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MATERIALS-PROPERTY-DESIGN CRITERIA FOR METALS

PART VI THE CONVENTIONAL SHORT-TIME ELEVATED-TEMPERATURE
PROPERTIES OF SELECTED LIGHT ALLOYS

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FOREWORD

This report was prepared by Battelle Memorial Institute, Columbus, Ohio, under Contract No. AF 33(616)-3965. The investigation was initiated under Project No. 7360, "Materials Analysis and Evaluation Techniques", Task No. 73605, "Design Data for Metals". It was administered under the direction of the Materials Laboratory, Directorate of Laboratories, Wright Air Development Center with Mr. D. A. Shinn acting as project engineer.

This research has been carried out under the supervision of H. J. Grover, Chief of the Applied Mechanics Division, with valuable consultation from S. A. Gordon. Other Battelle staff members who participated to considerable extent in the program include A. R. Hunter and I. E. Hanna.

This report covers work conducted from January 1, 1957, to June 30, 1957.

ABSTRACT

Described in this report is a compilation of data on the conventional short-time elevated-temperature properties of selected light alloys applicable to airframe and missile fabrication. The resulting recommended design data obtained in this study has been presented in such form as to be directly applicable to Bulletin ANC-5 (issued by the Air Force-Navy-Civil Panel) on "Strength of Metal Aircraft Elements".

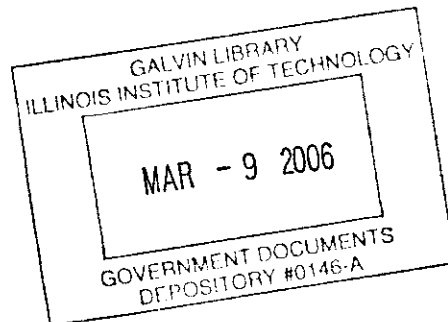
PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:



RICHARD R. KENNEDY
Chief, Metals Branch
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INTRODUCTION

In Part 5 of WADC TR 55-150, data on the conventional short-time elevated-temperature properties of selected stainless steels and some heat-resistant alloys were presented. Continued in Part VI is a compilation made on selected light alloys. The aim, as before, is to provide information to the ANC-5 Panel for supplementing and revising the current issue of the ANC-5 Bulletin on "Strength of Metal Aircraft Elements".

It should be emphasized that the recommended design curves included herein are not necessarily identical to any which will ultimately appear in ANC-5. Use of any data appearing herein is, therefore, subject to approval by the procuring or certificating agency.

The alloys and conditions considered in this report are 2014-T4, and -T6; 2024-T3, -T4, -T6, -T36, -T81, and -T86; 2218-T61; X2219-T6; 7075-T6 aluminum alloys; HK31A-T6, and HK31A-H24 magnesium alloy; and Ti(8Mn) titanium alloy. A short summary of alloy technical data and a description of each alloy are presented in the respective sections of this report.

Reference numbers appearing on graphs in this report refer to the Bibliography in WADC TR 55-150, Part 5, and to the supplementary list in the appendix of this report. Acknowledgement is given to those listed below who contributed greatly to this report:

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Continental
2014 ALUMINUM ALLOY

Alloy Specification

QQ-A-255

General

The alloy 2014 is a heat-treatable aluminum alloy and is used generally where high strength, relatively good formability, and high hardness are required. For example, some airframe sheet and plate applications utilize clad 2014-T6.

The chemical-composition limits of 2014 and its cladding material, 6003, are given in Table 1.

TABLE 1. CHEMICAL-COMPOSITION LIMITS OF
2014 ALUMINUM ALLOY AND ITS
CLADDING MATERIAL, 6003

Element	Weight Per Cent*	
	2014	6003
Copper	3.9 - 5.0	0.10
Silicon	0.50 - 1.2	0.35 - 1.0
Manganese	0.40 - 1.2	0.8
Magnesium	0.20 - 0.8	0.8 - 1.5
Iron	1.0	0.6
Chromium	0.10	0.35
Zinc	0.25	0.20
Titanium	0.15	0.10
Others, each	0.05	0.05
Total	0.15	0.15
Aluminum	Balance	Balance

*Weight per cent is maximum, unless shown as a range.

Alloy 2014 has a relatively stable and workable room-temperature-aged temper, -T4, permitting parts to be formed and subsequently artificially aged with minimum distortion. Typical mechanical-properties for clad 2014-T6 at room temperature are:

- (1) Ultimate tensile strength - 68,000 psi
- (2) Tensile yield strength - 60,000 psi
- (3) Elongation in 2 inches - 10 per cent.

The conventional short-time elevated-temperature properties of clad 2014-T6 aluminum alloy are shown in the following curves:

Tensile strength	Figures 1 through 7
Tensile yield strength	Figures 8 through 14
Compressive yield strength	Figures 15 and 16
Shear strength	Figures 17 and 18
Bearing strength	Figures 19 and 20
Bearing yield strength	Figures 21 and 22
Modulus of elasticity	Figure 23
Stress-strain curves	Figures 24 through 35

Heat Treatment

-T4 Condition (Solution Treatment)

A solution temperature in the range of 925 to 950 F is necessary to put most of the soluble copper into solution. Temperatures above 950 F closely approach the eutectic melting temperature of 1018 F, and temperatures below 925 F result in lower-than-typical values of strength. The time to effect proper solutioning may vary from 10 minutes to 1 hour in molten salt and from 30 minutes to 6 hours in air (where the metal comes to temperature less rapidly). A cold-water quench is normally employed, but for heavy or complicated shapes, water at 150 to 212 F is used.

-T6 Condition (Solution Treatment Plus Artificial Aging)

After the material is in the -T4 condition, the -T6 condition may be developed. Heating at 335 to 345 F for 8 to 12 hours or heating at 315 to 325 F for 16 to 20 hours may be used. The cooling rate from these temperatures is not critical, but should not be unduly low. The limits of the mechanical properties for clad 2014-T6 are given in Table 2.

TABLE 2. MINIMUM MECHANICAL PROPERTIES OF
CLAD 2014-T6 ALUMINUM ALLOY
(Sheet and Plate)

Thickness, in.	Ultimate Tensile Strength, psi	Tensile Yield Strength, psi	Elongation in 2 Inches, per cent
0.020 - 0.039	63,000	55,000	7
0.040 - 0.499	64,000	57,000	8
0.500 - 1.000	67,000	59,000	6
1.001 - 1.500	67,000	59,000	4
1.501 - 2.000	65,000	59,000	3
2.001 - 3.000	63,000	57,000	2

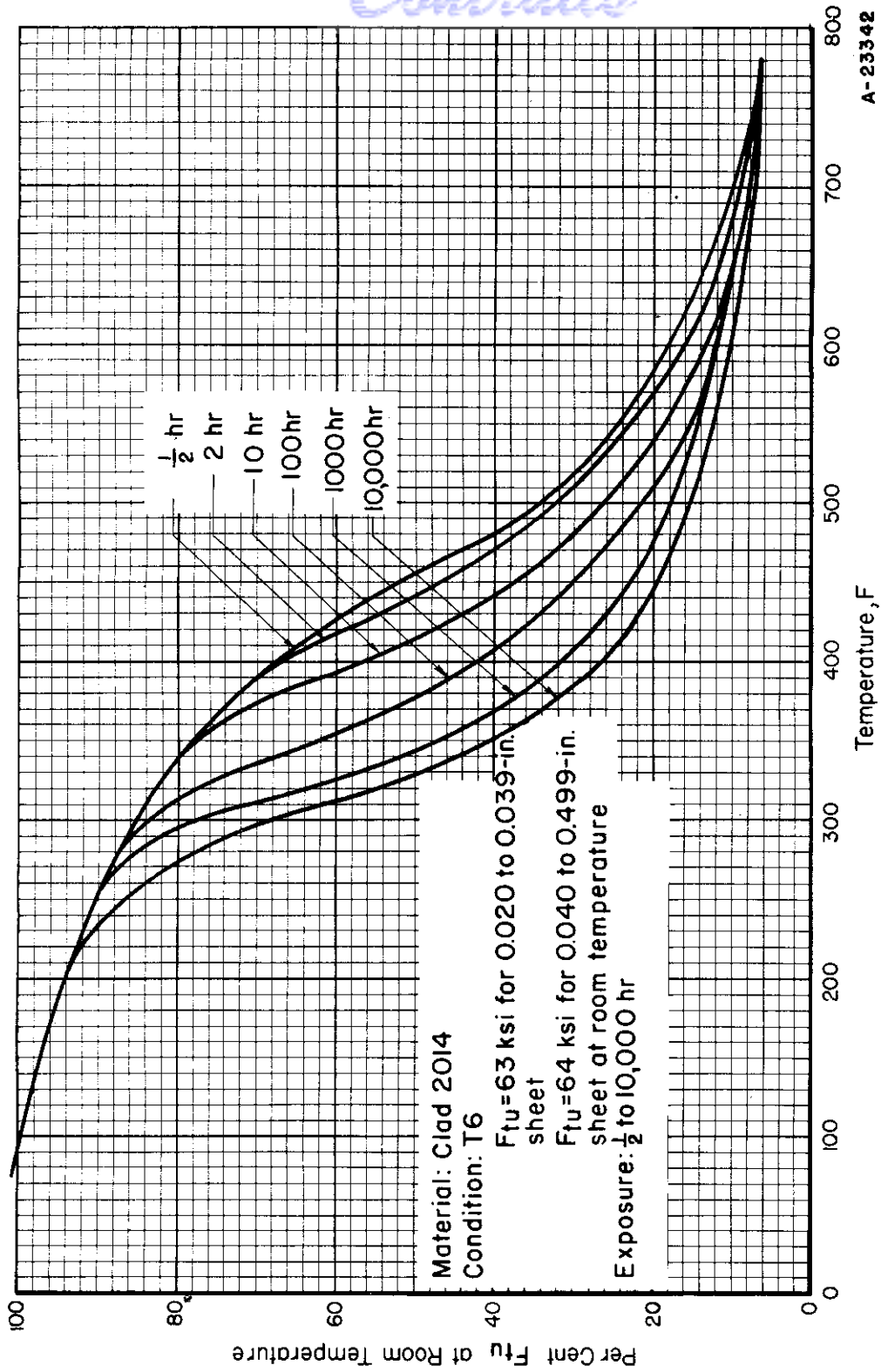


FIGURE 1. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF CLAD 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101, 58, 369.

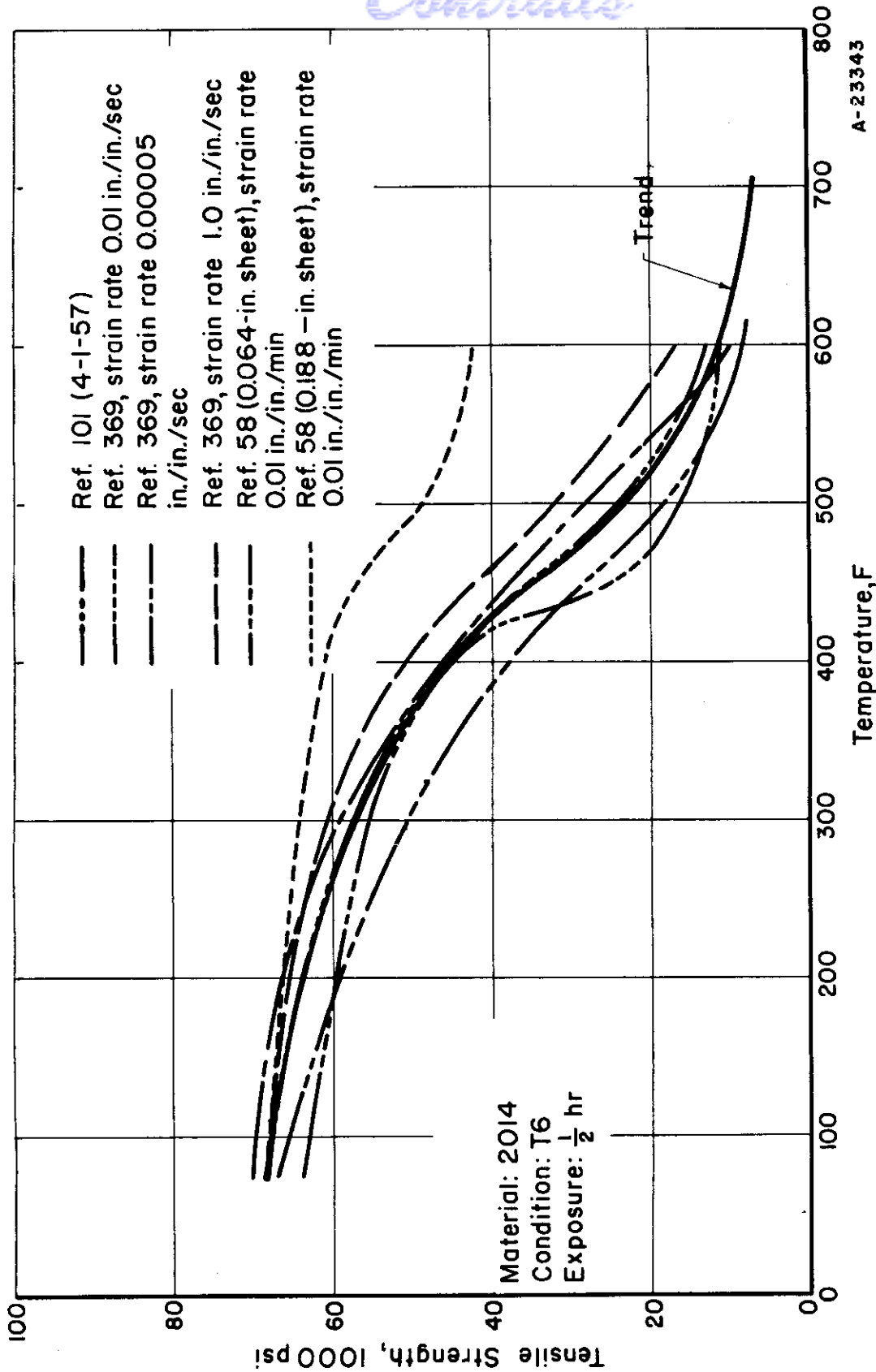
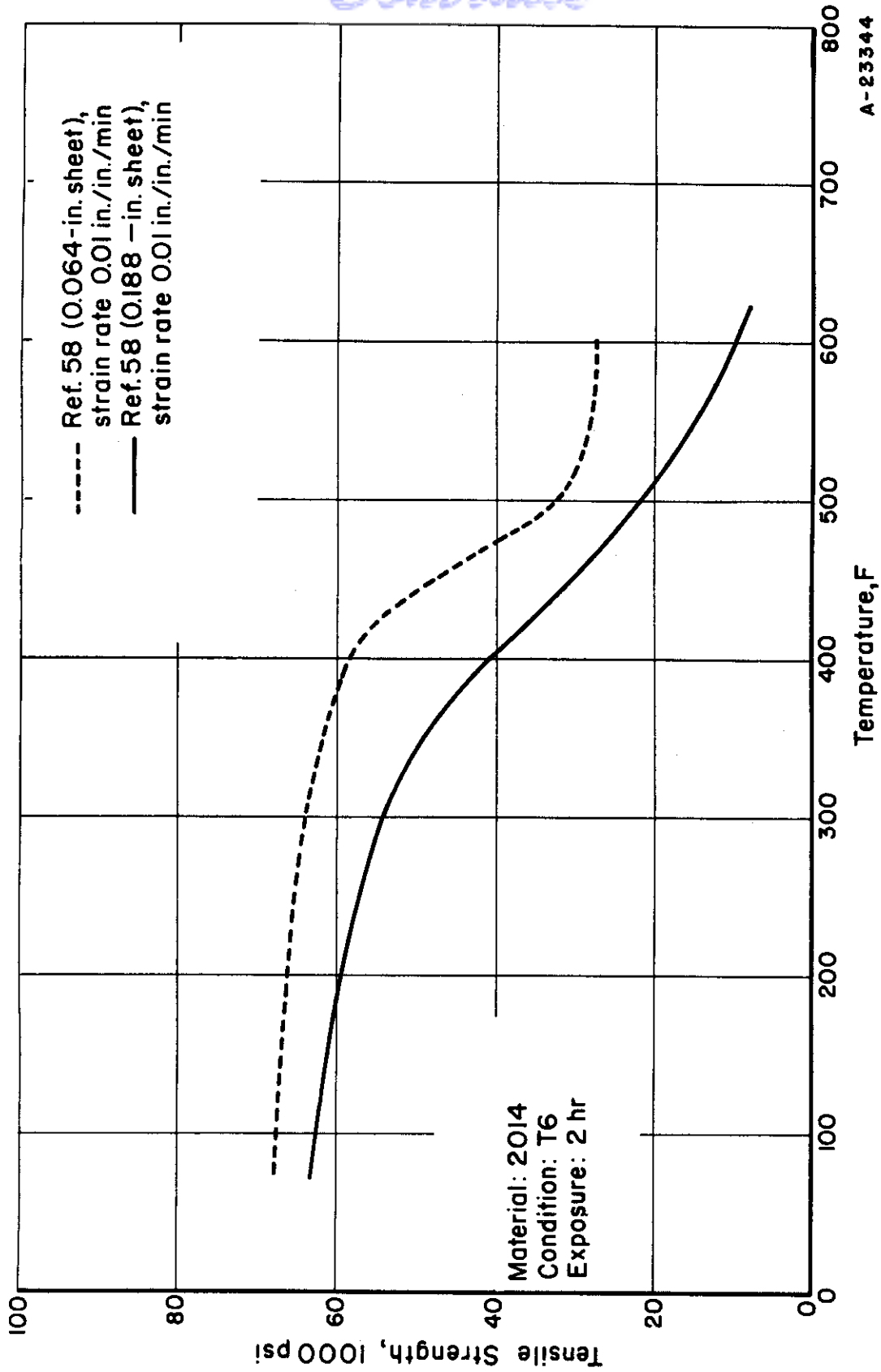


FIGURE 2. TENSILE STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



A-23344

FIGURE 3. TENSILE STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)

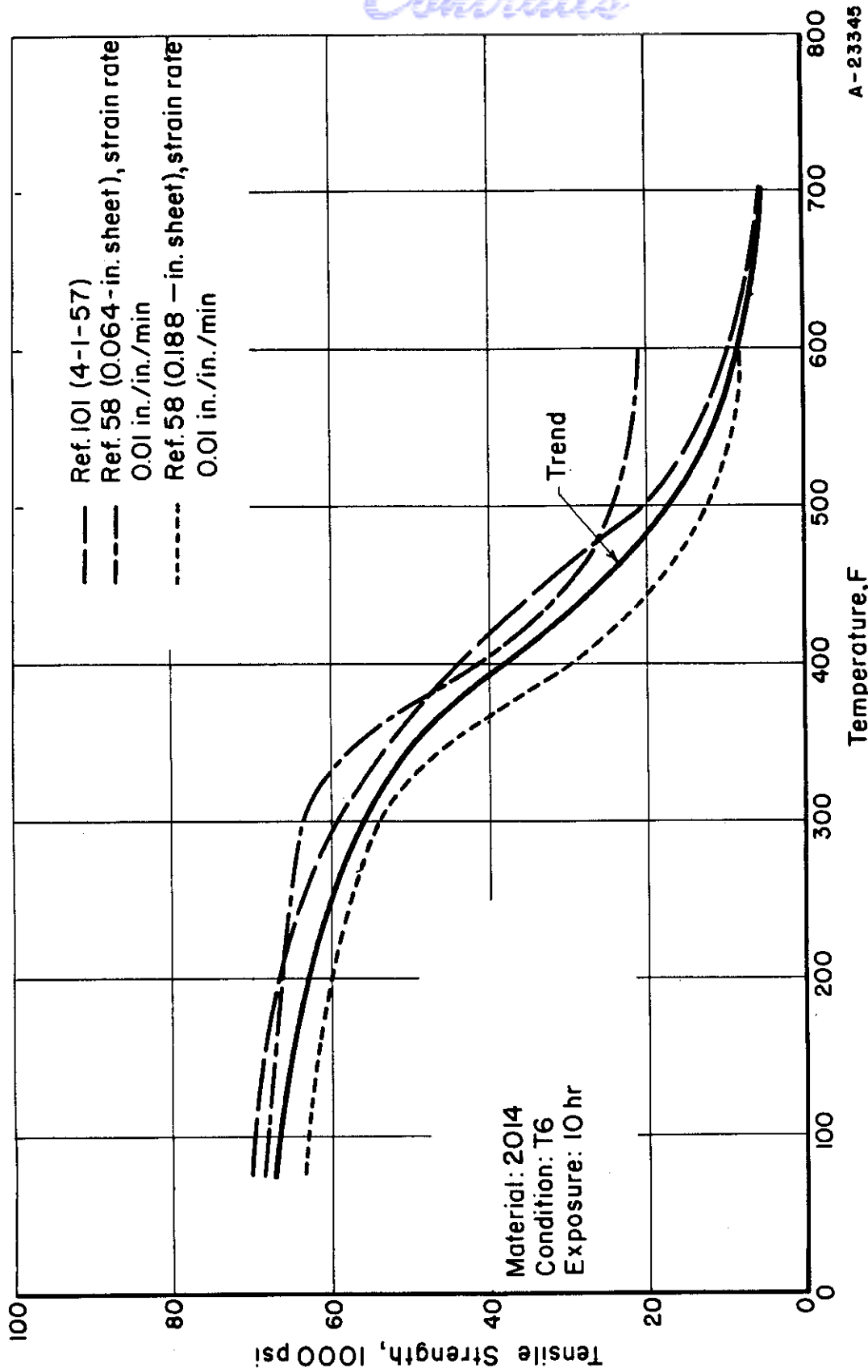
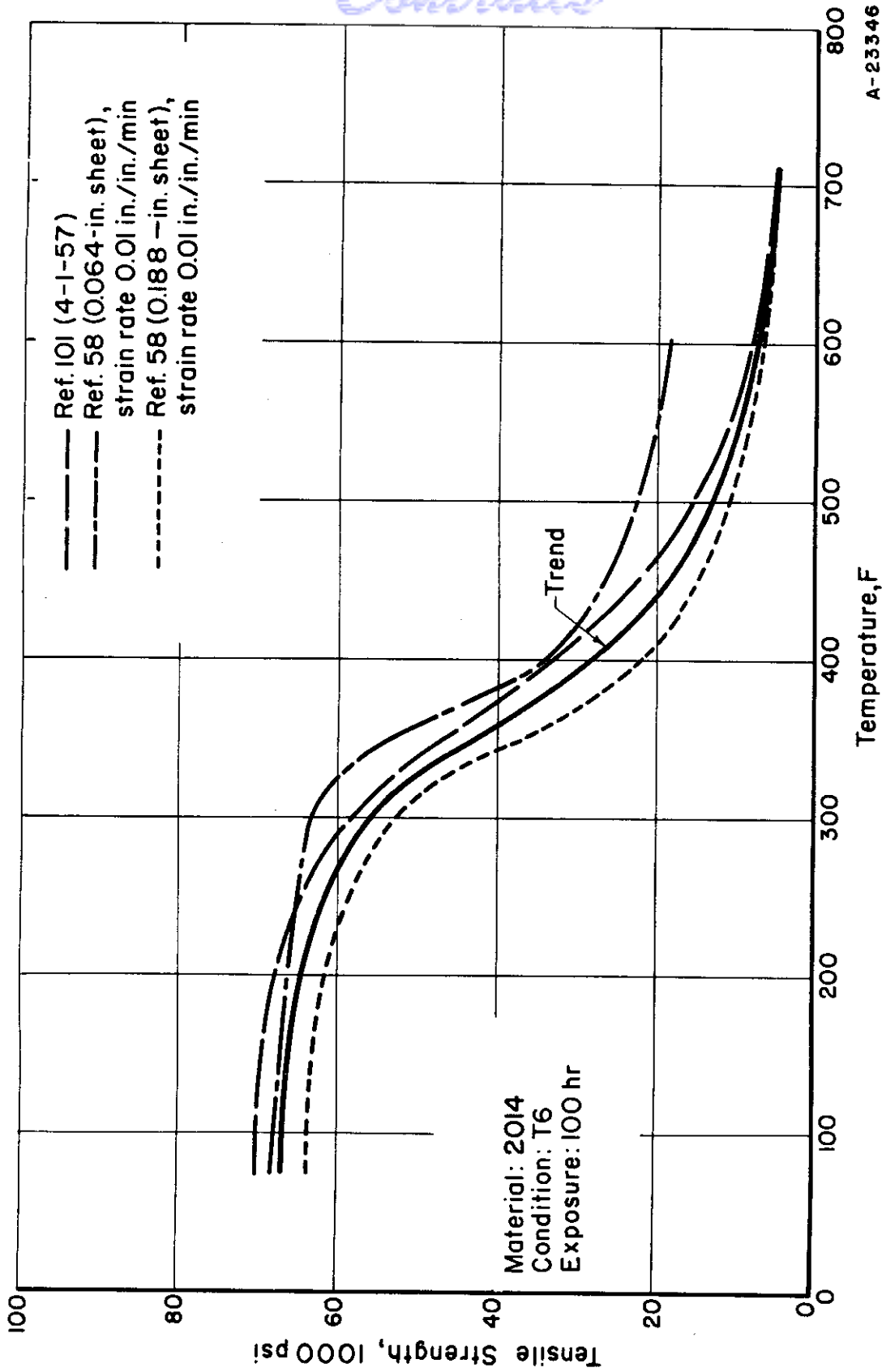
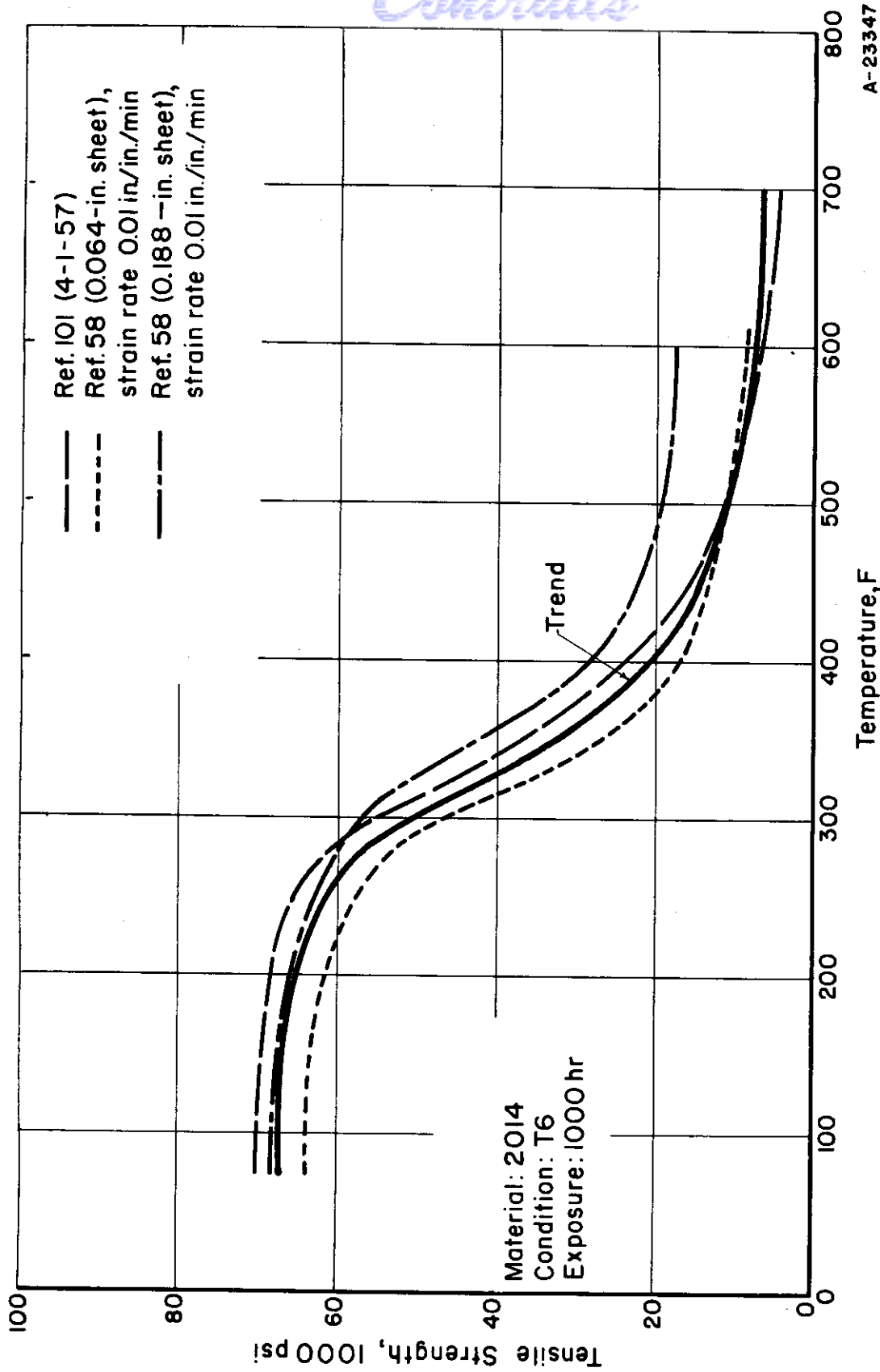


FIGURE 4. TENSILE STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)



A-23346

FIGURE 5. TENSILE STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)



A-23347

FIGURE 6. TENSILE STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

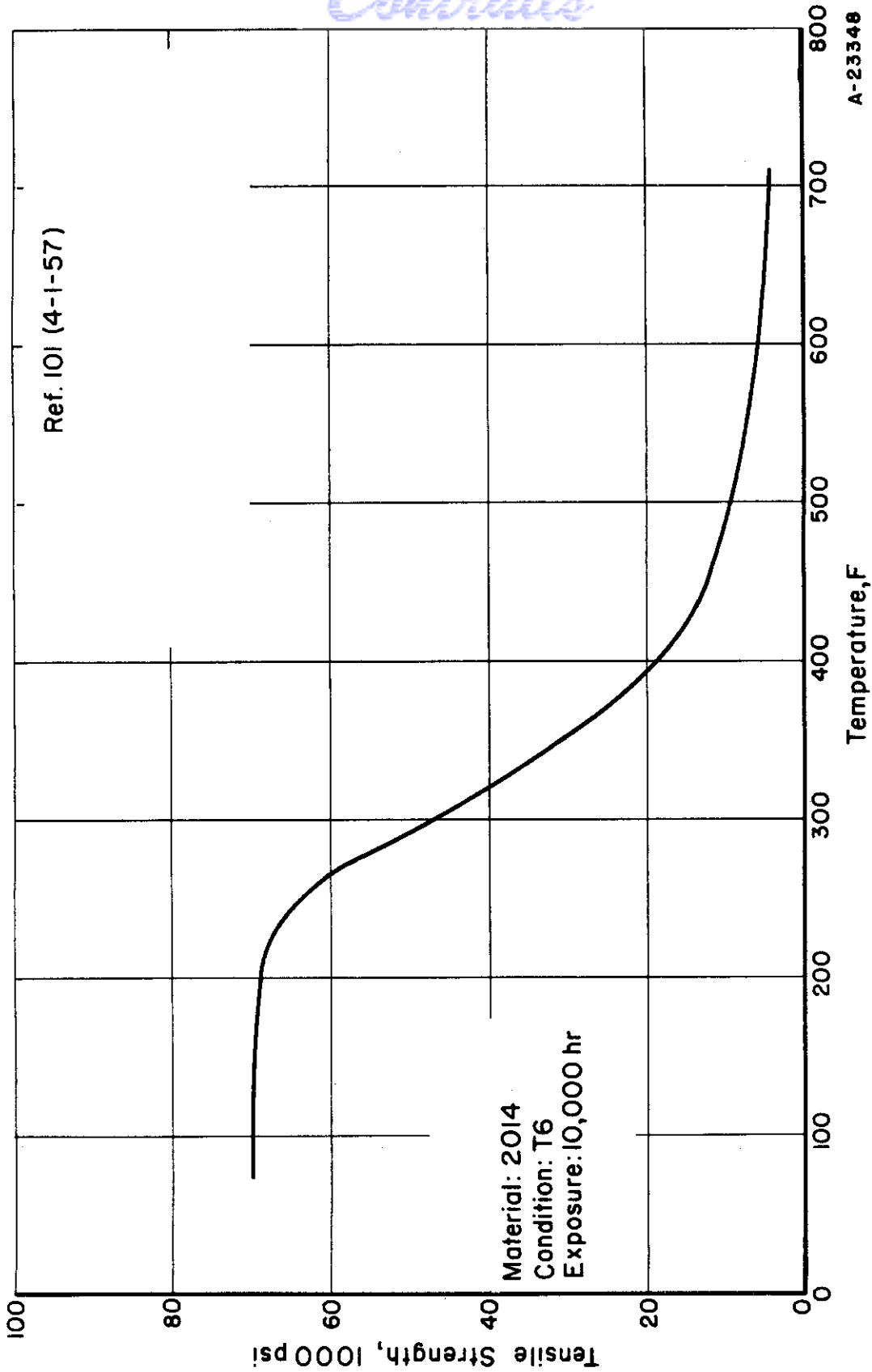


FIGURE 7. TENSILE STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

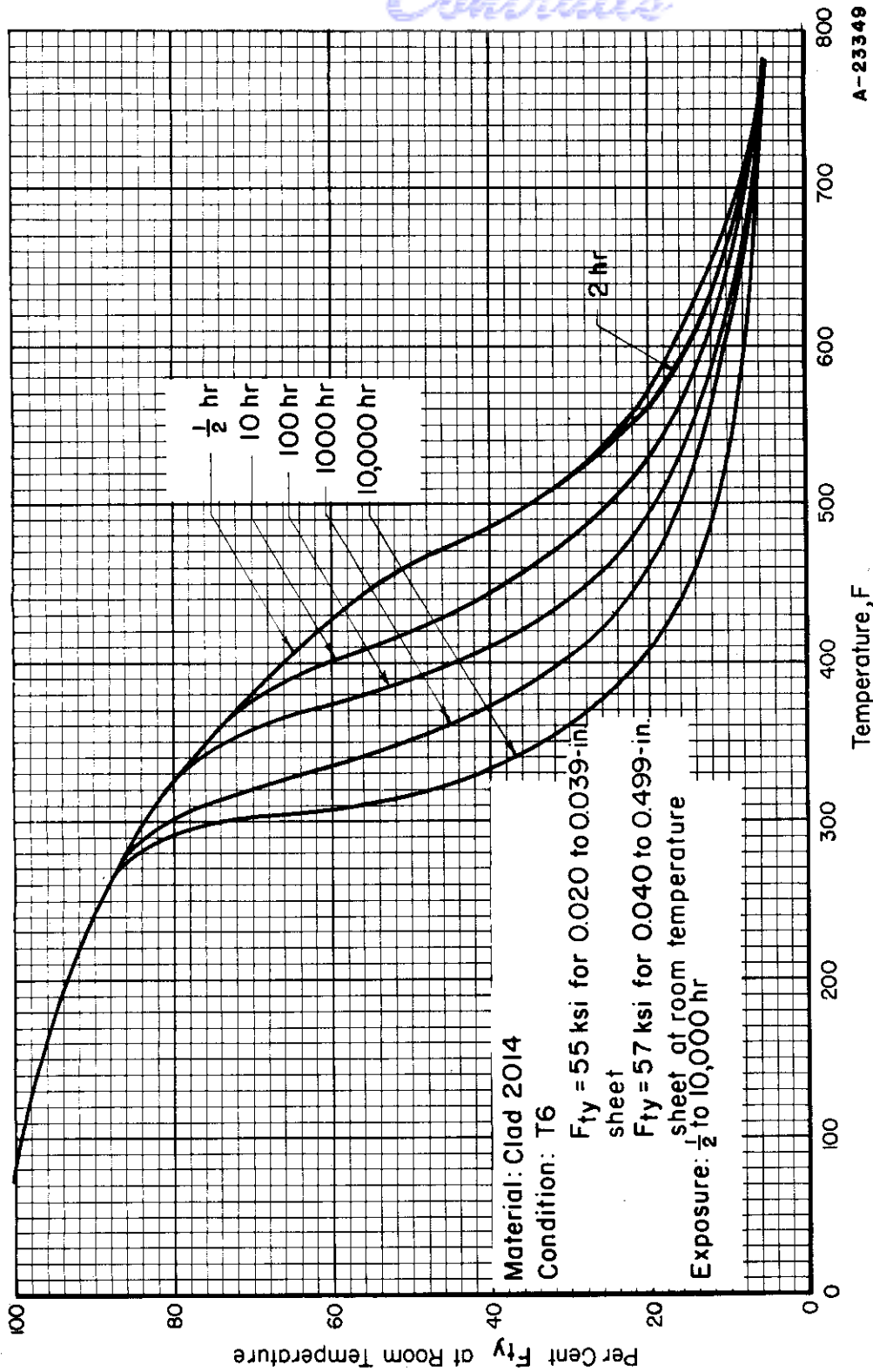


FIGURE 8. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF CLAD 2014-T6 ALUMI-NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101, 58, 369.

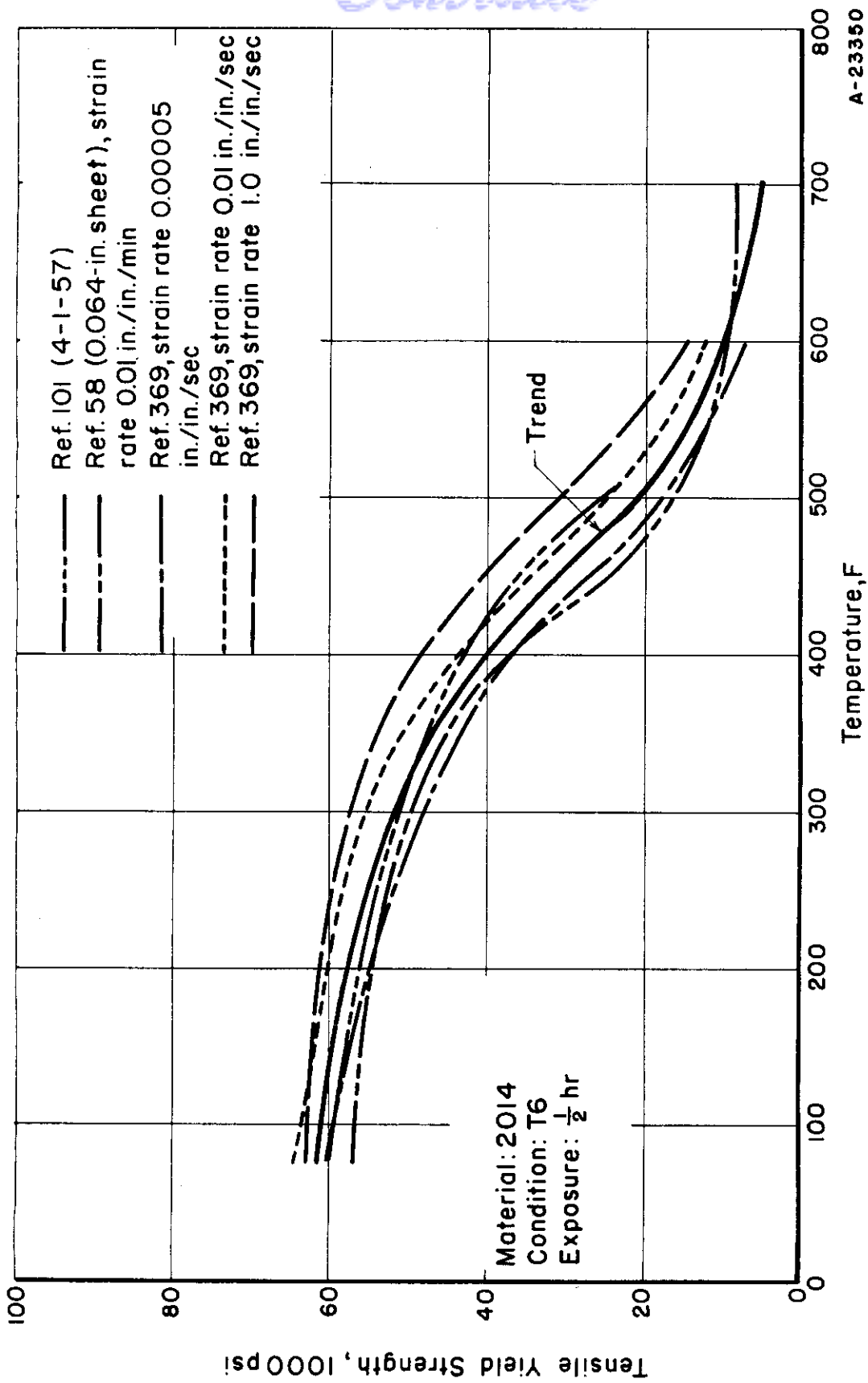


FIGURE 9. TENSILE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

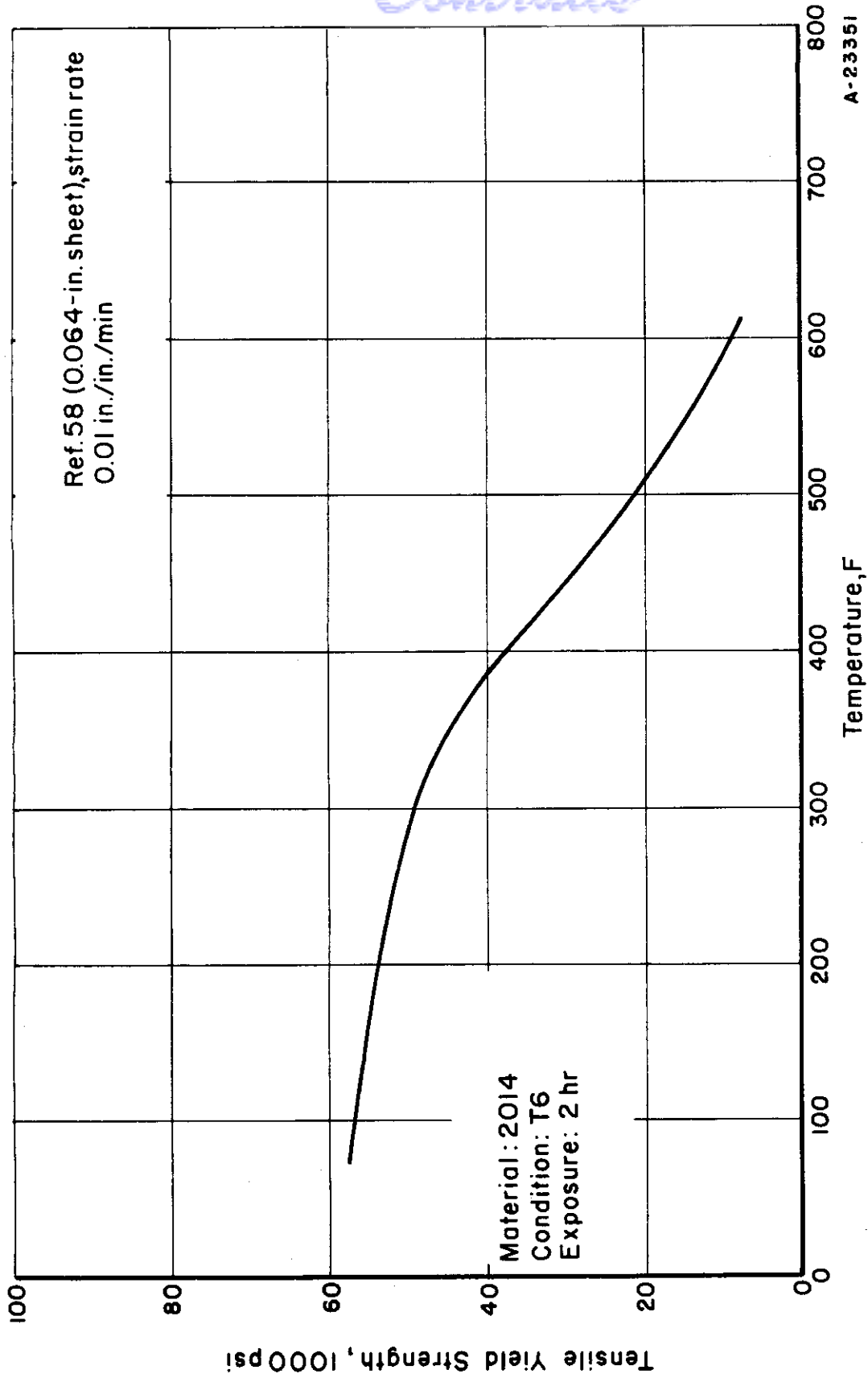


FIGURE 10. TENSILE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)

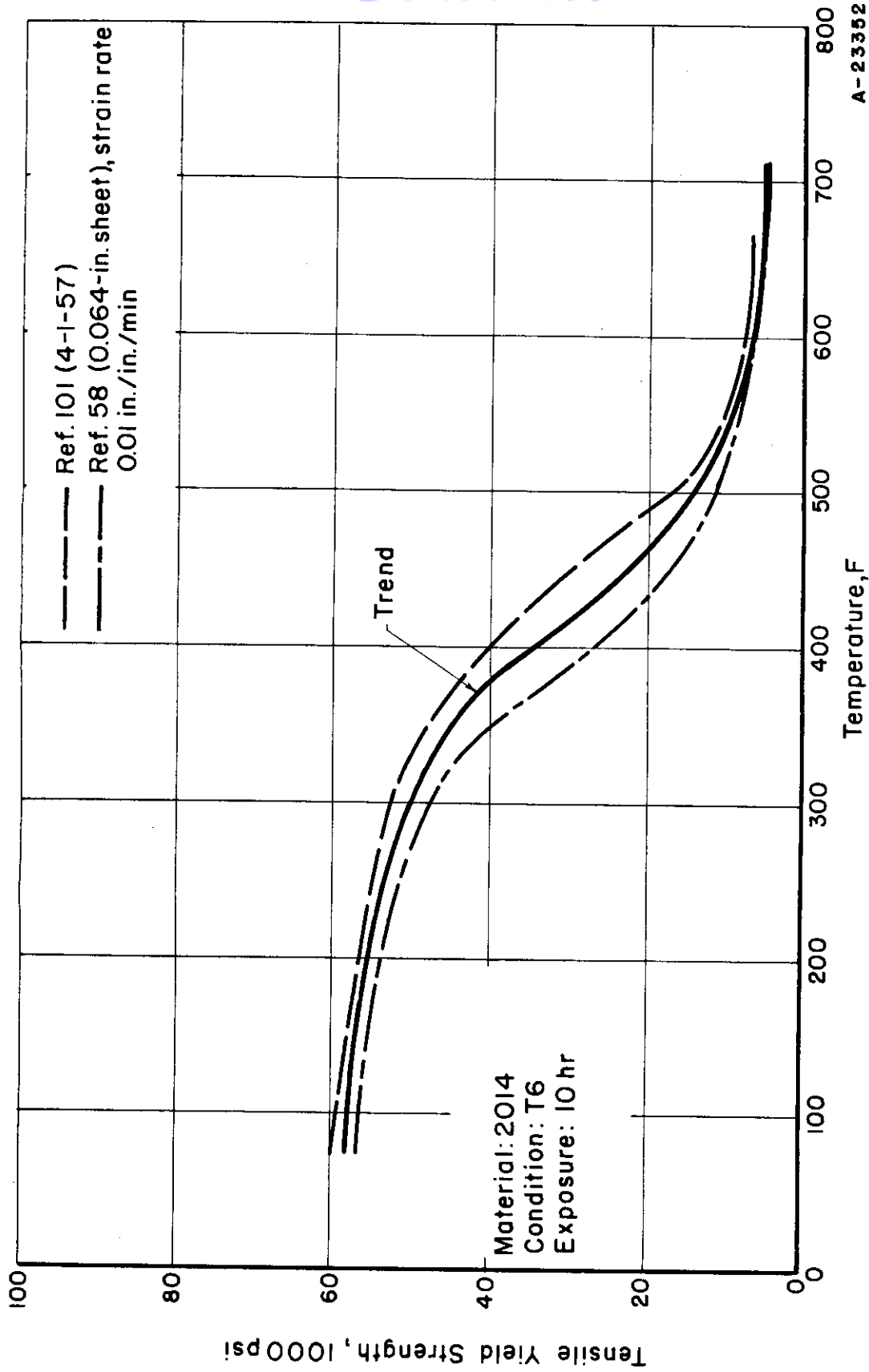


FIGURE 11. TENSILE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

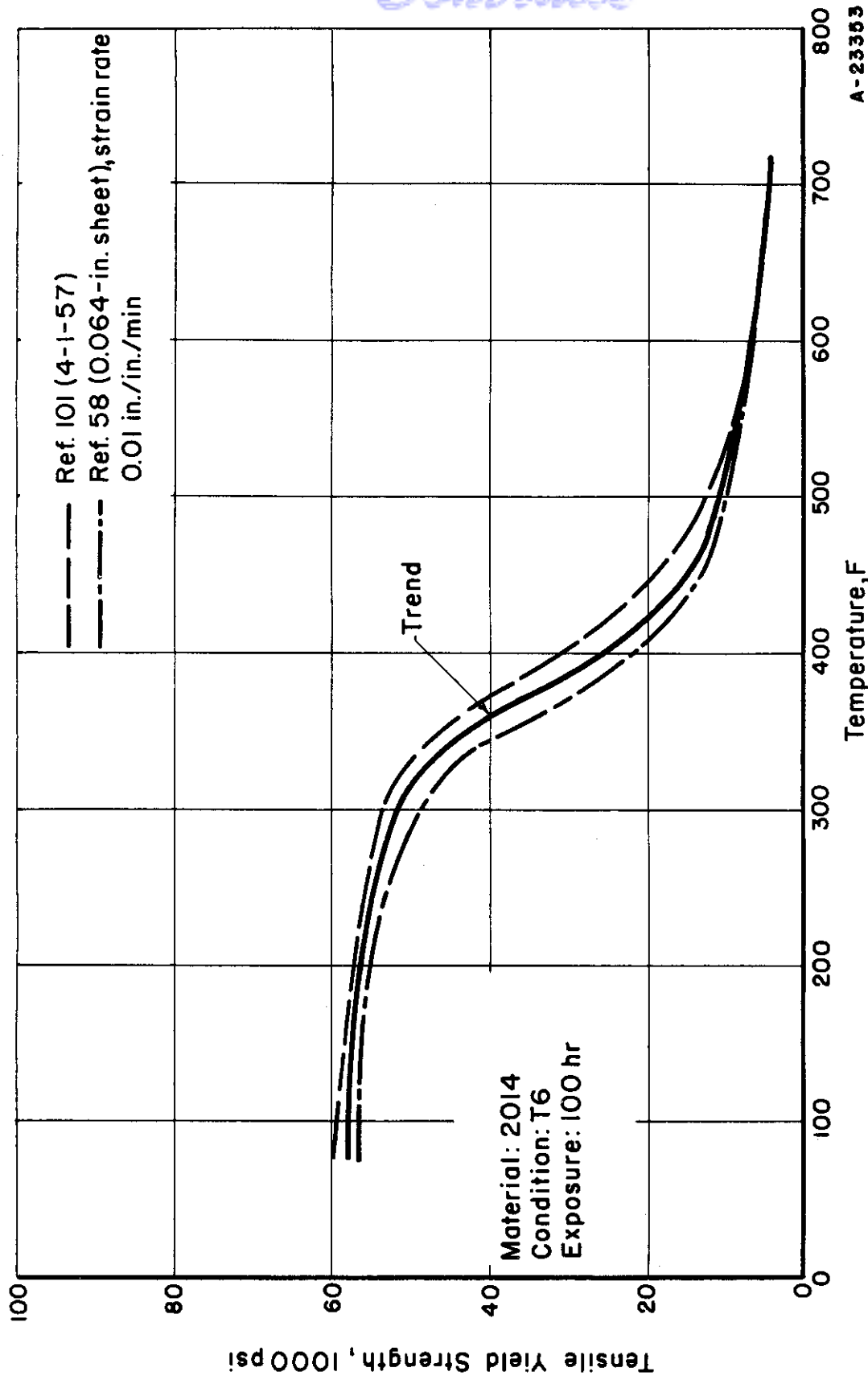
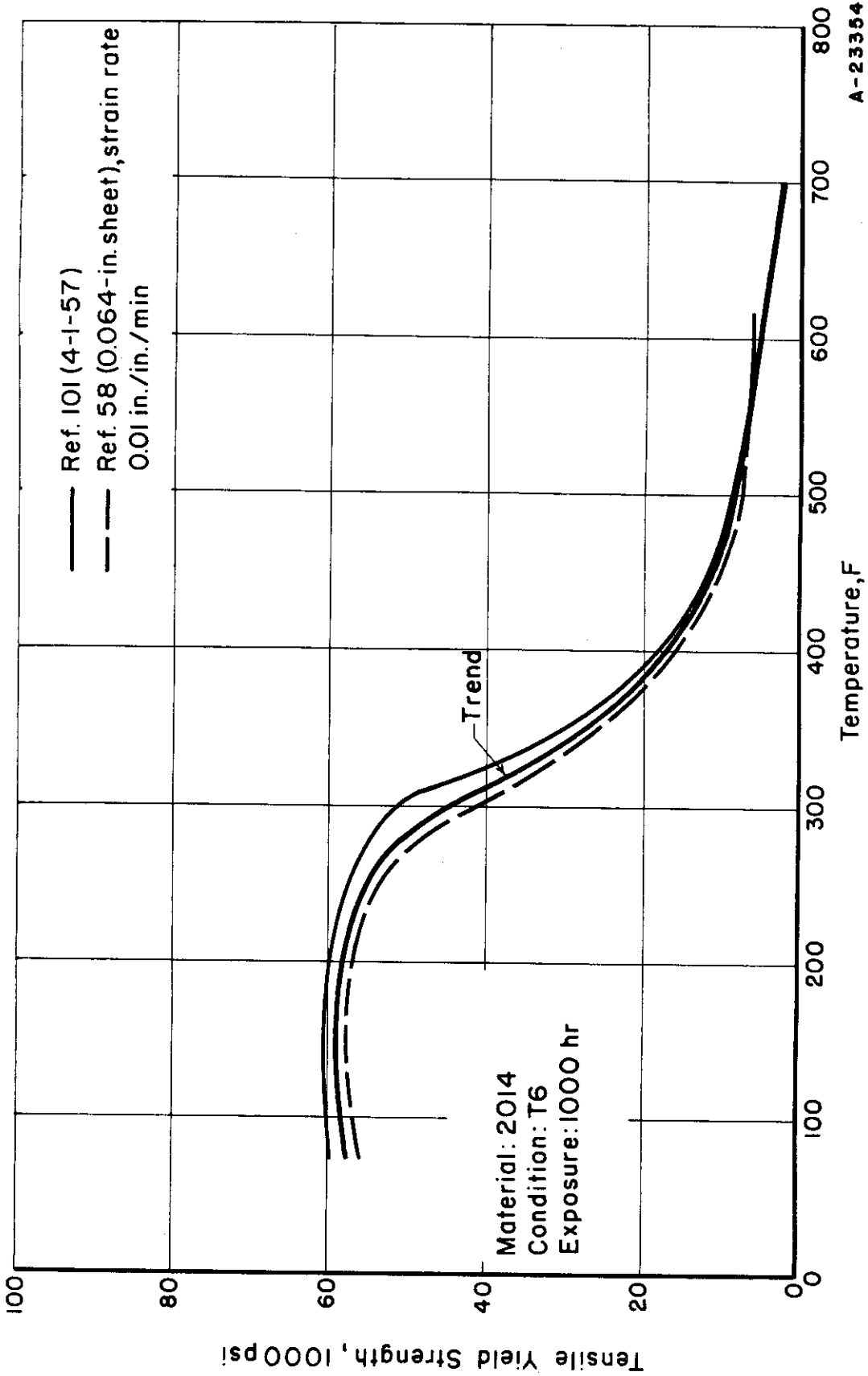
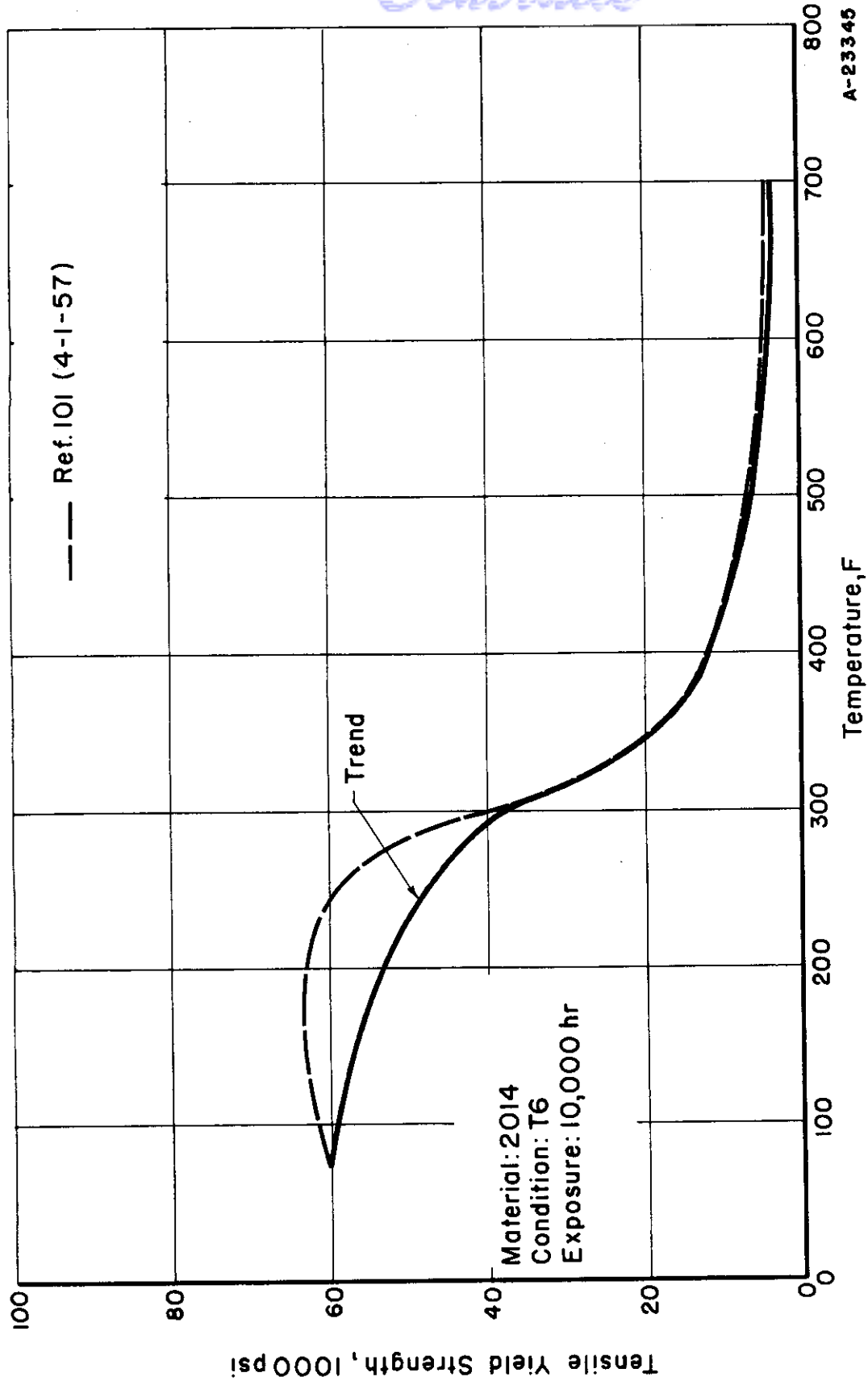


FIGURE 12. TENSILE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)



A-23354

FIGURE 13. TENSILE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)



A-23345

FIGURE 14. TENSILE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

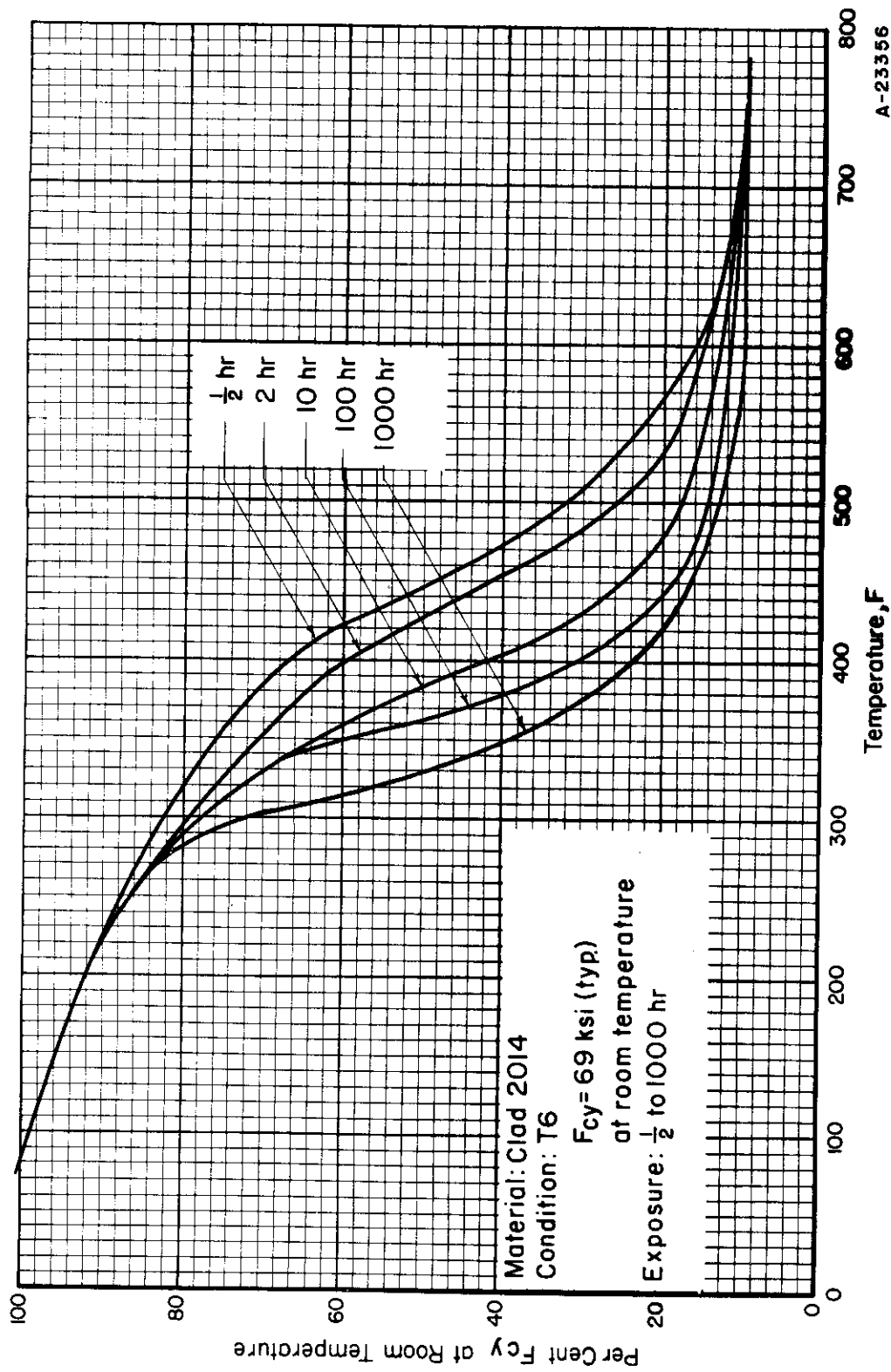
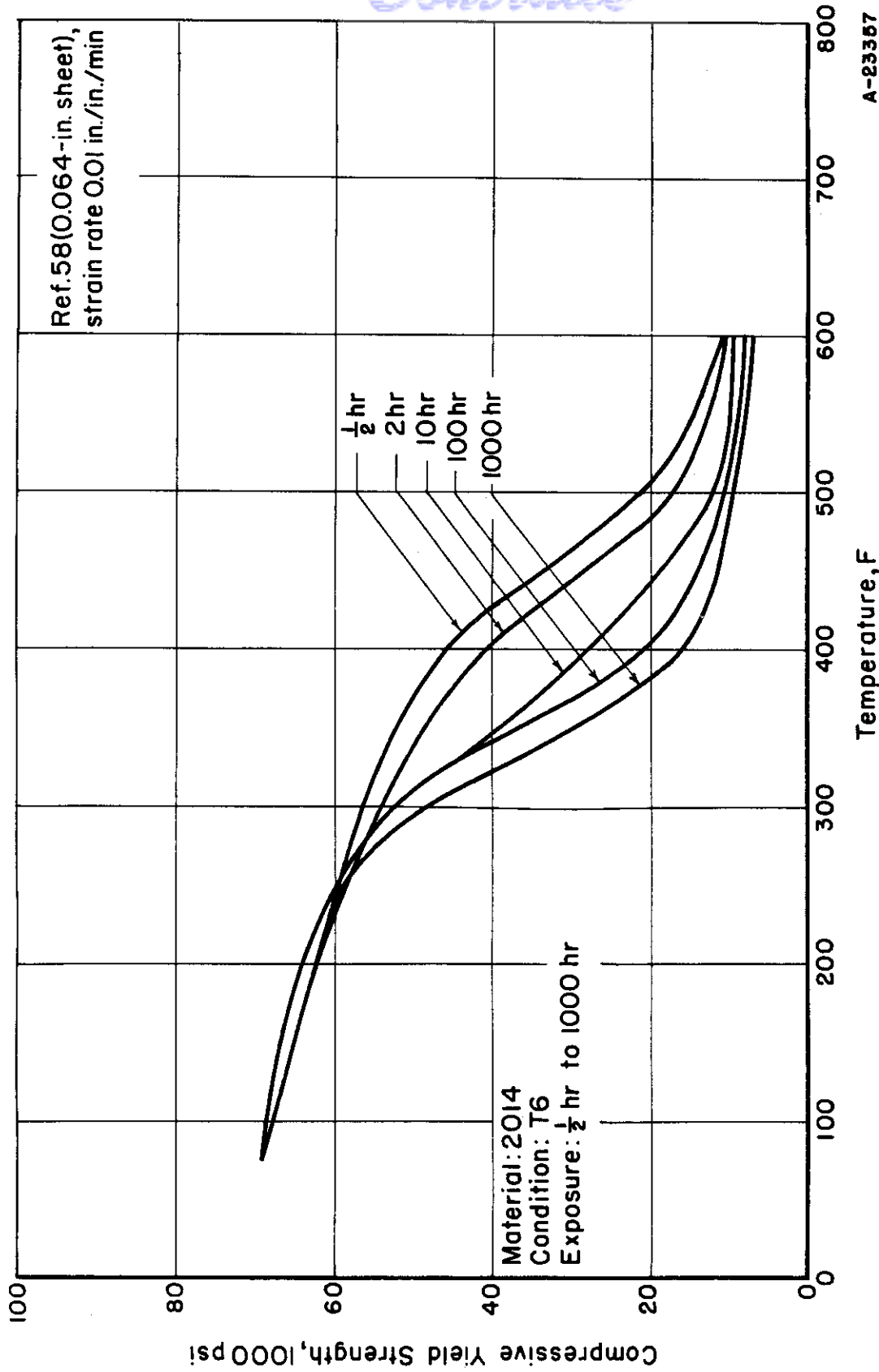


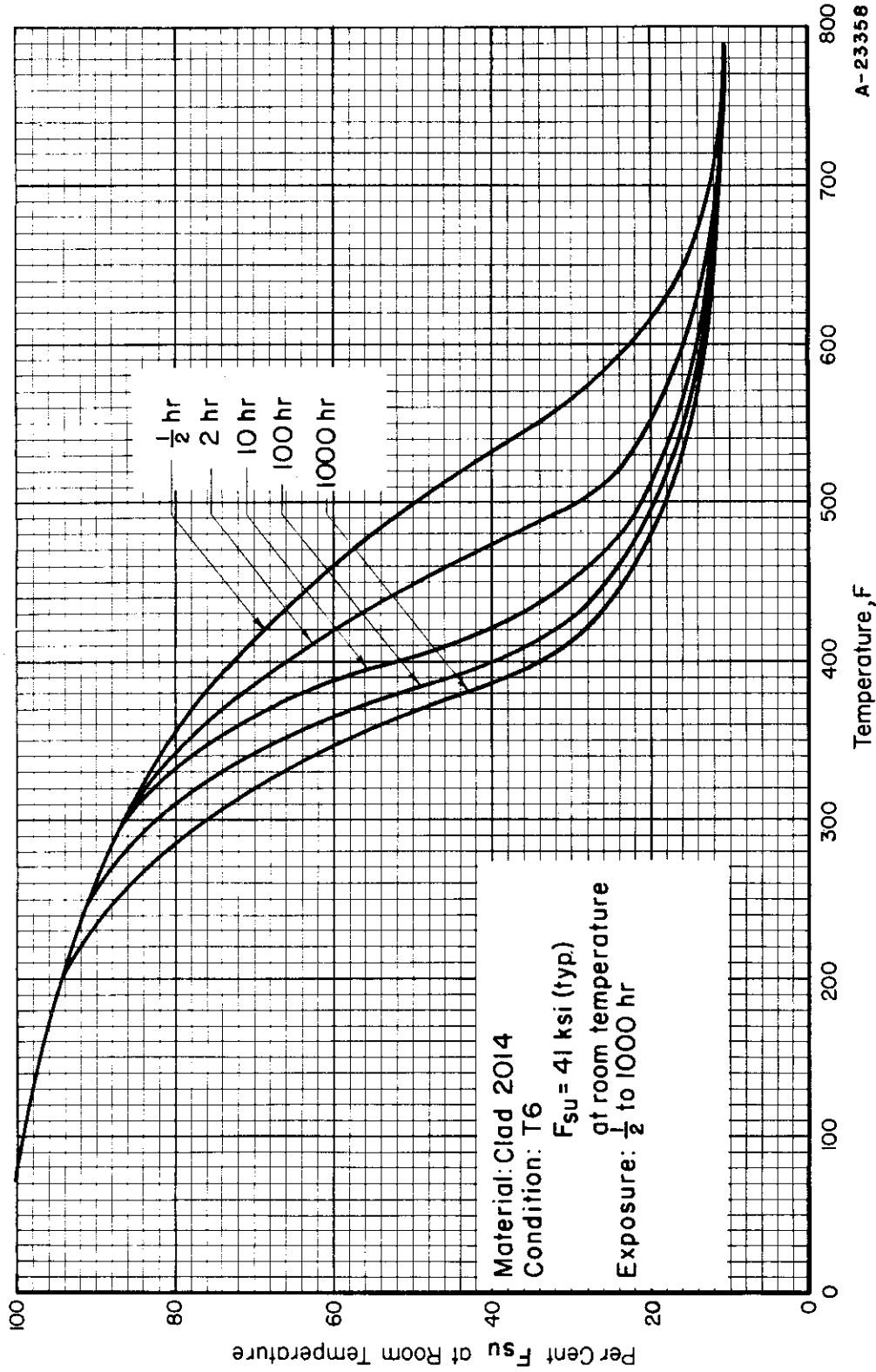
FIGURE 15. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF CLAD 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.



A-23367

FIGURE 16. COMPRESSIVE YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)



A-23358

FIGURE 17. DESIGN CURVES FOR SHEAR STRENGTH (F_{su}) OF CLAD 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

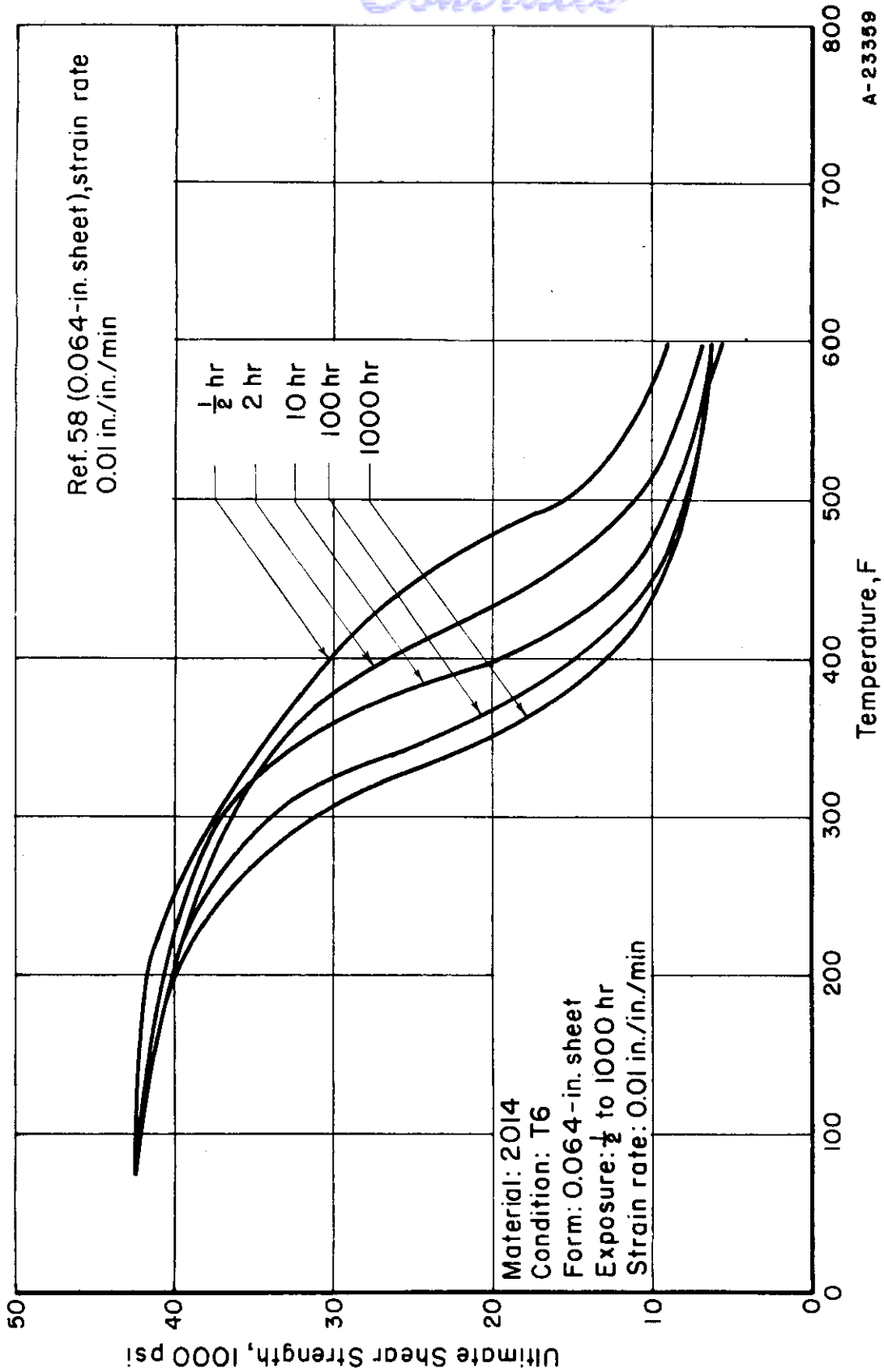


FIGURE 18. ULTIMATE SHEAR STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

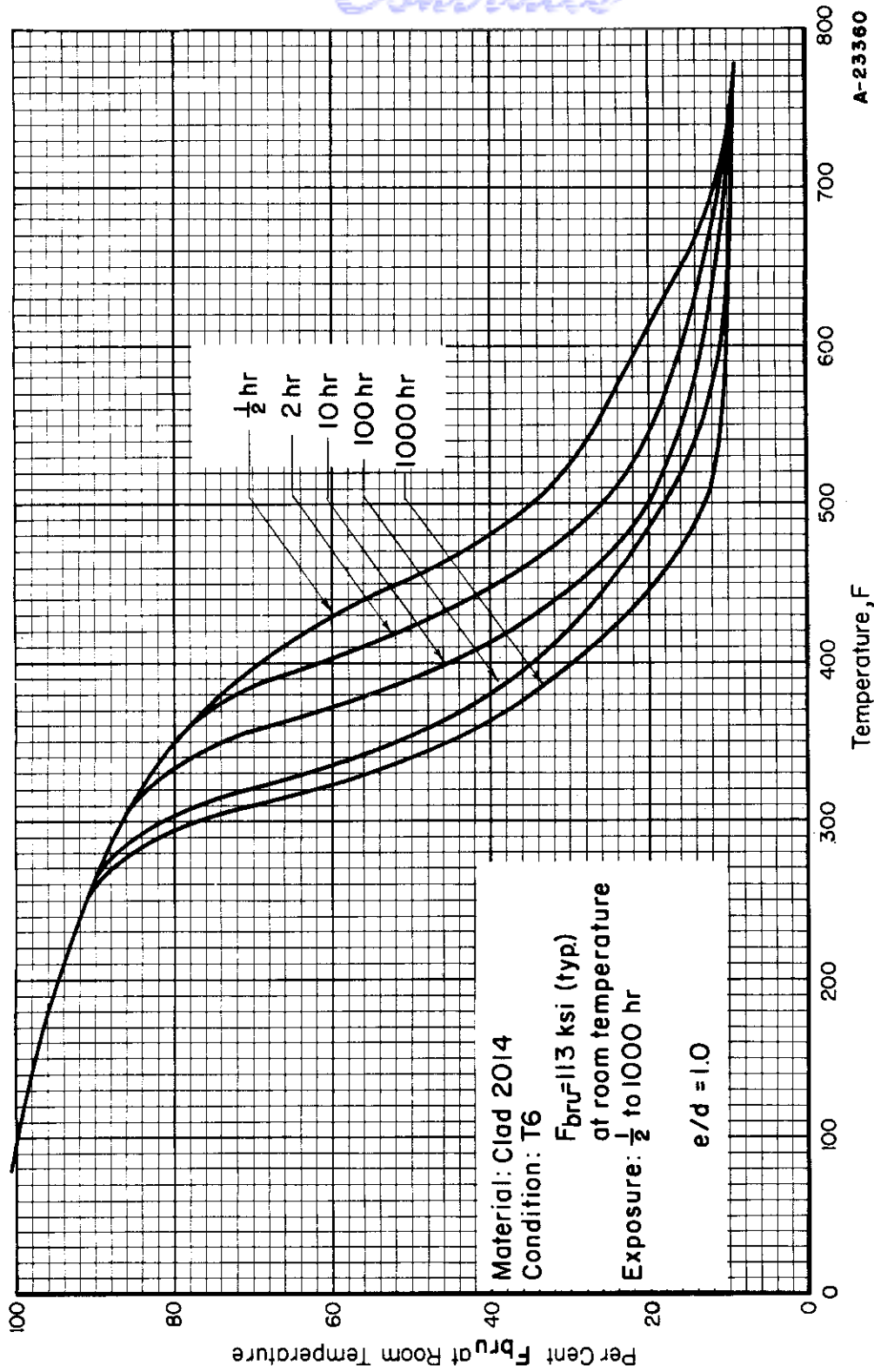


FIGURE 19. DESIGN CURVES FOR BEARING STRENGTH (F_{br}) OF CLAD 2014-T6 ALUMI-
 NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

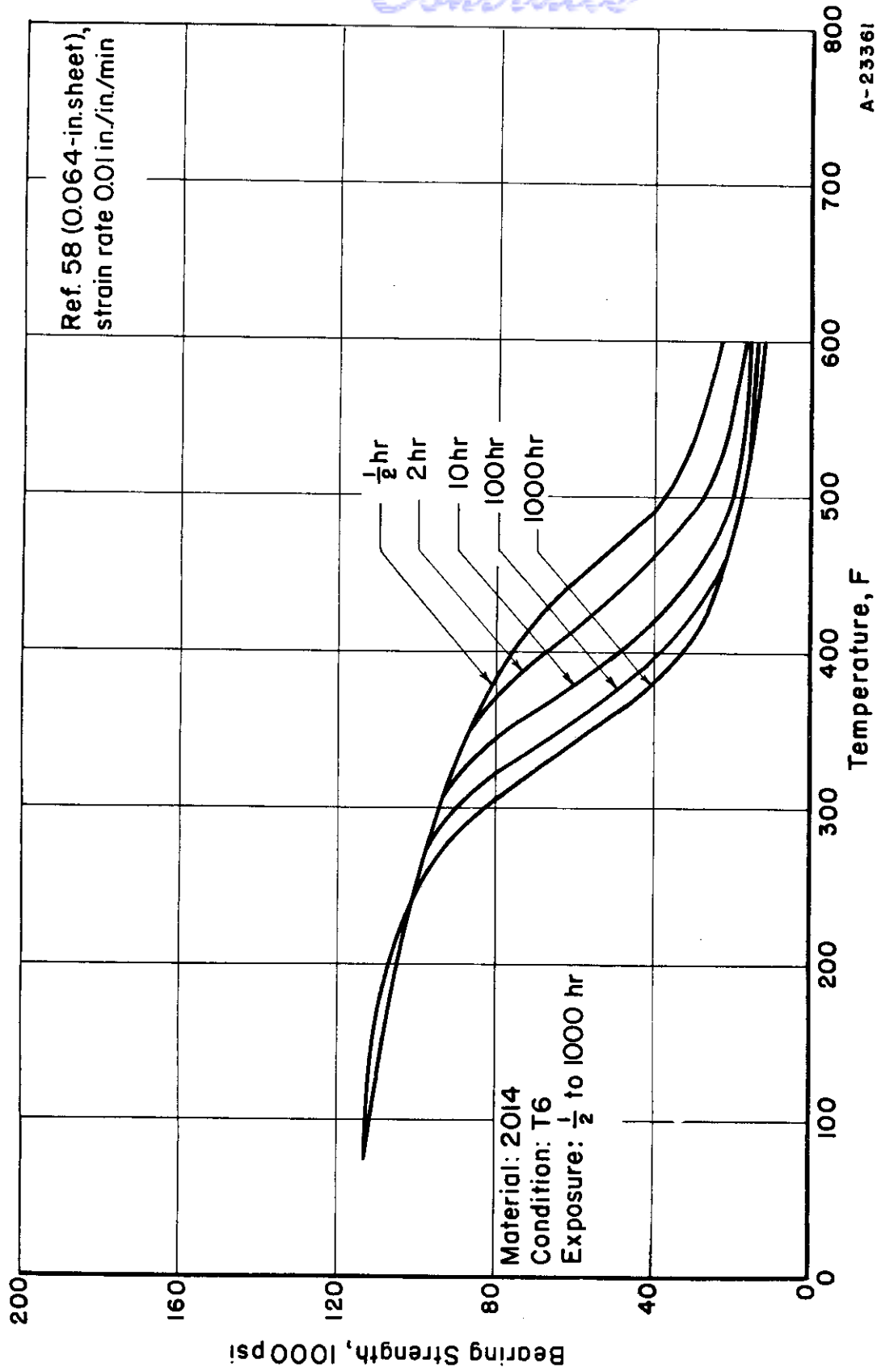


FIGURE 20. BEARING STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

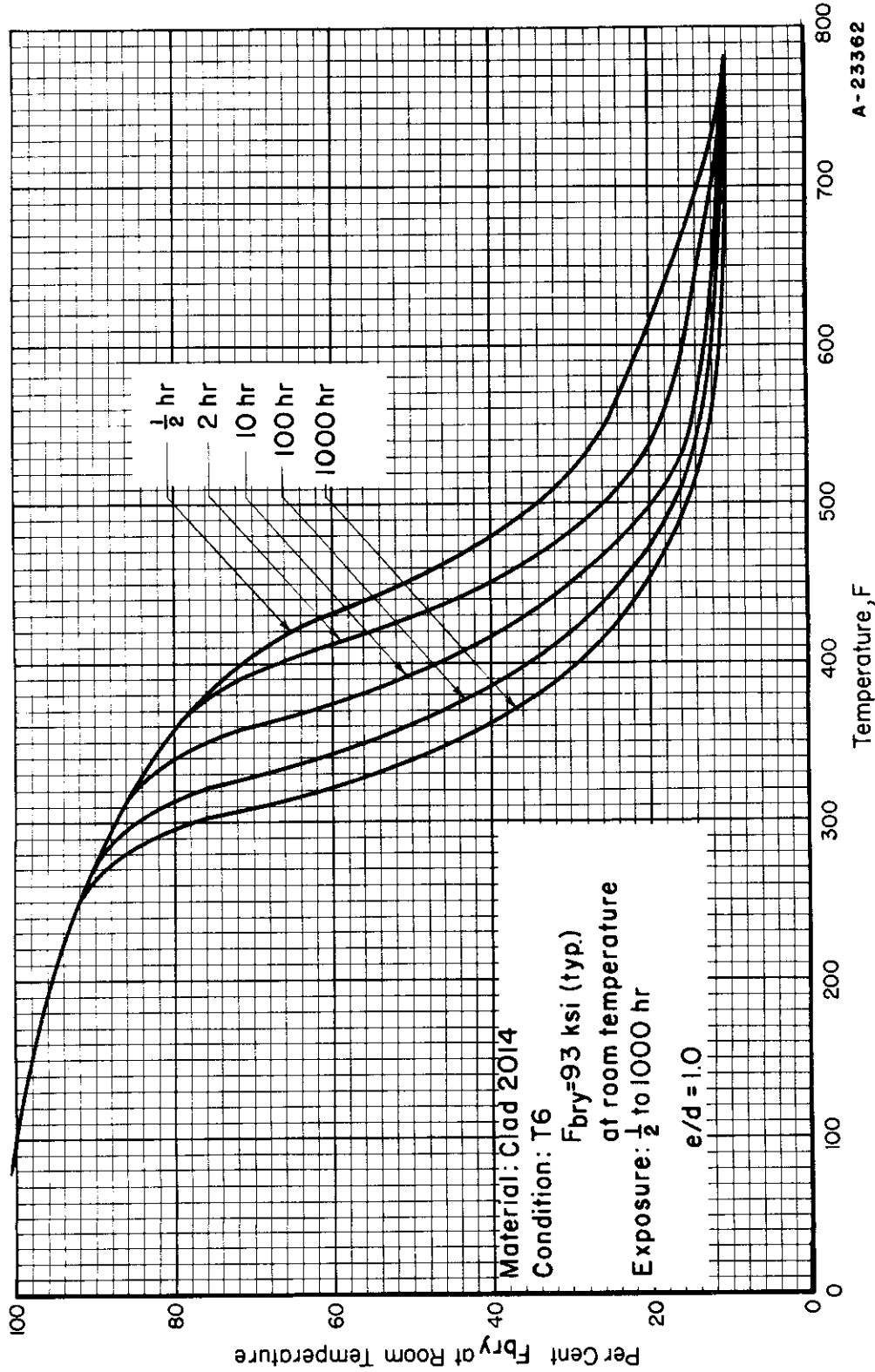


FIGURE 21. DESIGN CURVES FOR BEARING YIELD STRENGTH (F_{bry}) OF CLAD 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

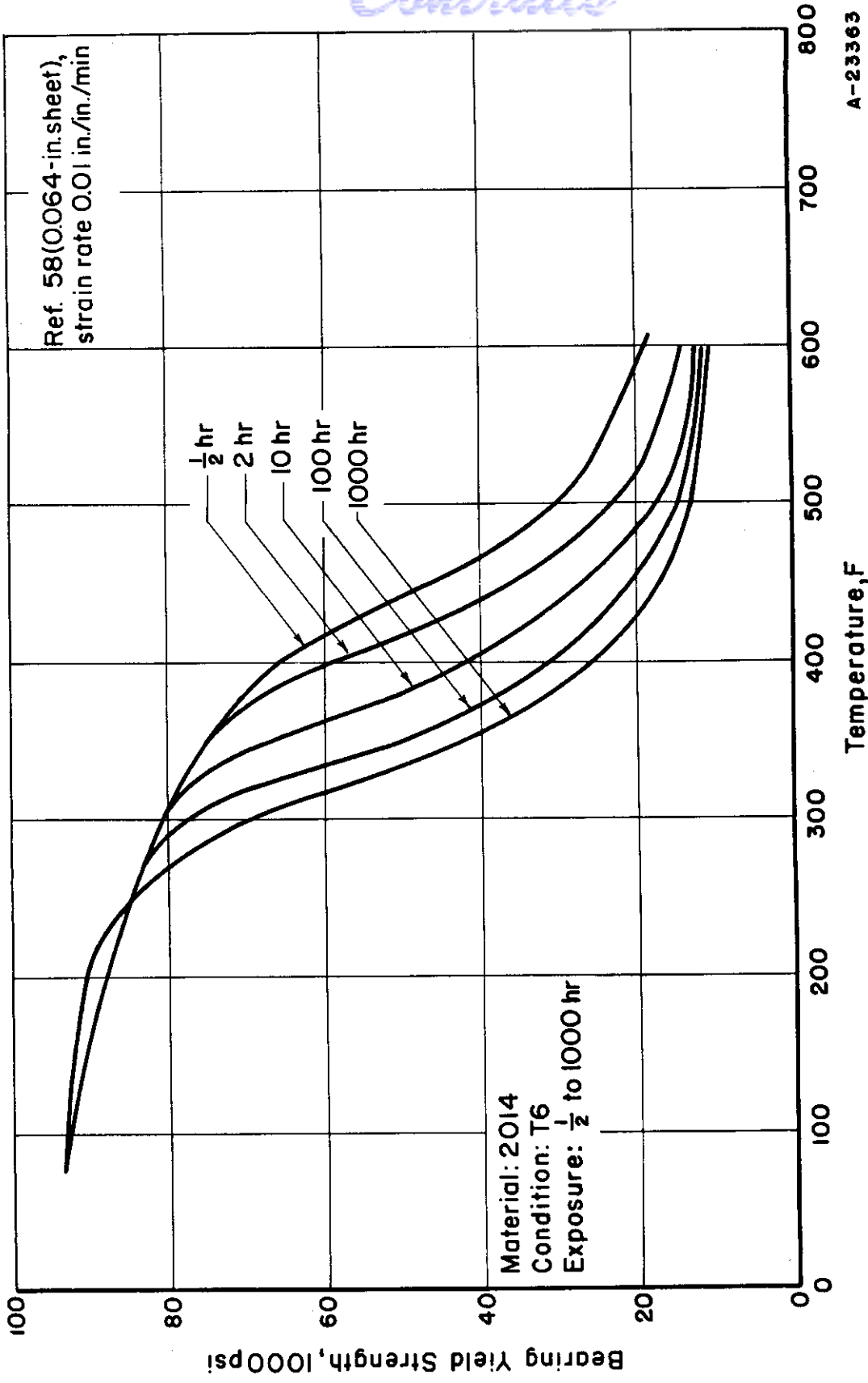


FIGURE 22. BEARING YIELD STRENGTH DATA FOR 2014-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

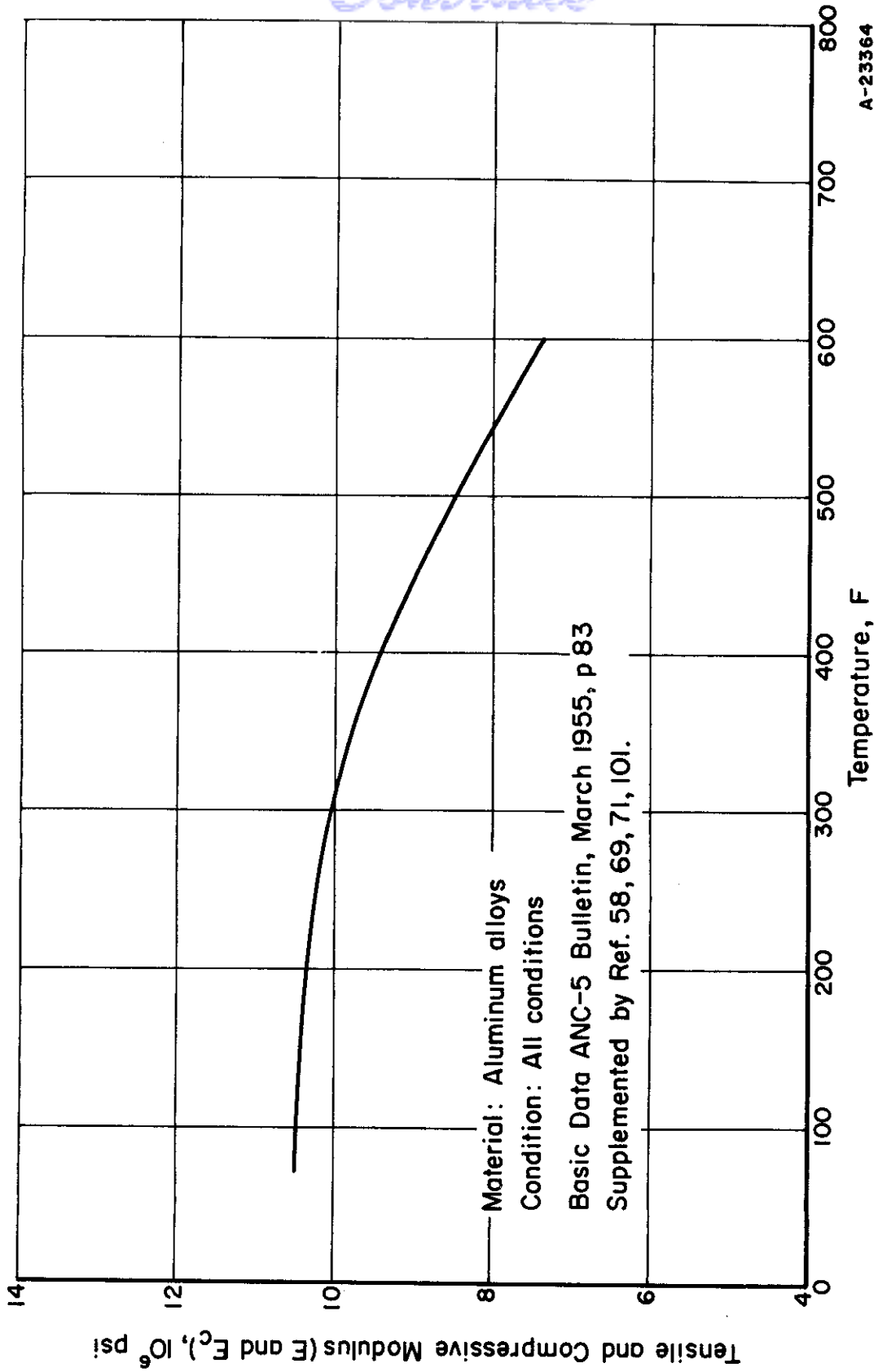


FIGURE 23. TENSILE AND COMPRESSIVE MODULUS (E AND E_c) FOR ALUMINUM ALLOYS AT ELEVATED TEMPERATURE

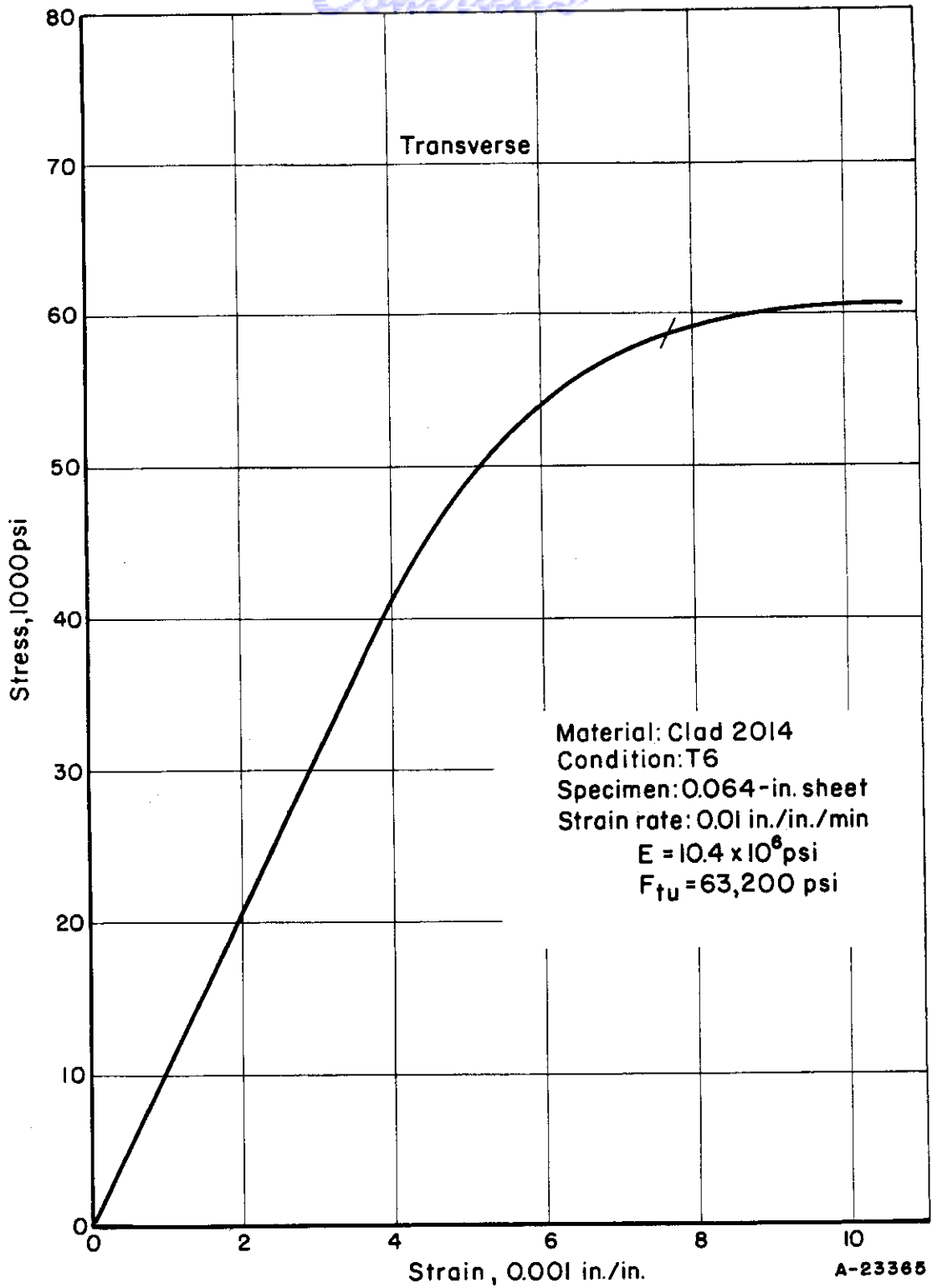


FIGURE 24. TENSILE STRESS-STRAIN CURVE FOR CLAD 2014-T6 ALUMINUM ALLOY AT ROOM TEMPERATURE (TRANSVERSE PROPERTY)

Ref. 58. p 115.

Contrails

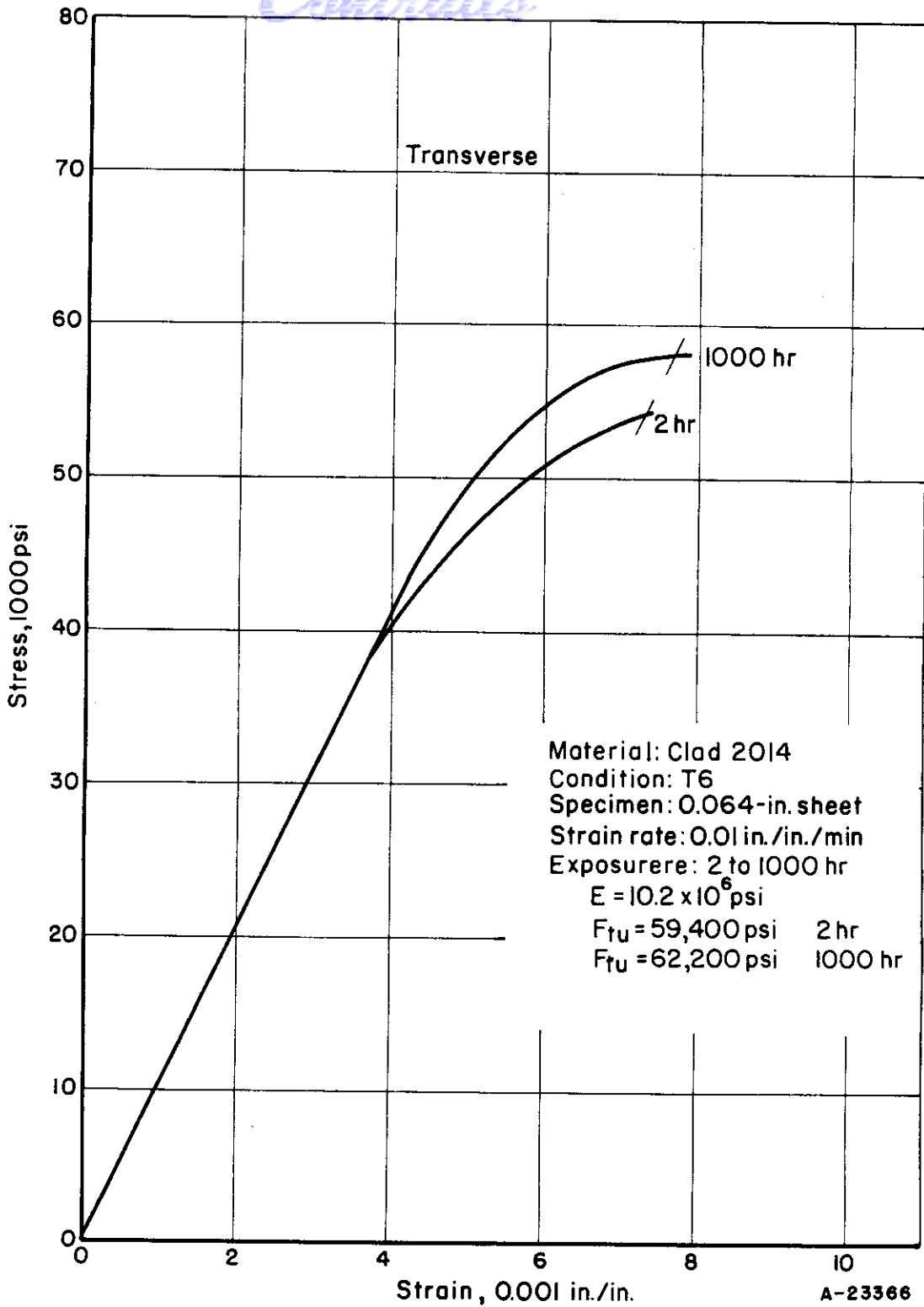


FIGURE 25. TENSILE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 200 F (TRANSVERSE PROPERTY)

Ref. 58, p 116.

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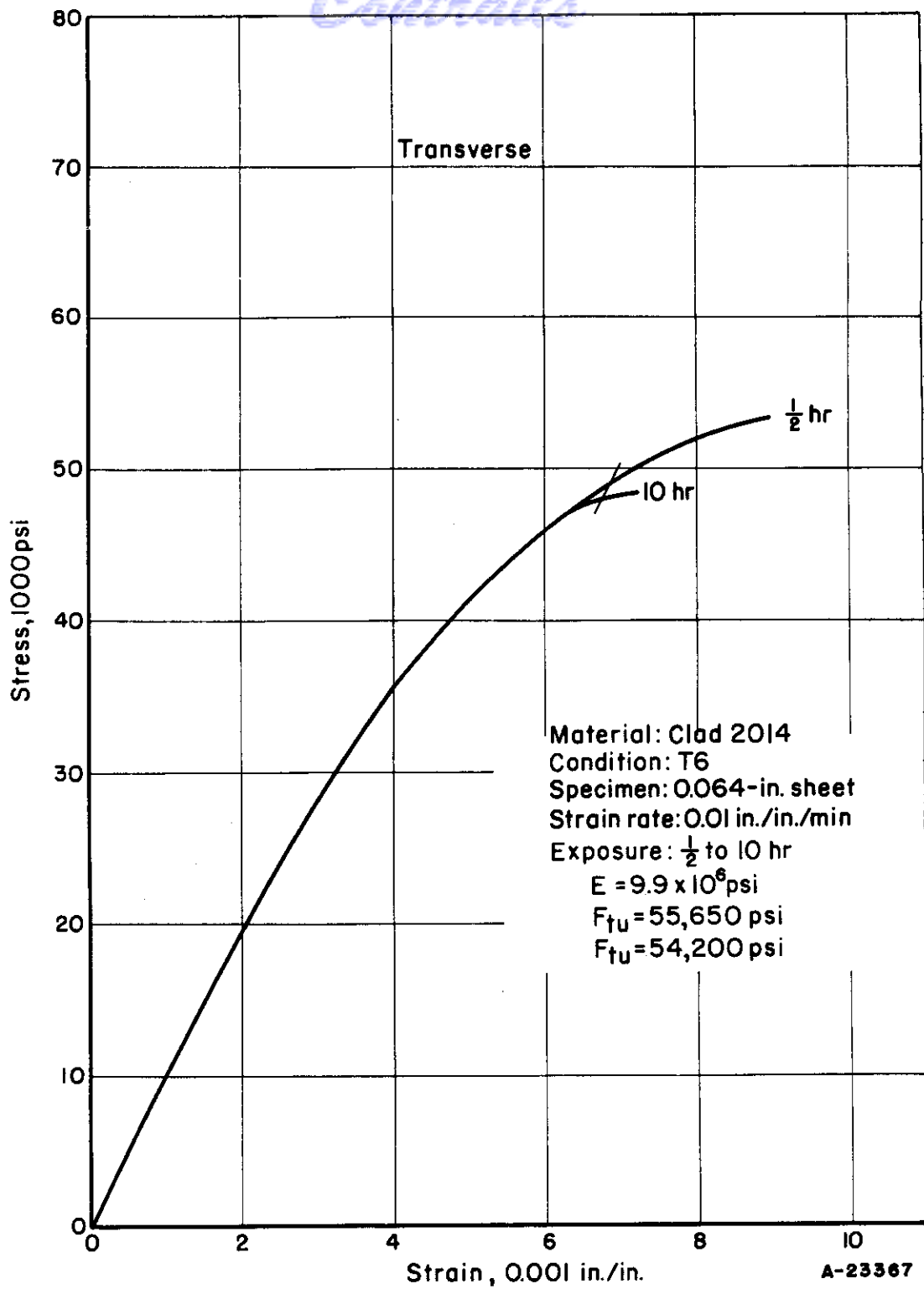


FIGURE 26. TENSILE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 300 F (TRANSVERSE PROPERTY)

Ref. 58, p 117.

WADC TR 55-150 Pt VI

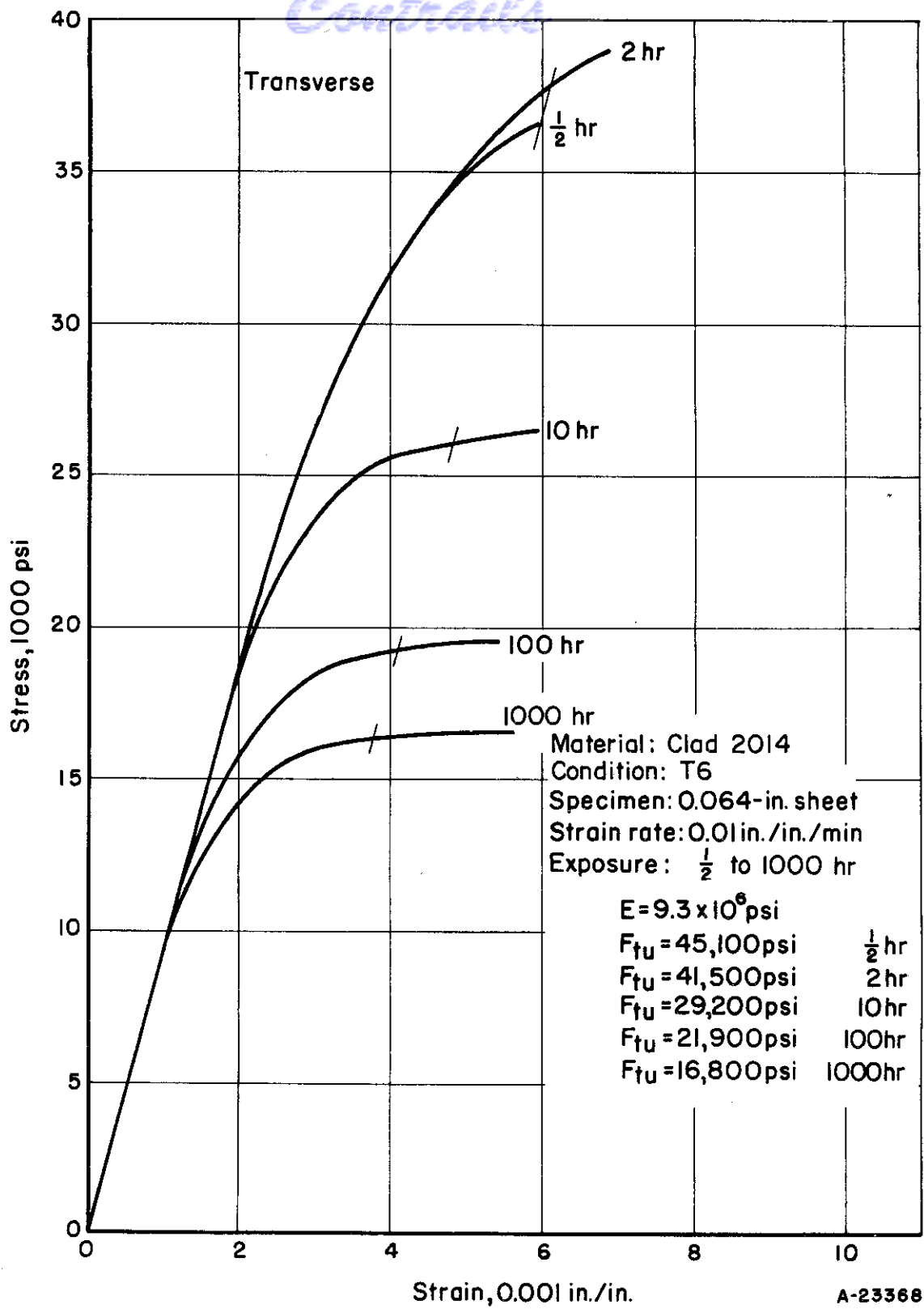


FIGURE 27. TENSILE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 400 F (TRANSVERSE PROPERTY)

Ref. 58, p 118.

