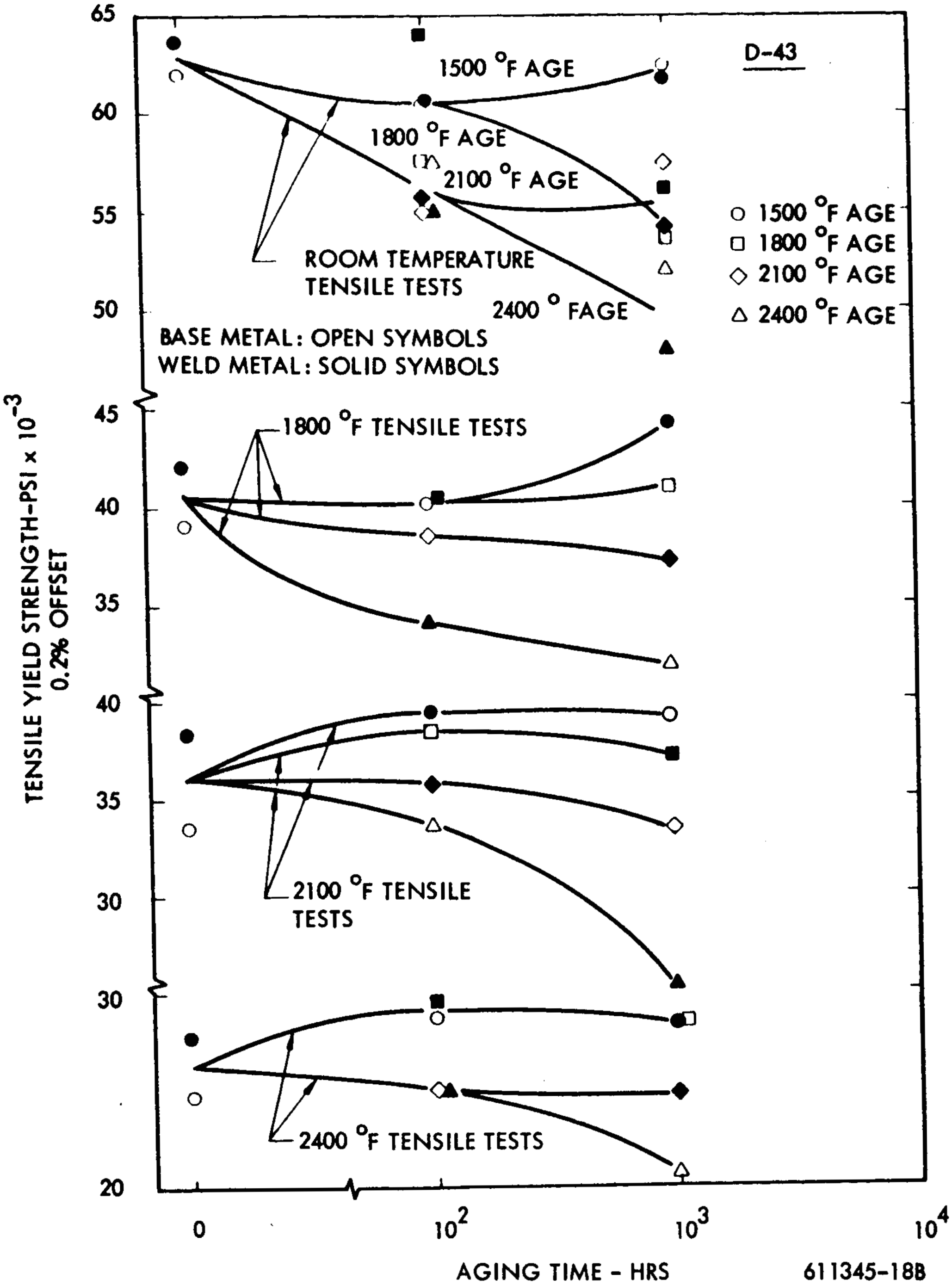
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 28 - Effect of Aging on the Elongation of D-43Y