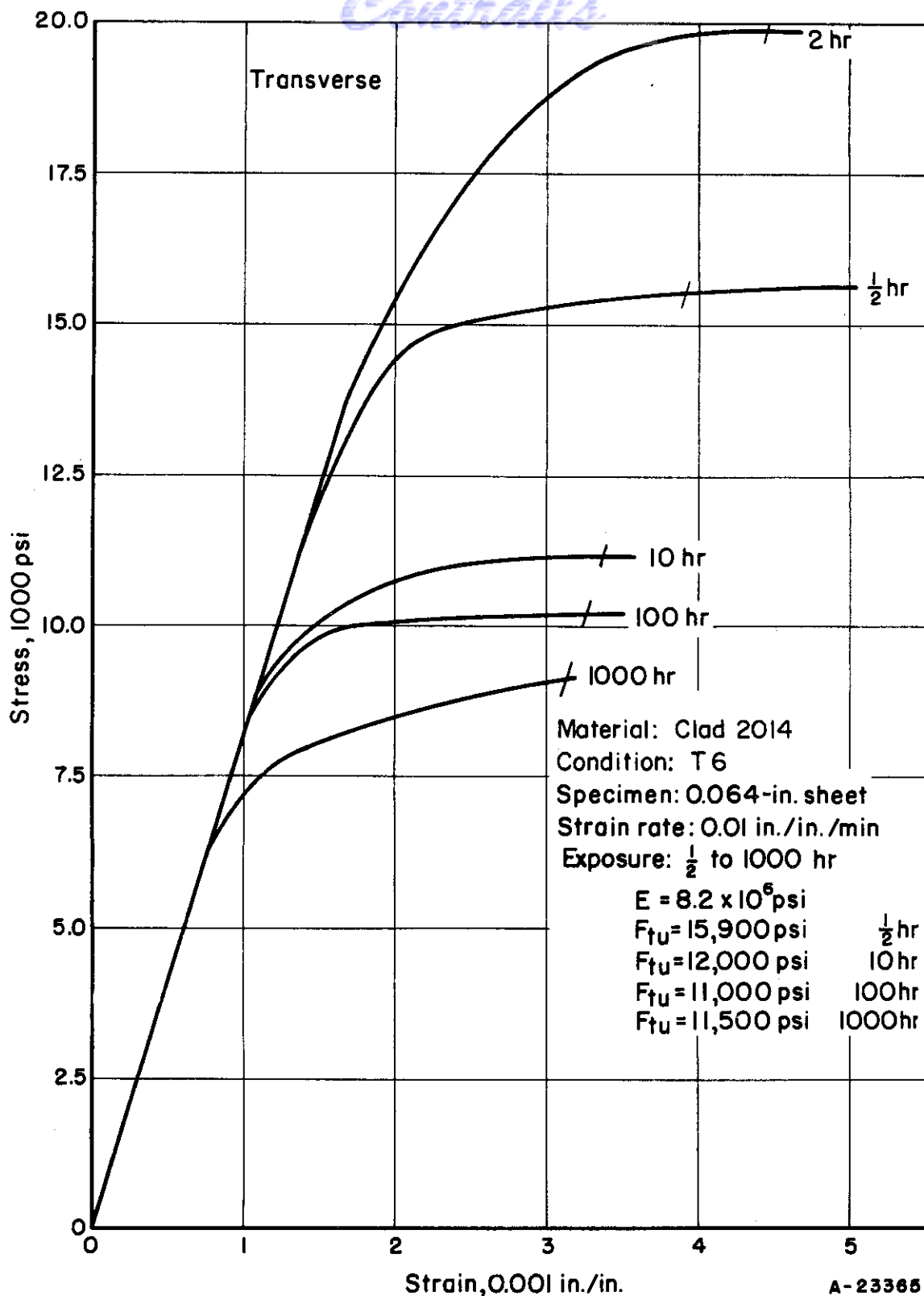


FIGURE 28. TENSILE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 500 F (TRANSVERSE PROPERTY)

Ref. 58, p 119.

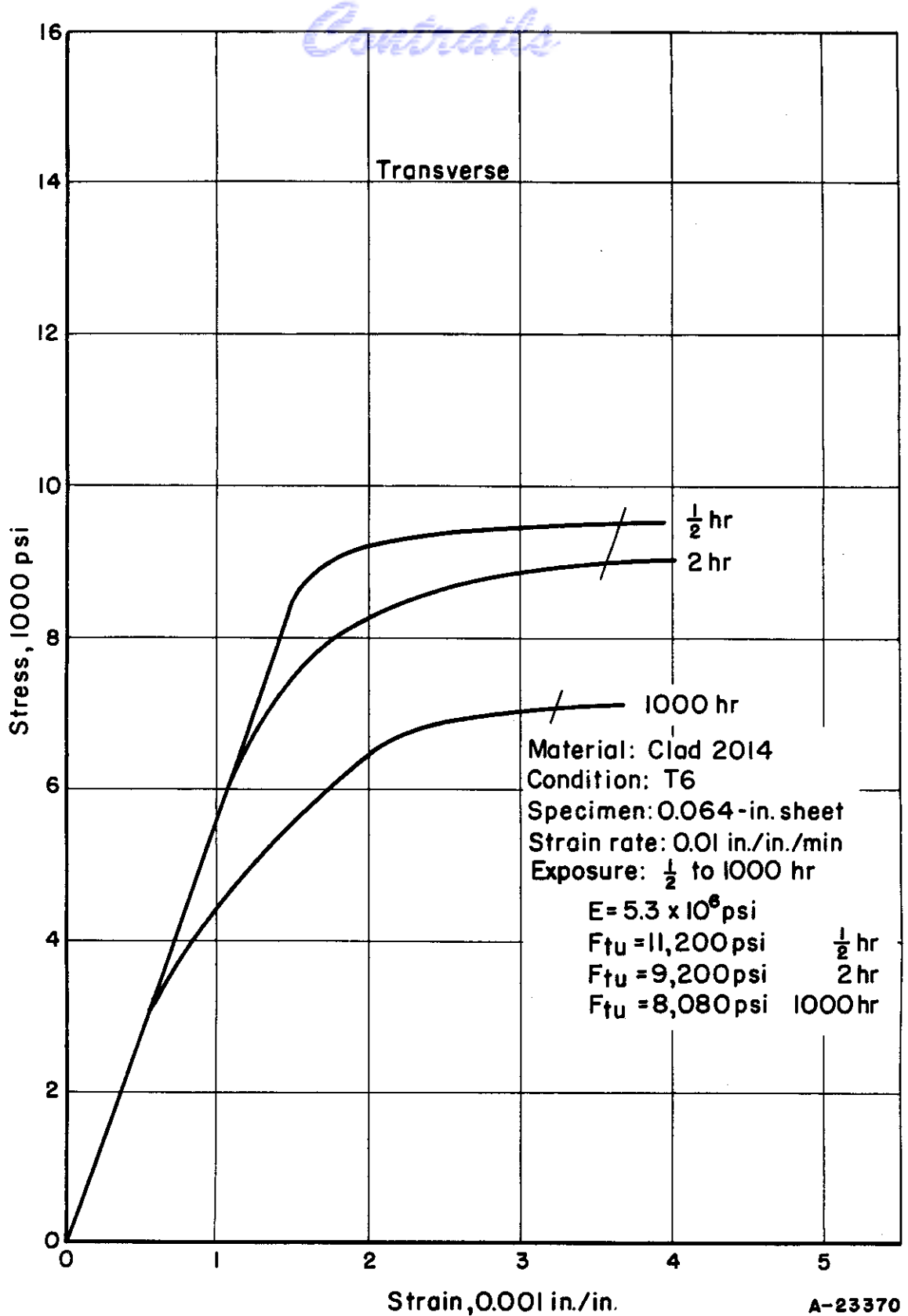


FIGURE 29. TENSILE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 600 F (TRANSVERSE PROPERTY)

Ref. 58, p 120.

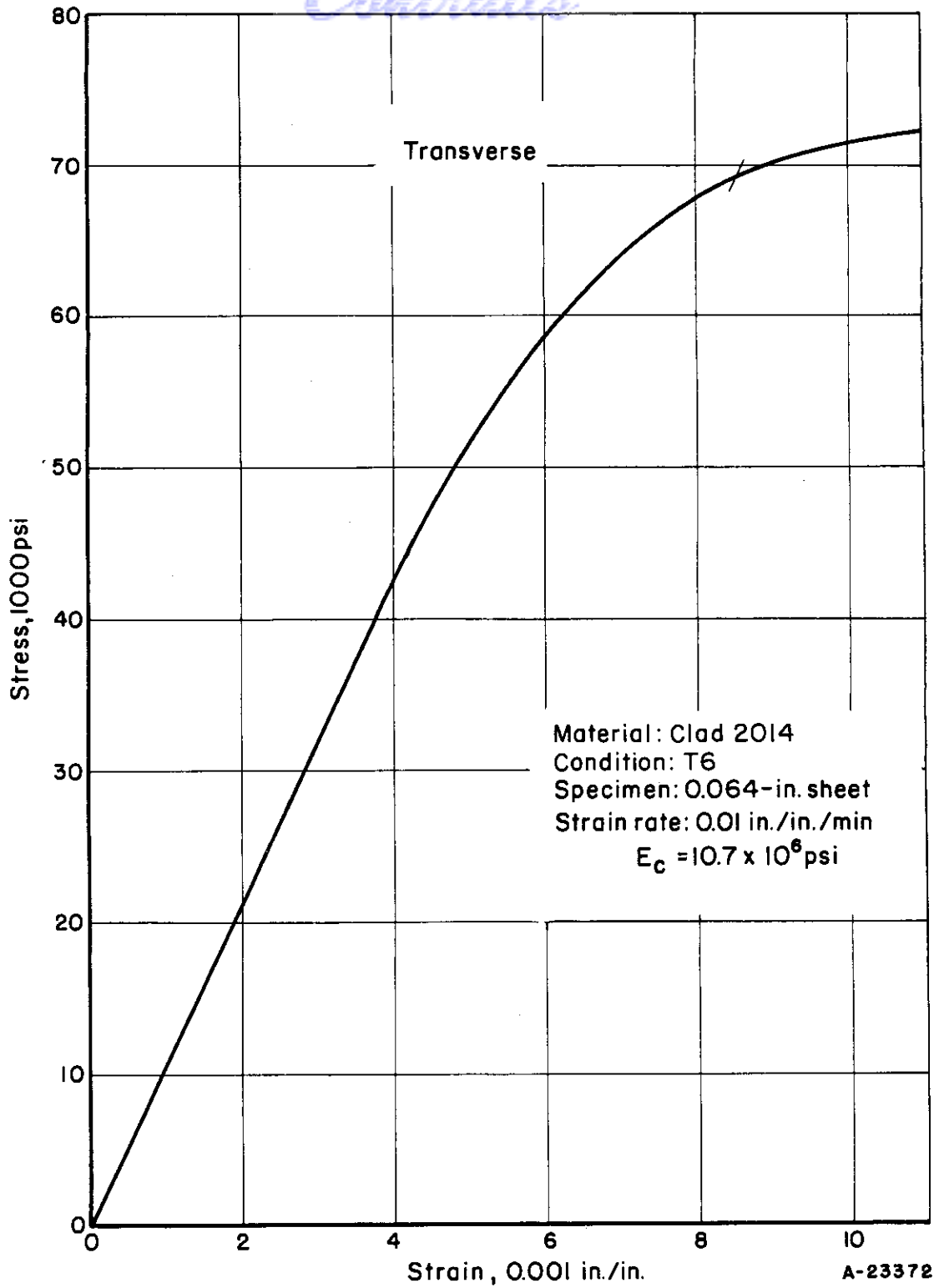


FIGURE 30. COMPRESSIVE STRESS-STRAIN CURVE FOR CLAD 2014-T6 ALUMINUM ALLOY AT ROOM TEMPERATURE (TRANSVERSE PROPERTY)

Ref. 58, p 121.

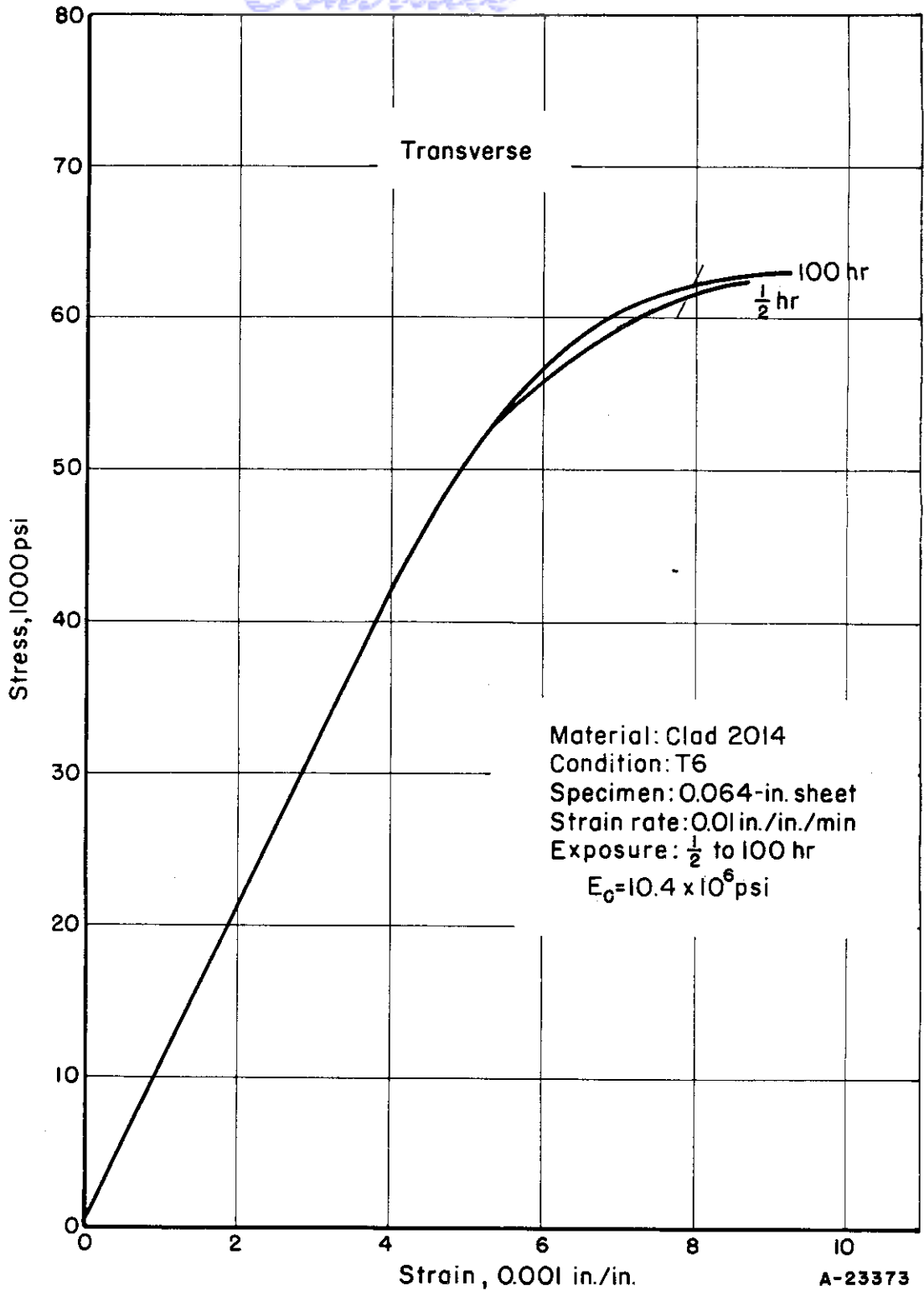


FIGURE 31. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 200 F (TRANSVERSE PROPERTY)

Ref. 58, p 122.

Comtrails

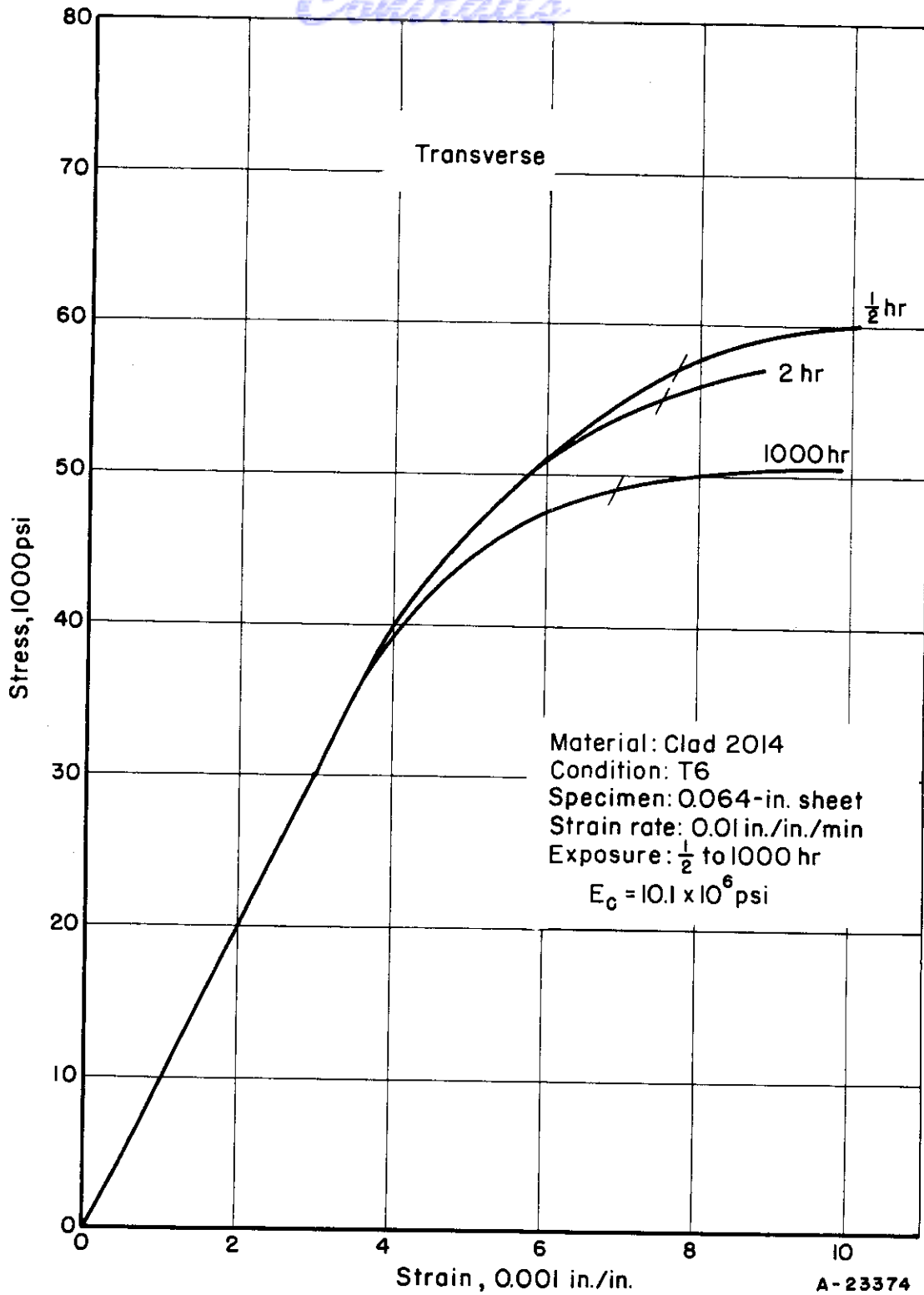


FIGURE 32. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 300 F (TRANSVERSE PROPERTY)

Ref. 58, p 123.

WADC TR 55-150 Pt VI

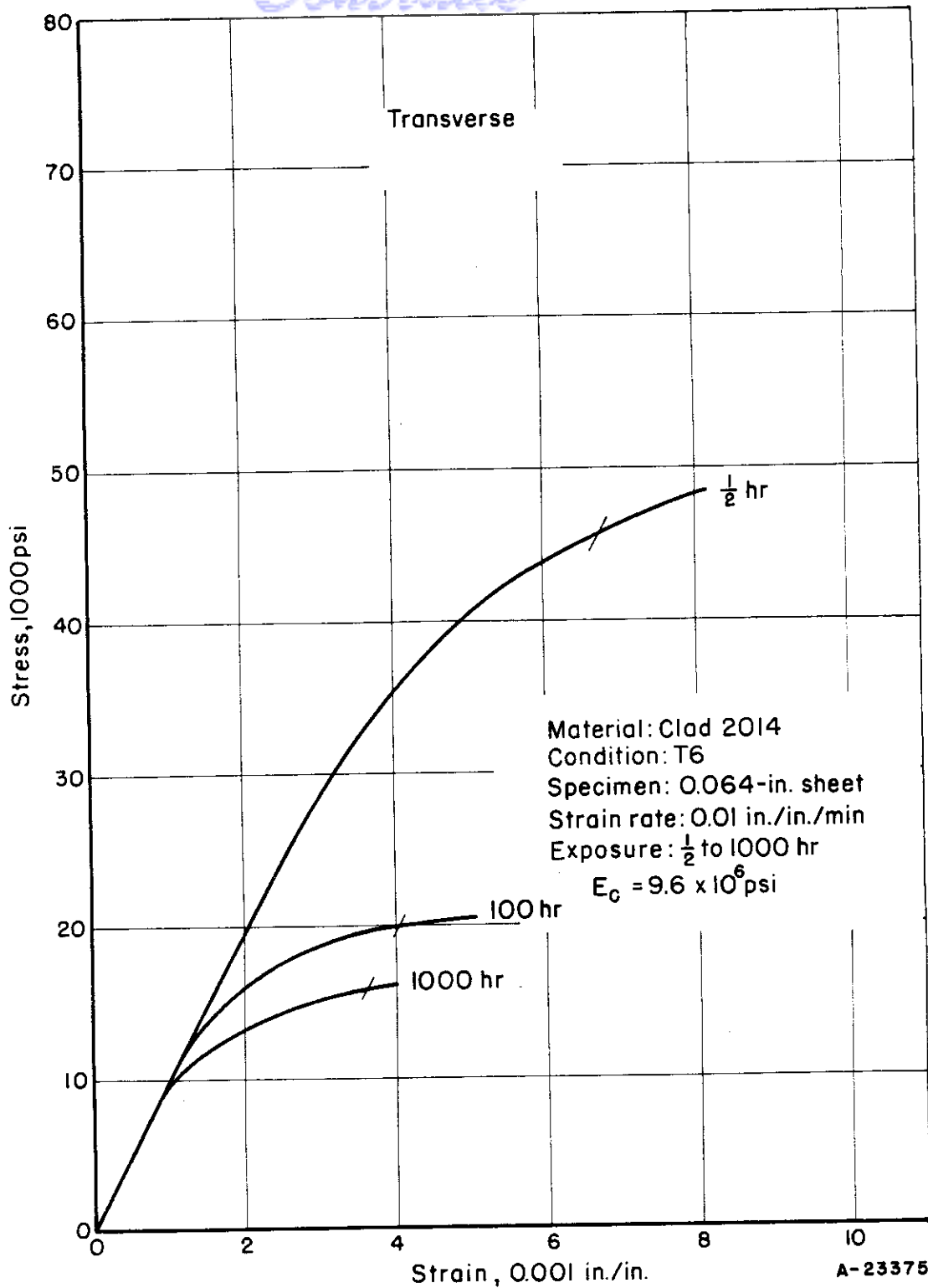


FIGURE 33. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 400 F (TRANSVERSE PROPERTY)

Ref. 58, p 124.

WADC TR 55-150 Pt VI

38

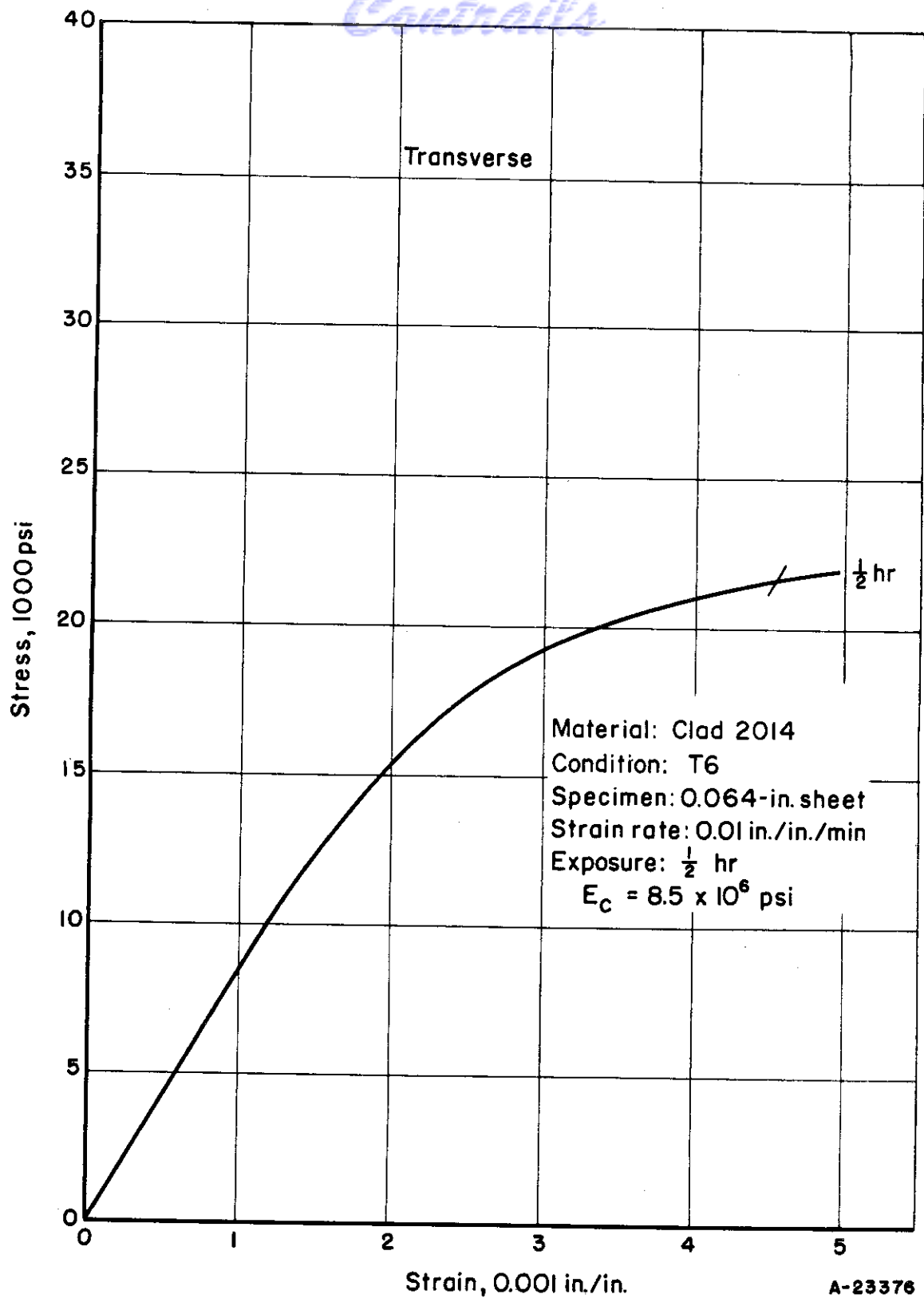


FIGURE 34. COMPRESSIVE STRESS-STRAIN CURVE FOR CLAD 2014-T6 ALUMINUM ALLOY AT 500 F (TRANSVERSE PROPERTY)

Ref. 58, p 125.

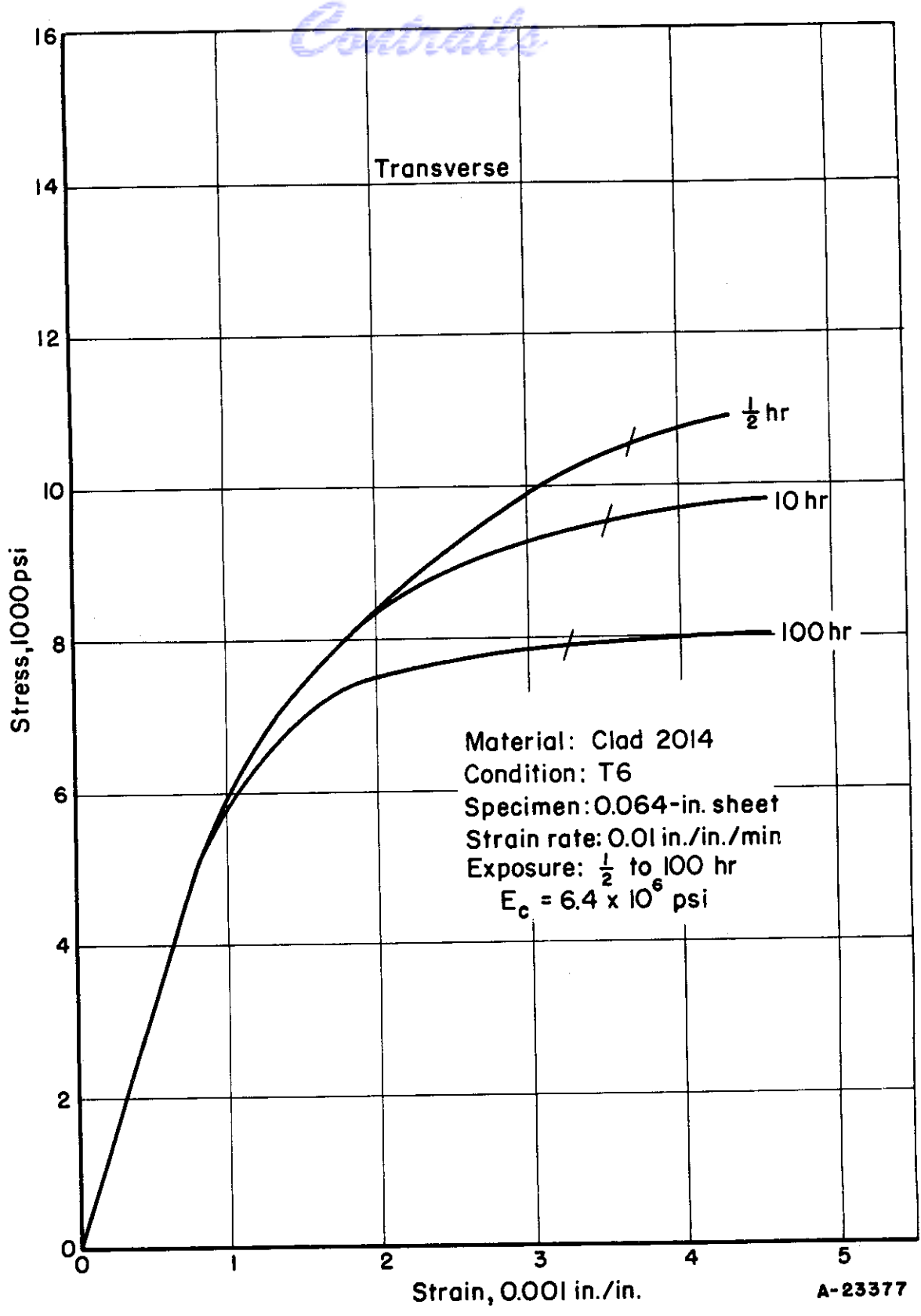


FIGURE 35. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2014-T6 ALUMINUM ALLOY AT 600 F (TRANSVERSE PROPERTY)

Ref. 58, p 126.

Alloy Specifications

QQ-A-355
QQ-A-362
AMS-4037D
AMS-4041D
AMS-4042D

General

2024 is a heat-treatable aluminum alloy. It is similar to 2014 in that the principal alloying agent is copper. It develops the highest naturally aged tensile strength of current commercial aluminum alloys. One of the highest available yield strengths in aluminum-alloy sheet products is obtained in 2024 by cold working approximately 5 per cent after solution heat treatment and then artificially aging to produce the -T86 condition. The ratio of yield strength to tensile strength is high and the elongation is low in the -T86 condition which may present some disadvantages from the fabricator's point of view.

In the naturally aged condition, the compressive yield strength of 2024 is less than the tensile yield strength. However, an artificial aging treatment increases both compressive yield strength and the tensile yield strength and makes them approximately equal in the longitudinal direction.

Artificial aging effects an improvement in the corrosion resistance of relatively thick sections. Such sections in the naturally aged conditions tend to be susceptible to an exfoliation-type corrosion. In the case of thin sheet, however, there is some sacrifice in corrosion resistance caused by artificial aging, although the corrosion resistance is excellent if the material is clad.

The chemical composition limits of 2024 and its cladding material, 1230, are given in Table 3.

TABLE 3. CHEMICAL-COMPOSITION LIMITS
OF 2024 ALUMINUM ALLOY AND
ITS CLADDING MATERIAL, 1230

Element	Weight Per Cent*	
	2024	1230
Copper	3.8 - 4.9	0.10
Magnesium	1.2 - 1.8	--
Manganese	0.30 - 0.9	0.05
Silicon	0.50	0.7**
Iron	0.50	--
Chromium	0.10	--
Zinc	0.25	0.10
Others, each	0.05	0.05
Total	0.15	0.15
Aluminum	Balance	Balance

*Weight per cent is maximum, unless shown as a range.

**Silicon plus iron.

The conventional short-time elevated-temperature properties of clad 2024 aluminum alloy are shown in the following curves:

Tensile strength	Figures 36, 37, 64, 66-72, 96-102
Tensile yield strength	Figures 38, 39, 65, 73-79, 103-109
Compressive yield strength	Figures 40, 41, 80, 81, 110, 111
Shear strength	Figures 42, 43, 82, 83, 112, 113
Bearing ultimate strength	Figures 44, 45, 84, 85, 114, 115
Bearing yield strength	Figures 46, 47, 86, 87, 116, 117
Stress-strain curves	Figures 48-63, 88-95, 118-125.

Heat Treatment

The -T3, -T4, -T6, -T36, -T81, and -T86 conditions for 2024 are described below.

-T3 Condition (Solution Treatment Plus Flattening or Straightening)

The -T3 condition is essentially the -T4 condition followed by sufficient cold work to flatten or straighten (approximately 1 per cent stretch).

-T4 Condition (Solution Treatment Plus Natural Aging)

The -T4 condition is achieved by heating to 910 - 930 F, quenching in cold water, and aging at room temperature. Variations in alloy lots account

for variations in the rates of aging and in some cases as long as 4 days are required to achieve the -T4 condition.

-T6 Condition (Solution Treatment Plus Artificial Aging)

For this condition, the material is solution heat treated by heating to 910 - 930 F and quenching in cold water. It is then aged at 370 - 380 F for 9 to 12 hours and air cooled.

-T36 Condition (-T4 Condition Plus Cold Work)

This condition consists of -T4 solution treatment followed by cold work (approximately 5.5 per cent reduction).

-T81 Condition (-T3 Condition Plus Artificial Aging)

This condition is achieved by solution heat treating at 910 - 930 F, flattening, and aging at 370 - 380 F.

-T86 Condition (-T36 Condition Plus Artificial Aging)

After solution heat treating and cold working (-T36), the material is aged at 370 - 380 F. A shorter time is required for aging from the -T36 condition than from the -T81 condition because the previous cold working has an accelerating effect on aging of the alloy.

The mechanical-property limits of 2024-T3 and clad 2024-T3, -T81, and -T86 (sheet) are shown in Tables 4 through 6.

TABLE 4. MINIMUM MECHANICAL PROPERTIES OF
2024-T3 (SHEET) ALUMINUM ALLOY
(AMS 4037D)

Thickness, in.	Ultimate Tensile Strength, psi	Tensile Yield Strength, psi	Elongation in 2 Inches, per cent
0.010 - 0.020	64,000	42,000	12
0.021 - 0.051	64,000	42,000	15
0.052 - 0.128	64,000	42,000	17
0.129 - 0.249	64,000	42,000	15

TABLE 5. MINIMUM MECHANICAL PROPERTIES OF CLAD
2024-T3 (SHEET) ALUMINUM ALLOY
(AMS 4041D)

Thickness, in.	Ultimate Tensile Strength, psi		Tensile Yield Strength, psi		Elongation in 2 Inches, per cent	
	0.008 - 0.009	58,000		39,000		10
0.010 - 0.020	59,000		39,000		12	
0.021 - 0.062	59,000		39,000		15	
0.063 - 0.128	62,000		40,000		15	
0.129 - 0.249	62,000		40,000		13	

TABLE 6. MINIMUM MECHANICAL PROPERTIES OF CLAD
2024-T81 AND 2024-T86 (SHEET) ALUMINUM
ALLOY

Thickness, in.	Ultimate Tensile Strength, psi		Tensile Yield Strength, psi		Elongation in 2 Inches, per cent	
	-T81	-T86	-T81	-T86	-T81	-T86
0.010 - 0.062	62,000	-	54,000	-	5	-
0.020 - 0.062	-	66,000	-	62,000	-	3
0.063 - 0.249	65,000	70,000	56,000	66,000	5	3

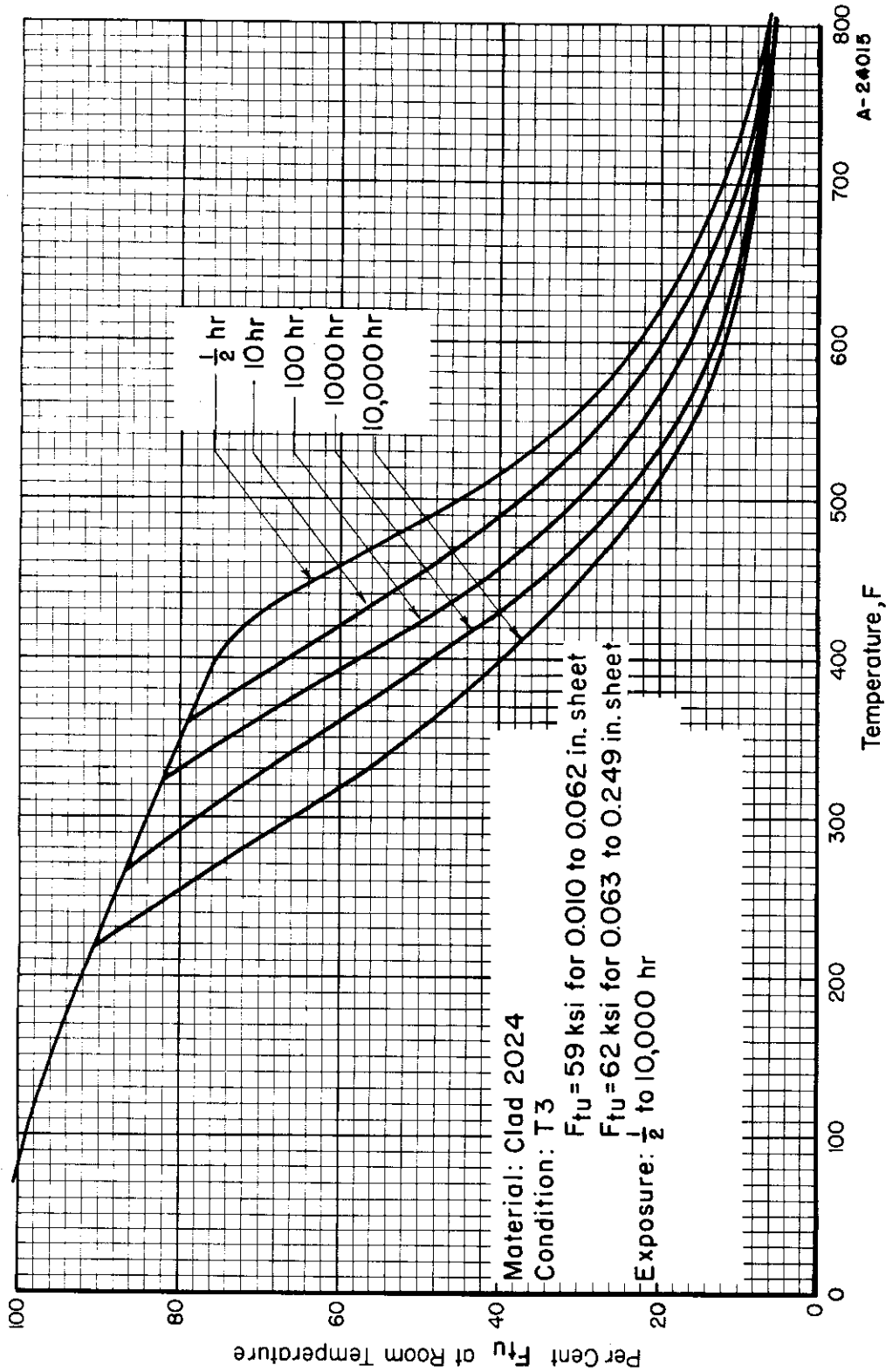


FIGURE 36. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF CLAD 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101 (design curve).
 Ref. 71, 369, 373 (supplementary data).

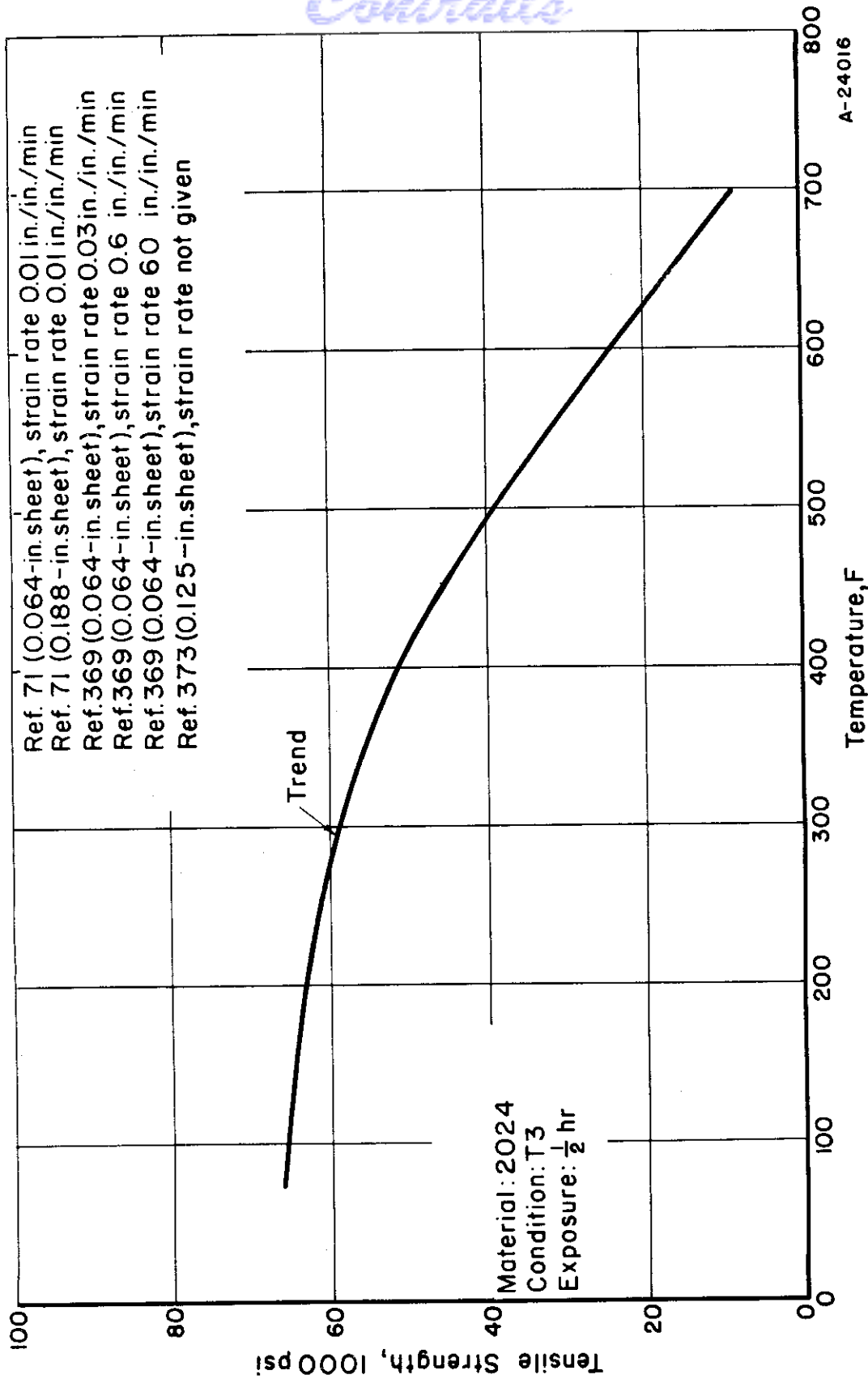


FIGURE 37. TENSILE STRENGTH DATA FOR 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

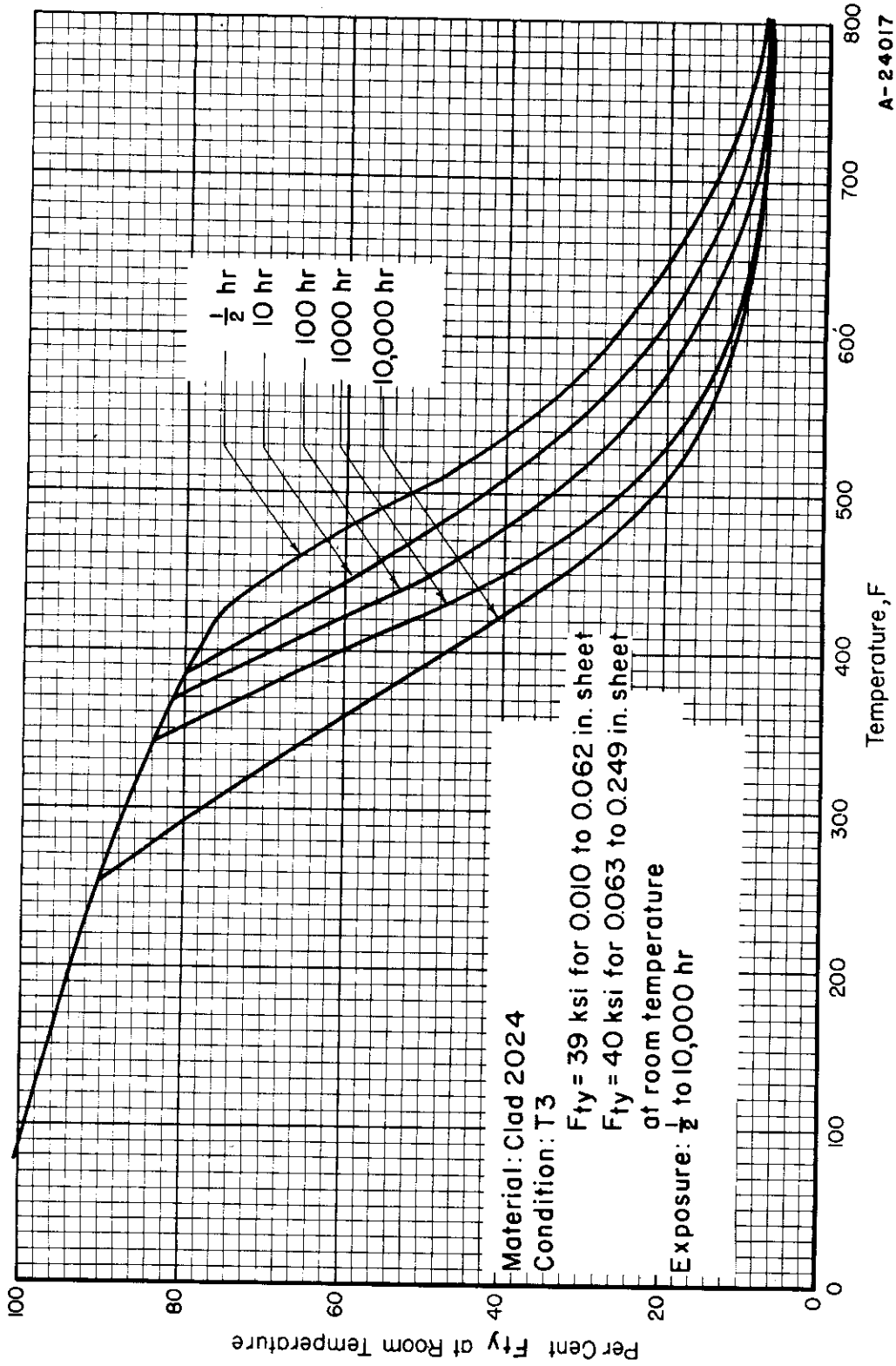


FIGURE 38. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF CLAD 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101 (design curve).
 Ref. 71, 369 (supplementary data).

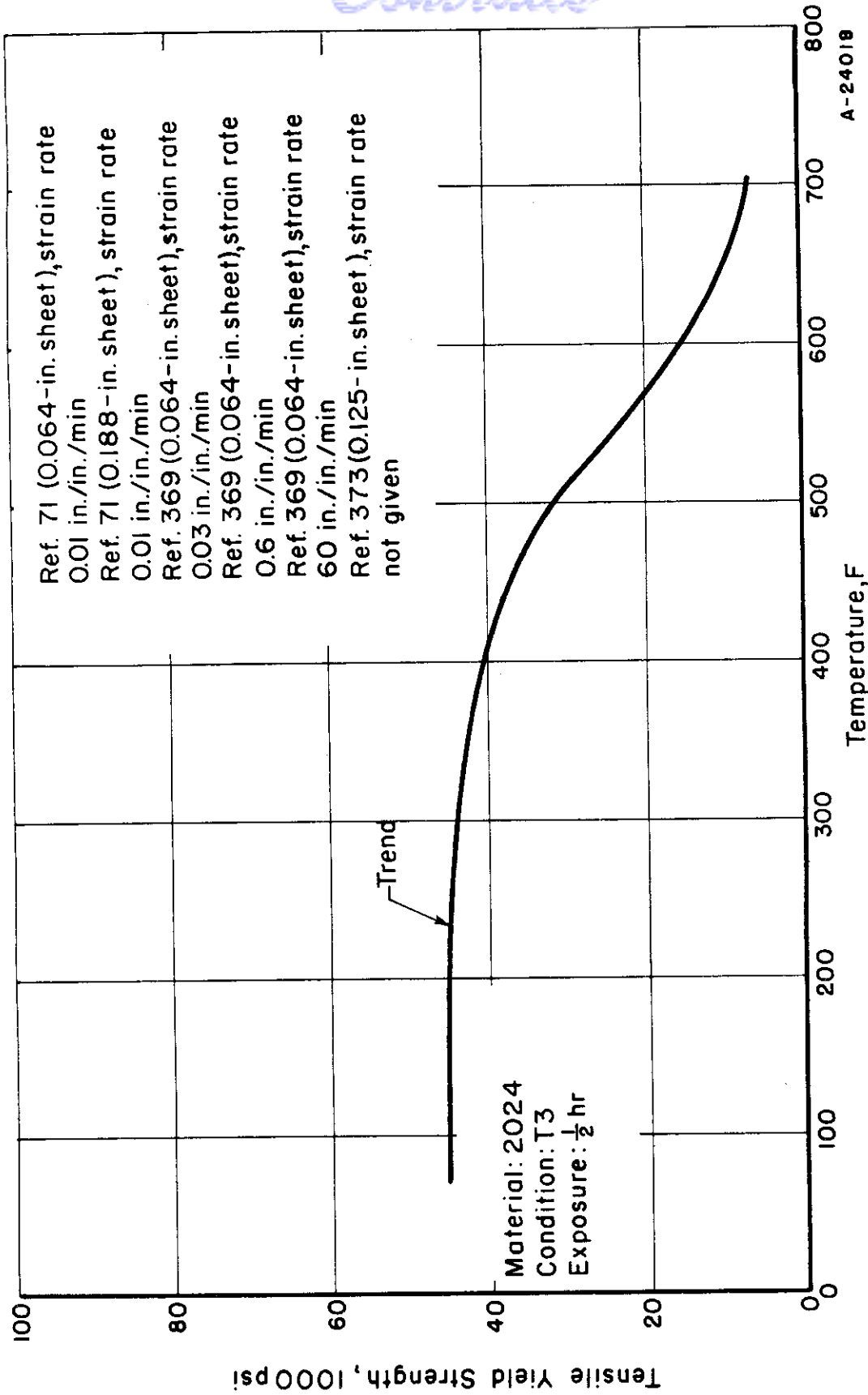


FIGURE 39. TENSILE YIELD STRENGTH DATA FOR 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

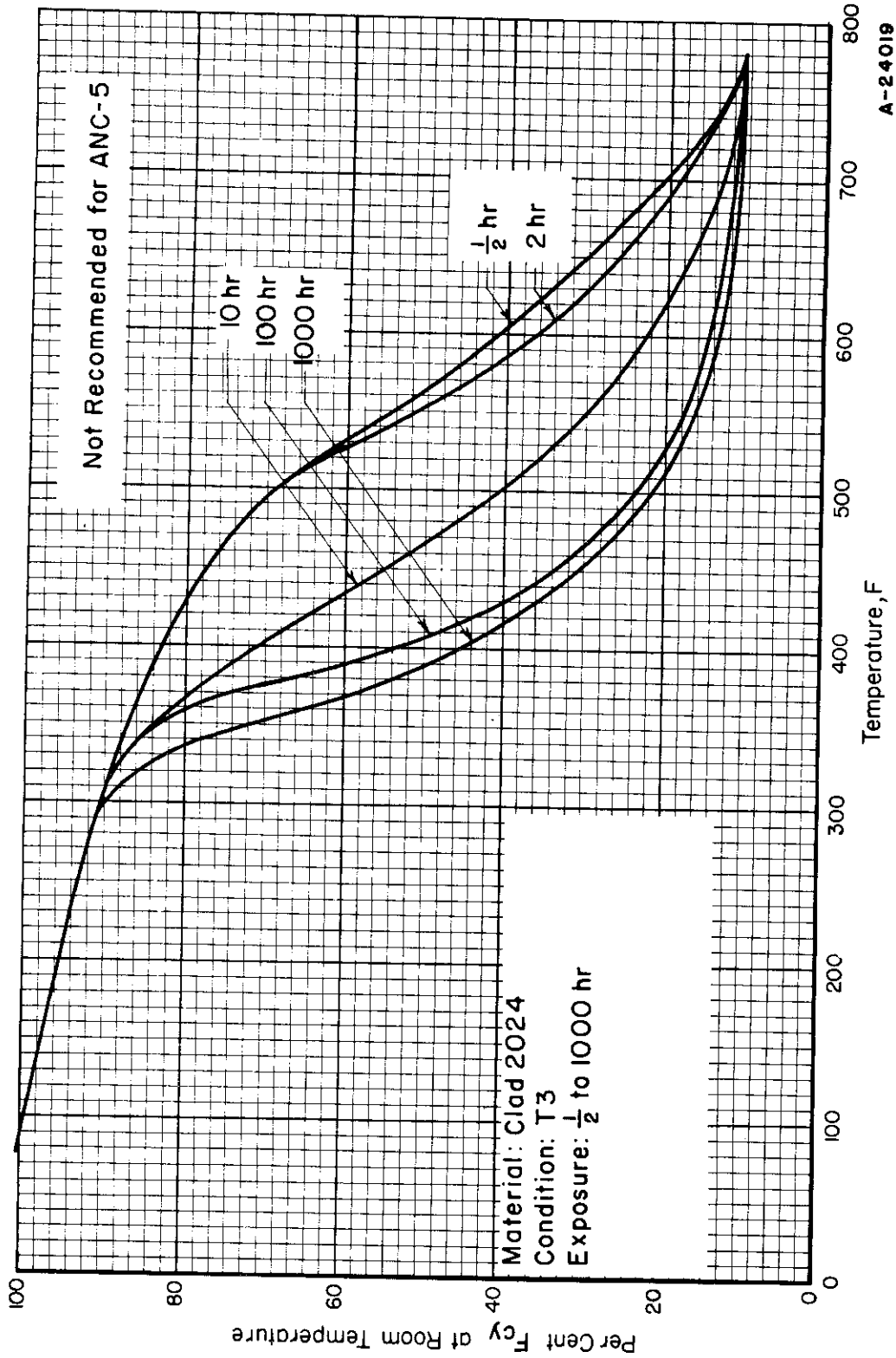


FIGURE 40. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF CLAD 2024-T3 ALUMI-
NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 71.

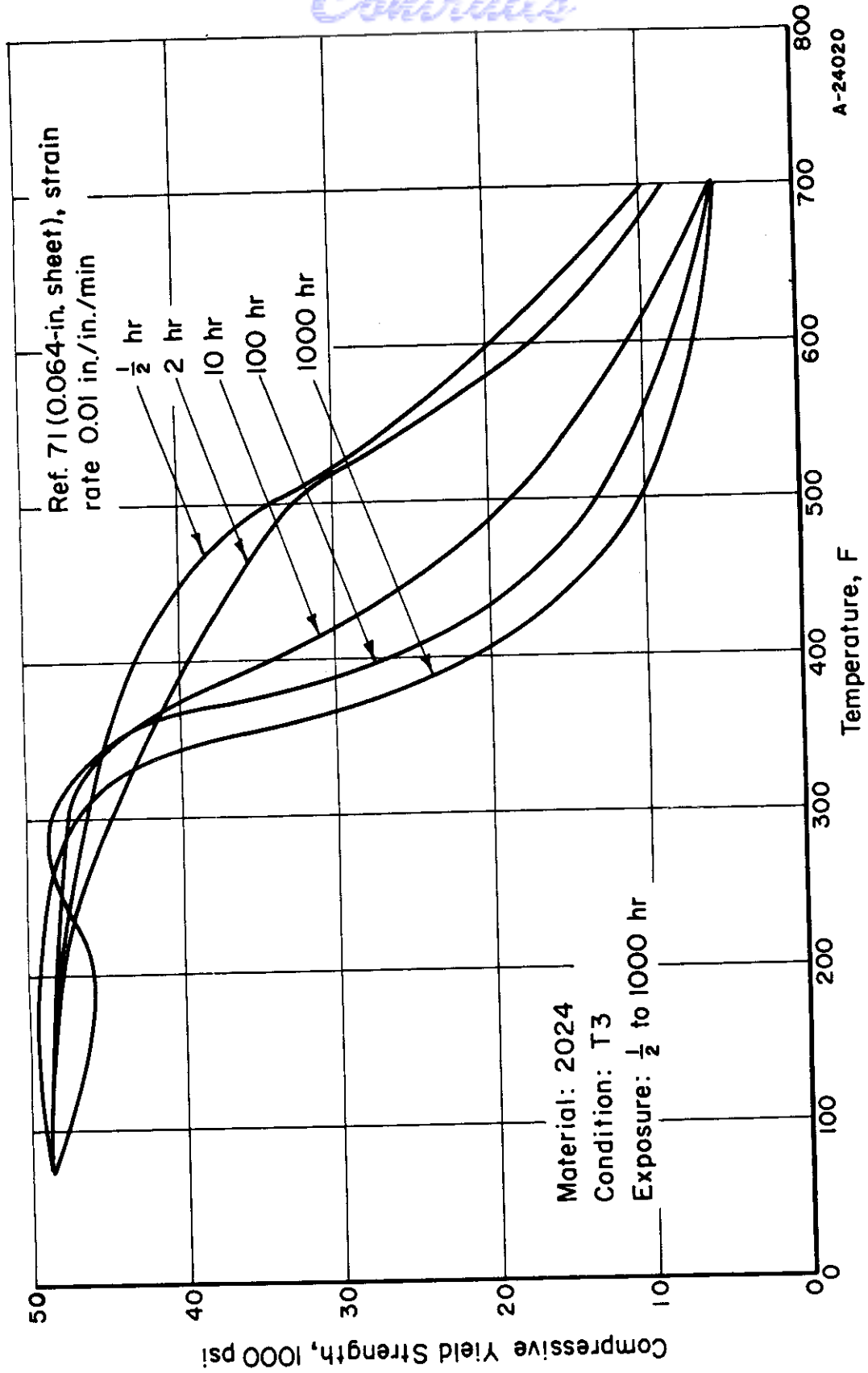


FIGURE 41. COMPRESSIVE YIELD STRENGTH DATA FOR 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

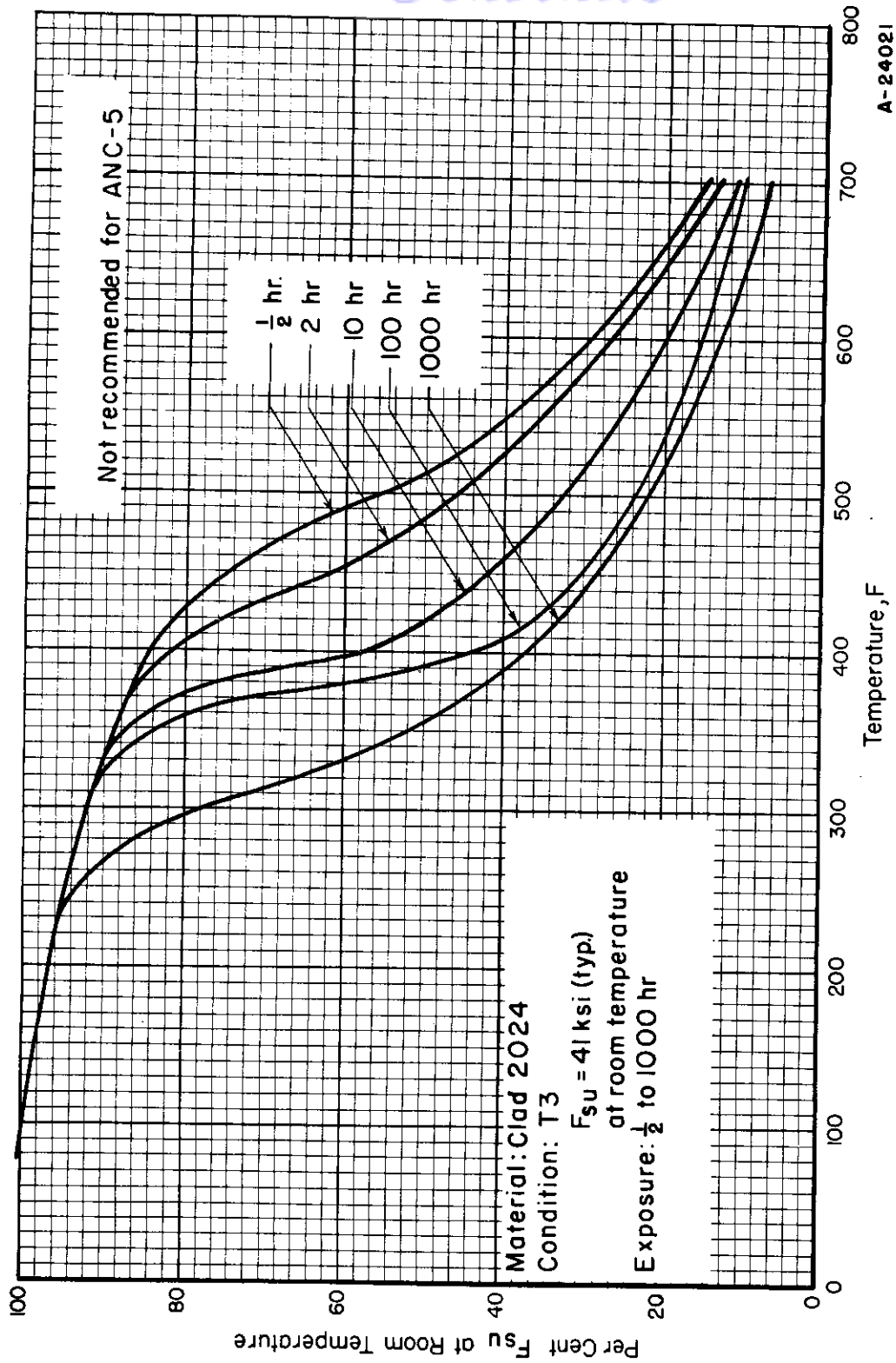


FIGURE 42. DESIGN CURVES FOR SHEAR STRENGTH (F_{su}) OF CLAD 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 71.

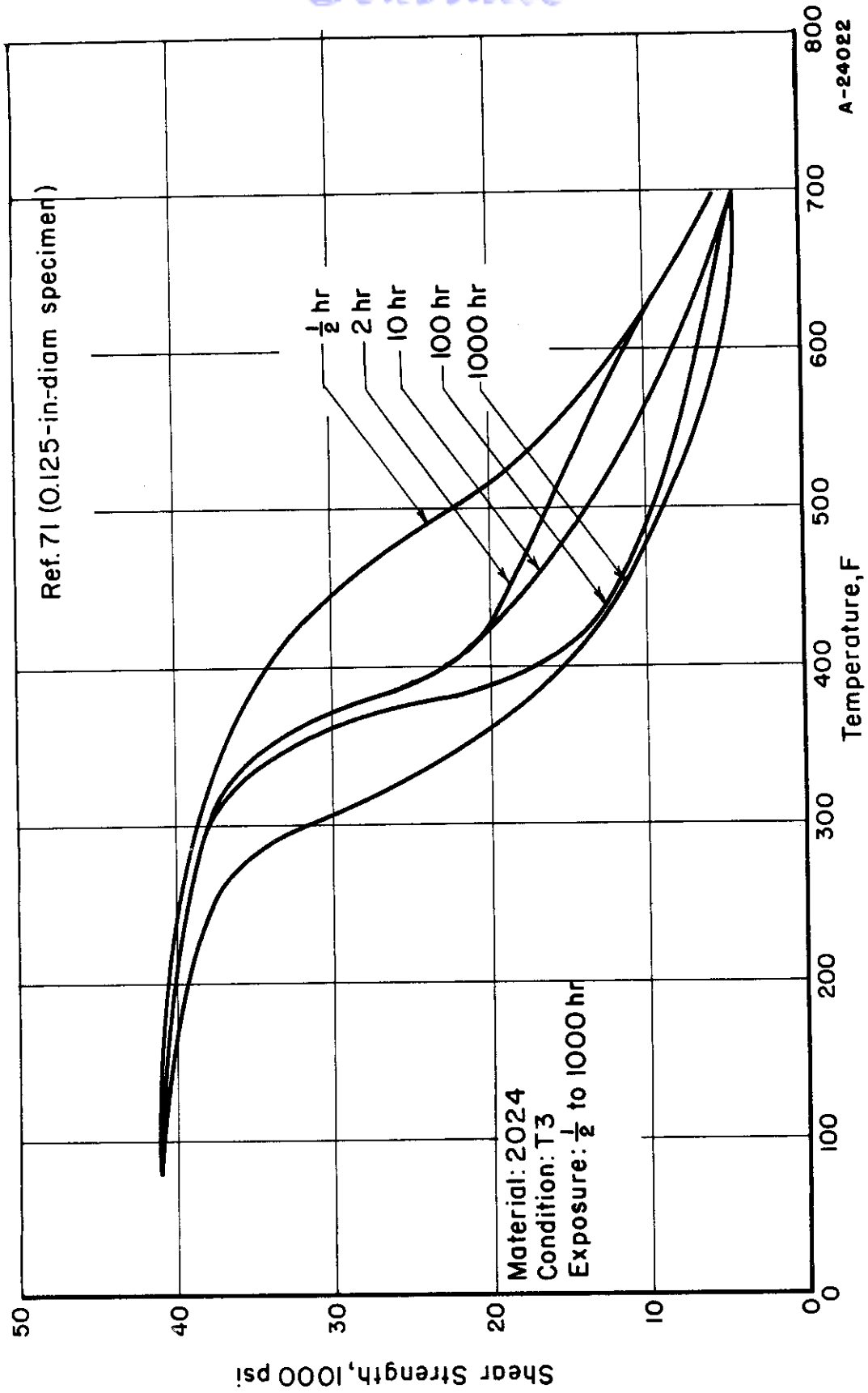


FIGURE 43. SHEAR STRENGTH DATA FOR 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

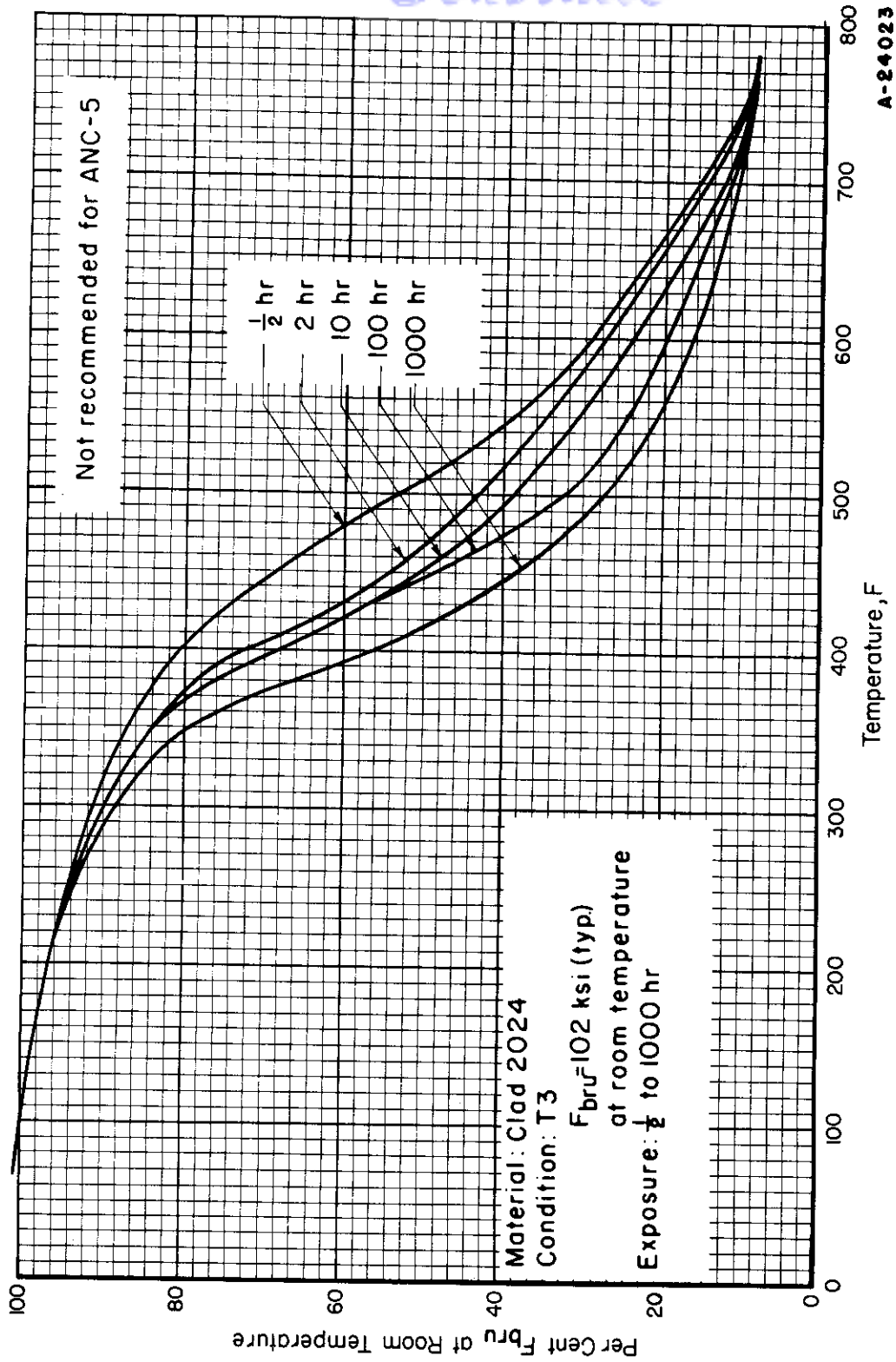


FIGURE 44. DESIGN CURVES FOR BEARING STRENGTH (F_{bru}) OF CLAD 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 71.

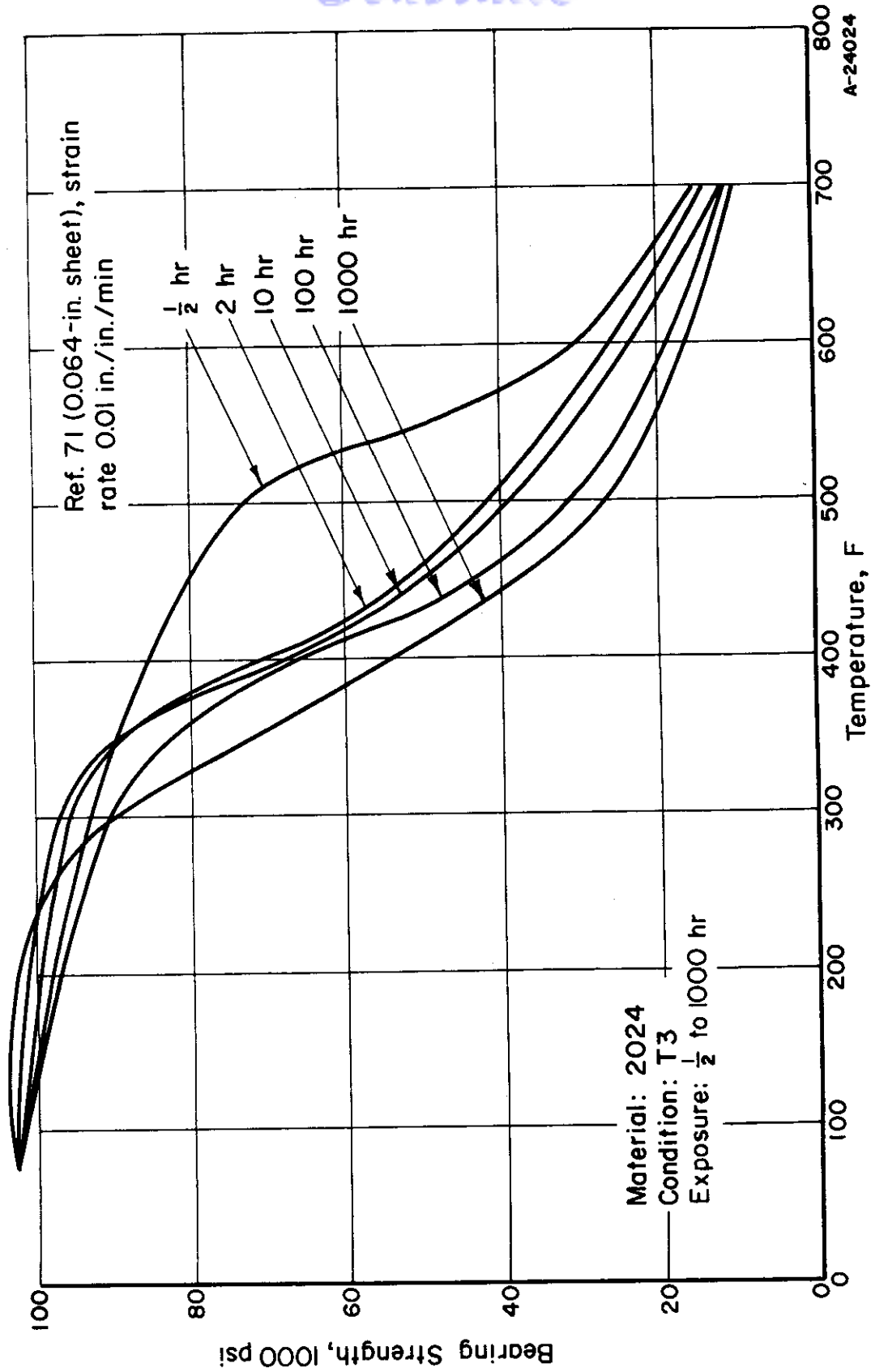


FIGURE 45. BEARING STRENGTH DATA FOR 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

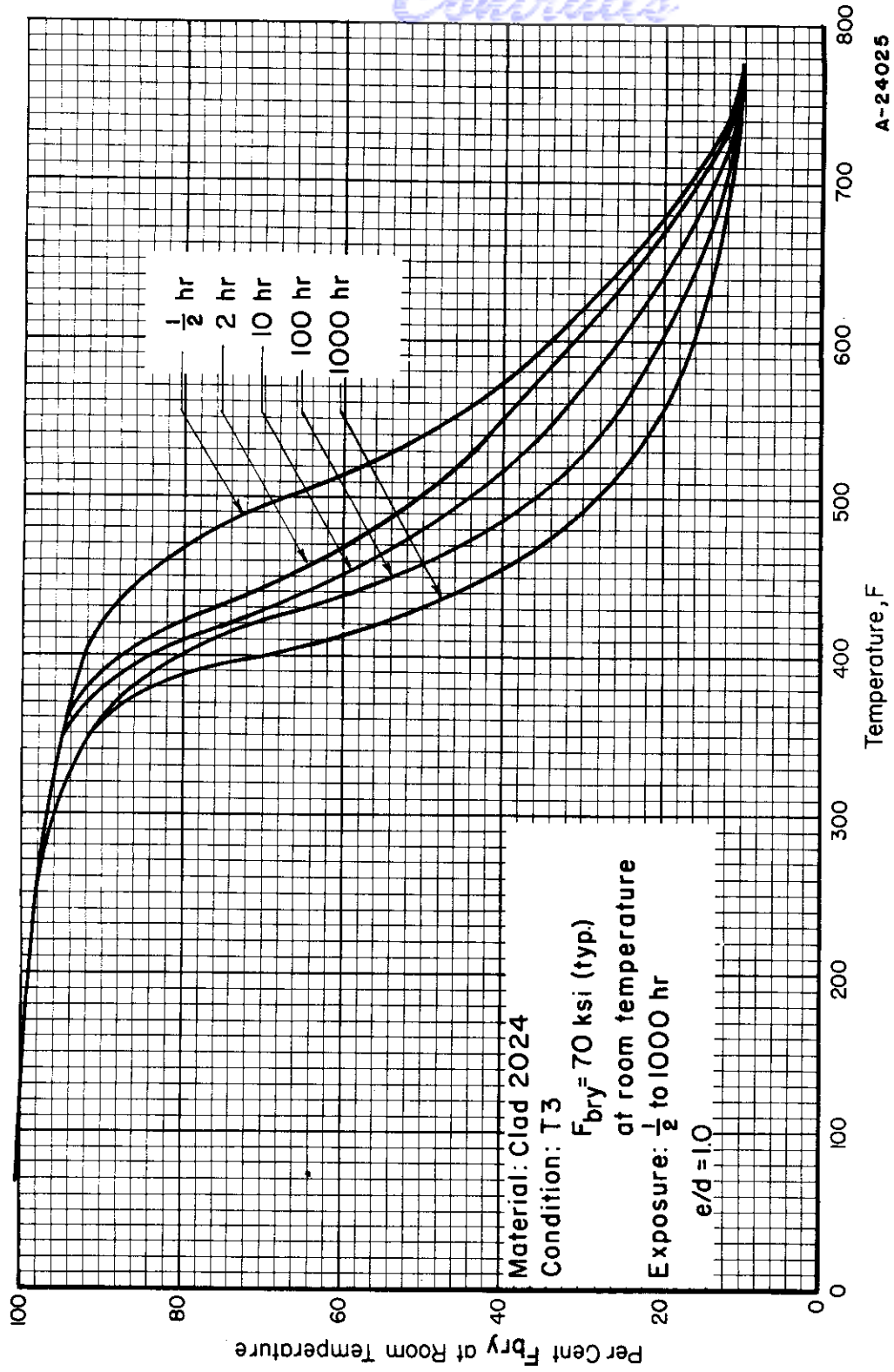


FIGURE 46. DESIGN CURVES FOR BEARING YIELD STRENGTH (F_{bry}) OF CLAD 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 71.

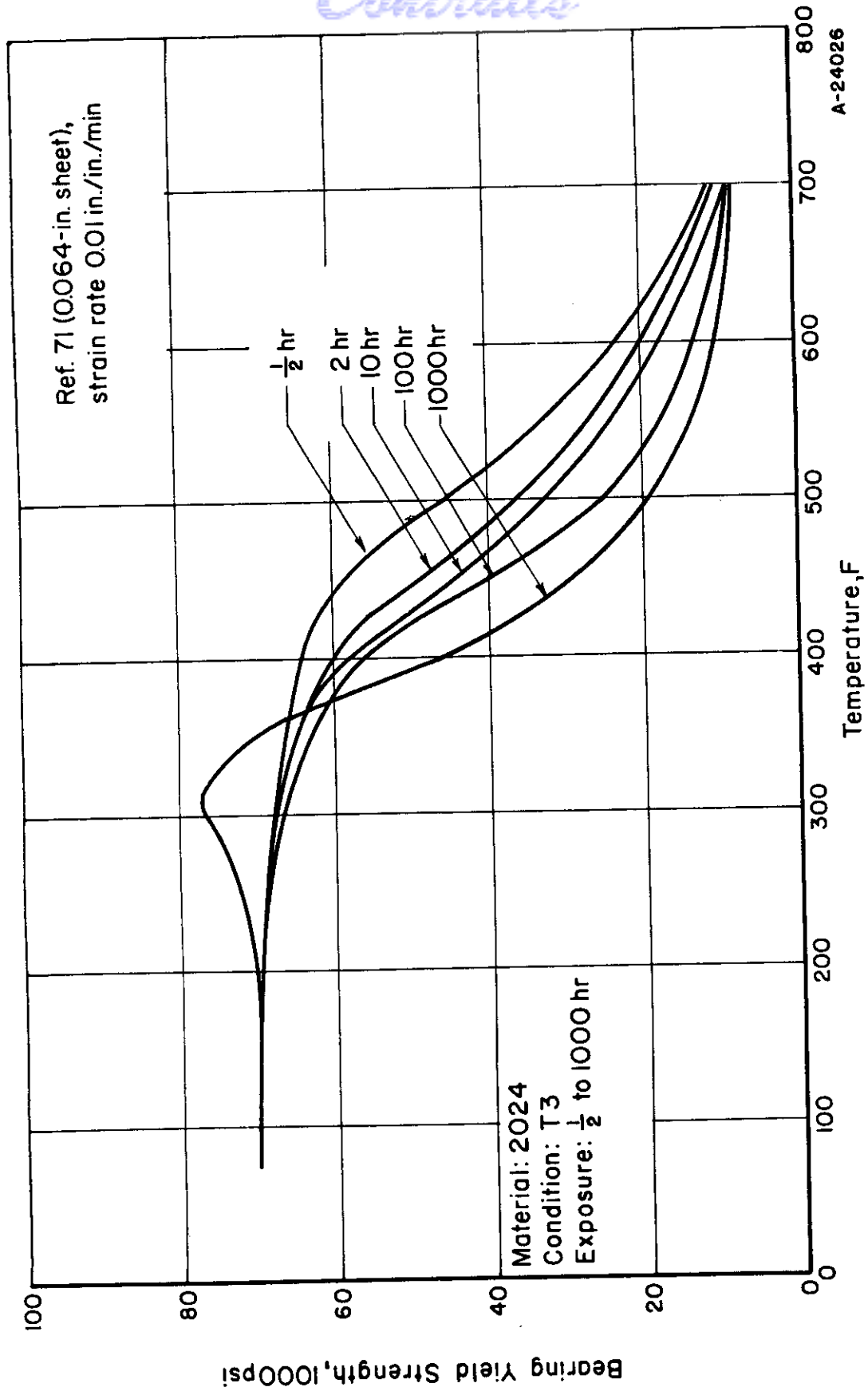


FIGURE 47. BEARING YIELD STRENGTH DATA FOR 2024-T3 ALUMINUM ALLOY AT ELE-VATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

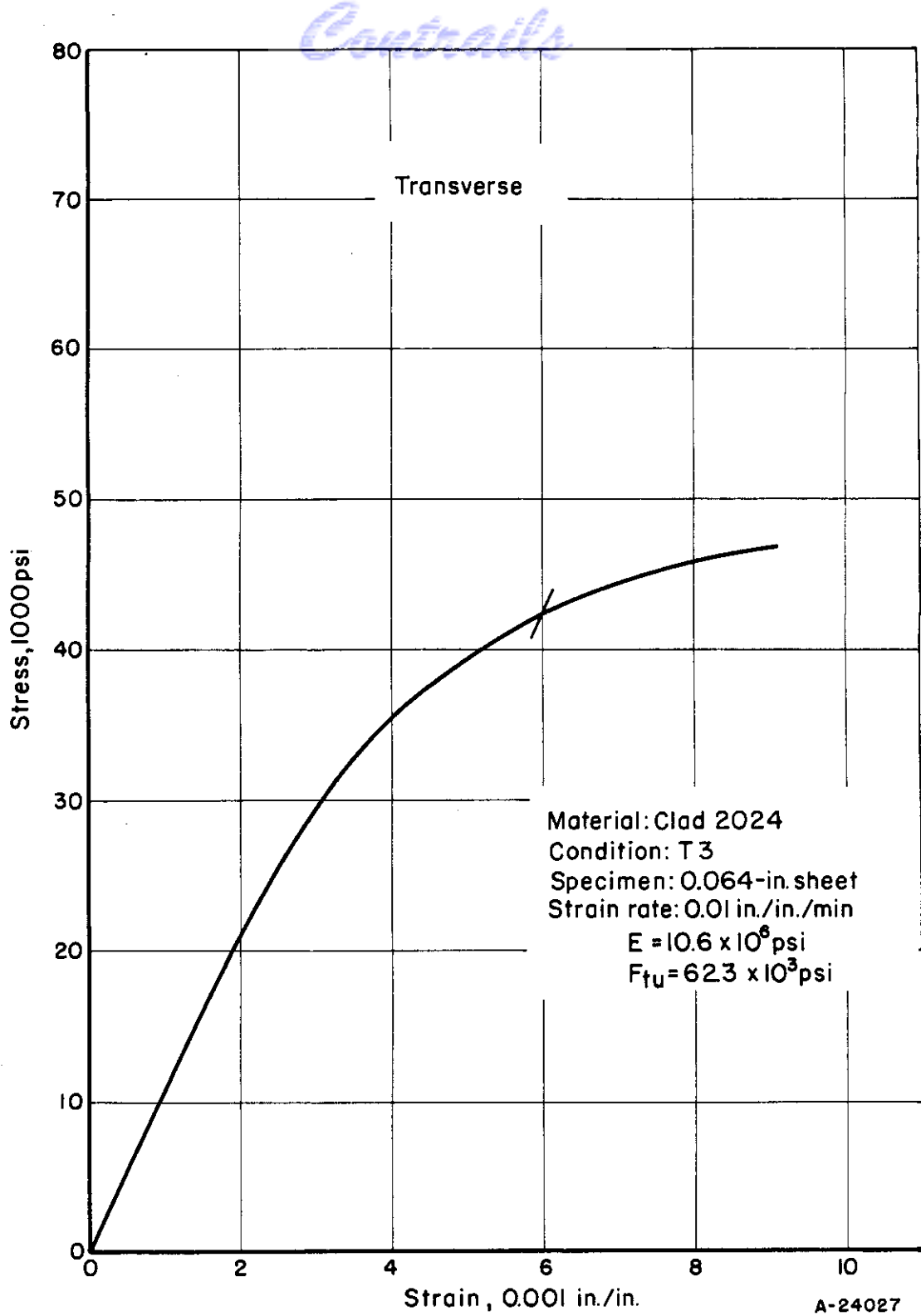


FIGURE 48. TENSILE STRESS-STRAIN CURVE FOR CLAD 2024-T3 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 71.

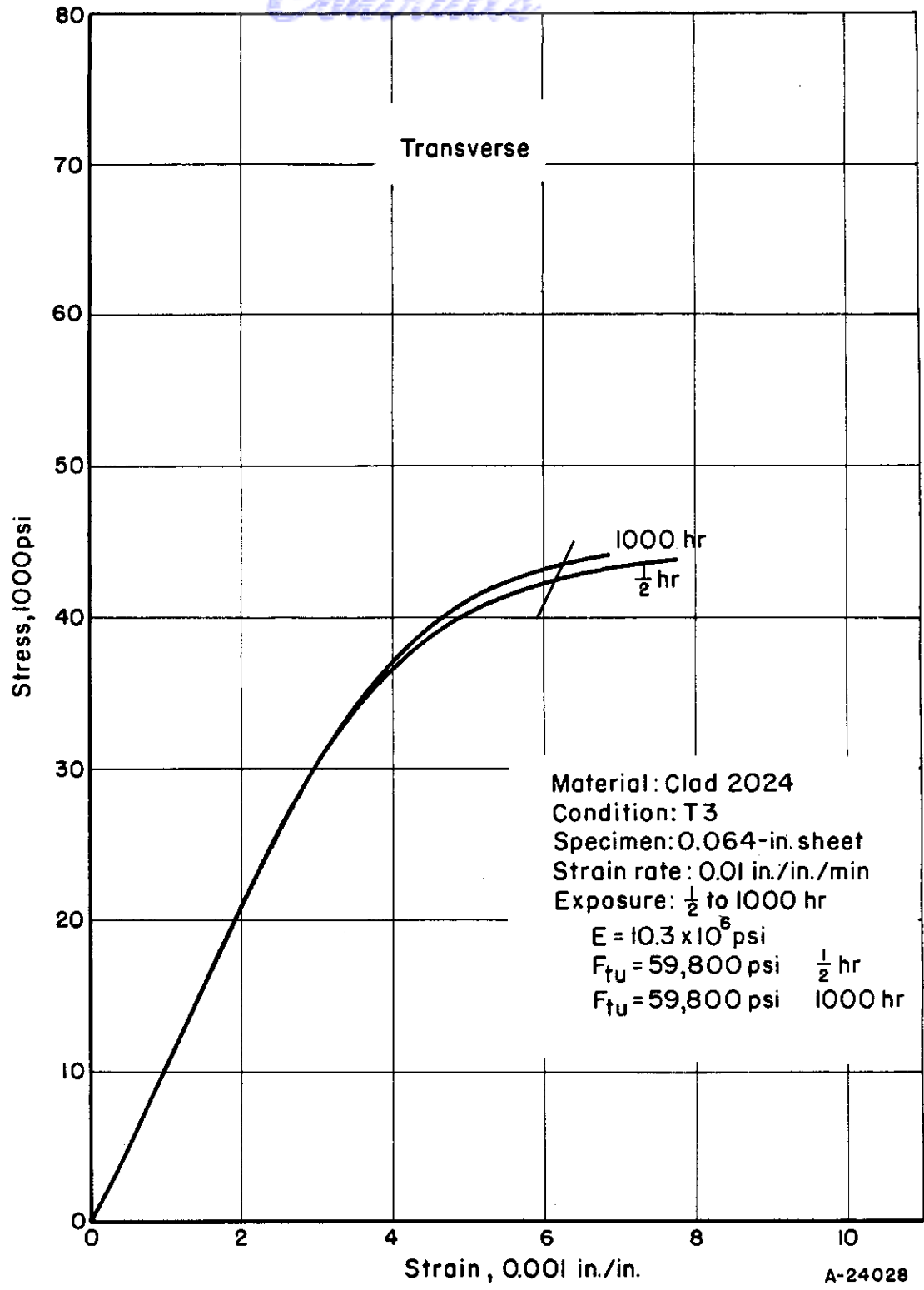


FIGURE 49. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 212 F

Ref. 71, p. 2.

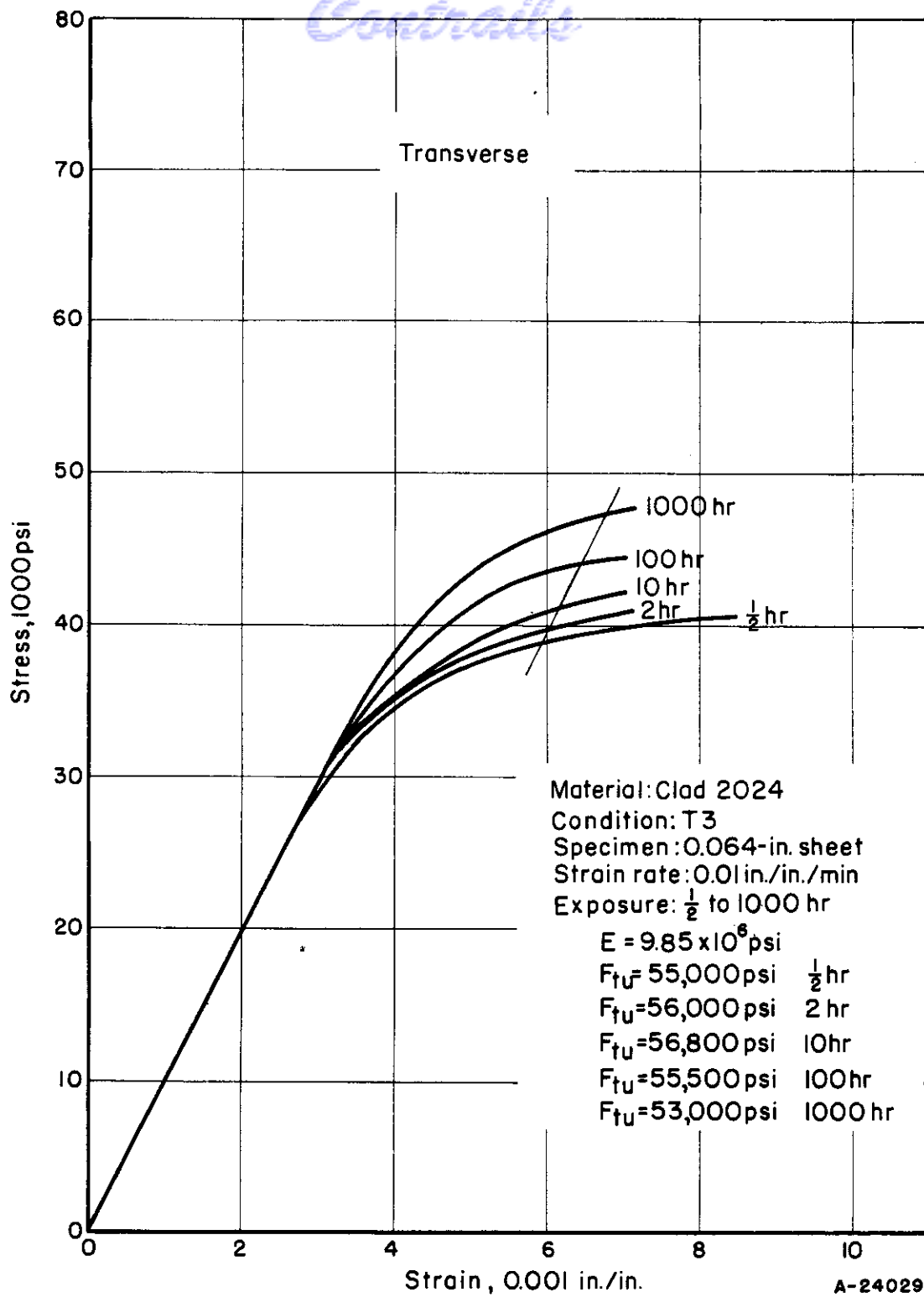


FIGURE 50. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 300 F

Ref. 71, p 3.

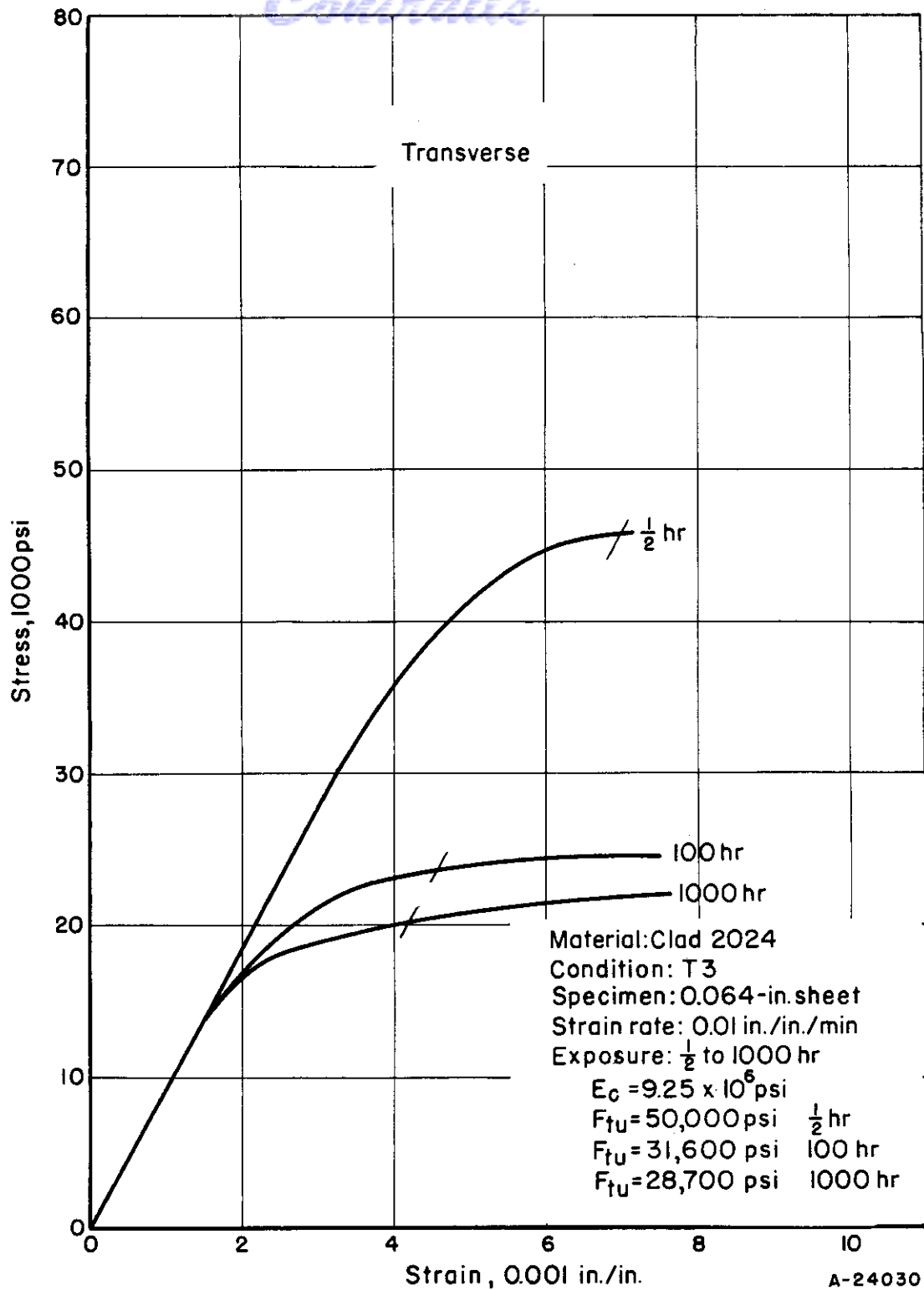


FIGURE 51. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 400 F

Ref. 71, p 4.

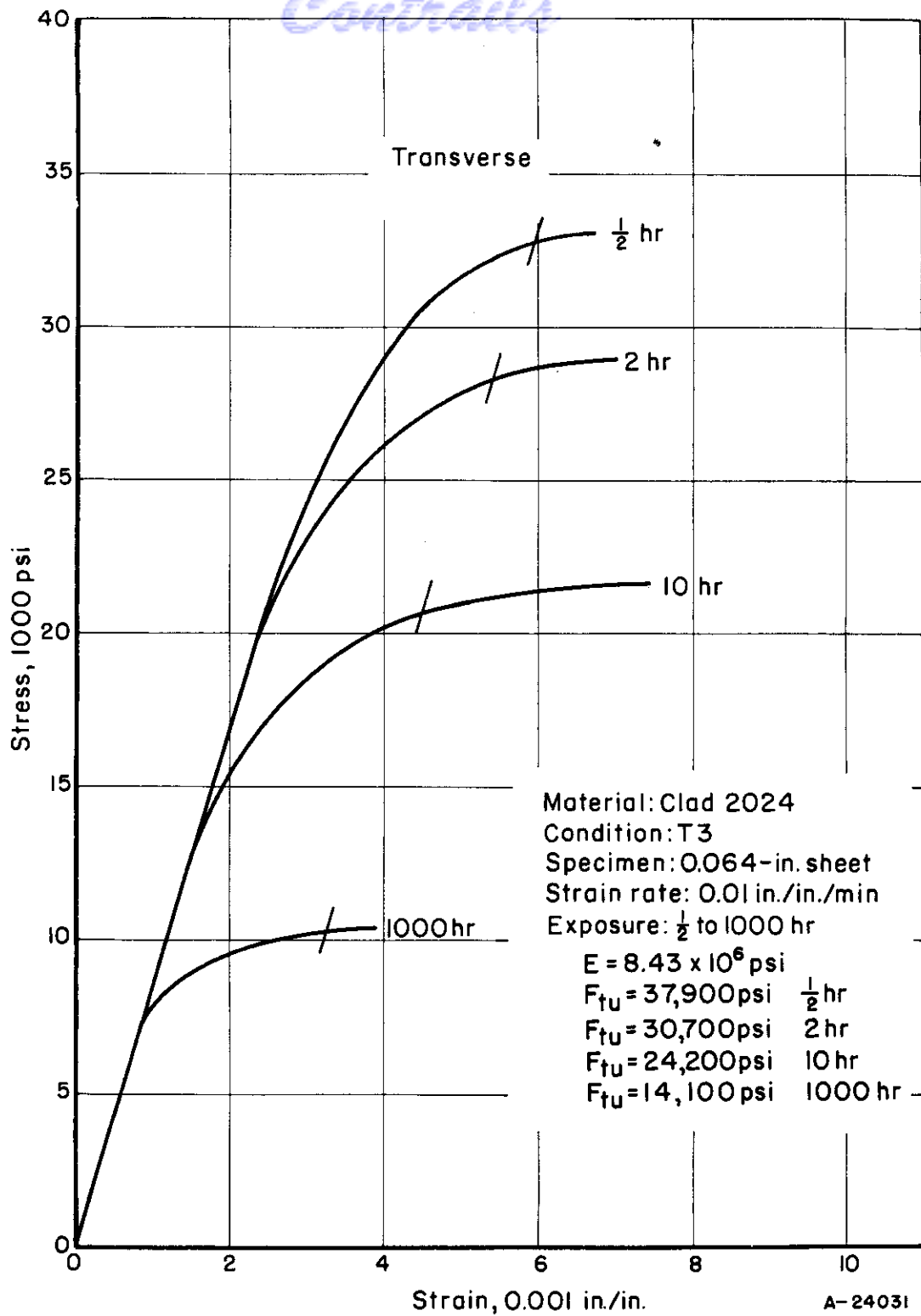


FIGURE 52. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 500 F

Ref. 71, p 5.

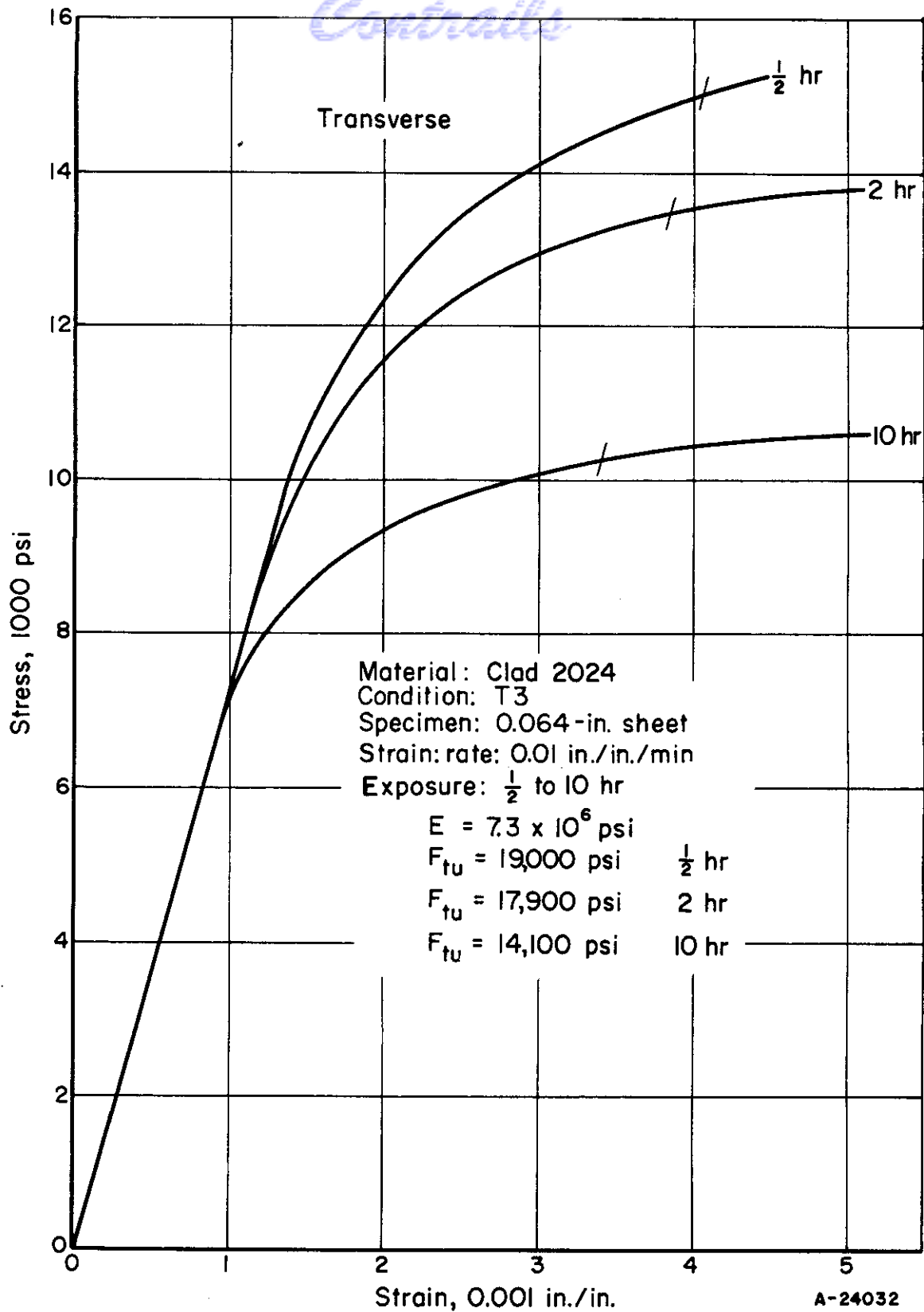


FIGURE 53. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 600 F

Ref. 71, p 6.

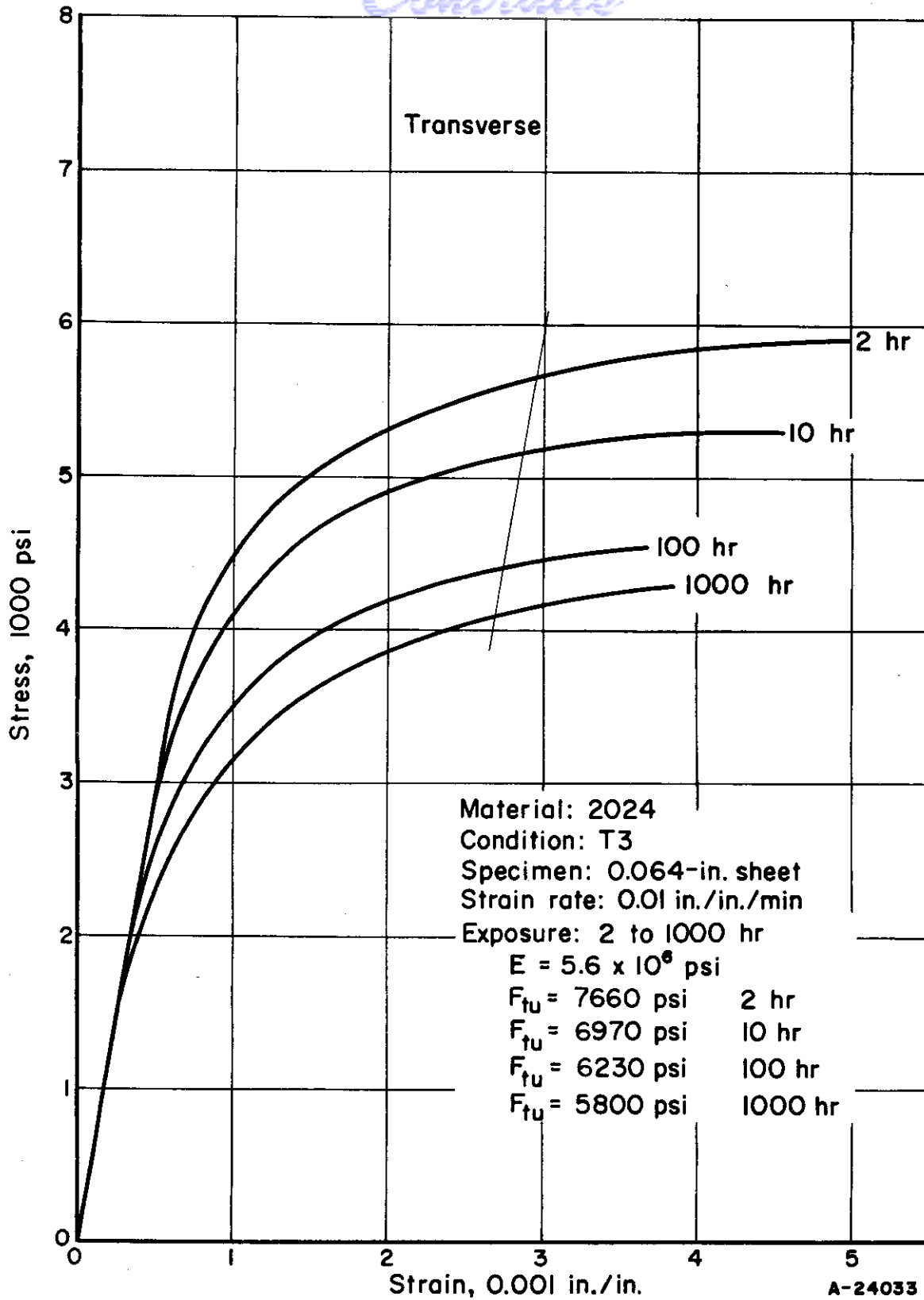


FIGURE 54. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 700 F

Ref. 71, p 7.

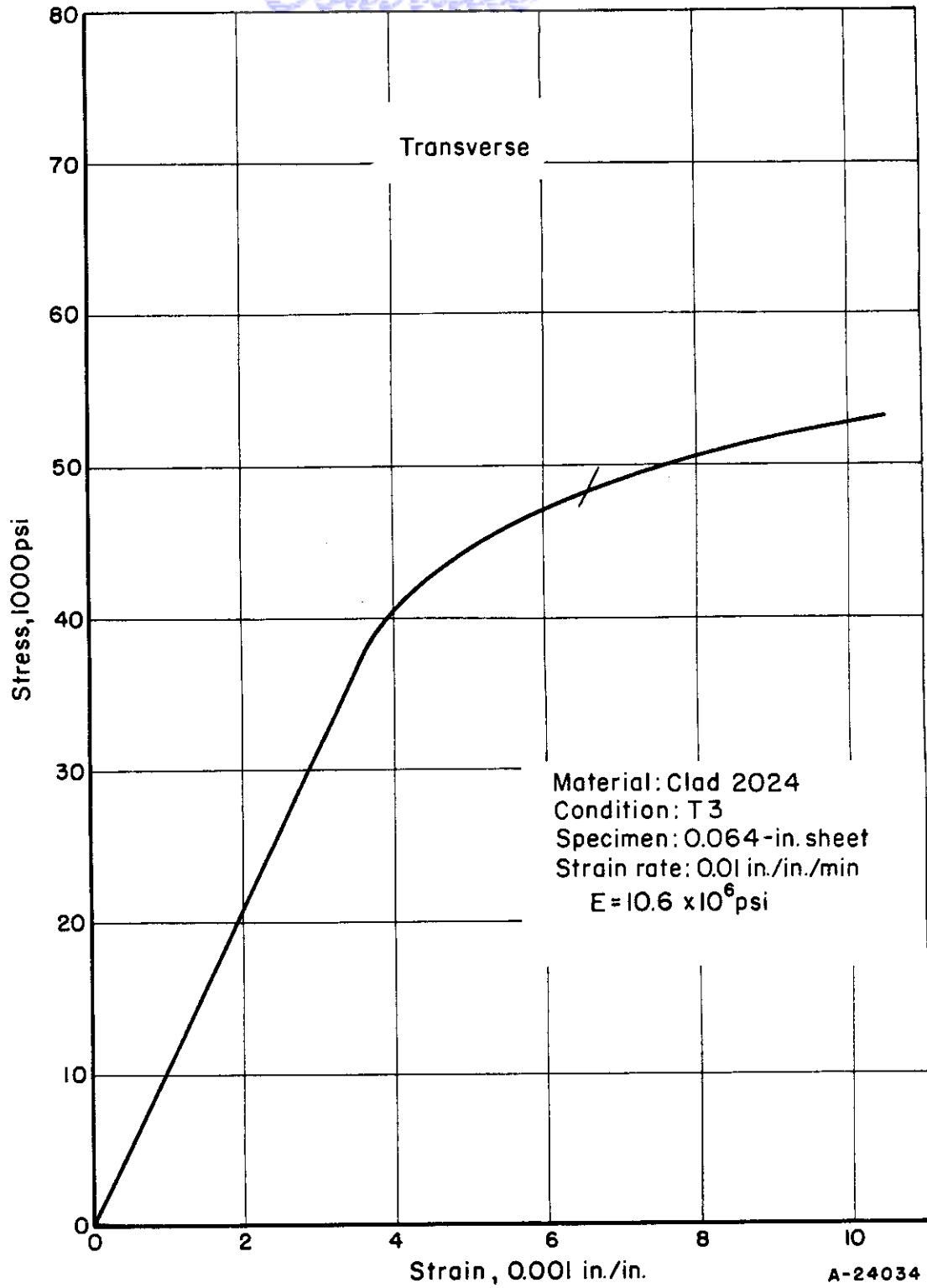


FIGURE 55. COMPRESSIVE STRESS-STRAIN CURVE FOR CLAD 2024-T3 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 71, 8.

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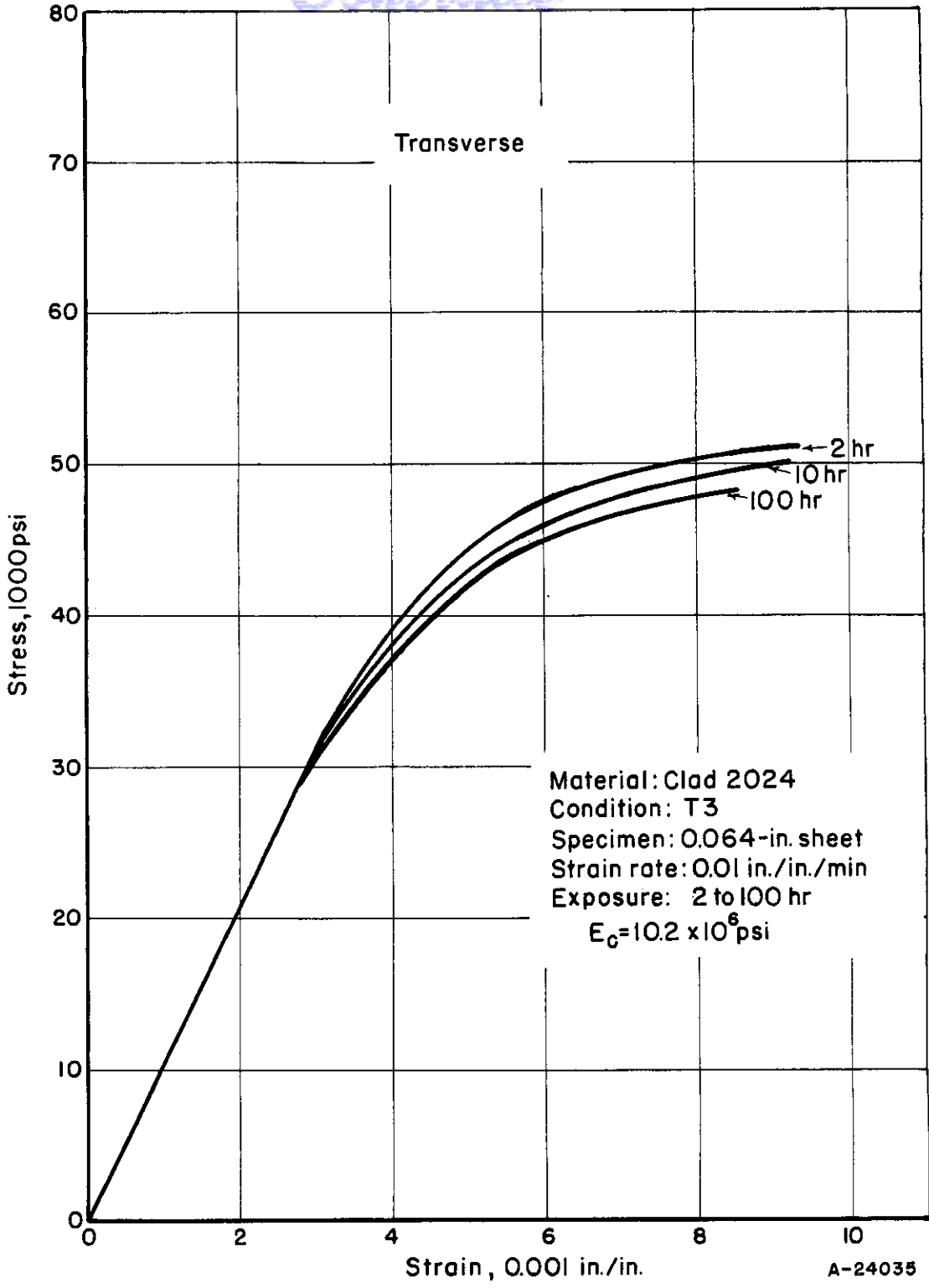


FIGURE 56. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 212 F

Ref. 71.

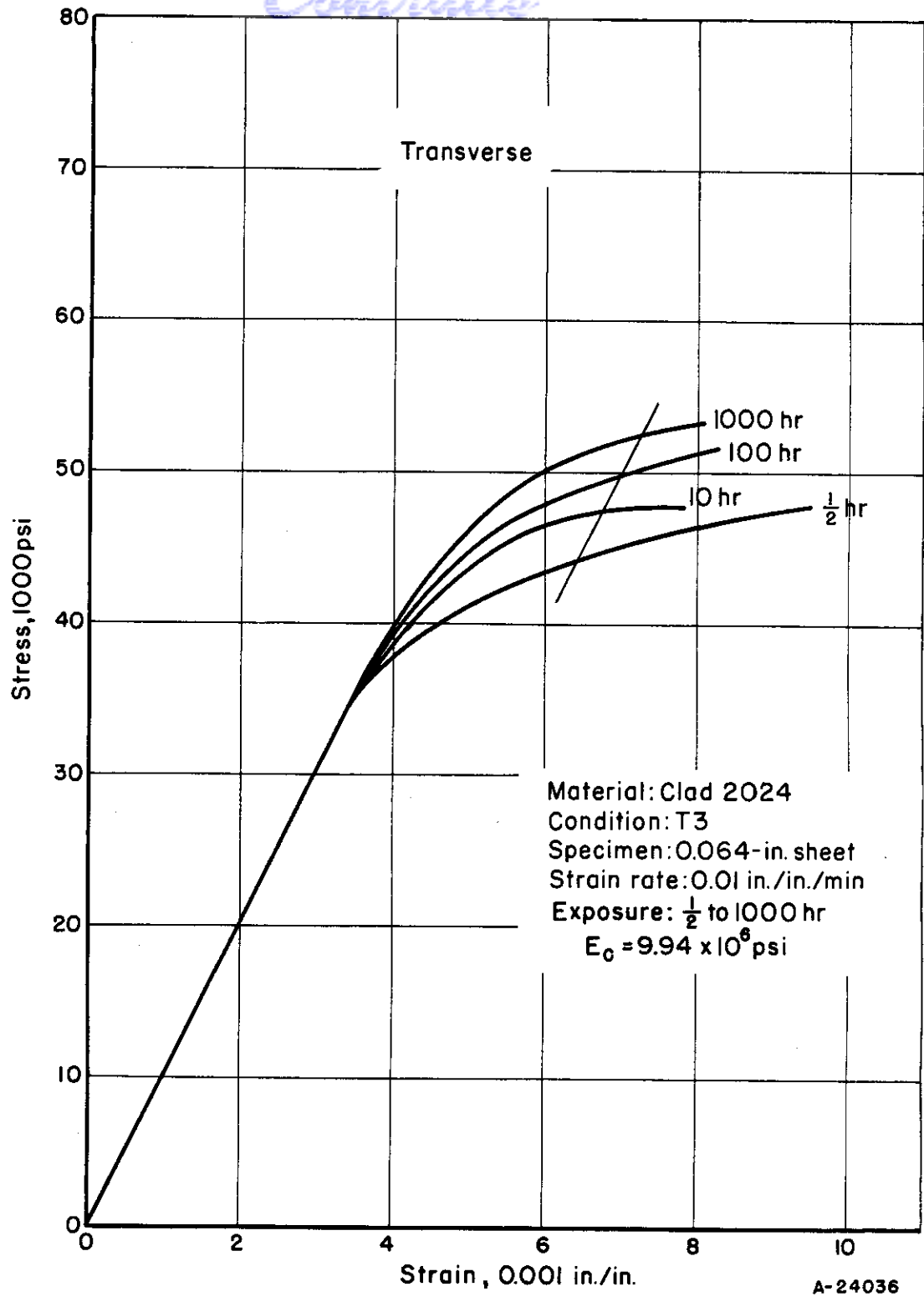


FIGURE 57. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 300 F

Ref. 71, p 10.

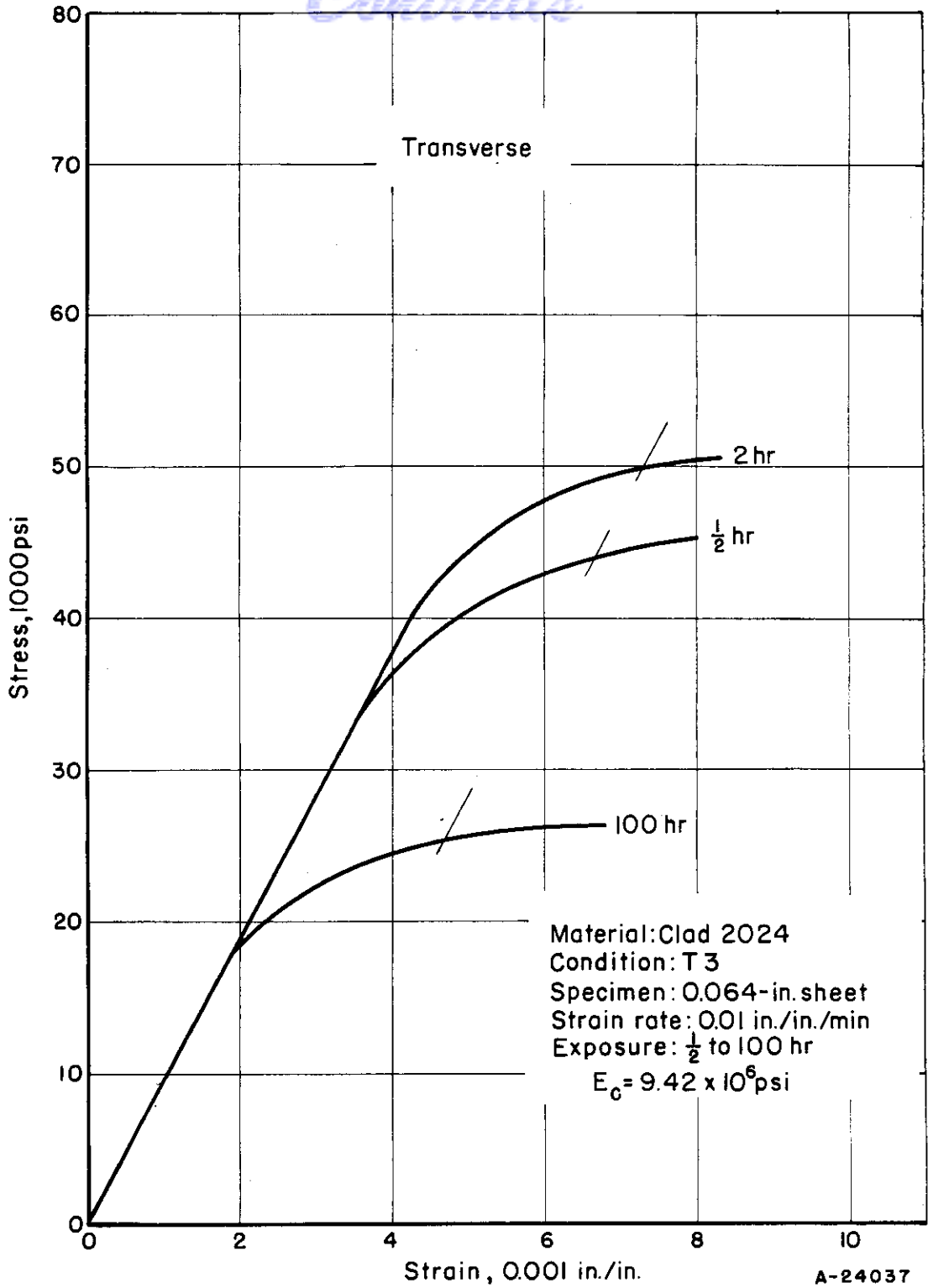


FIGURE 58. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 400 F

Ref. 71.

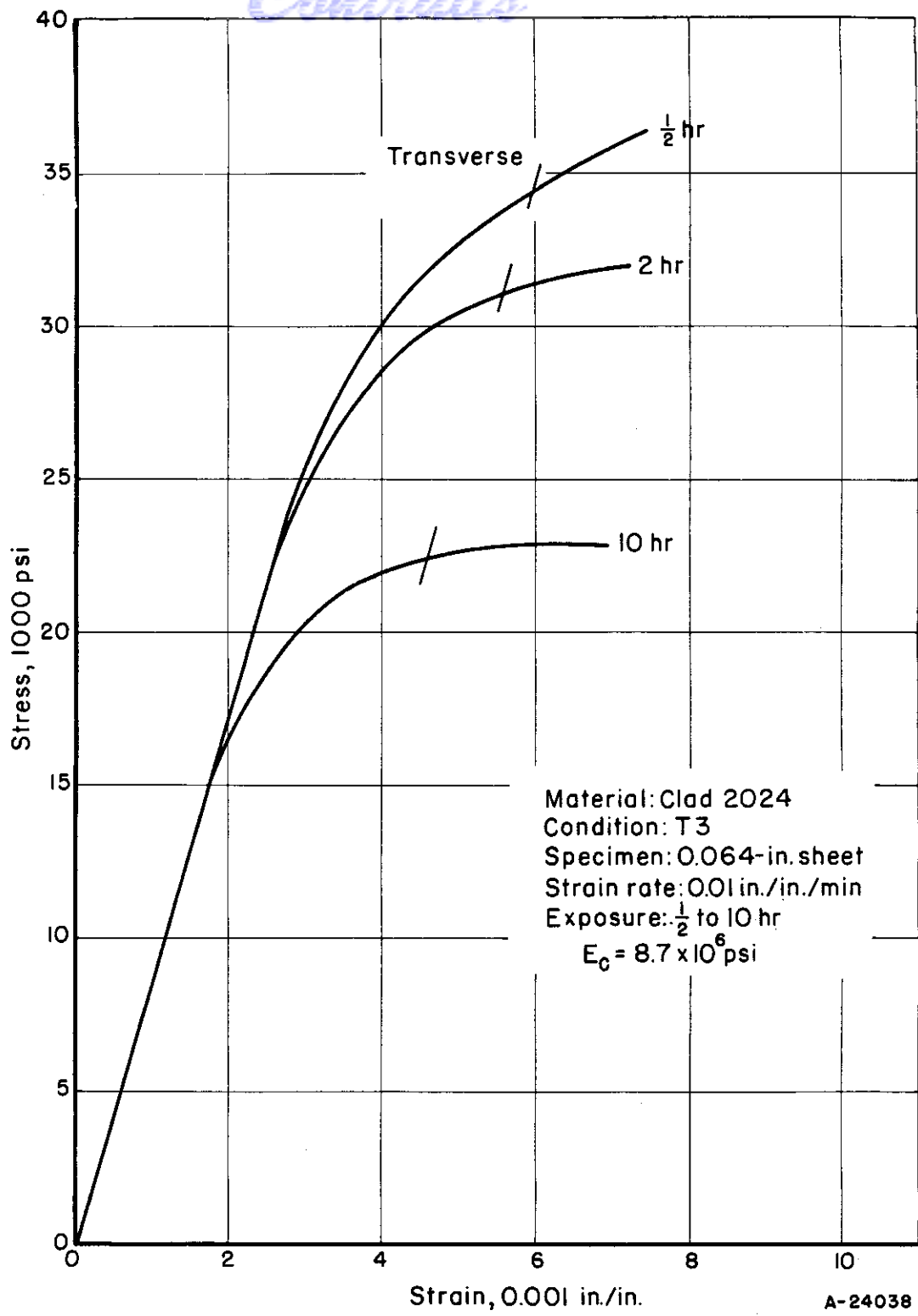


FIGURE 59. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 500 F

Ref. 71.

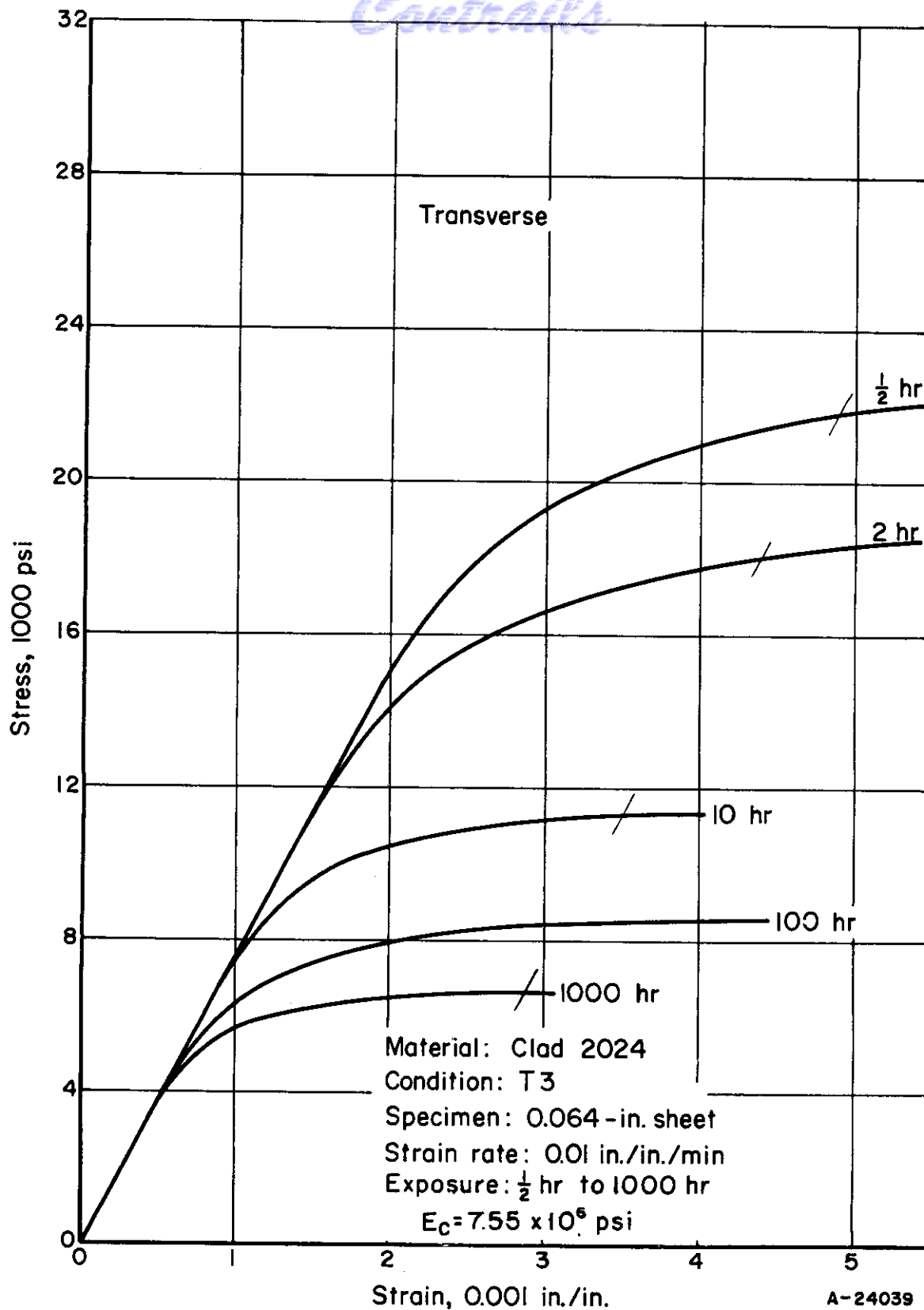


FIGURE 60. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 600 F

Ref. 71.

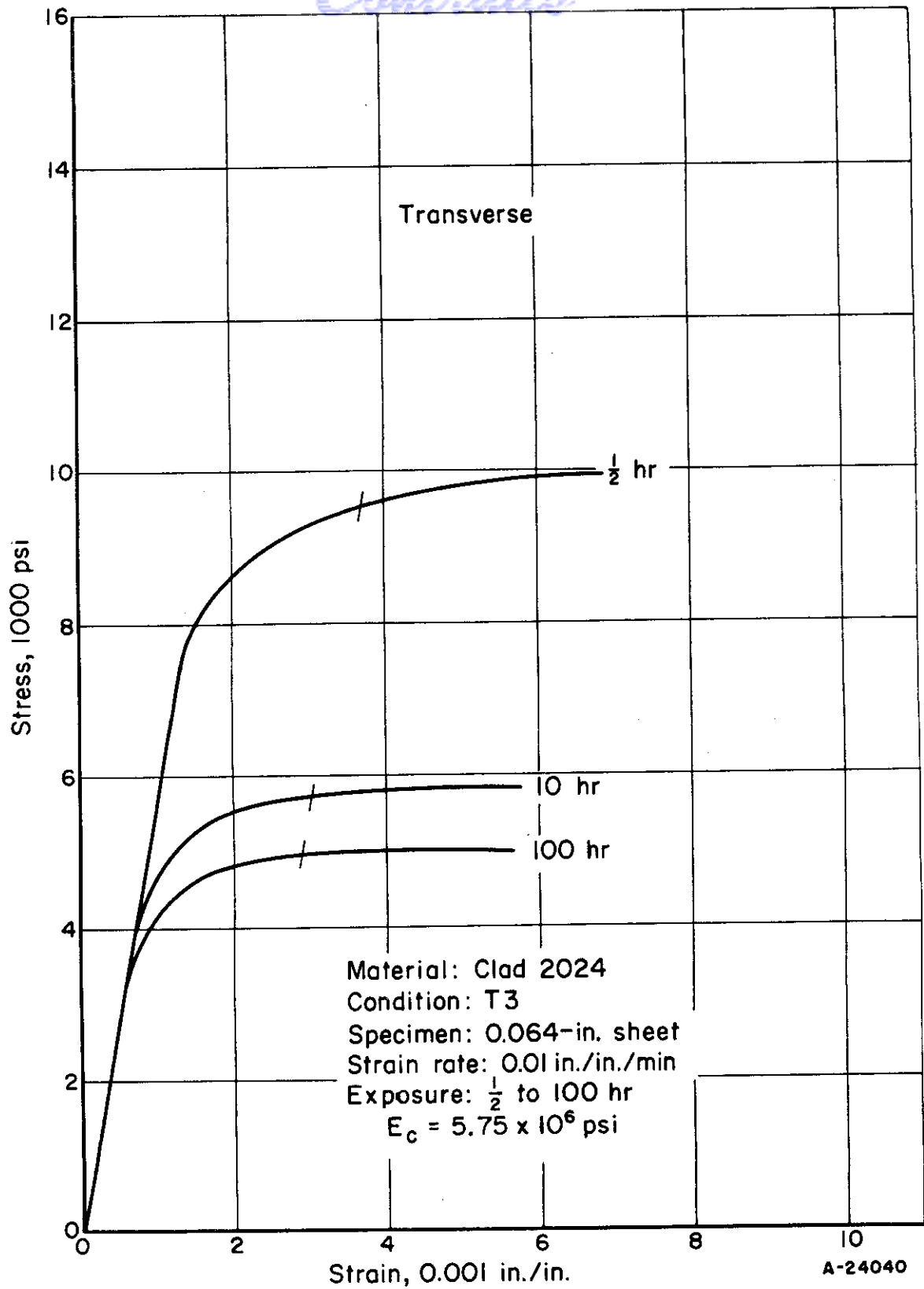


FIGURE 61. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT 700 F

Ref. 71.

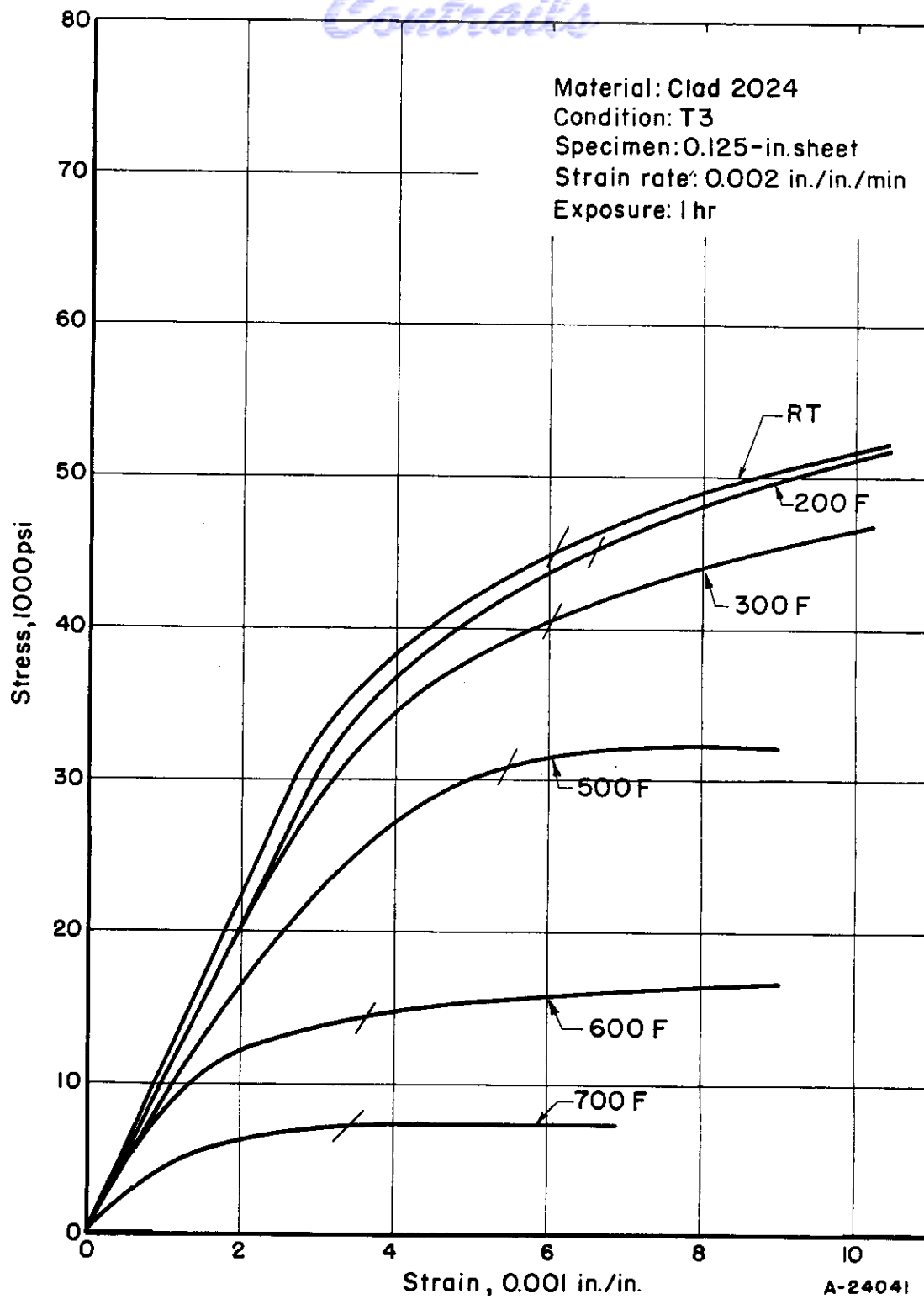


FIGURE 62. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T3 ALUMINUM ALLOY AT ELEVATED TEMPERATURE

Ref. 371.

WADC TR 55-150 Pt VI

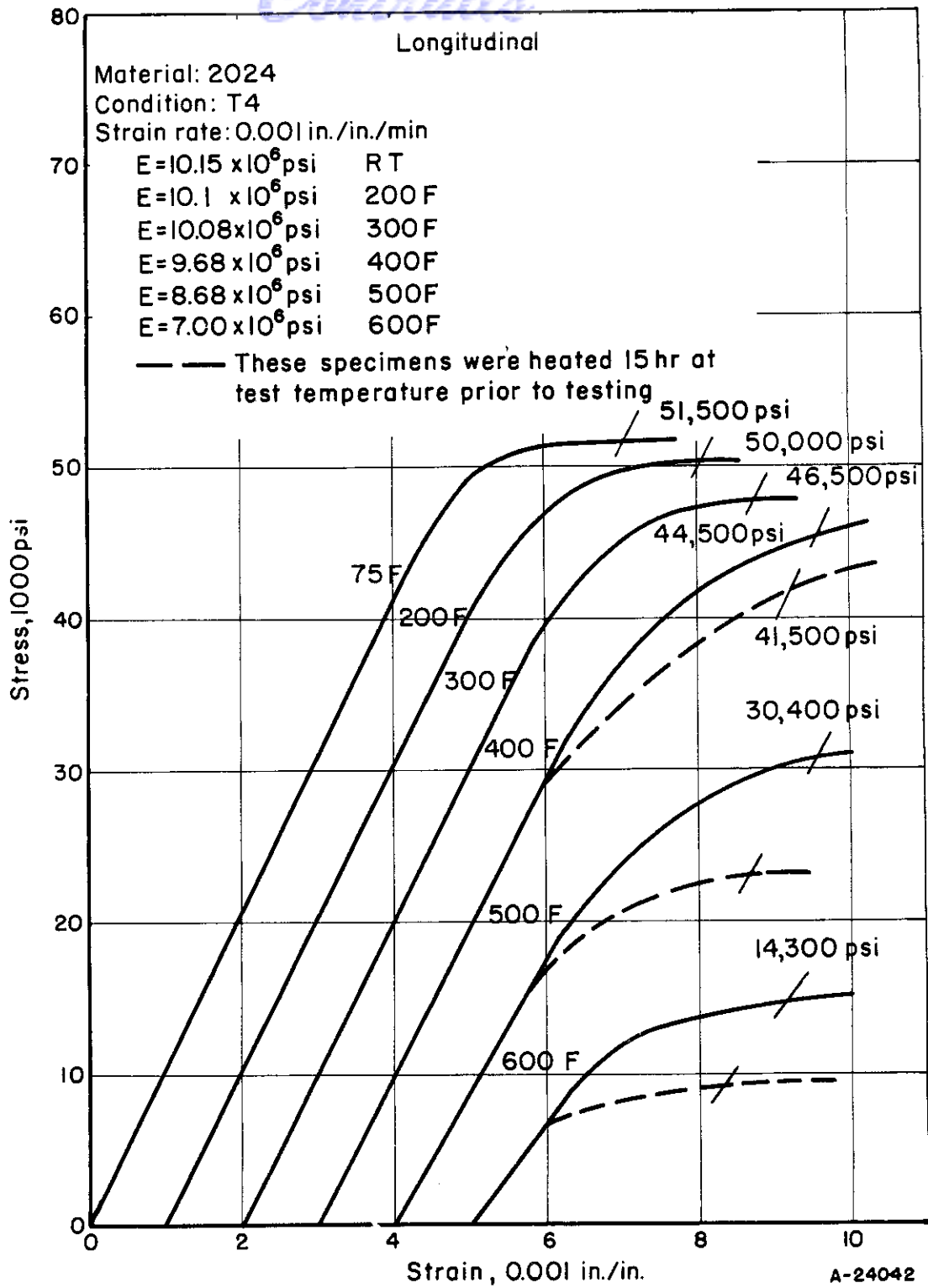


FIGURE 63. TENSILE STRESS-STRAIN CURVES FOR 2024-T4 ALUMINUM ALLOY AT ROOM AND ELEVATED TEMPERATURE

Ref. 69, p 13.

WADC TR 55-150 Pt VI

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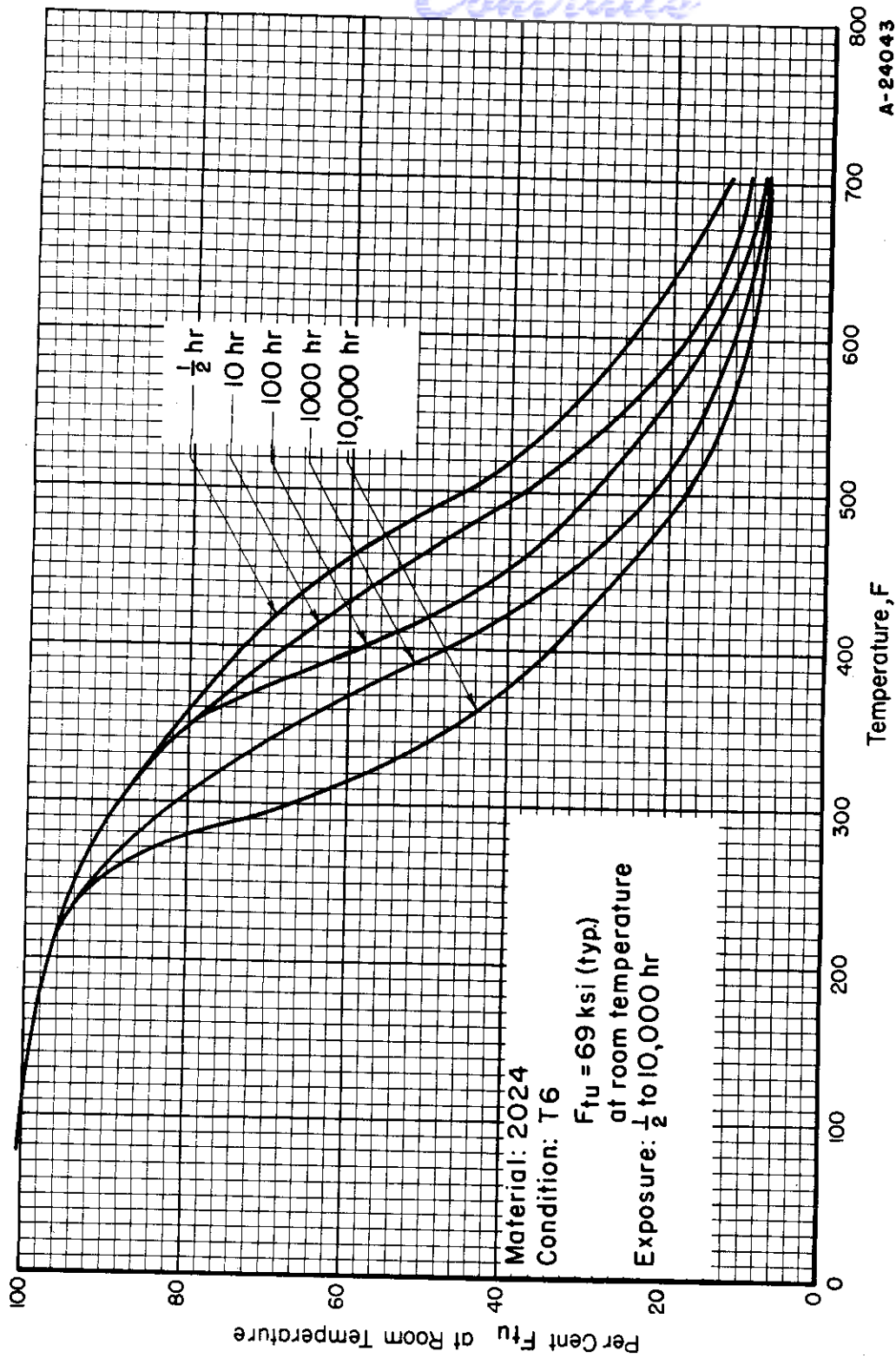


FIGURE 64. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF 2024-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101.

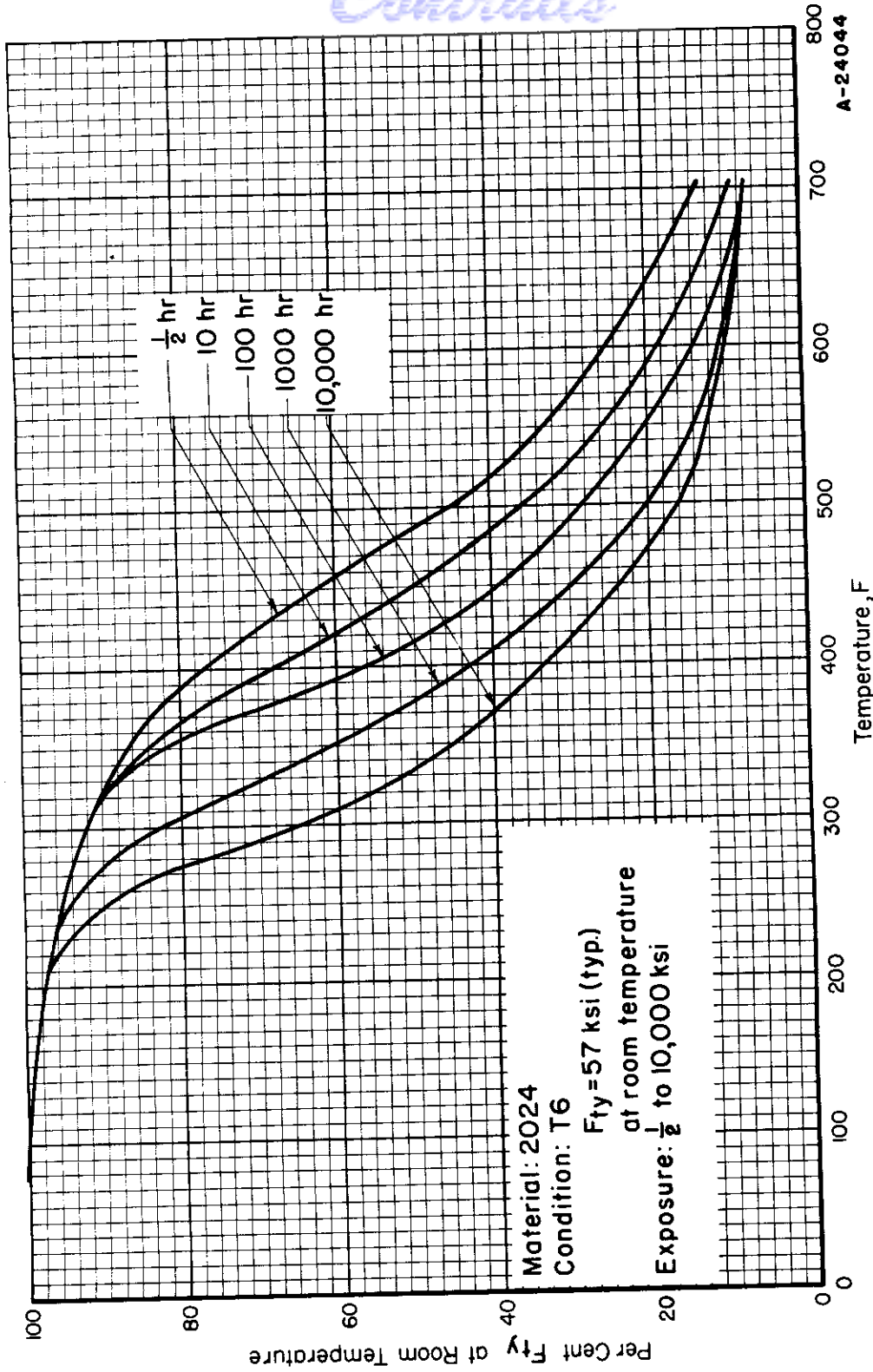


FIGURE 65. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF 2024-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101.

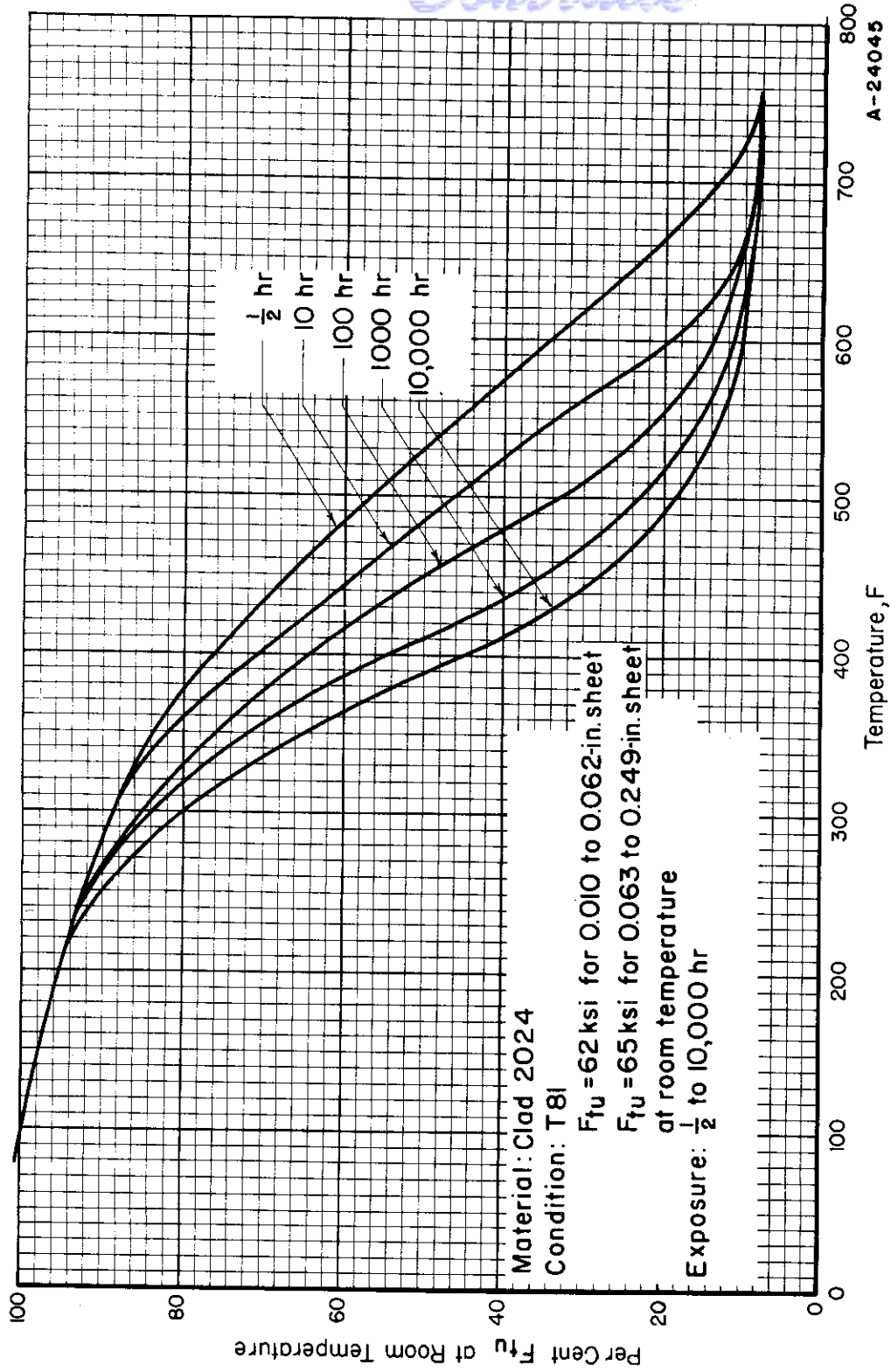
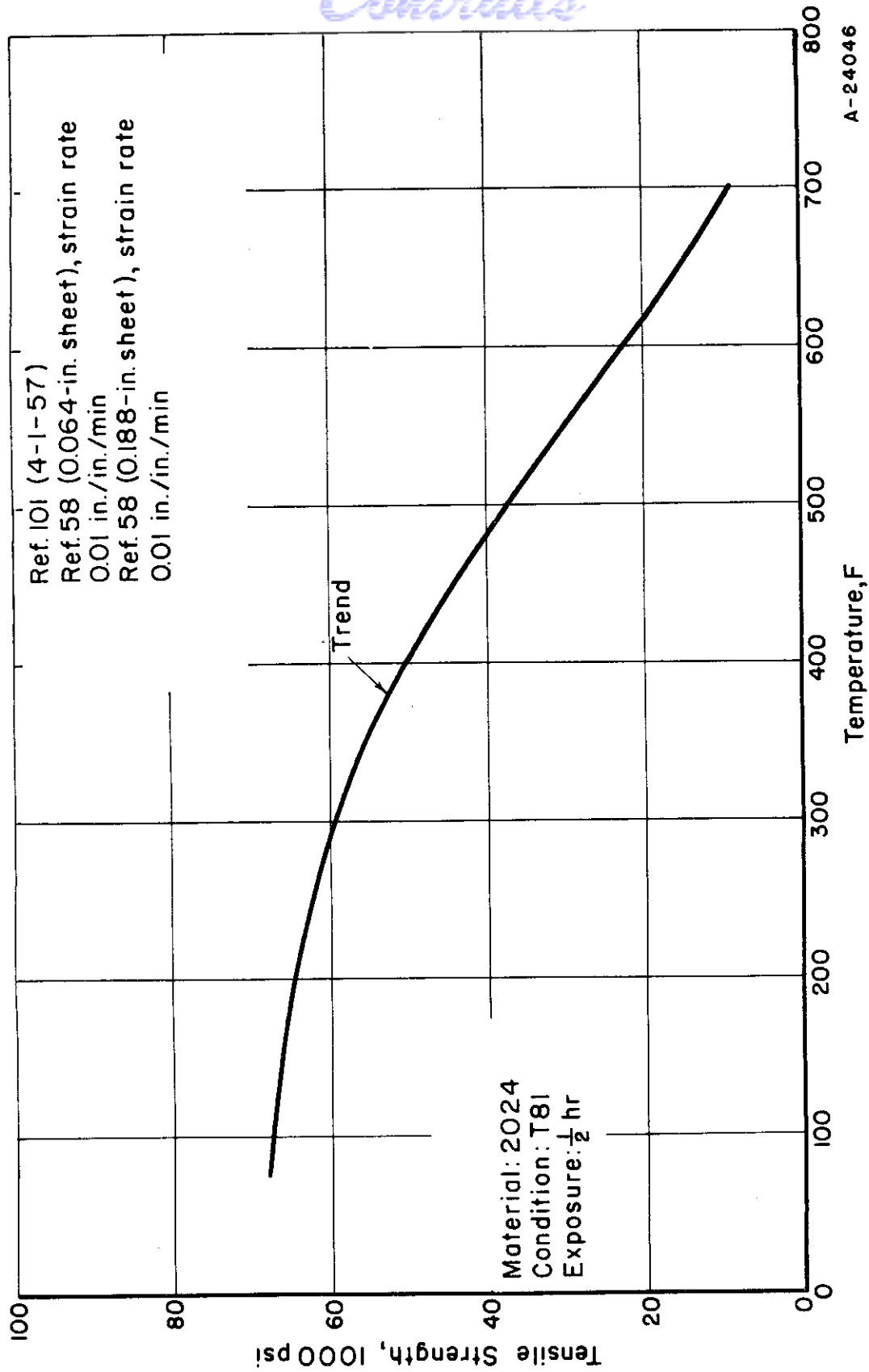


FIGURE 66. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF CLAD 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 58, 101.



A-24046

FIGURE 67. TENSILE STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

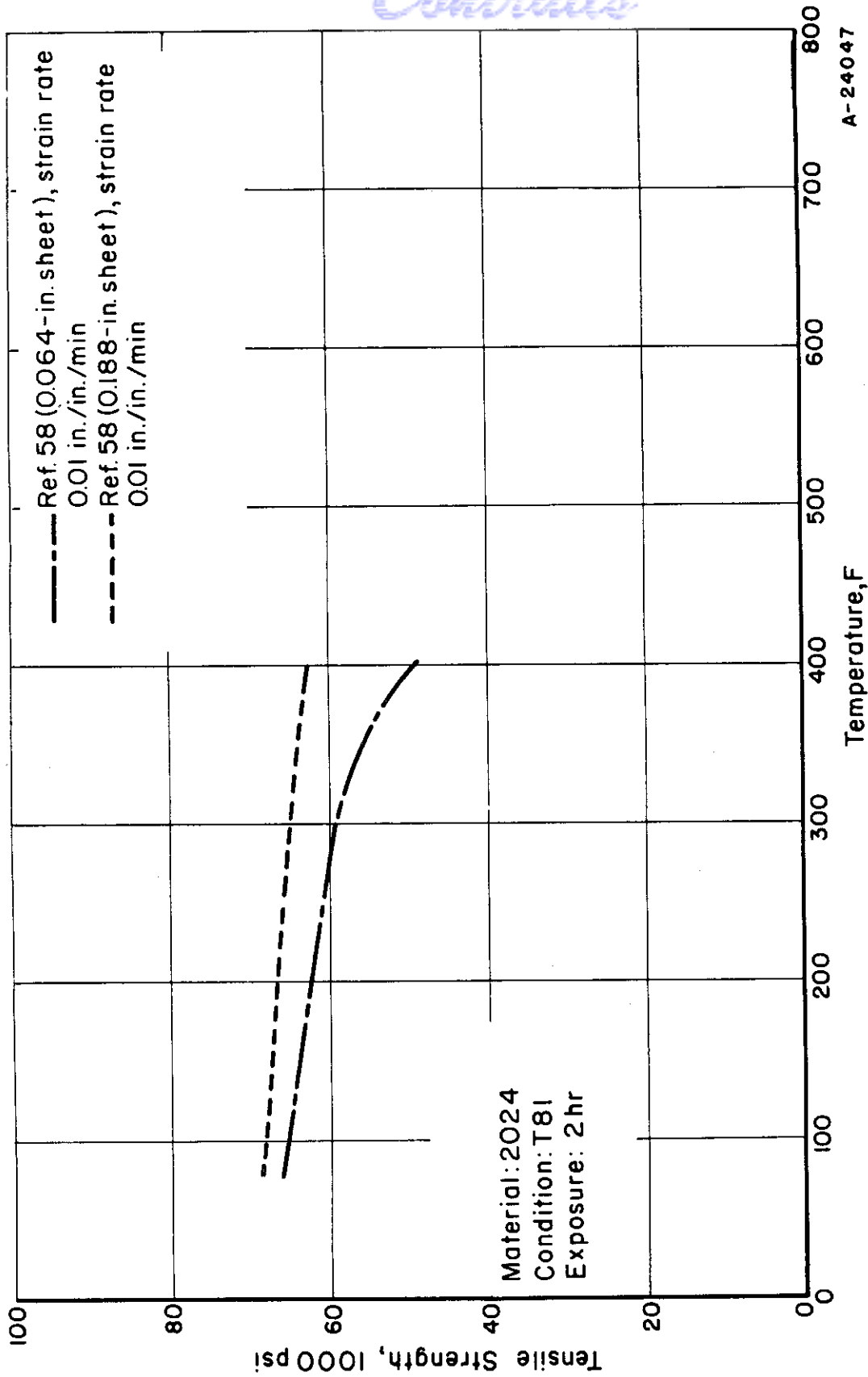
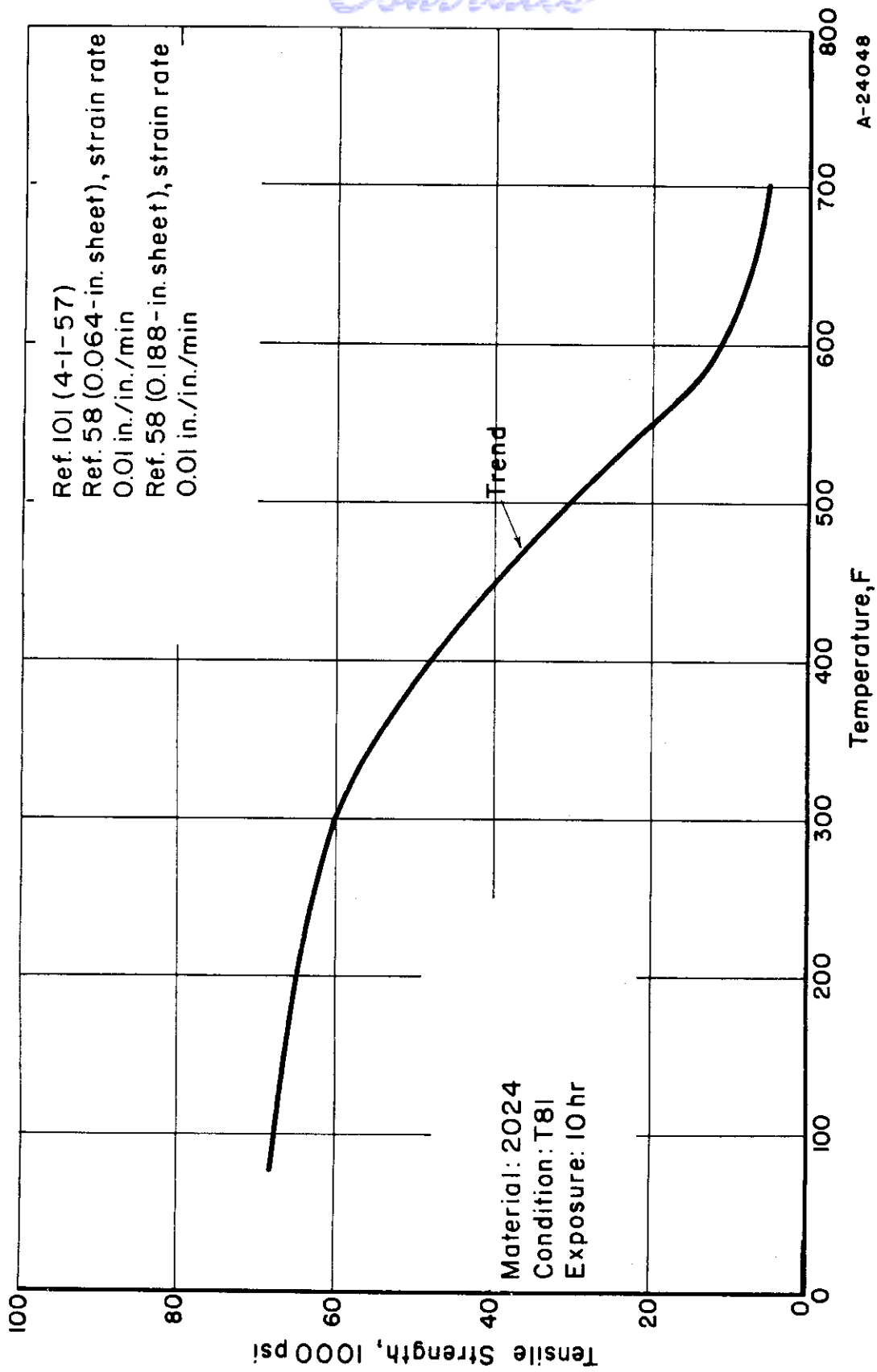


FIGURE 68. TENSILE STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)

A-24047



A-24048

FIGURE 69. TENSILE STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

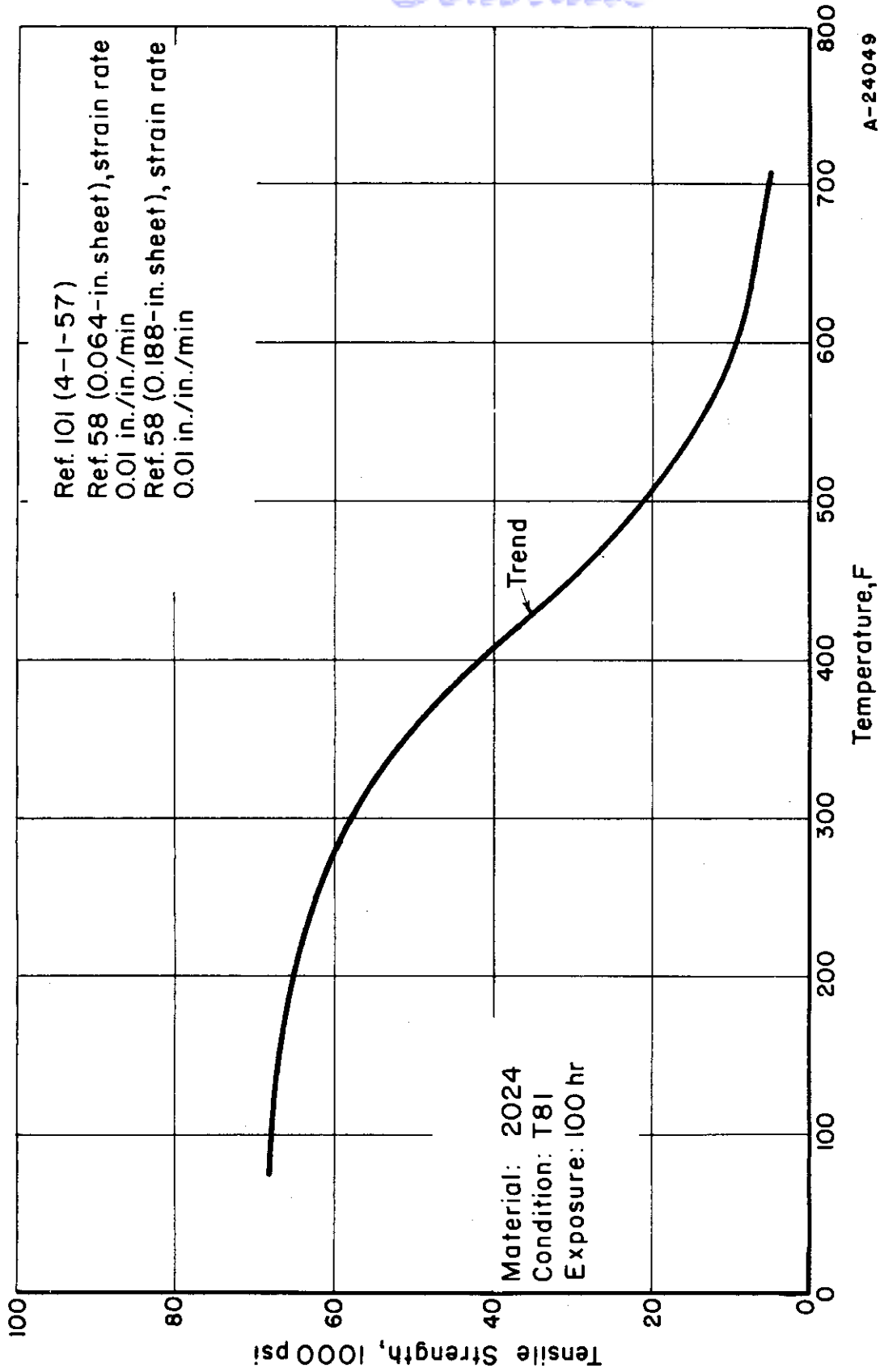


FIGURE 70. TENSILE STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)

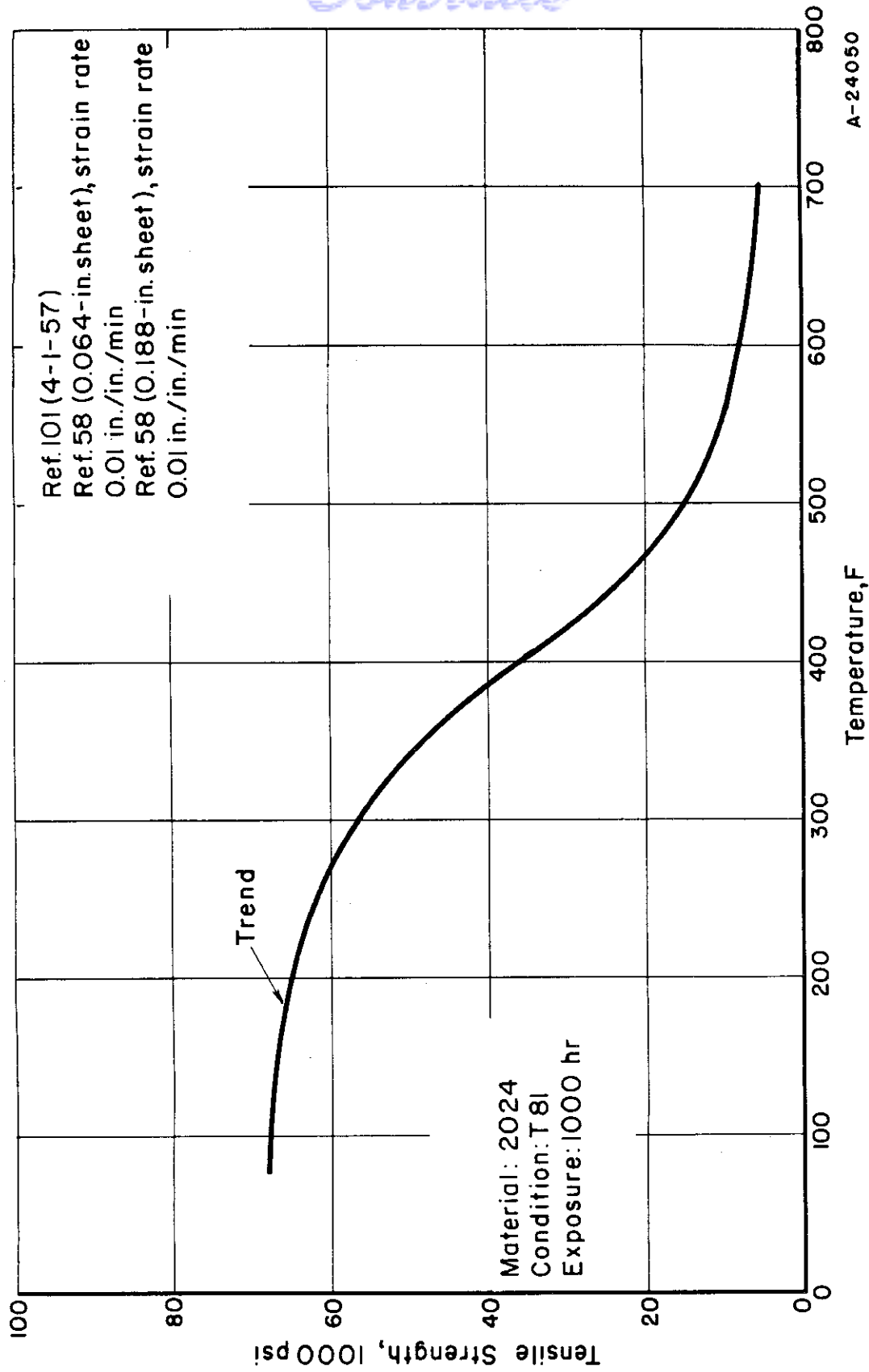


FIGURE 71. TENSILE STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

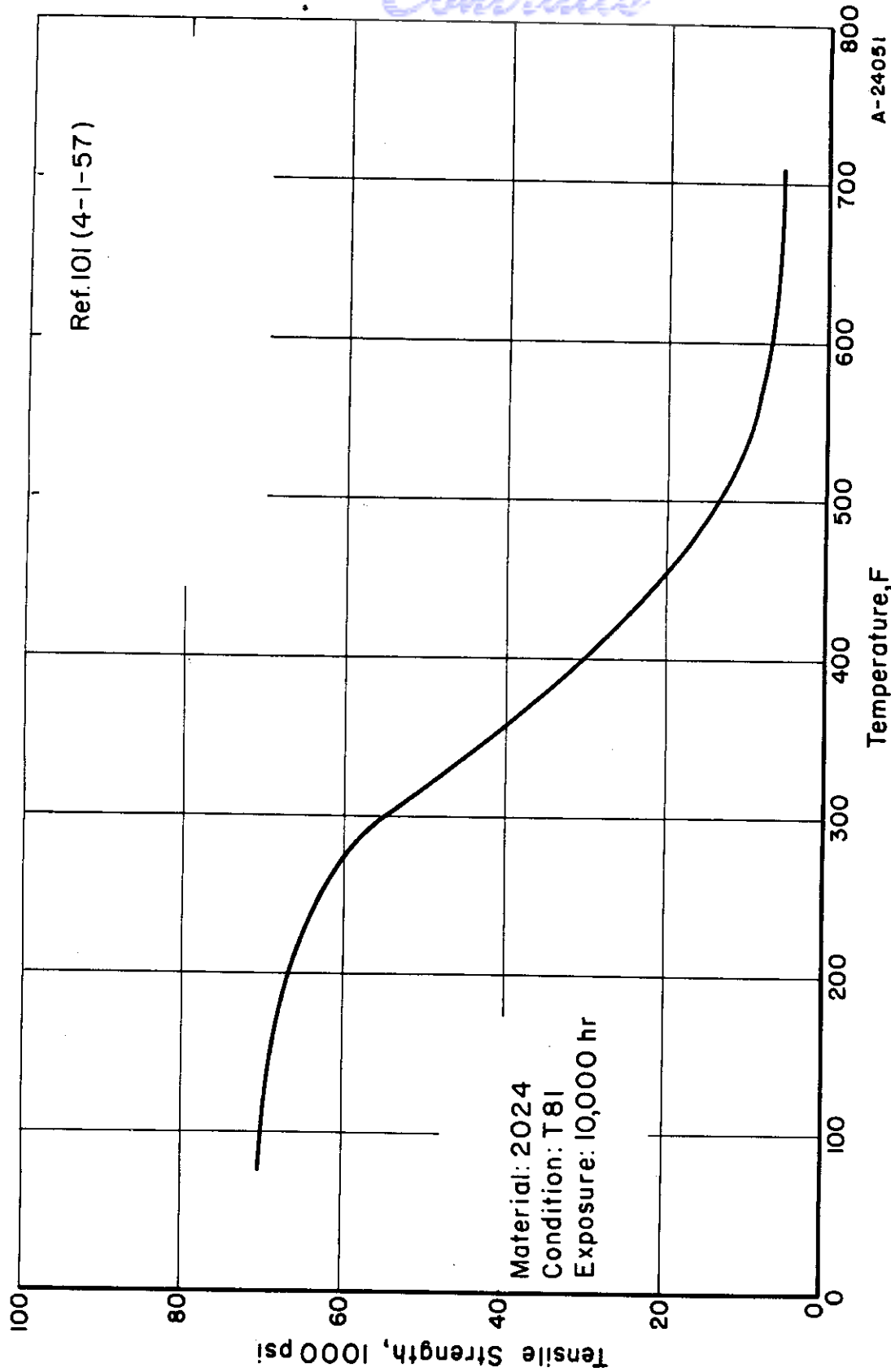


FIGURE 72. TENSILE STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

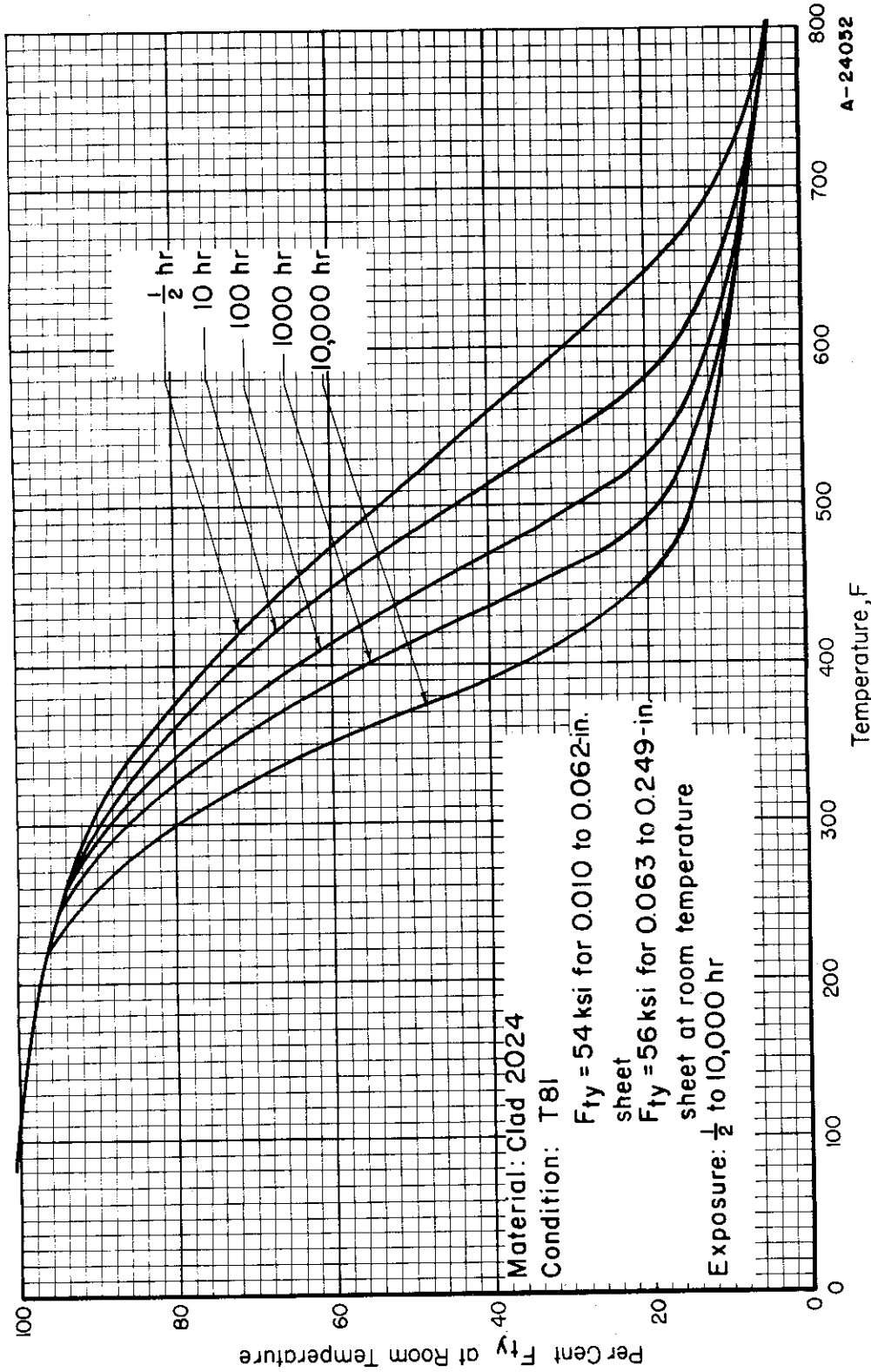


FIGURE 73. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF CLAD 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101, (design curve)
Ref. 58 (supplementary data)

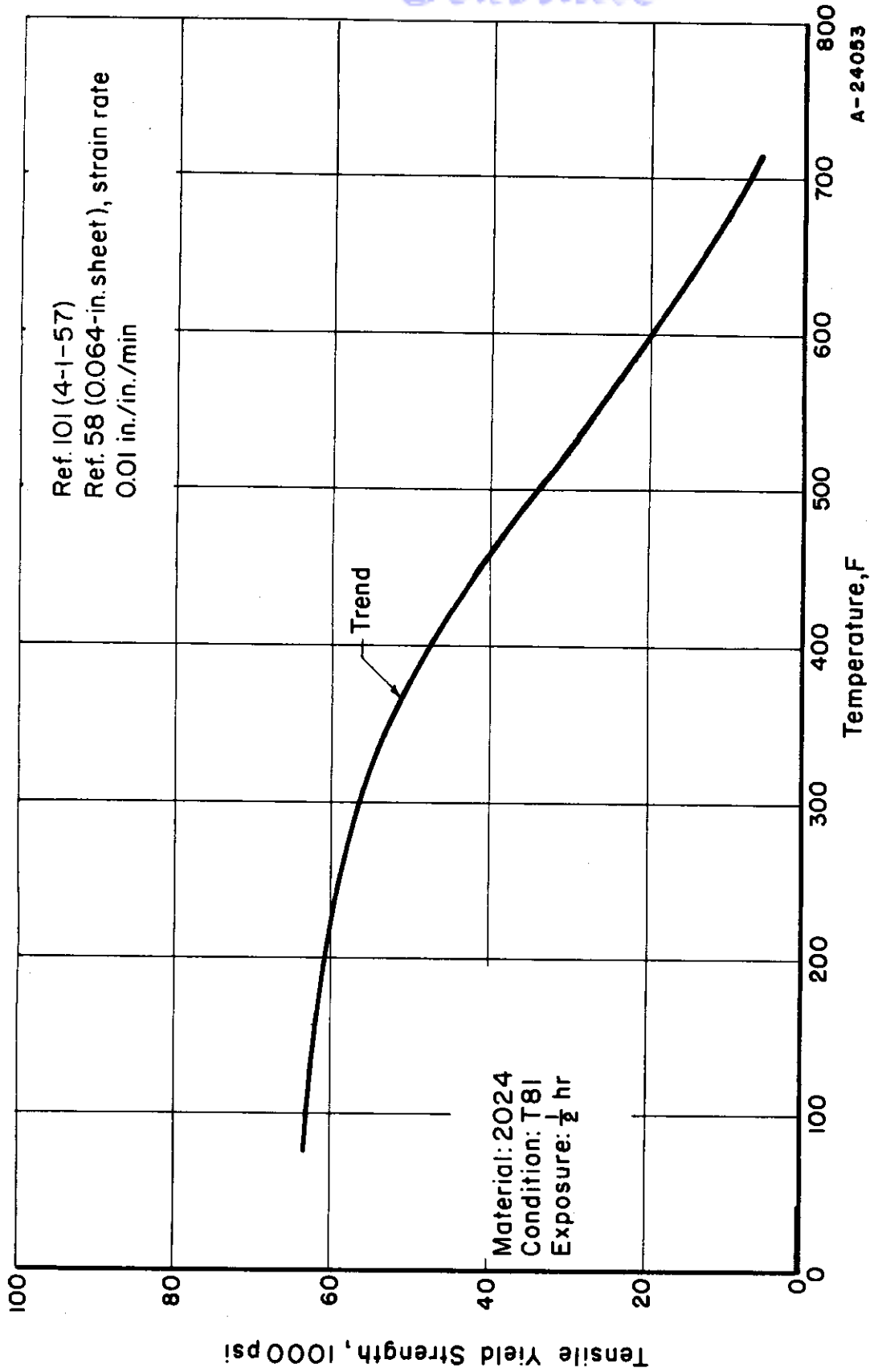
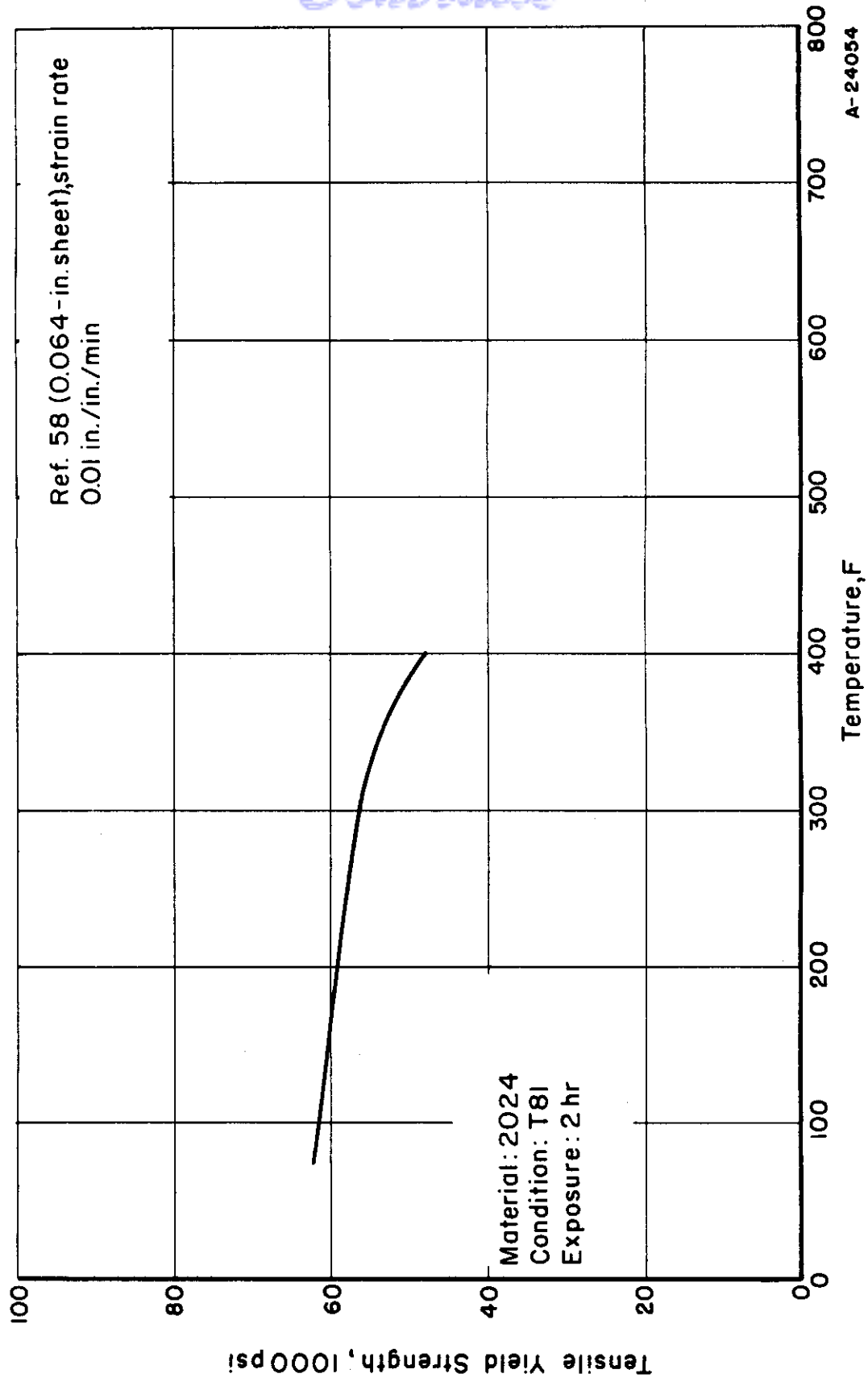


FIGURE 74. TENSILE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



A-24054

FIGURE 75. TENSILE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)

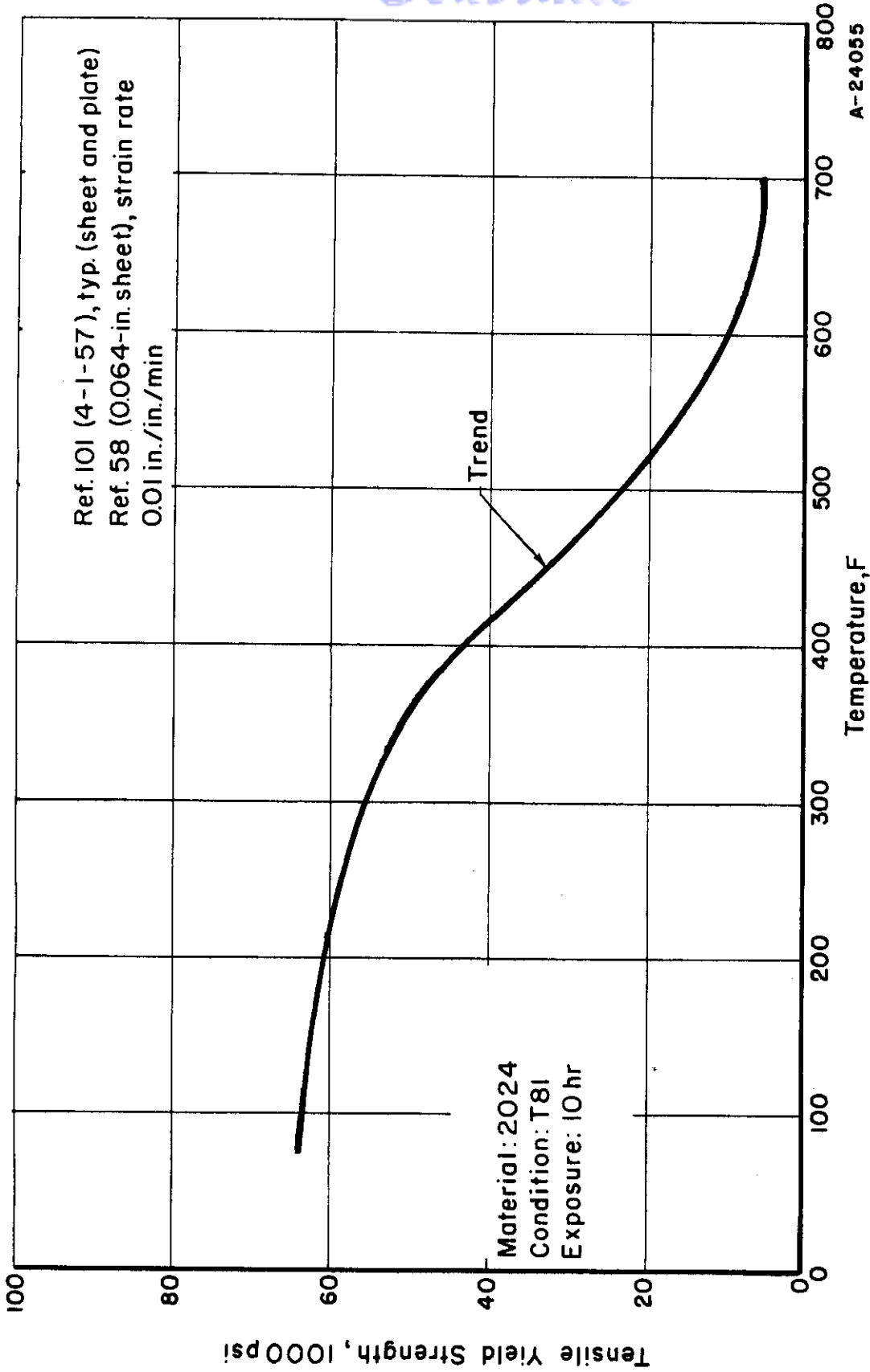


FIGURE 76. TENSILE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

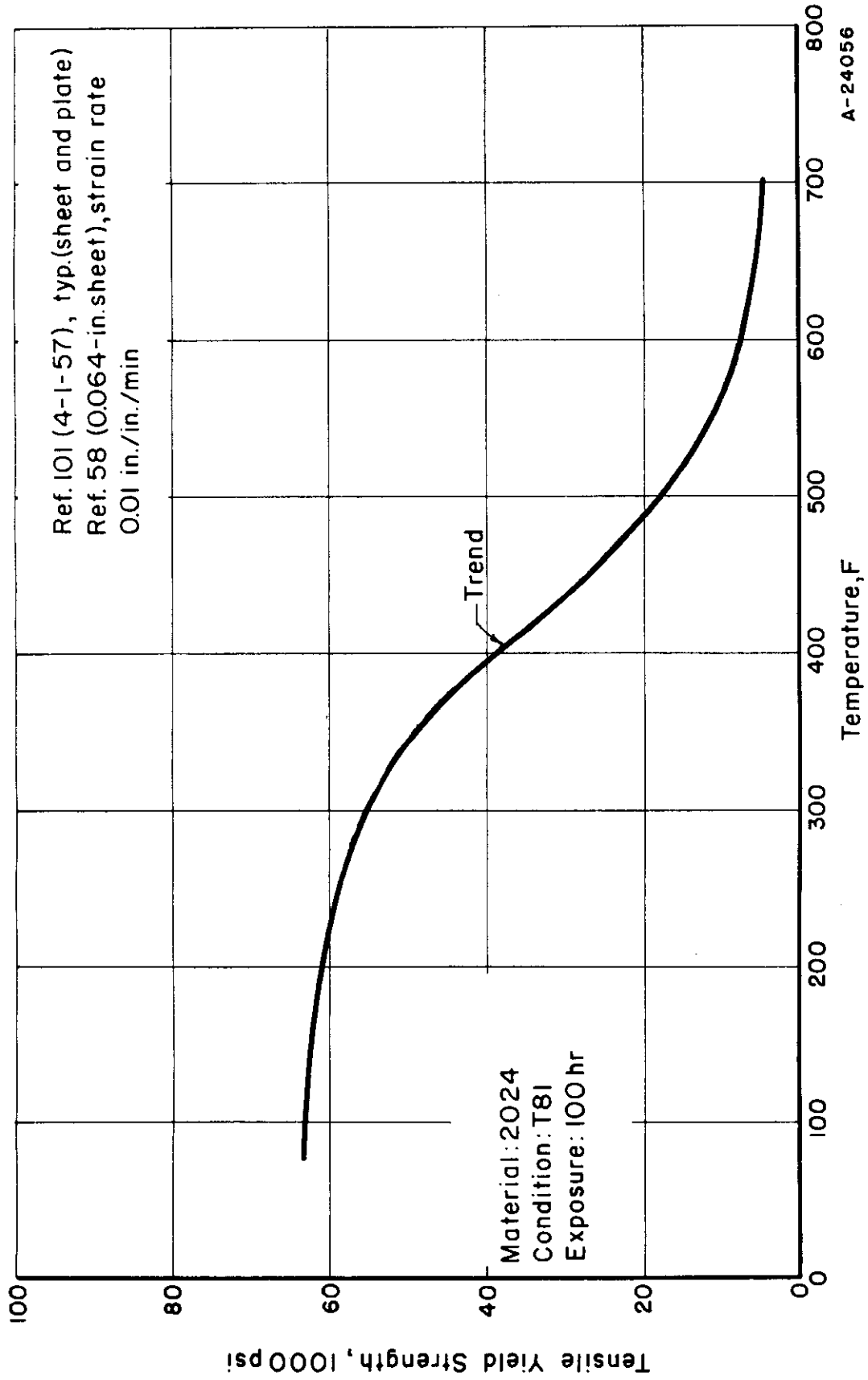


FIGURE 77. TENSILE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)

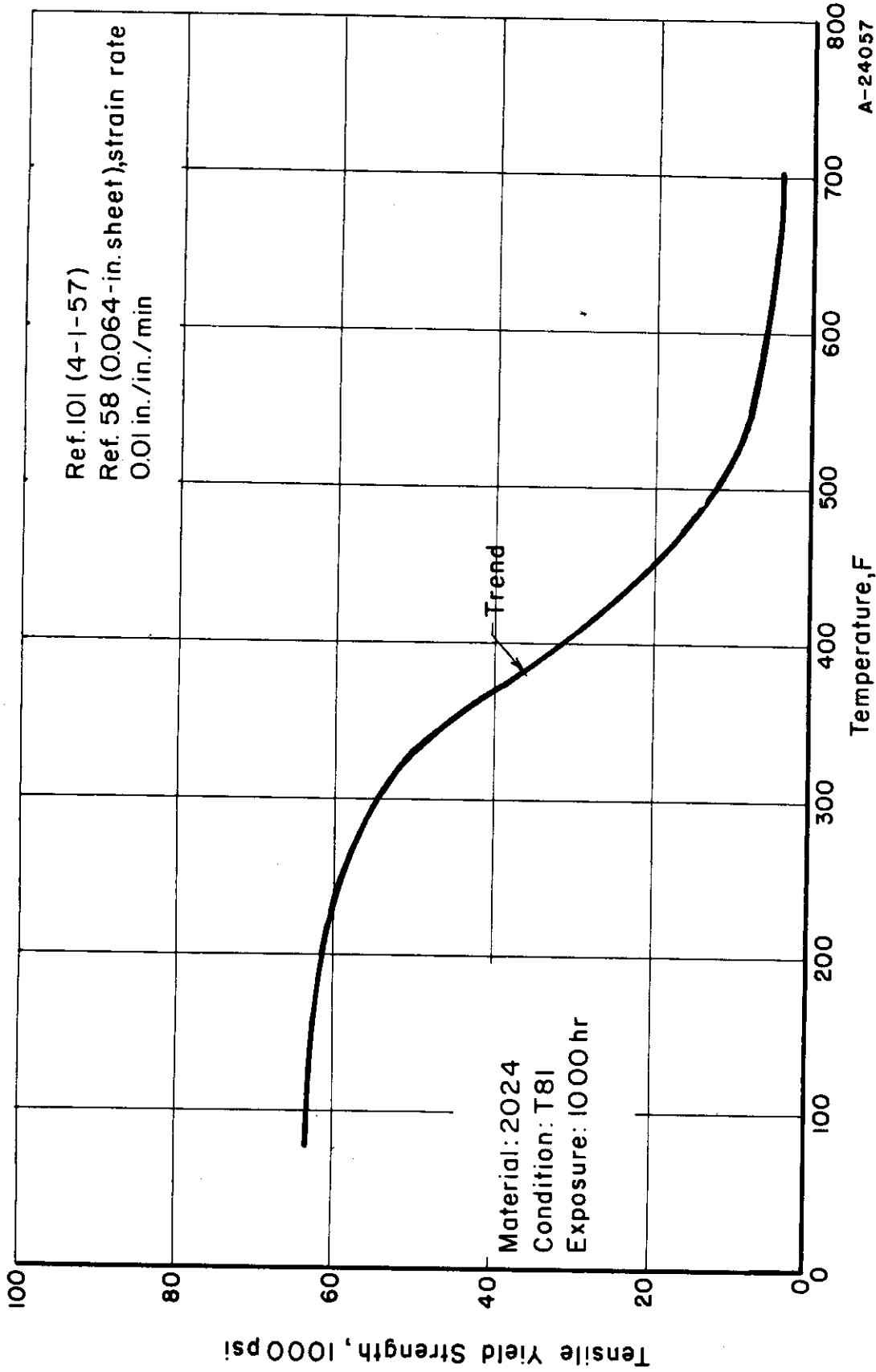


FIGURE 78. TENSILE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

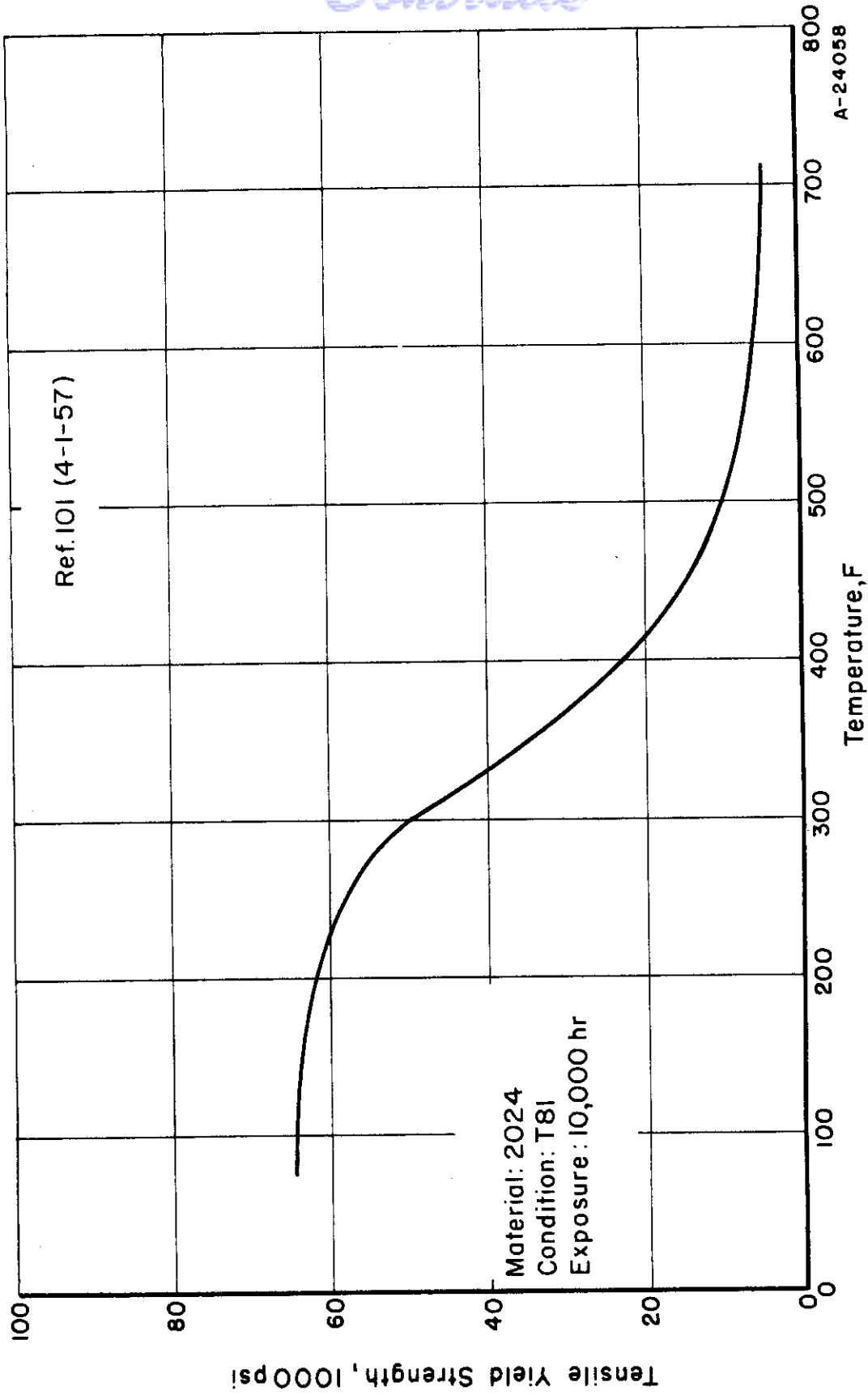


FIGURE 79. TENSILE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

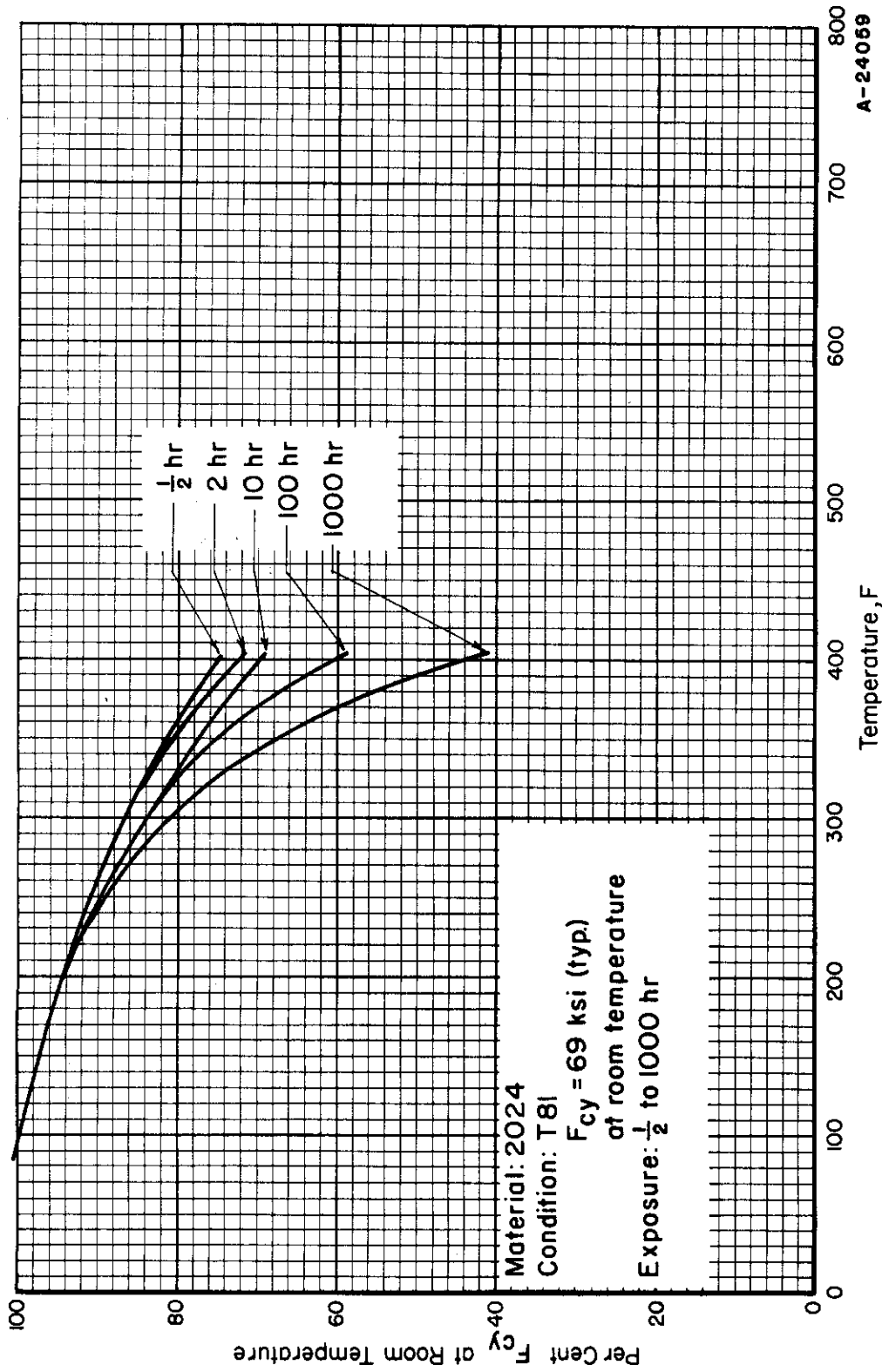


FIGURE 80. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF CLAD 2024-T81 ALUMI-
 NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

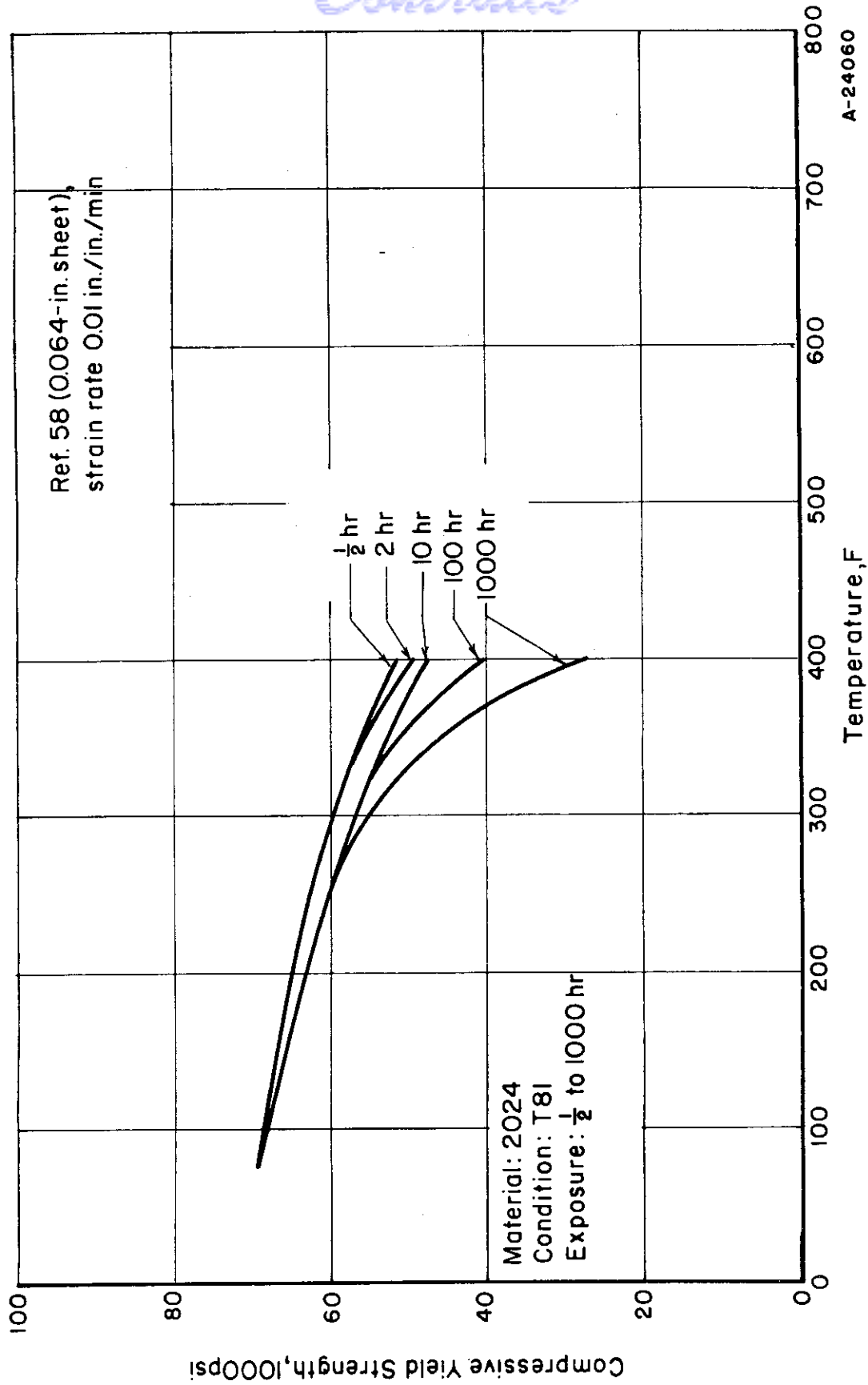


FIGURE 81. COMPRESSIVE YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

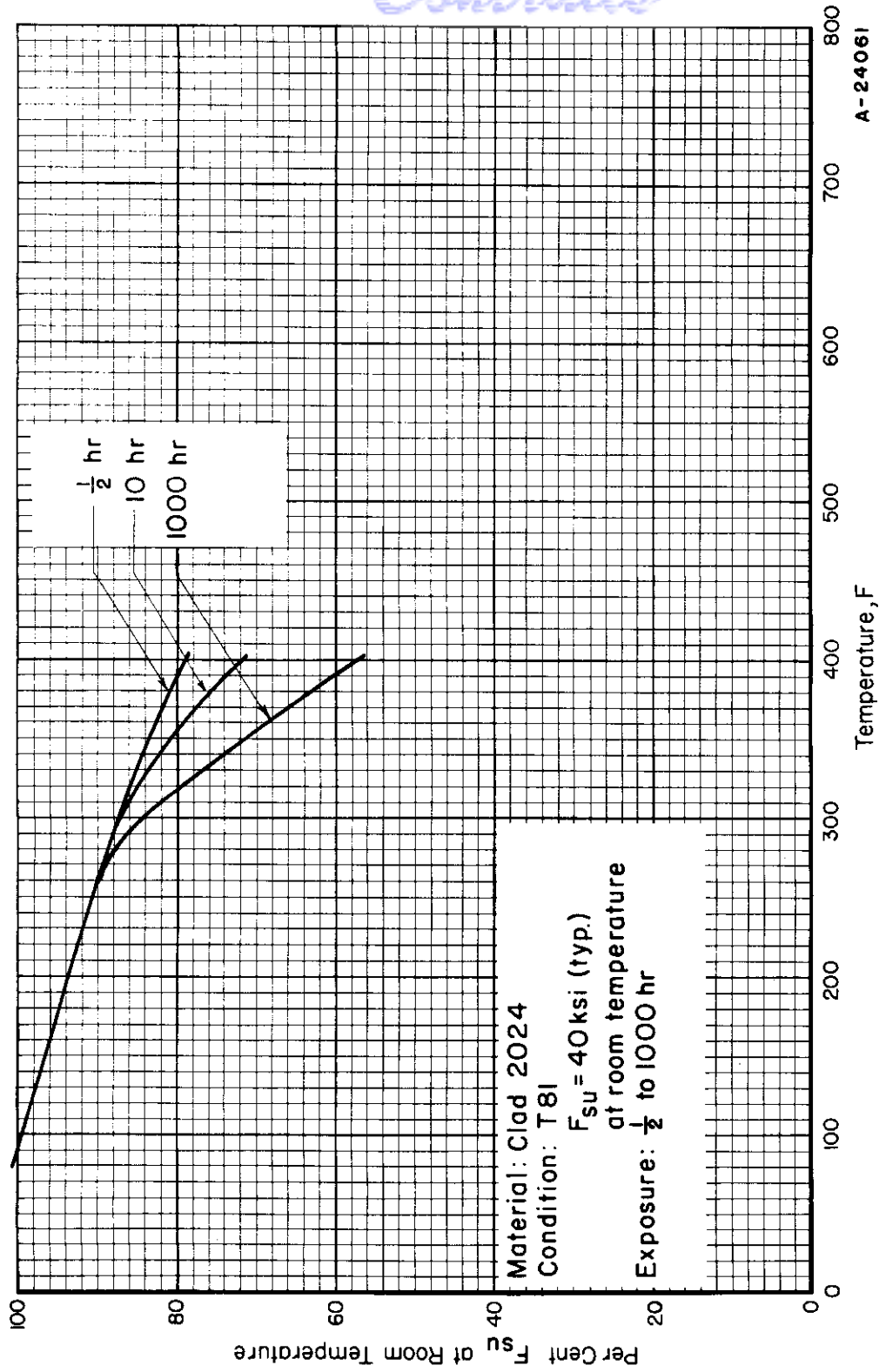


FIGURE 82. DESIGN CURVES FOR SHEAR STRENGTH (F_{su}) OF CLAD 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