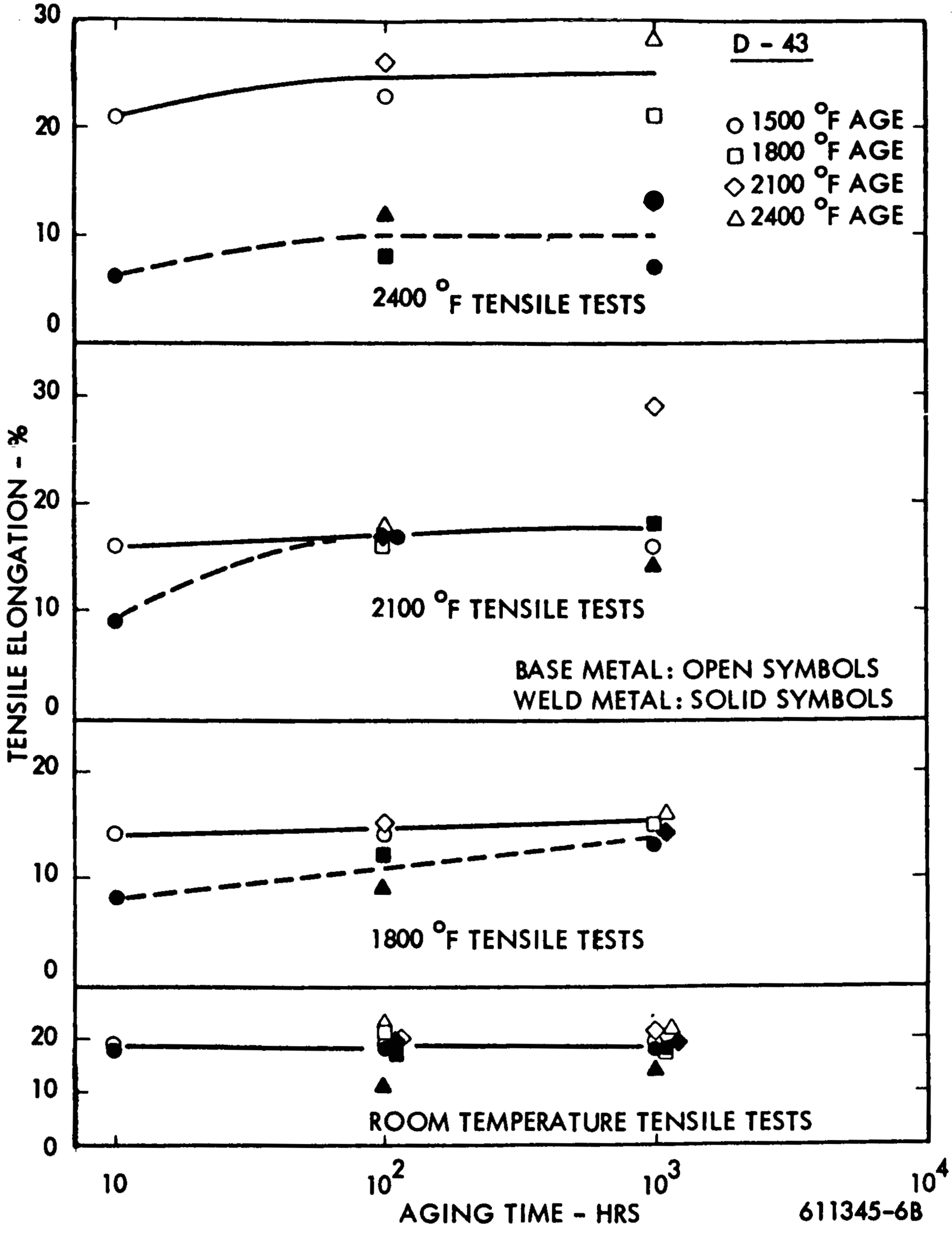
NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 29 - Effect of Aging on the Tensile Strength of D-43



NOTE: OPTIMUM WELD PARAMETERS, ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 30 - Effect of Aging on the Yield Strength of D-43



NOTE: OPTIMUM WELD PARAMETERS ALL SAMPLES ANNEALED 1 HR. AT 2400 °F PRIOR TO AGING AND TESTING

FIGURE 31 - Effect of Aging on the Elongation of D-43

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