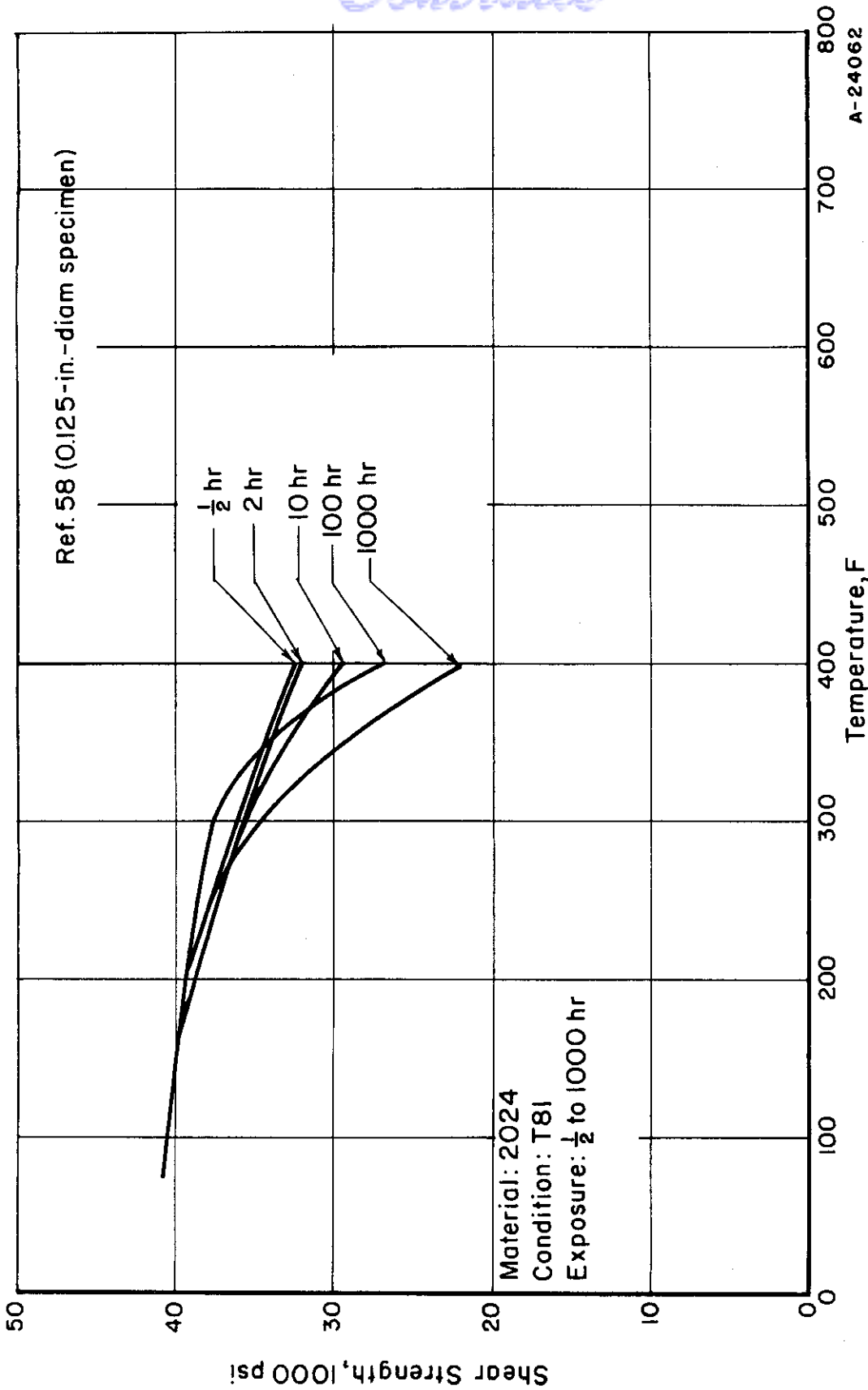


FIGURE 83. SHEAR STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

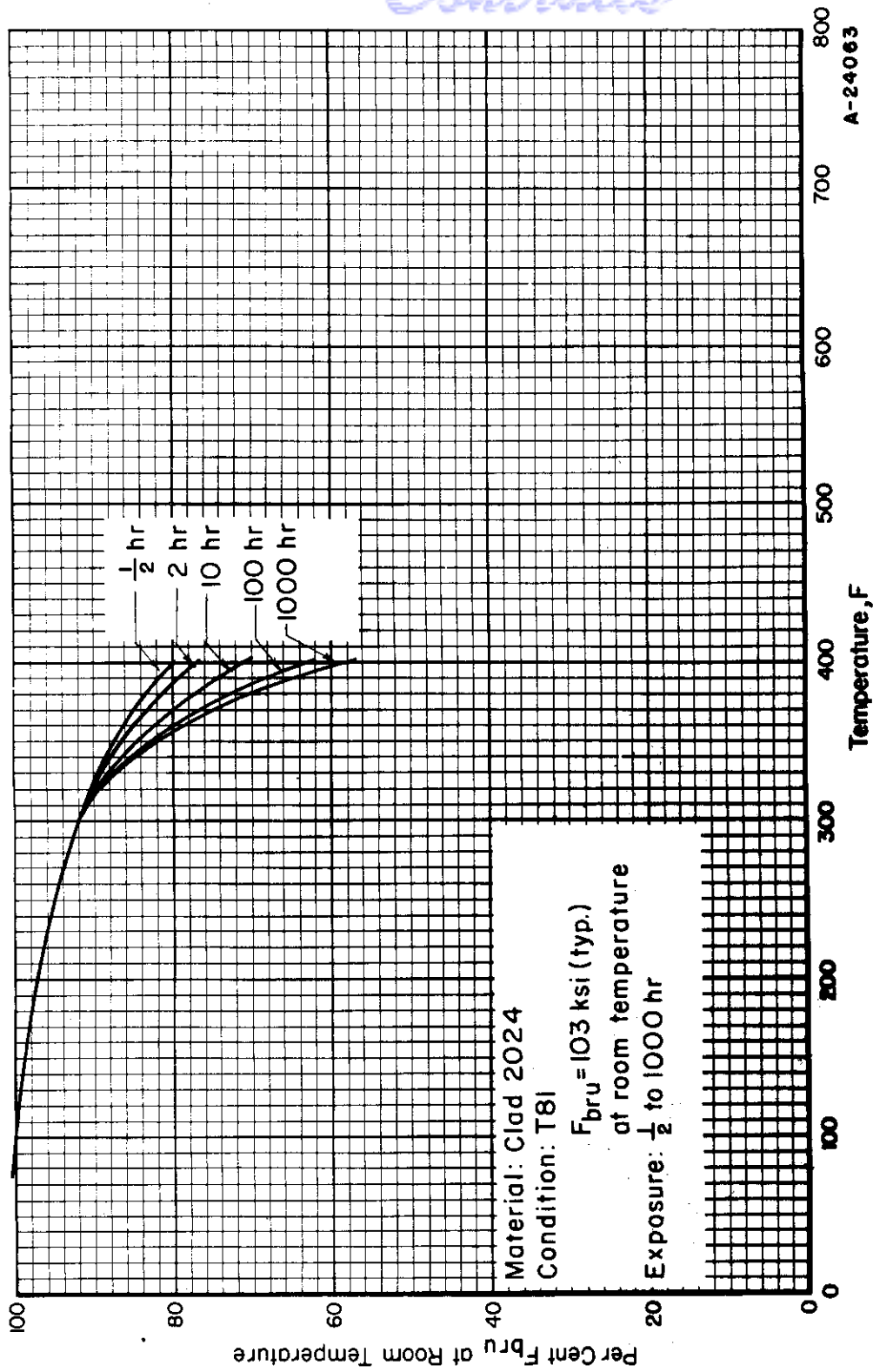


FIGURE 84. DESIGN CURVES FOR BEARING STRENGTH (F_{bru}) OF CLAD 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

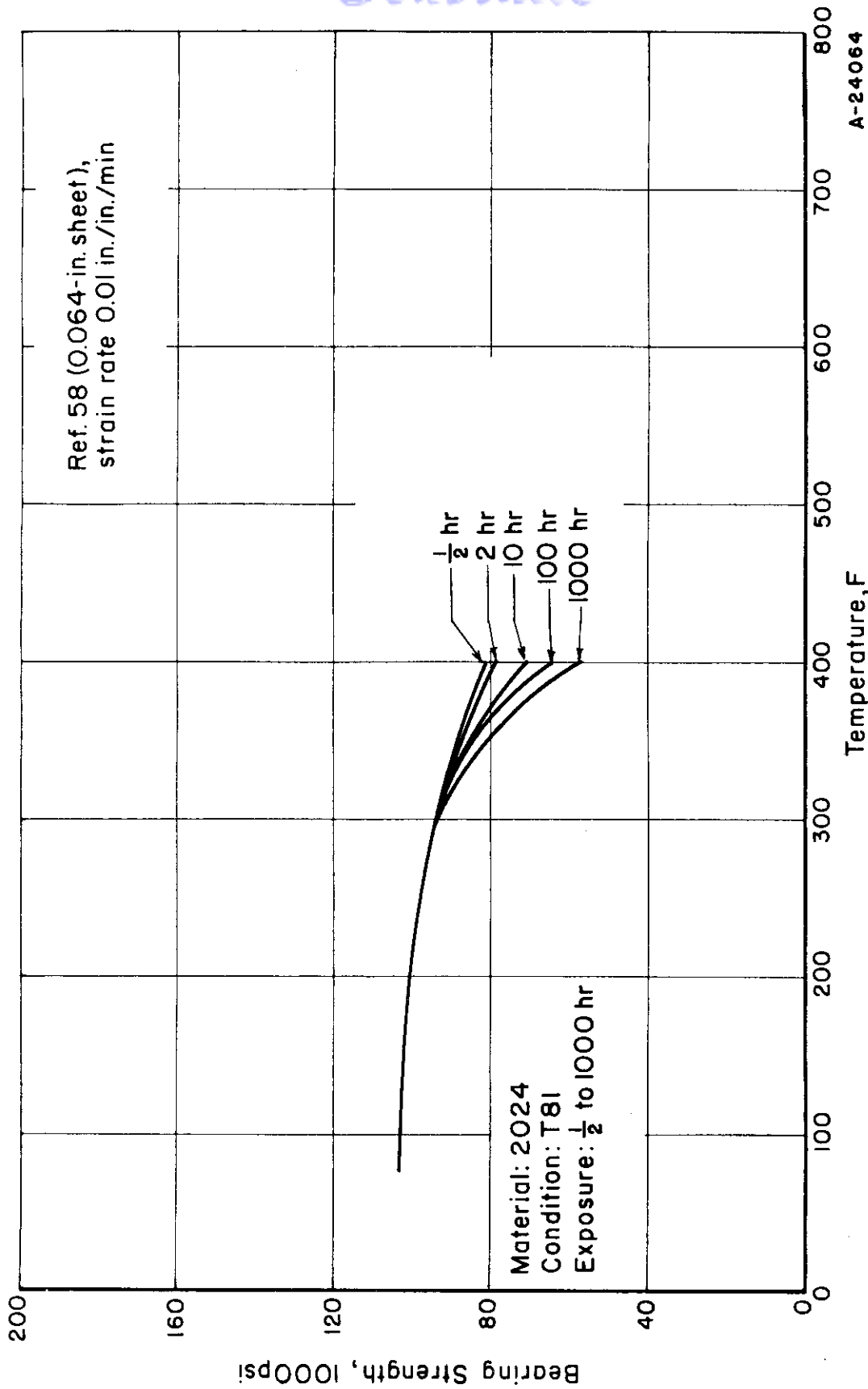


FIGURE 85. BEARING STRENGTH DATA FOR 2014-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

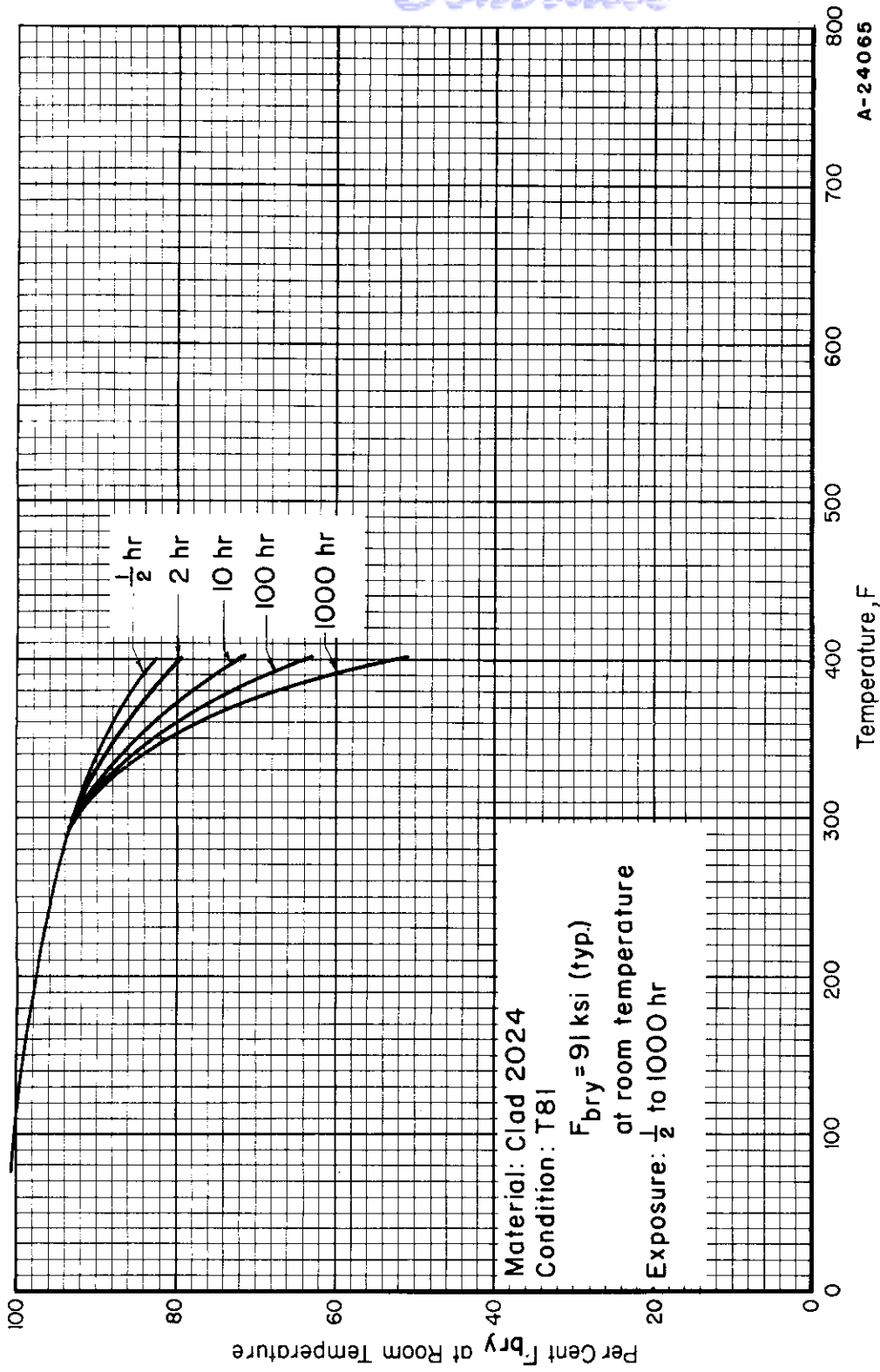


FIGURE 86. DESIGN CURVES FOR BEARING YIELD STRENGTH (F_{bry}) OF CLAD 2024-T81 ALUMI-
 NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

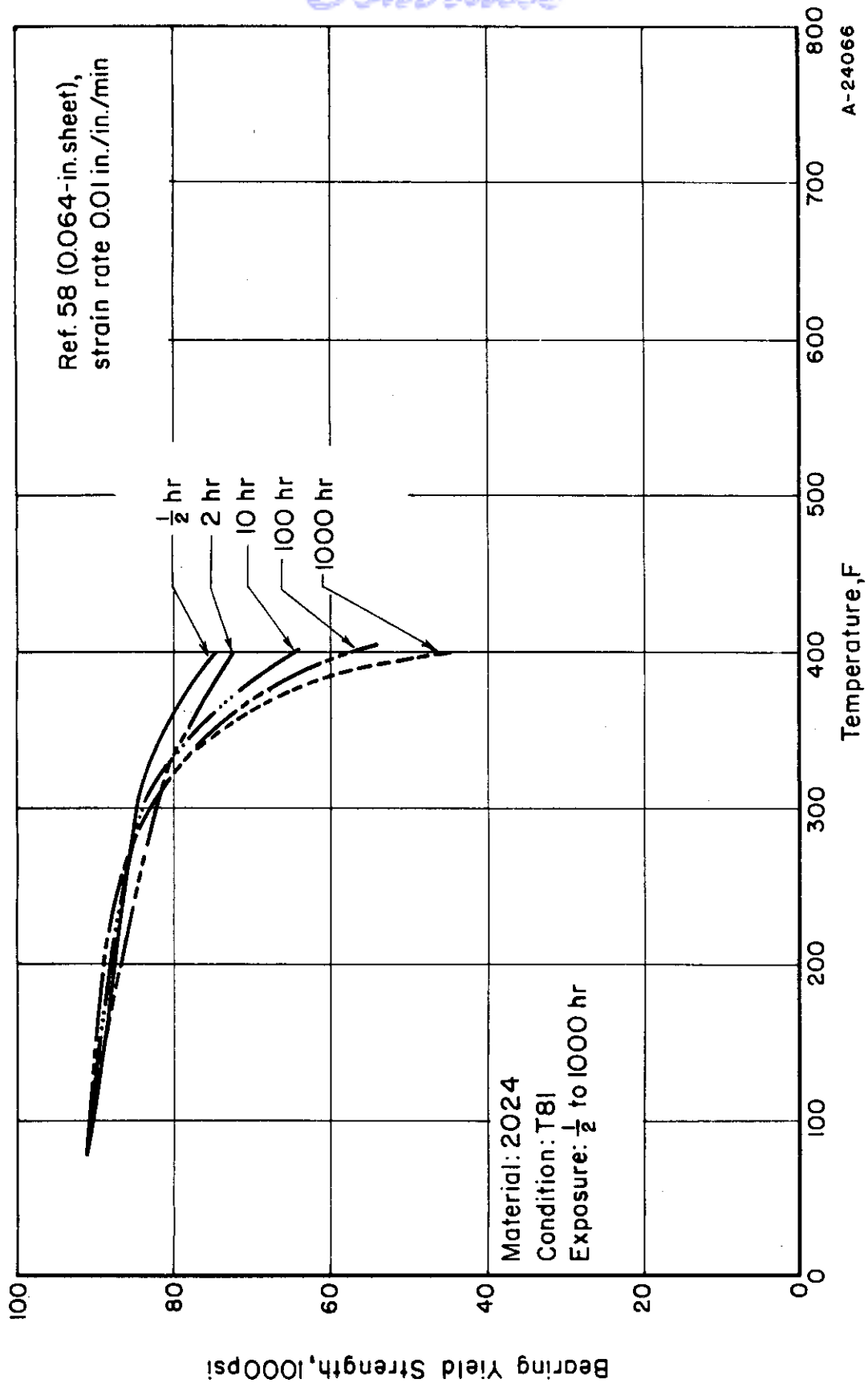


FIGURE 87. BEARING YIELD STRENGTH DATA FOR 2024-T81 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

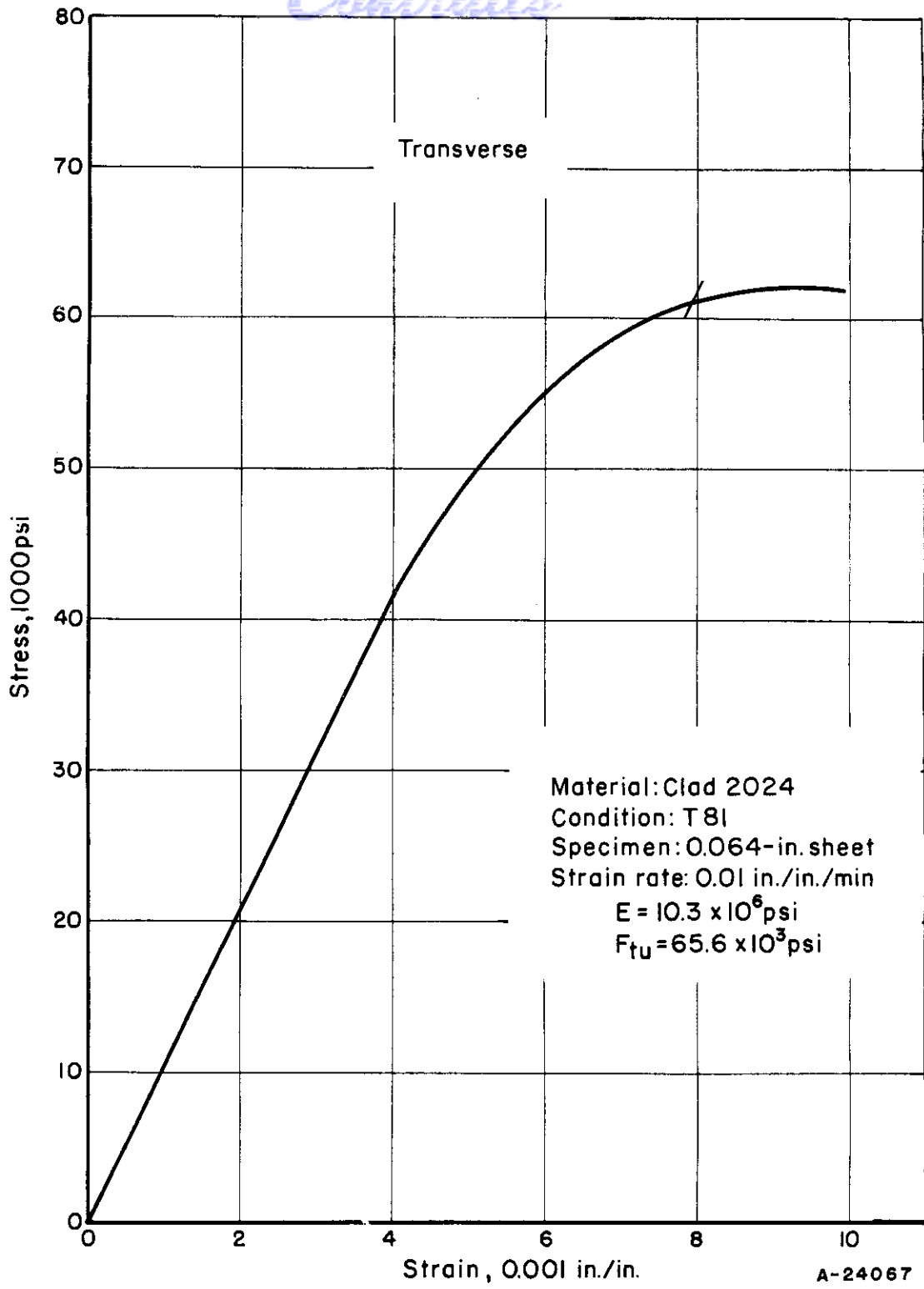


FIGURE 88. TENSILE STRESS-STRAIN CURVE FOR CLAD 2024-T81 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 58, p 133.

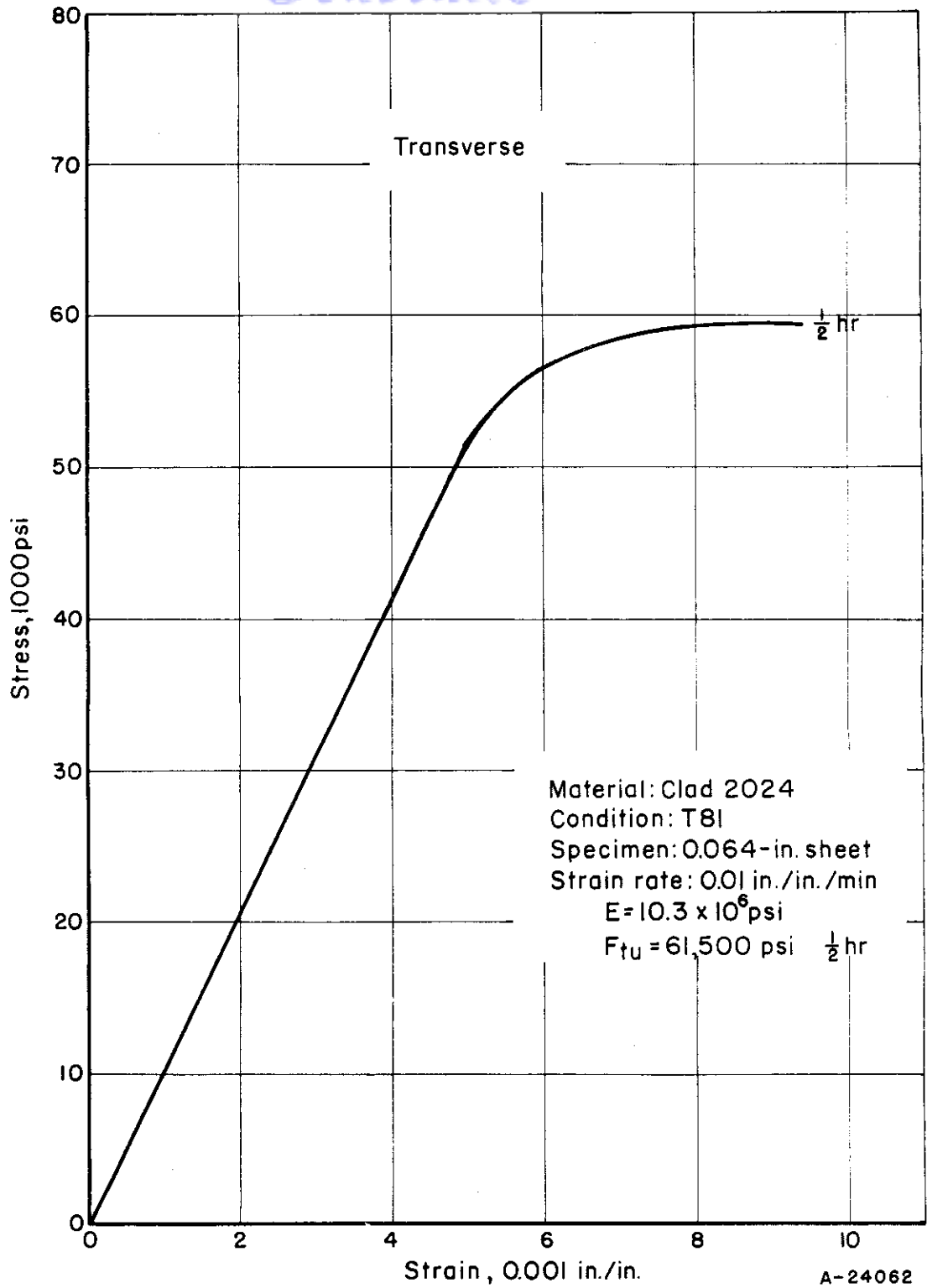


FIGURE 89. TENSILE STRESS-STRAIN CURVE FOR CLAD 2024-T81 ALUMINUM ALLOY AT 200 F

Ref. 58.

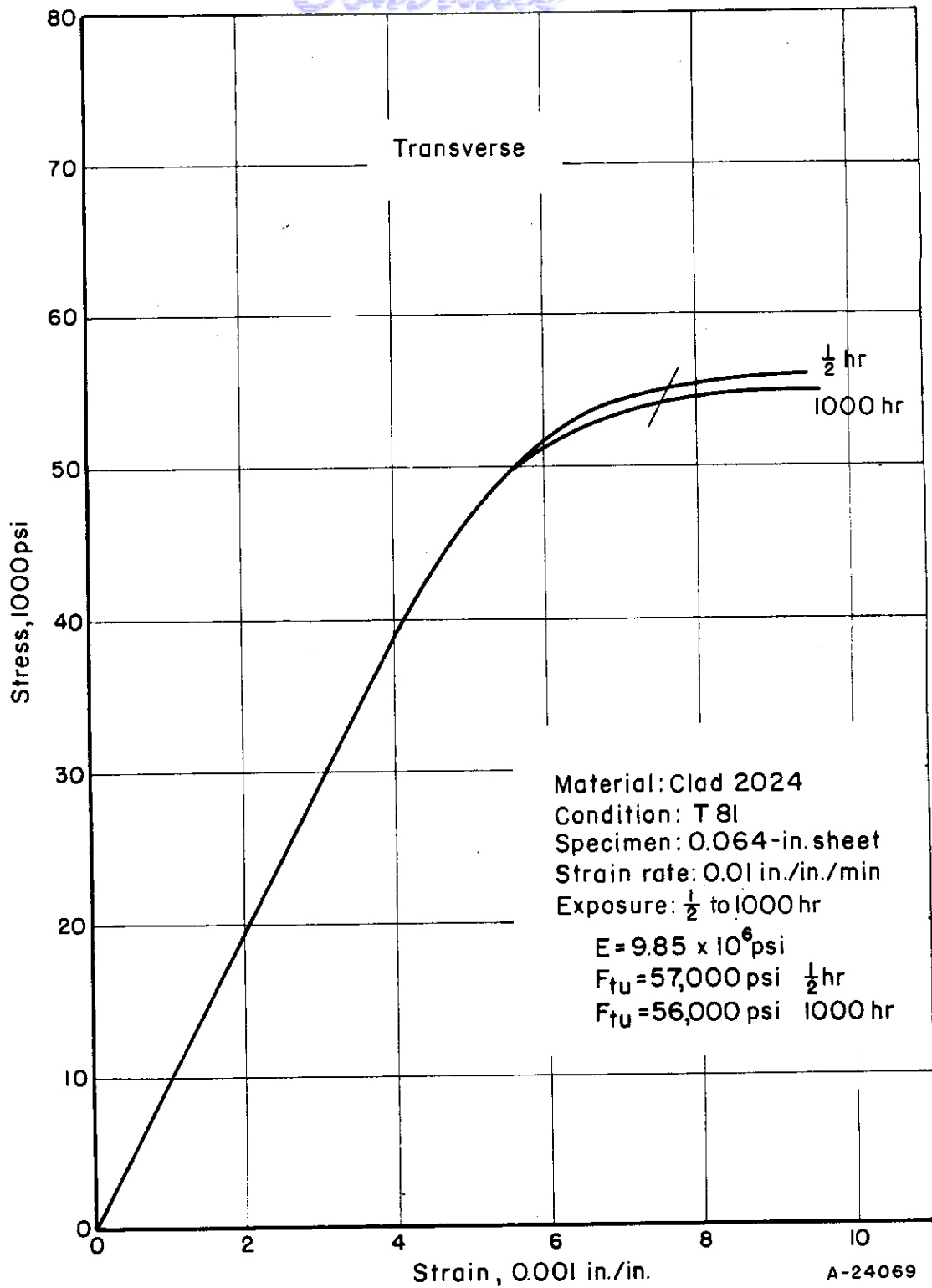


FIGURE 90. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T81 ALUMINUM ALLOY AT 300 F

Ref. 58.

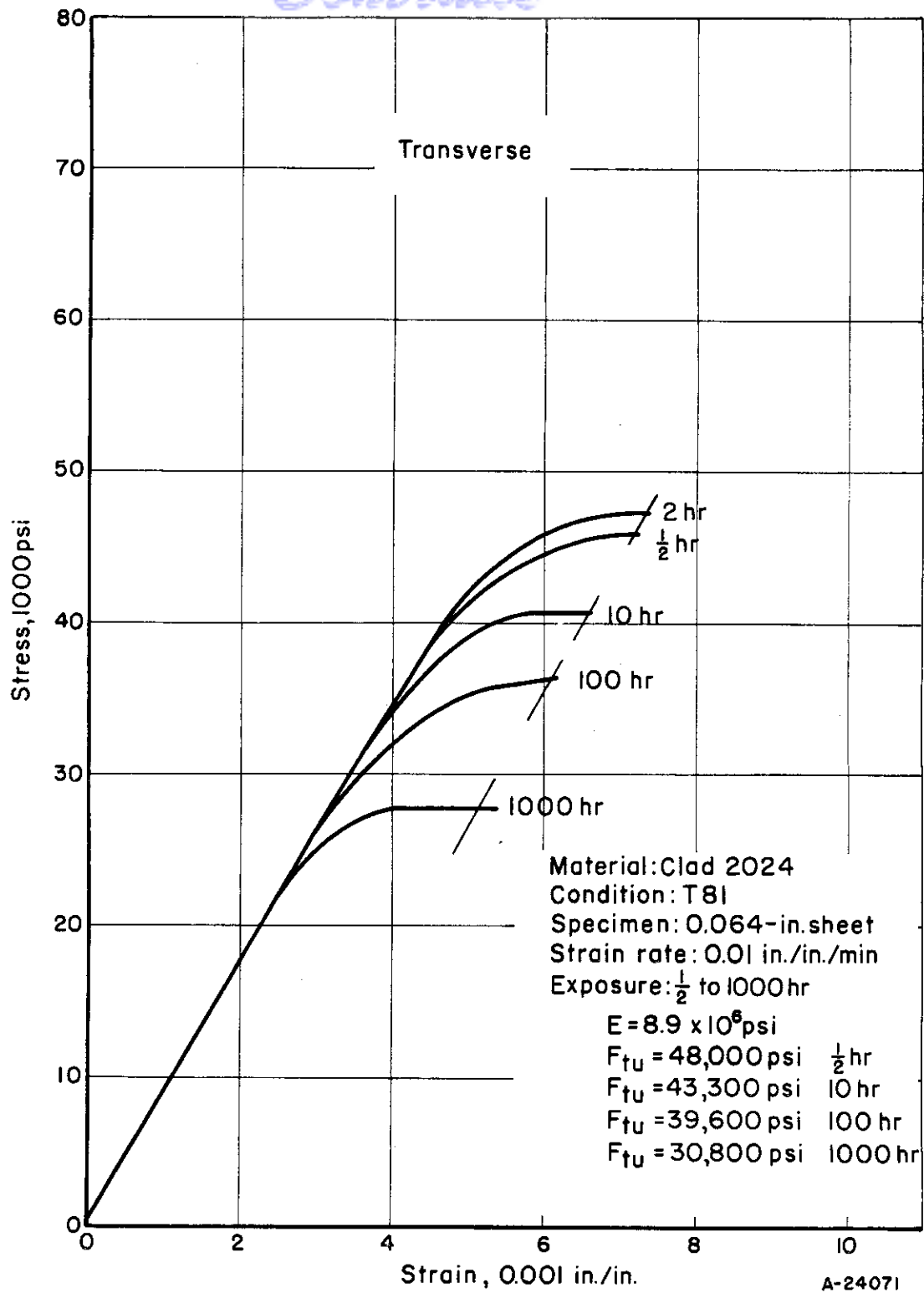


FIGURE 91. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T81 ALUMINUM ALLOY AT 400 F

Ref. 58.

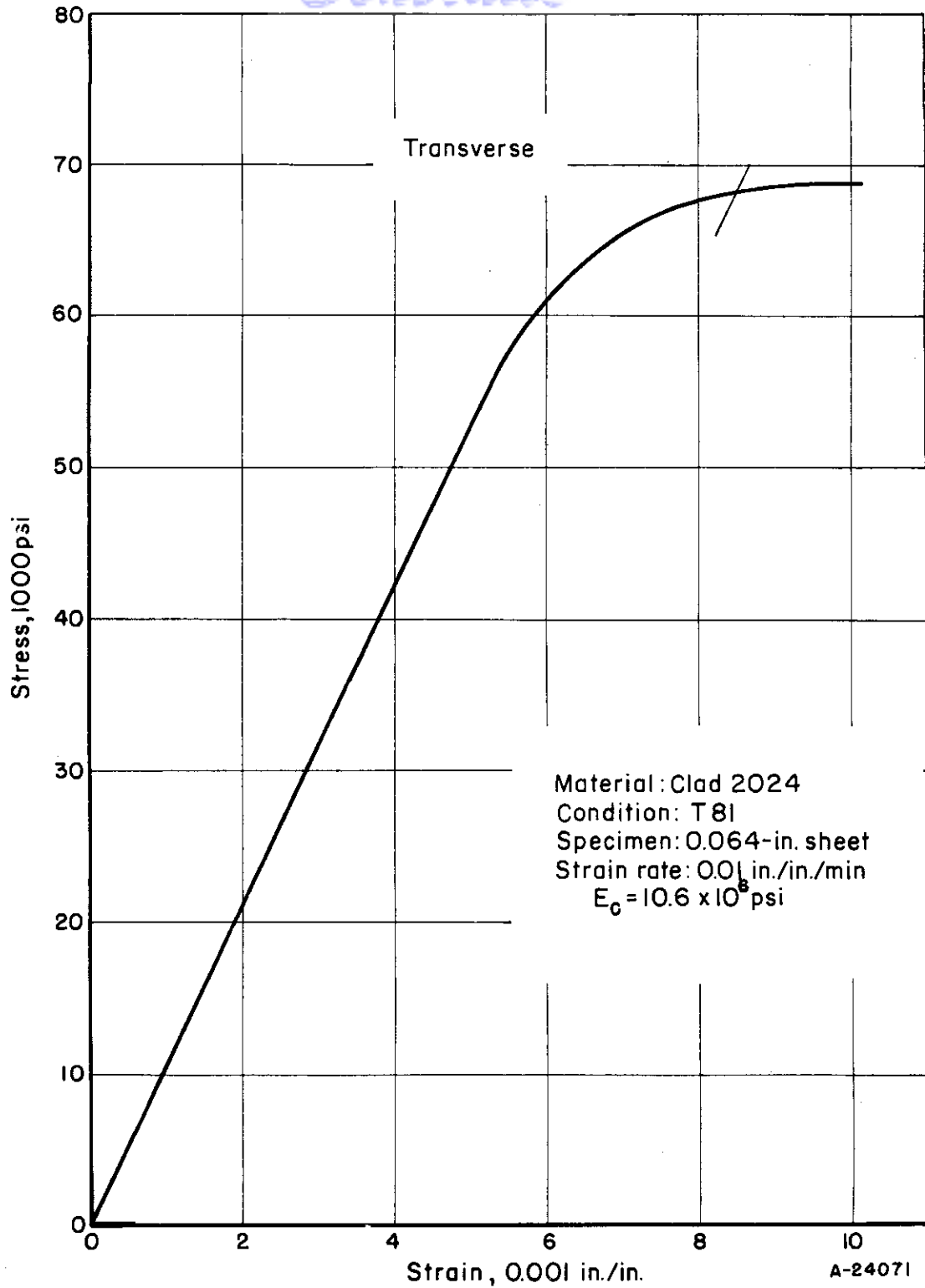


FIGURE 92. COMPRESSIVE STRESS-STRAIN CURVE FOR CLAD 2024-T81 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 58.

WADC TR 55-150 Pt VI

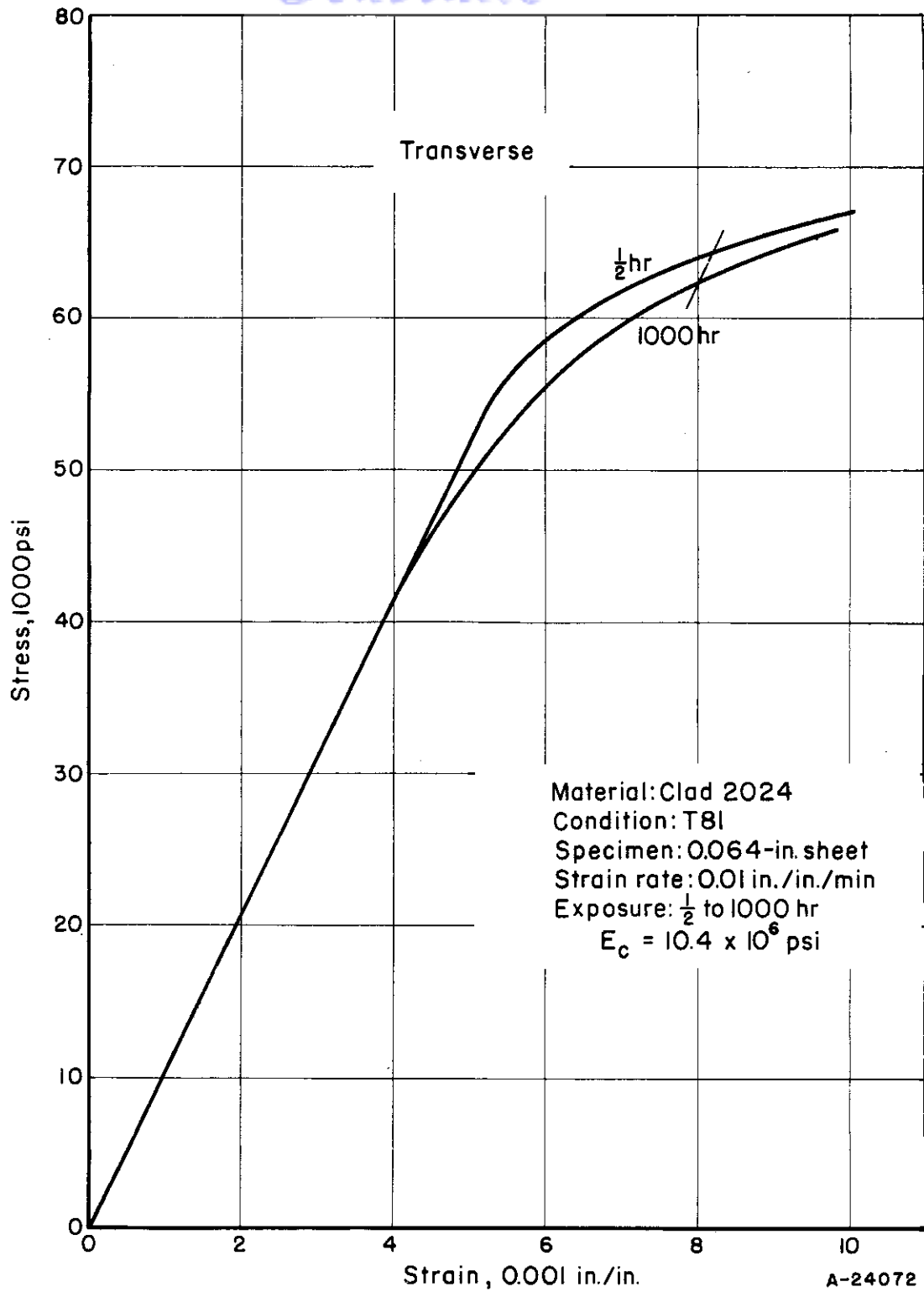


FIGURE 93. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T81 ALUMINUM ALLOY AT 200 F

Ref. 58.

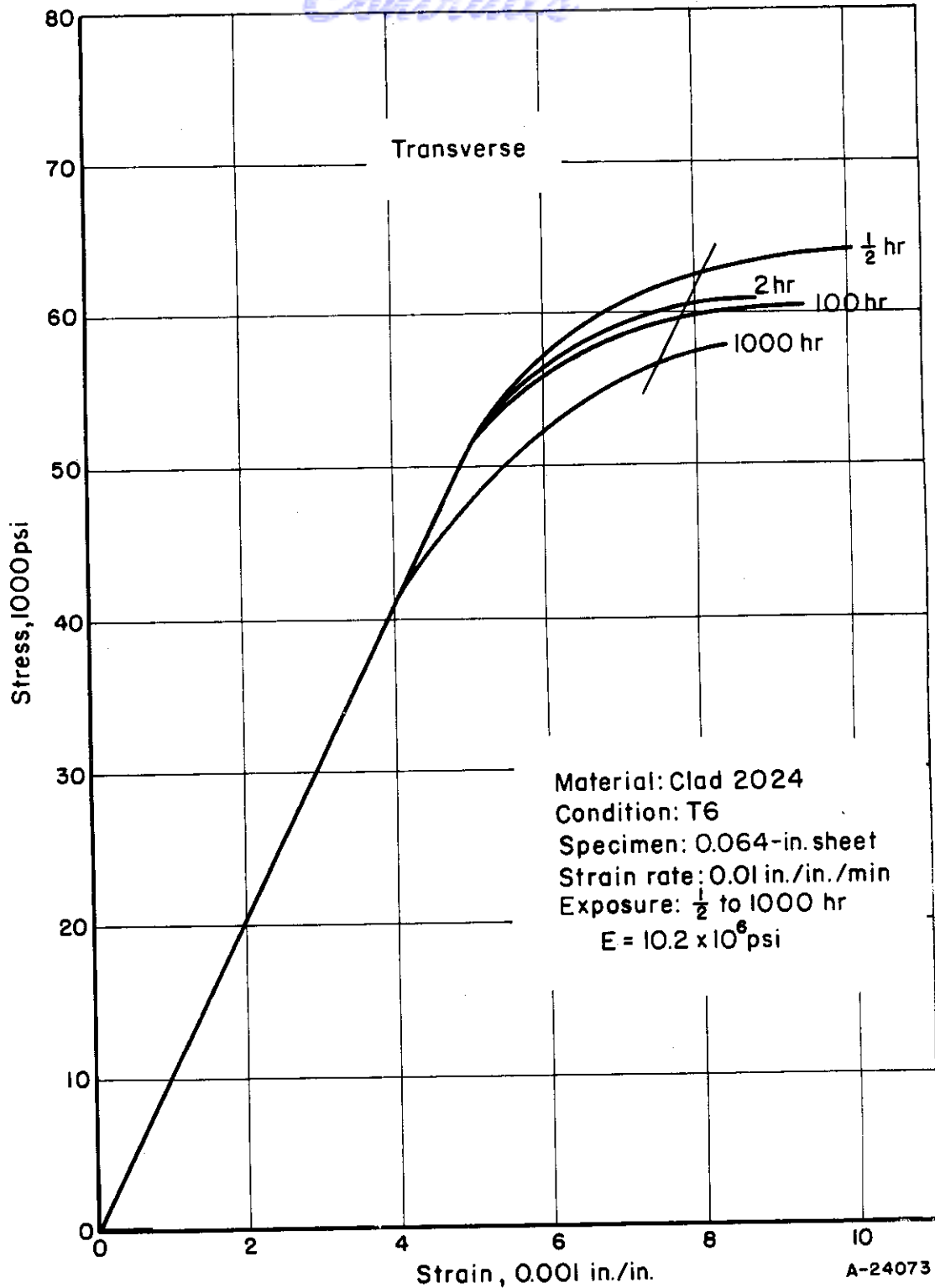


FIGURE 94. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T81 ALUMINUM ALLOY AT 300 F

Ref. 58.

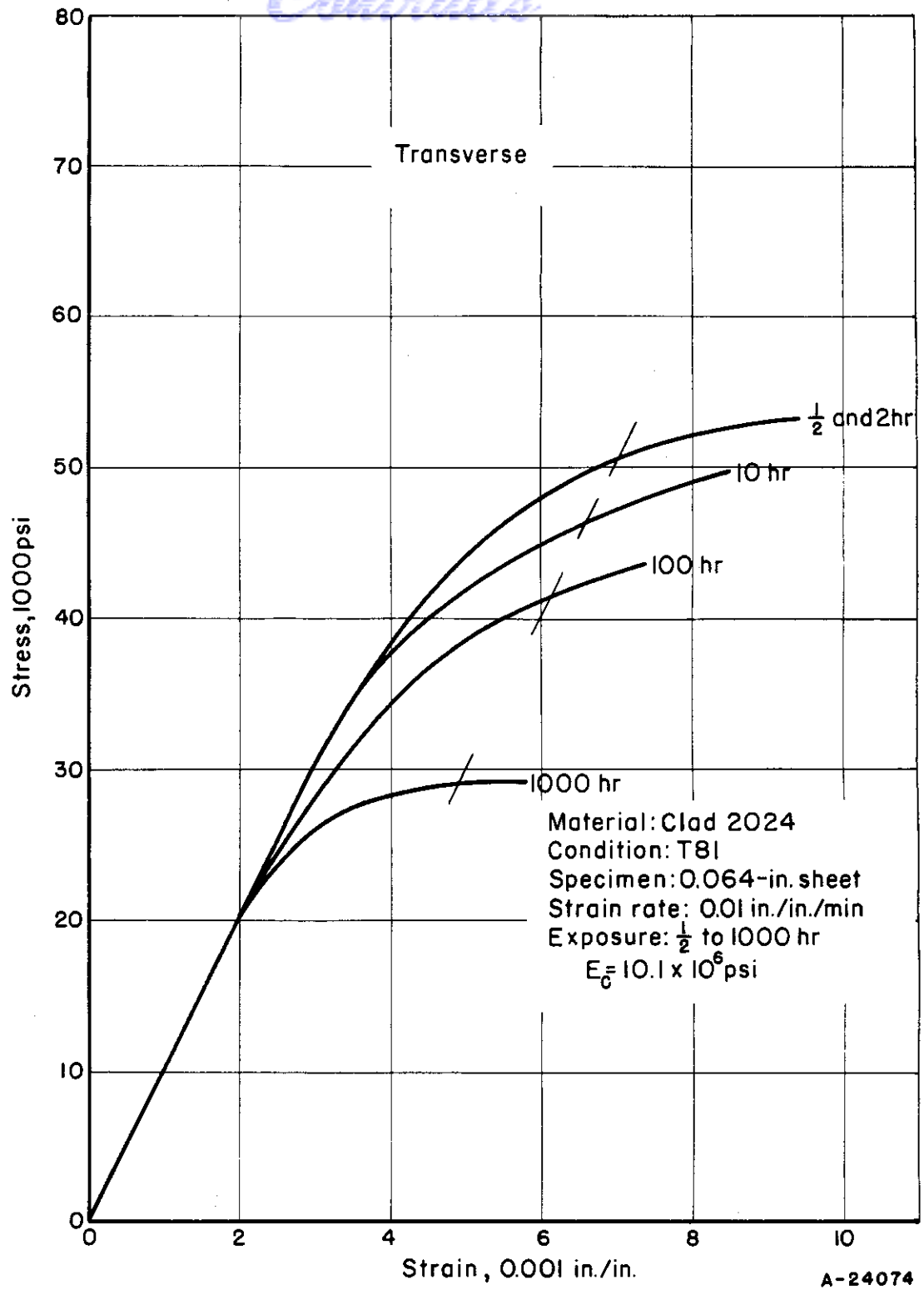


FIGURE 95. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T81 ALUMINUM ALLOY AT 400 F

Ref. 58.

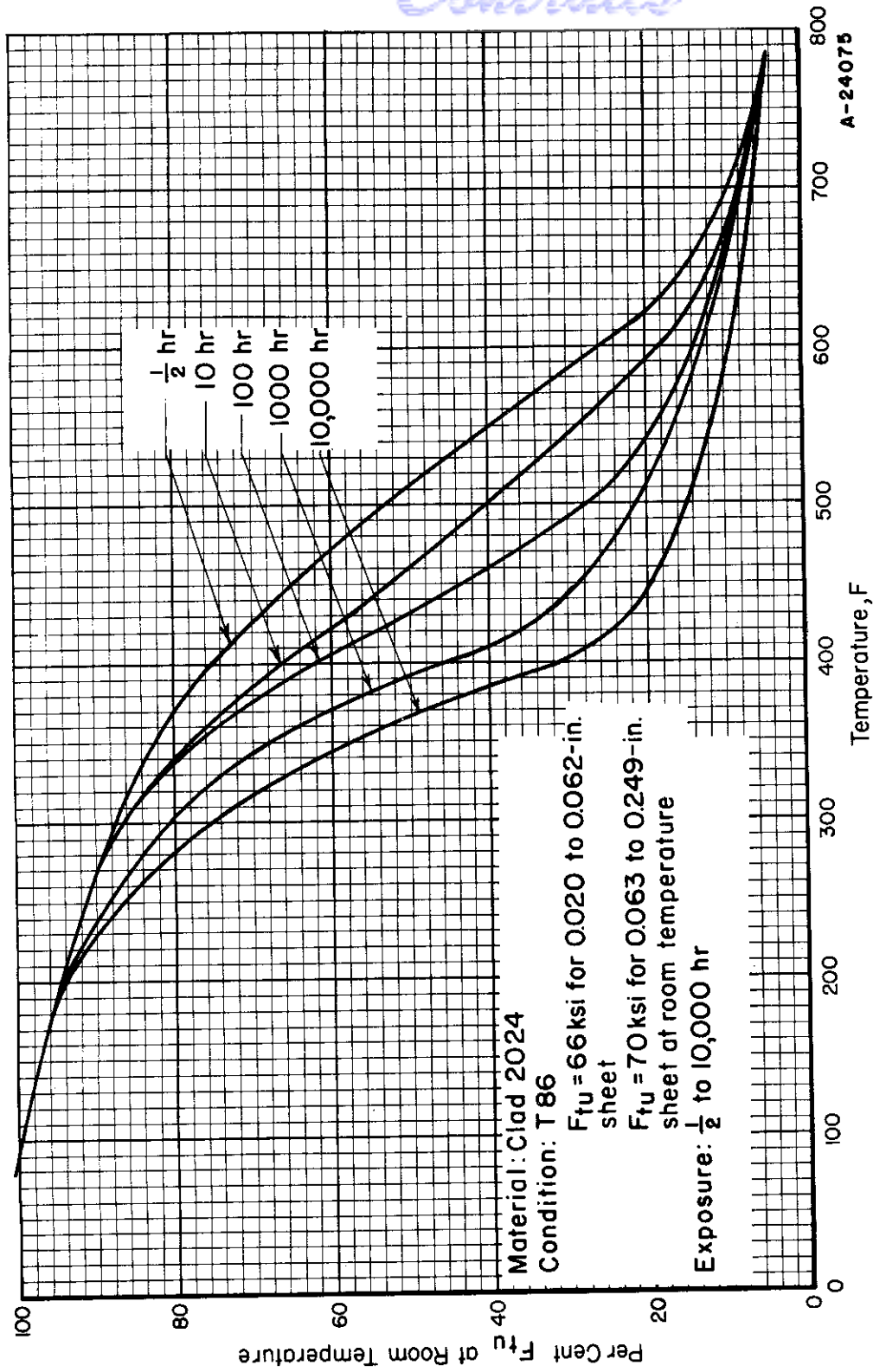


FIGURE 96. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF CLAD 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101, 58.

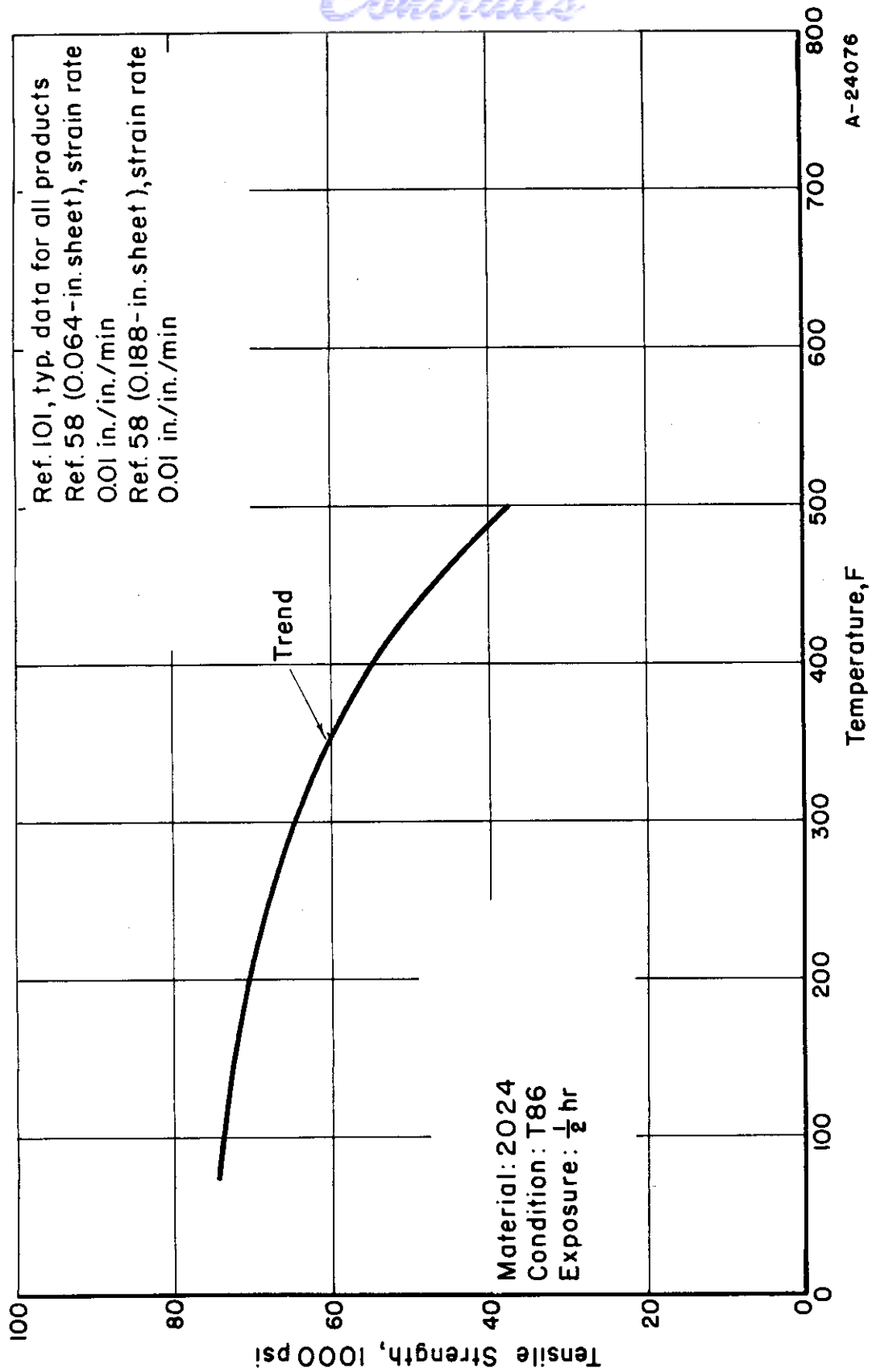
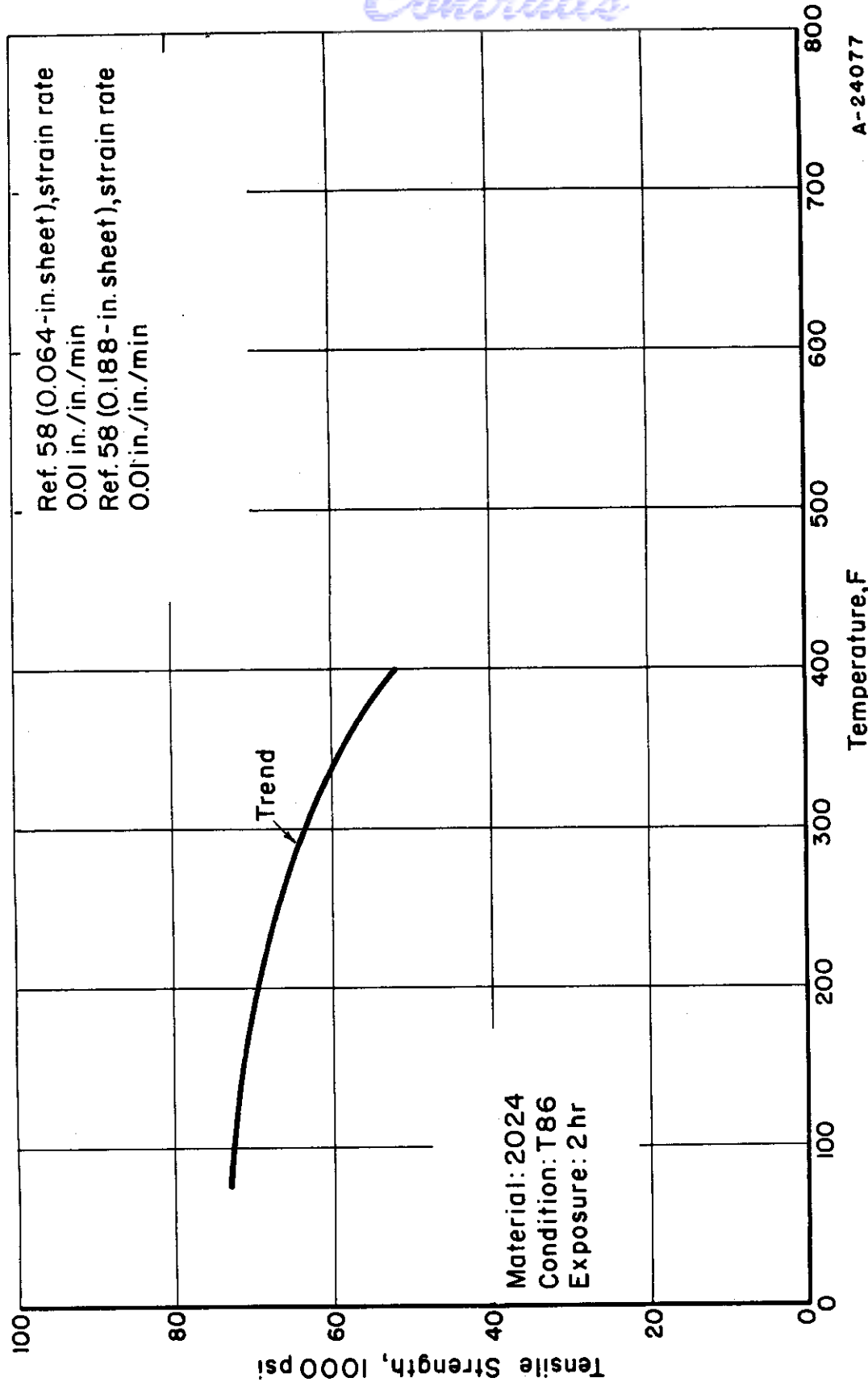


FIGURE 97. TENSILE STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



A-24077

FIGURE 98. TENSILE STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)

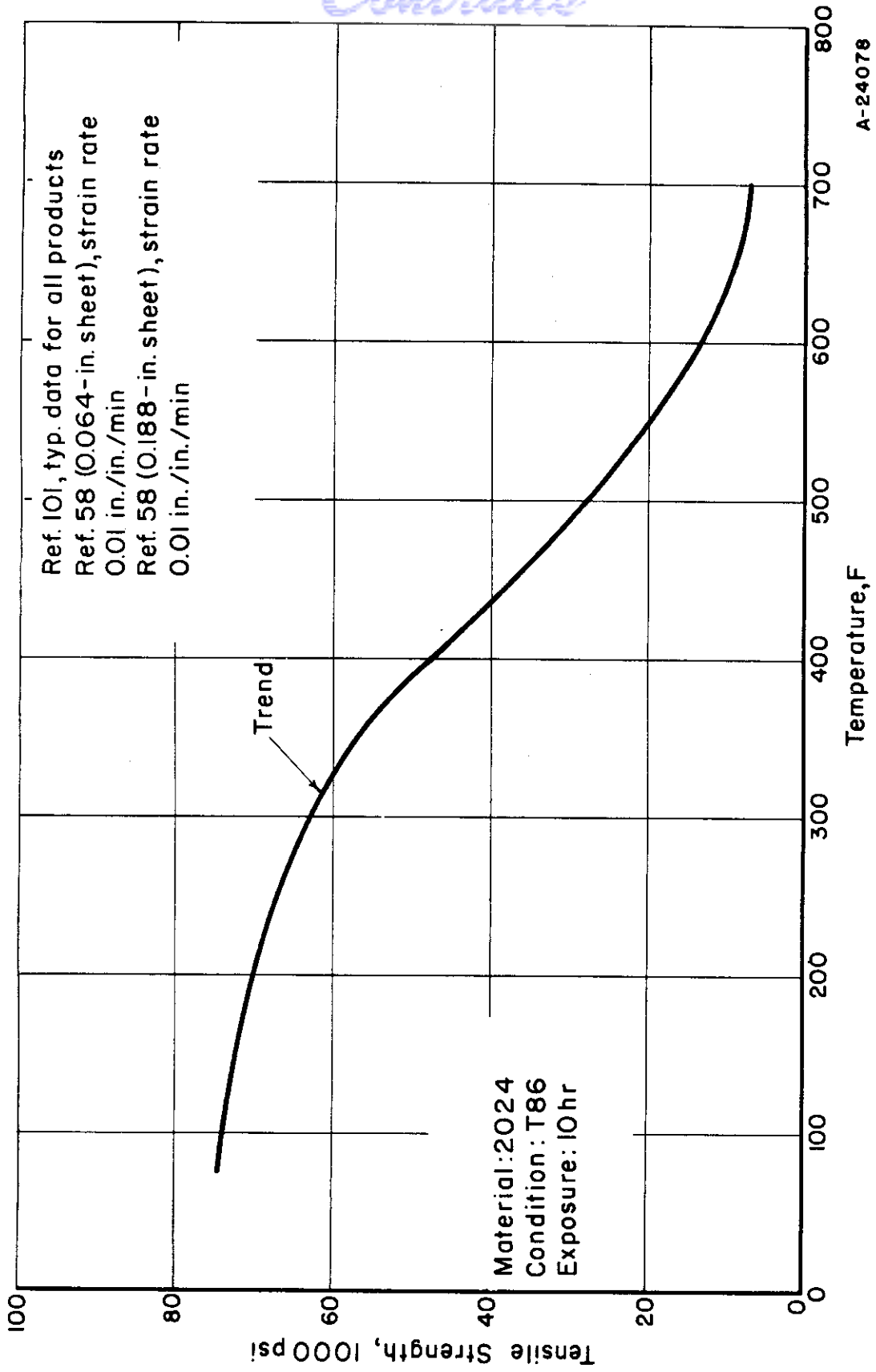


FIGURE 99. TENSILE STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

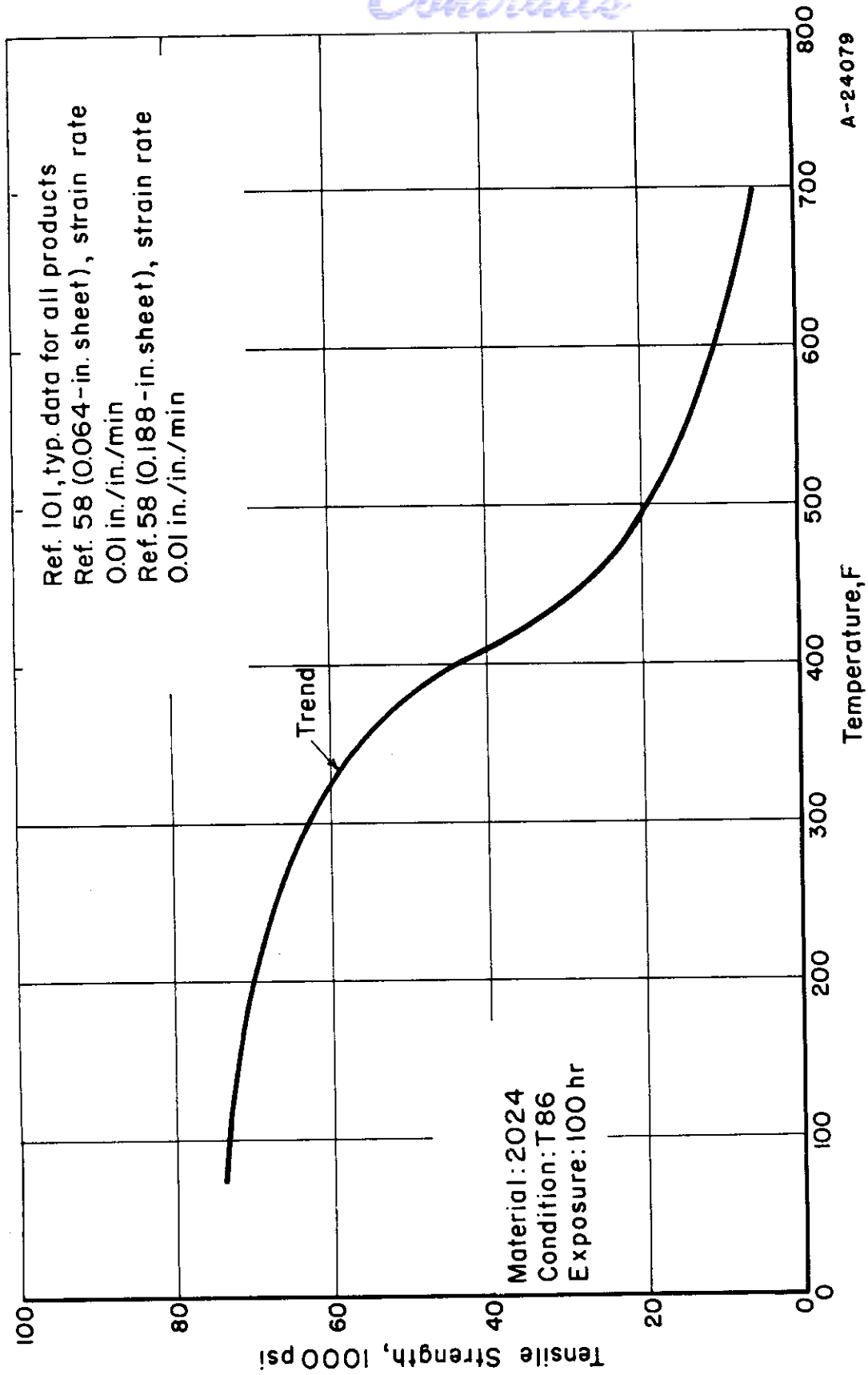


FIGURE 100. TENSILE STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)

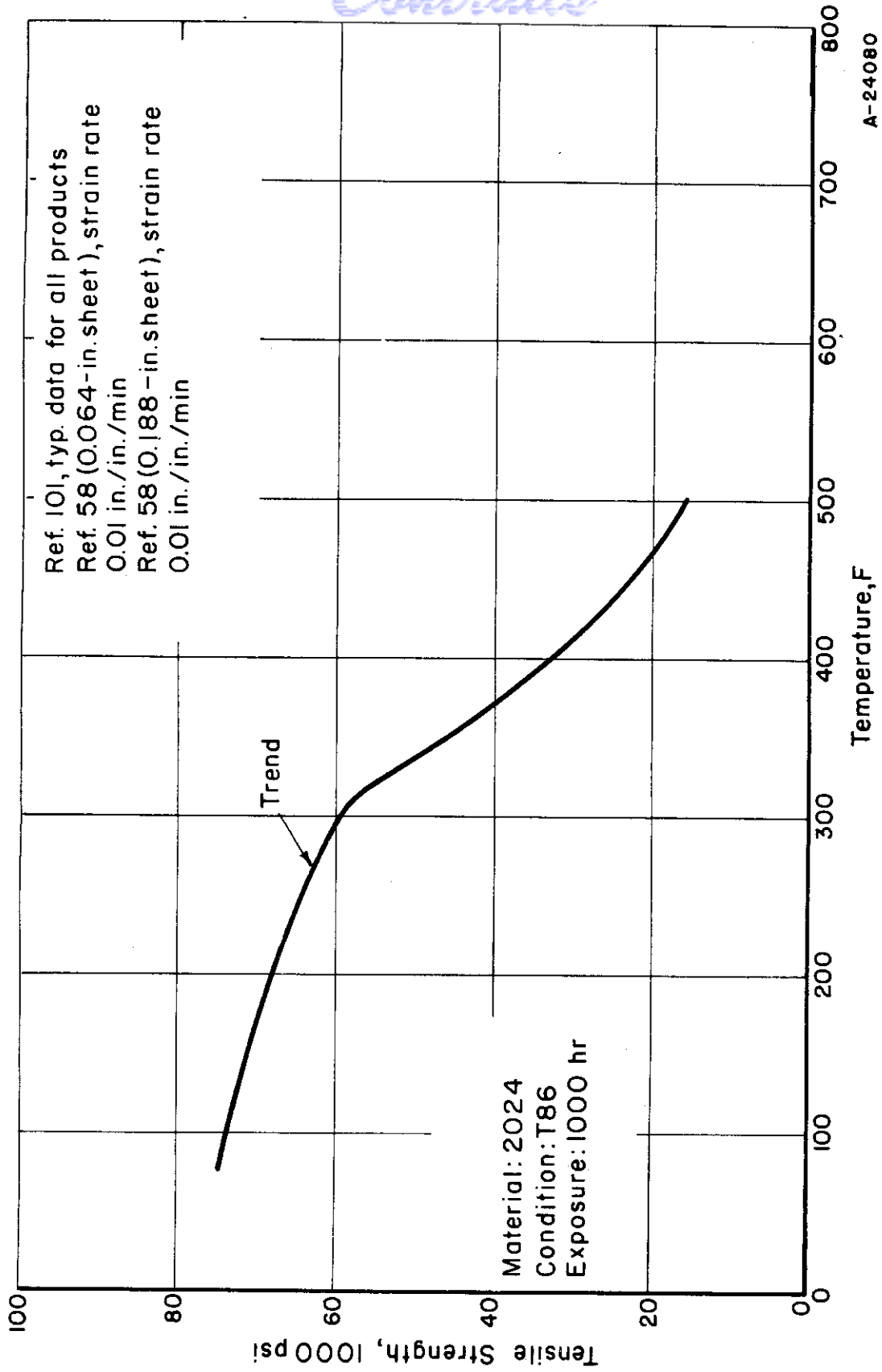


FIGURE 101. TENSILE STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

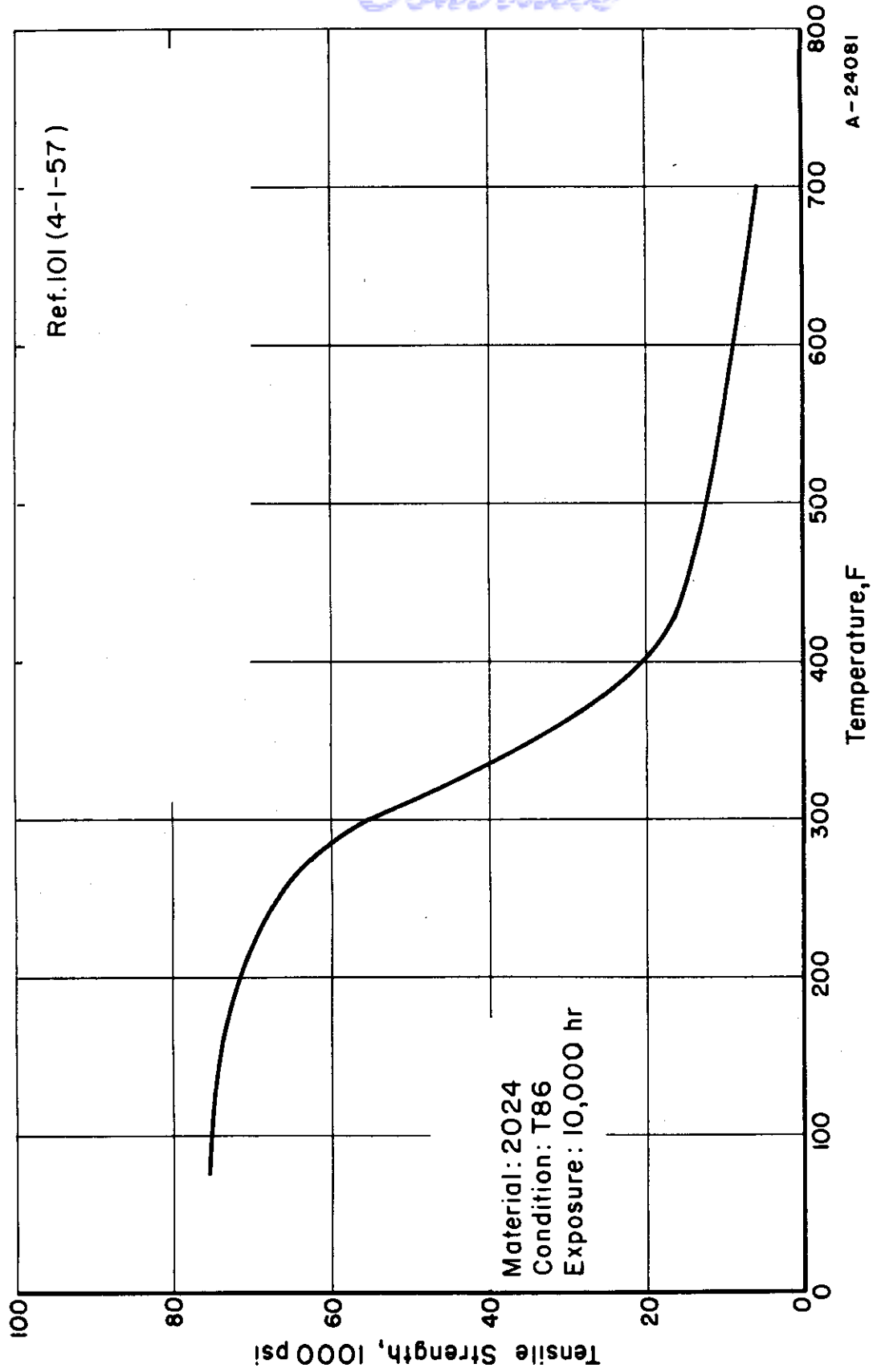


FIGURE 102. TENSILE STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

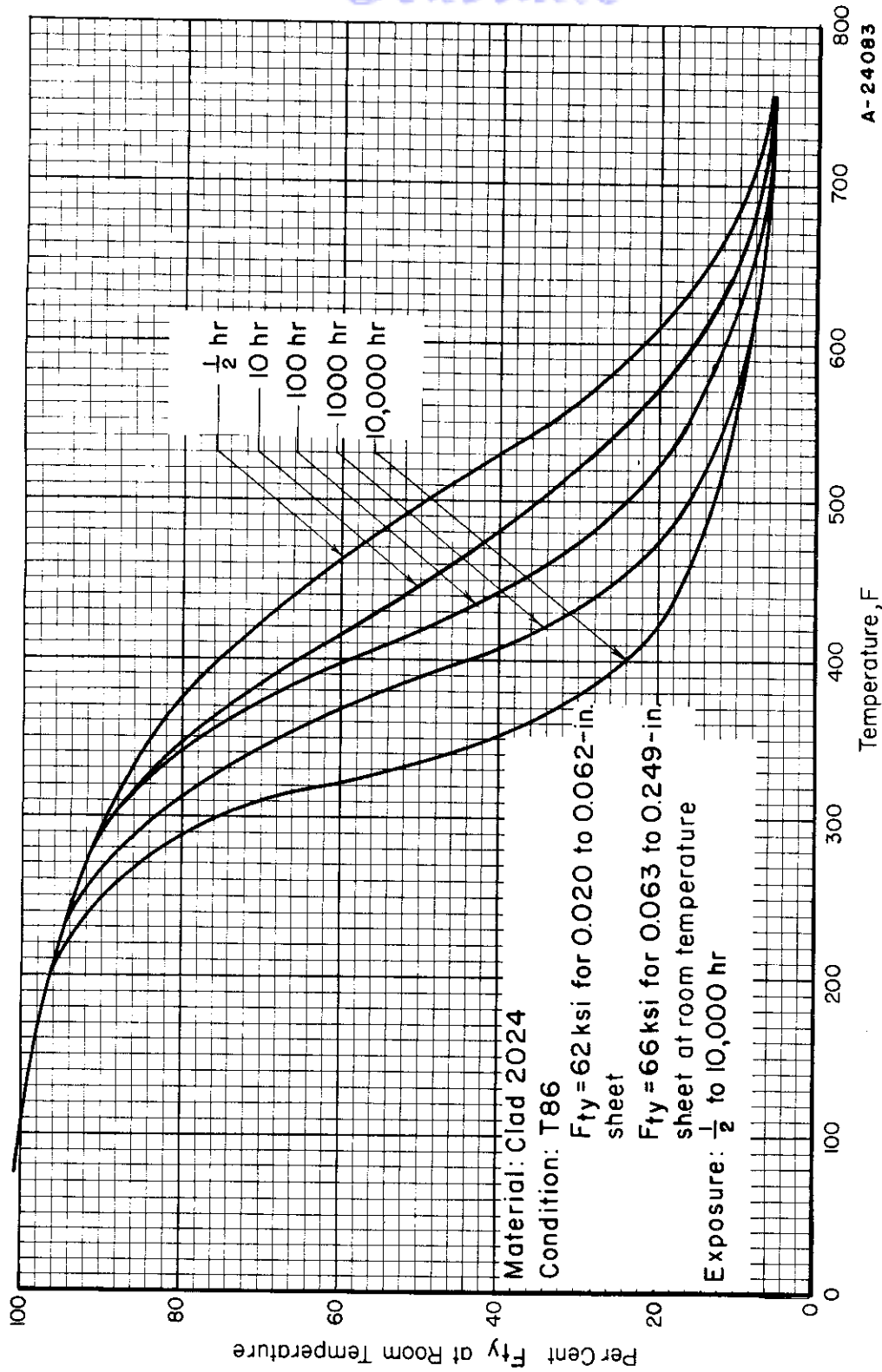


FIGURE 103. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF CLAD 2024-T86 ALUMI-
 NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 58, 101.

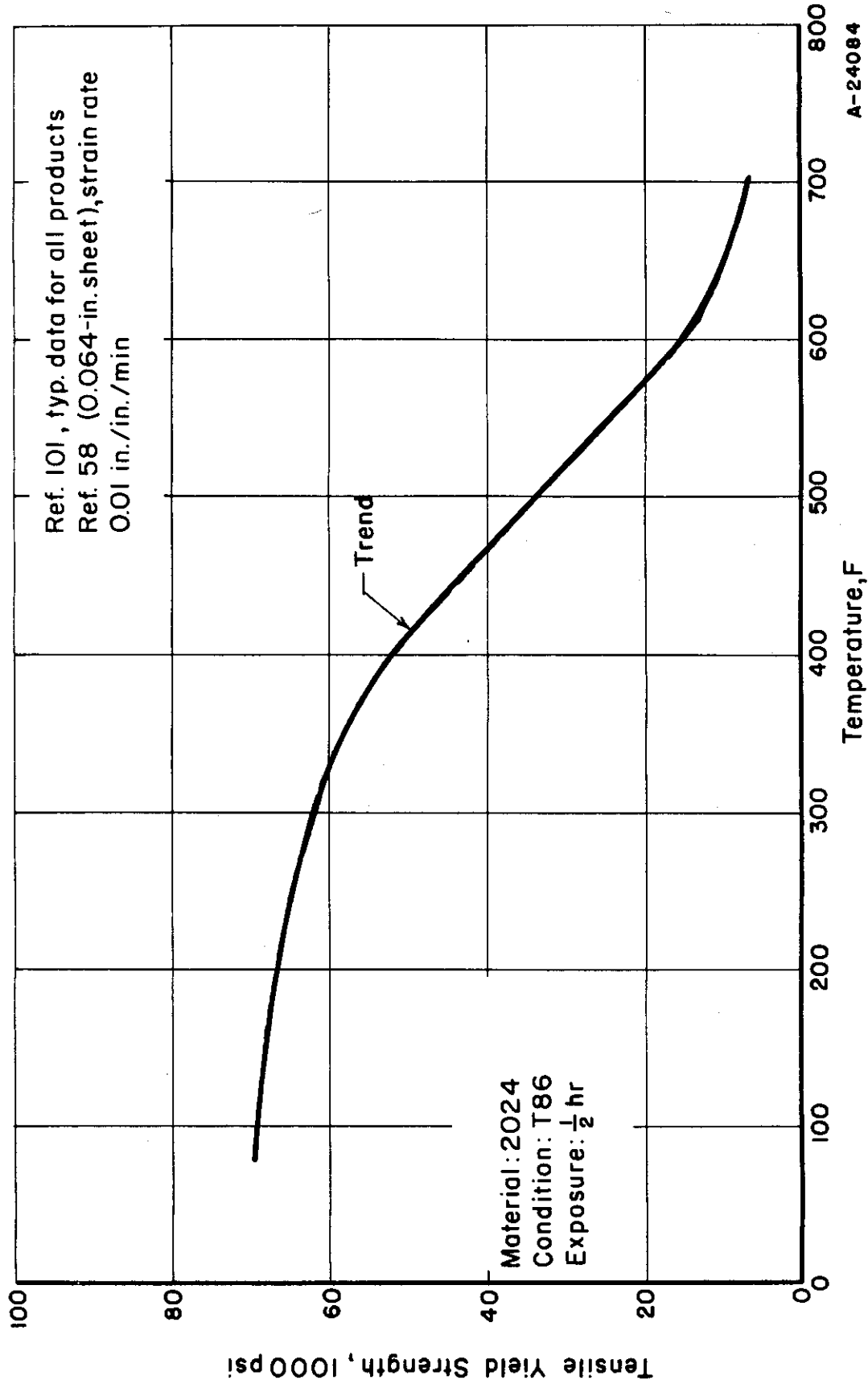


FIGURE 104. TENSILE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

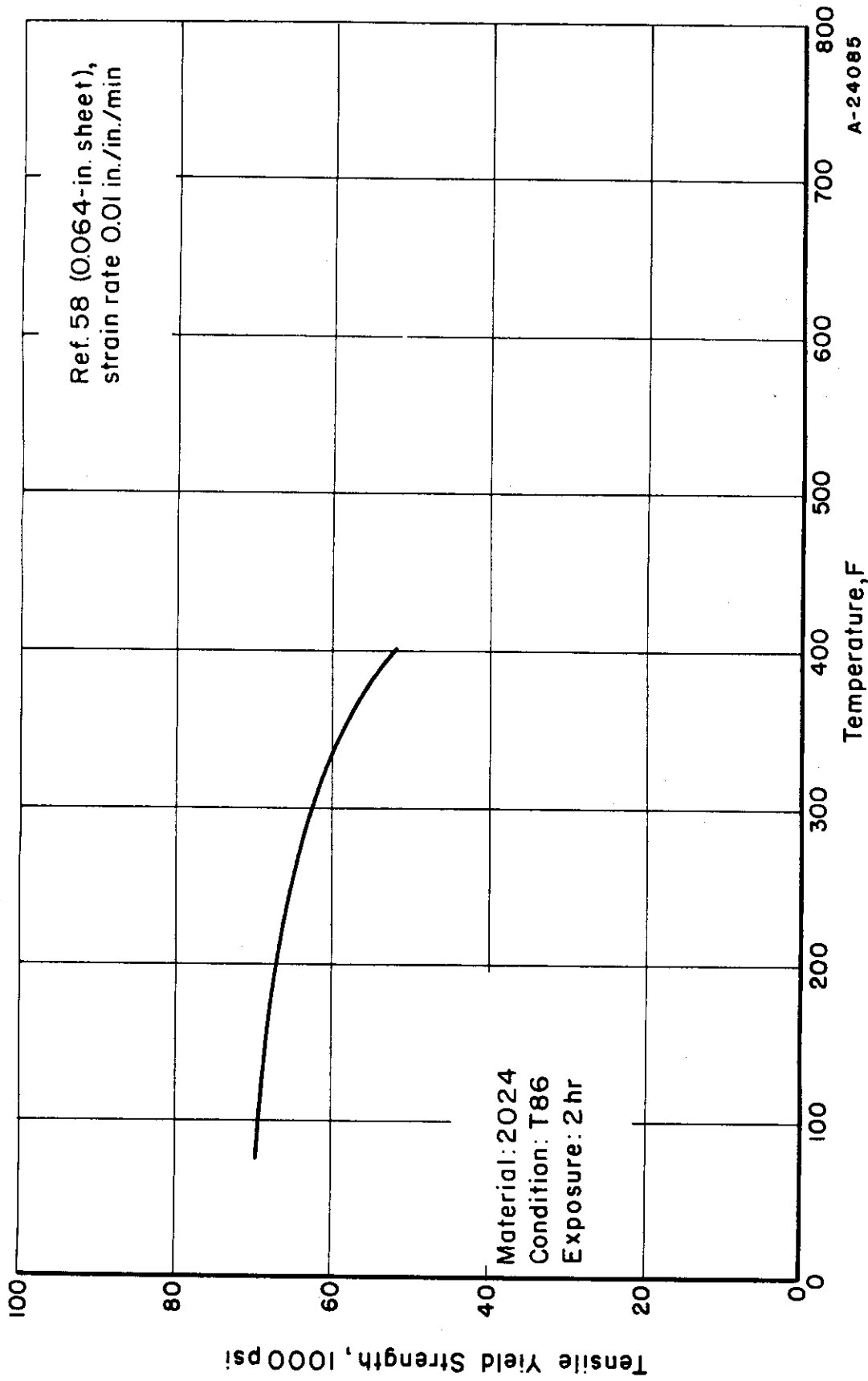


FIGURE 105. TENSILE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)

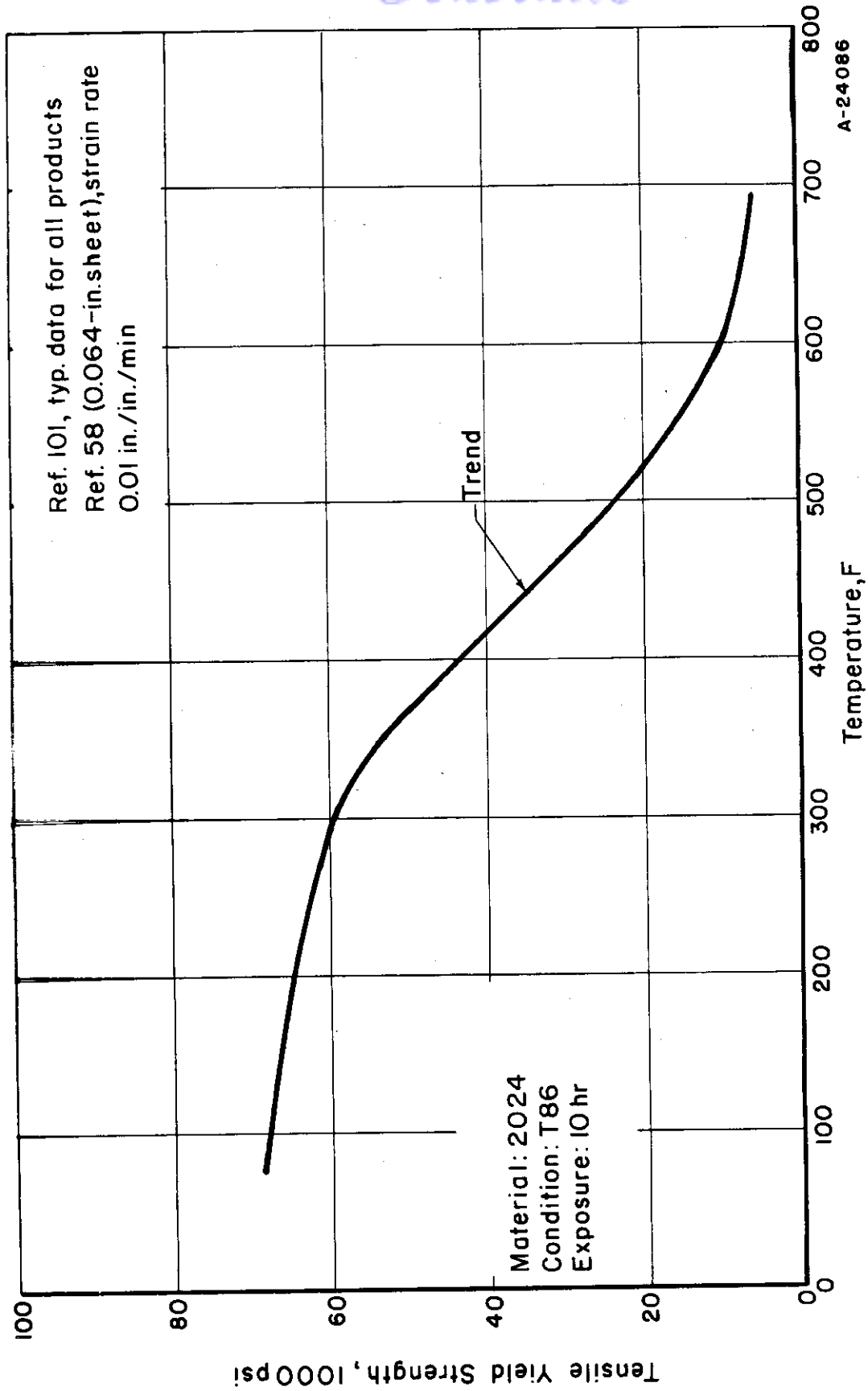


FIGURE 106. TENSILE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

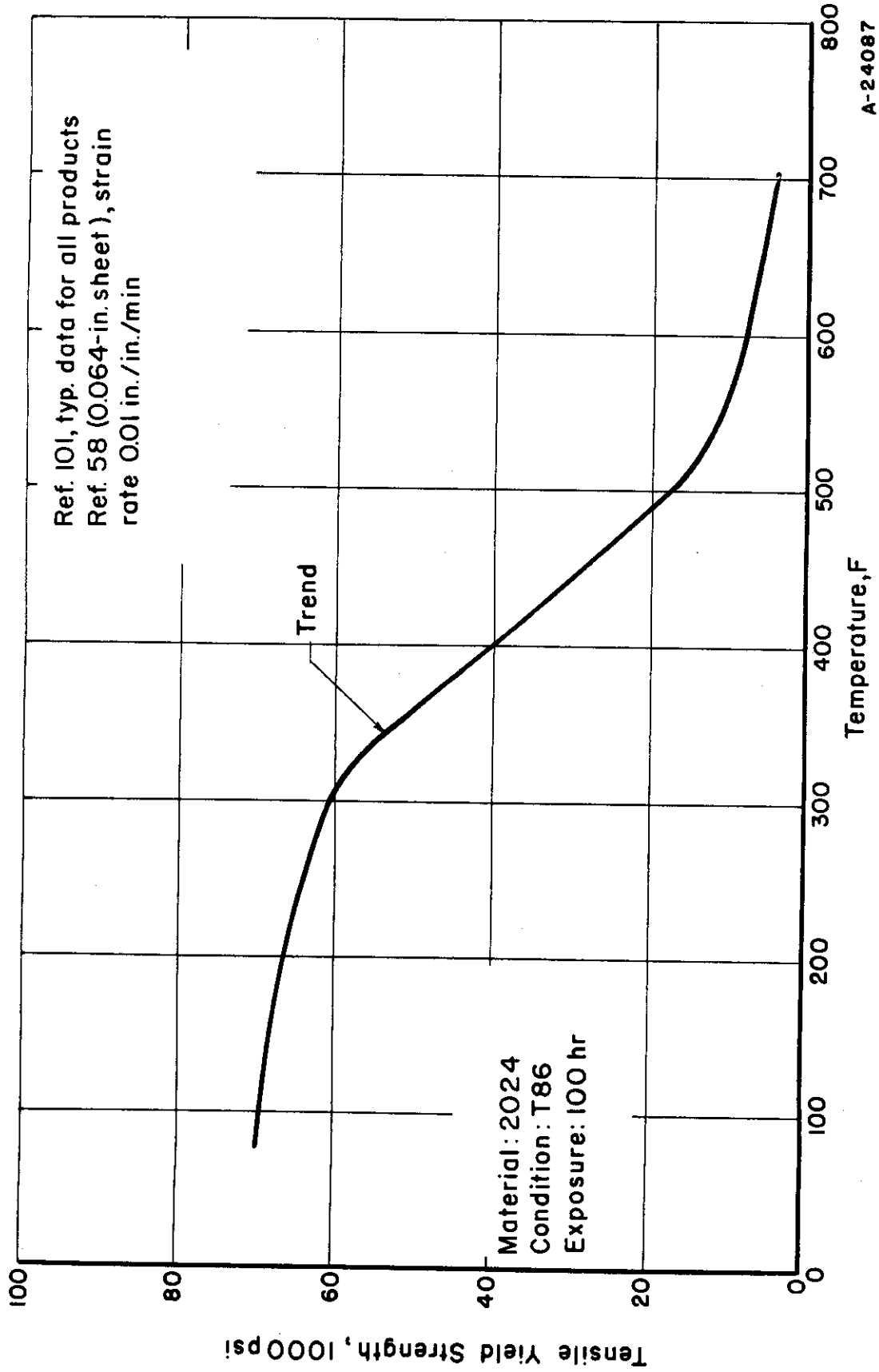


FIGURE 107. TENSILE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)

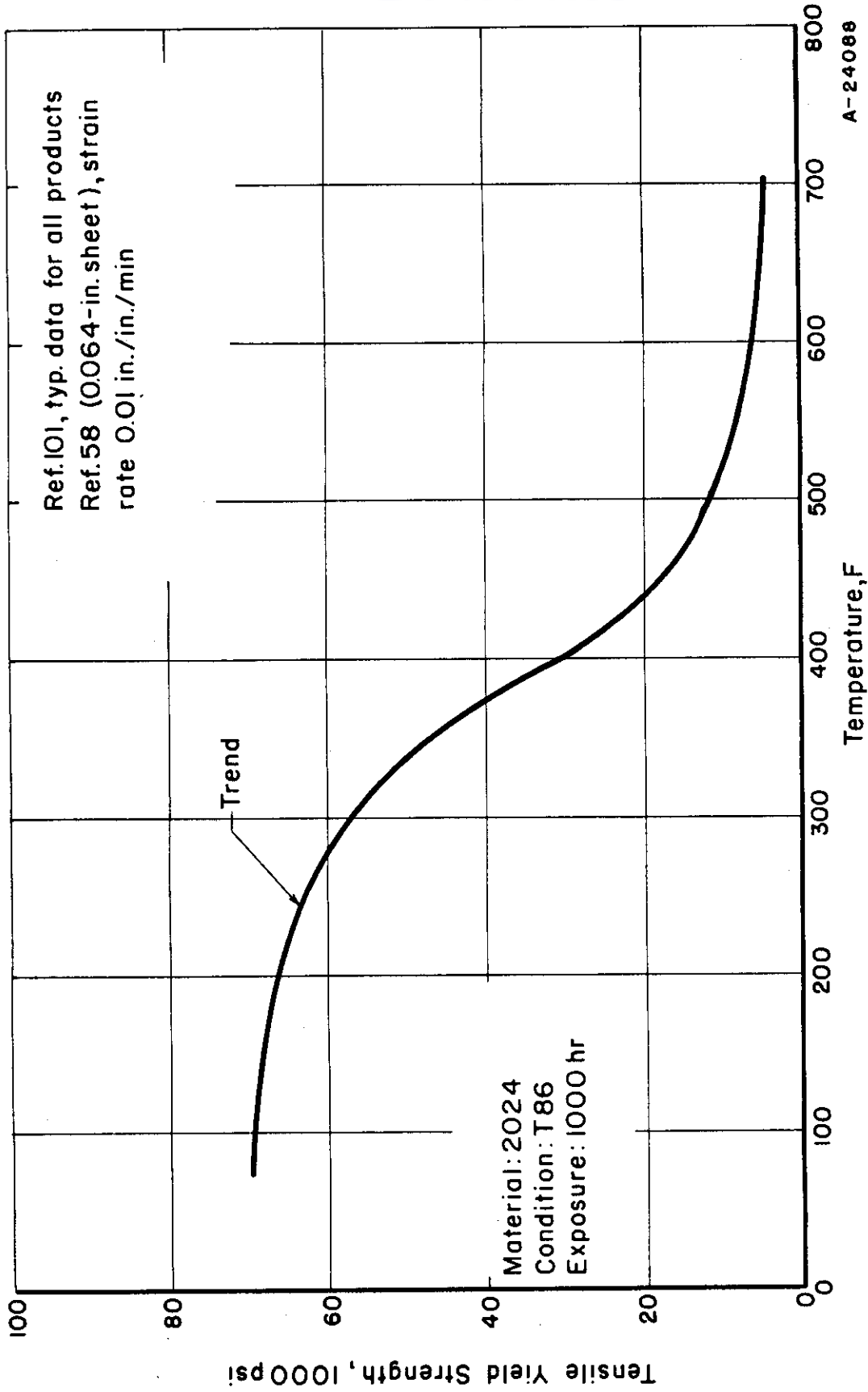


FIGURE 108. TENSILE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

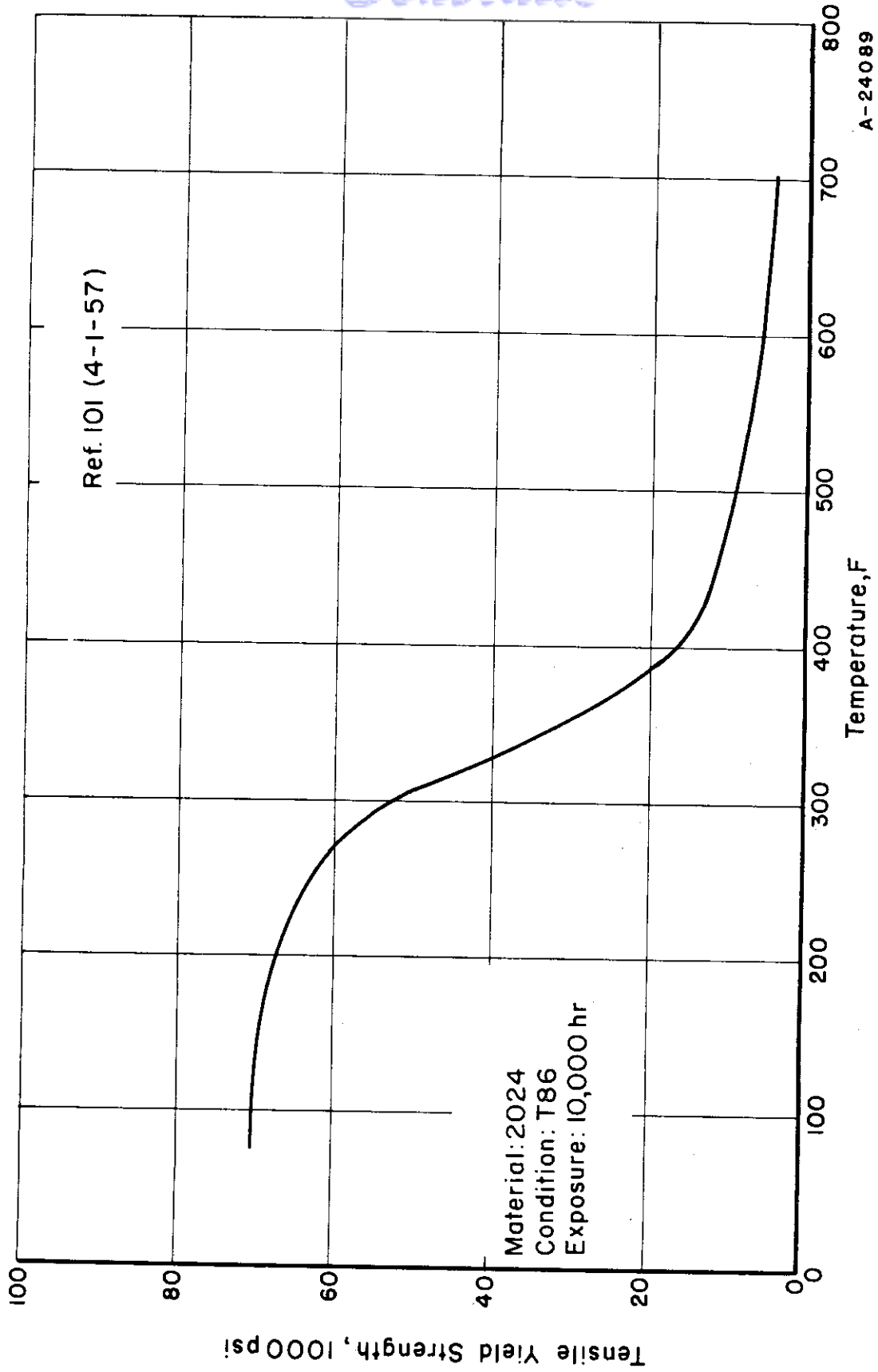


FIGURE 109. TENSILE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

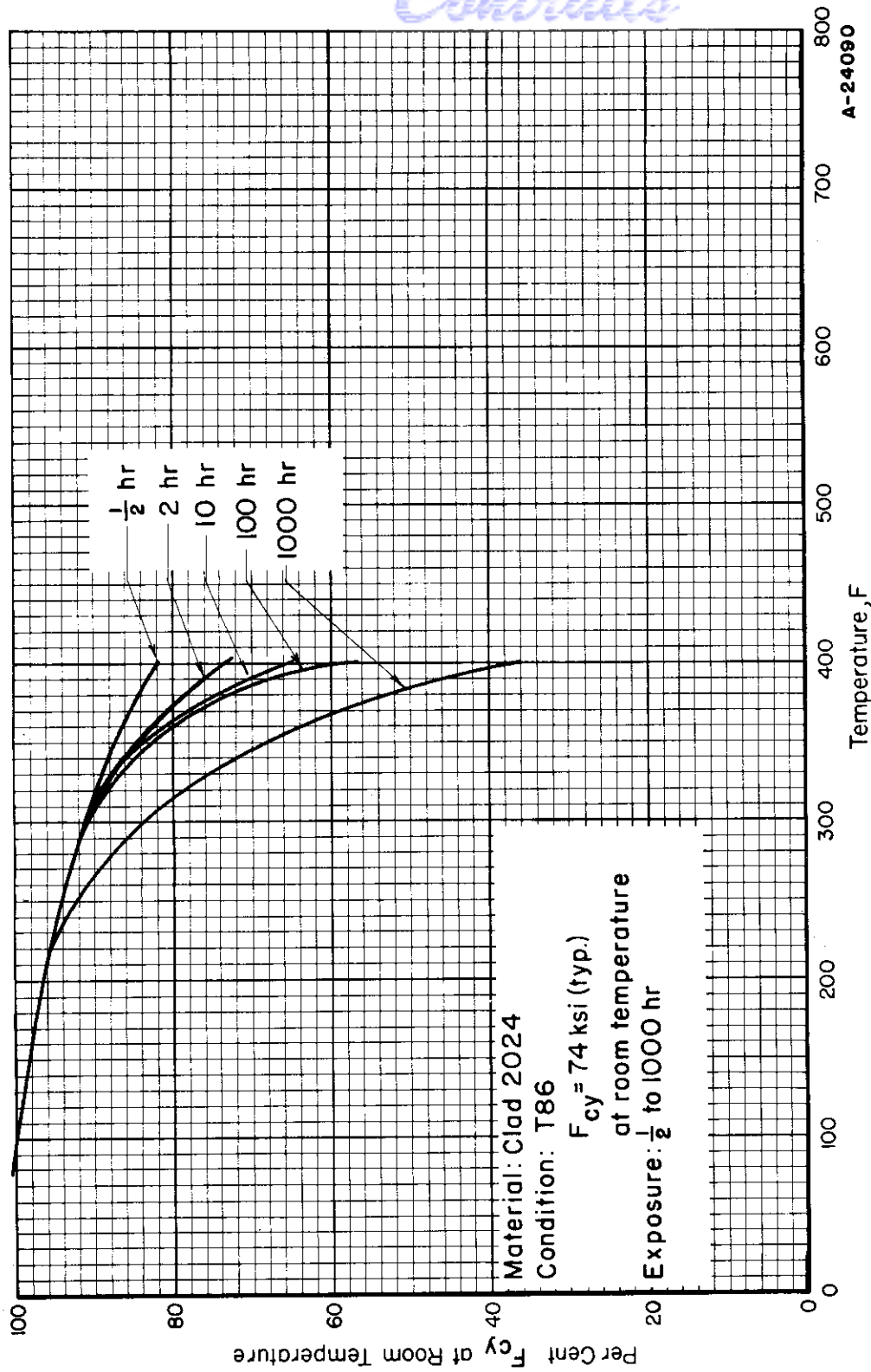


FIGURE 110. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF CLAD 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

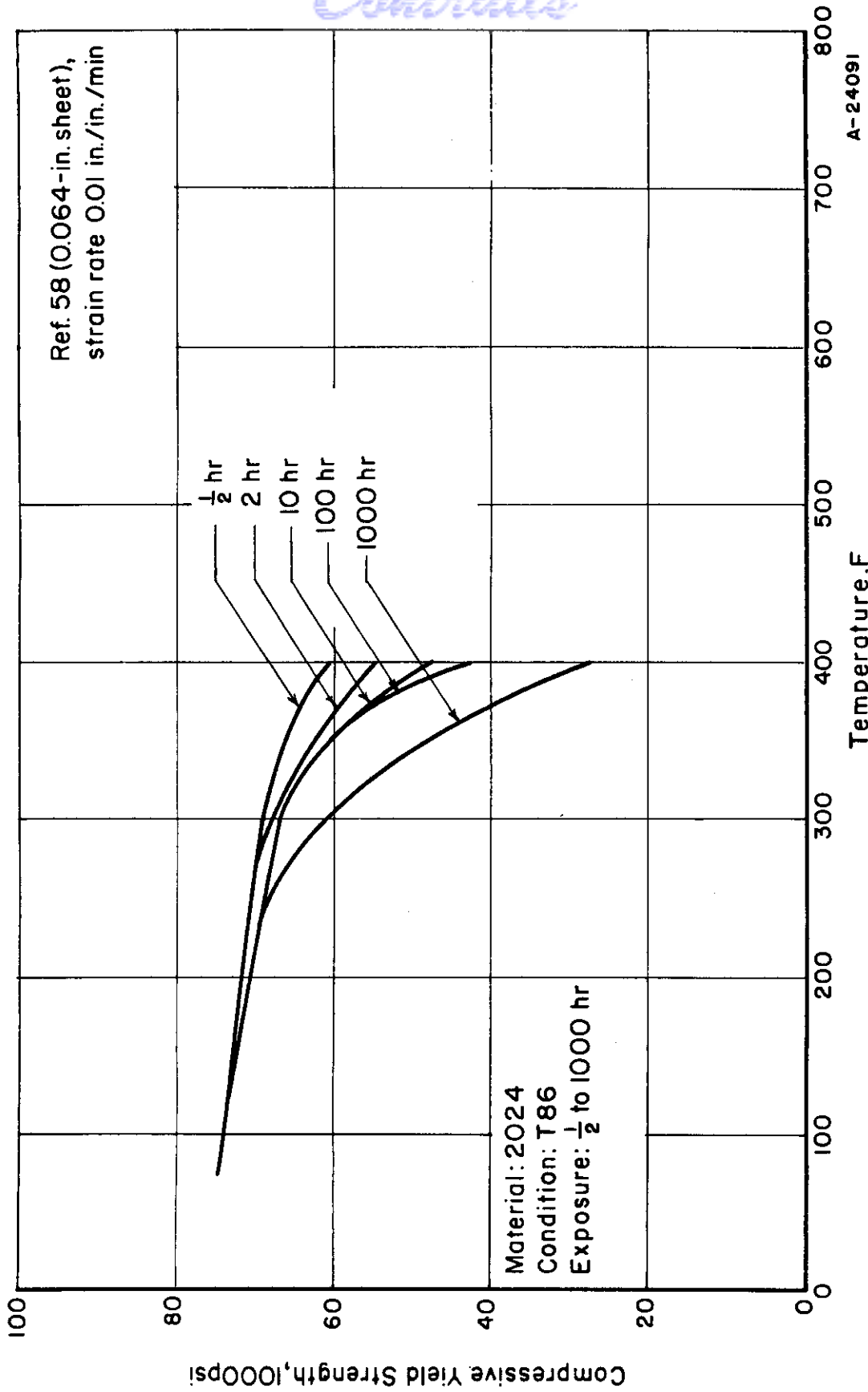


FIGURE III. COMPRESSIVE YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

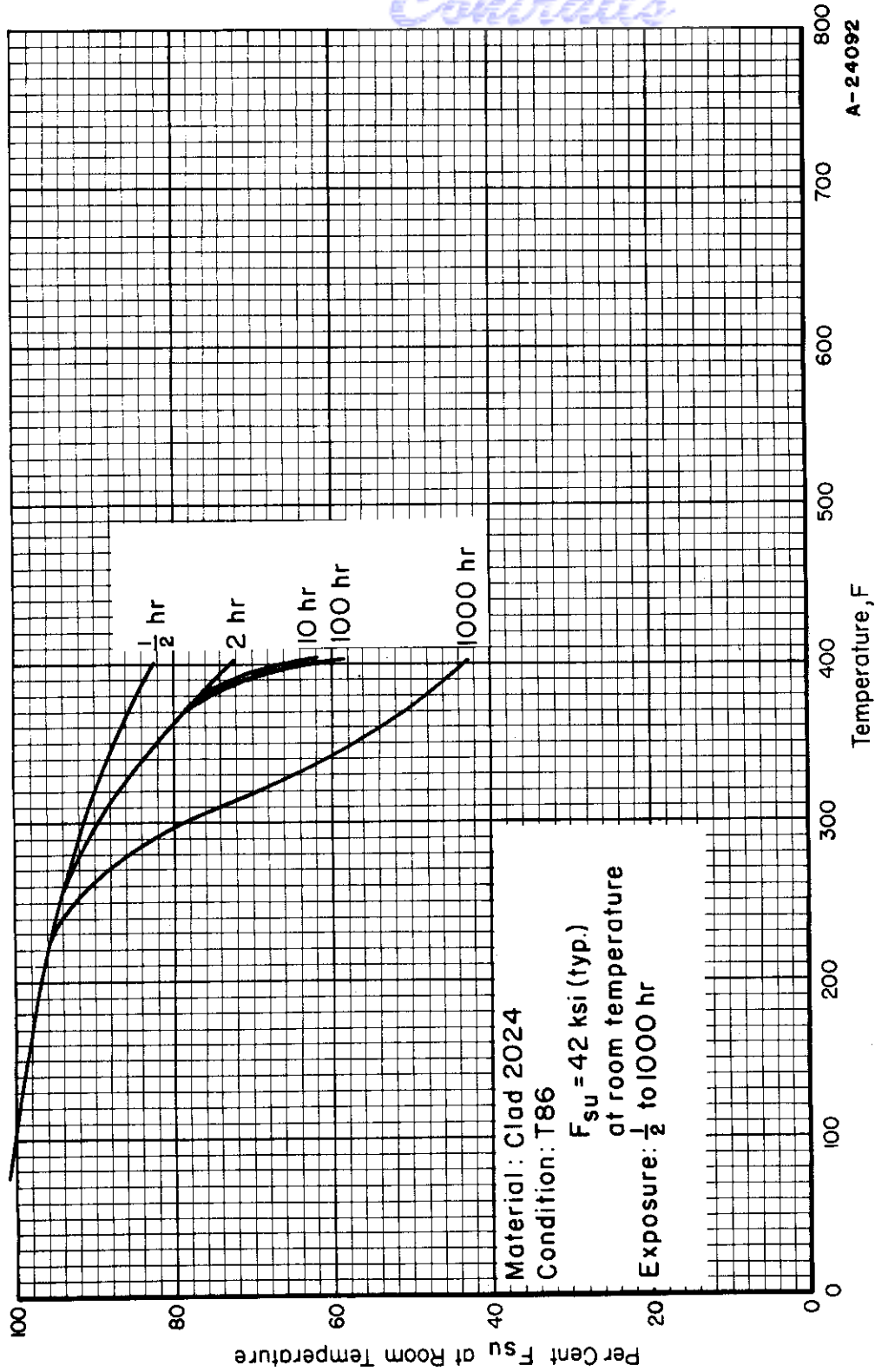


FIGURE 112. DESIGN CURVES FOR SHEAR STRENGTH (F_{su}) OF CLAD 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

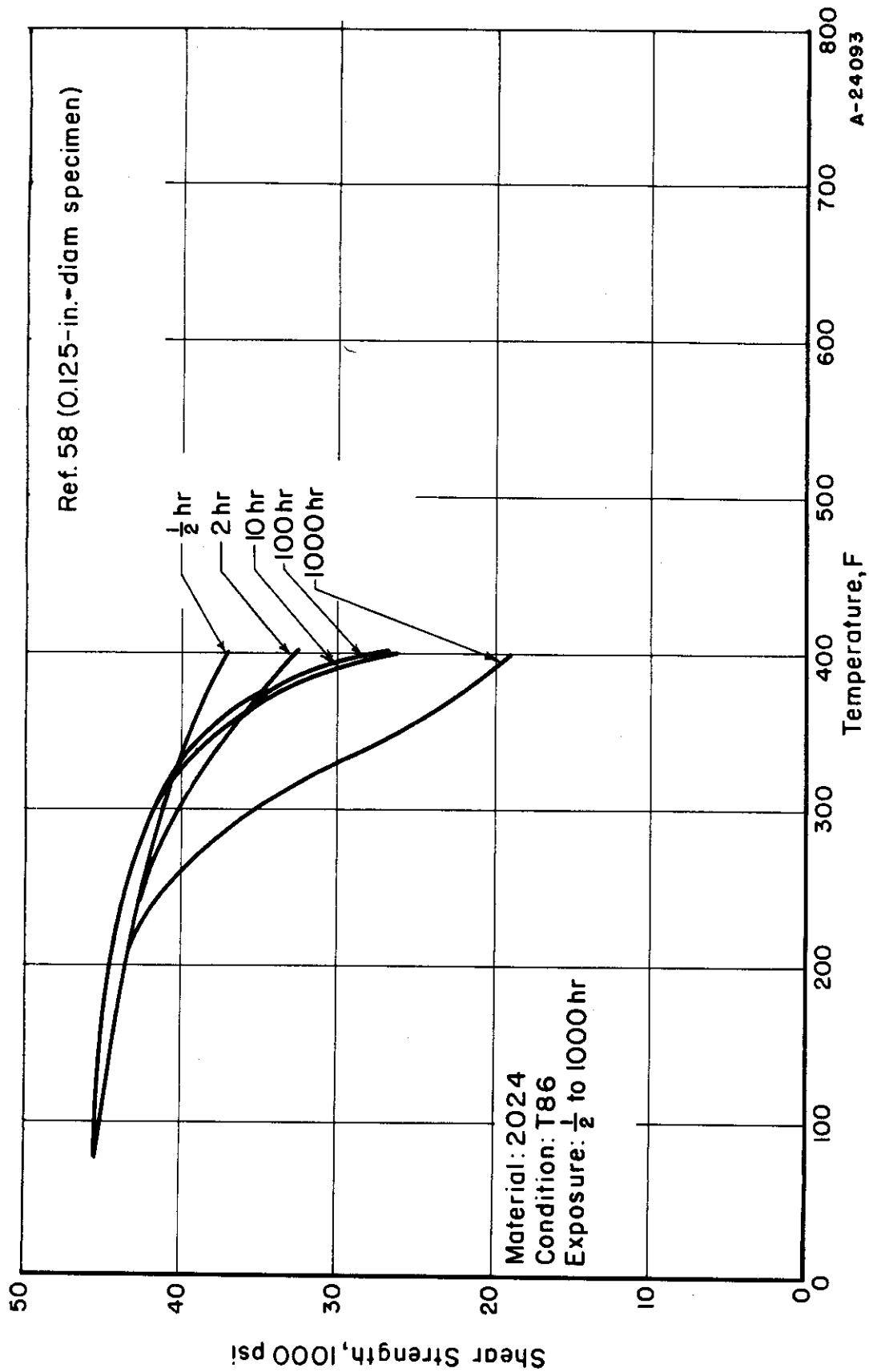


FIGURE 113. SHEAR STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

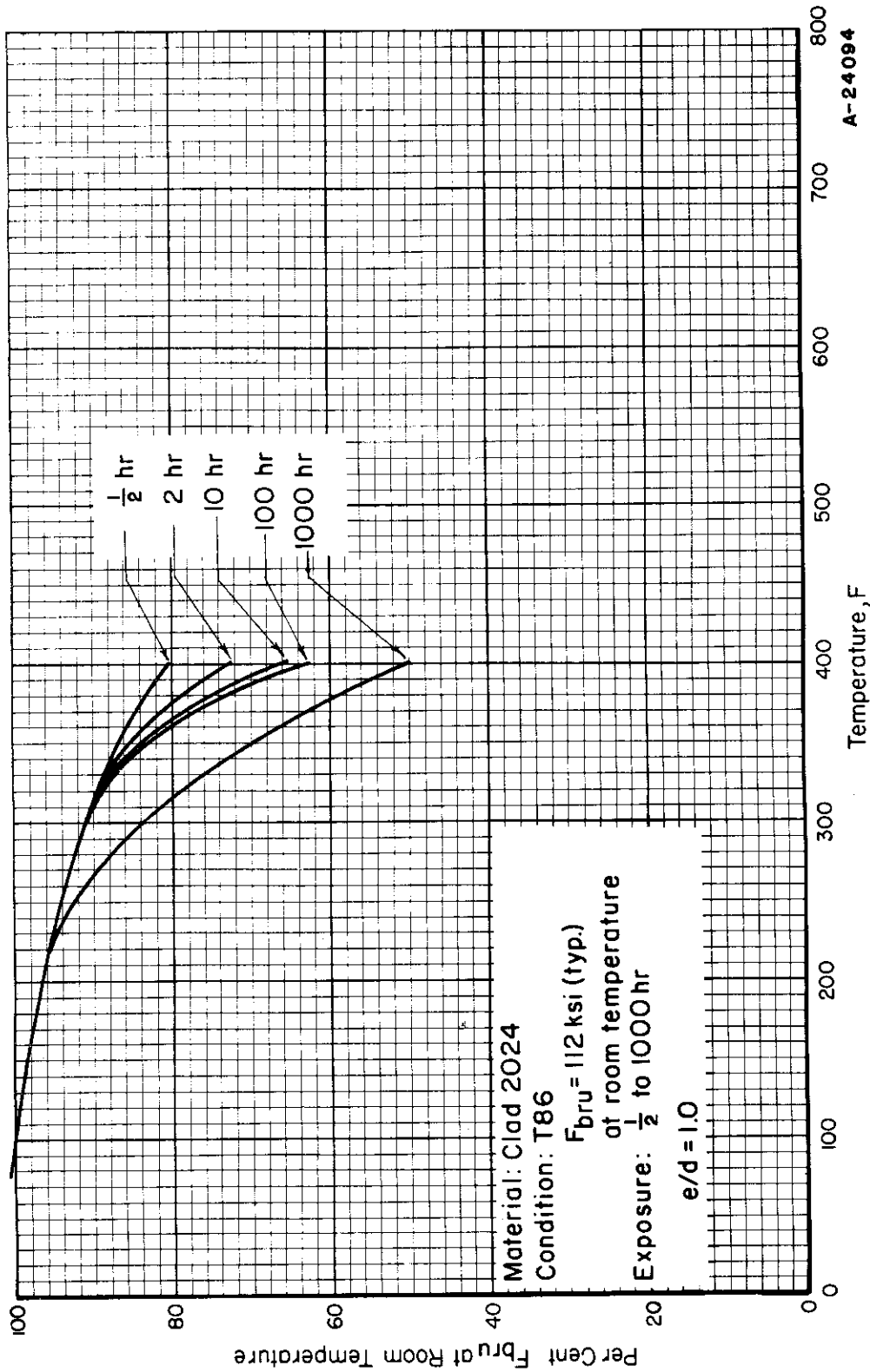


FIGURE 114. DESIGN CURVES FOR BEARING STRENGTH (F_{bru}) OF CLAD 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

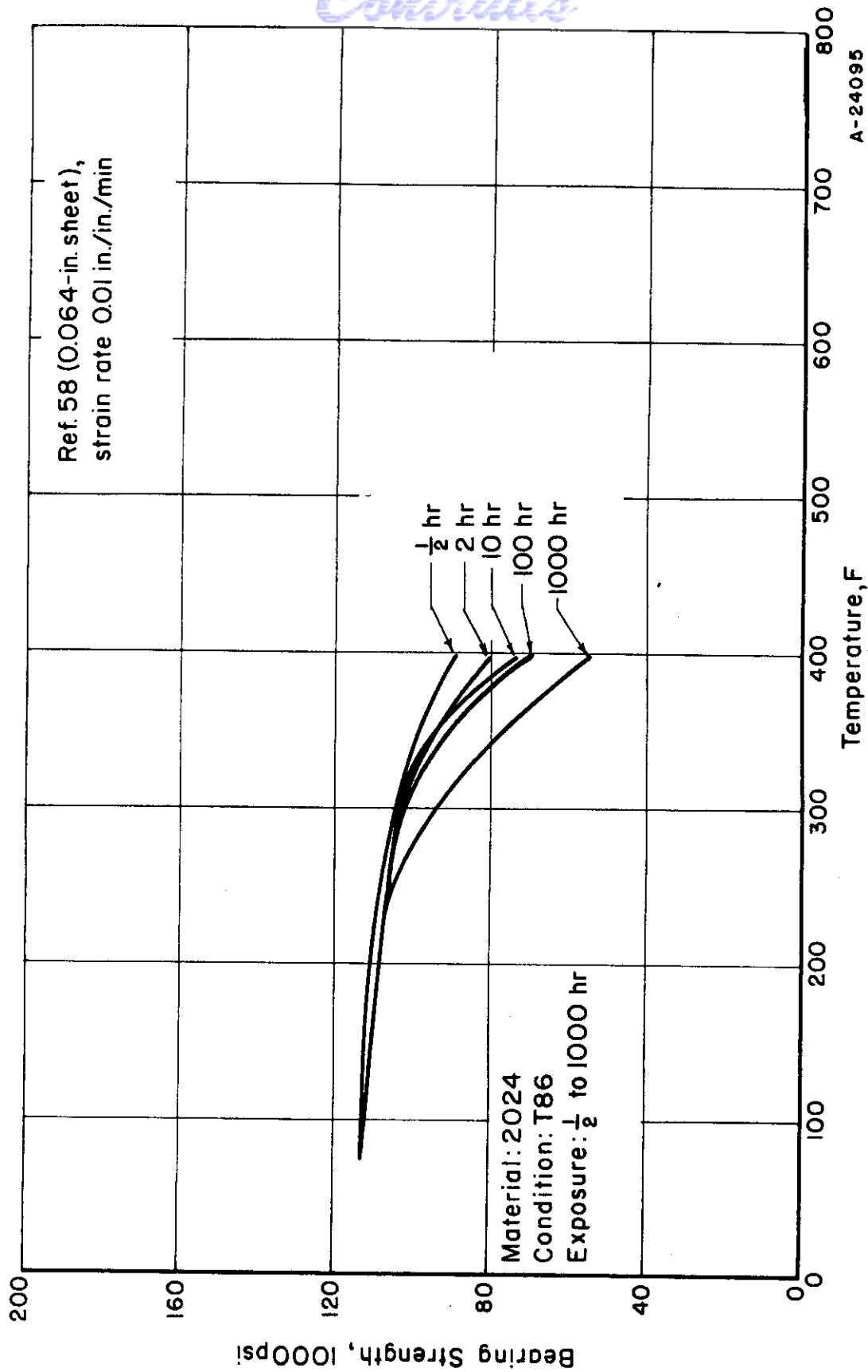


FIGURE 115. BEARING STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

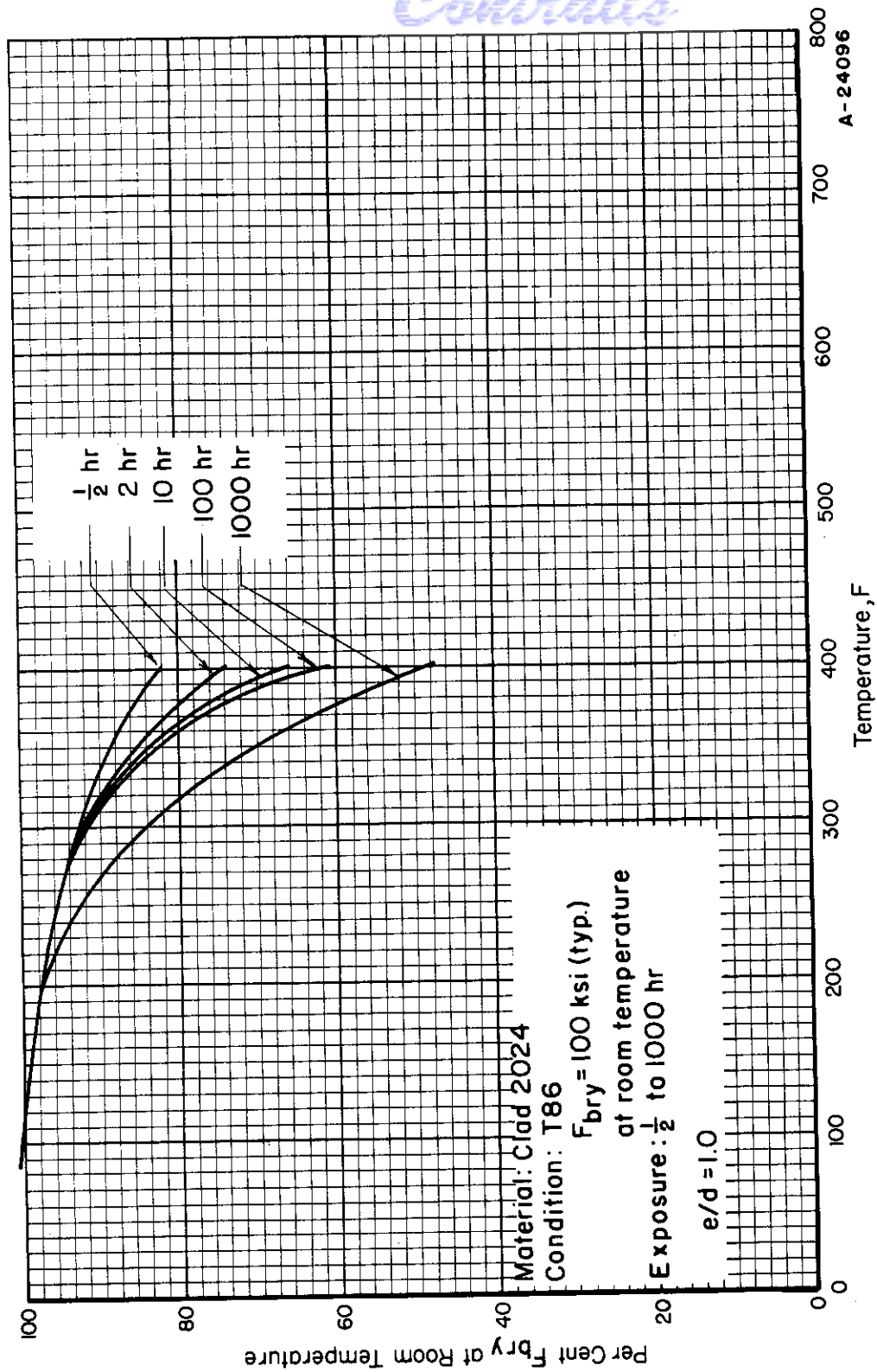


FIGURE 116. DESIGN CURVES FOR BEARING YIELD STRENGTH (F_{bry}) OF CLAD 2024-T86 ALUMI-
 NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

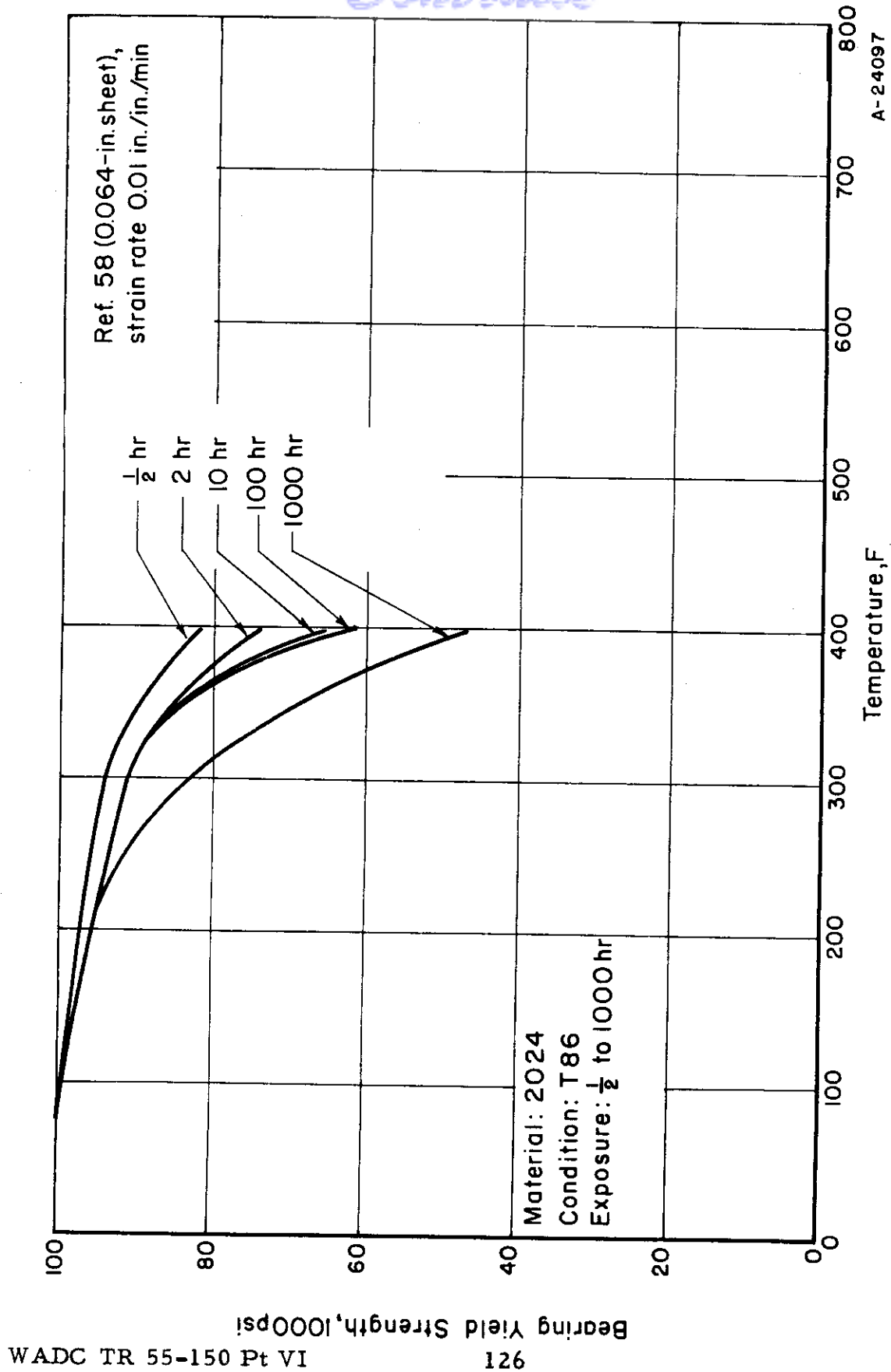


FIGURE 117. BEARING YIELD STRENGTH DATA FOR 2024-T86 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO EXPOSURE)

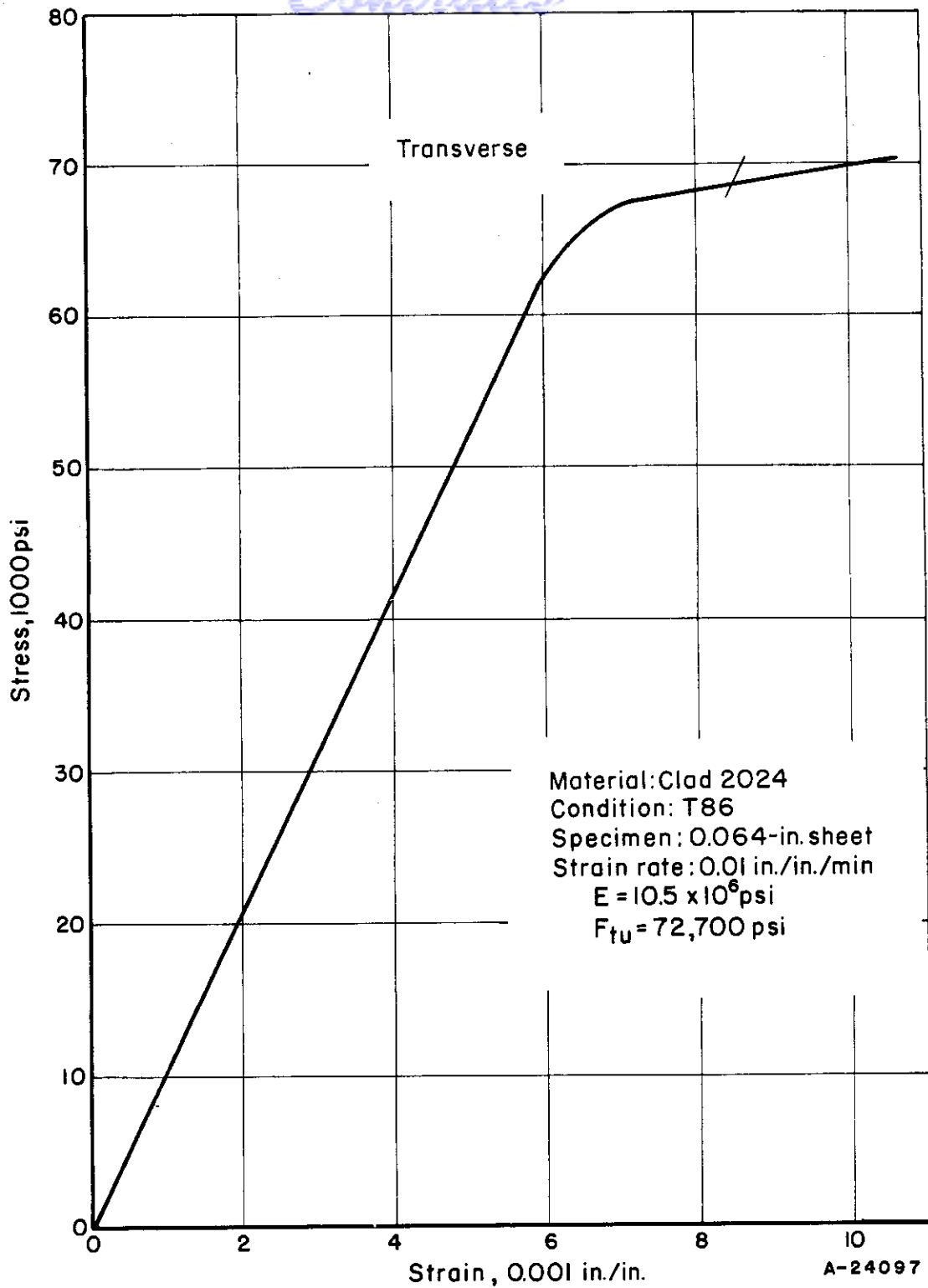


FIGURE 118. TENSILE STRESS-STRAIN CURVE FOR CLAD 2024-T86 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 58.

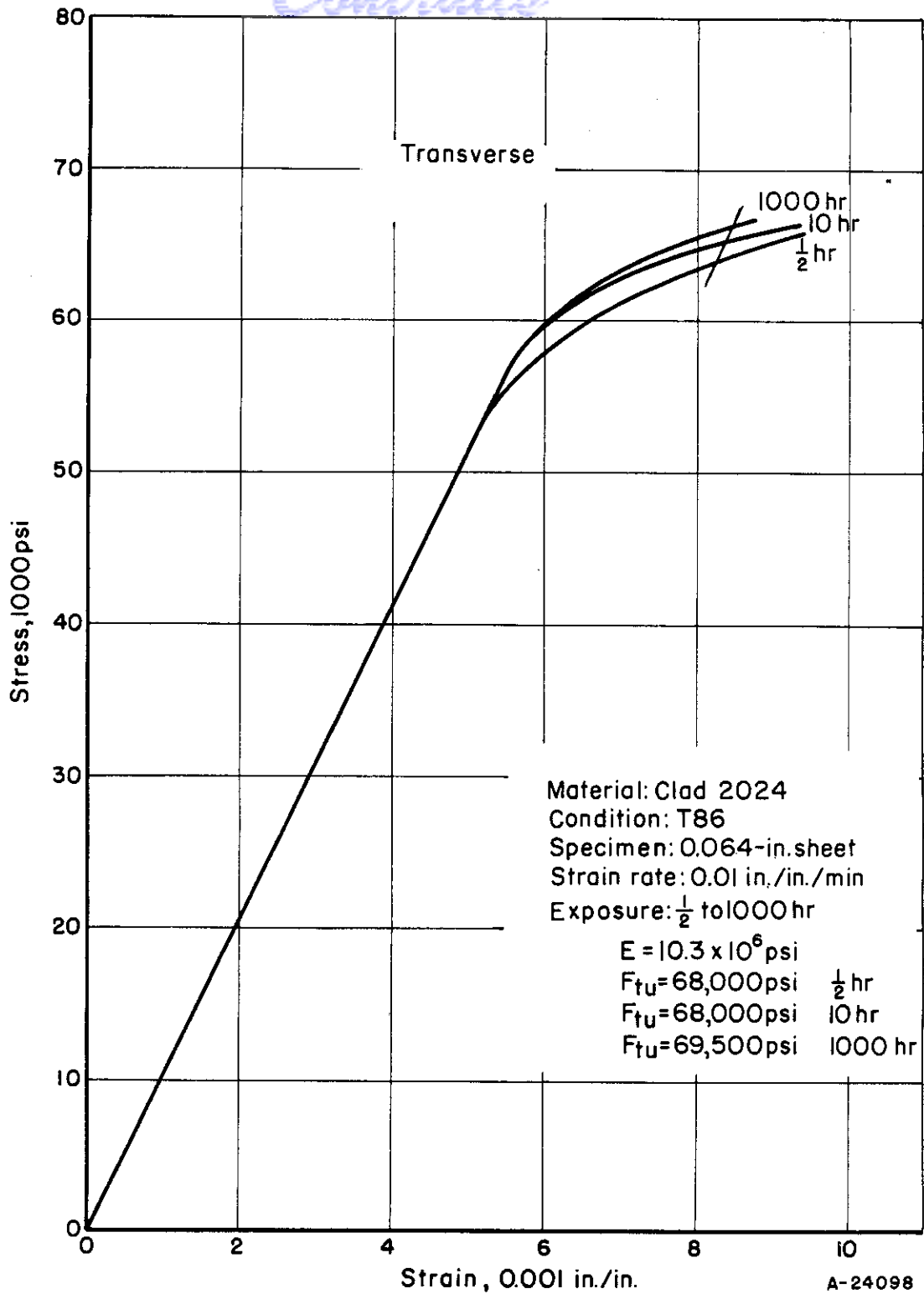


FIGURE 119. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T86 ALUMINUM ALLOY AT 200 F

Ref. 58.

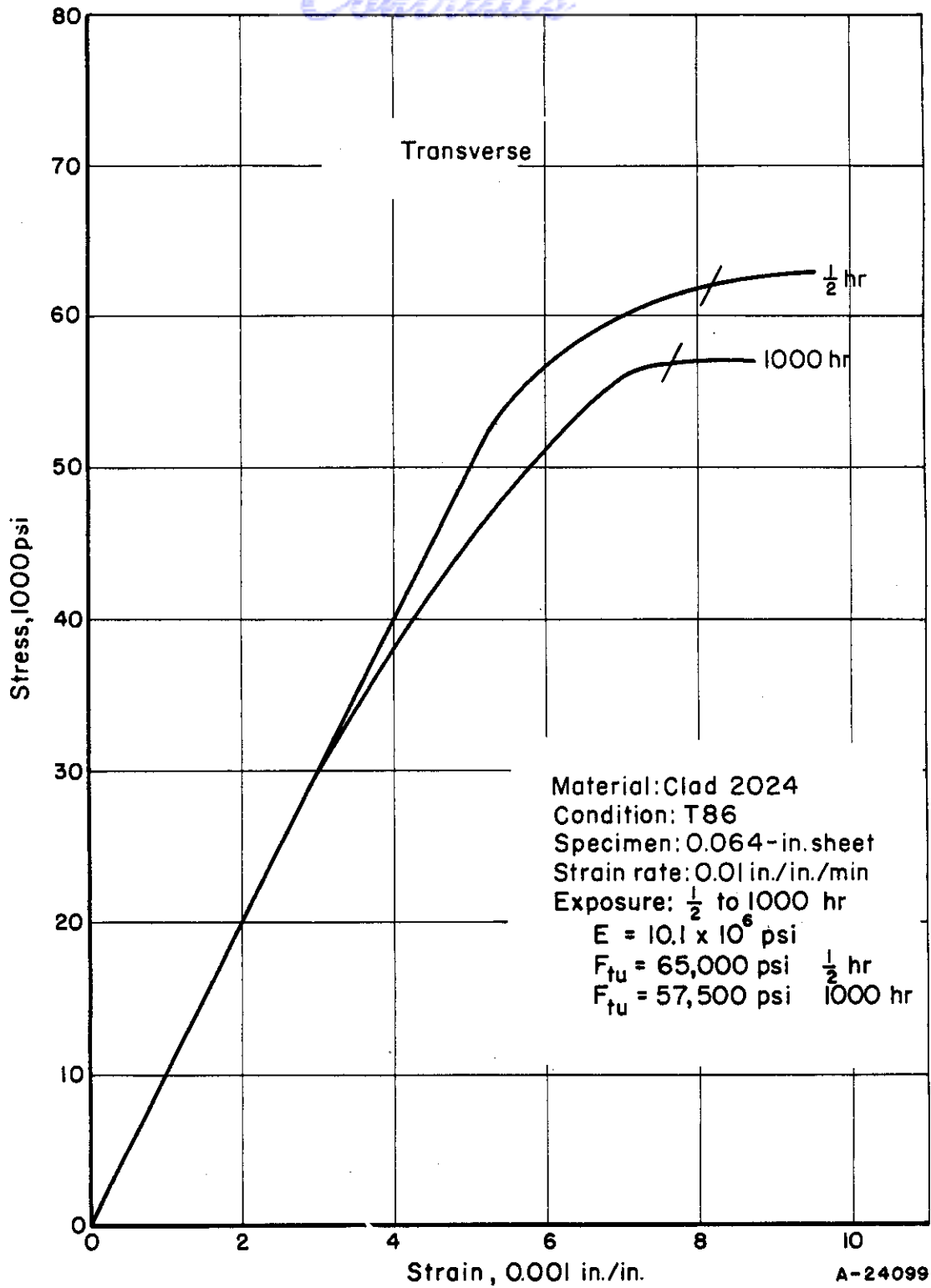


FIGURE 120. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T86 ALUMINUM ALLOY AT 300 F

Ref. 58.

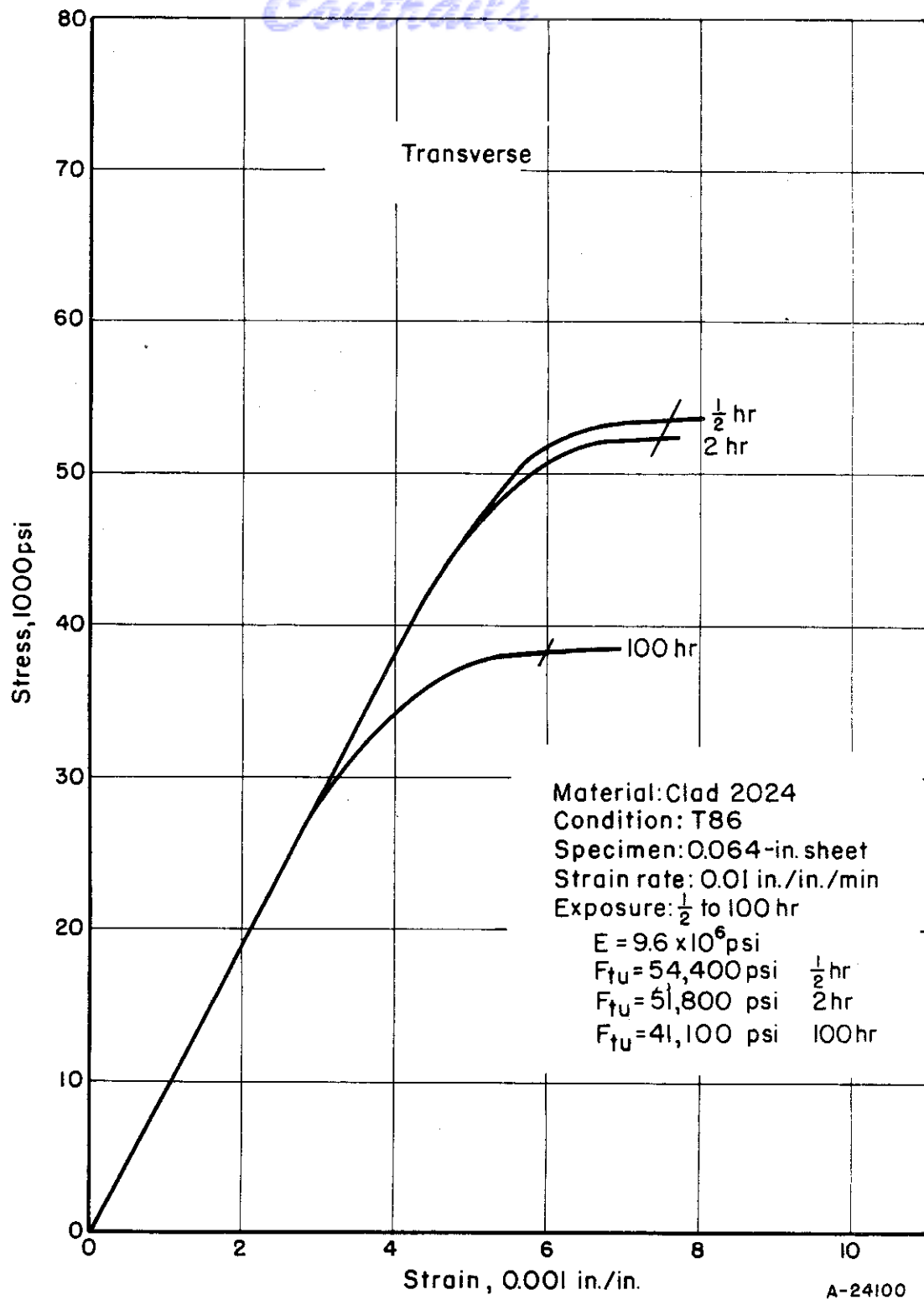


FIGURE 121. TENSILE STRESS-STRAIN CURVES FOR CLAD 2024-T86 ALUMINUM ALLOY AT 400 F

Ref. 58.

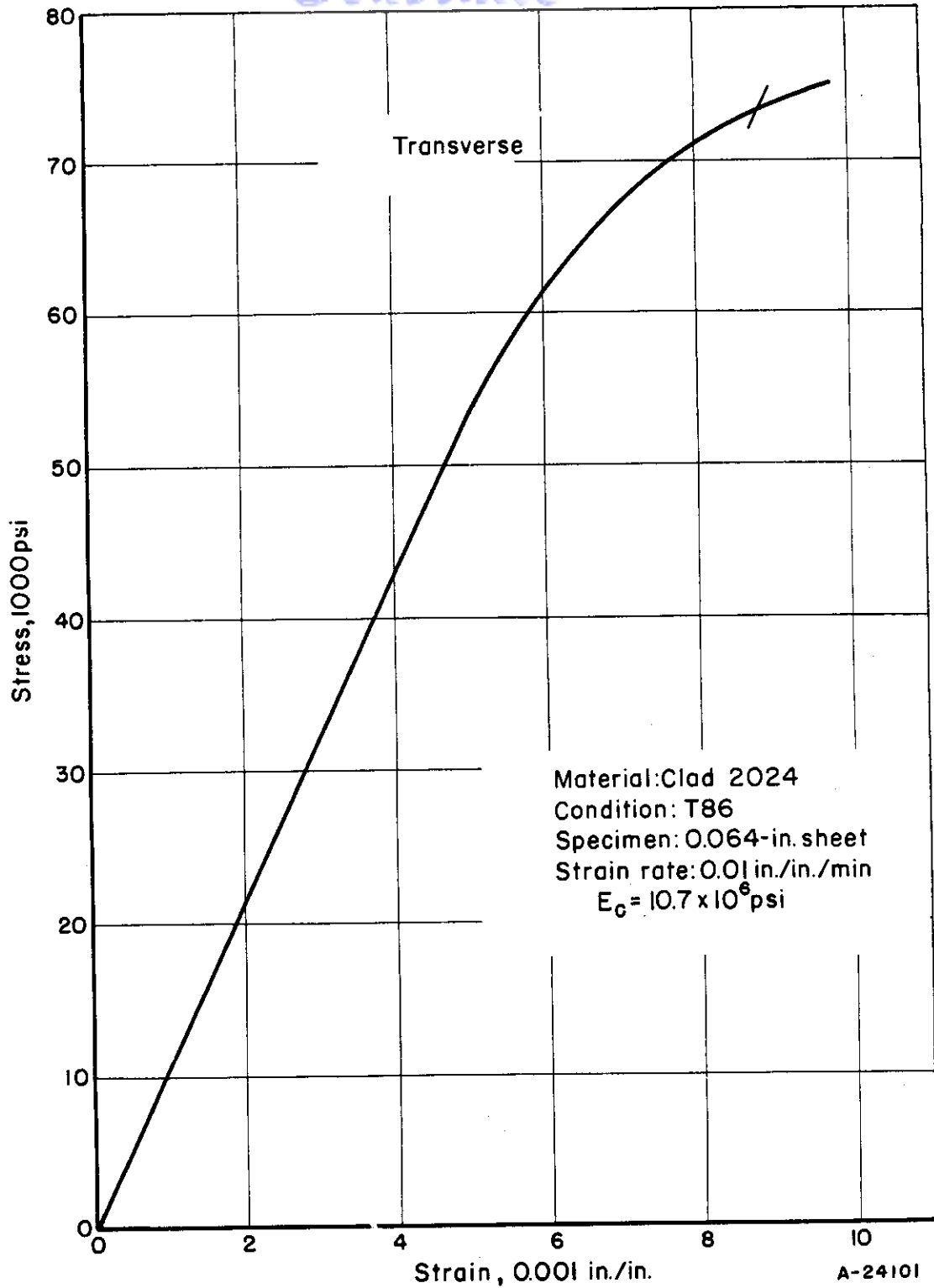


FIGURE 122. COMPRESSIVE STRESS-STRAIN CURVE FOR CLAD 2024-T86 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 58.

WADC TR 55-150 Pt VI

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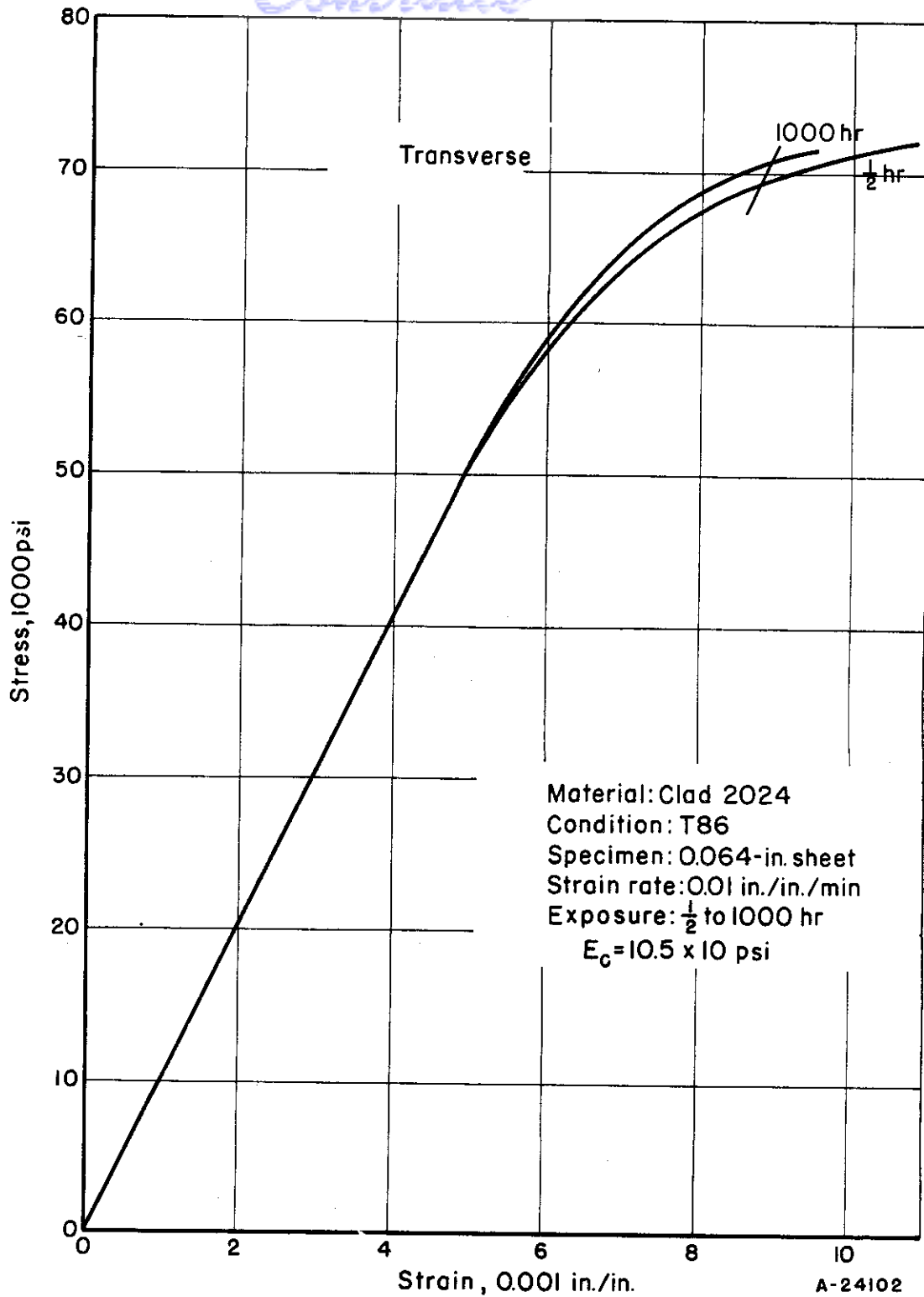


FIGURE 123. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T86 ALUMINUM ALLOY AT 200 F

Ref. 58.

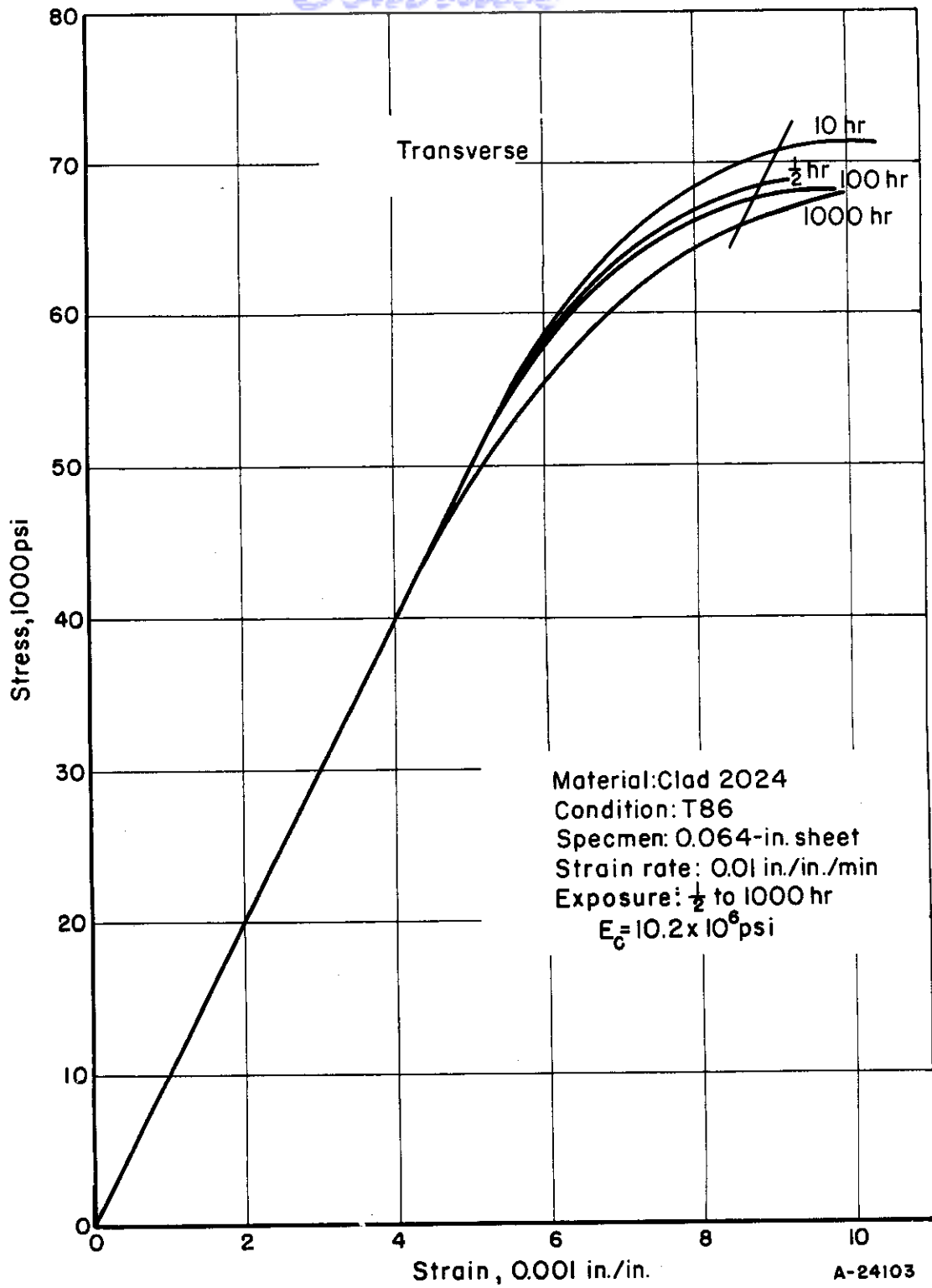


FIGURE 124. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T86 ALUMINUM ALLOY AT 300 F

Ref. 58.

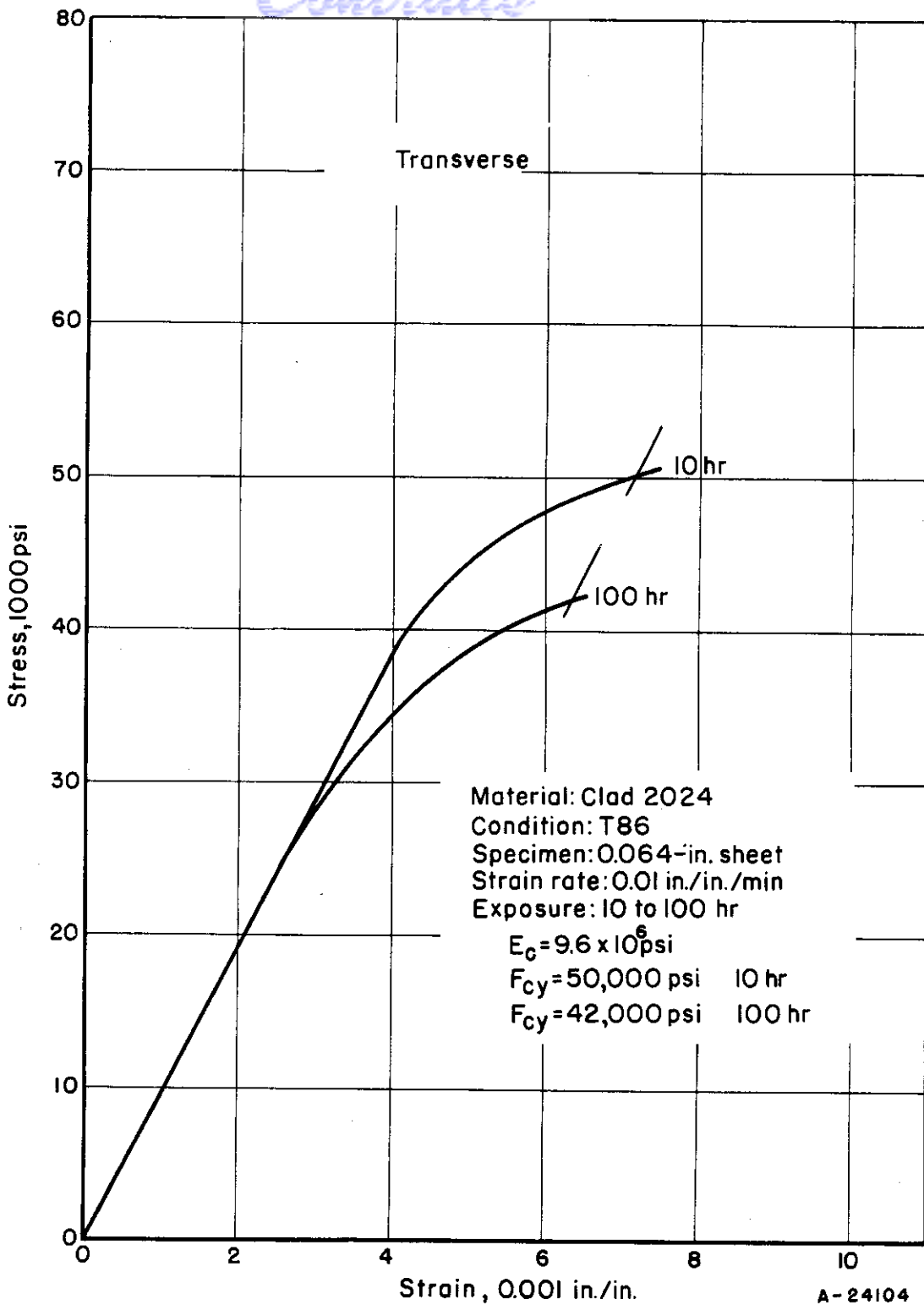


FIGURE 125. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 2024-T86 ALUMINUM ALLOY AT 400 F

Ref. 58.

Alloy Specifications

Specifications Forthcoming

General

2218 is an aluminum-alloy modification of the 2018 series in which, in addition to the major alloying element copper, about 2 per cent nickel is added. The nickel imparts stability and improved strength at elevated temperature, but with a slight reduction in room-temperature strength.

The chemical-composition limits for 2218 are given in Table 7.

TABLE 7. CHEMICAL-COMPOSITION LIMITS OF
2218 ALUMINUM ALLOY

Element	Weight Per Cent*
Copper	3.5 - 4.5
Nickel	1.7 - 2.3
Magnesium	1.2 - 1.8
Silicon	0.9
Iron	1.0
Manganese	0.20
Chromium	0.10
Zinc	0.25
Others, each	0.05
Total	0.15
Aluminum	Balance

*Weight per cent is maximum, unless shown as a range.

The conventional short-time elevated-temperature properties of 2218 are shown in the following curves:

Stress-strain curves

Figures 126 and 127.

Continails

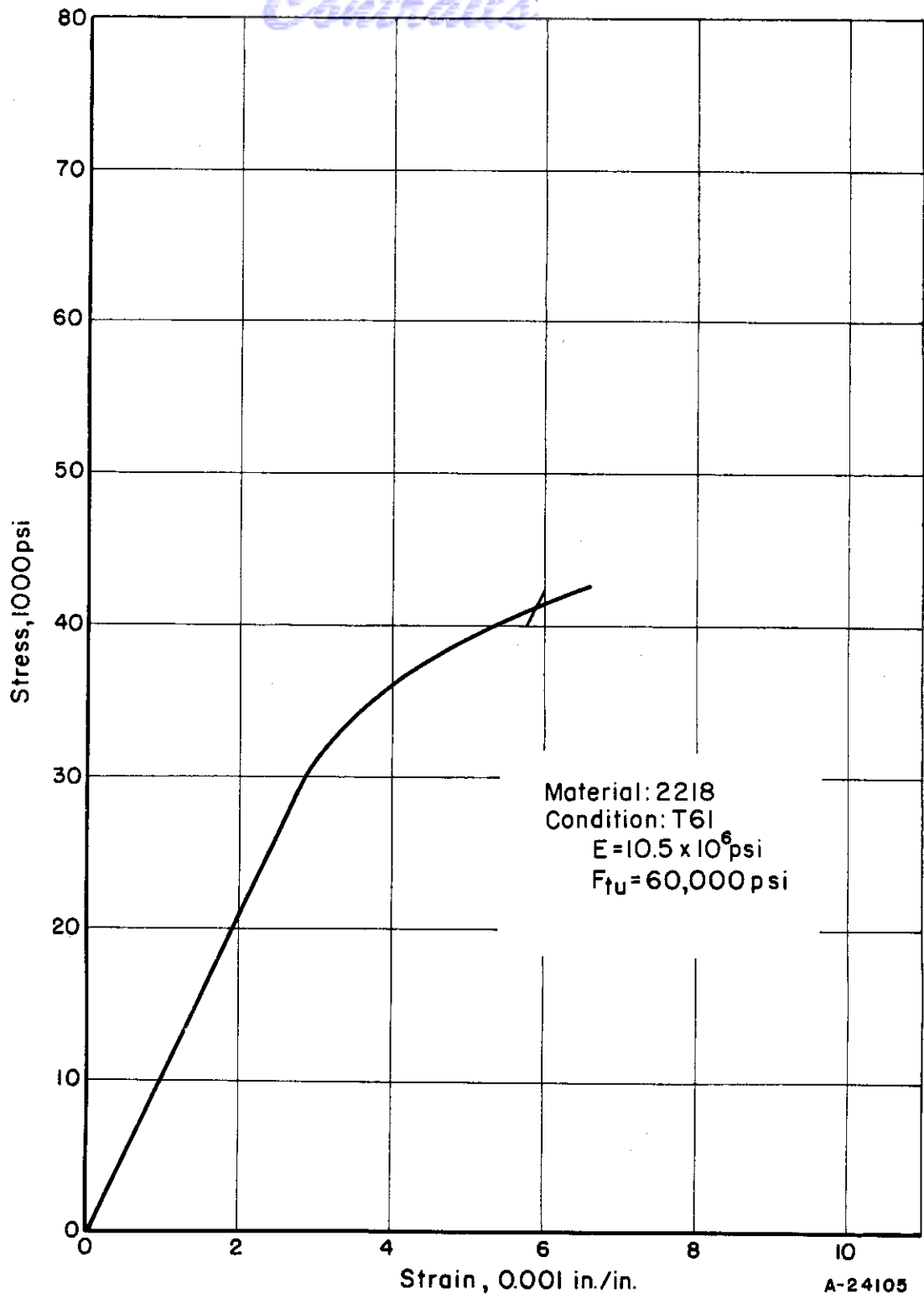


FIGURE 126. TENSILE STRESS-STRAIN CURVE FOR 2218-T61 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 101.

WADC TR 55-150 Pt VI

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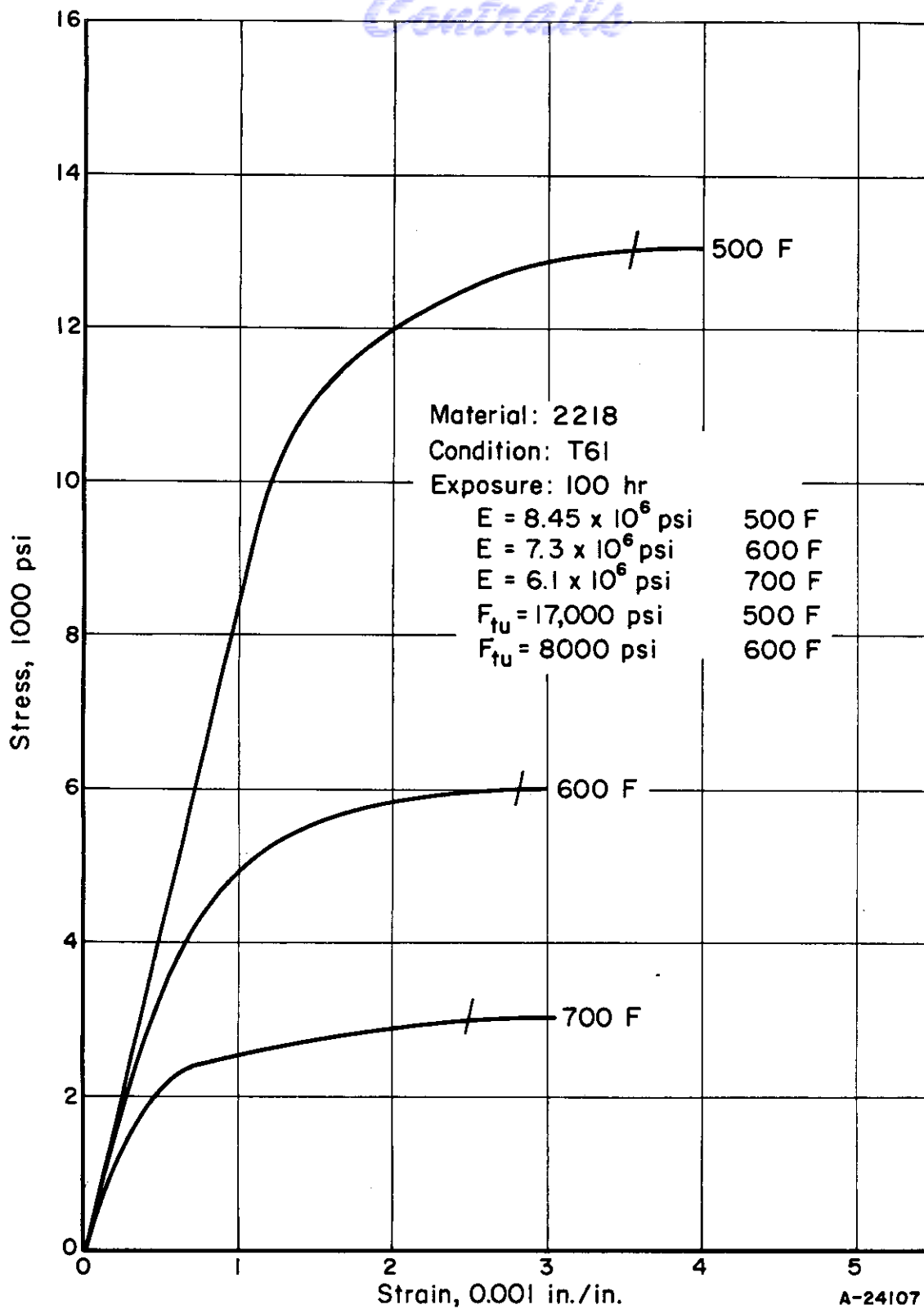


FIGURE 127. TENSILE STRESS-STRAIN CURVES FOR 2218-T61 ALUMI-NUM ALLOY AT ELEVATED TEMPERATURE

Ref. 101.

Contrails

X2219 ALUMINUM ALLOY (EXPERIMENTAL)

Alloy Specifications

Specifications Forthcoming

General

X2219 is an experimental aluminum alloy having good strength properties, particularly in the temperature range 500 - 650 F. It is well suited to forgings, as it exhibits low directionality tendencies. Other forms such as sheet, plate, and extrusions are being investigated.

The nominal composition of X2219 is given in Table 8.

TABLE 8. NOMINAL CHEMICAL COMPOSITION OF X2219
(EXPERIMENTAL) ALUMINUM ALLOY

Element	Weight Per Cent
Copper	6.0
Manganese	0.3
Vanadium	0.10
Zirconium	0.15

Some typical tensile properties of X2219-T6 forgings are shown in the following curves:

Tensile strength	Figures 128 and 129
Tensile yield strength	Figures 130 and 131
Stress-strain curve	Figure 132.

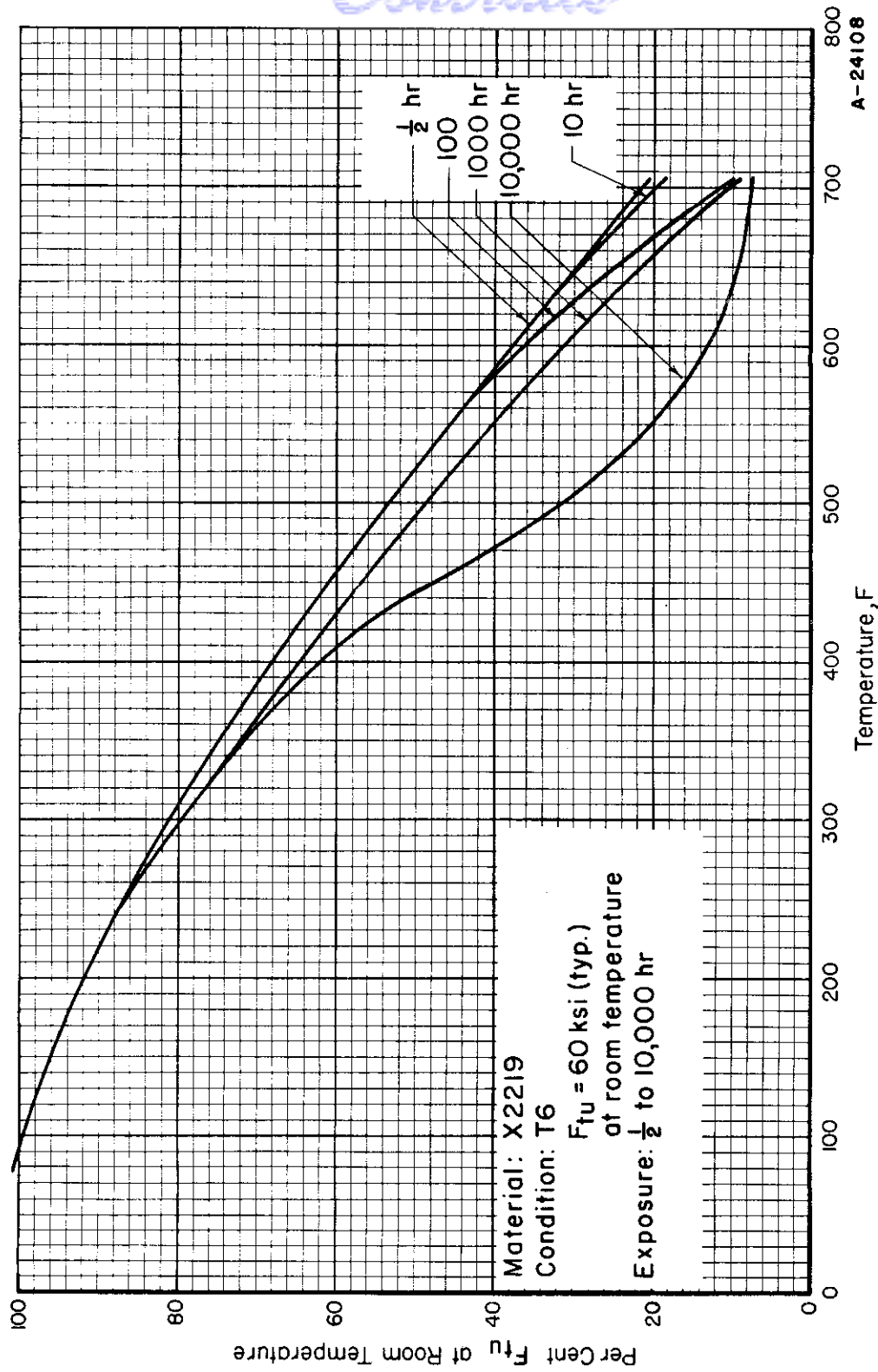


FIGURE 128. DESIGN CURVES (TENTATIVE) FOR TENSILE STRENGTH (F_{tu}) OF X2219-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101.

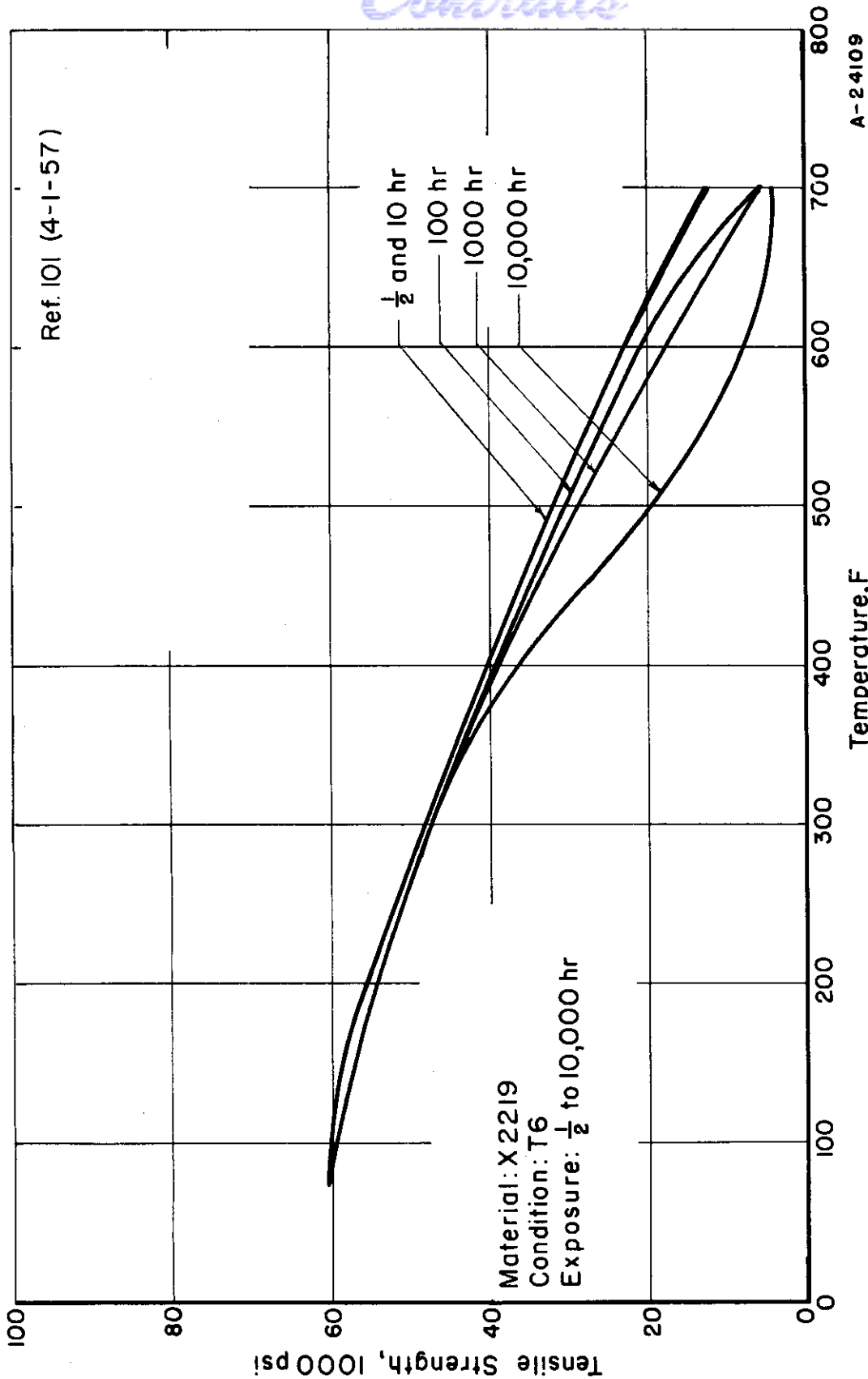


FIGURE 129. TENSILE STRENGTH DATA FOR X2219-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

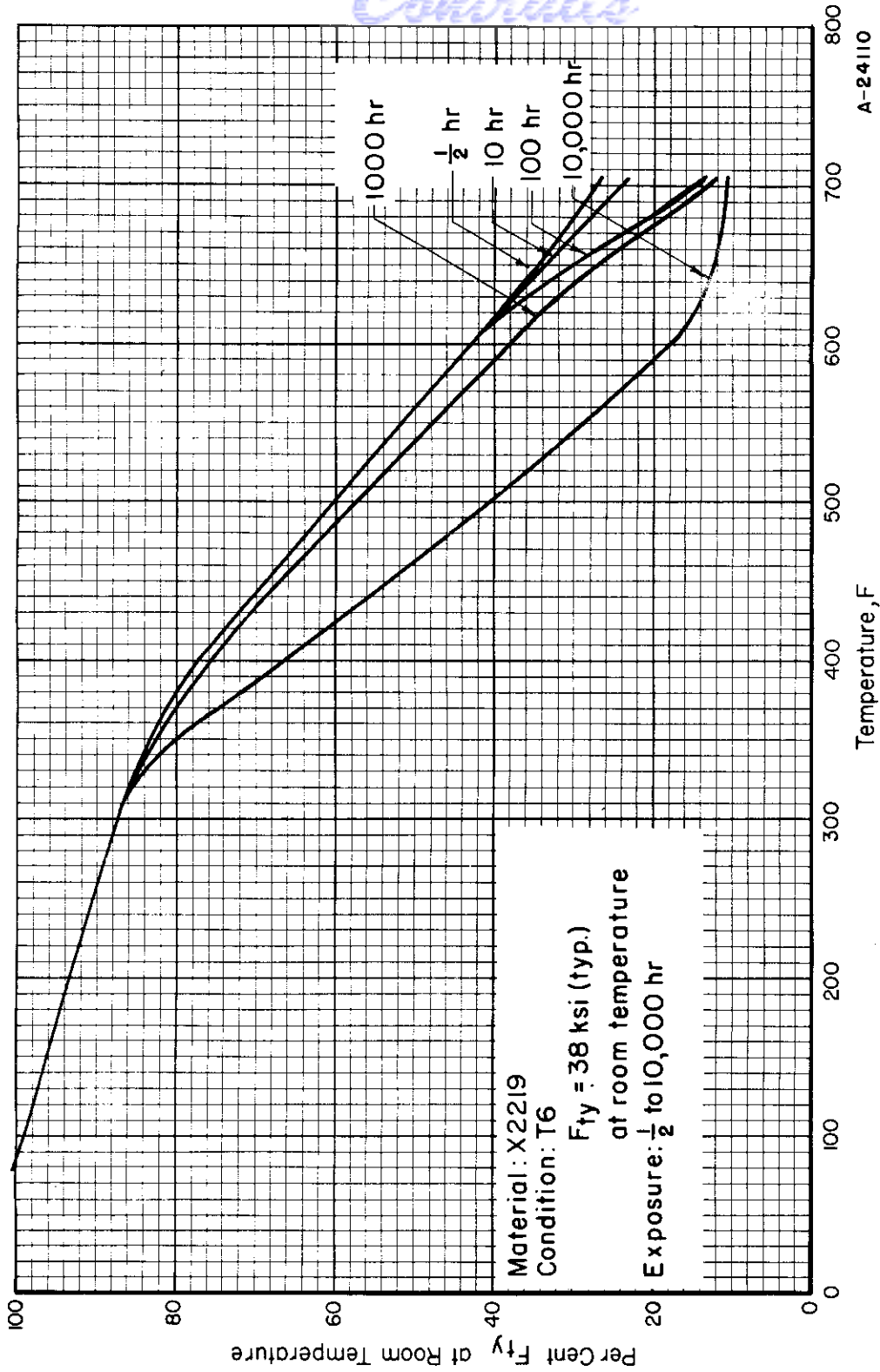


FIGURE 130. DESIGN CURVES (TENTATIVE) FOR TENSILE YIELD STRENGTH (F_{ty}) OF X2219-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101.

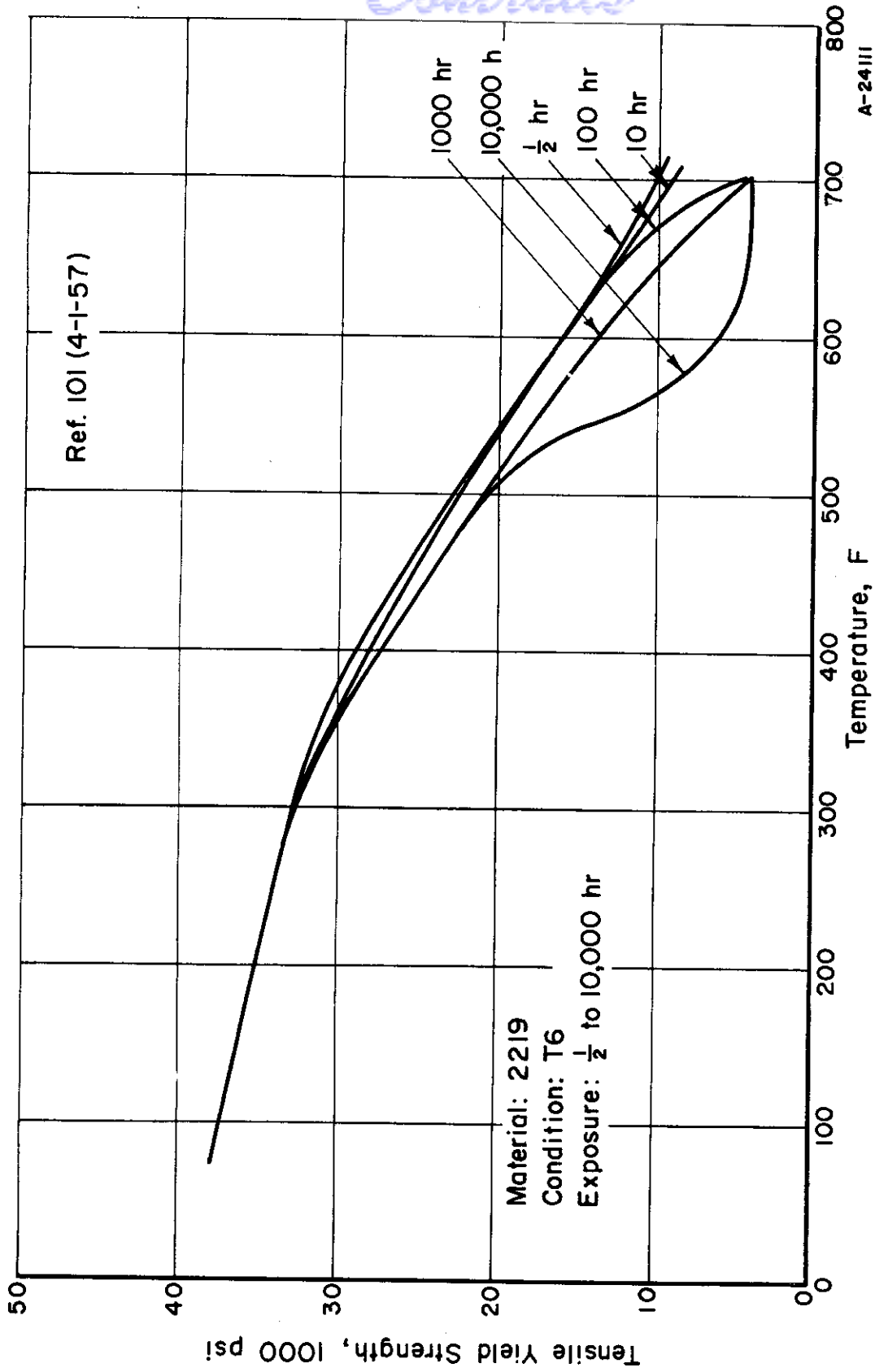


FIGURE 131. TENSILE YIELD STRENGTH DATA FOR X2219-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

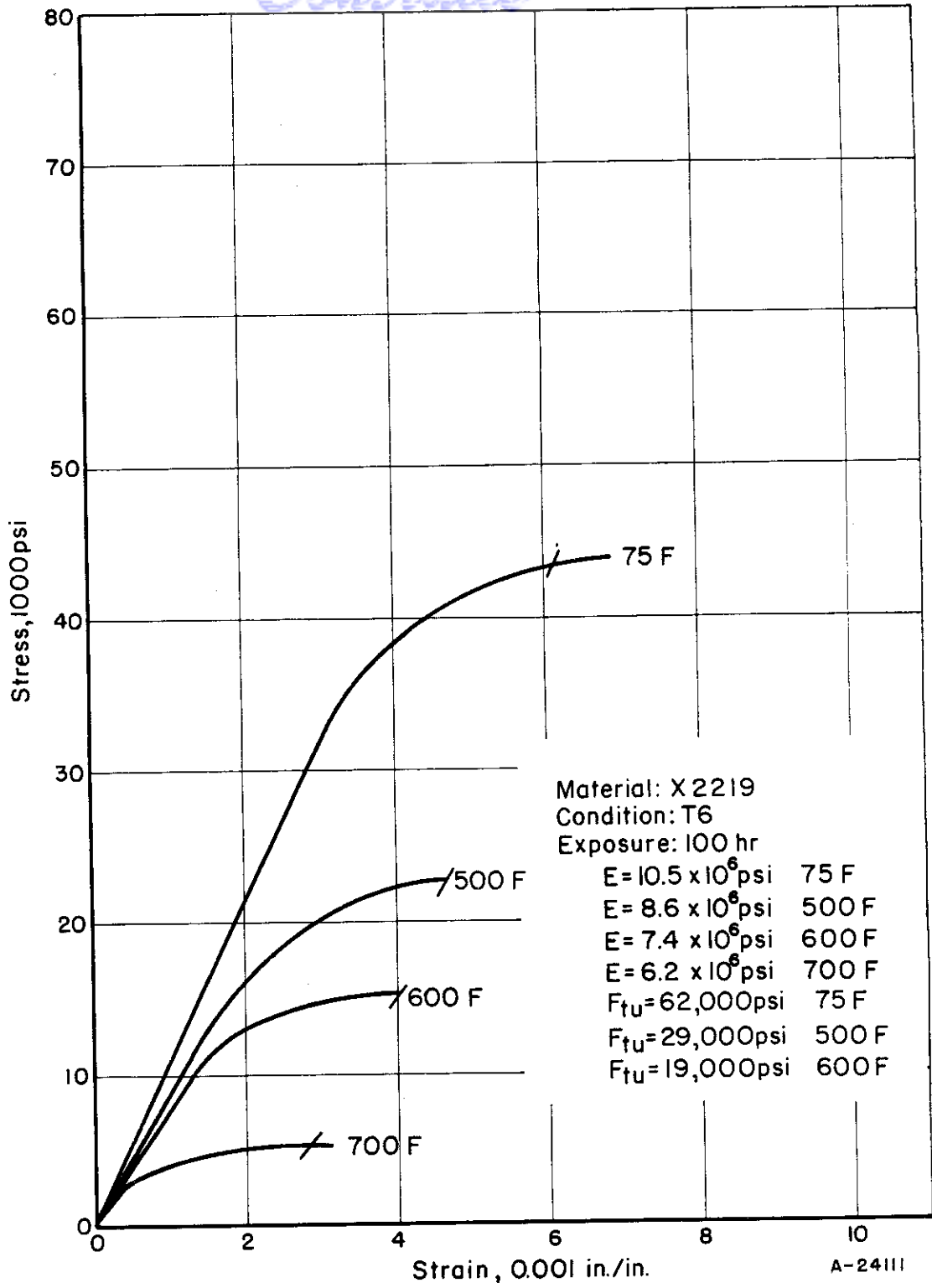


FIGURE 132. TENSILE STRESS-STRAIN CURVES FOR X2219-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE

Ref. 101.

Continental
7075 ALUMINUM ALLOY

Alloy Specifications

QQ-A-283
QQ-A-287
AMS 4045B
AMS 4049B

General

7075 is an age-hardening aluminum alloy. The principal hardening element is zinc, with magnesium, copper, and chromium contributing in a complex manner to the hardening phenomenon. It is furnished in sheet form, both bare and clad with 7072 alloy.

The chemical-composition limits of 7075 and its cladding material, 7072, are given in Table 9.

TABLE 9. CHEMICAL-COMPOSITION LIMITS OF 7075
ALUMINUM ALLOY AND ITS CLADDING
MATERIAL, 7072

Element	Weight Per Cent*	
	7075	7072
Zinc	5.1 - 6.1	0.8 - 1.3
Magnesium	2.1 - 2.9	0.10
Copper	1.2 - 2.0	0.10
Chromium	0.18 - 0.40	-
Manganese	0.30	0.10
Iron	0.7	-
Silicon	0.50	0.7**
Titanium	0.20	-
Others, each	0.05	0.05
Total	0.15	0.15
Aluminum	Balance	Balance

*Weight per cent is maximum, unless shown as a range.

**Silicon plus iron.

The following heat-treatment schedules are typical in developing the -T6 condition (solution heat treated and aged).

-W Condition (Solution Treatment)

The material is heated to 860 - 930 F for 10 minutes to 1 hour in a salt bath (longer in air) and quenched in cold water.

-T6 Condition (-W Condition Plus Artificial Aging)

After the material is in the -W condition, the material is heated to 245 - 255 F for 22 to 26 hours; or it may be heated to 205 - 215 F for 4 to 6 hours and then reheated to 310 - 320 F for 8 to 10 hours. The cooling rate from these temperatures is not critical.

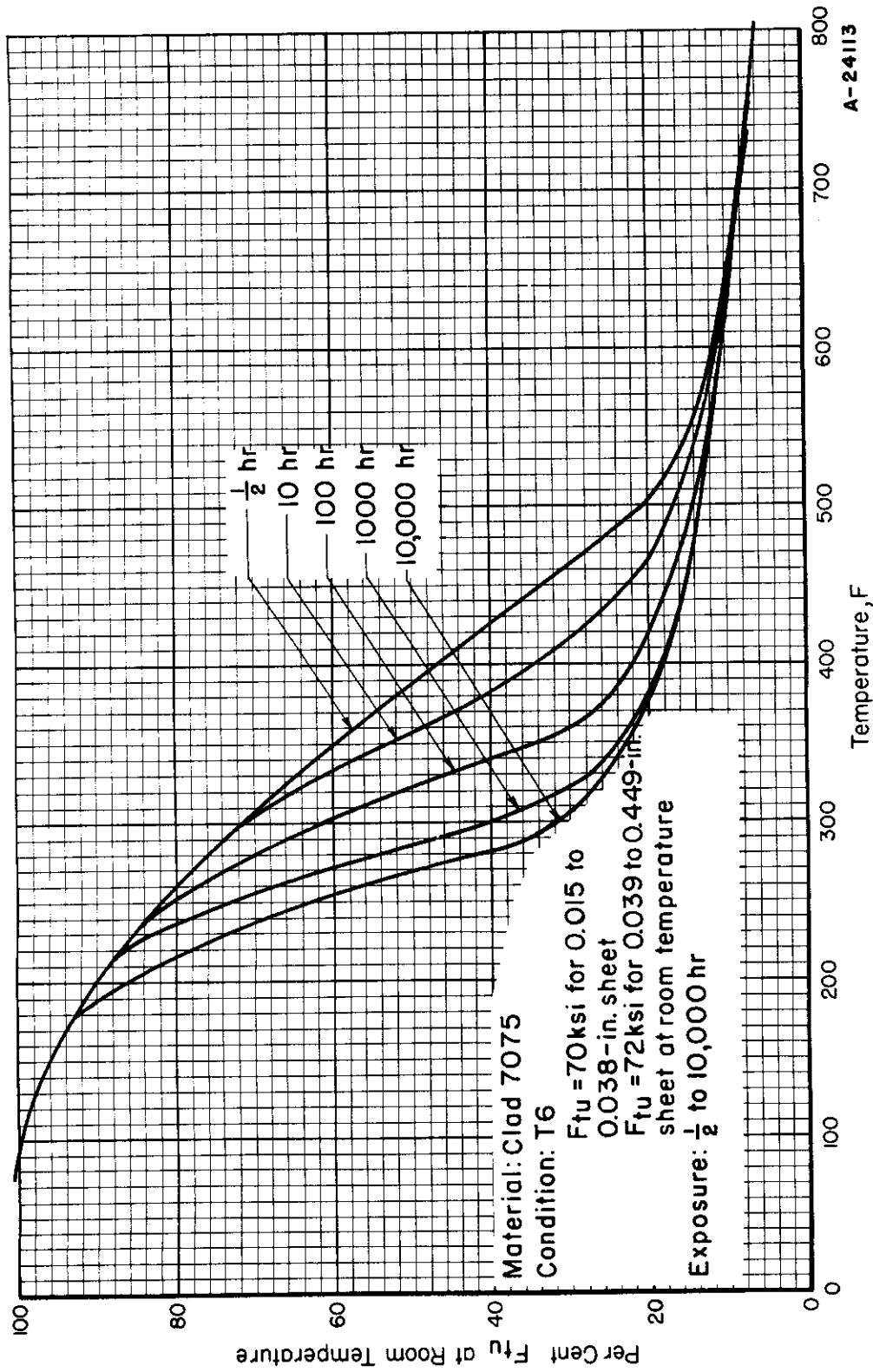
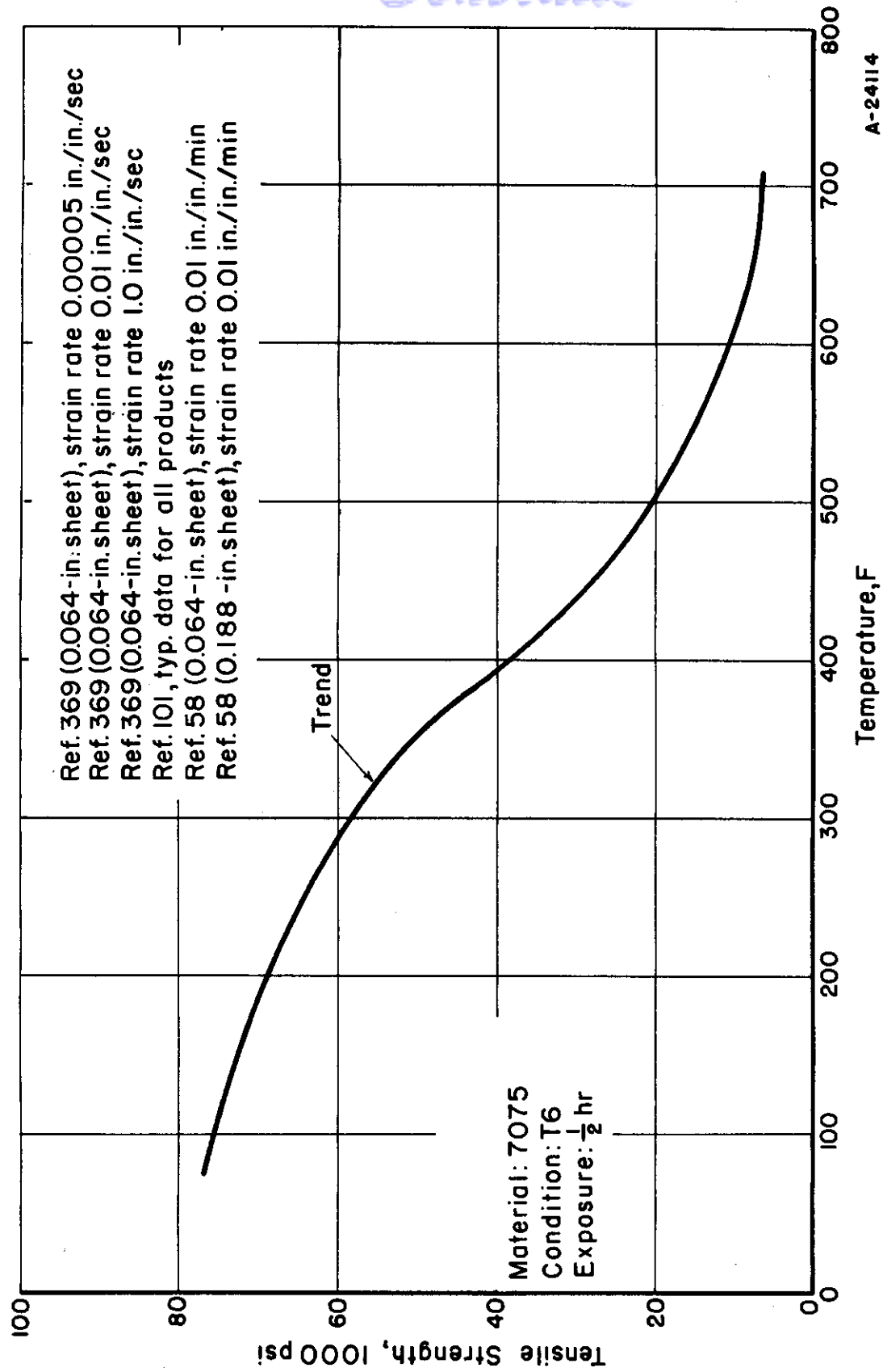


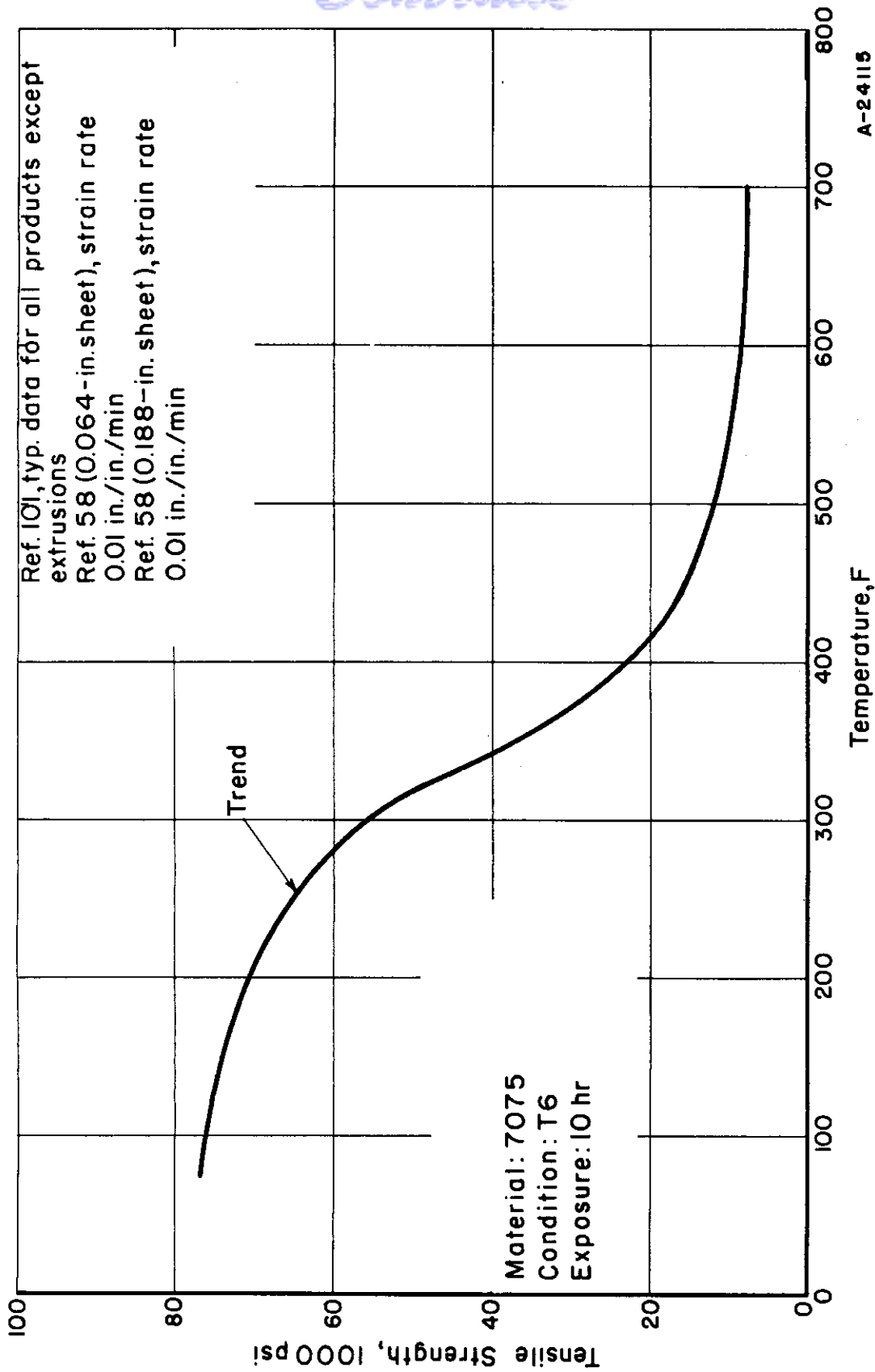
FIGURE 133. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF CLAD 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101 (basic data).
 Ref. 369, 58 (supplementary data).



A-24114

FIGURE 134. TENSILE STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



A-24115

FIGURE 135. TENSILE STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

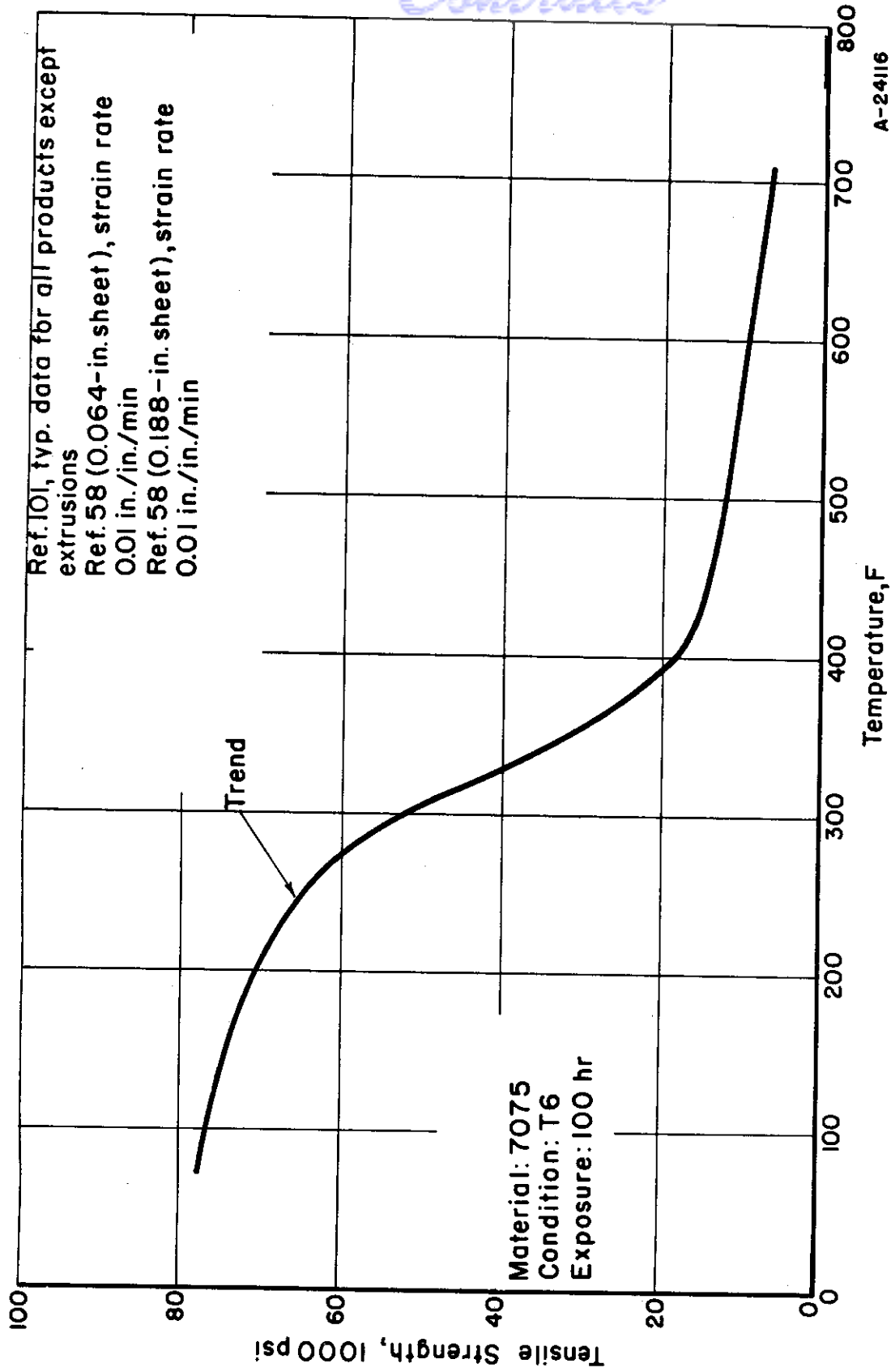
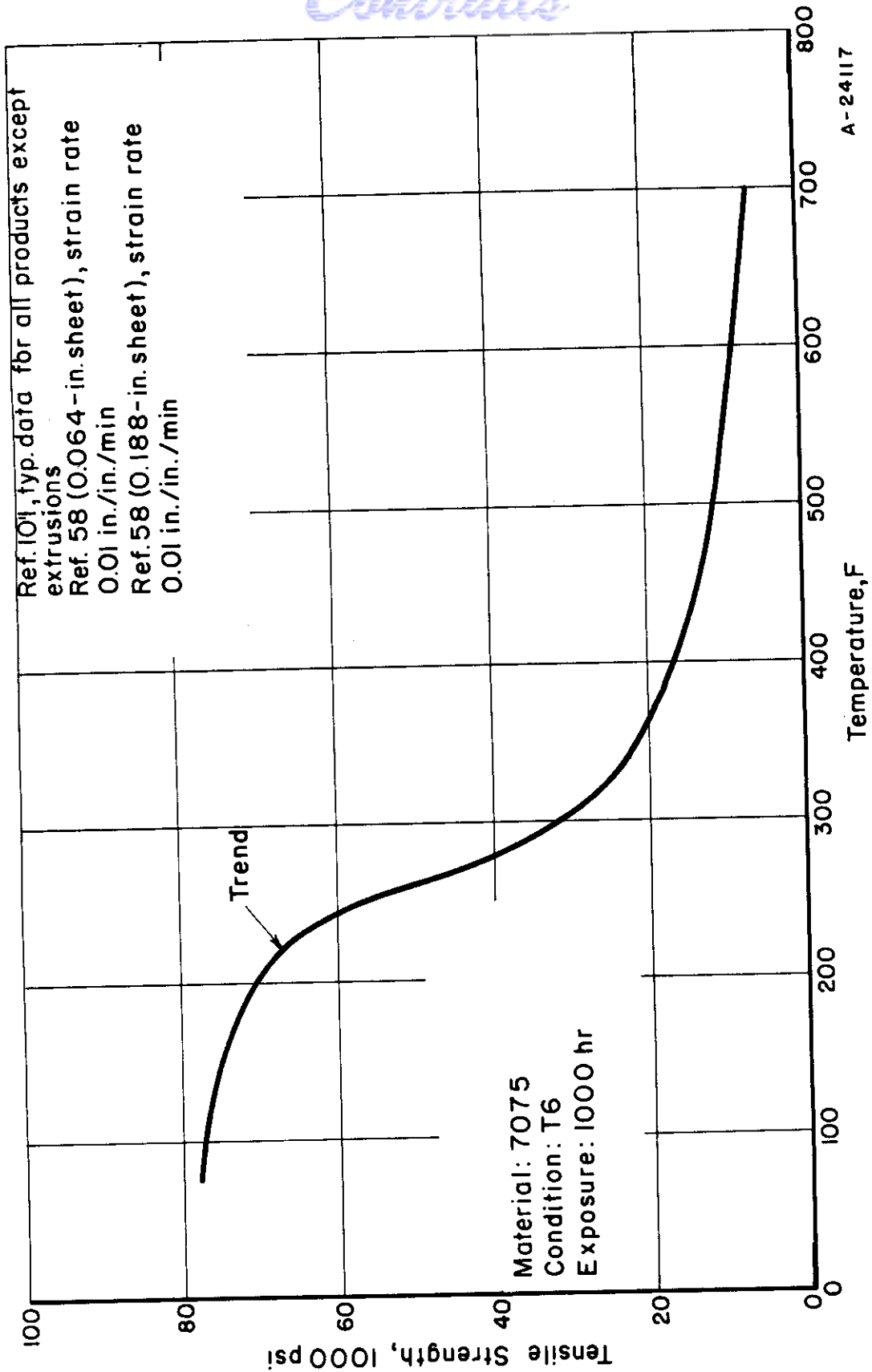


FIGURE 136. TENSILE STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)



A-24117

FIGURE 137. TENSILE STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

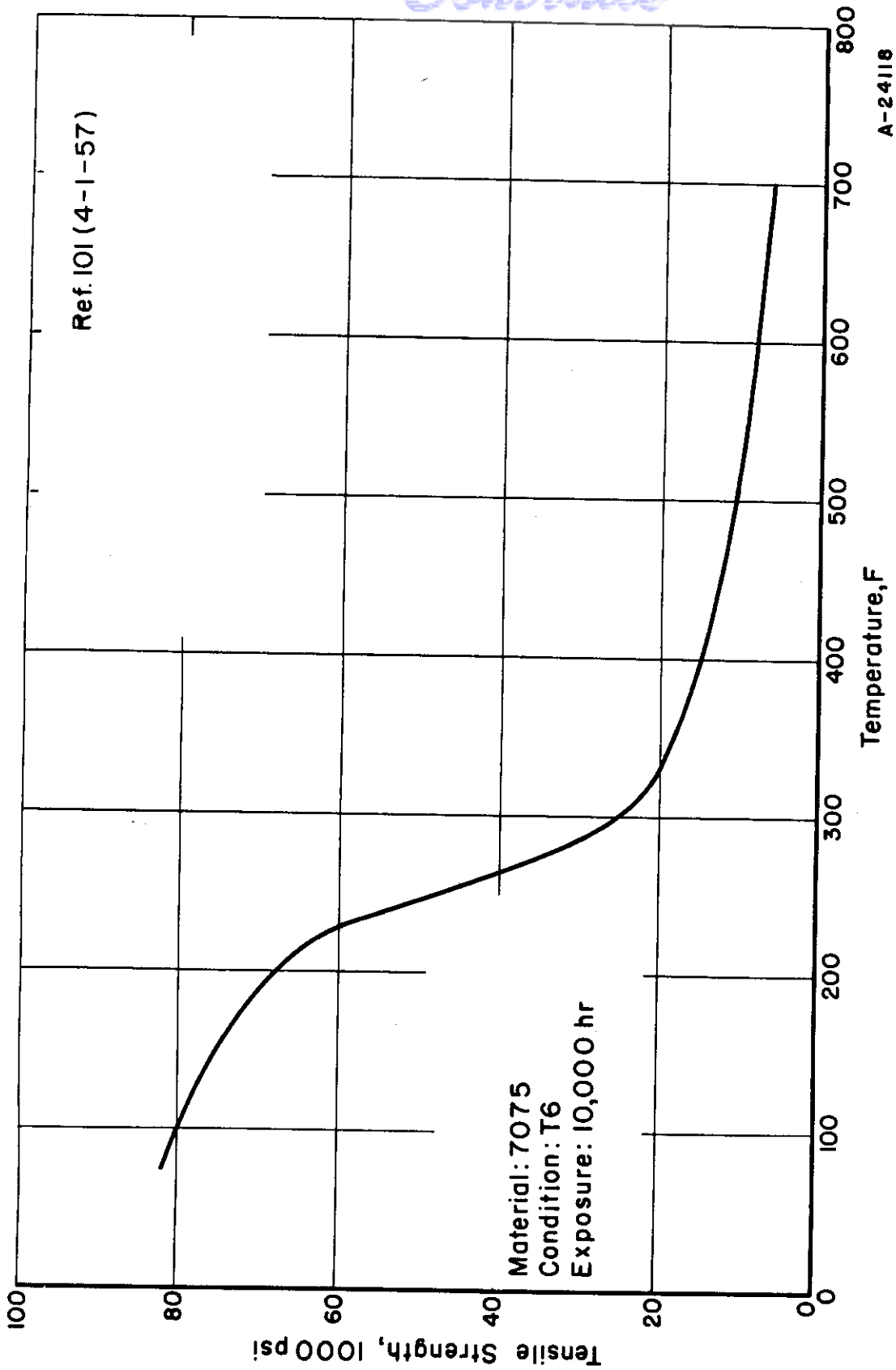
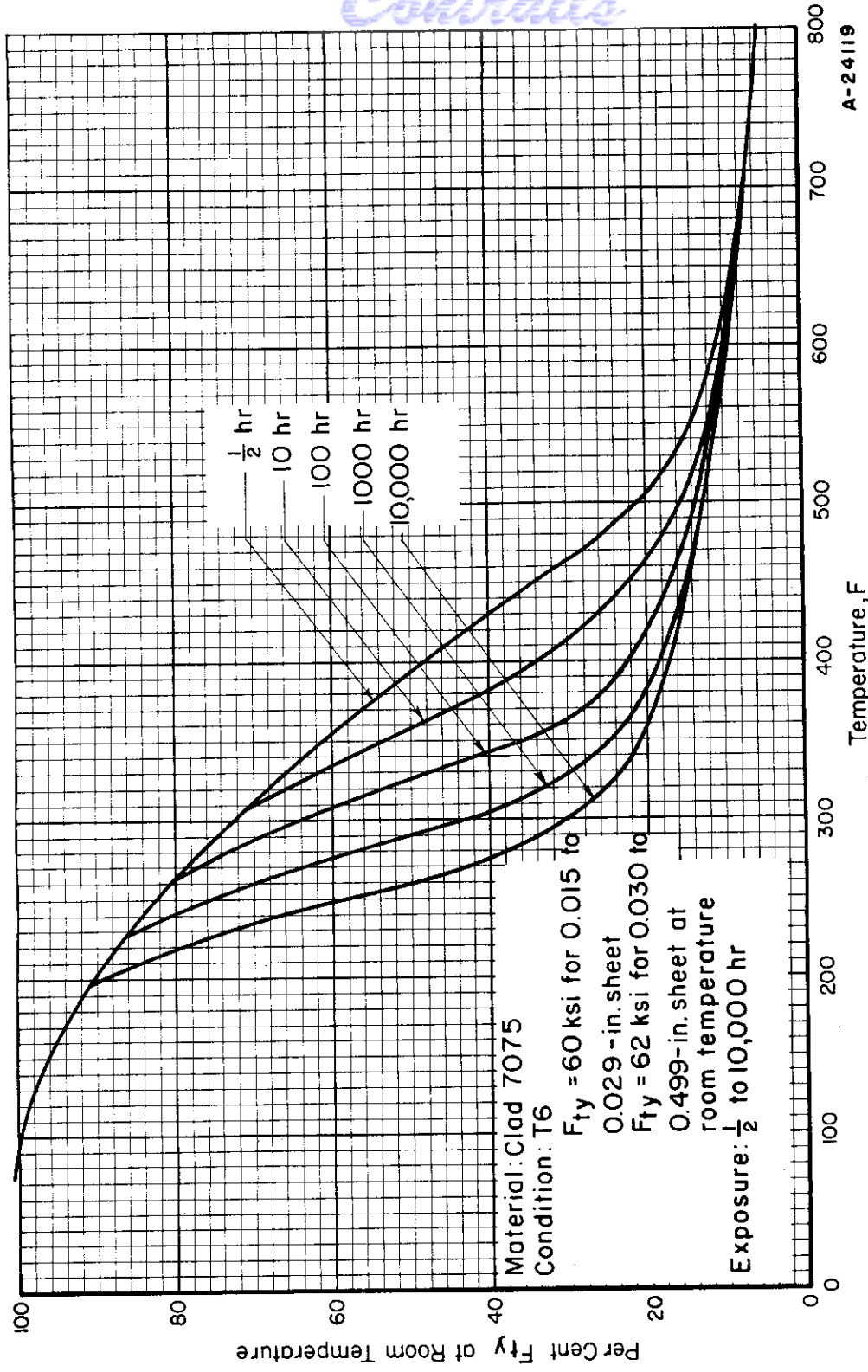


FIGURE 138. TENSILE STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)



A-24119

FIGURE 139. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF CLAD 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 10,000-HOUR EXPOSURE)

Ref. 101 (basic data).
Ref. 57, 58, 369 (supplementary data).

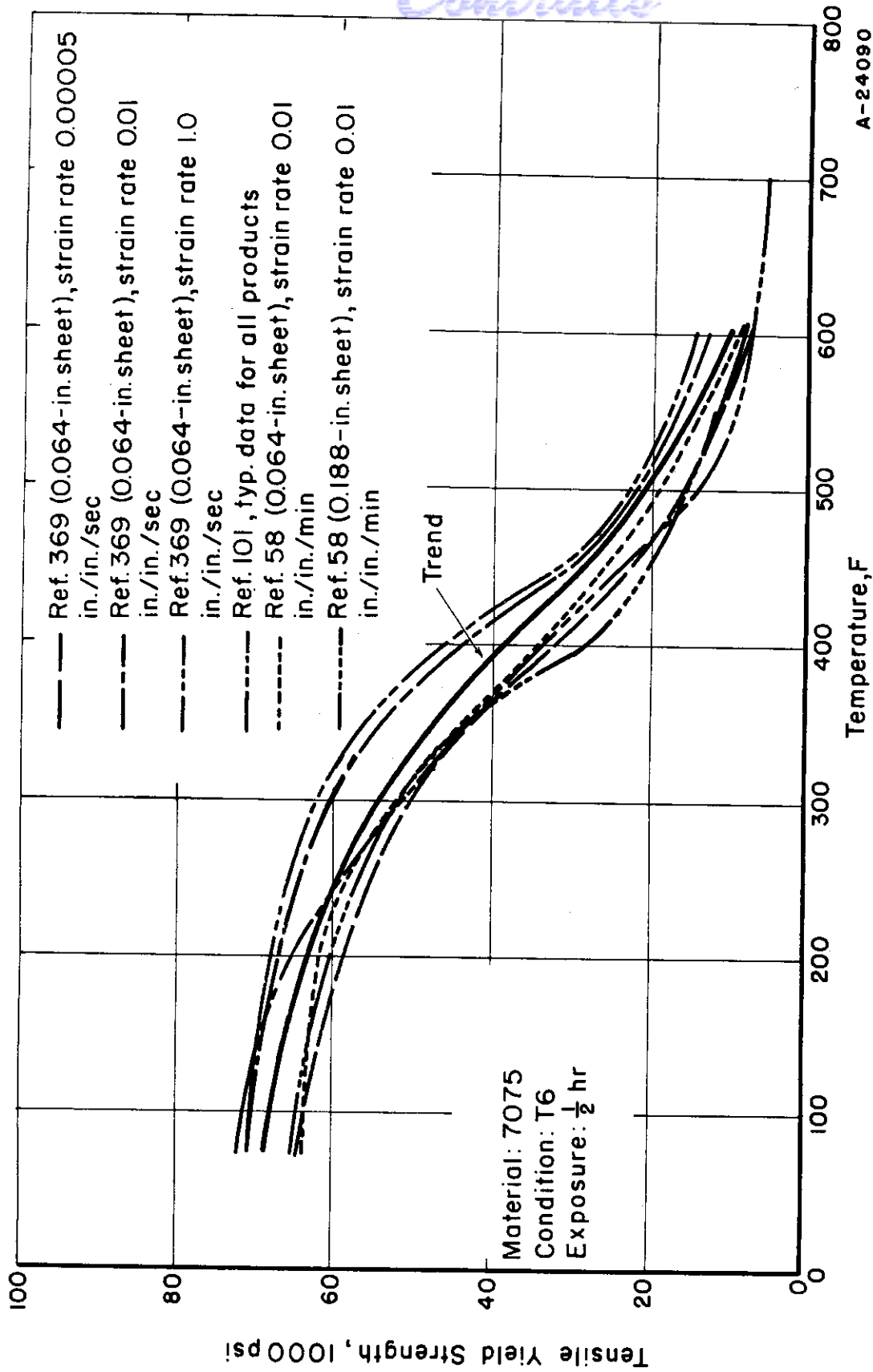
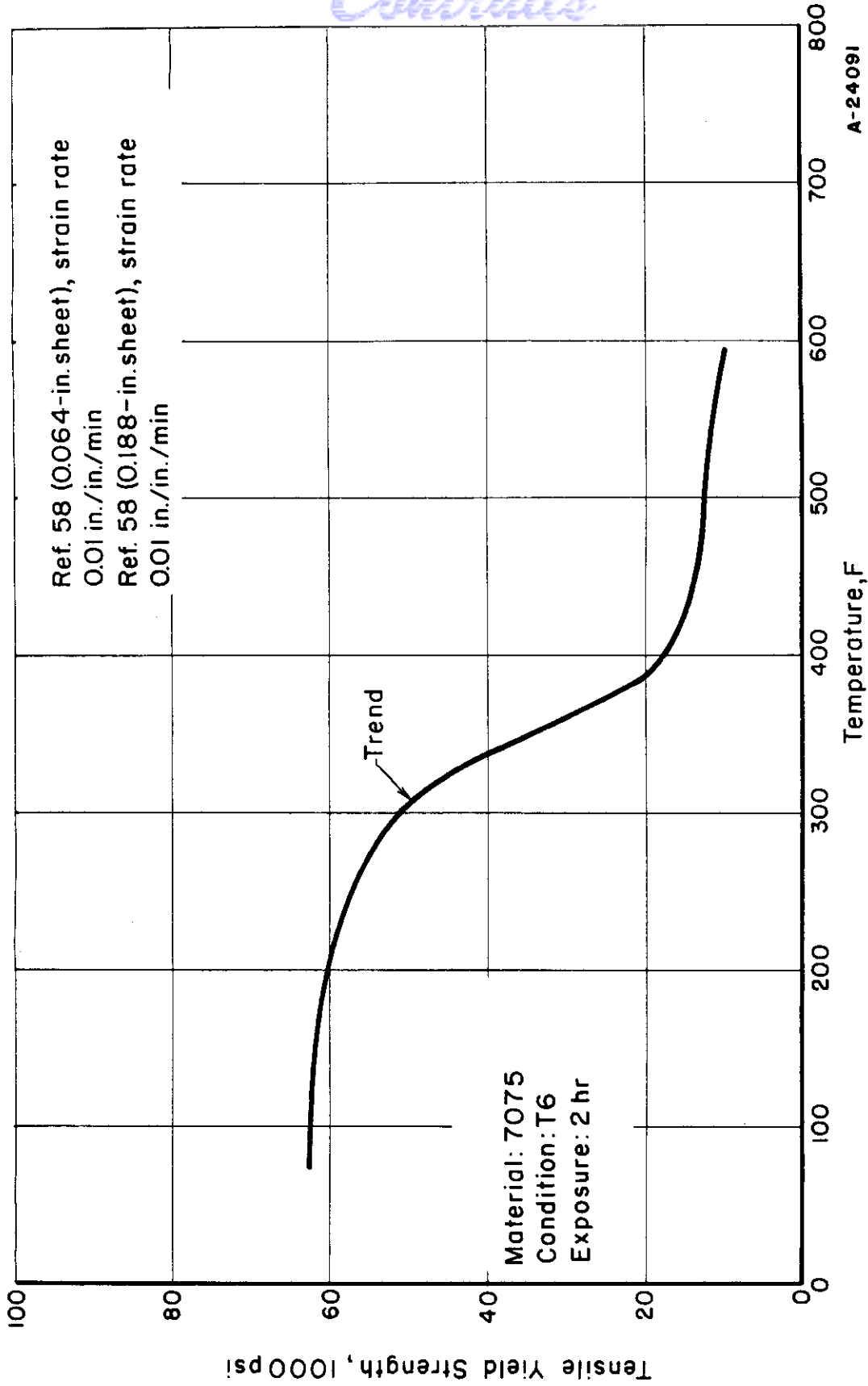
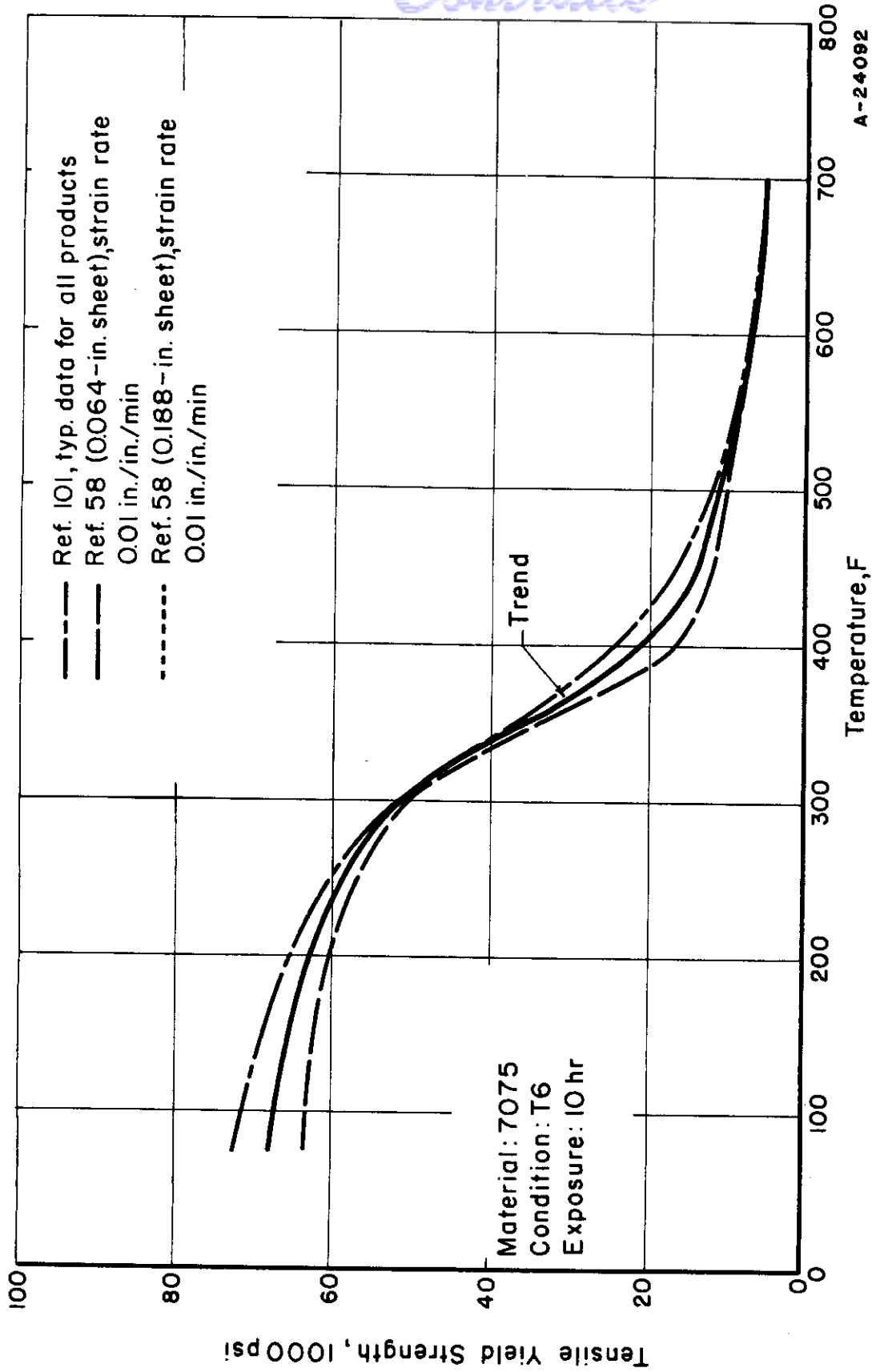


FIGURE 140. TENSILE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



A-24091

FIGURE 141. TENSILE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (2-HOUR EXPOSURE)



A-24092

FIGURE 142. TENSILE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10-HOUR EXPOSURE)

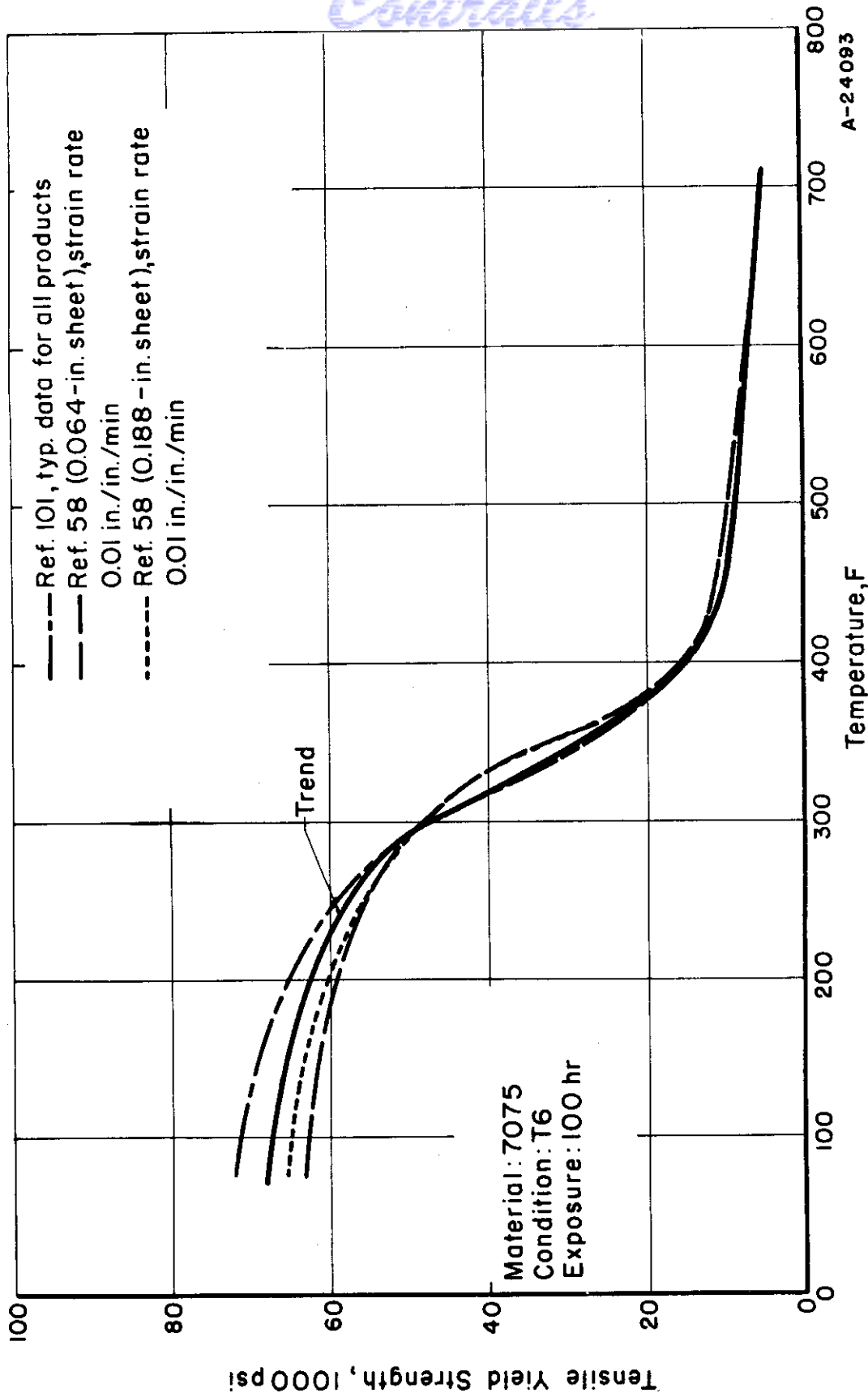
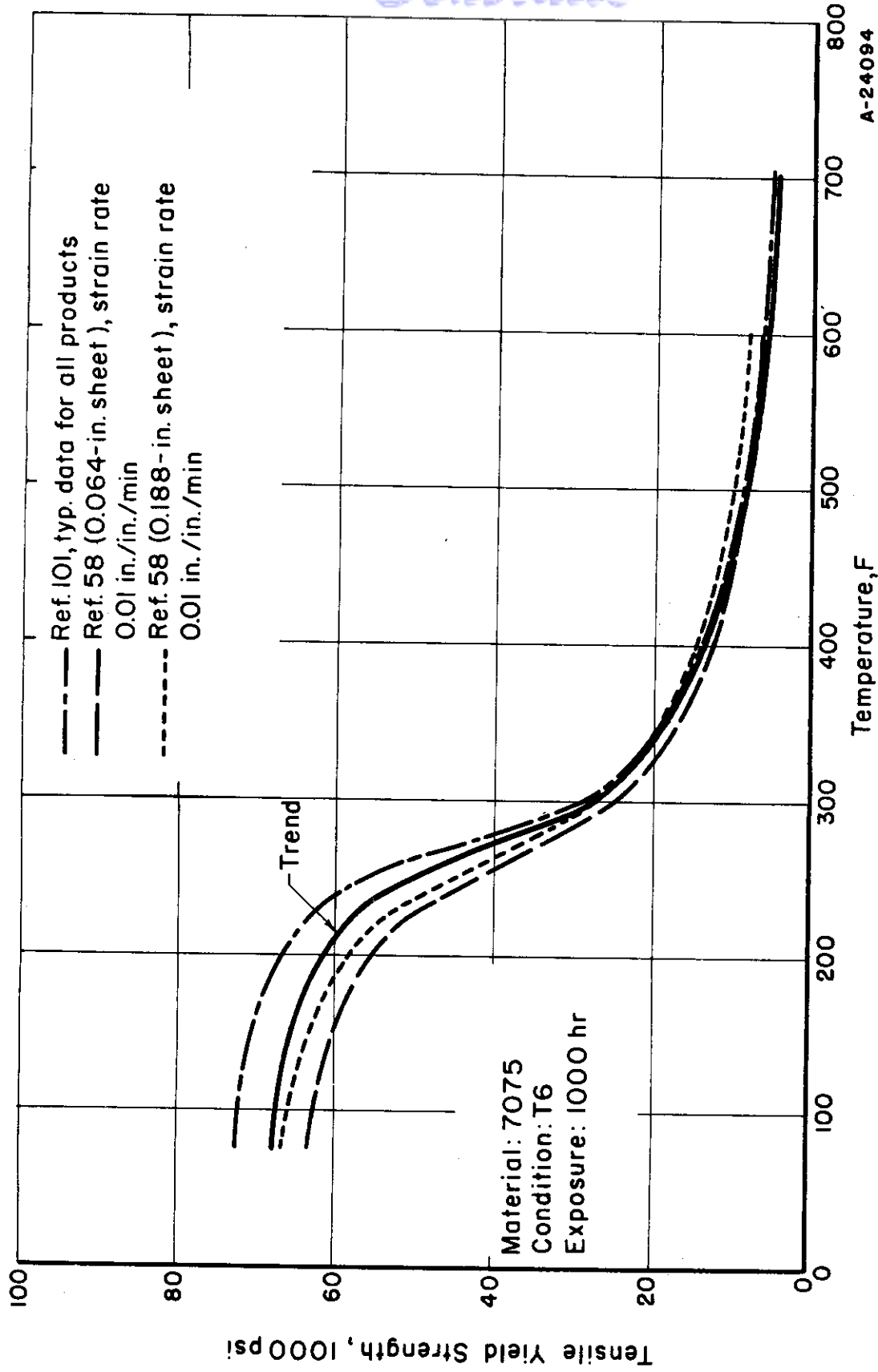


FIGURE 143. TENSILE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (100-HOUR EXPOSURE)



A-24094

FIGURE 144. TENSILE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1000-HOUR EXPOSURE)

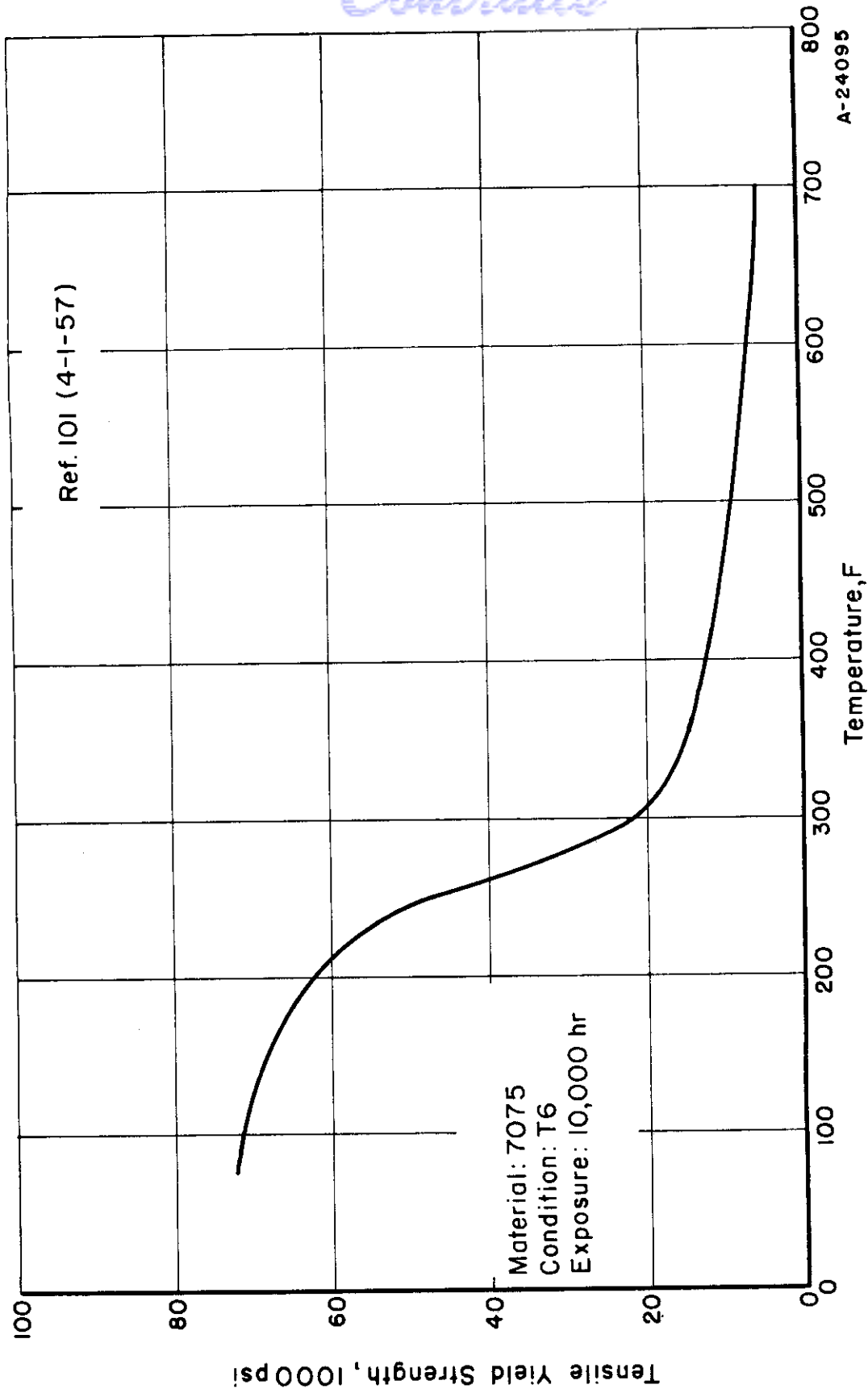


FIGURE 145. TENSILE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (10,000-HOUR EXPOSURE)

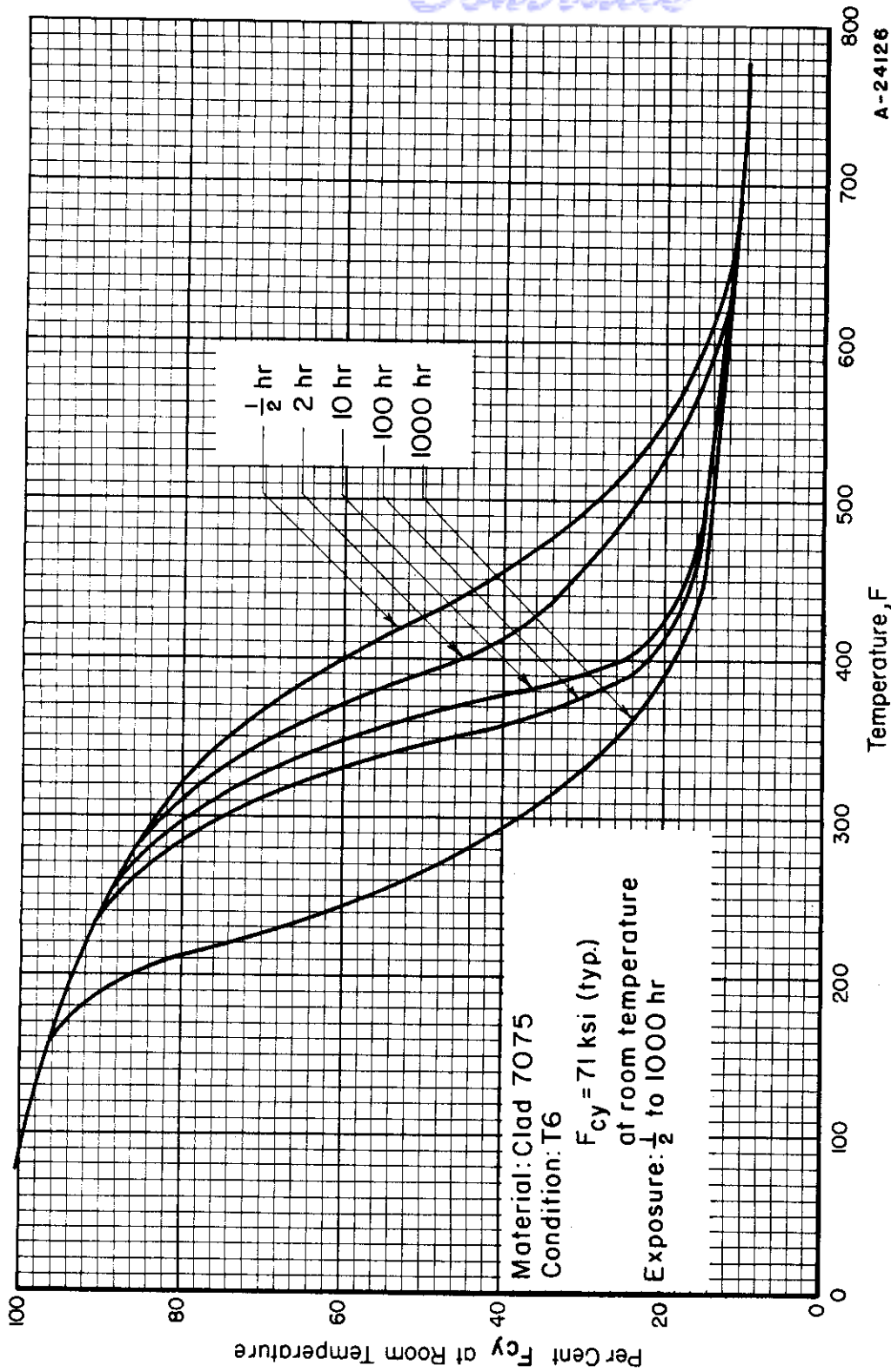


FIGURE 146. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF CLAD 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 57, 58.

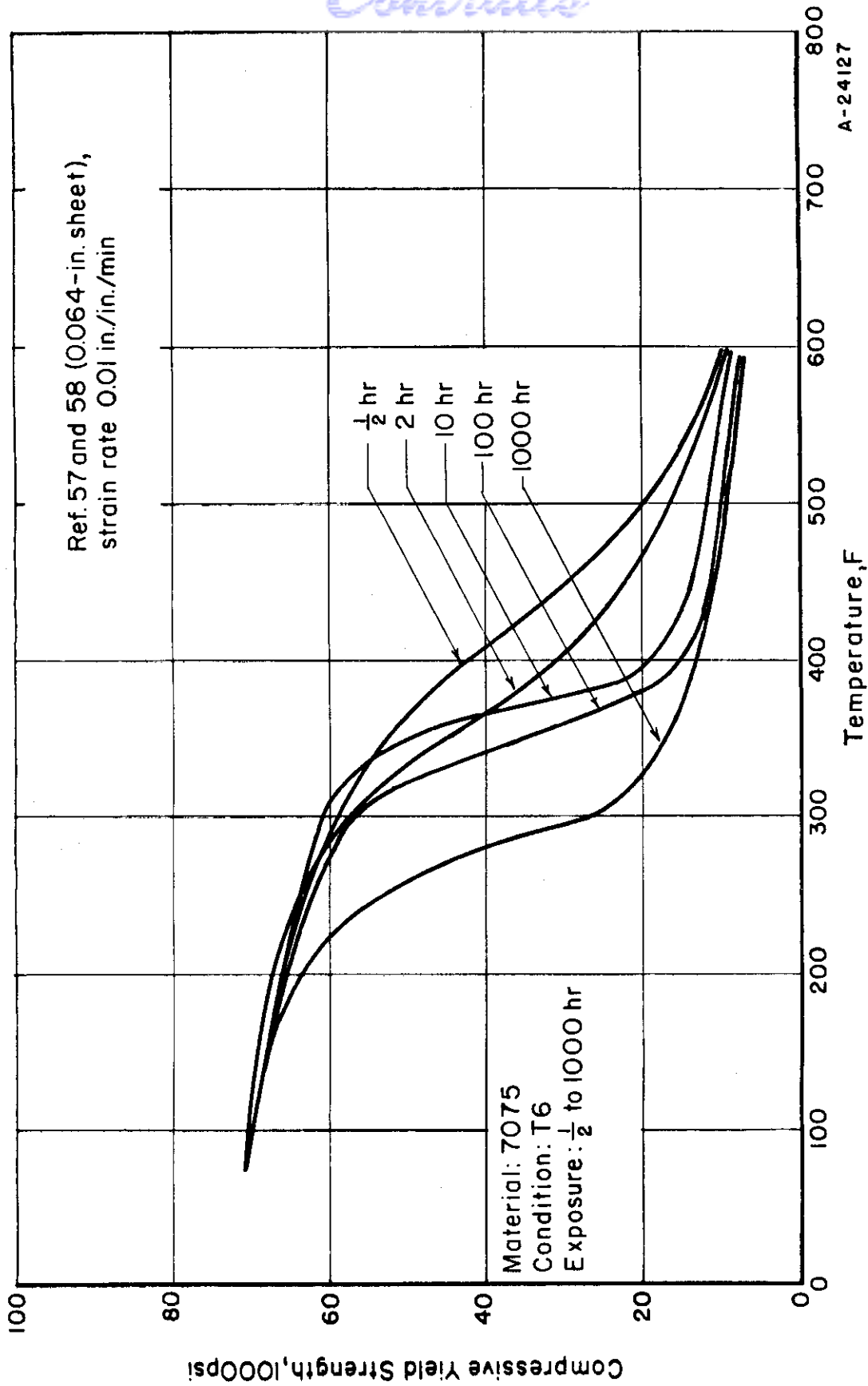


FIGURE 147. COMPRESSIVE YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

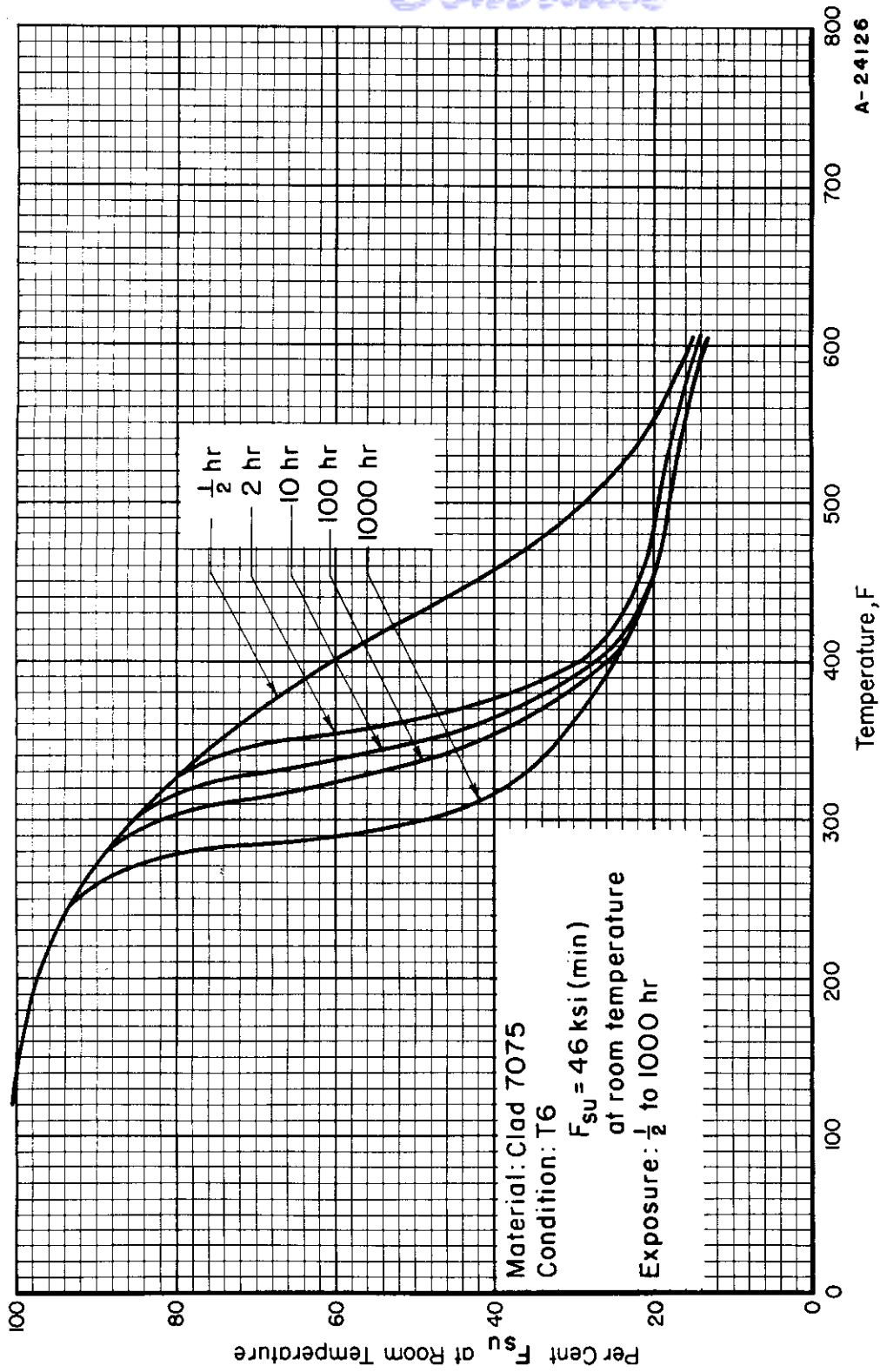


FIGURE 148. DESIGN CURVES FOR SHEAR STRENGTH (F_{su}) OF CLAD 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

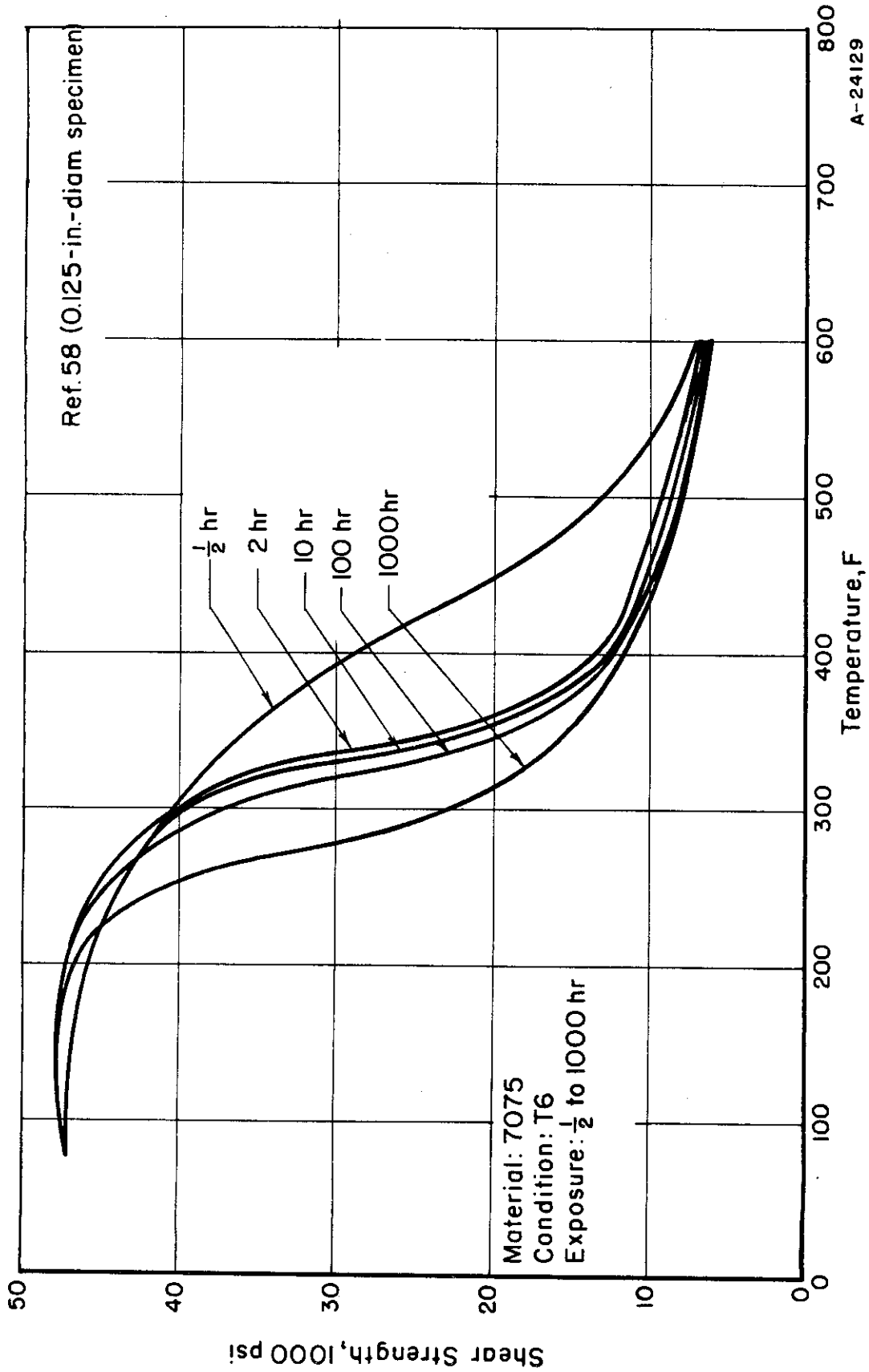


FIGURE 149. SHEAR STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

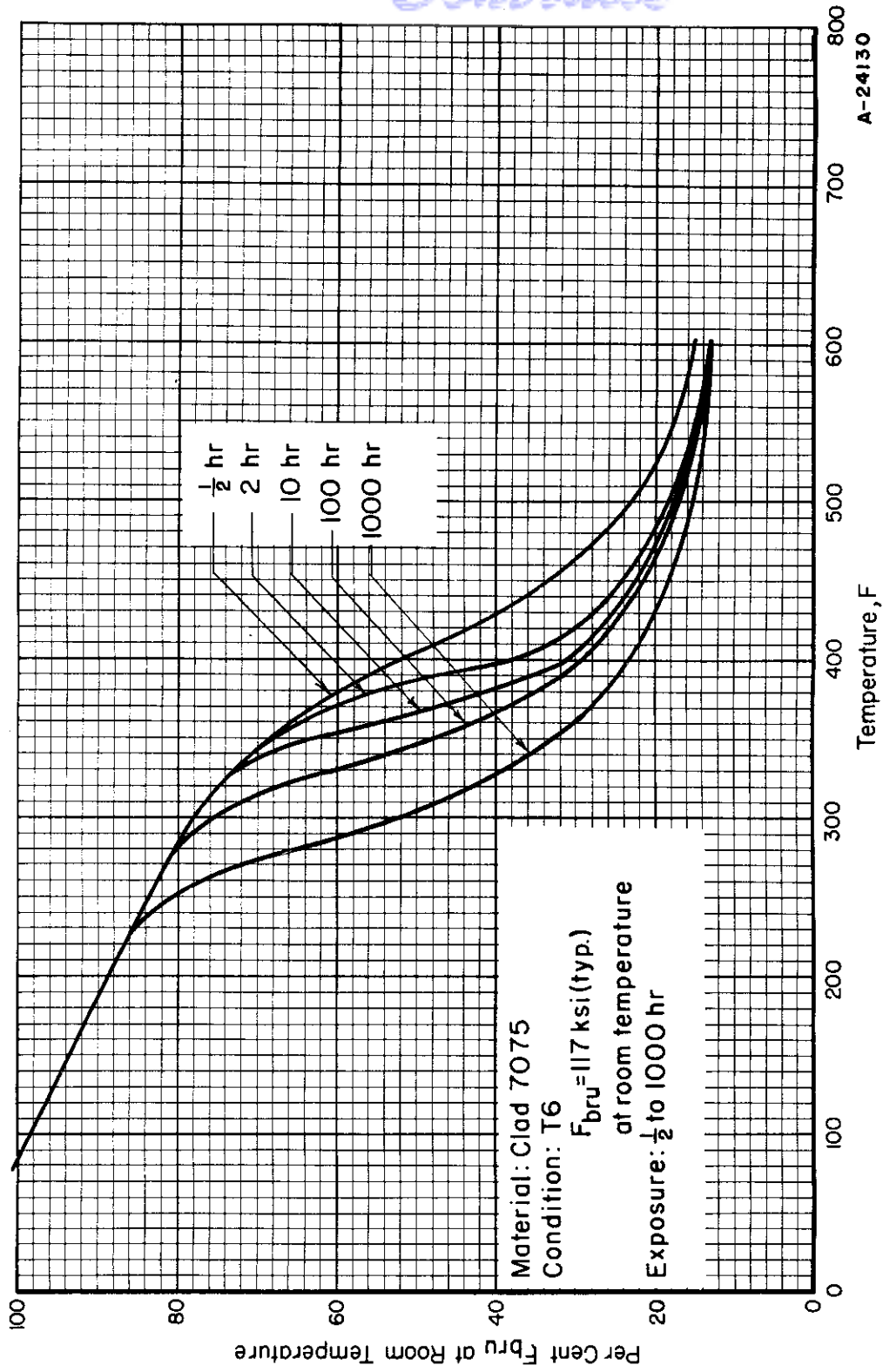


FIGURE 150. DESIGN CURVES FOR BEARING STRENGTH (F_{bru}) OF CLAD 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58, 57.

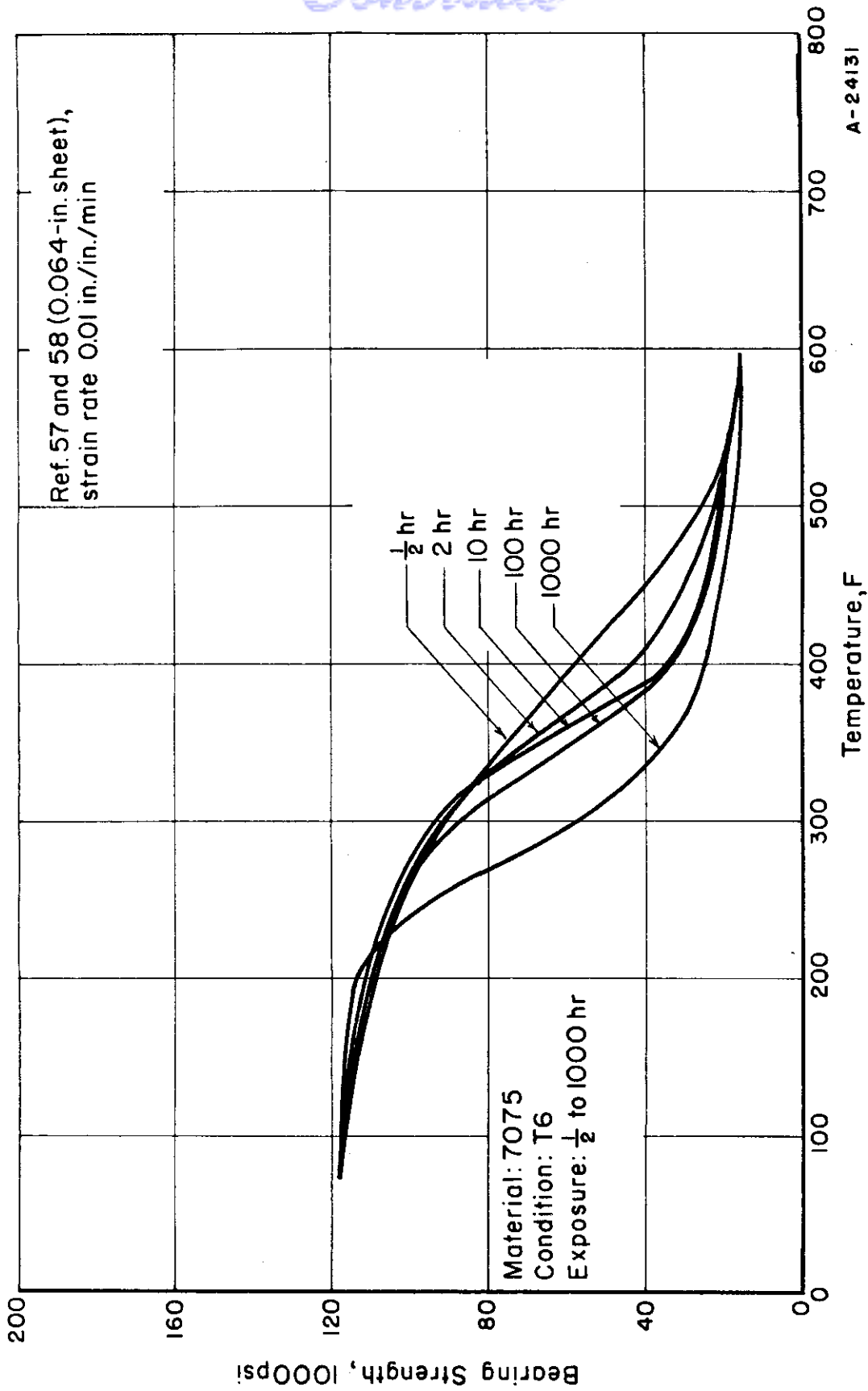


FIGURE 151. BEARING STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

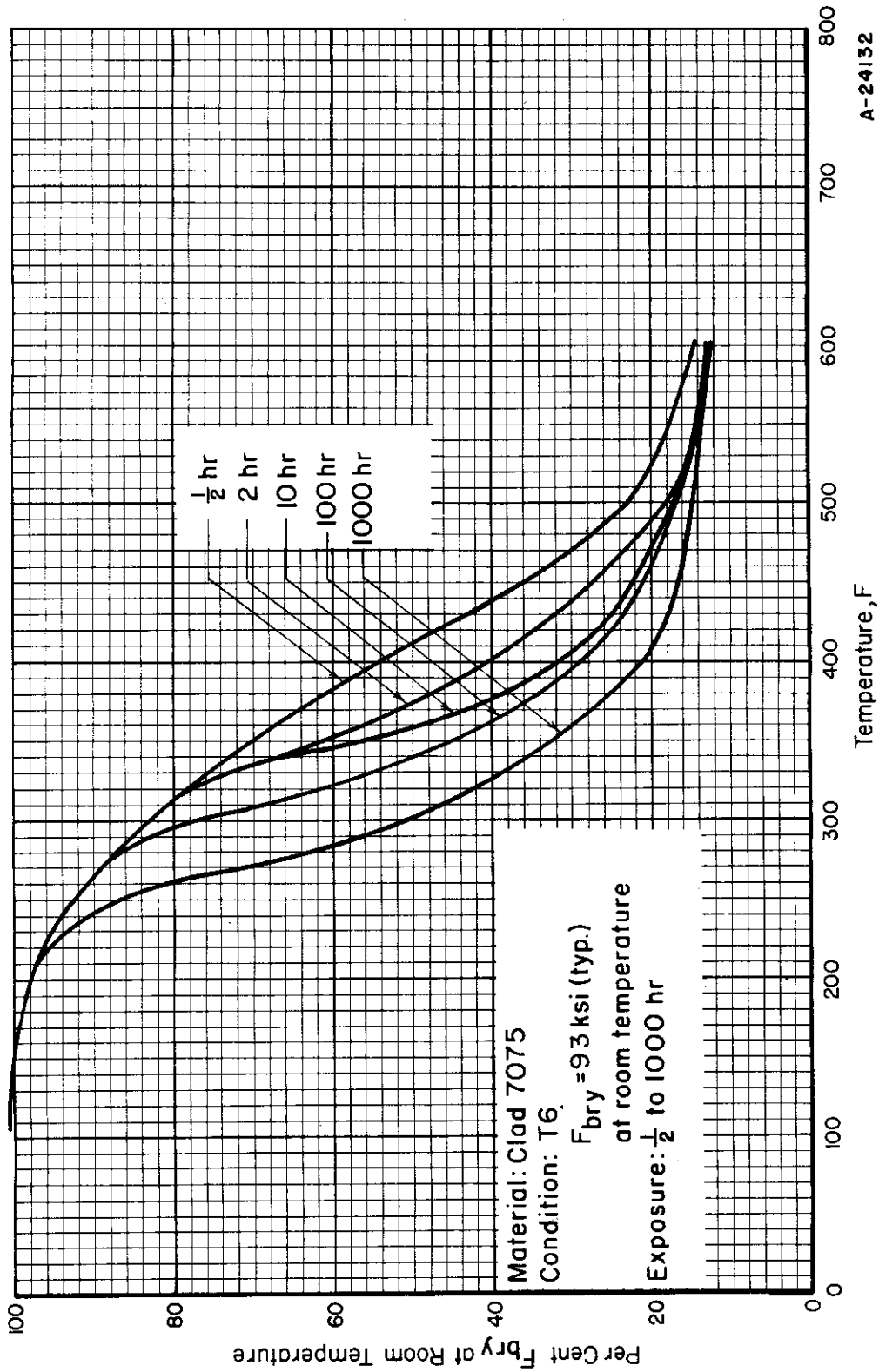


FIGURE 152. DESIGN CURVES FOR BEARING YIELD STRENGTH (F_{bry}) OF CLAD 7075-T6 ALUMI-
 NUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 57, 58.

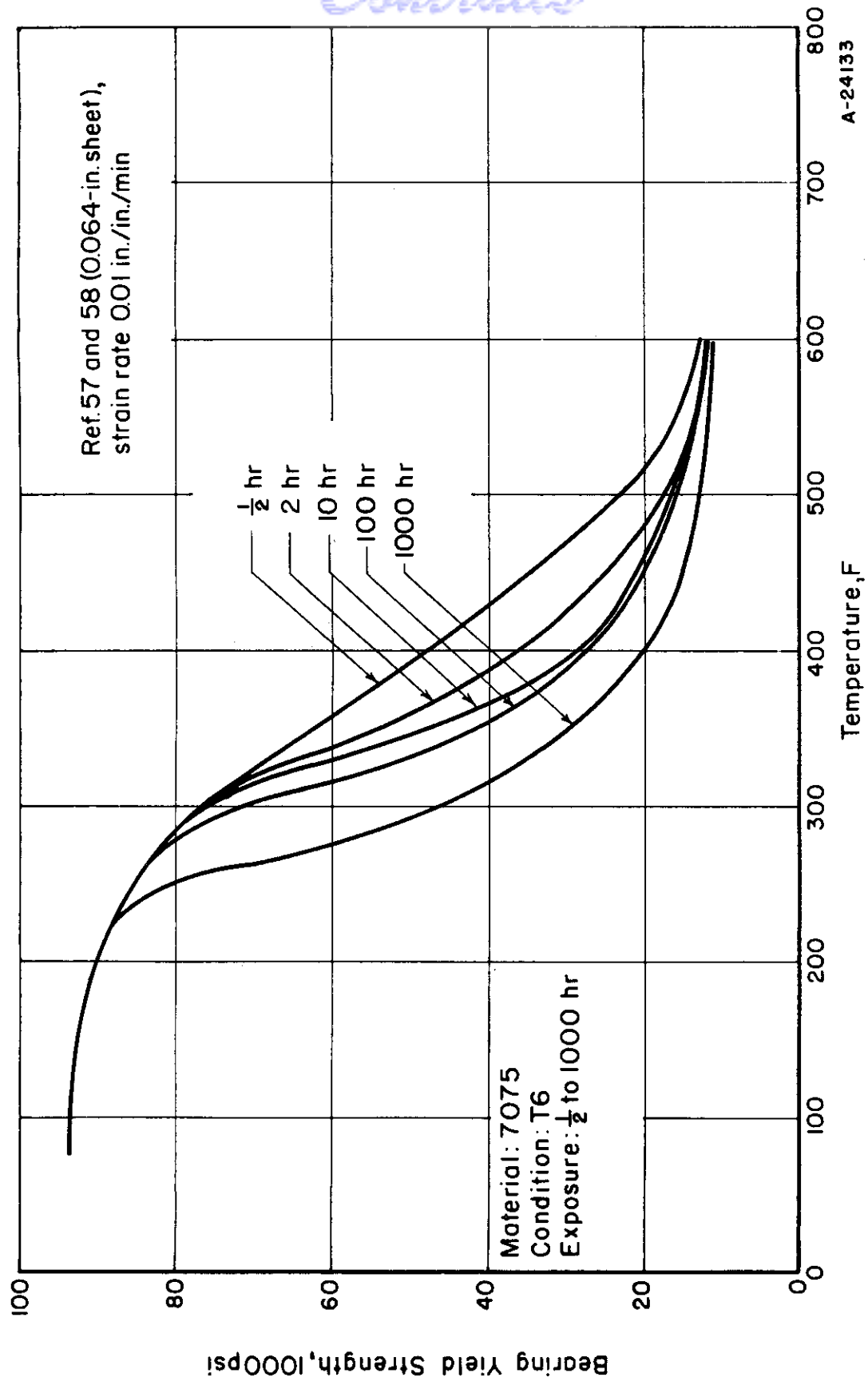


FIGURE 153. BEARING YIELD STRENGTH DATA FOR 7075-T6 ALUMINUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

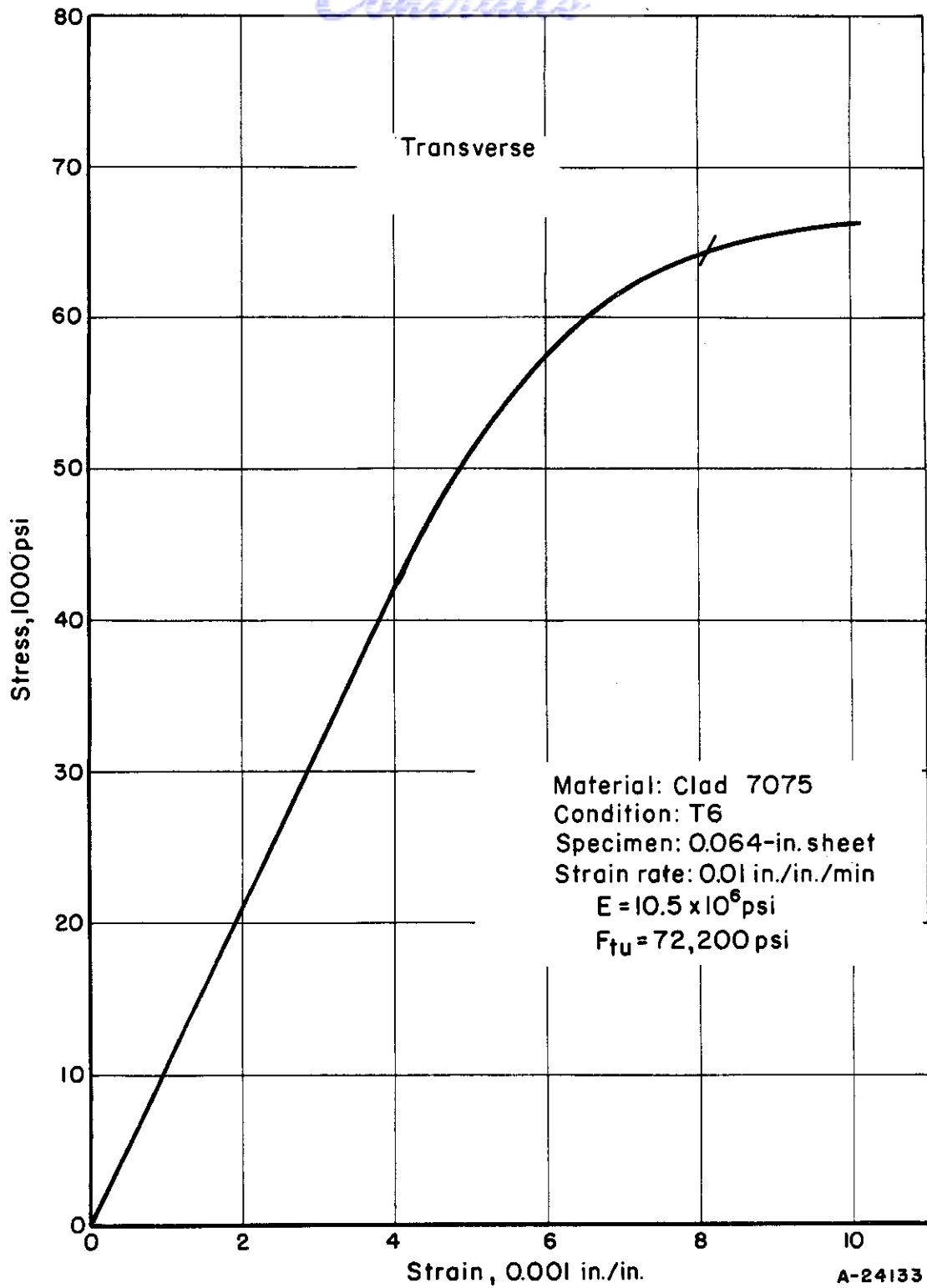


FIGURE 154. TENSILE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 71.

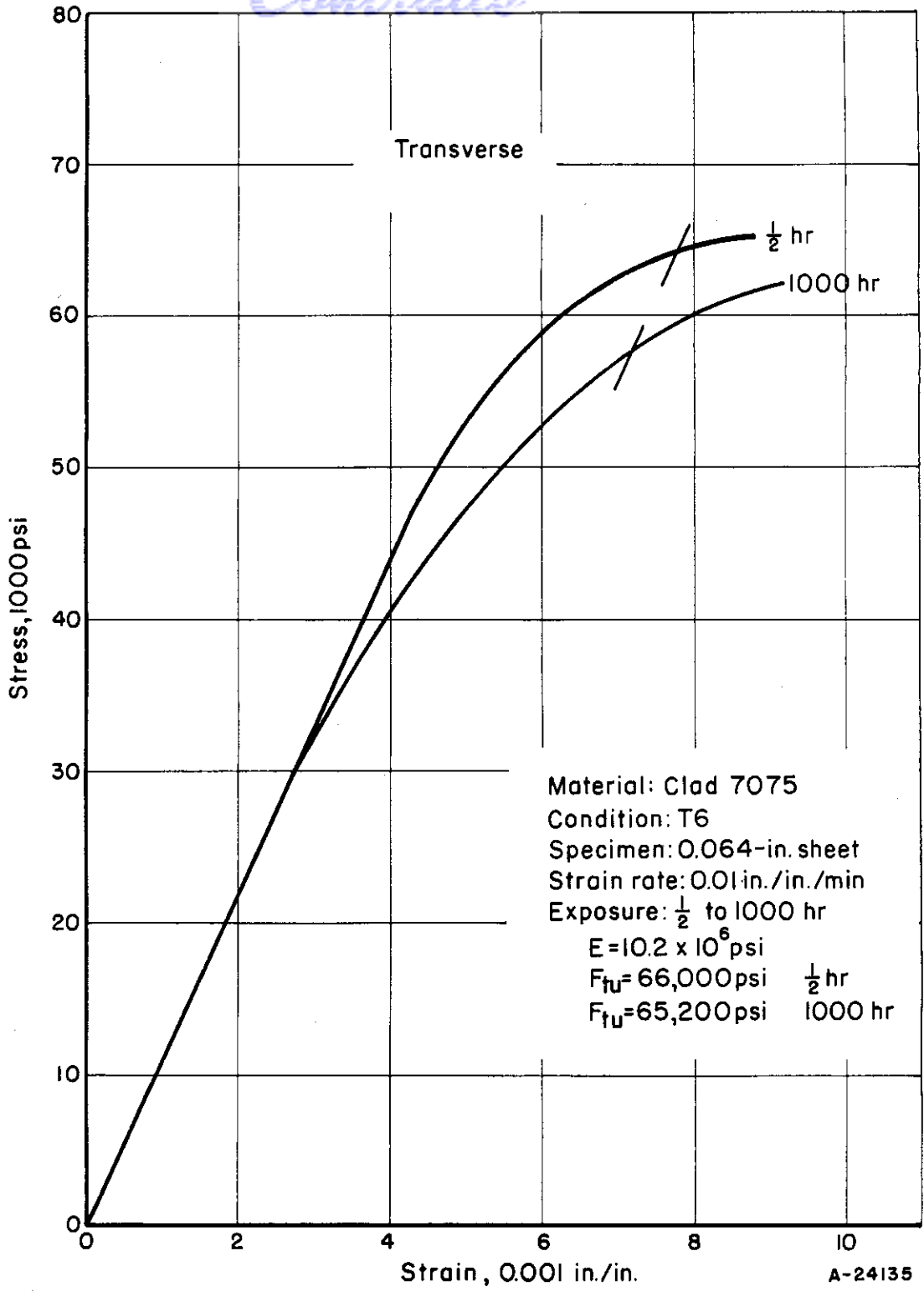


FIGURE 155. TENSILE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 200 F

Ref. 58.

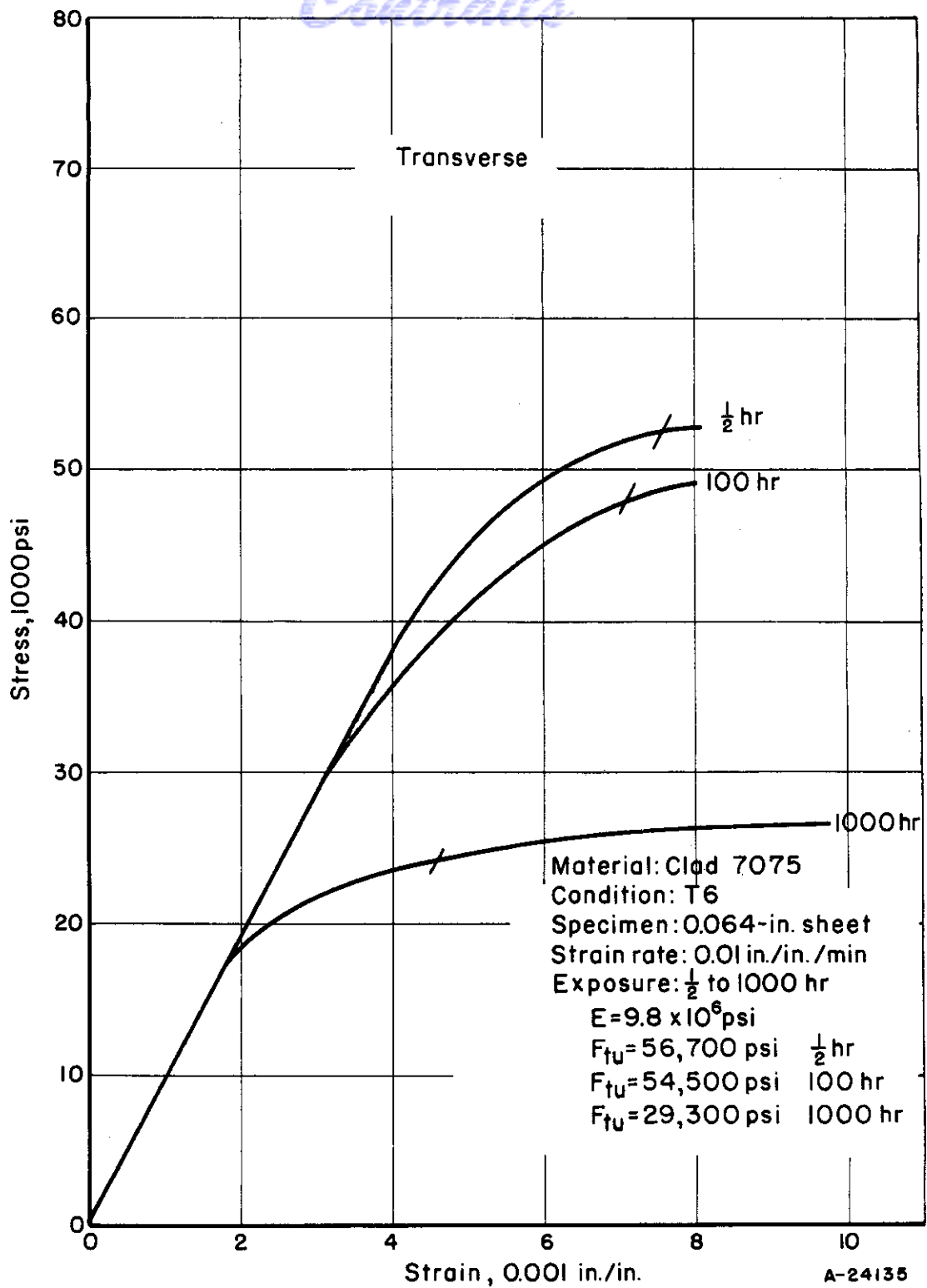


FIGURE 156. TENSILE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 300 F

Ref. 71.

Contrails

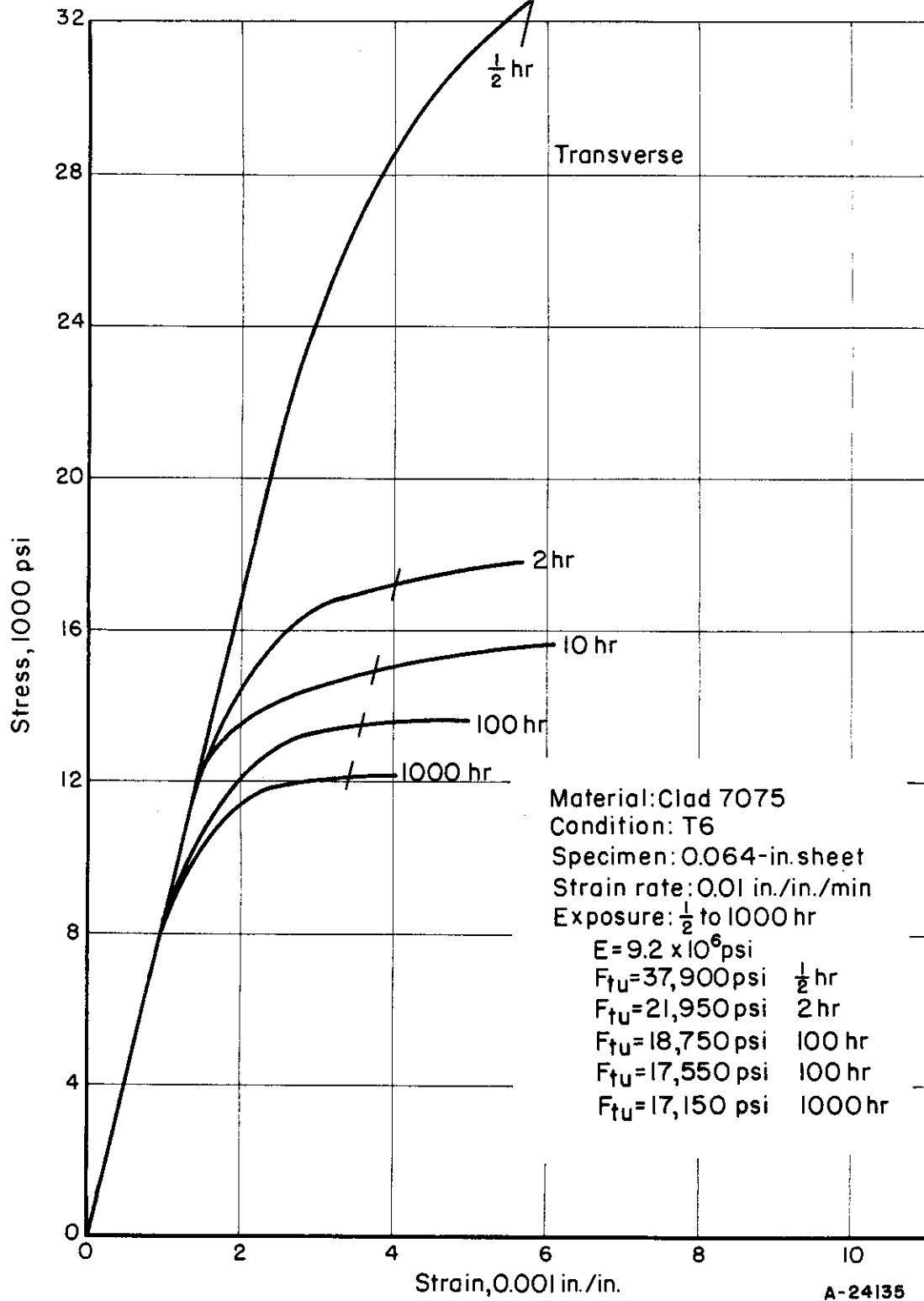


FIGURE 157. TENSILE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 400 F

Ref. 71, p 24.

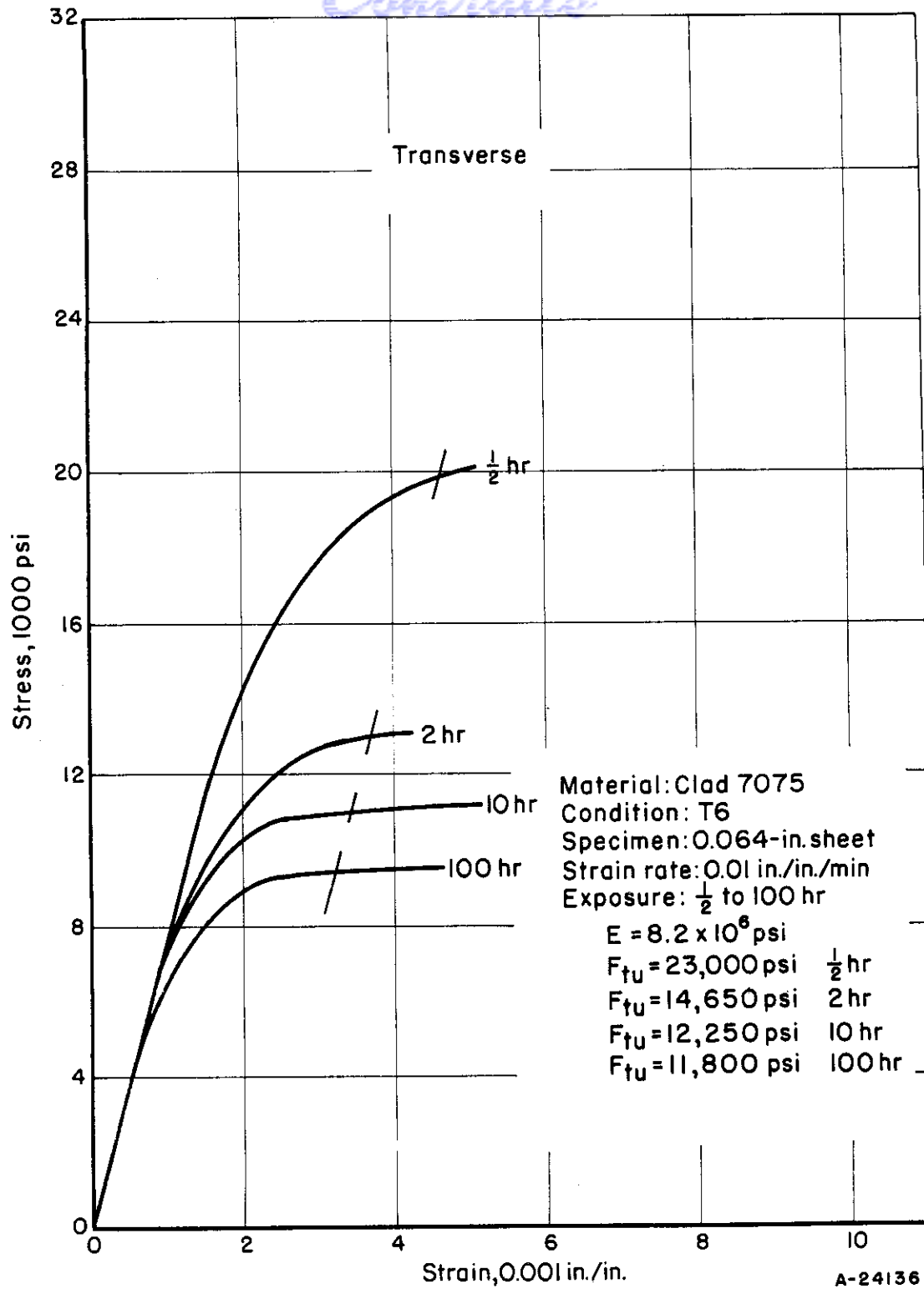


FIGURE 158. TENSILE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 500 F

Ref. 71.

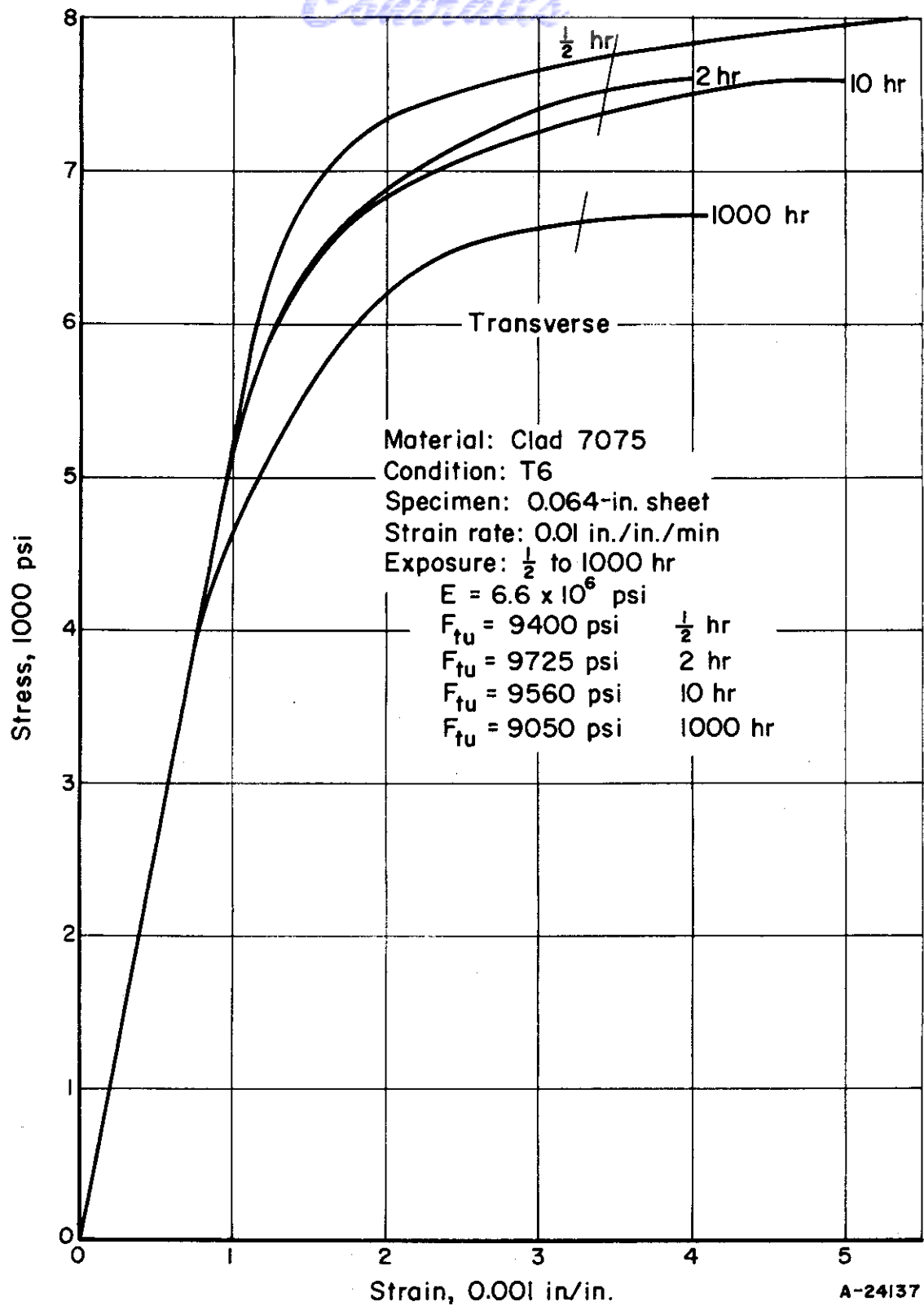


FIGURE 159. TENSILE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 600 F

Ref. 71.

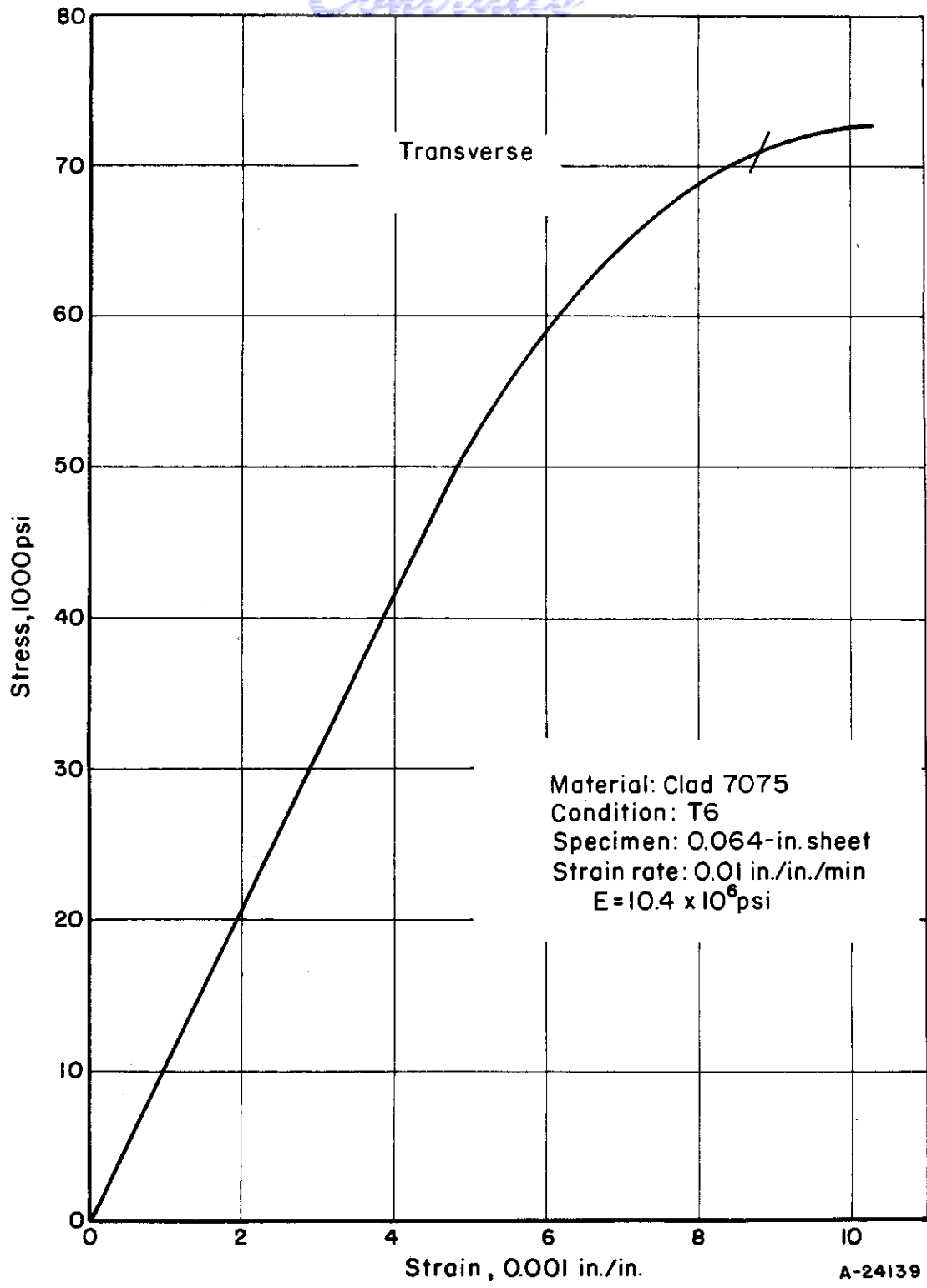


FIGURE 160. COMPRESSIVE STRESS-STRAIN CURVE FOR CLAD 7075-T6 ALUMINUM ALLOY AT ROOM TEMPERATURE

Ref. 71.

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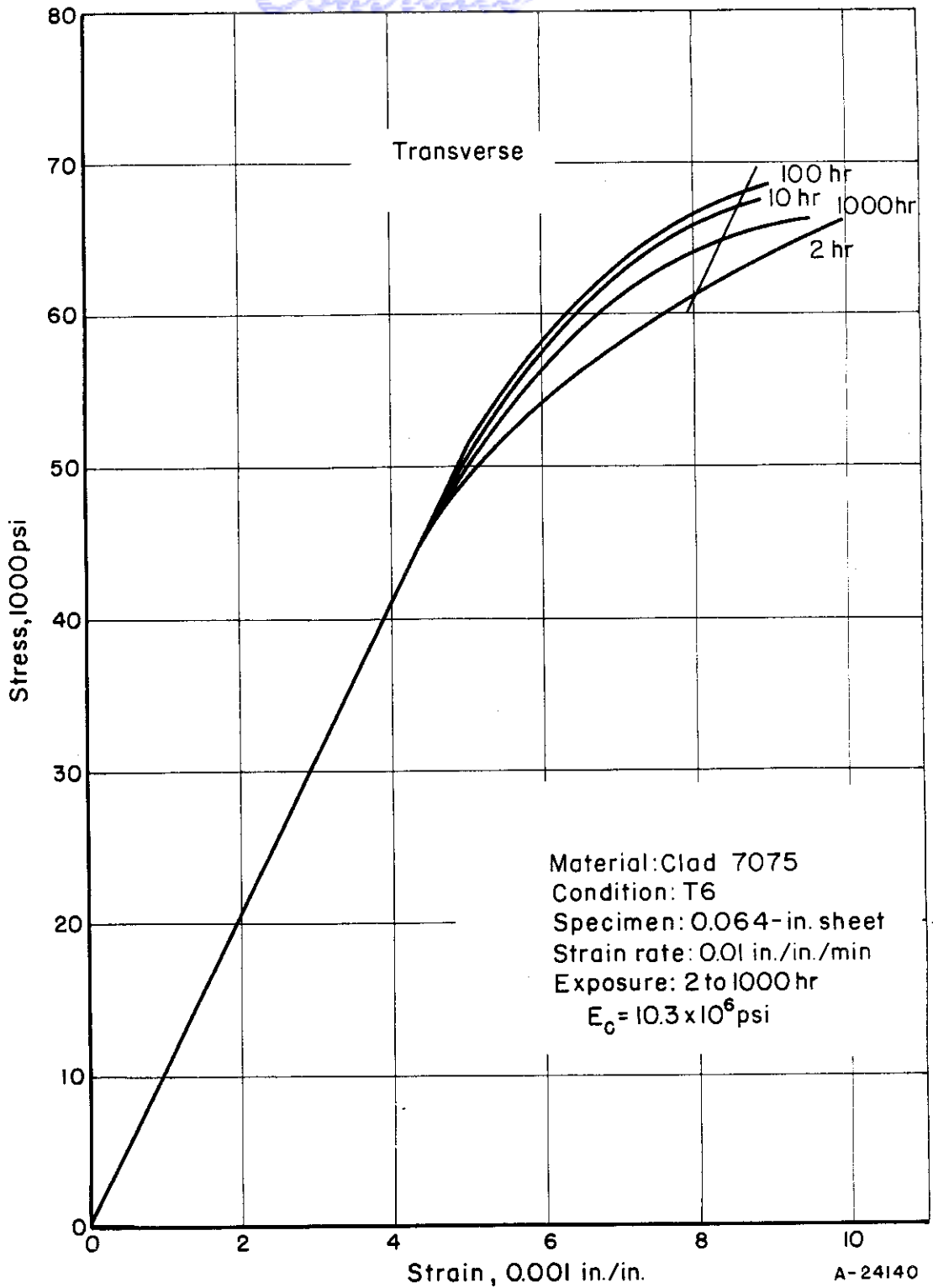


FIGURE 161. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 200 F

Ref. 58.

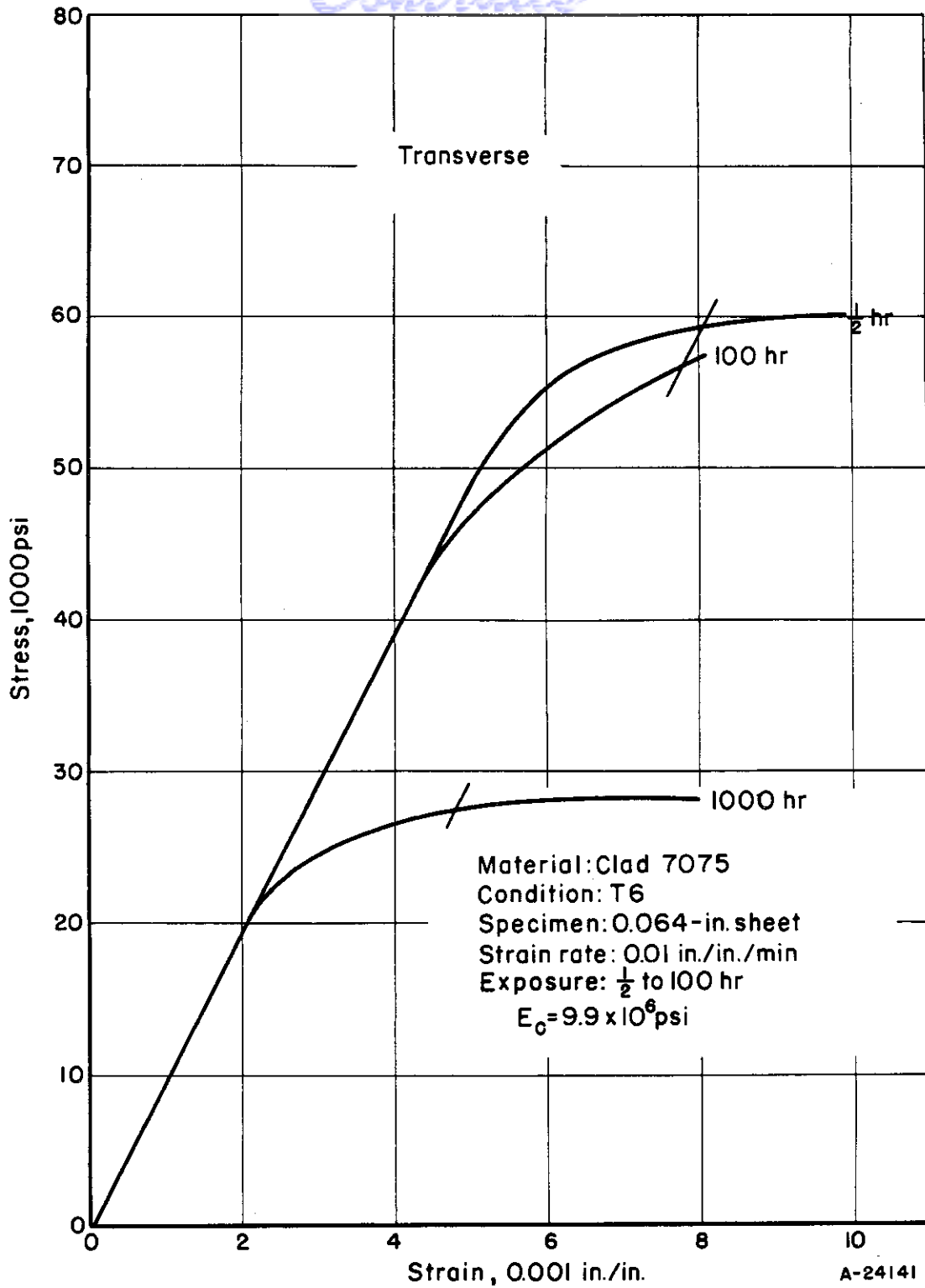


FIGURE 162. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 300 F

Ref. 71.

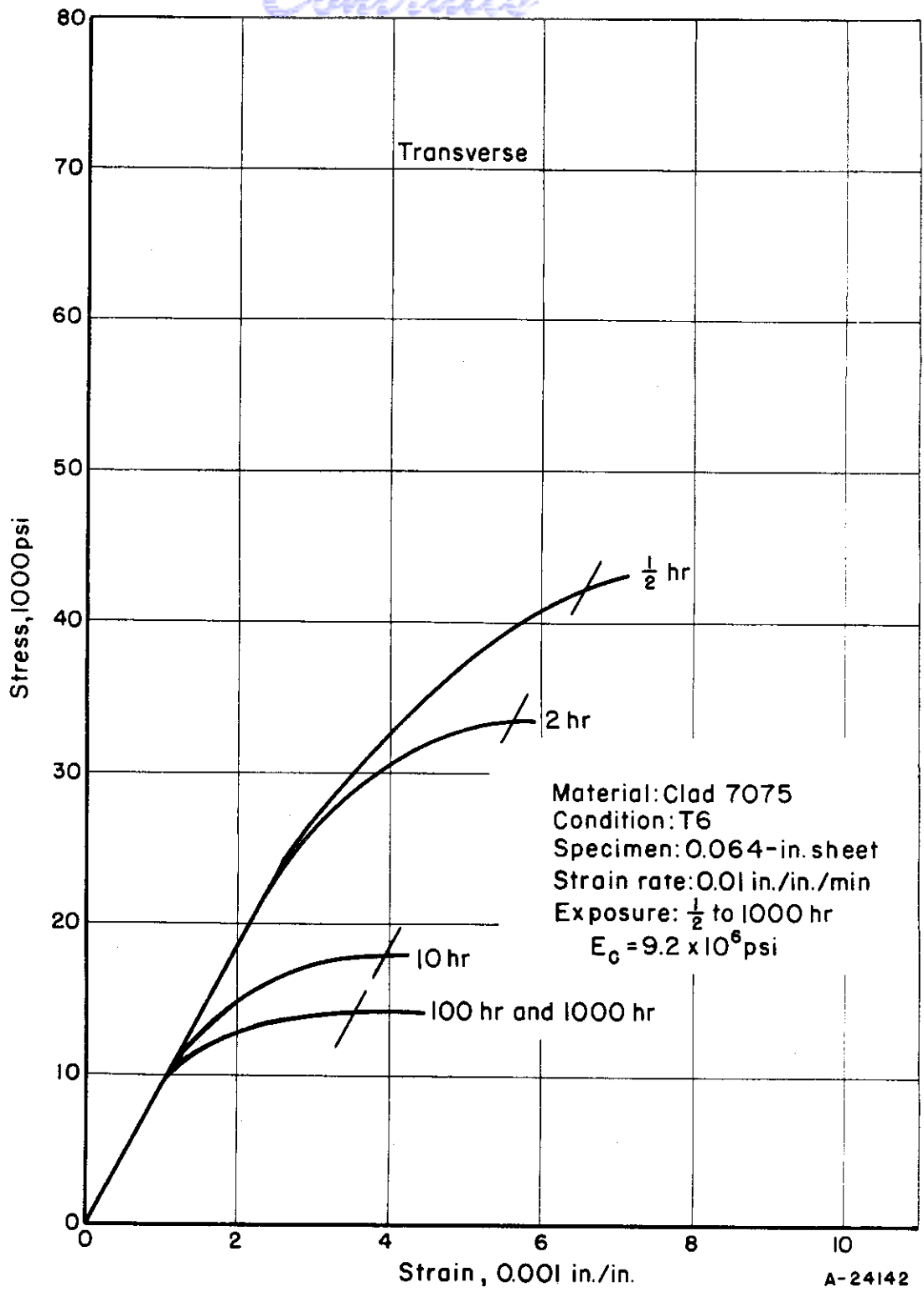


FIGURE 163. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 400 F

Ref. 71.

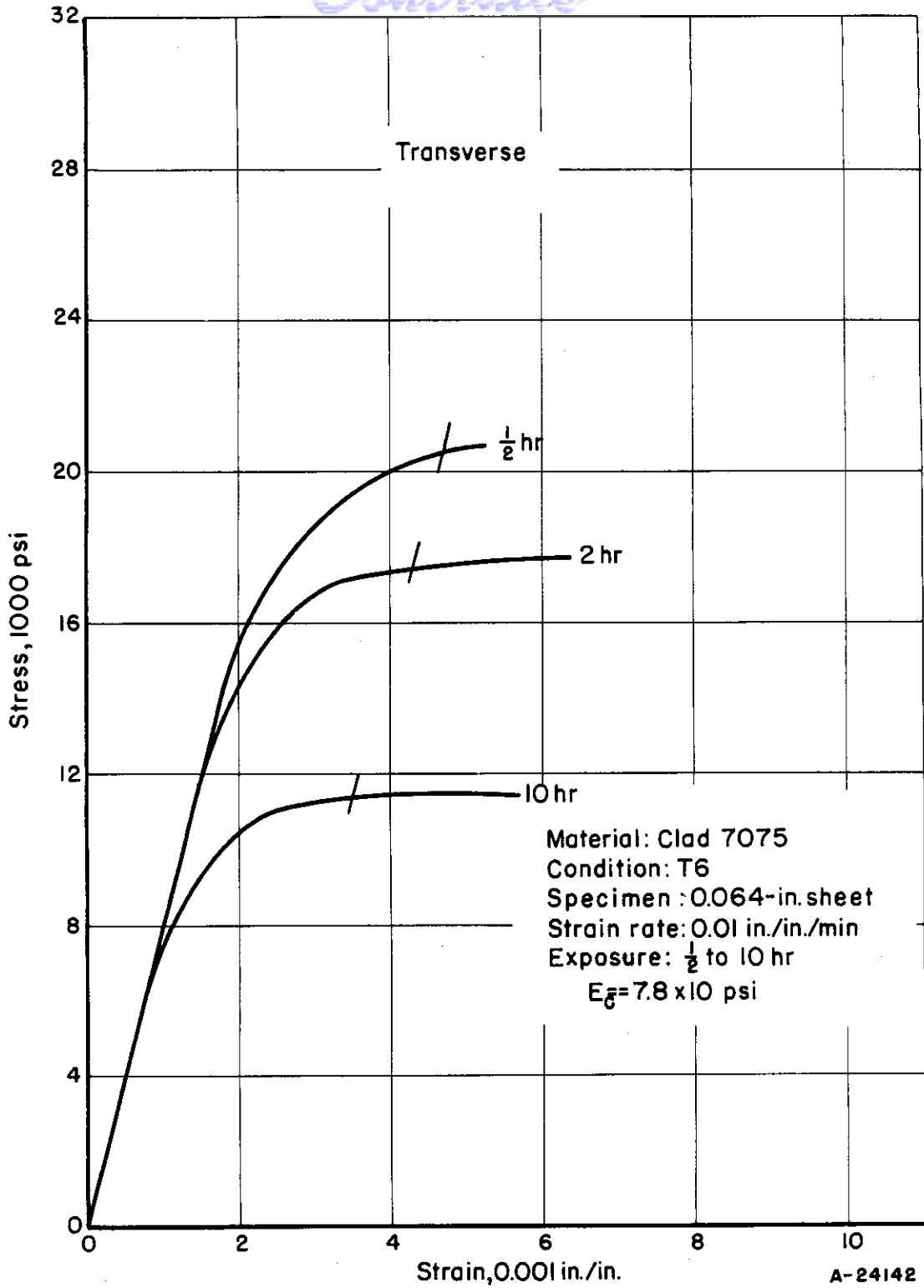


FIGURE 164. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 500 F

Ref. 71.

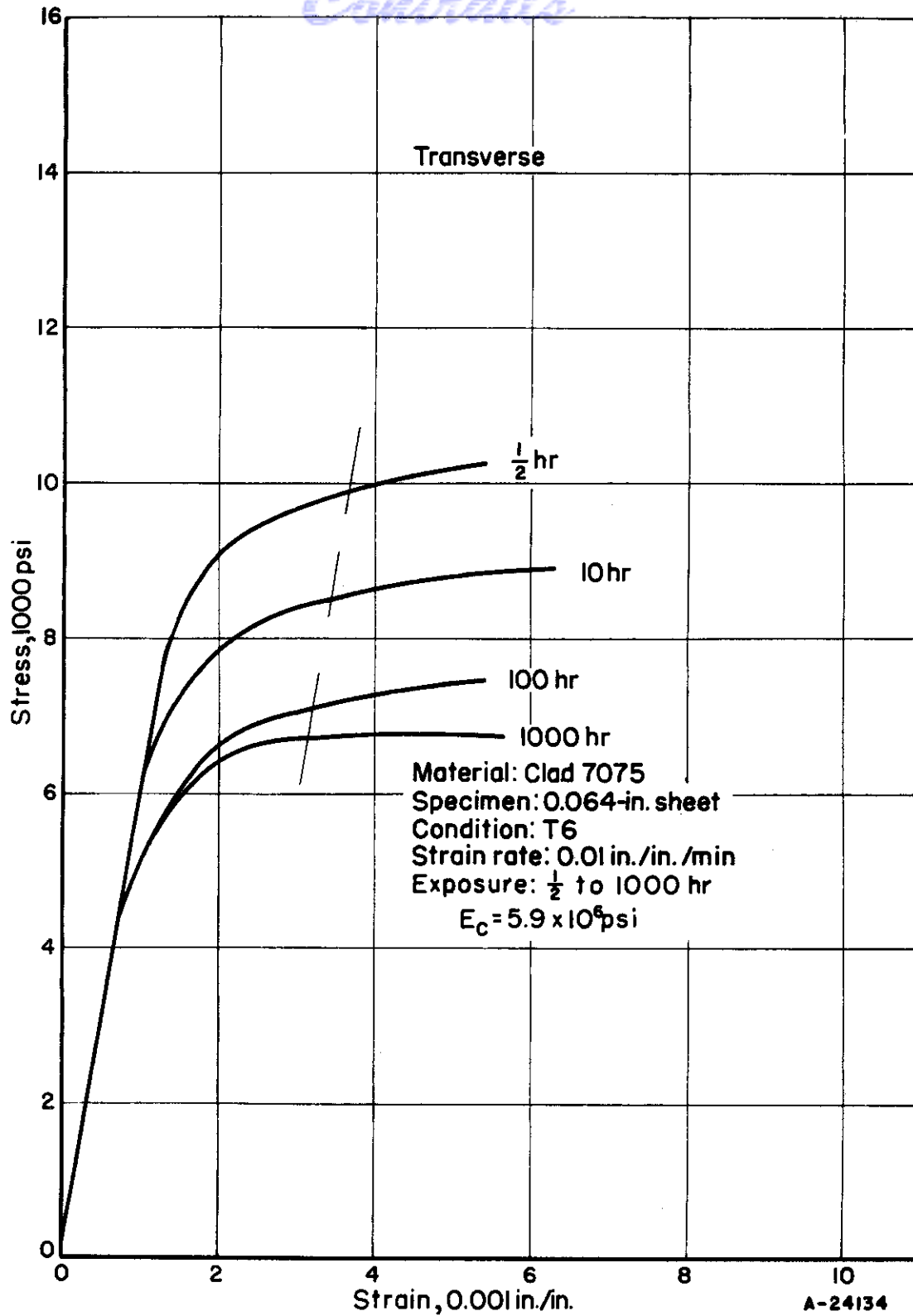


FIGURE 165. COMPRESSIVE STRESS-STRAIN CURVES FOR CLAD 7075-T6 ALUMINUM ALLOY AT 600 F

Ref. 71.

Continuals
HK31A MAGNESIUM ALLOY

Alloy Specifications

MIL-M-26075
Specifications Forthcoming

General

HK31A is a magnesium-base alloy which has been developed to maintain strength in the 300 - 700 F range of temperature. The principal alloying elements are thorium and zirconium. Zirconium is added to reduce grain size, because sand cast HK31A has a tendency toward a coarse grain structure. The nominal chemical composition of HK31A is given in Table 11.

TABLE 11. CHEMICAL COMPOSITION OF
HK31A MAGNESIUM ALLOY

Element	Weight Per Cent
Thorium	2.5 - 4.0
Zirconium	0.5 - 1.0
Magnesium	Remainder

Normal mill schedules supply HK31A-H24 sheet and plate in thicknesses from 0.016 to 2.0 inches and having the minimum mechanical properties outlined in Table 12.

TABLE 12. MINIMUM MECHANICAL PROPERTIES OF
HK31A-H24 MAGNESIUM ALLOY*

Ultimate tensile (F_{tu})	34,000 psi
Tensile yield (F_{ty})	26,000 psi
Elongation (e) in 2 inches	4 per cent

*MIL-M-26075 - gage 0.016 to 0.125 inch.

The conventional short-time elevated-temperature properties of HK31A are shown in the following curves:

Tensile strength	Figures 166, 167, 172, 173, 178, 179, 184, 185, 195
Tensile yield strength	Figures 168, 169, 174, 175, 180, 181, 186, 187
Compressive yield strength	Figures 170, 171, 176, 177, 182, 183, 188, 189
Modulus of elasticity	Figures 190, 192, 194
Stress-strain curves	Figures 191, 193, 195.

Heat Treatment

Parts fabricated from HK31A can be solution treated and aged to the -T6 condition. The procedure consists of solution treating at 1050 F for one-half hour and aging at 400 F for 16 hours.

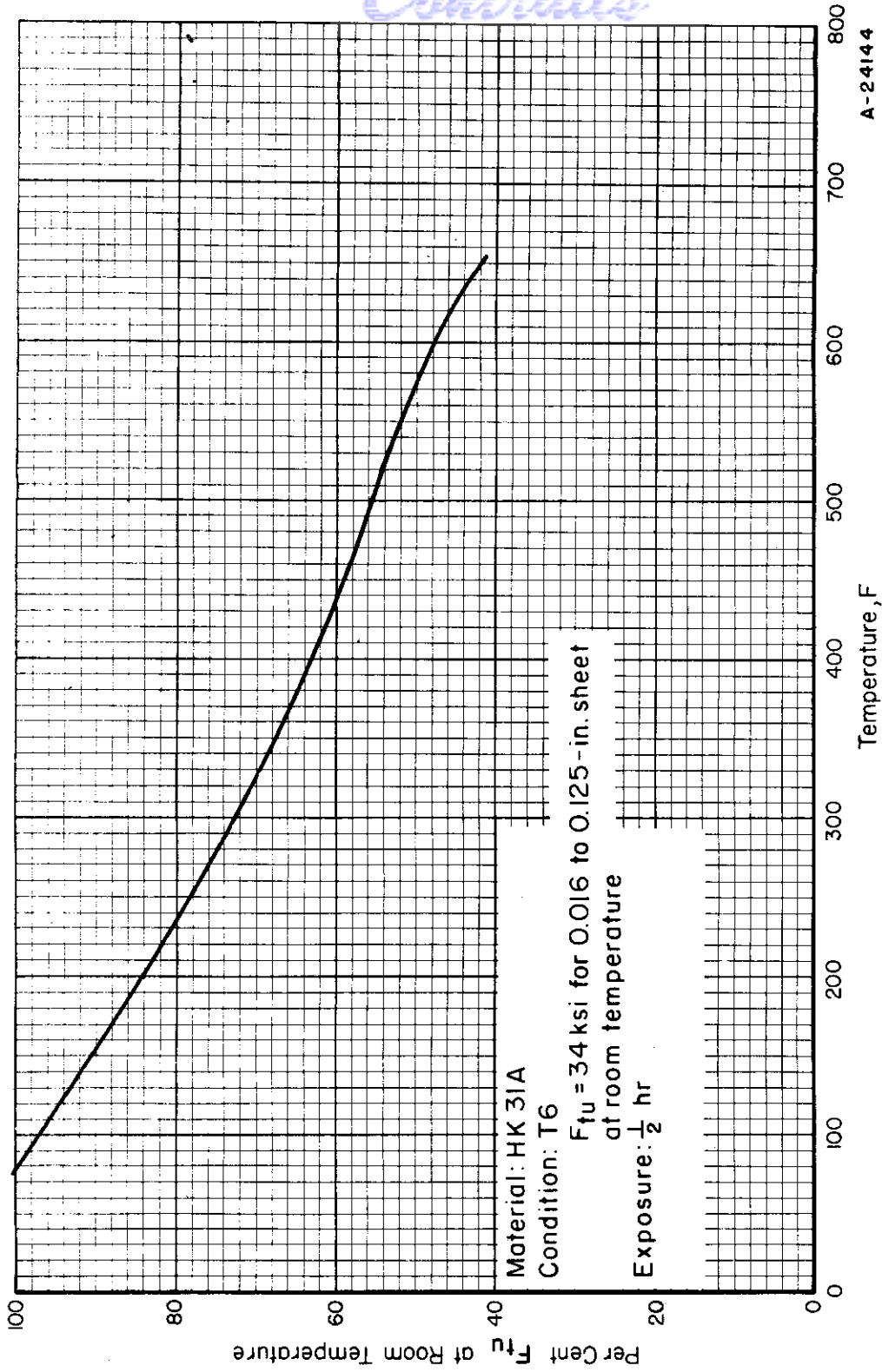
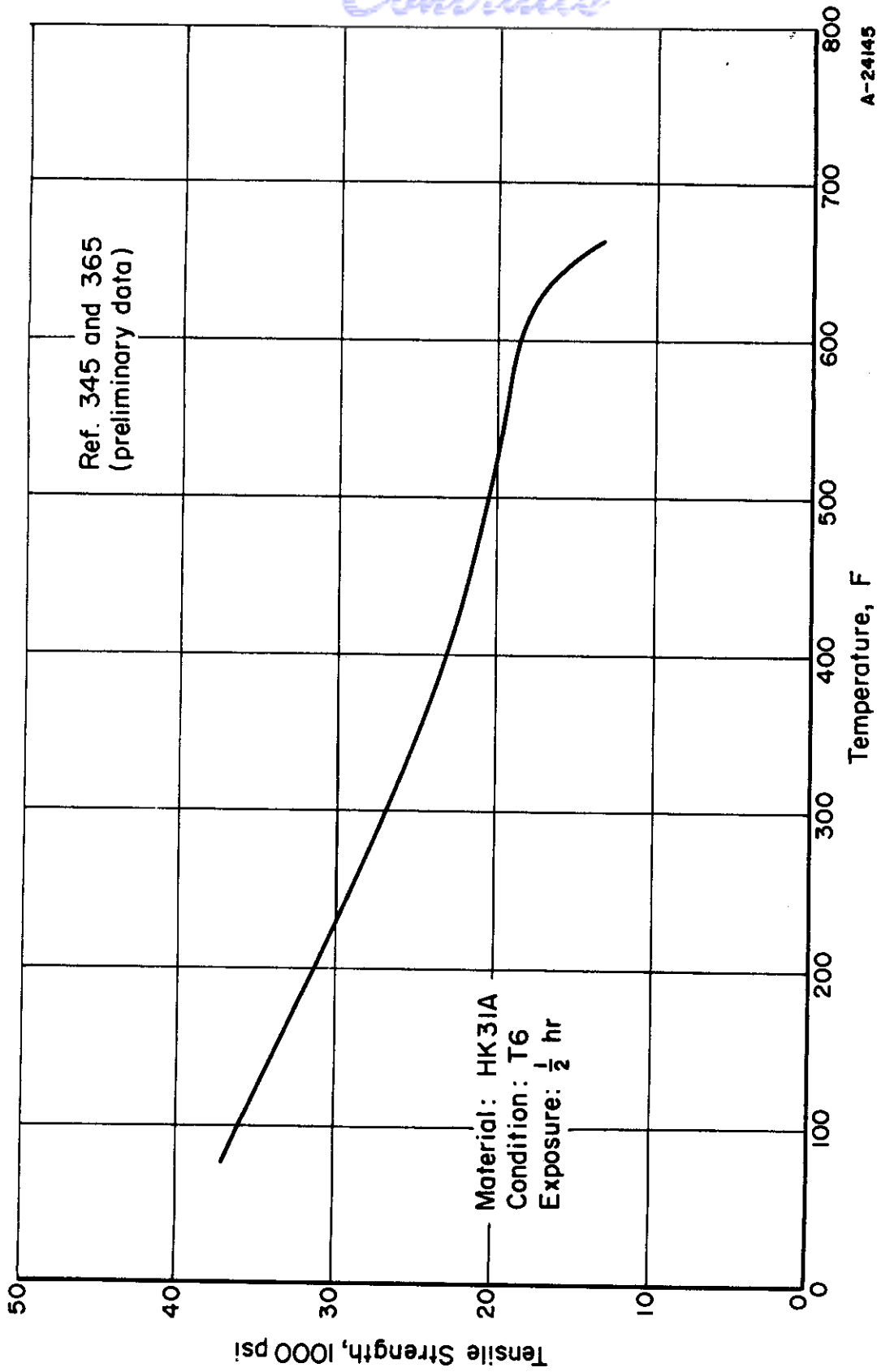


FIGURE 166. DESIGN CURVE FOR TENSILE STRENGTH (F_{tu}) OF HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 365, 345.



A-24145

FIGURE 167. TENSILE STRENGTH DATA FOR HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

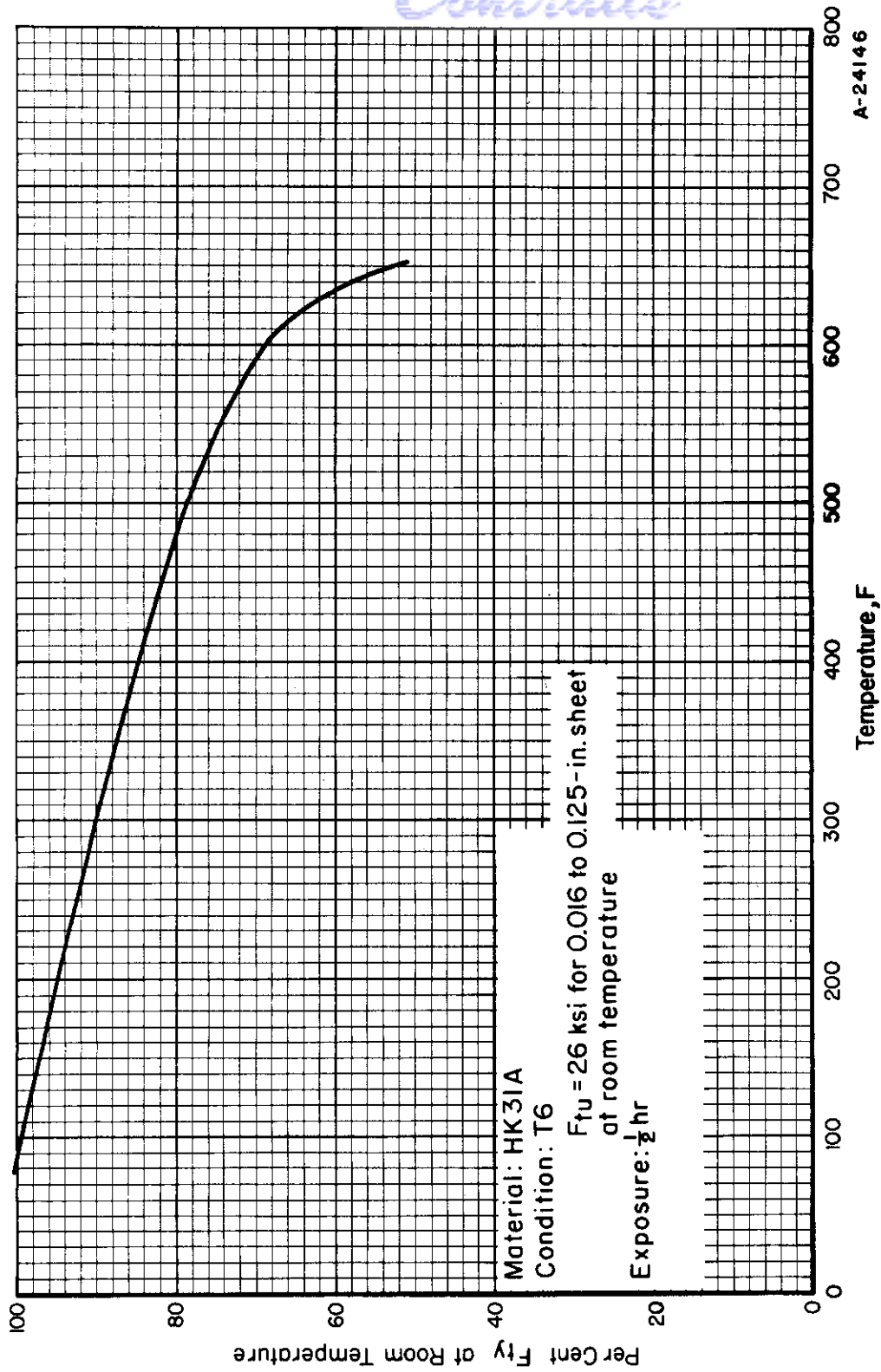


FIGURE 168. DESIGN CURVE FOR TENSILE YIELD STRENGTH (F_{ty}) OF HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 365, 345.

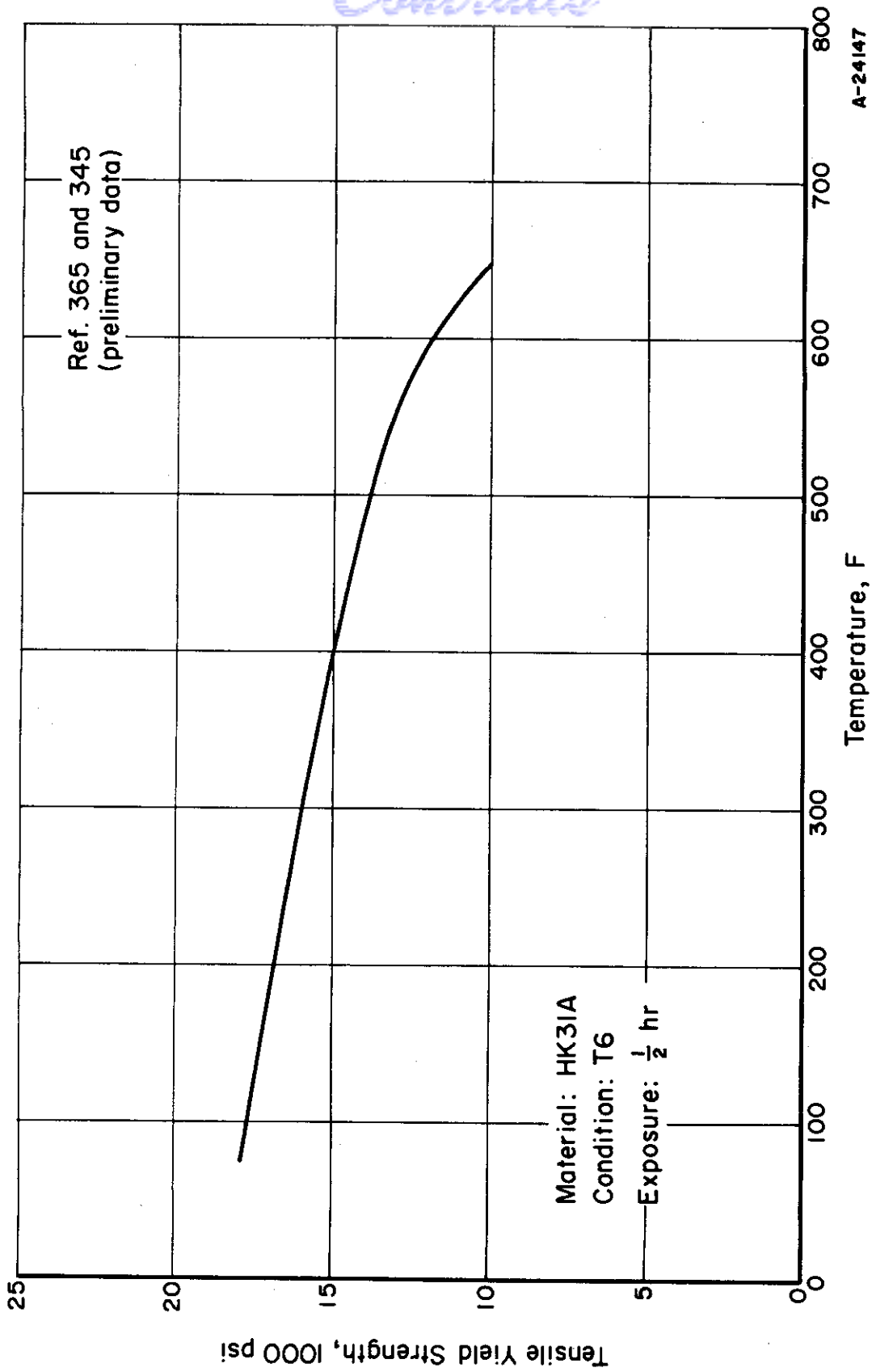


FIGURE 169. TENSILE YIELD STRENGTH DATA FOR HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

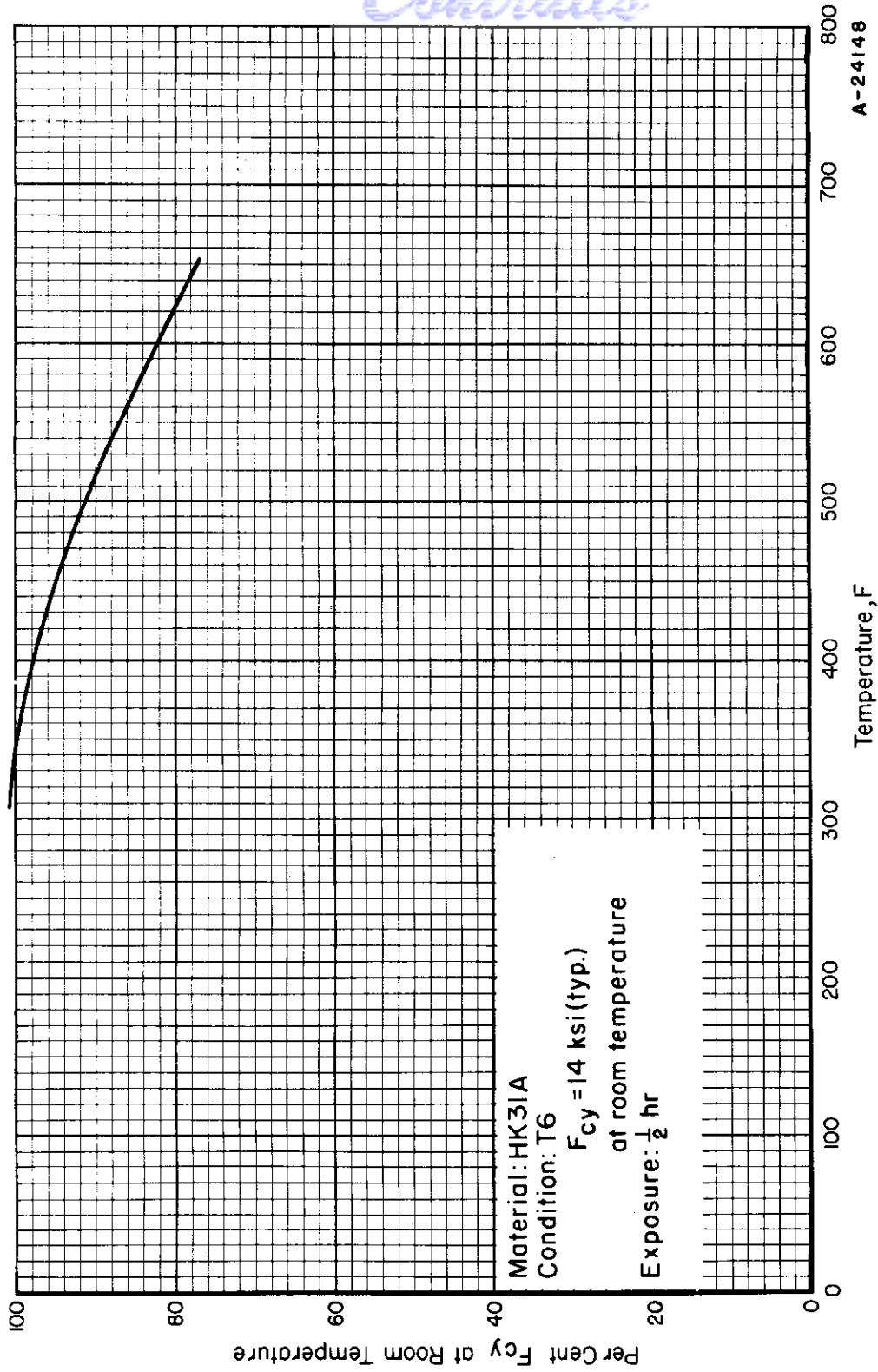


FIGURE 170. DESIGN CURVE FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 365.

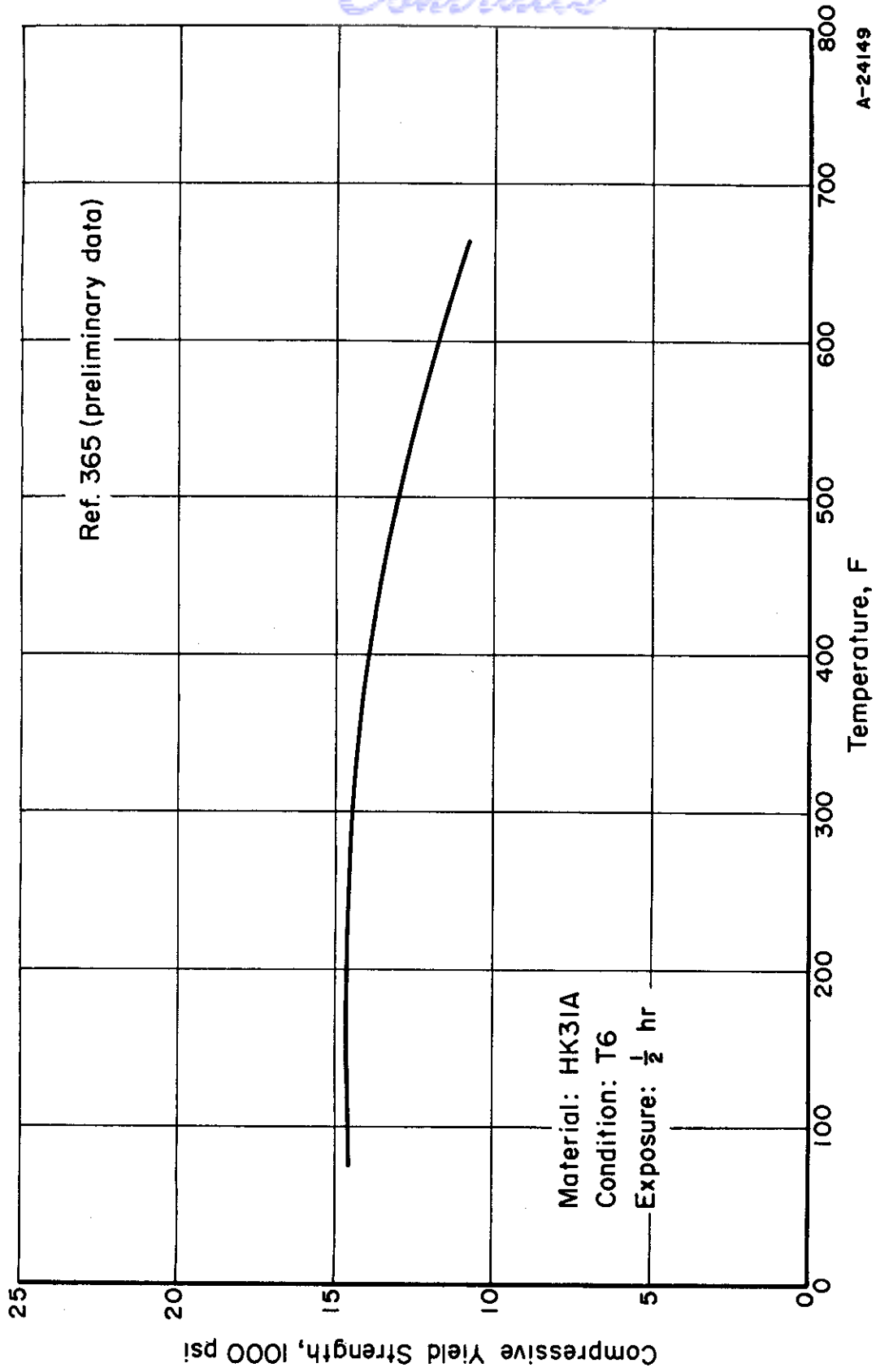


FIGURE 171. COMPRESSIVE YIELD STRENGTH DATA FOR HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

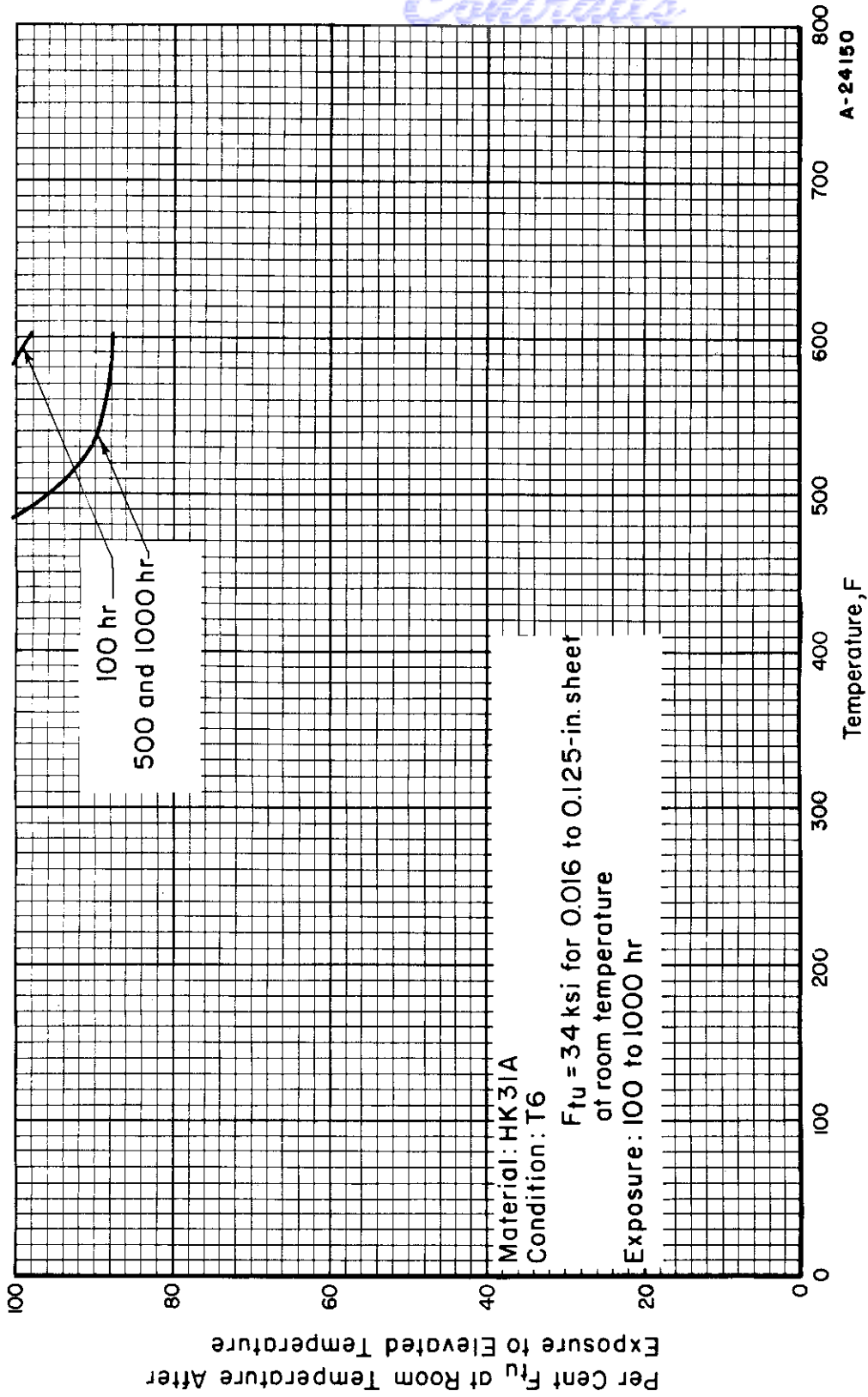


FIGURE 172. DESIGN CURVES FOR TENSILE STRENGTH (F_{tu}) OF HK31A-T6 MAGNESIUM ALLOY AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

Ref. 364, 345.

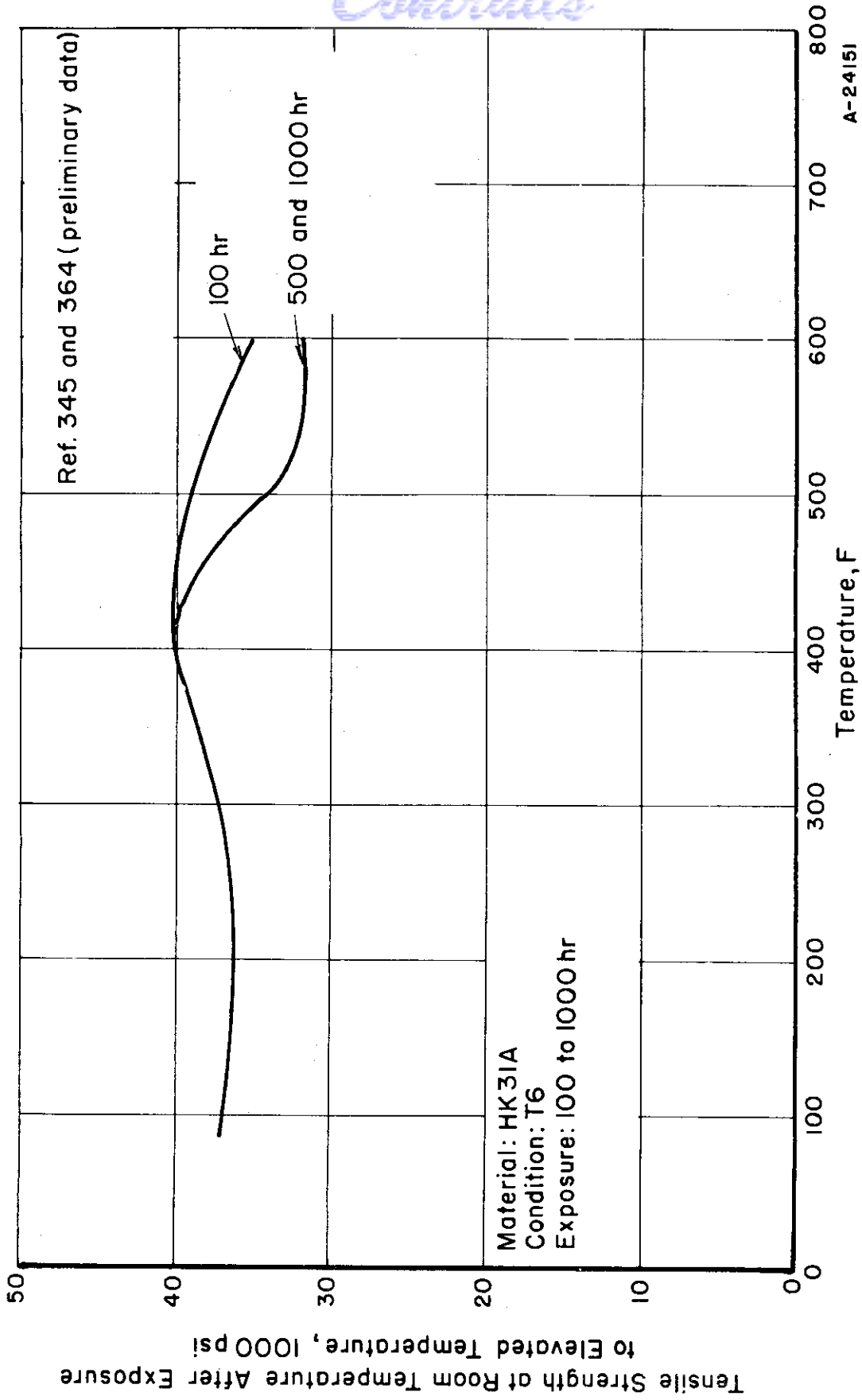
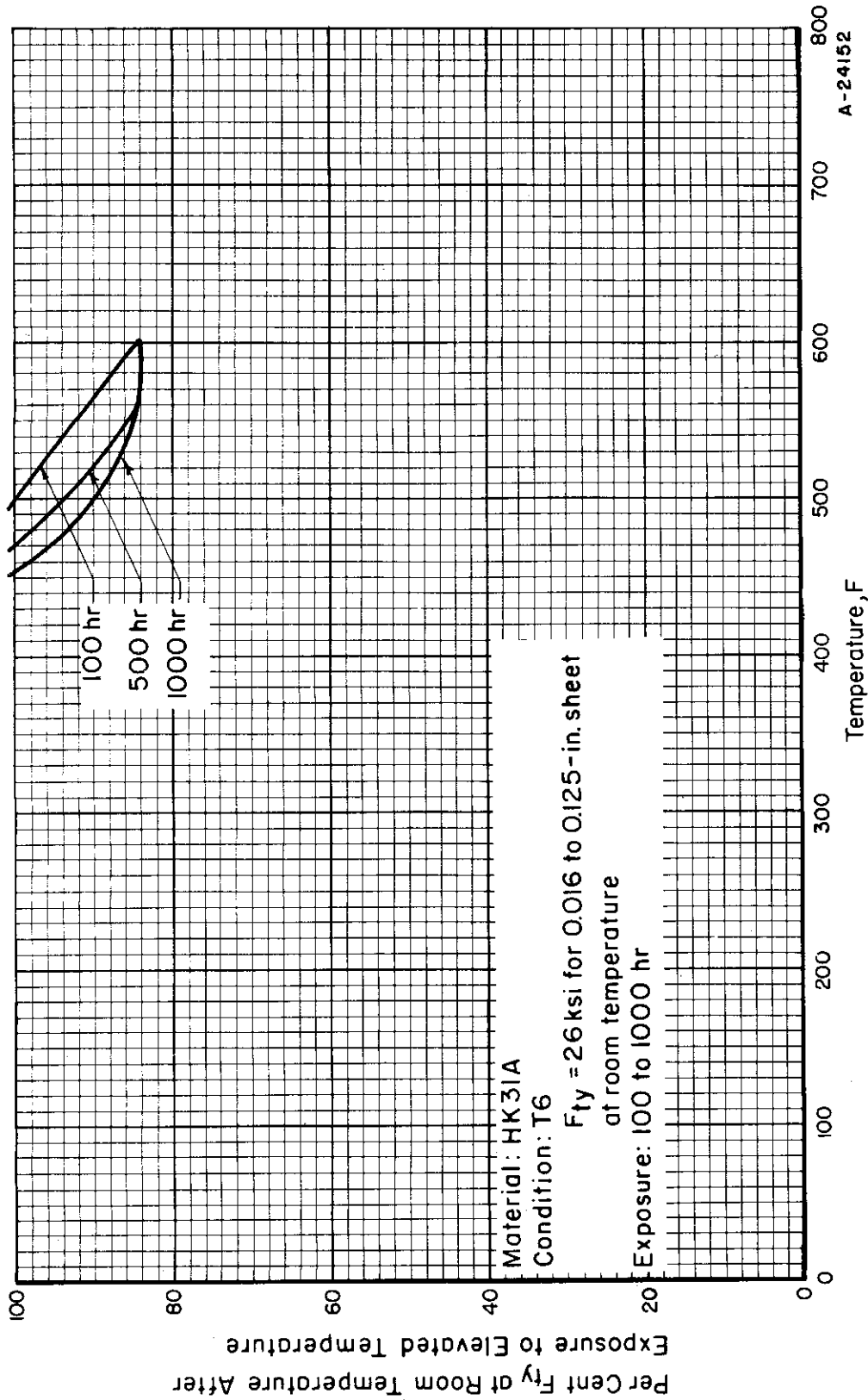


FIGURE 173. TENSILE STRENGTH DATA FOR HK31A-T6 MAGNESIUM ALLOY TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)



JRE 174. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF HK31A-T6 MAGNESIUM ALLOY AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

Ref. 364, 345.

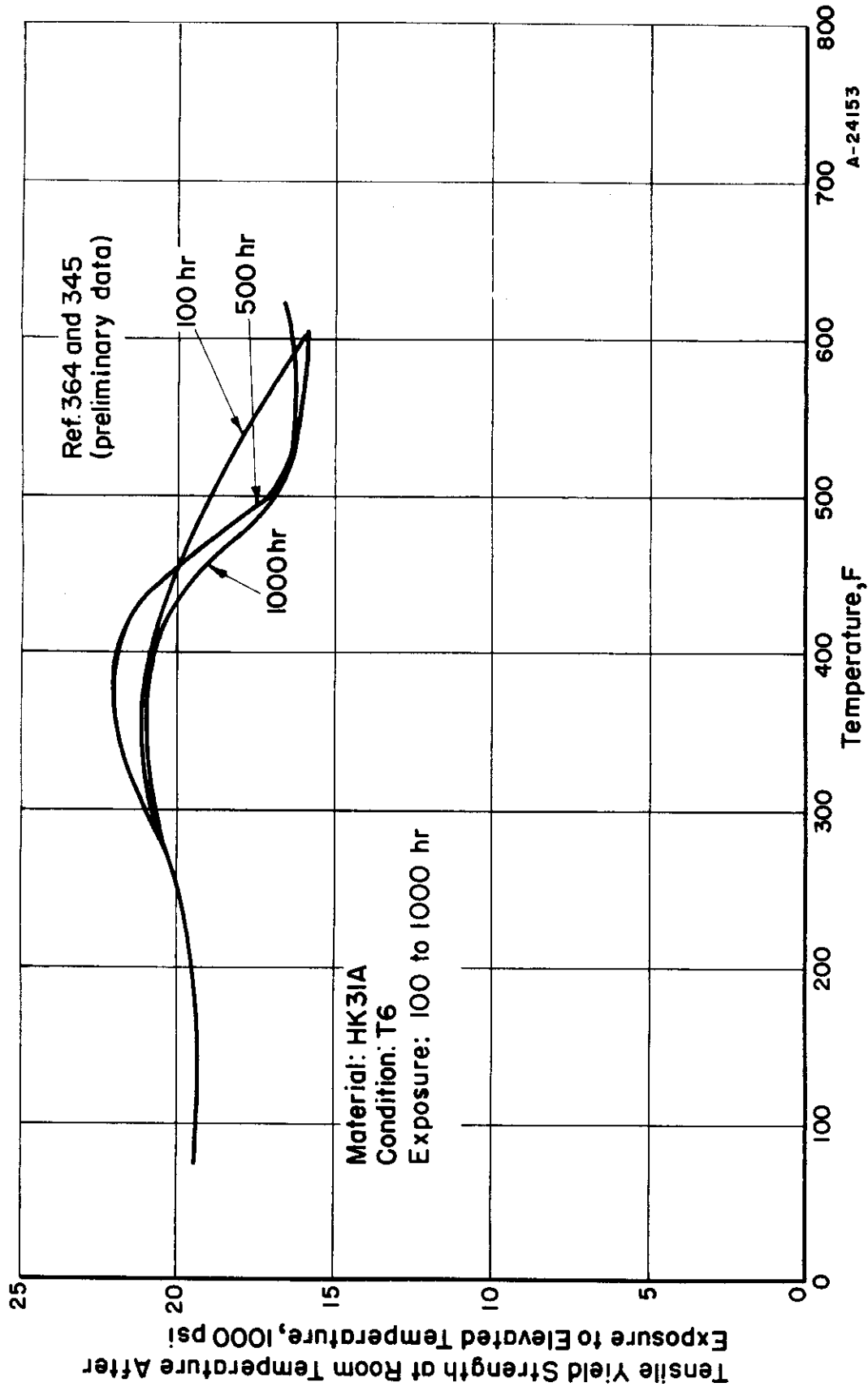


FIGURE 175. TENSILE YIELD STRENGTH DATA FOR HK31A-T6 MAGNESIUM ALLOY TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

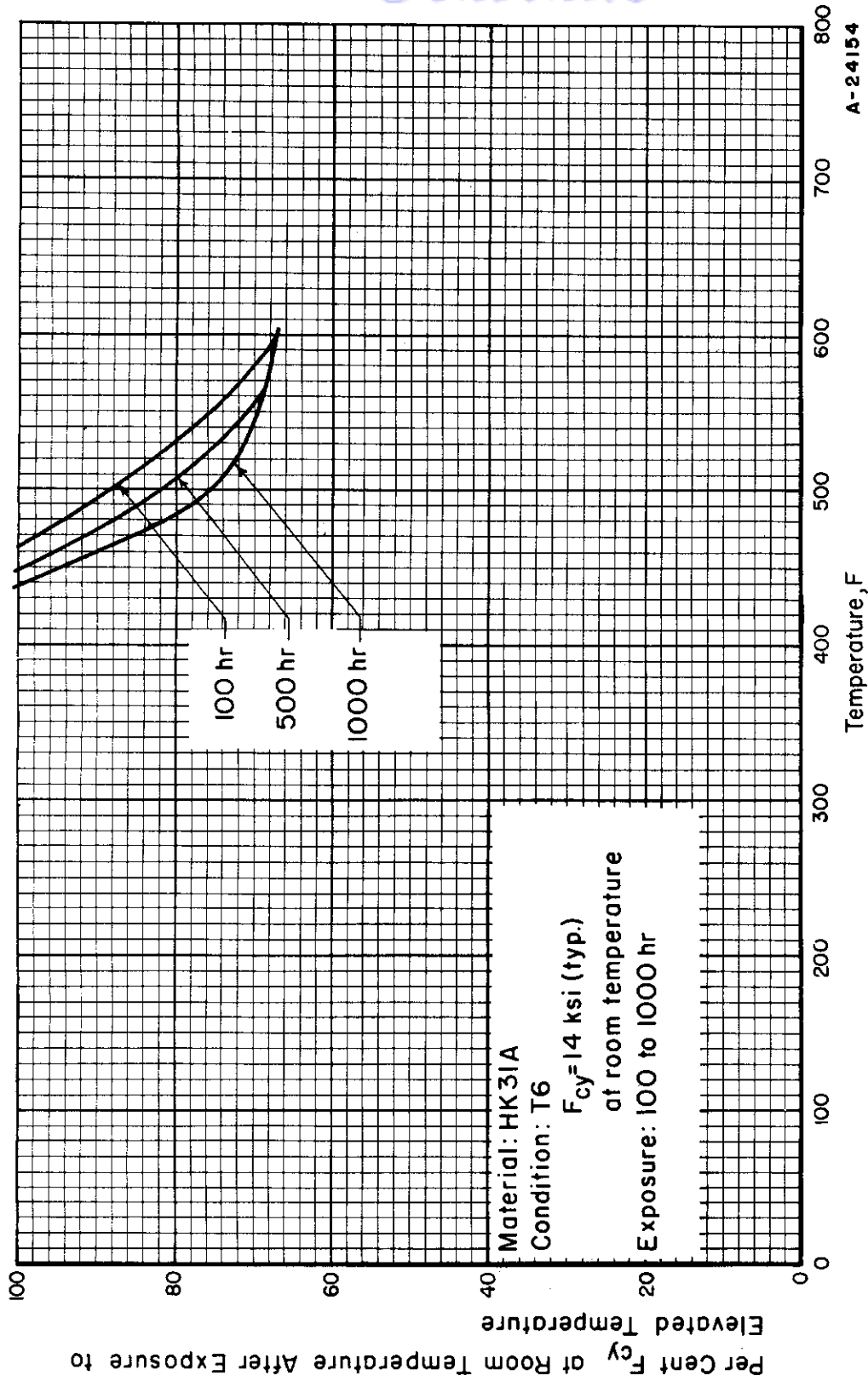
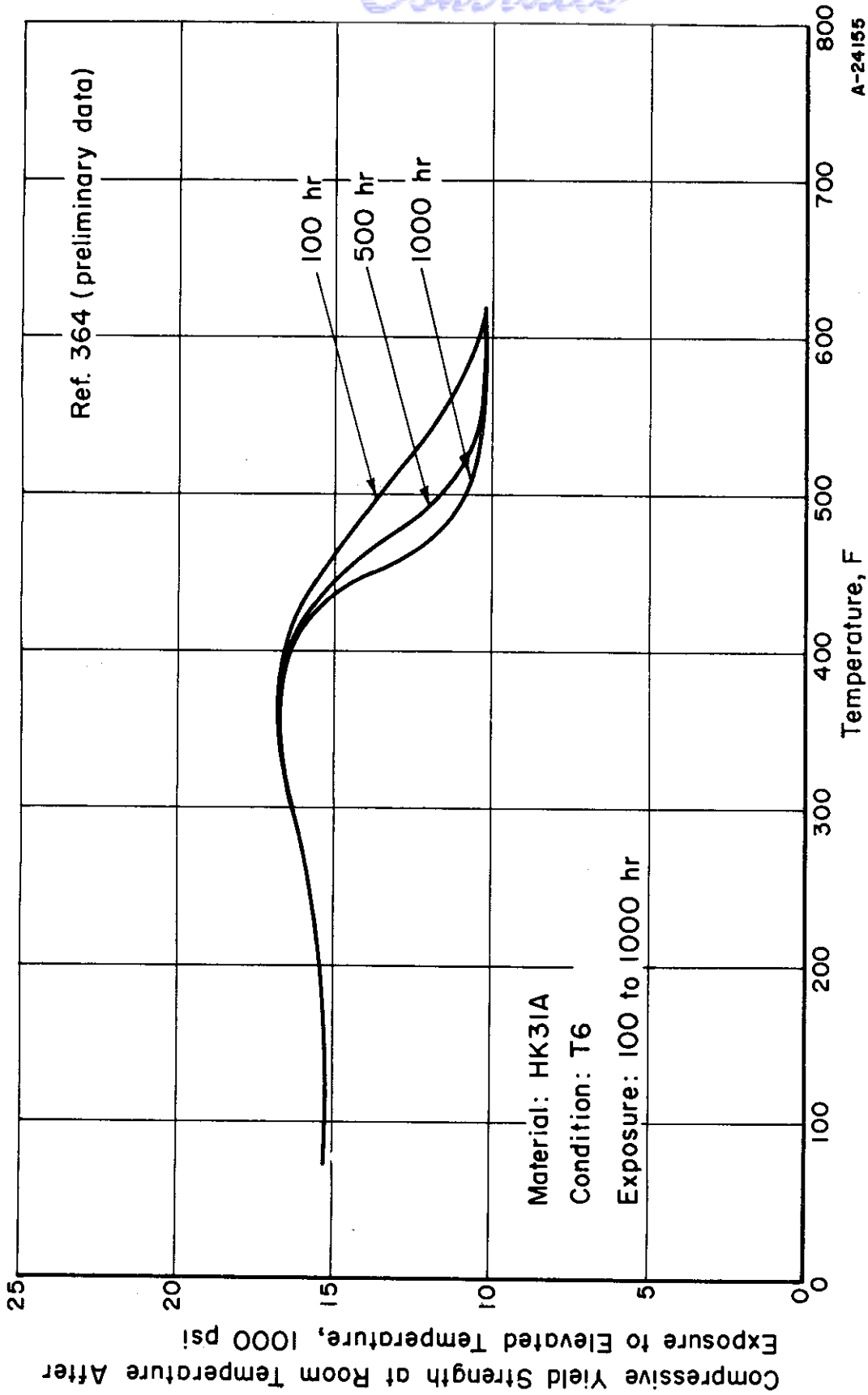


FIGURE 176. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF HK31A-T6 MAGNESIUM ALLOY AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

Ref. 364.



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FIGURE 177. COMPRESSIVE YIELD STRENGTH DATA FOR HK31A-T6 MAGNESIUM ALLOY TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

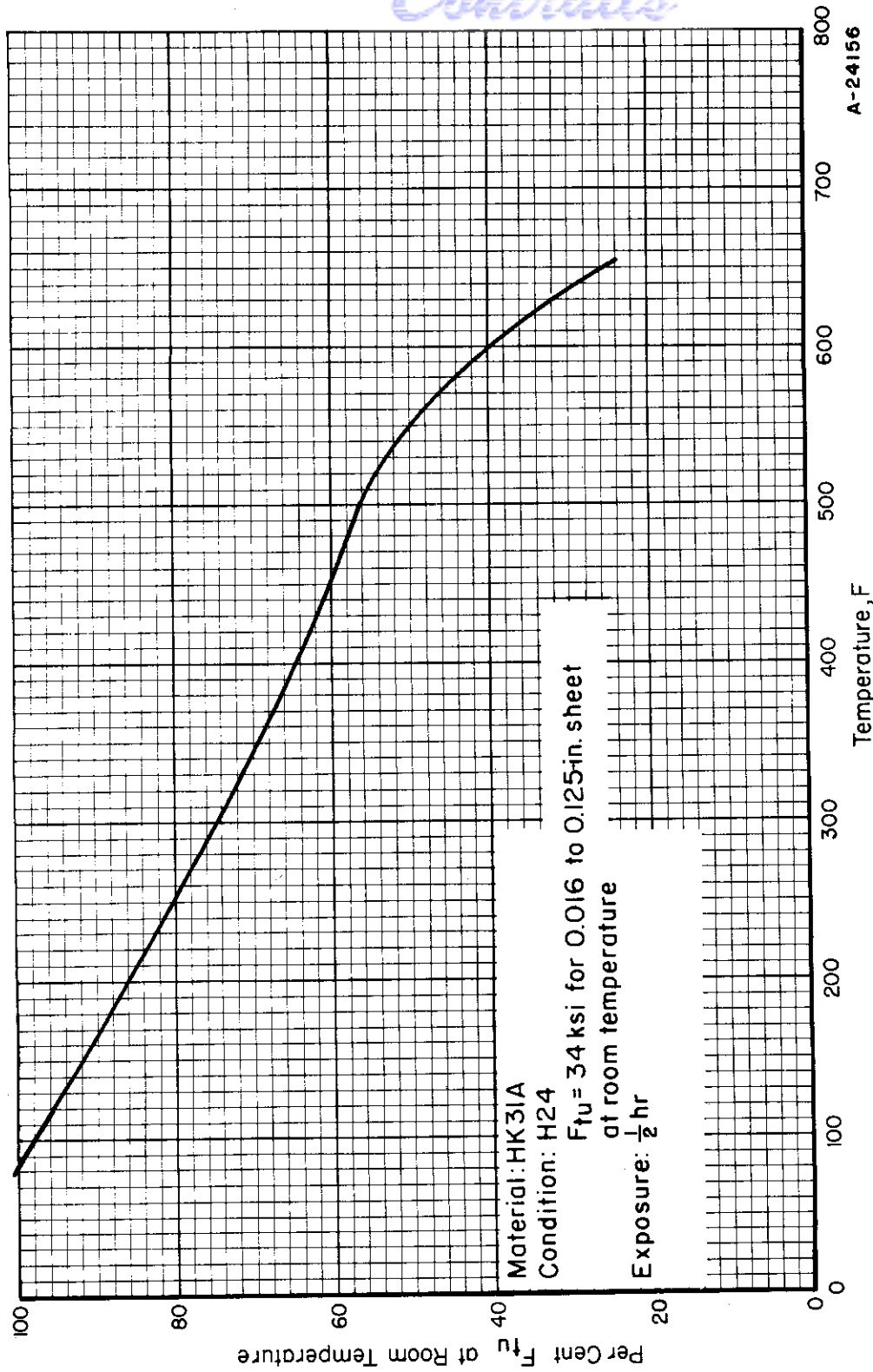


FIGURE 178. DESIGN CURVE FOR TENSILE STRENGTH (F_{tu}) OF HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 365, 345.

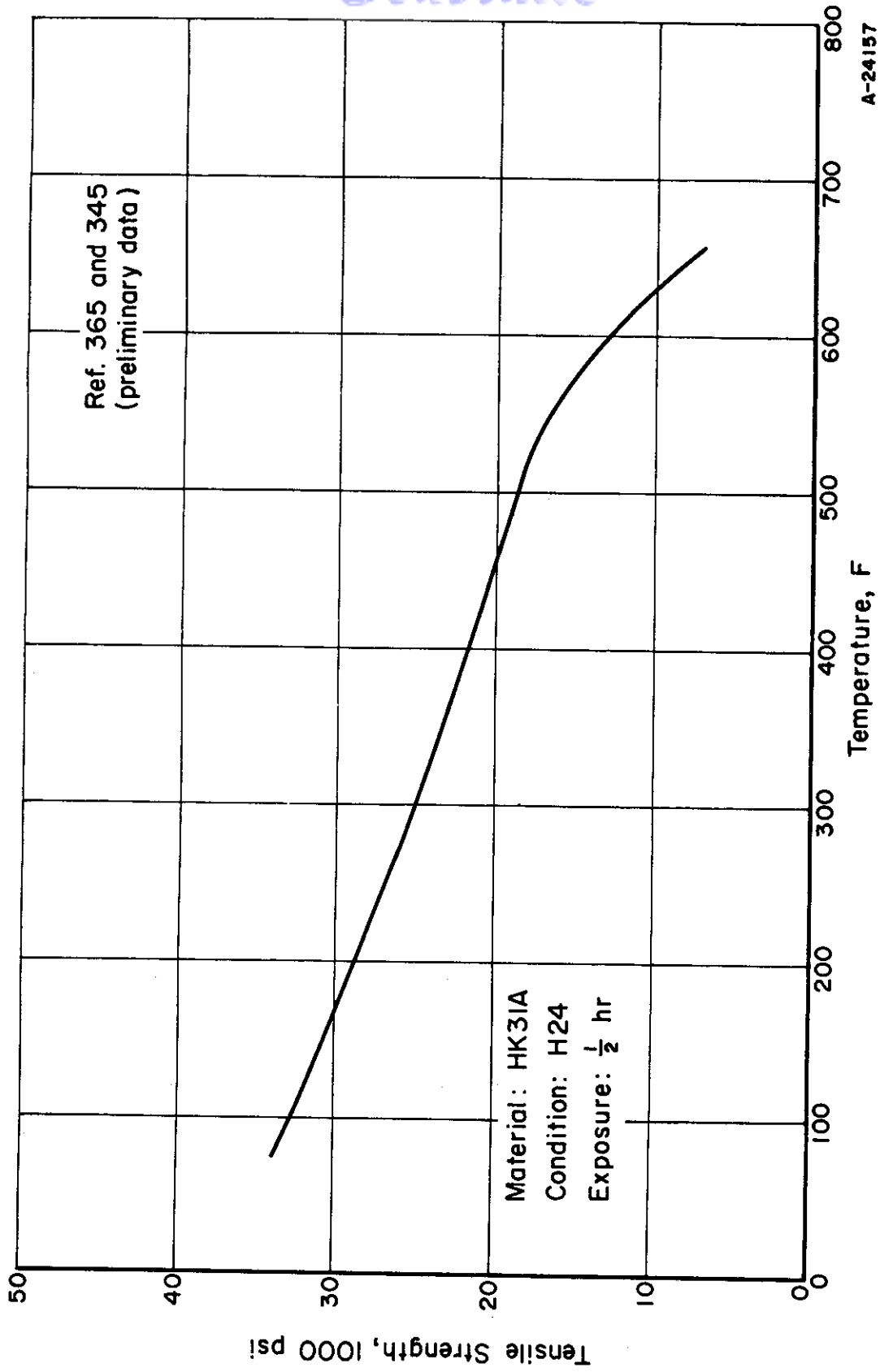


FIGURE 179. TENSILE STRENGTH DATA FOR HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

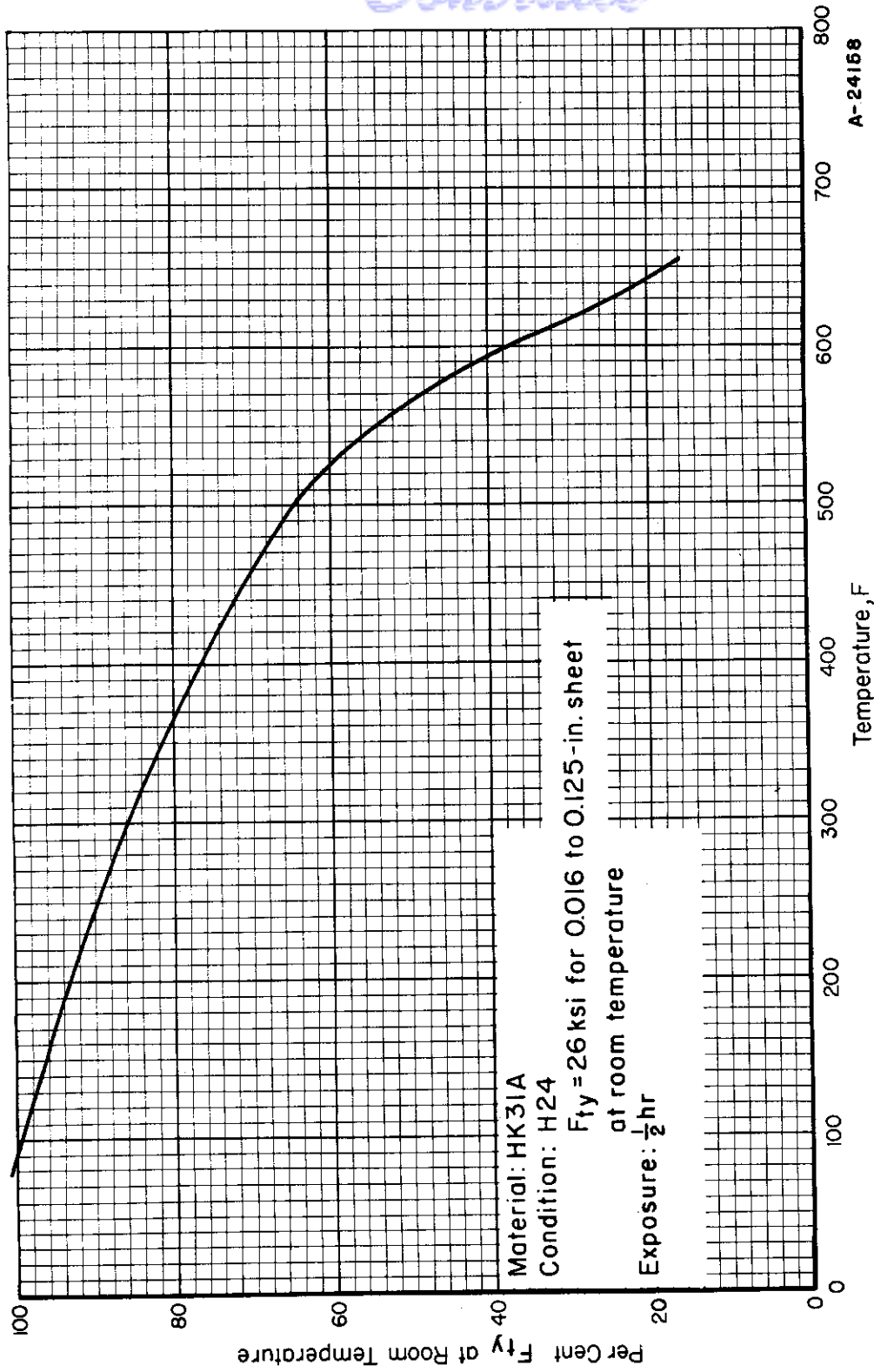


FIGURE 180. DESIGN CURVE FOR TENSILE YIELD STRENGTH (F_{ty}) OF HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 365, 345.

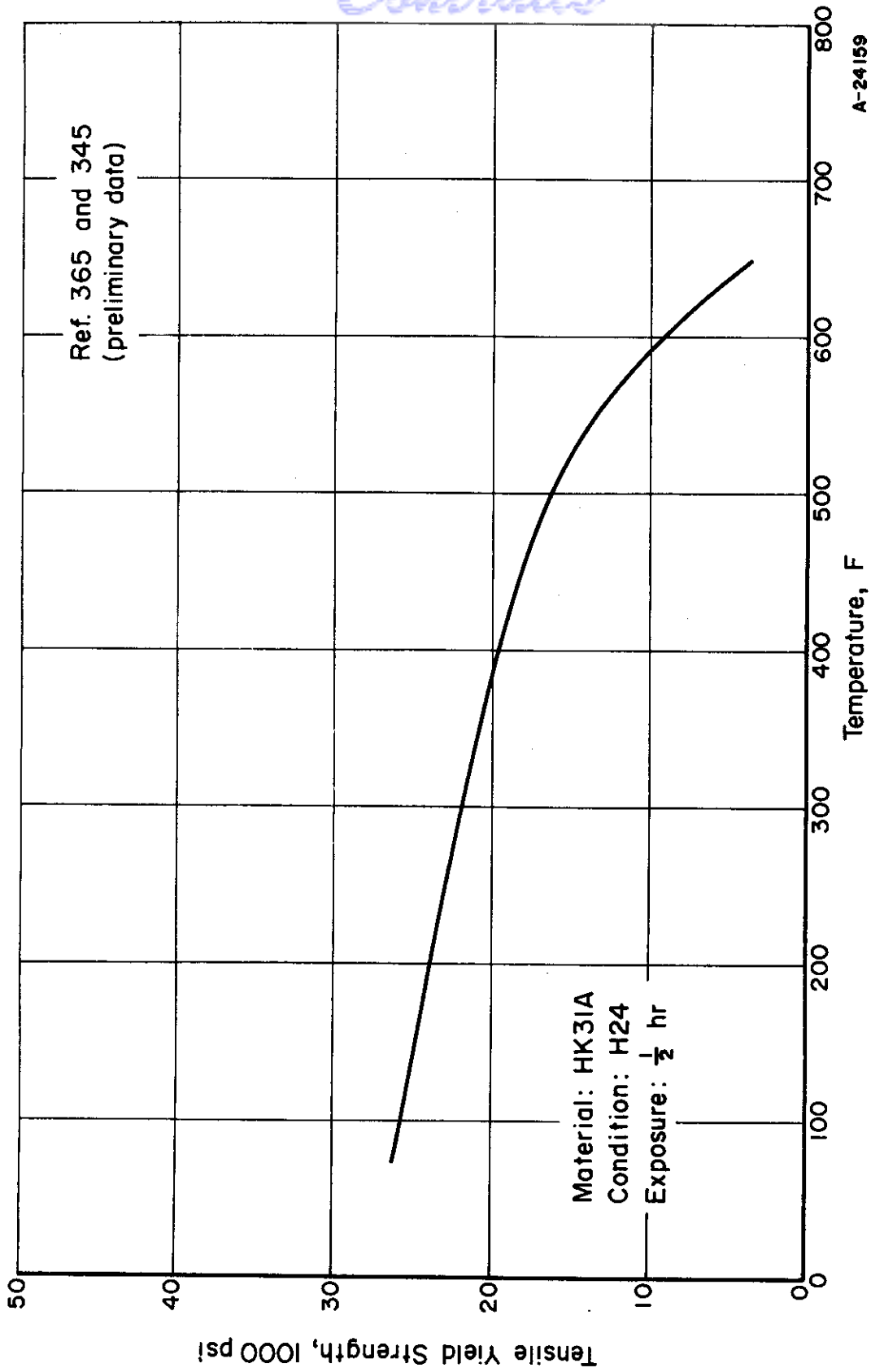


FIGURE 181. TENSILE YIELD STRENGTH DATA FOR HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

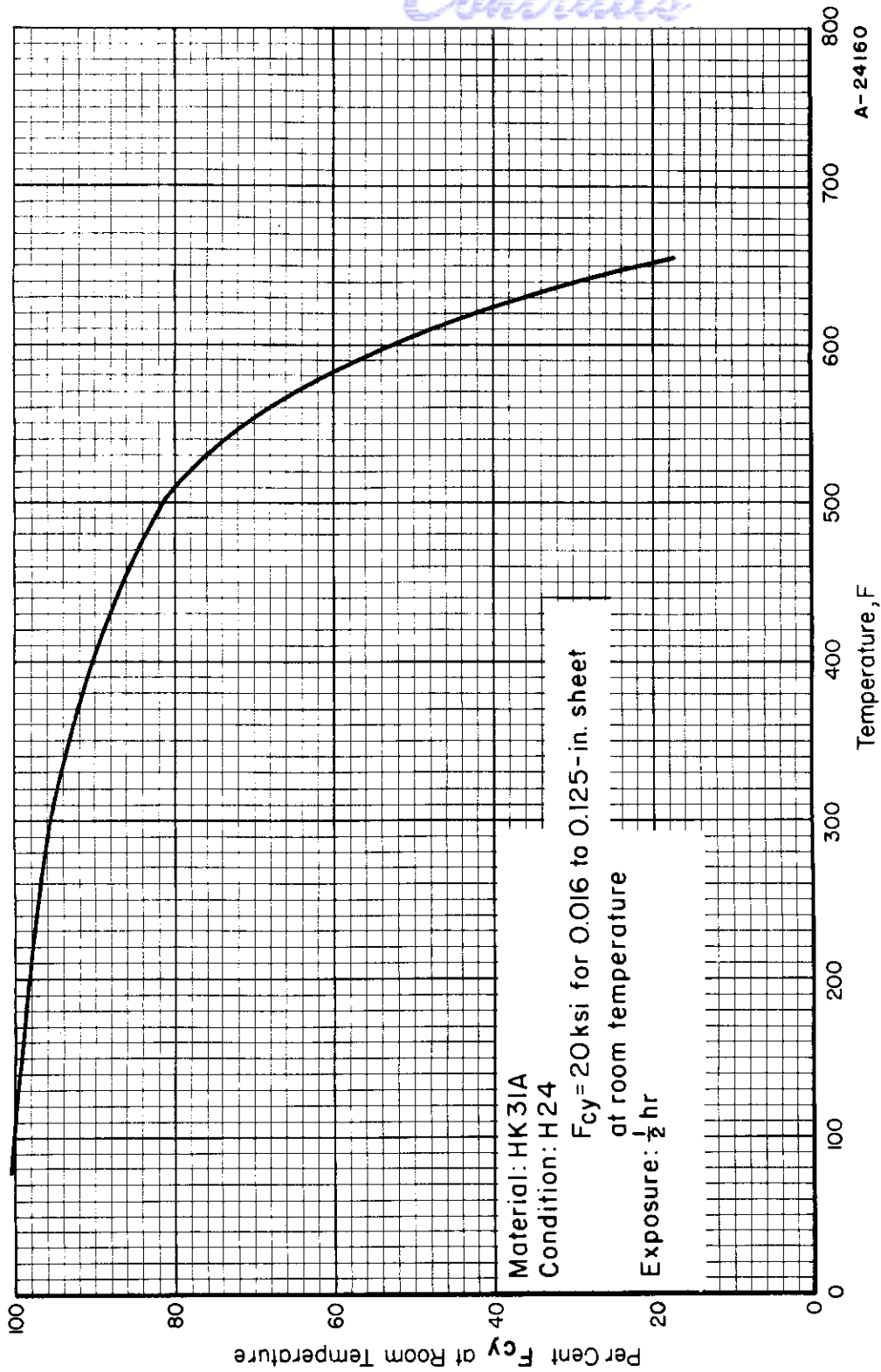


FIGURE 182. DESIGN CURVE FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 365, 345.

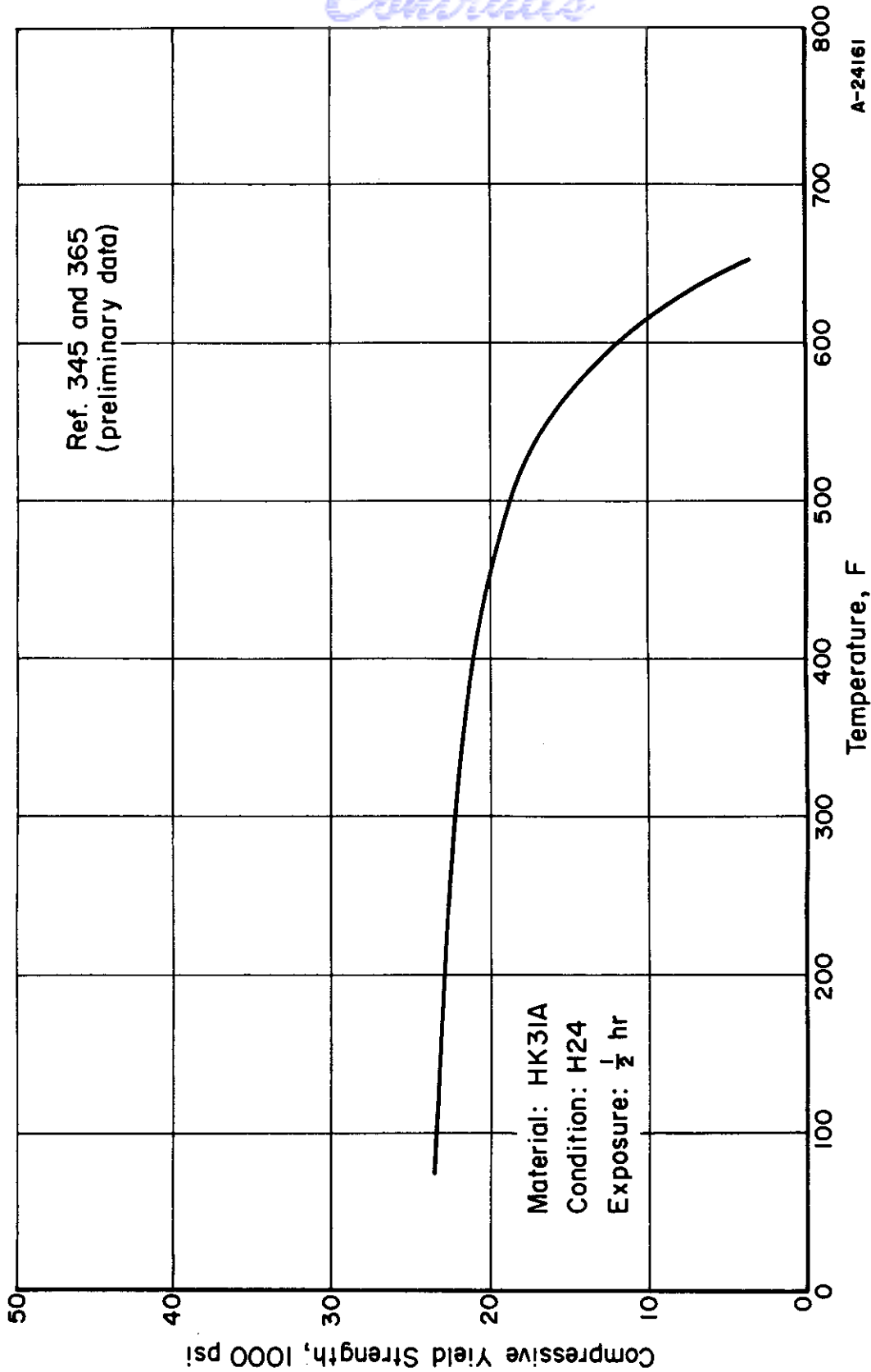


FIGURE 183. COMPRESSIVE YIELD STRENGTH DATA FOR HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

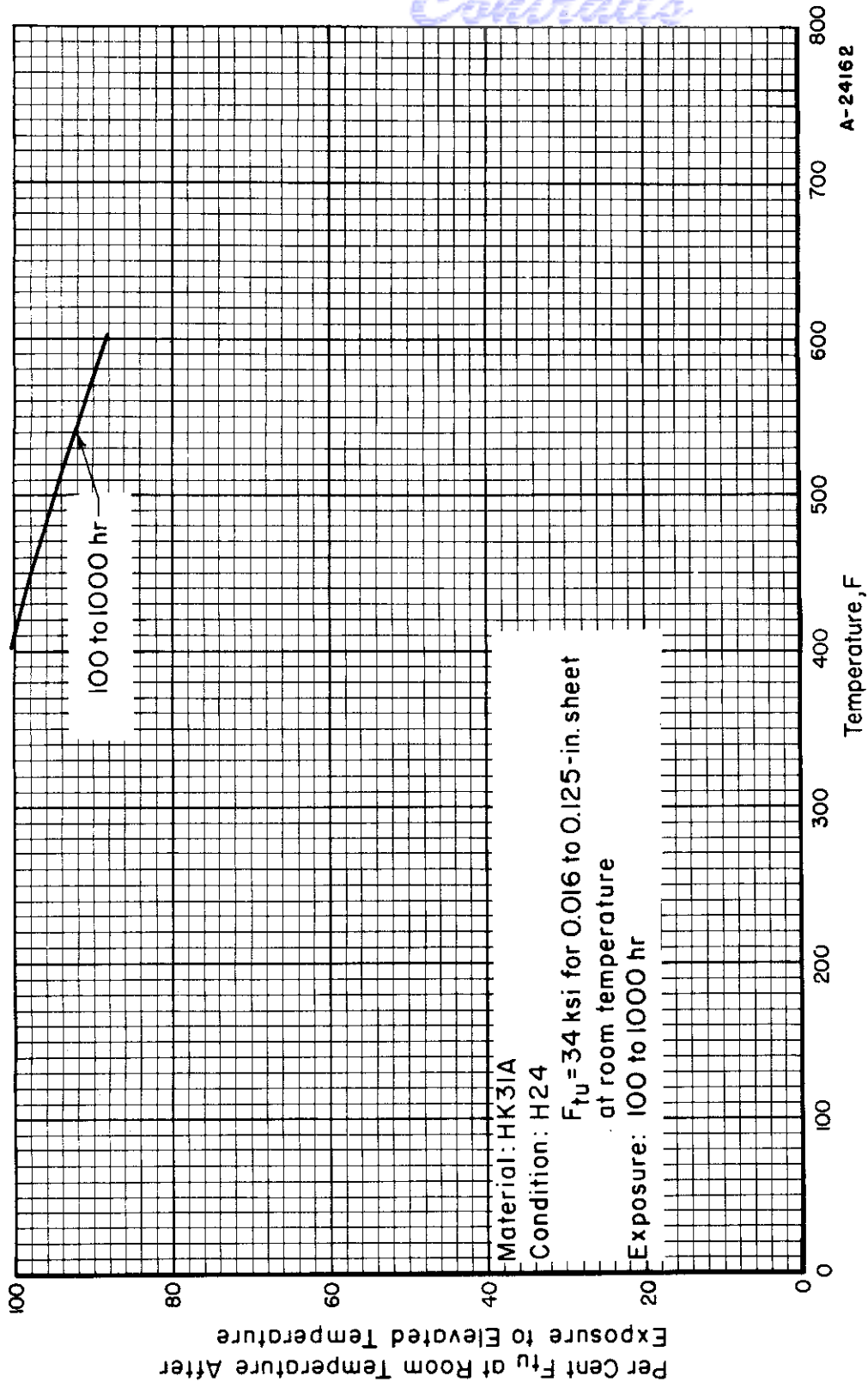


FIGURE 184. DESIGN CURVE FOR TENSILE STRENGTH (F_{tu}) OF HK31A-H24 MAGNESIUM ALLOY AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

Ref. 364, 345.

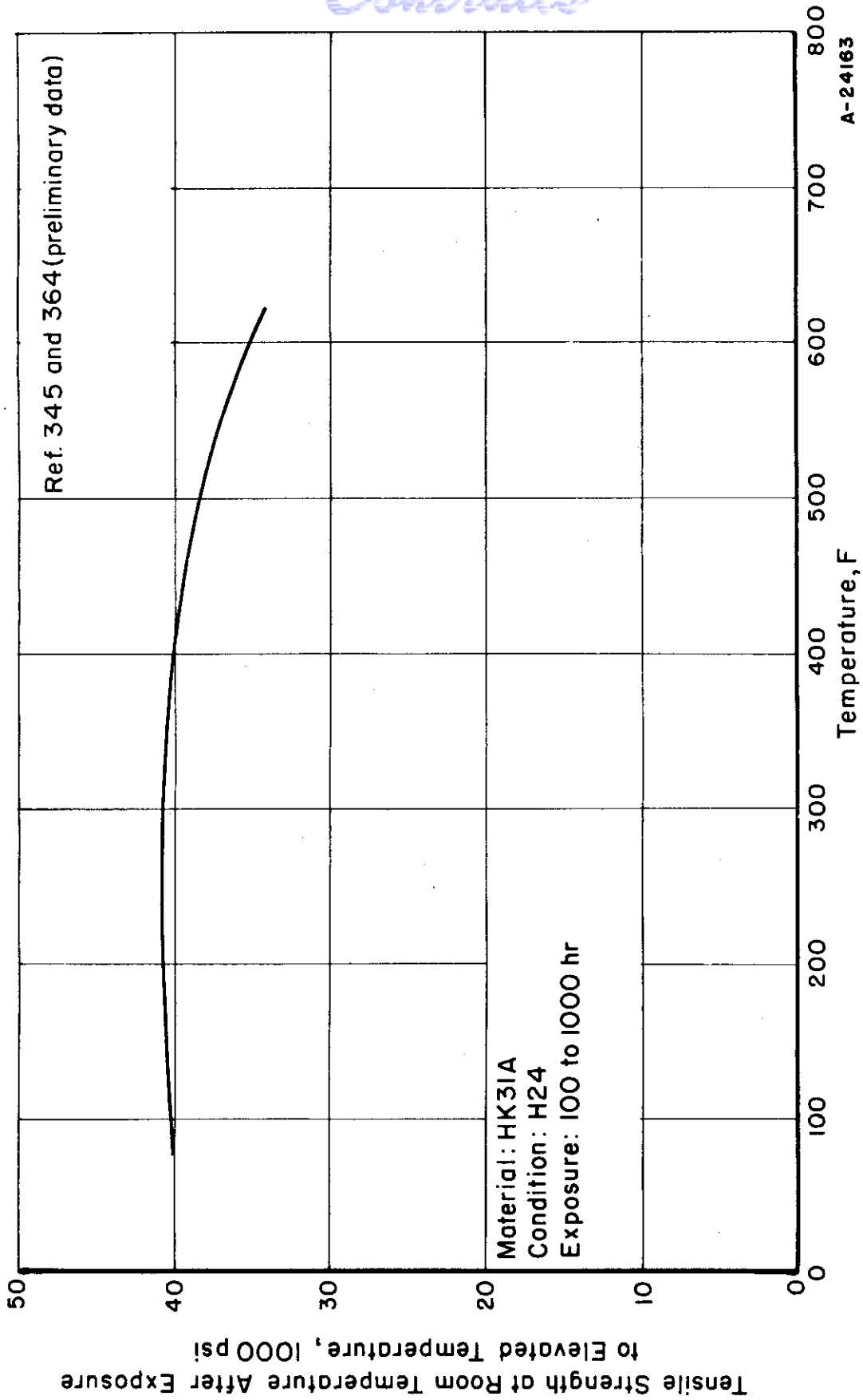


FIGURE 185. TENSILE STRENGTH DATA FOR HK31-H24 MAGNESIUM ALLOY TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

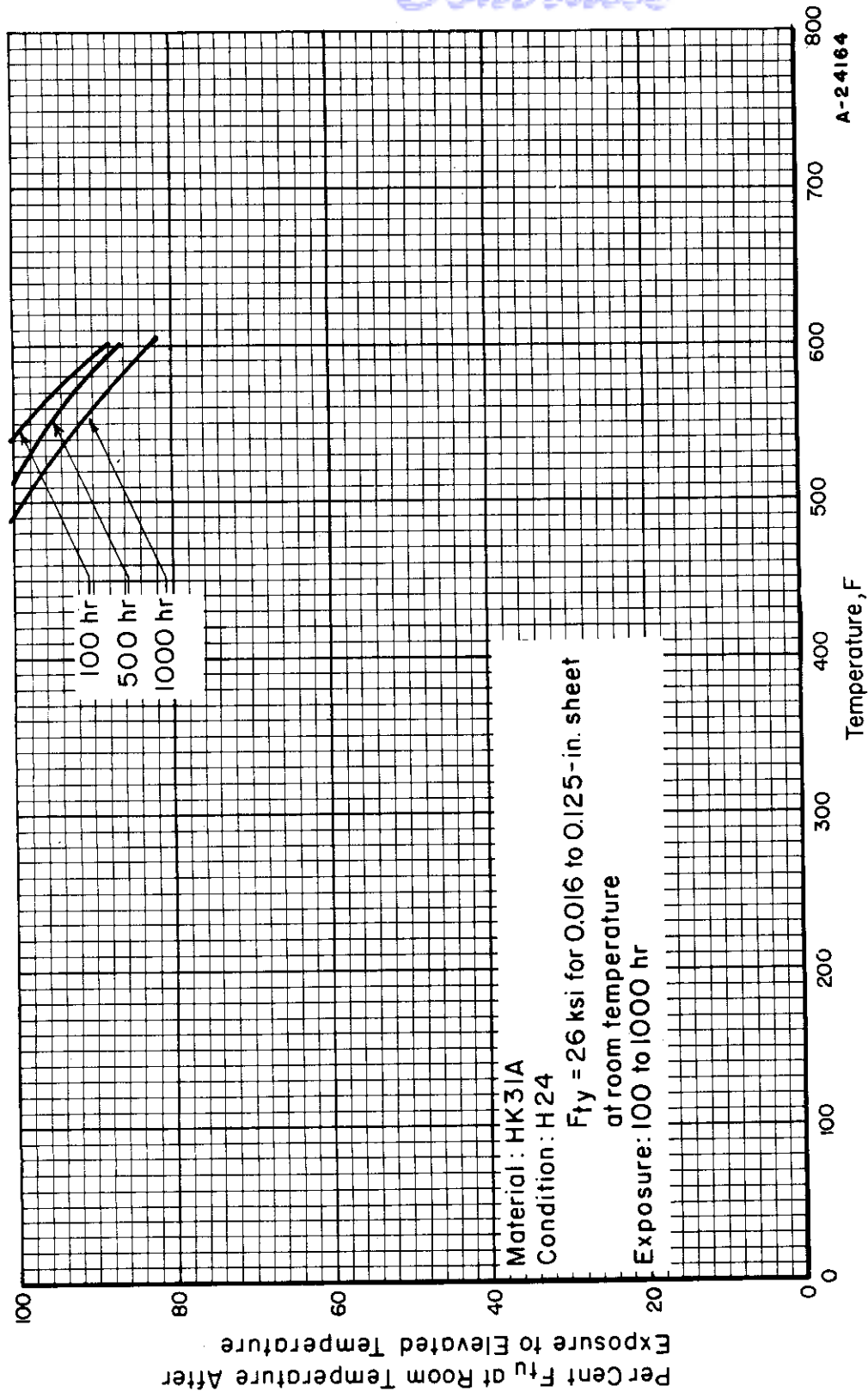
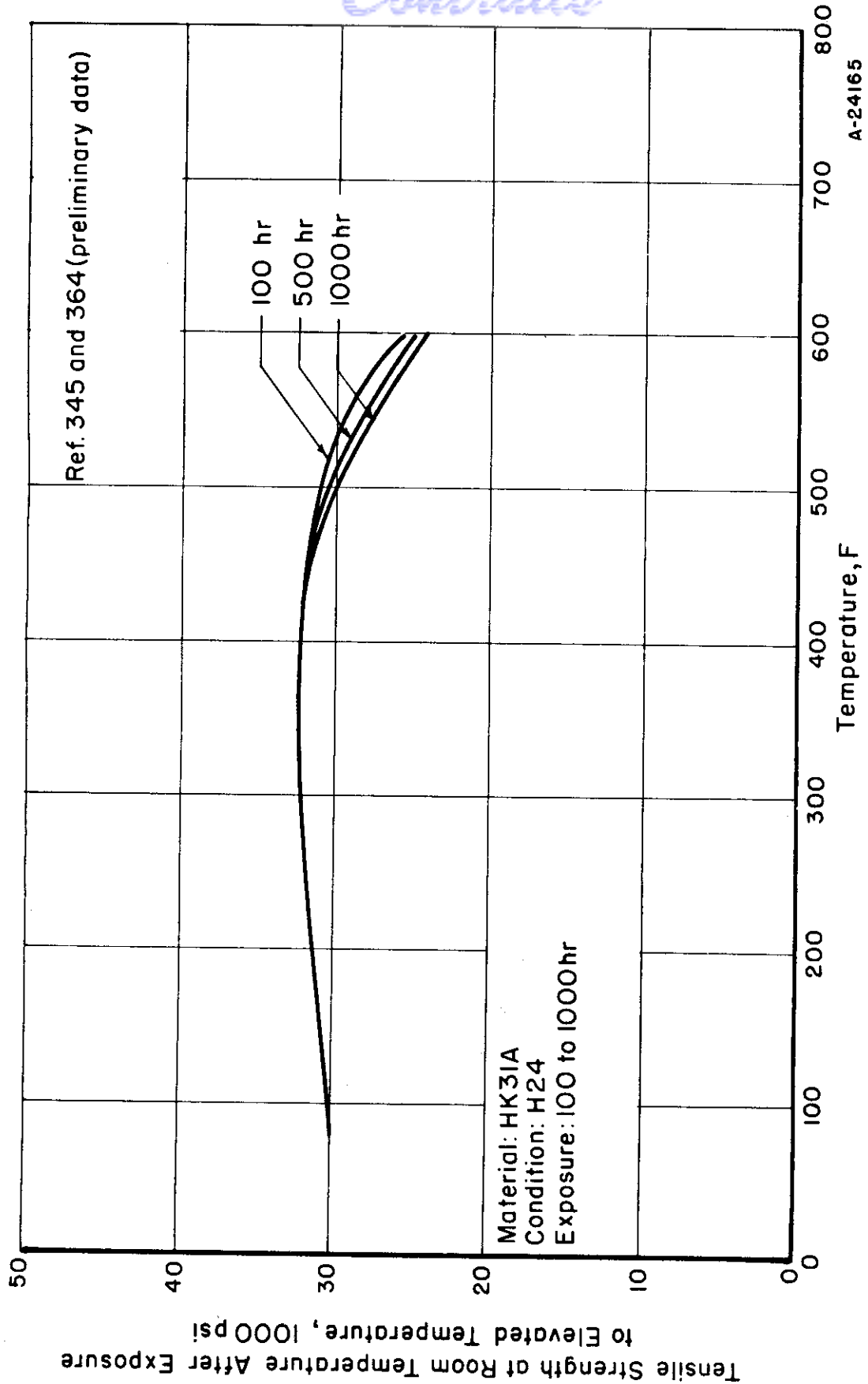


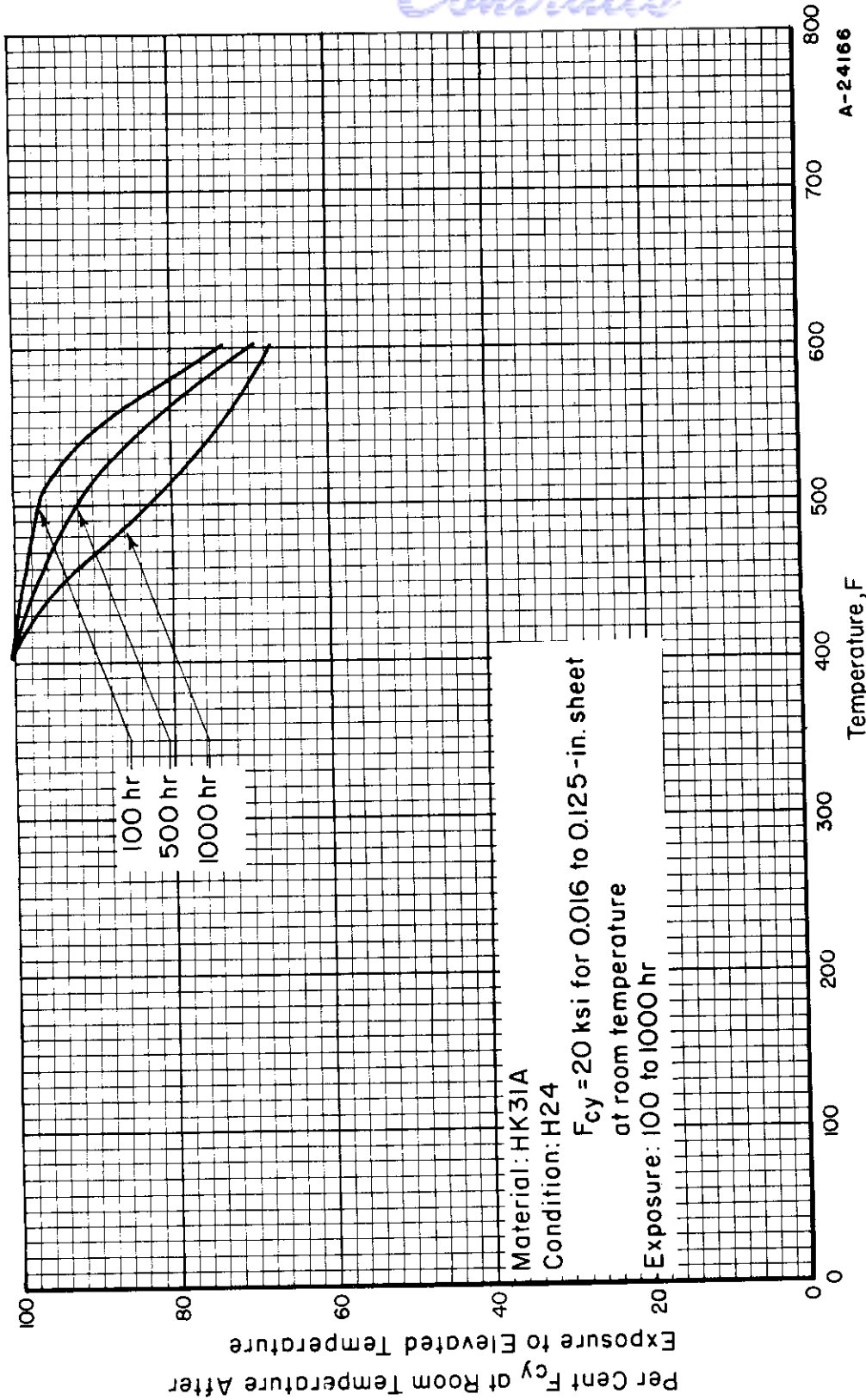
FIGURE 186. DESIGN CURVES FOR TENSILE YIELD STRENGTH (F_{ty}) OF HK31A-H24 MAGNESIUM ALLOY AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

Ref. 364, 345.



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FIGURE 187. TENSILE YIELD STRENGTH DATA FOR HK31A-H24 MAGNESIUM ALLOY TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)



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FIGURE 188. DESIGN CURVES FOR COMPRESSIVE YIELD STRENGTH (F_{cy}) OF HK31A-H24 MAGNESIUM ALLOY AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

Ref. 364.

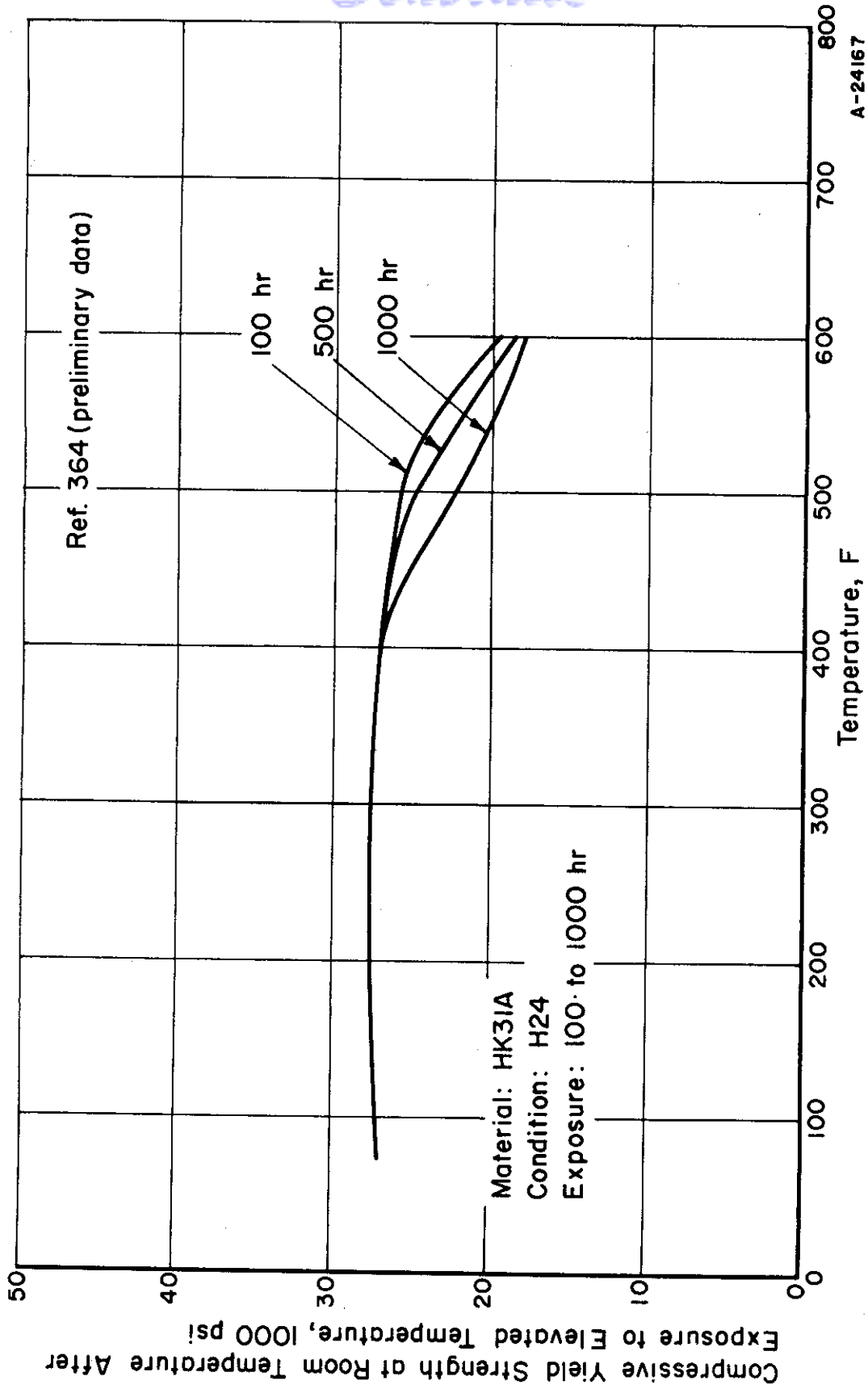


FIGURE 189. COMPRESSIVE YIELD STRENGTH DATA FOR HK31A-H24 MAGNESIUM ALLOY TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO ELEVATED TEMPERATURE (100 TO 1000-HOUR EXPOSURE)

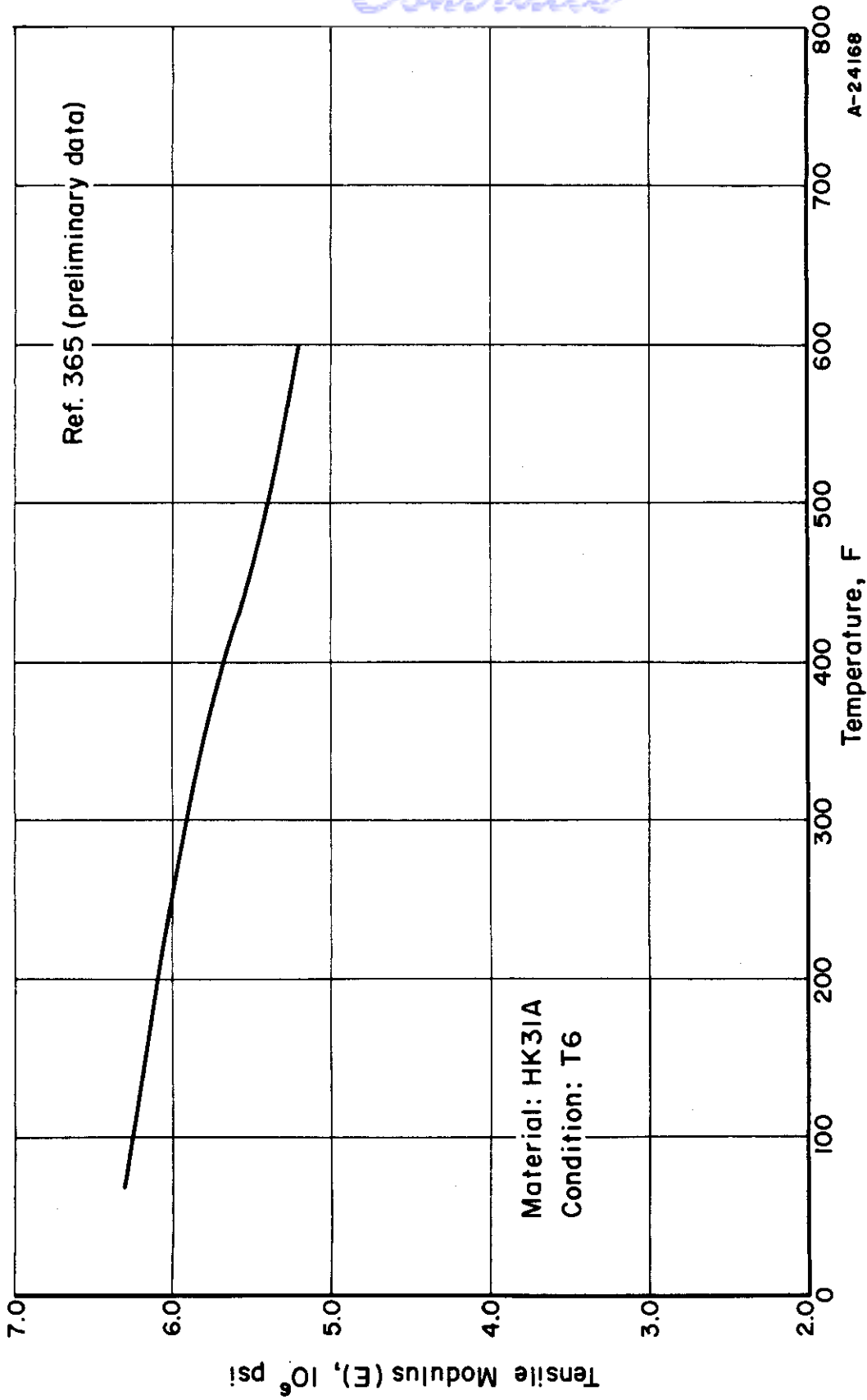


FIGURE 190. TENSILE MODULUS (E) OF HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE

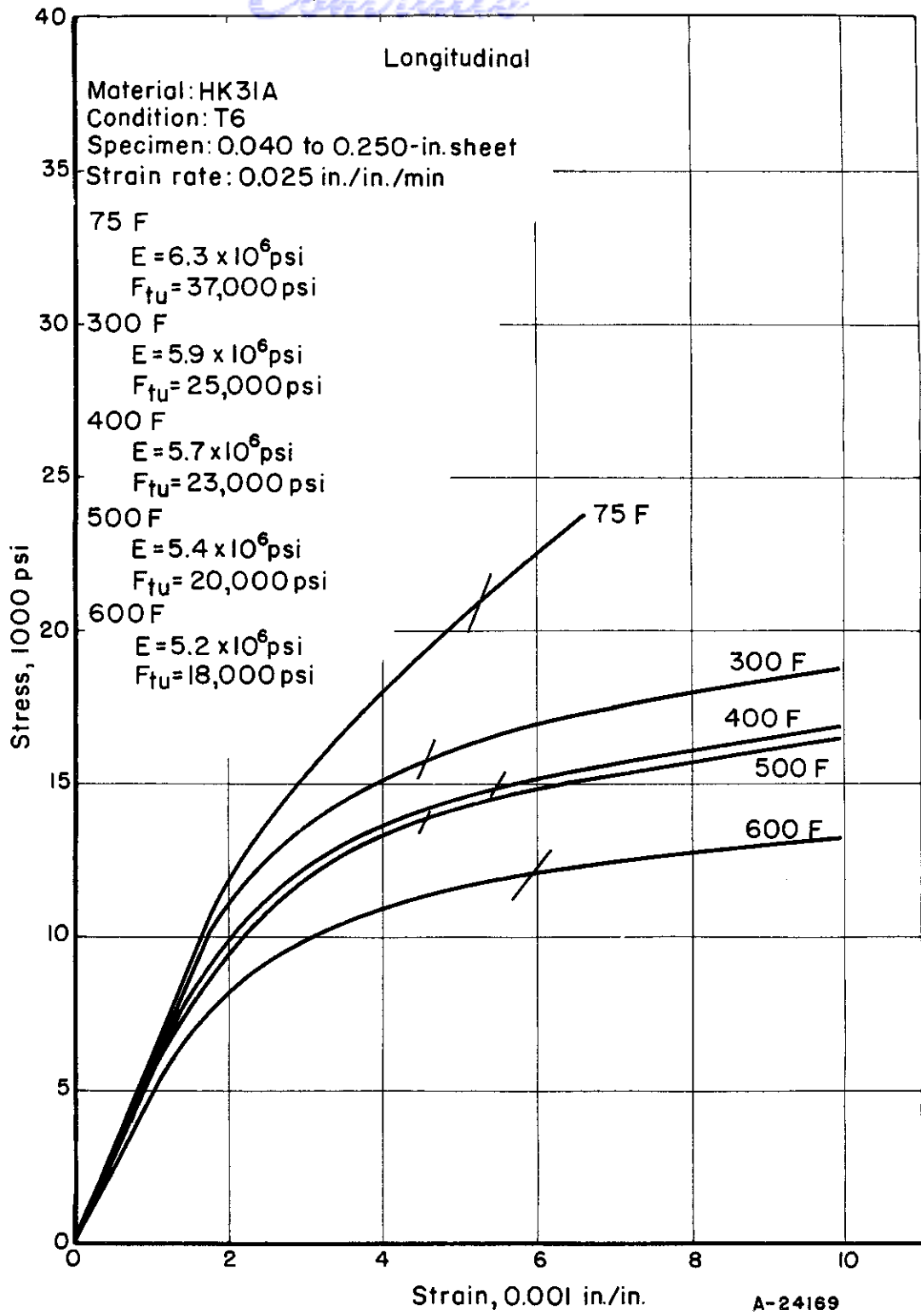


FIGURE 191. TENSILE STRESS-STRAIN CURVES FOR HK31A-T6 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE

Ref. 365.

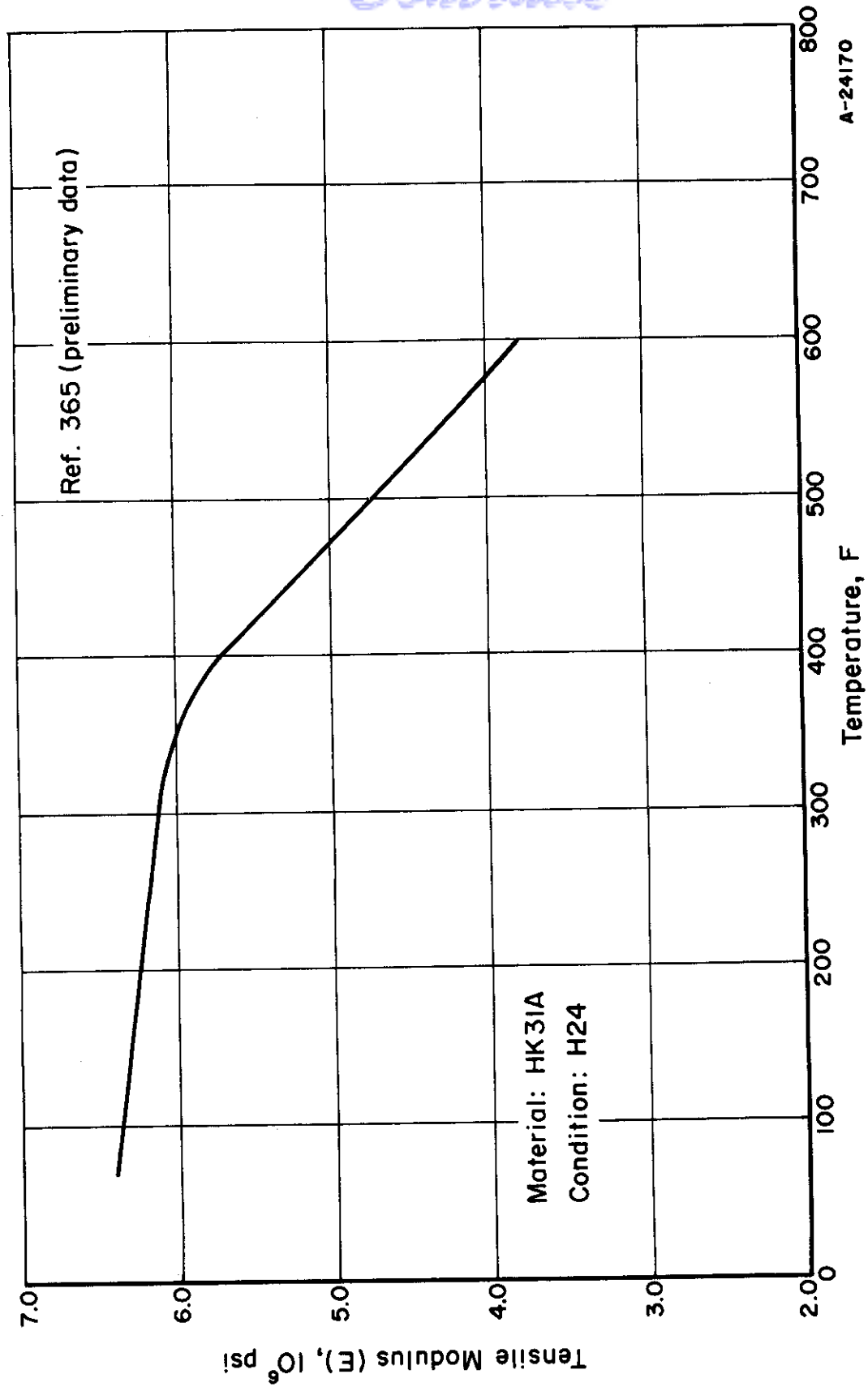


FIGURE 192. TENSILE MODULUS (E) OF HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE

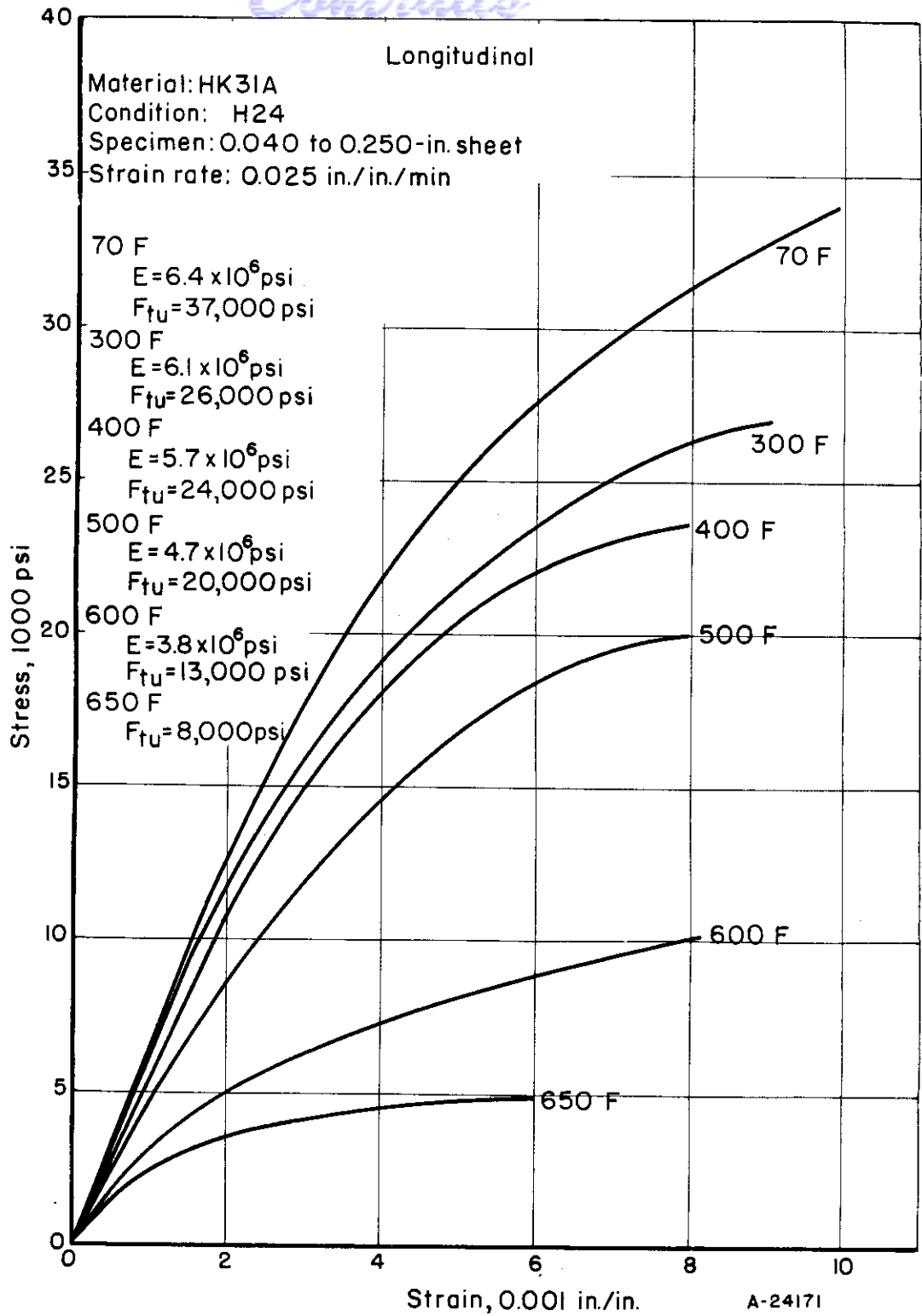


FIGURE 193. TENSILE STRESS-STRAIN CURVES FOR HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE

Ref. 365.

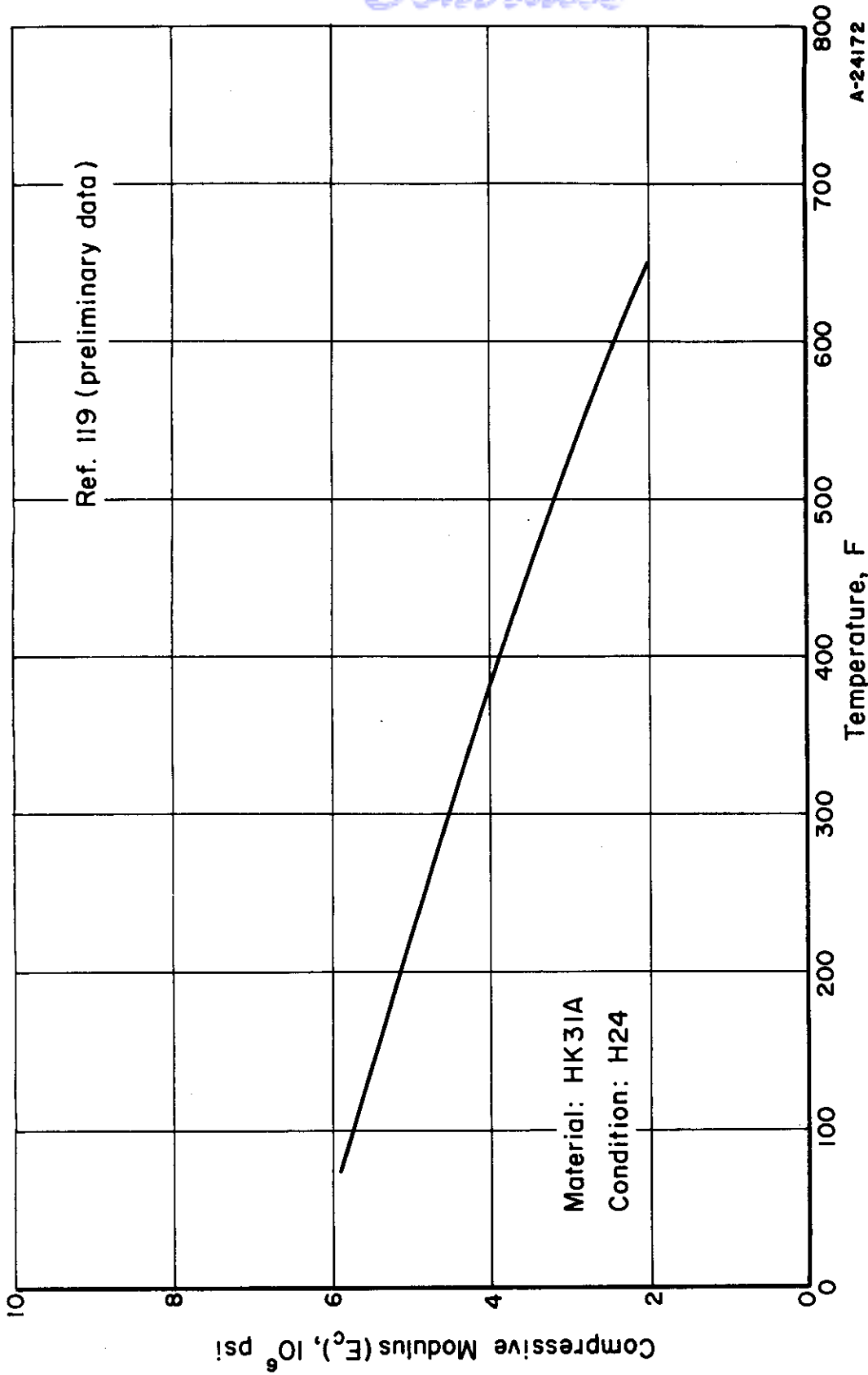


FIGURE 194. COMPRESSIVE MODULUS (E_c) OF HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE

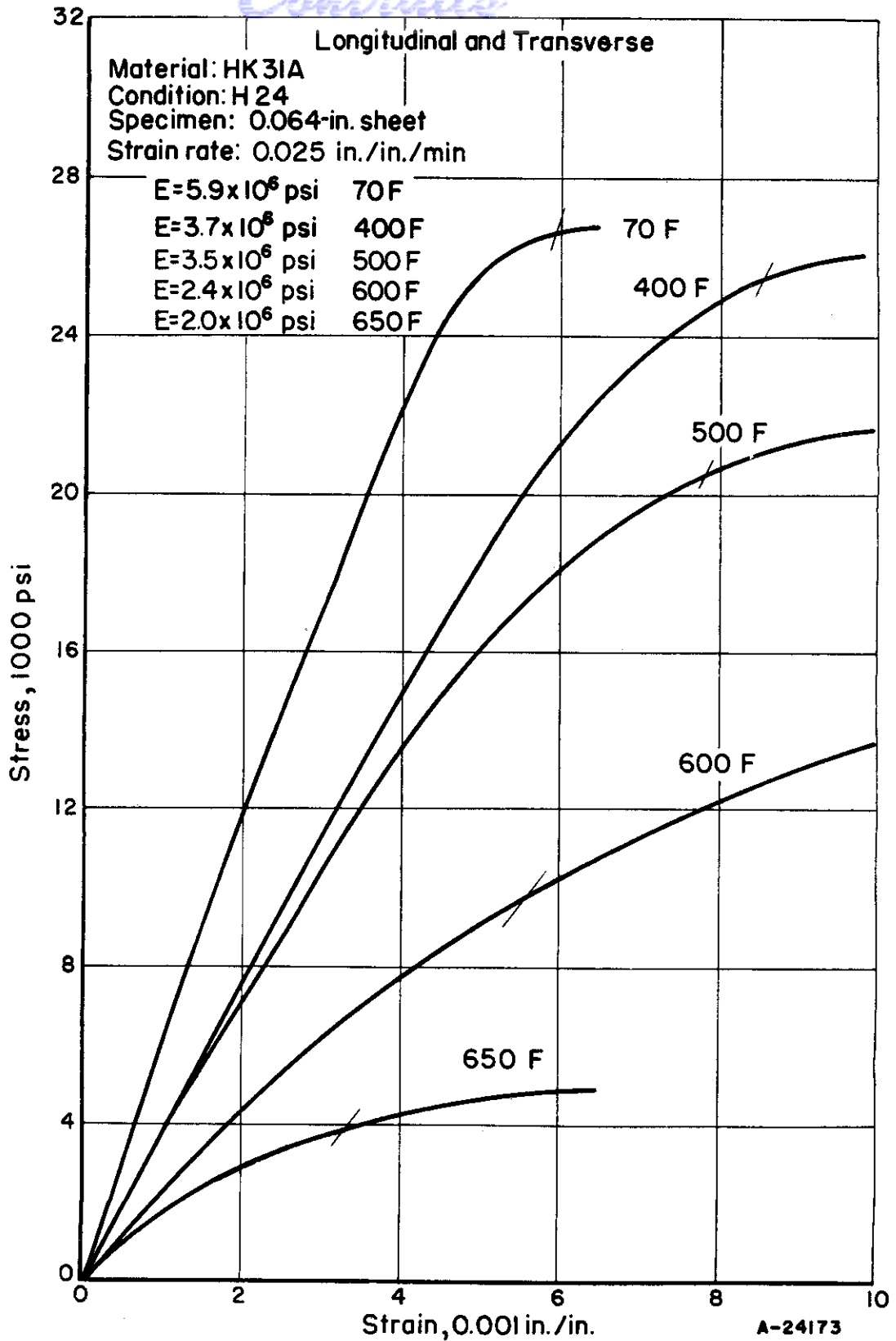


FIGURE 195. COMPRESSIVE STRESS-STRAIN CURVES FOR HK31A-H24 MAGNESIUM ALLOY AT ELEVATED TEMPERATURE

Ref. 119, p 10.

Continuity
Ti-8Mn TITANIUM ALLOY

Alloy Specifications

MIL-T-9046, Class 1
AMS 4908A

General

Ti-8Mn is an alpha-beta type titanium alloy. It exhibits reasonable stability and good strength at temperatures up to about 800 F. The limiting chemical composition of Ti-8Mn is given in Table 13.

TABLE 13. CHEMICAL-COMPOSITION LIMITS
OF 8Mn TITANIUM ALLOY

Element	Weight Per Cent
Manganese	7.0 - 9.0
Carbon	0.20 max
Other elements, total	0.80 max
Titanium	91.0 min

Ti-8Mn is usually used in the annealed condition and has the minimum mechanical properties given in Table 14. Ti-8Mn may be annealed by heating for 1 hour at 1200 - 1300 F, furnace cooling about 5 F/min to below 1050 F, and then air cooling to room temperature.

TABLE 14. MINIMUM MECHANICAL PROPERTIES OF
8Mn TITANIUM ALLOY (AMS 4908)

Property	
Ultimate tensile (F_{tu})	120,000 psi
Tensile yield (F_{ty})	110,000 psi
Elongation (e) in 2 inches	10 per cent

The conventional short-time elevated-temperature properties of Ti-8Mn are shown in the following curves:

Tensile strength	Figures 196 and 197
Tensile yield strength	Figures 198 and 199
Compressive yield strength	Figures 200 and 201
Shear strength	Figures 202 and 203
Bearing strength	Figures 204 and 205
Bearing yield strength	Figures 206 and 207
Modulus of elasticity	Figures 208 and 215
Stress-strain curves	Figures 209 through 214, 216 through 224.

Heat Treatment

Ti-8Mn may be hardened by heating into the alpha-beta solutioning range between about 1250 and 1450 F, quenching to retain the beta formed during solutioning, and subsequently heating to between 800 and 1000 F to precipitate a fine alpha dispersion in retained beta. The heat treatment of titanium alloys, in general, is currently receiving much attention and has not reached the level of confidence nor the ease in handling enjoyed by many other metal alloy compositions. This situation is being overcome by the rapid advancement of titanium technology. Data contained in this report have been limited to the annealed condition of the alloy.

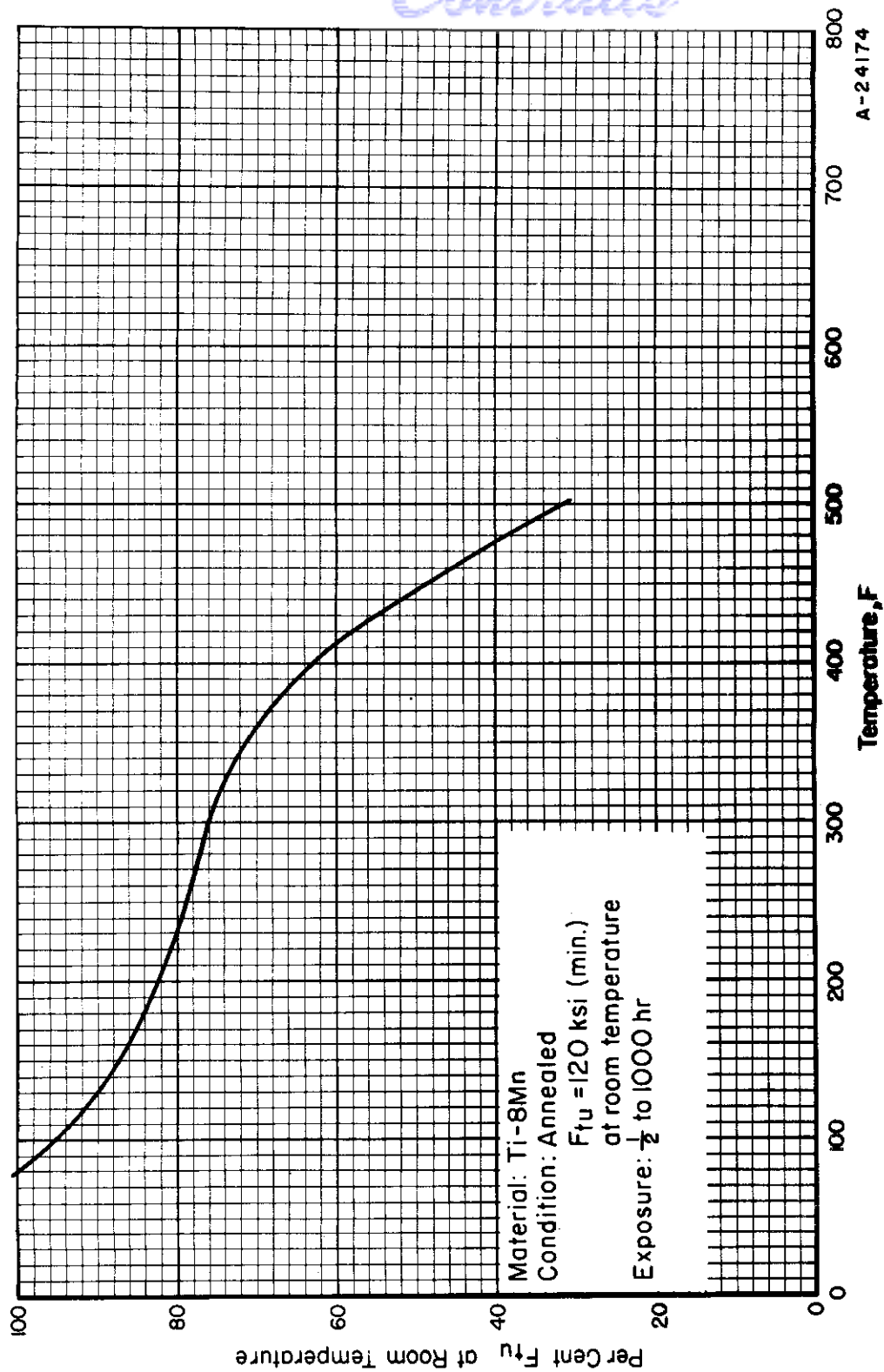


FIGURE 196. DESIGN CURVE FOR TENSILE STRENGTH (F_{tu}) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58, 369, 368.

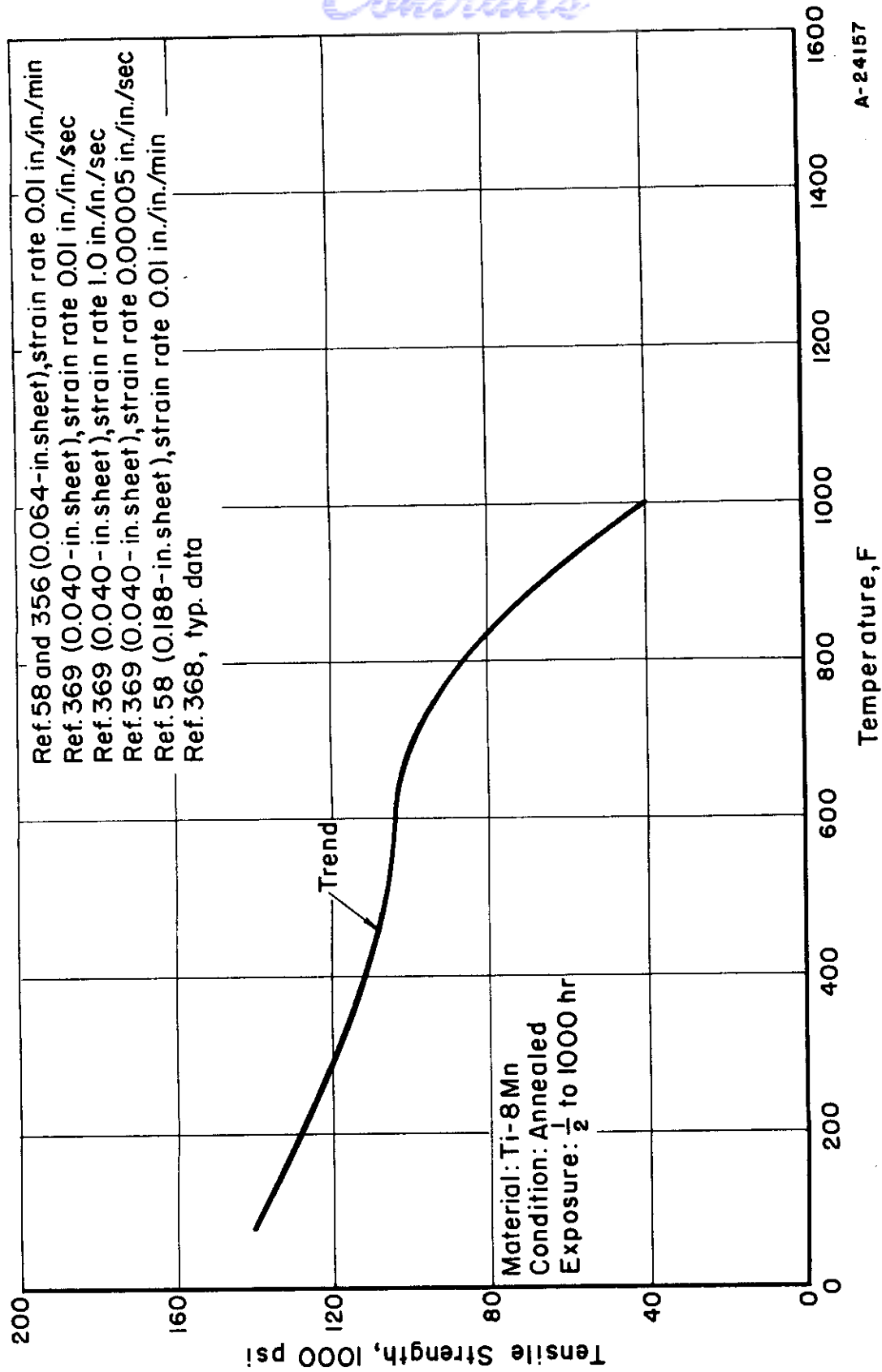


FIGURE 197. TENSILE STRENGTH DATA FOR Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

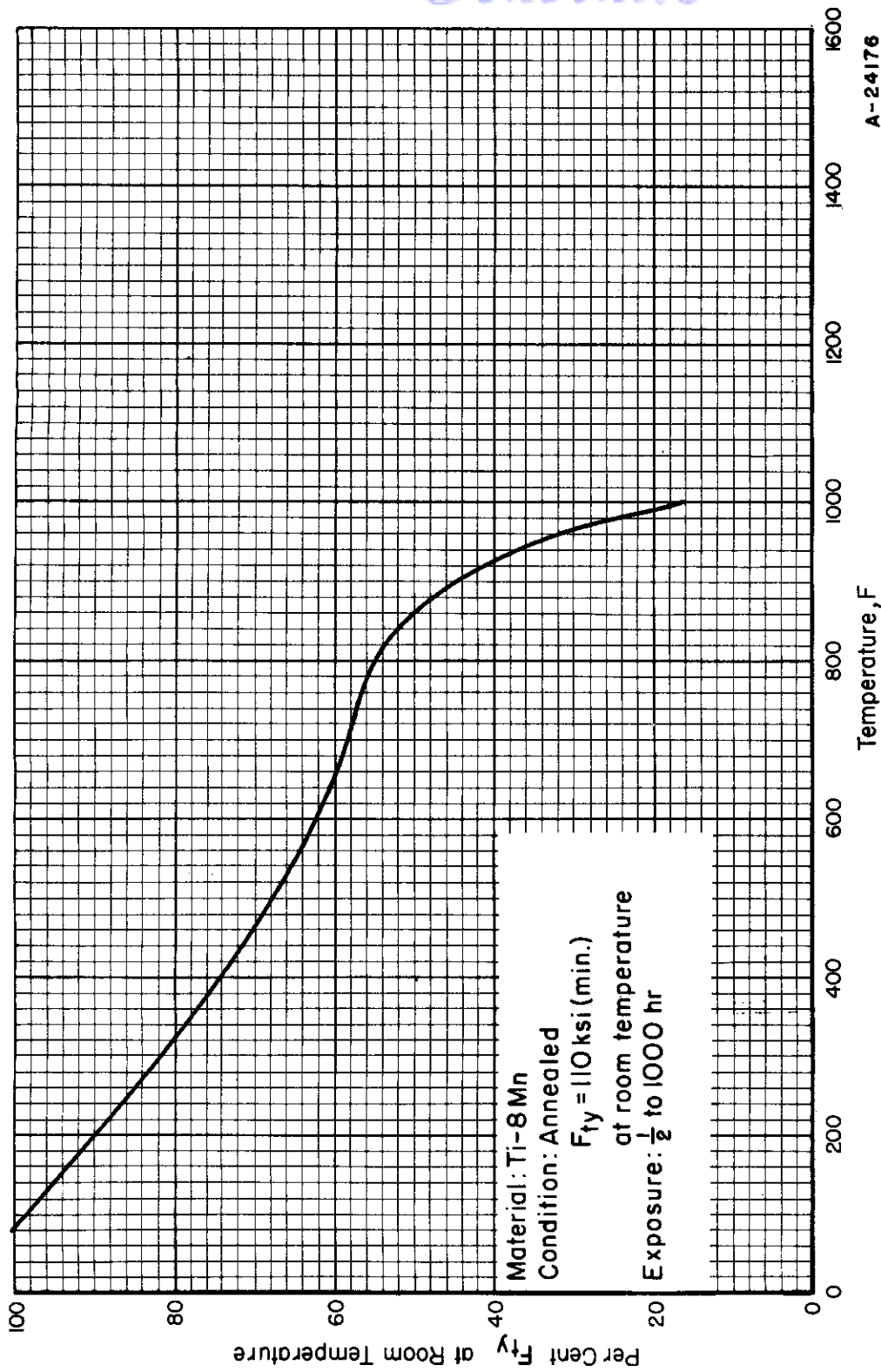
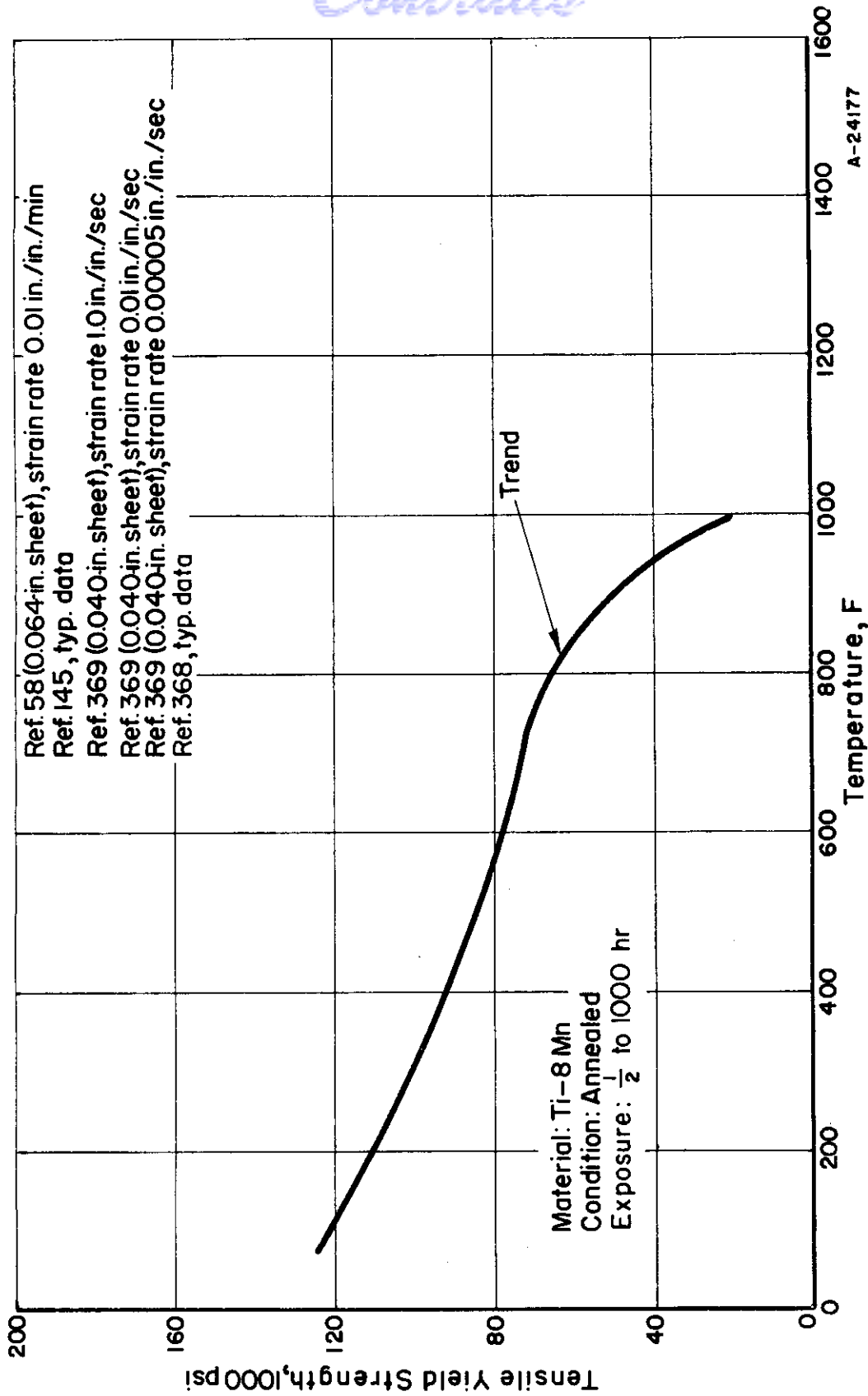


FIGURE 198. DESIGN CURVE FOR TENSILE YIELD STRENGTH (F_{ty}) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58, 368, 369, 145.



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FIGURE 199. TENSILE YIELD STRENGTH DATA FOR Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

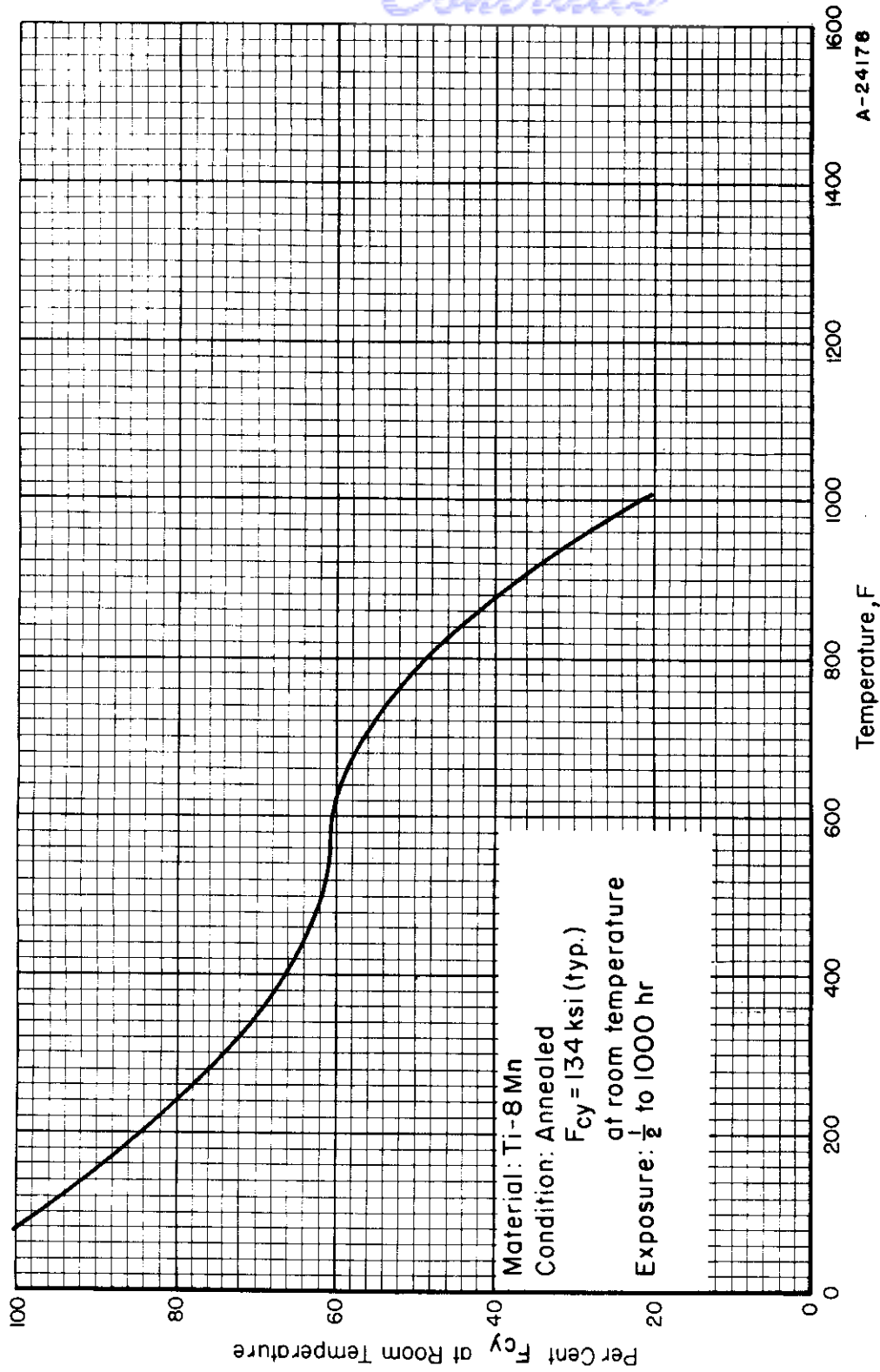
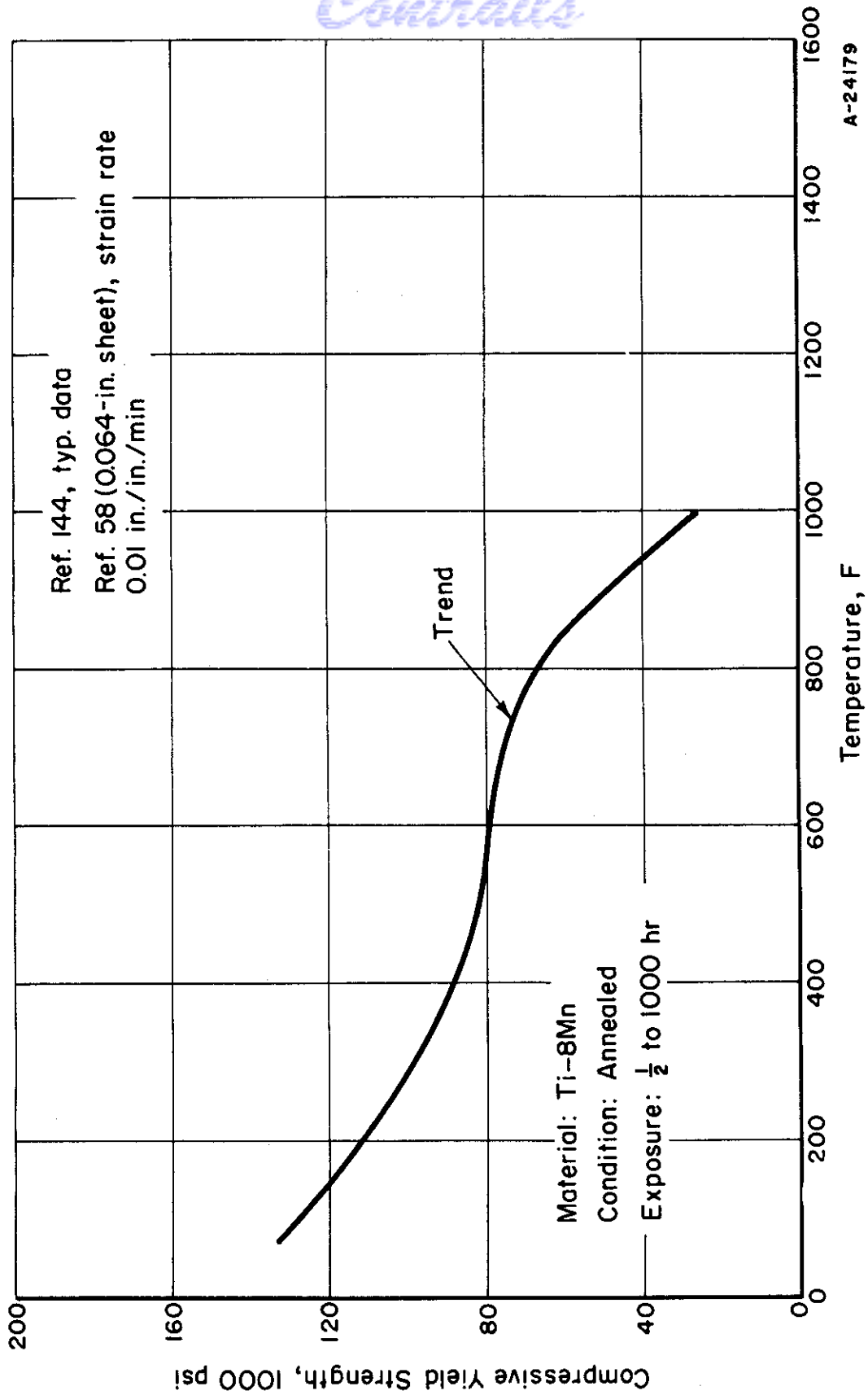


FIGURE 200. DESIGN CURVE FOR COMPRESSION YIELD STRENGTH (F_{cy}) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 144, 58.



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FIGURE 201. COMPRESSIVE YIELD STRENGTH DATA FOR Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

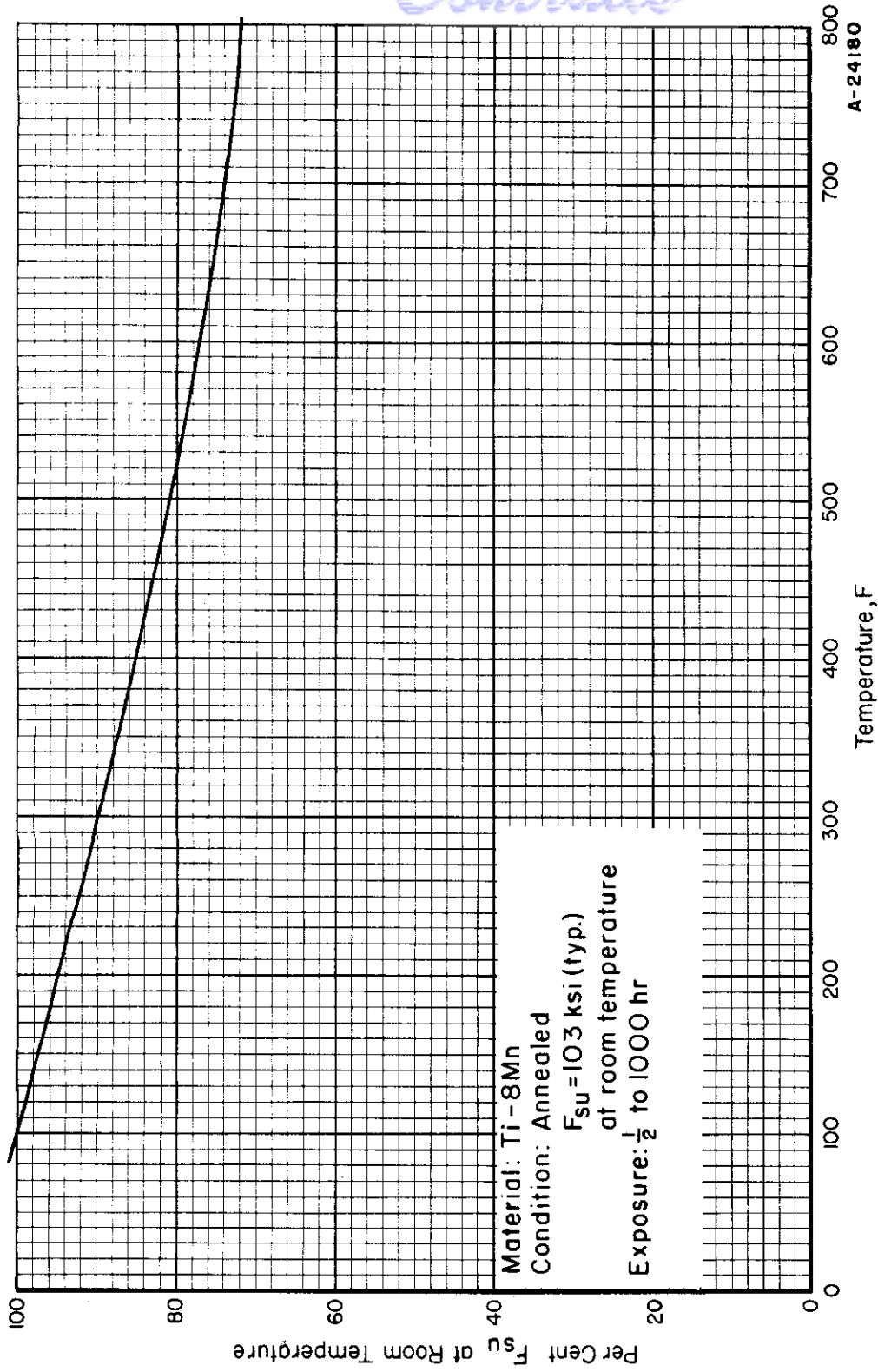


FIGURE 202. DESIGN CURVE FOR SHEAR STRENGTH (F_{su}) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

Ref. 58.

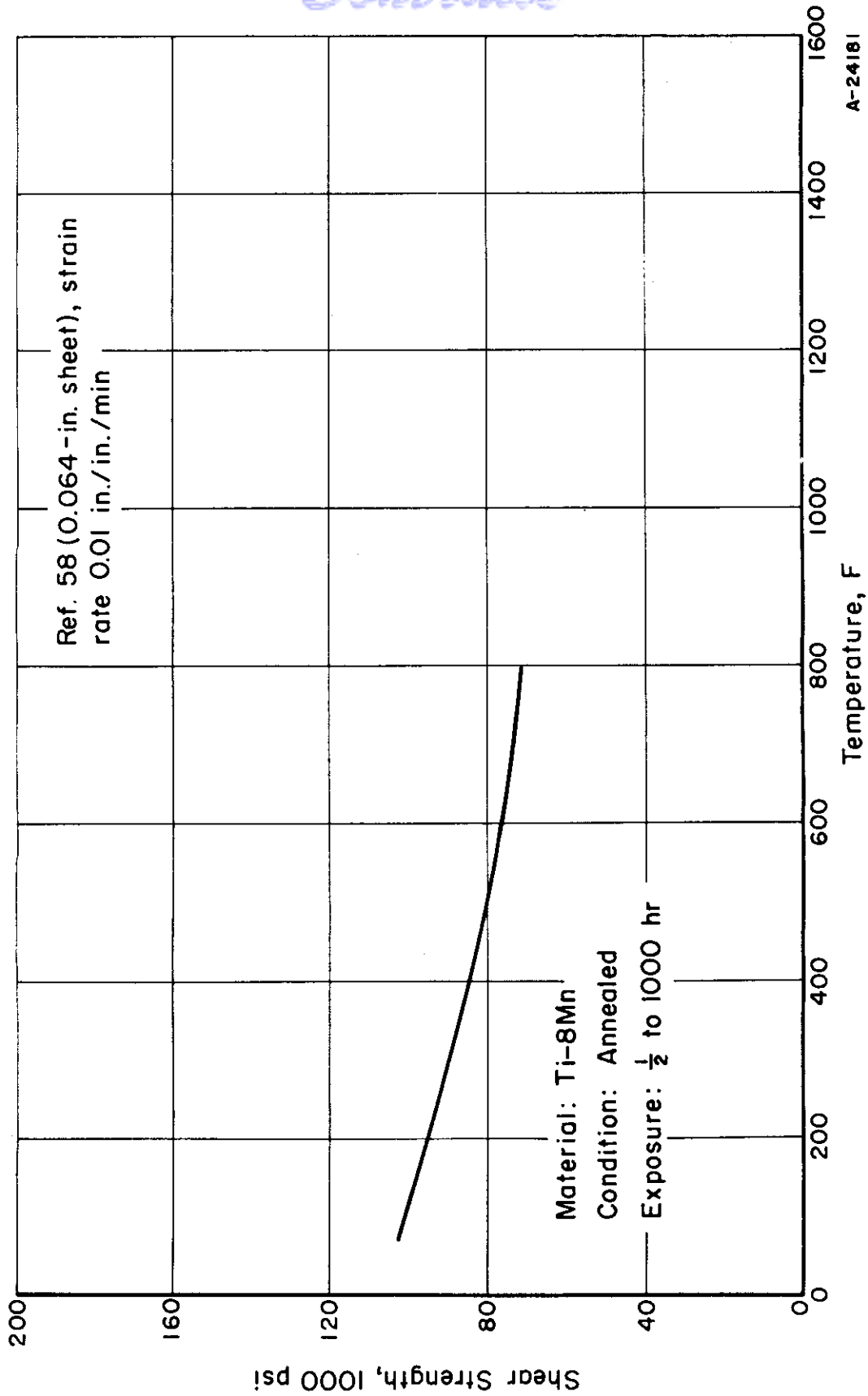


FIGURE 203. SHEAR STRENGTH DATA FOR Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2 TO 1000-HOUR EXPOSURE)

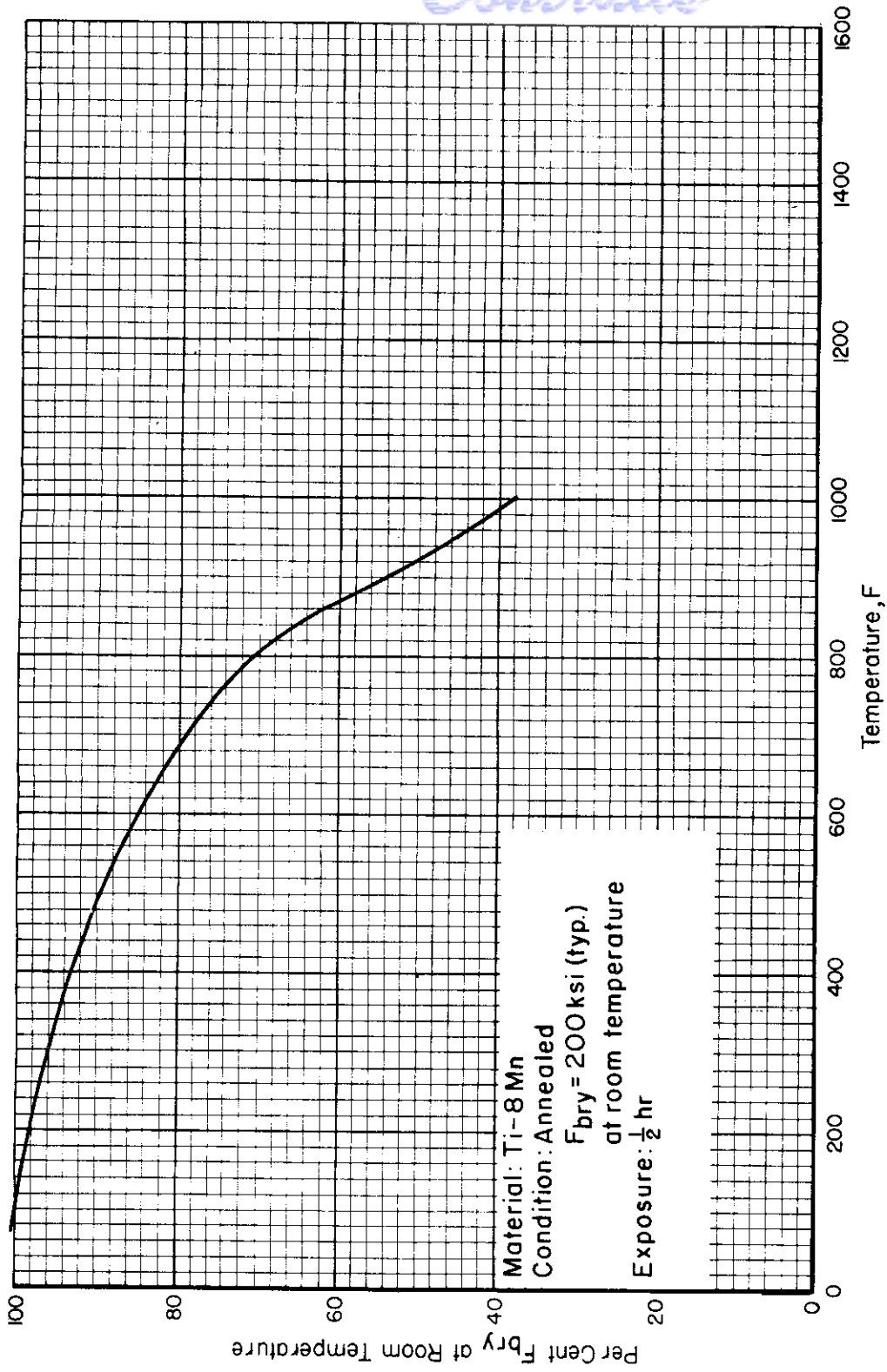
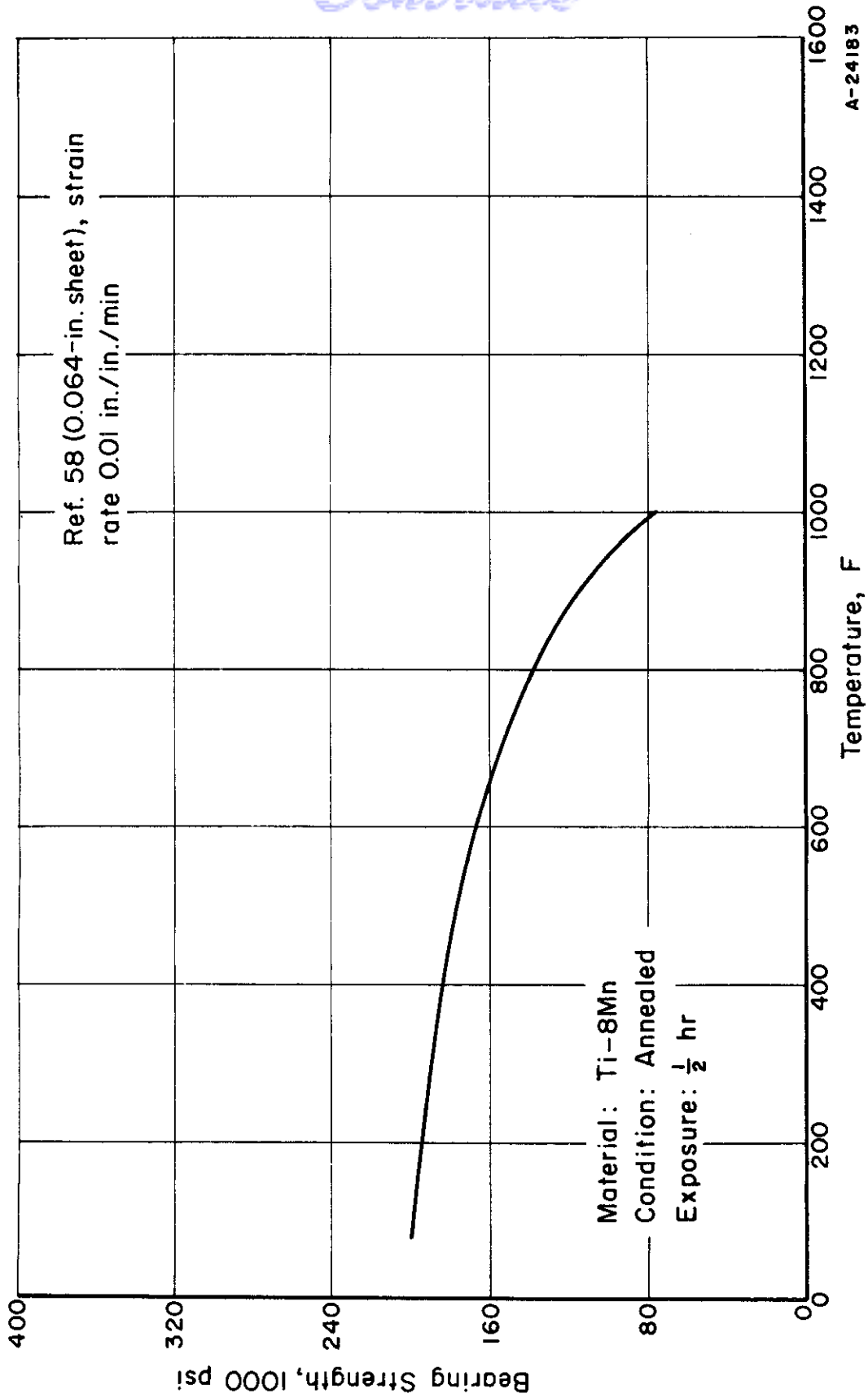


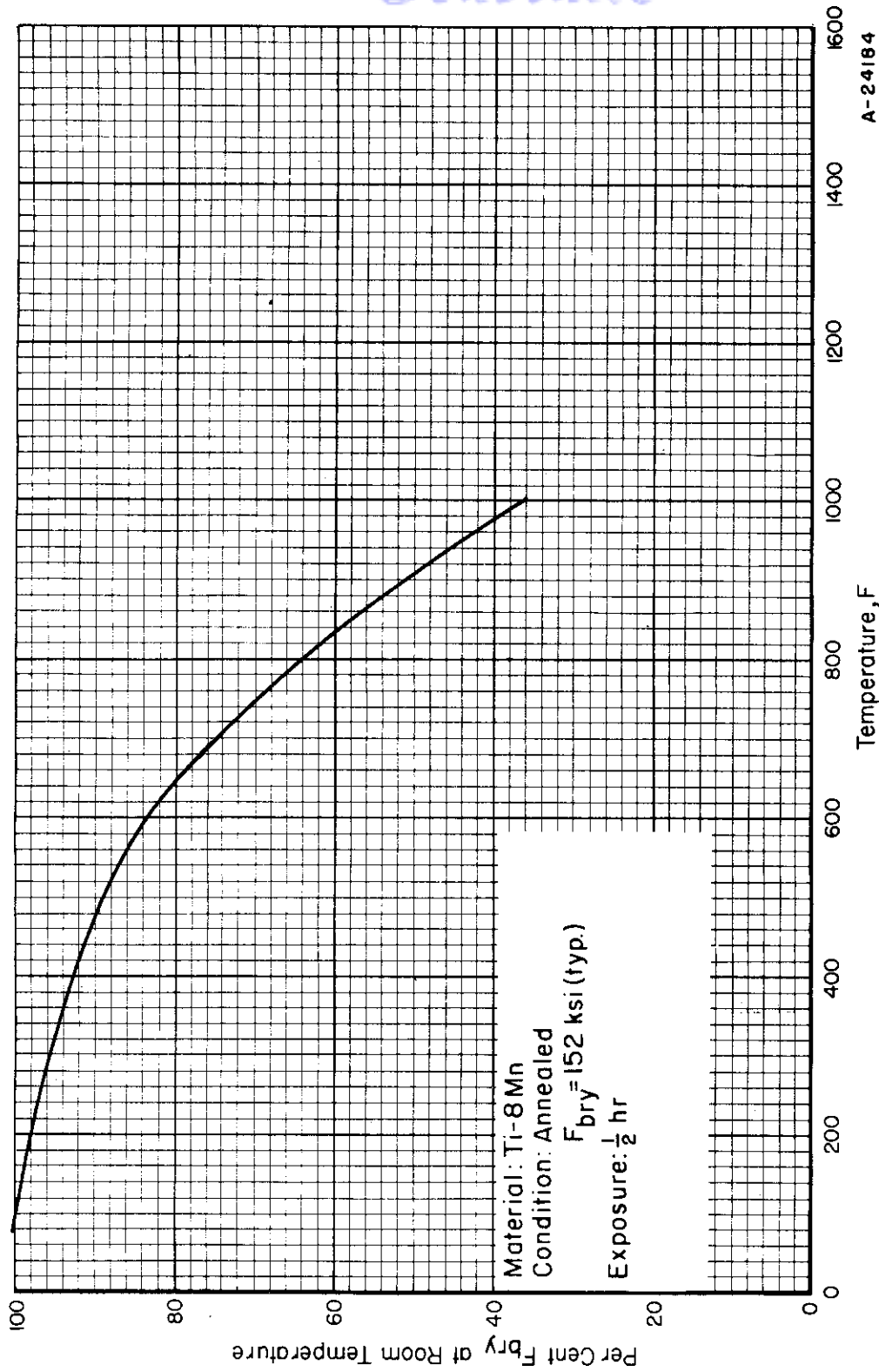
FIGURE 204. DESIGN CURVE FOR BEARING STRENGTH (F_{bru}) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE.)

Ref. 58.



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FIGURE 205. BEARING STRENGTH DATA FOR Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



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FIGURE 206. DESIGN CURVE FOR BEARING YIELD STRENGTH (F_{bry}) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)

Ref. 58.

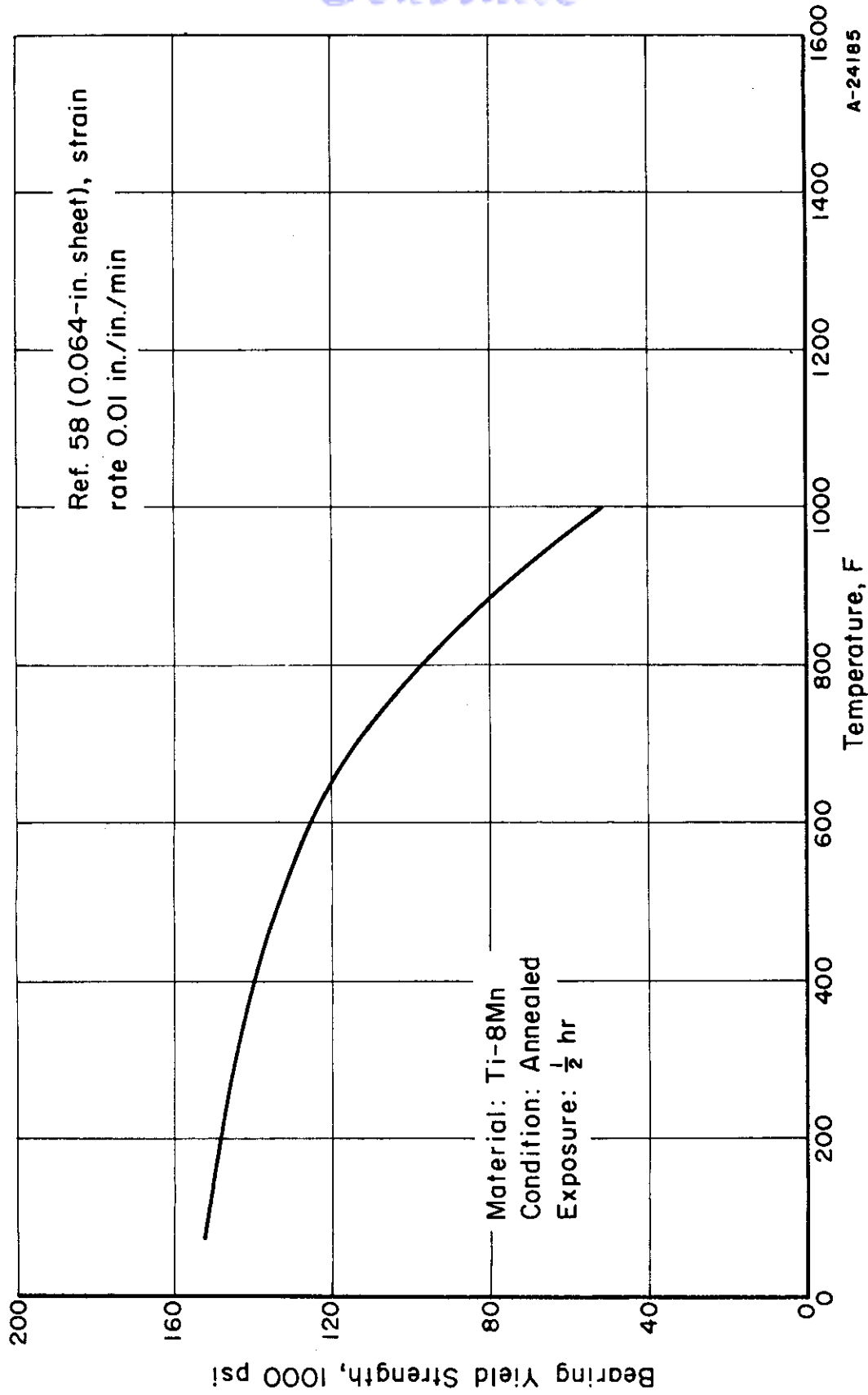
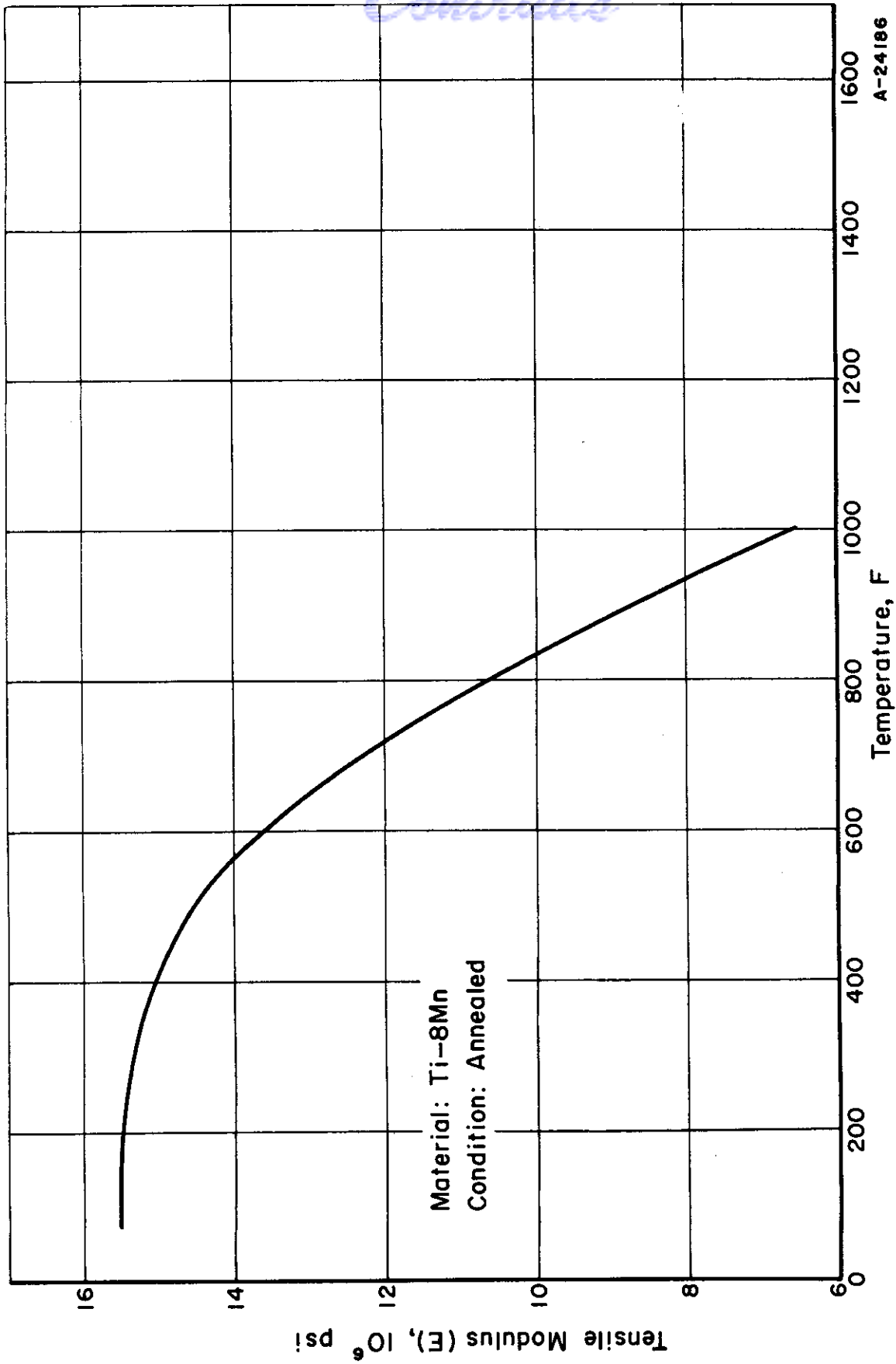


FIGURE 207. BEARING YIELD STRENGTH DATA FOR Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE (1/2-HOUR EXPOSURE)



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FIGURE 208. TENSILE MODULUS (E) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE

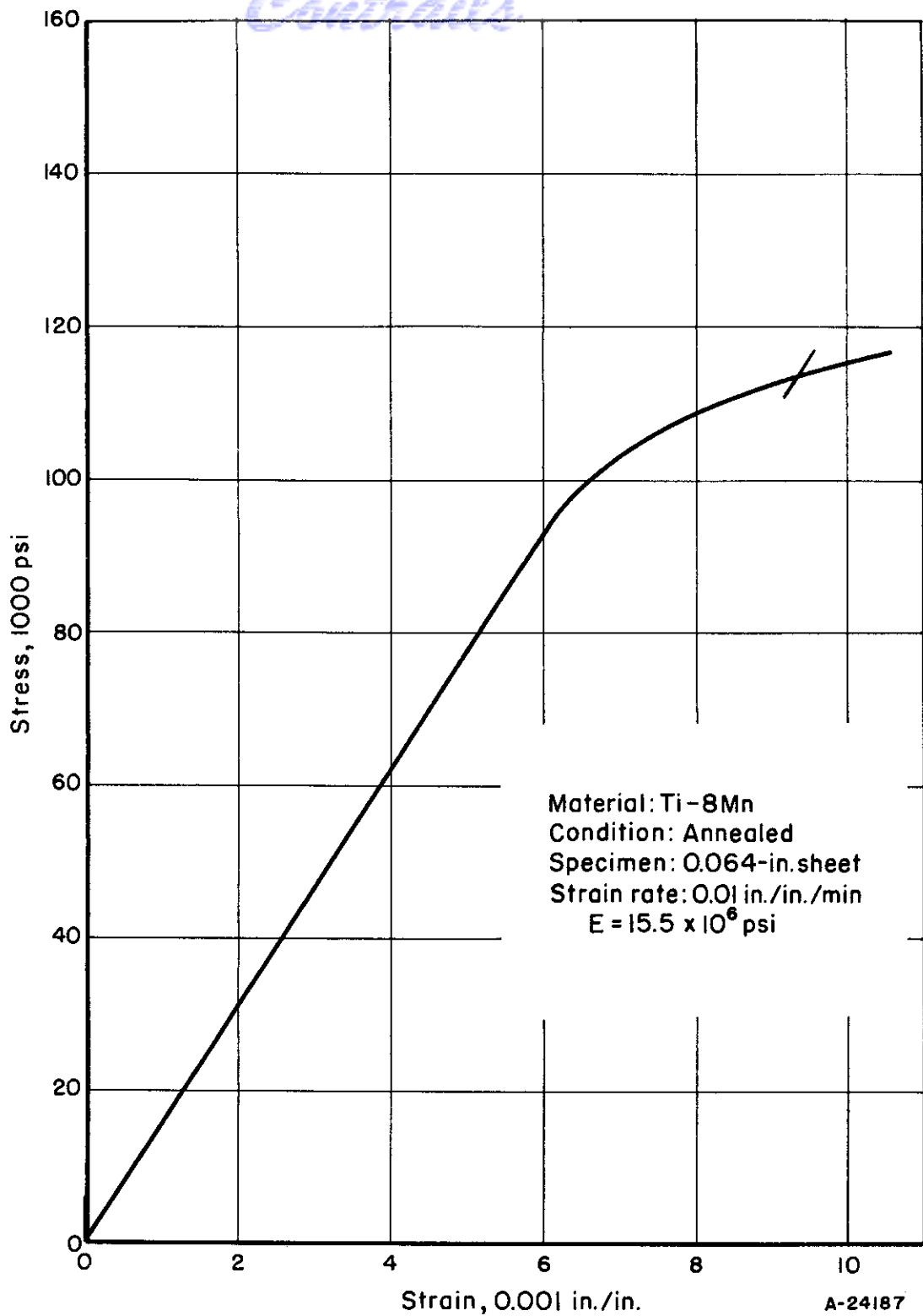


FIGURE 209. TENSILE STRESS-STRAIN CURVE FOR Ti-8Mn TITANIUM ALLOY AT ROOM TEMPERATURE

Ref. 58, 248, 207.

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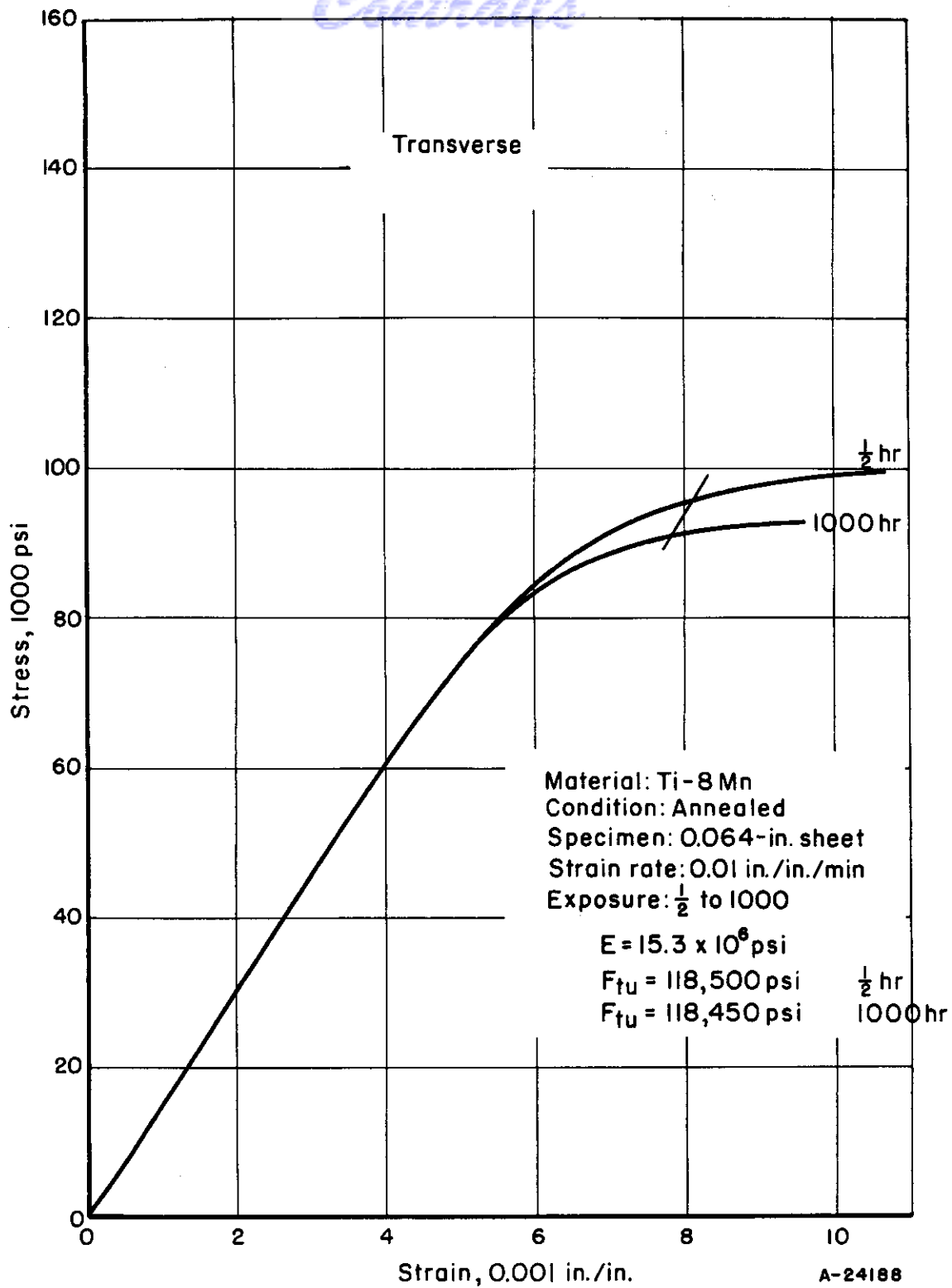


FIGURE 210. TENSILE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 300 F

Ref. 58.

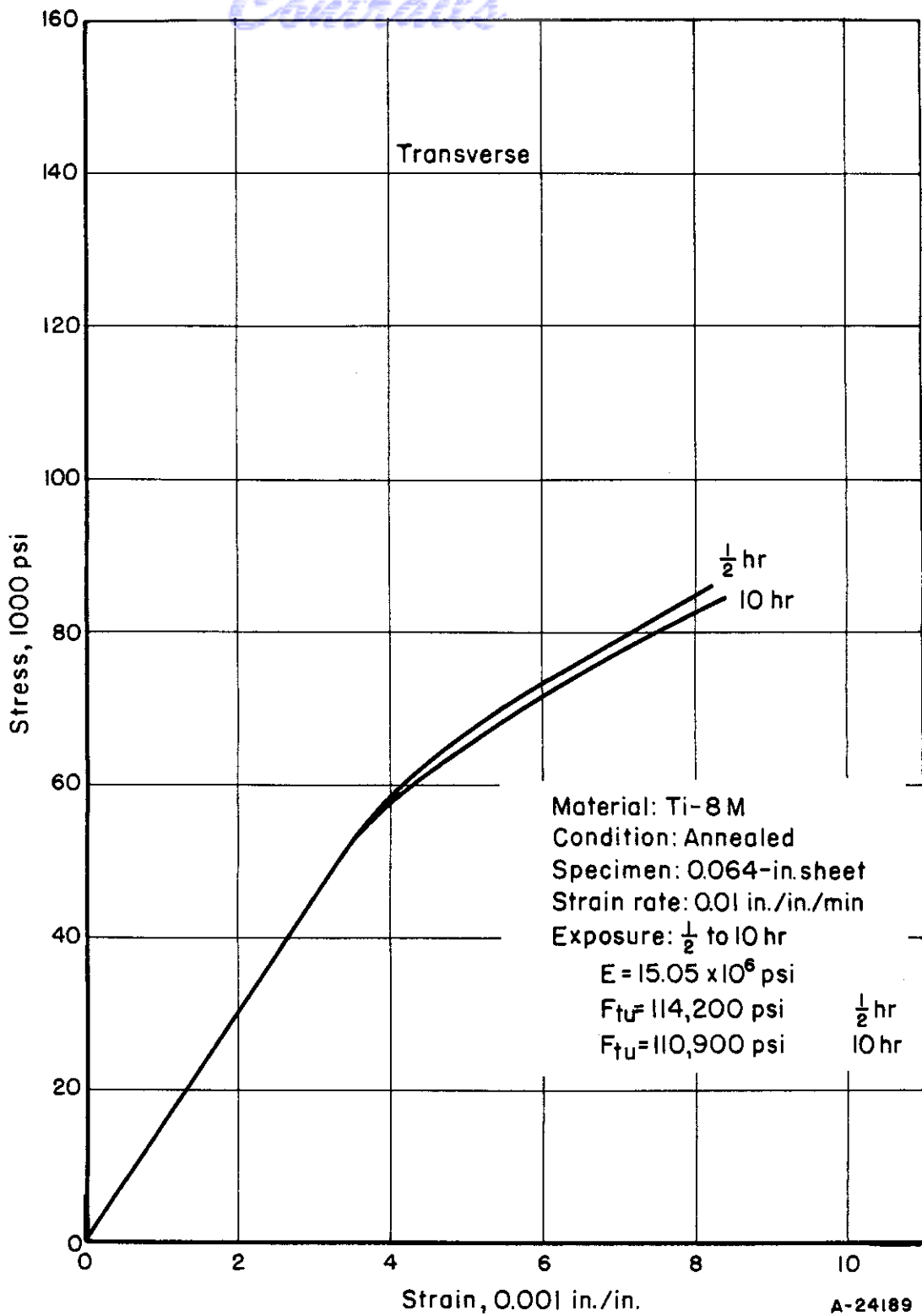


FIGURE 211. TENSILE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 400 F

Ref. 356.

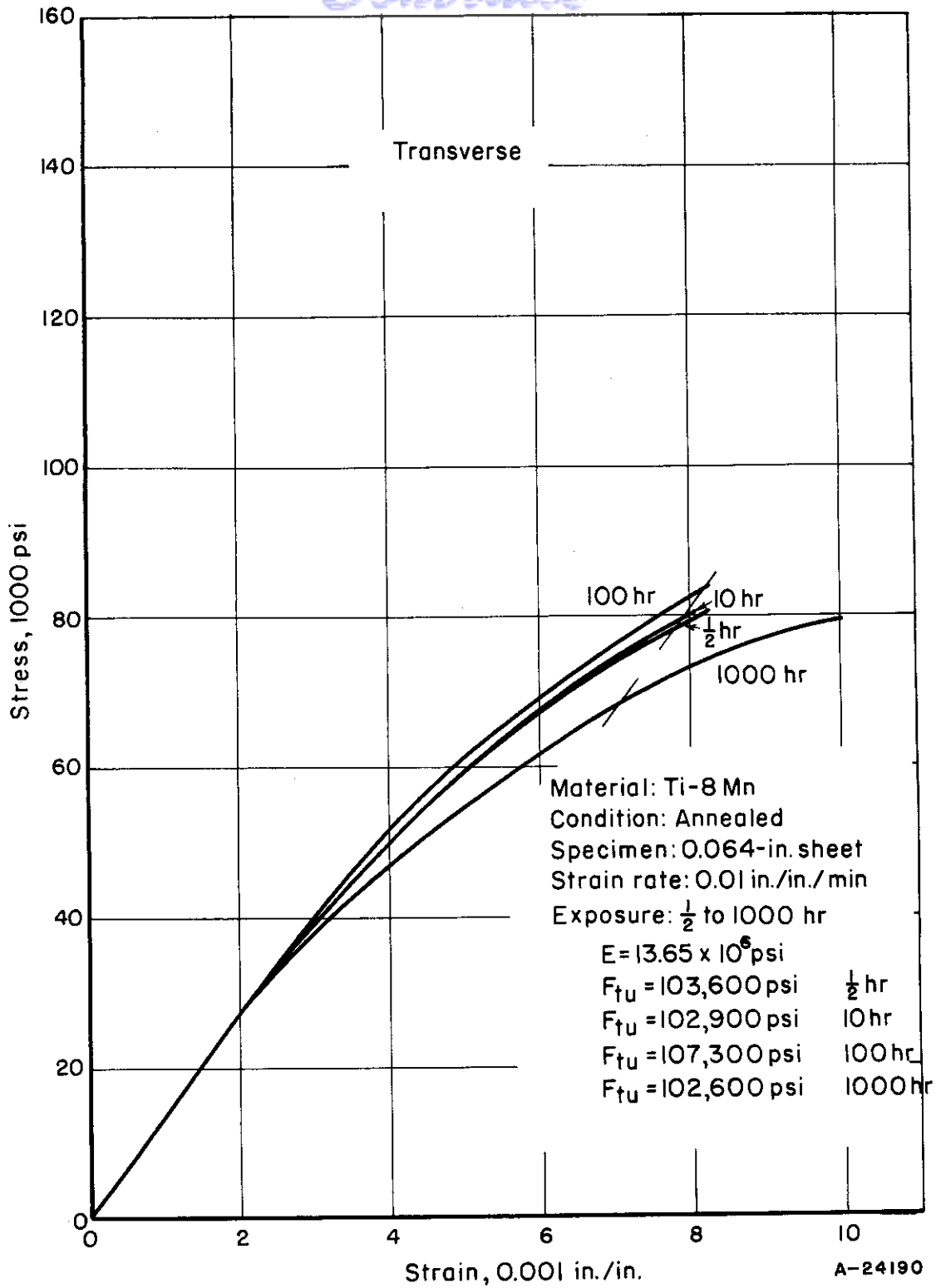


FIGURE 212. TENSILE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 600 F

Ref. 356.
Ref. 58.

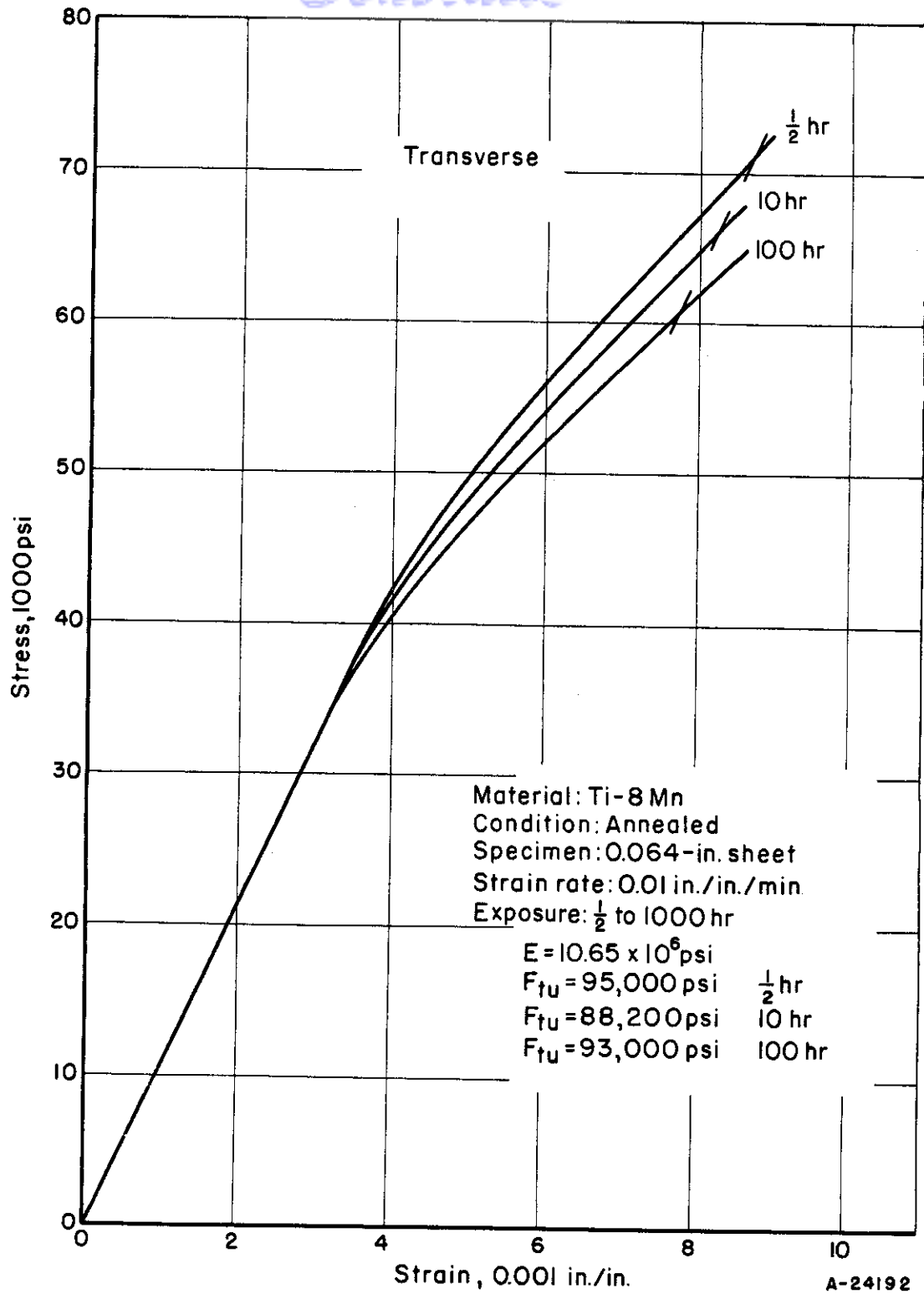


FIGURE 213. TENSILE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 800 F

Ref. 356.

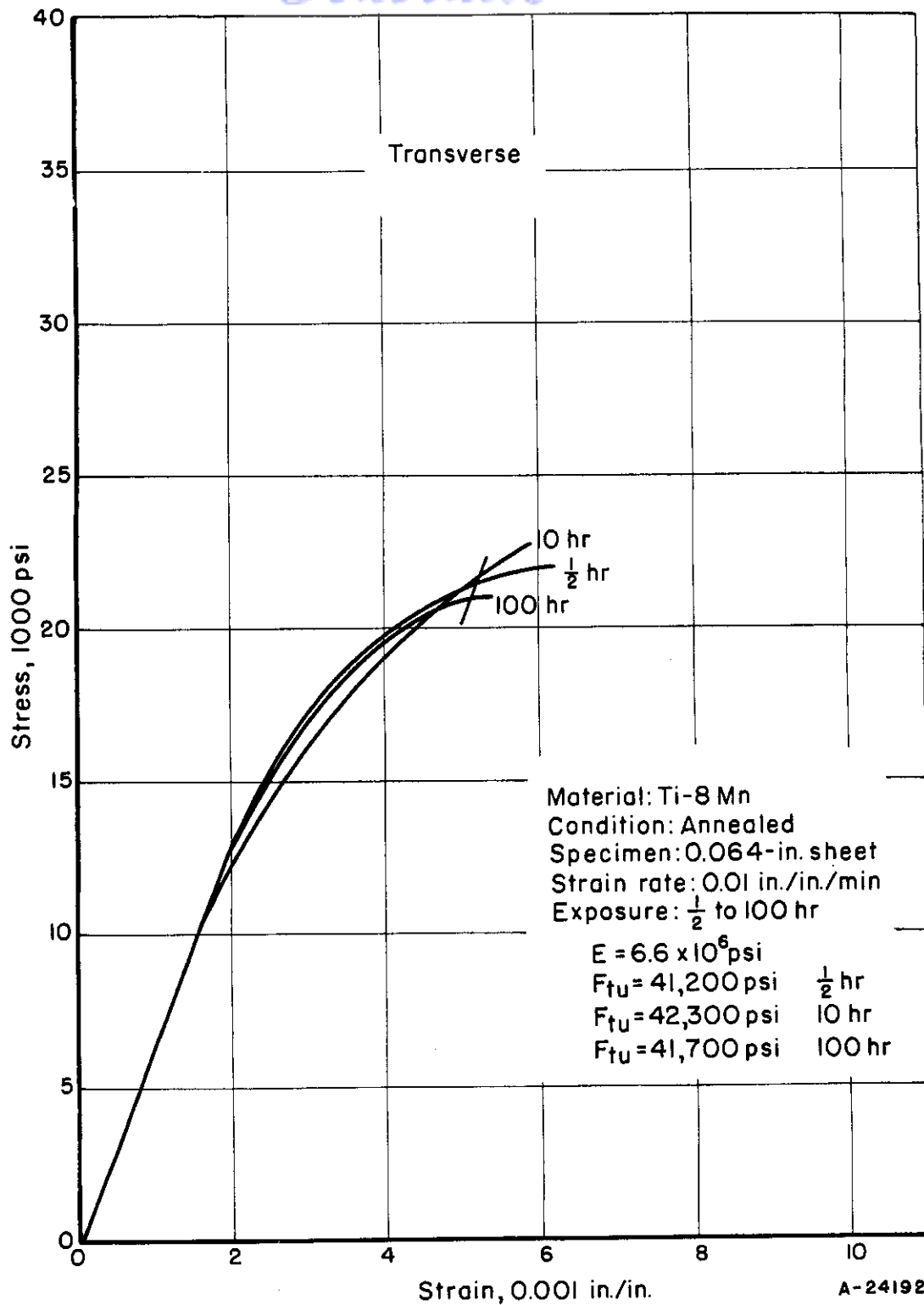


FIGURE 214. TENSILE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 1000 F (TRANSVERSE PROPERTY)

Ref. 356.

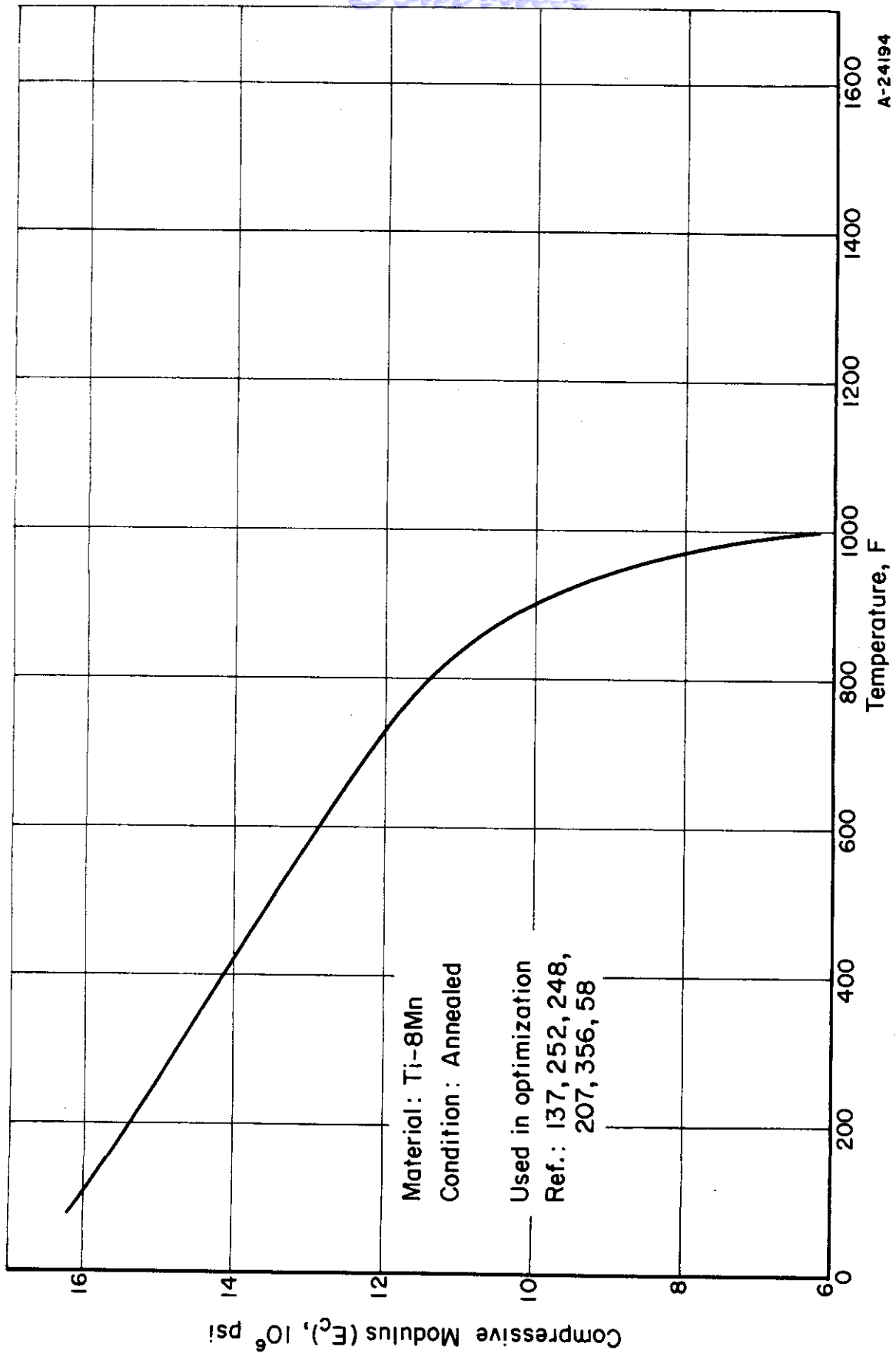


FIGURE 215. COMPRESSIVE MODULUS (E_c) OF Ti-8Mn TITANIUM ALLOY AT ELEVATED TEMPERATURE

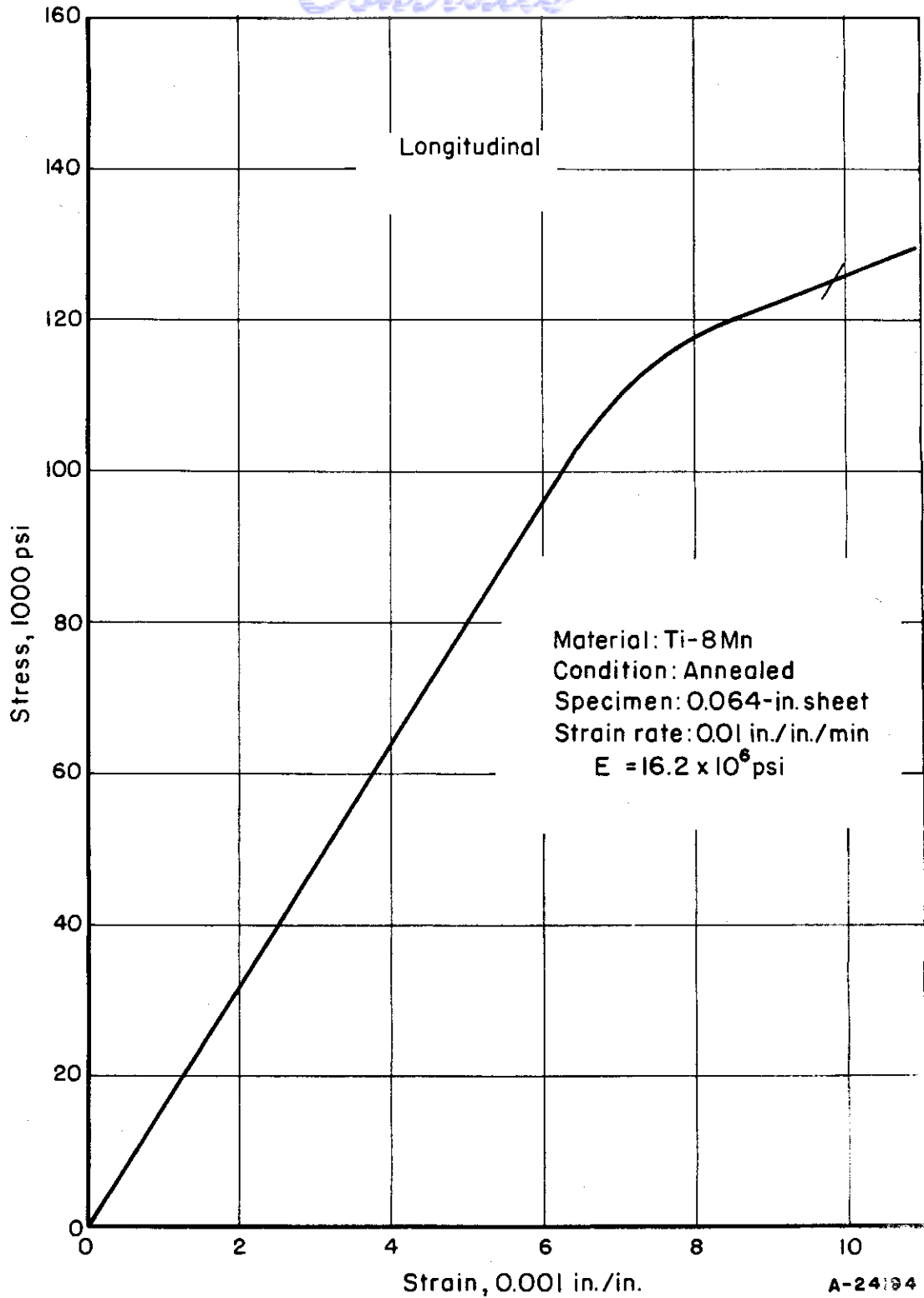


FIGURE 216. COMPRESSIVE STRESS-STRAIN CURVE FOR Ti-8Mn TITANIUM ALLOY AT ROOM TEMPERATURE (LONGITUDINAL PROPERTY)

Ref. 252.

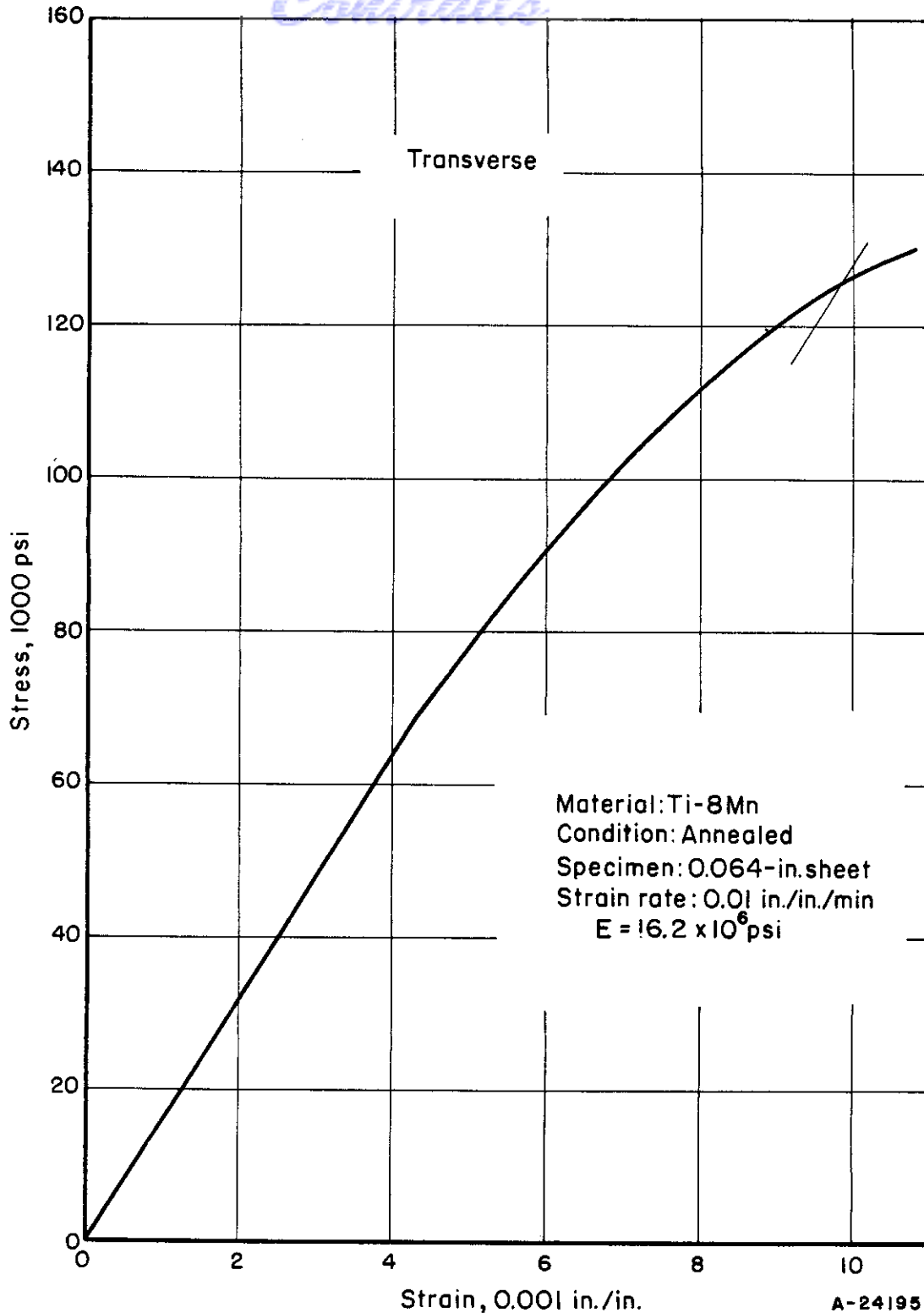


FIGURE 217. COMPRESSIVE STRESS-STRAIN CURVE FOR Ti-8Mn TITANIUM ALLOY AT ROOM TEMPERATURE (TRANSVERSE PROPERTY)

Ref. 58, 356.

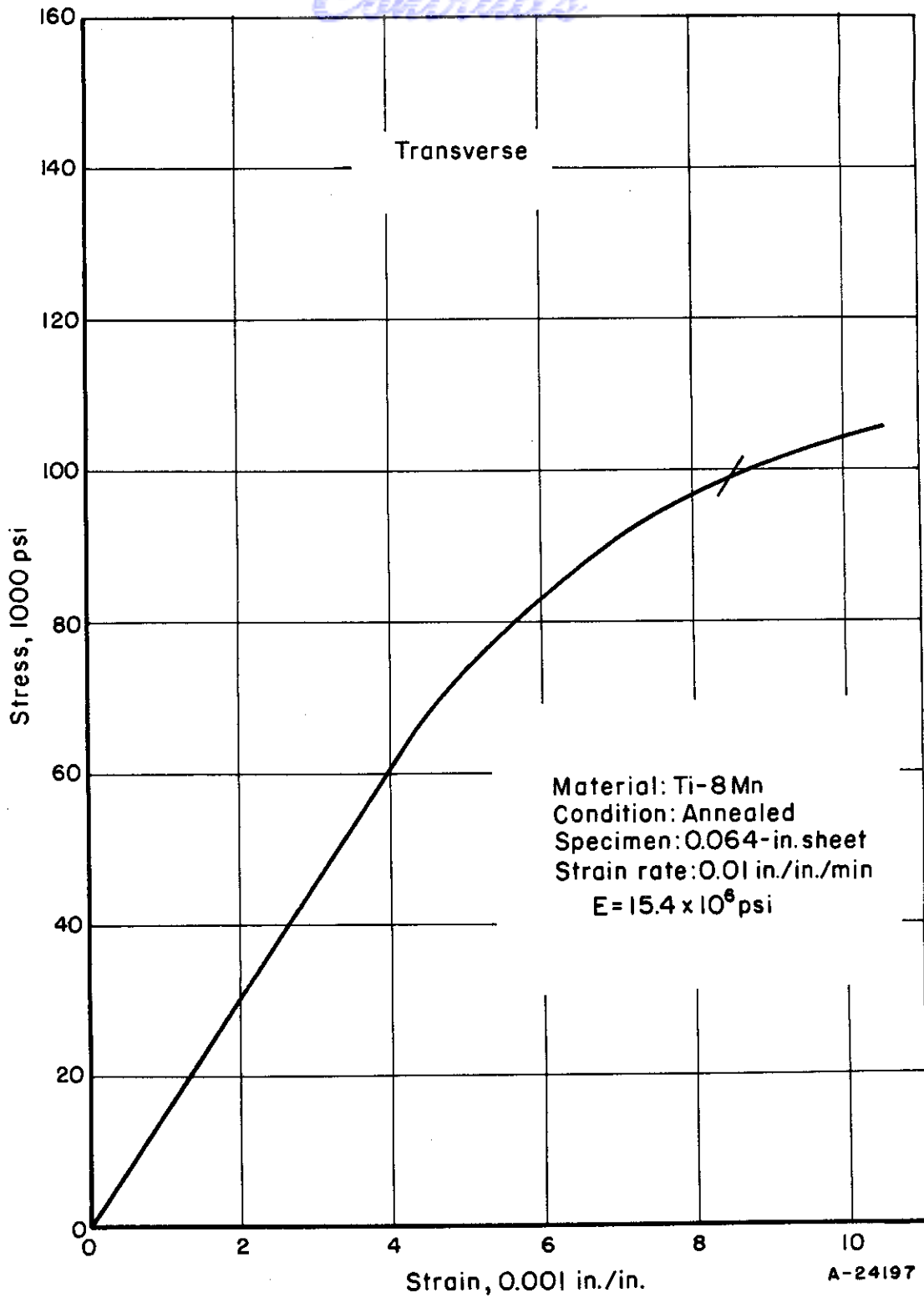


FIGURE 218. COMPRESSIVE STRESS-STRAIN CURVE FOR Ti-8Mn TITANIUM ALLOY AT 200 F

Ref. 207.

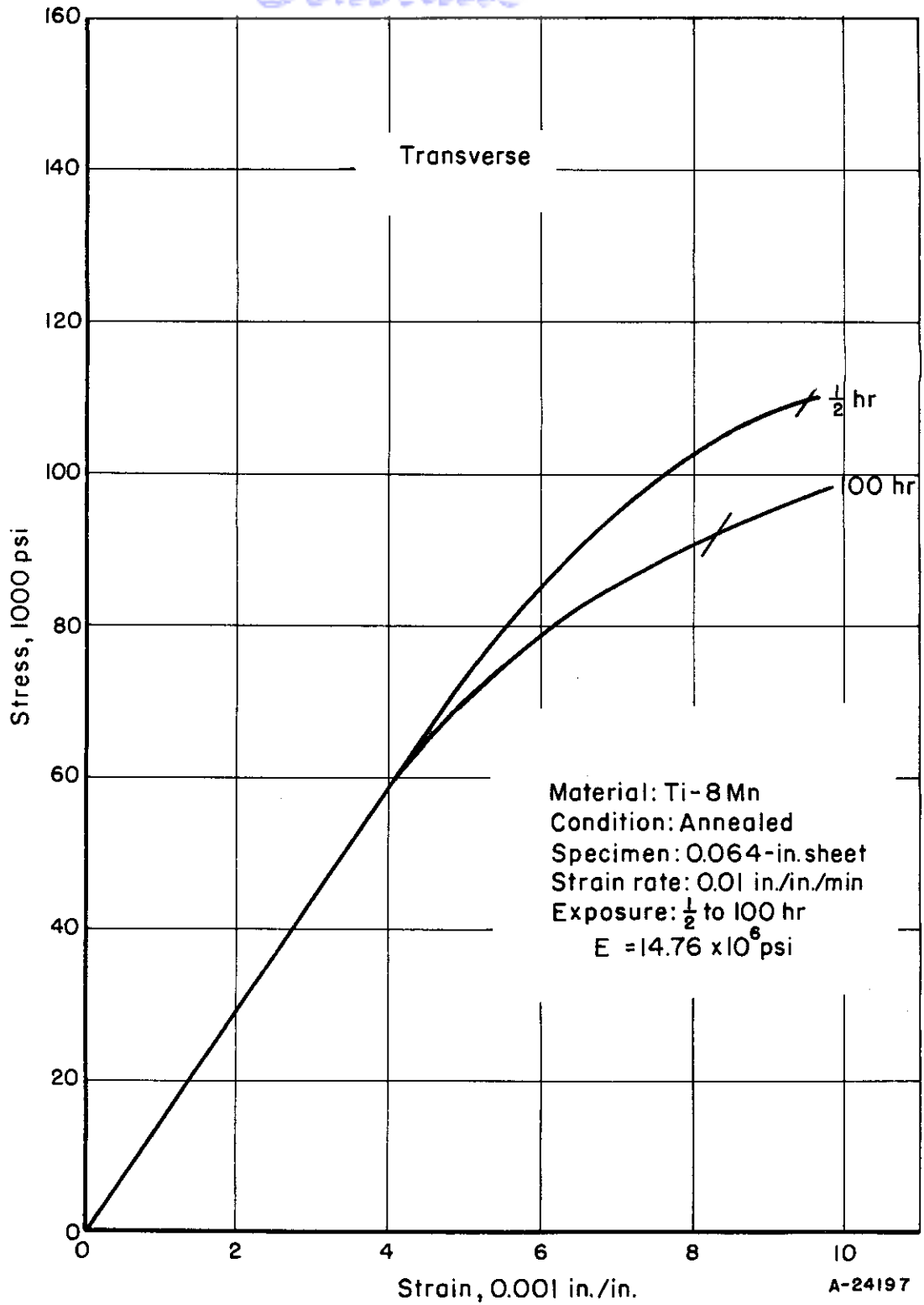


FIGURE 219. COMPRESSIVE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 300 F

Ref. 58.

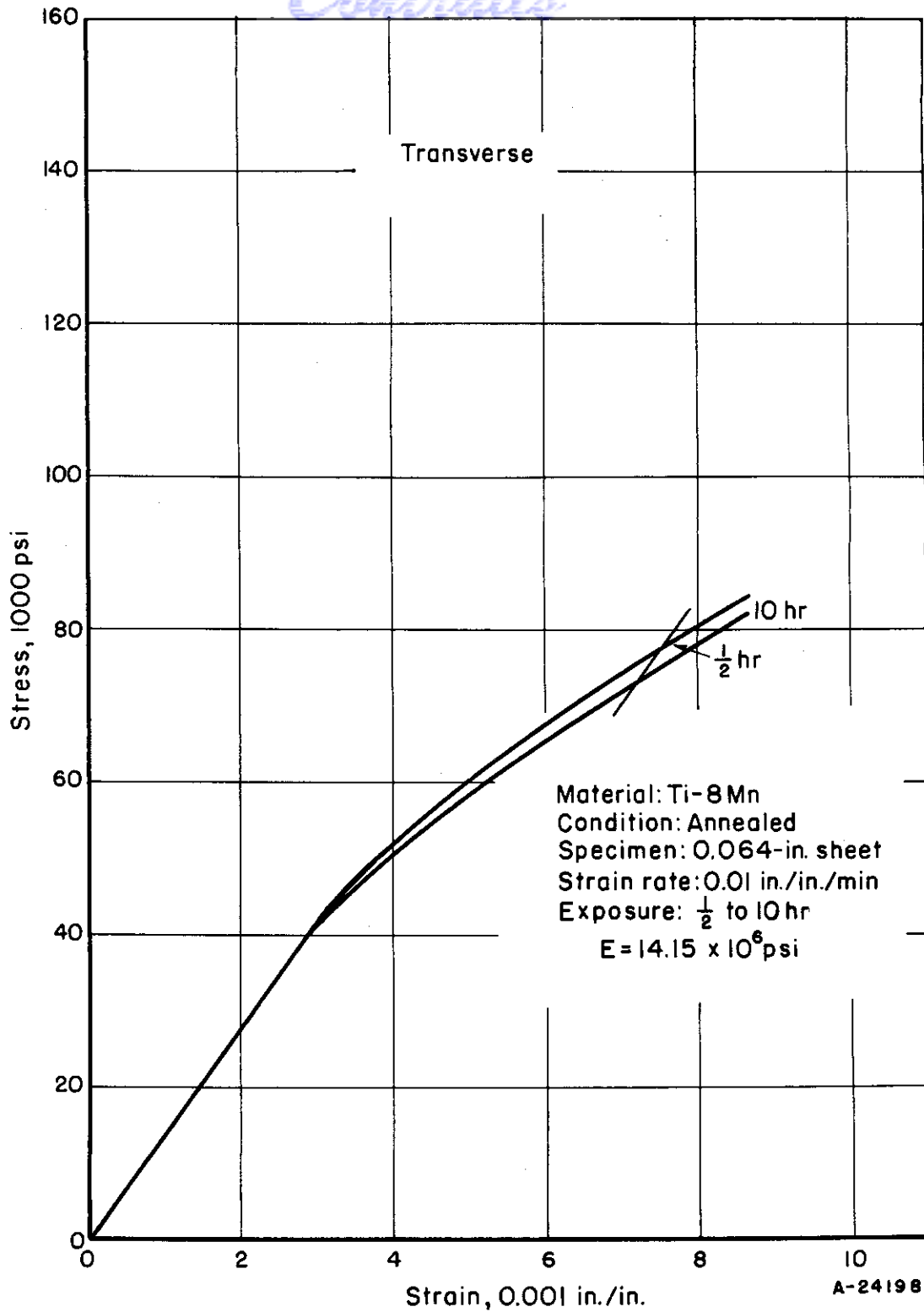


FIGURE 220. COMPRESSIVE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 400 F

Ref. 356.

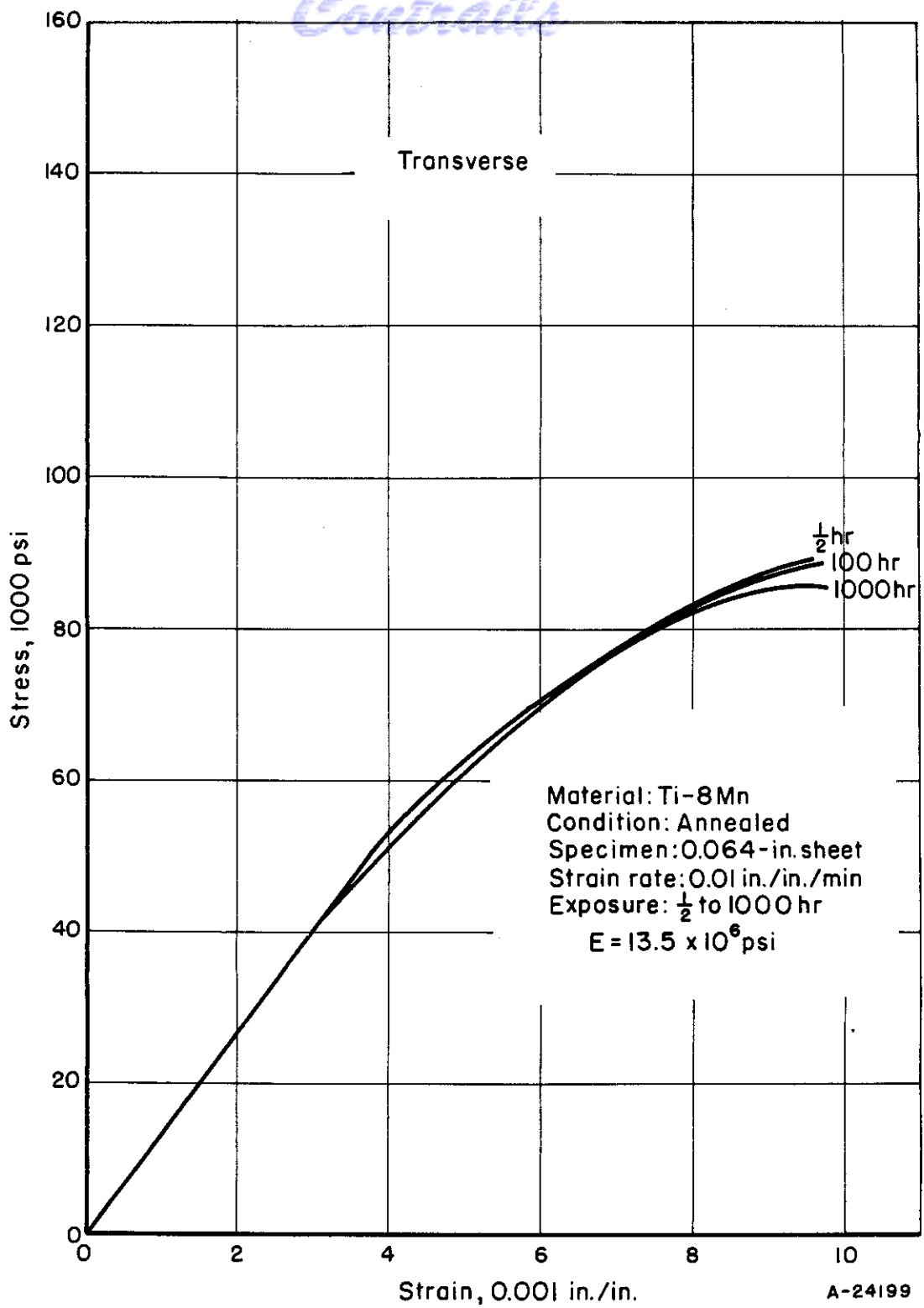


FIGURE 221. COMPRESSIVE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 500 F

Ref. 58.

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Contrails

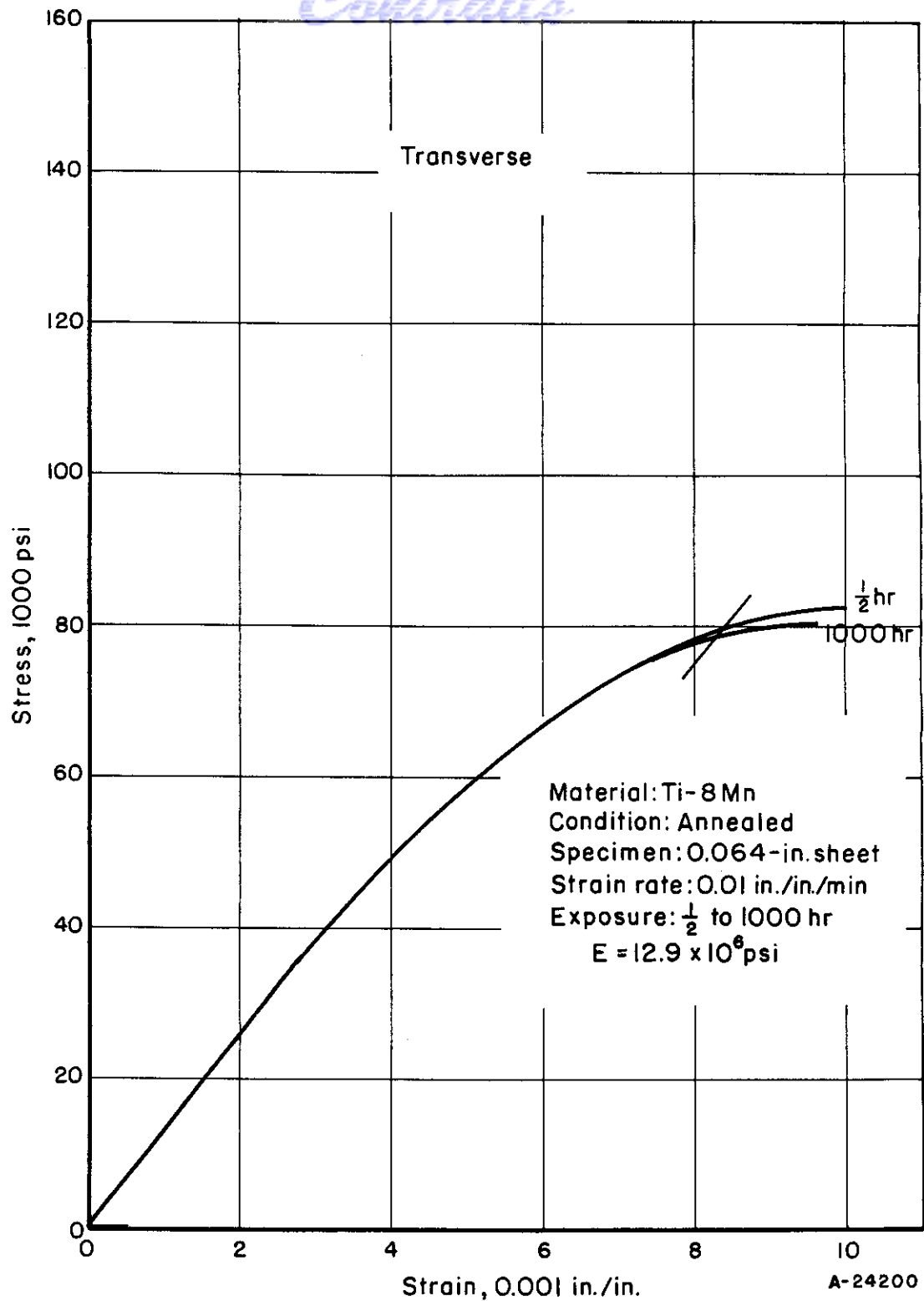


FIGURE 222. COMPRESSIVE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 600 F (TRANSVERSE PROPERTY)

Ref. 356, 58.

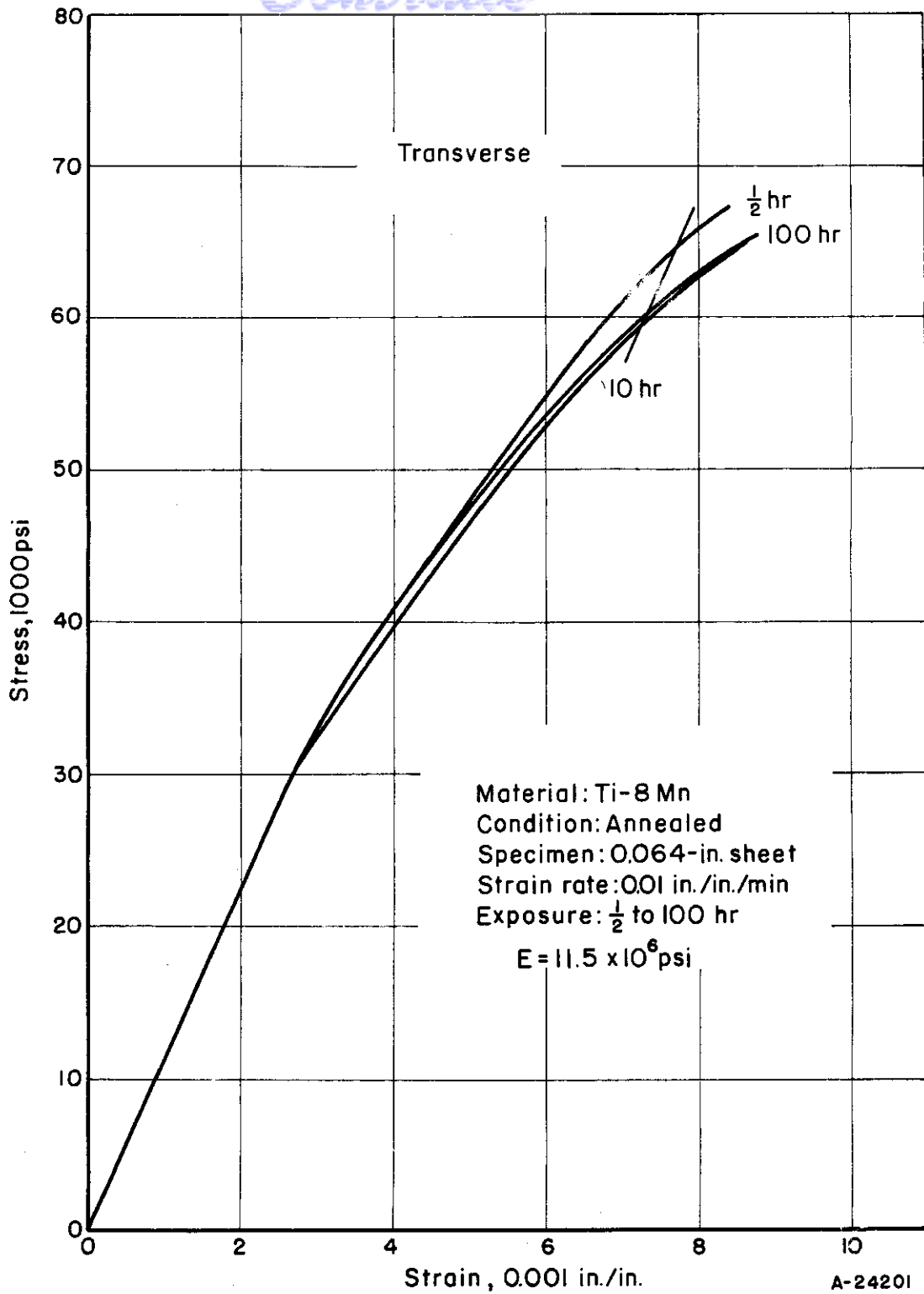


FIGURE 223. COMPRESSIVE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 800 F

Ref. 356.

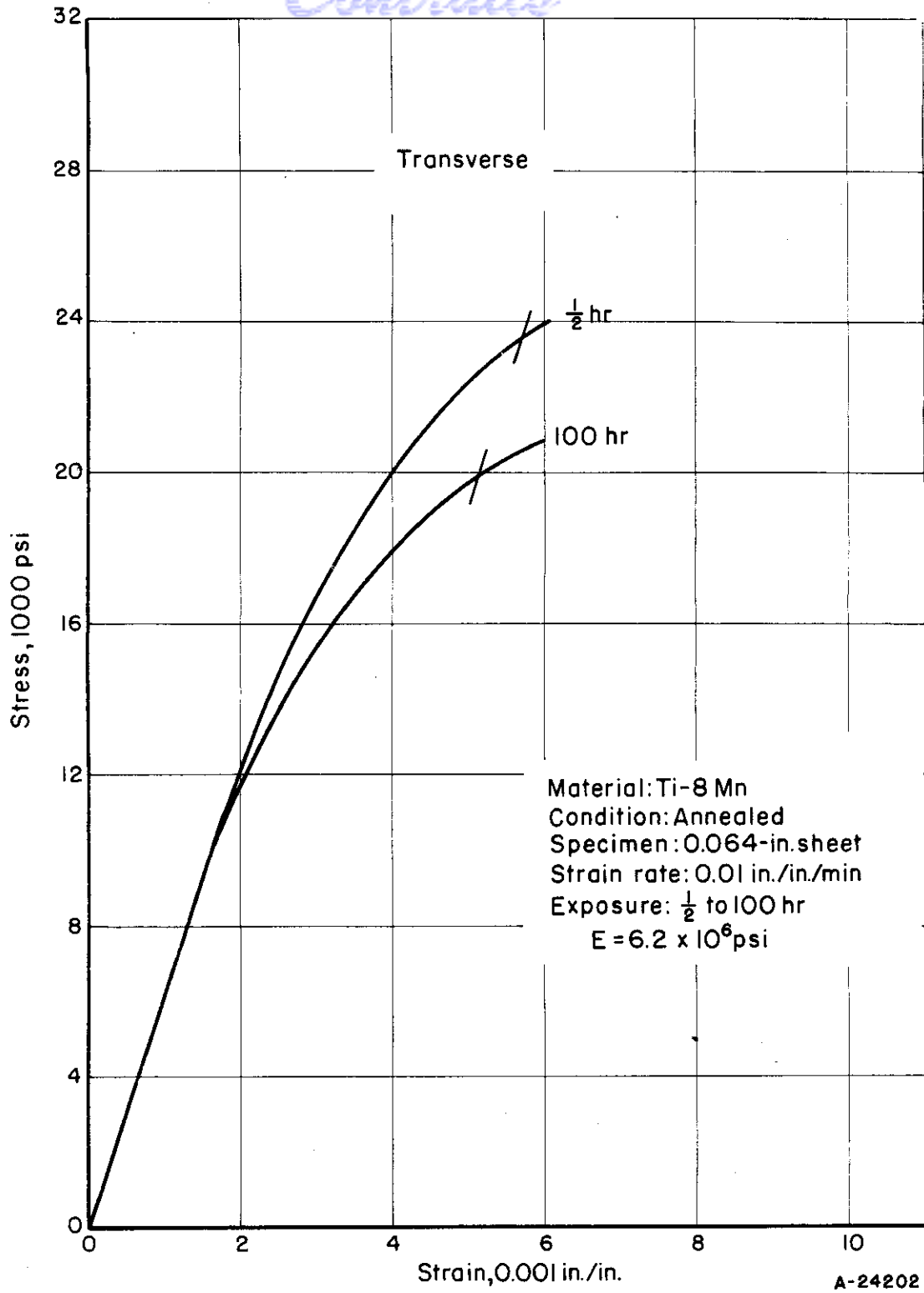


FIGURE 224. COMPRESSIVE STRESS-STRAIN CURVES FOR Ti-8Mn TITANIUM ALLOY AT 1000 F

Ref. 356.

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