(NASA-TM-78221) WELD BEAD REINFORCEMENT REMOVAL: A METHOD OF IMPROVING THE STRENGTH AND DUCTILITY OF PEAKED WELDS IN 2219-T87 ALUMINUM ALLOY PLATE (NASA) 36 p HC A03/MF A01 N79-21351
CSCL 20K G3/37 Unclas 14733

NASA TECHNICAL MEMORANDUM

NASA TM-78221

WELD BEAD REINFORCEMENT REMOVAL - A METHOD OF IMPROVING THE STRENGTH AND DUCTILITY OF PEAKED WELDS IN 2219-T87 ALUMINUM ALLOY PLATE

By Charles V. Lovoy
Materials and Processes Laboratory

January 1979

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

MSFC - Form 3190 (Rev June 1971)

ACKNOWLEDGMENTS

The author would like to thank the following personnel of the Materials and Processes Laboratory, Marshall Space Flight Center: Mr. J. Sexton for his effort in welding the panels, Mr. E. Risch for his support of radiographic inspection of the welds, Mr. J. Carroll for his work in machining the tensile specimens, and Mr. N. Tiller for his activities in clevis development and mechanical testing. Appreciation is also extended to Mr. P. Munafo for his technical assistance.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Concluded)

LIST OF TABLES

TECHNICAL MEMORANDUM 78221

WELD BEAD REINFORCEMENT REMOVAL - A METHOD OF IMPROVING THE STRENGTH AND DUCTILITY OF PEAKED WELDS IN 2219-T87 ALUMINUM ALLOY PLATE

SUMMARY

Weld peaking in butt welds of aluminum alloy plate, 1/2-in. (1.27 cm) thick and thicker, is often encountered in aerospace pressure vessel fabrication. This peaking, in many instances, is beyond the limits imposed by the applicable specification and can not always be corrected by mechanical means. As a consequence, these welds are dispositioned for rework (second heat) or accepted analytically as being "fit-for-purpose."

This program was initiated on the premise that it would be possible to enhance the tensile strength and ductility of peaked welds by removing the reinforcing bead. These increased properties would, in turn, allow greater analytical flexibility in dispositioning excessively peaked welds and improve the reliability of structures in which they were encountered.

The study employed 2219-T87 aluminum alloy, a common aerospace structural material. Weld specimens were fabricated using the tungsten inert gas (TIG) process and 2319 filler wire. Two plate thicknesses were included: 1/2 in. (1.27 cm) and 1 in. (2.54 cm). All welds were made in the down hand position, and the panels were fixtured to produce target peak angles after welding of 0, 6, 9, 12 and 15 degrees. The weld bead was removed from every other test specimen, cut from each weld panel, to provide an optimum means of comparing the test results.

The ultimate tensile strength of peaked weld specimens with the reinforcing bead removed was consistently higher than adjacent specimens in which the bead was left intact. Improvement was on the order of 2 to 3 percent for peak angles of 5.8 to 10 degrees and 10 to 22 percent for welds with peak angles of 11.7 to 16.9 degrees. In general, the 1-in. (2.54 cm) plate peaked welds exhibited greater strength improvement, on a percentage basis, than the 1/2-in.

(1.27 cm) plate welds. Conversely, the 1-in. (2.54 cm) plate peaked welds displayed much greater degradation in strength than 1/2-in. (1.27 cm) plate peaked welds when tested with intact weld beads combined with peak angles greater than 9 degrees.

Peak welds were also evaluated as to their ability to straighten after the application of a cyclic stress in excess of the yield strength. All tensile specimens which achieved the target loads without tensile failure exhibited some improvement in alignment after each stress cycle. The peak weld specimens with the weld bead reinforcement removed and faired with the plate surface contour yielded superior alignment than intact weld bead specimens. None of the peak weld specimens straightened completely, including those which were loaded to the maximum cycle stress of 35 ksi (241 MN/m^2). As expected, the tensile failure rate during stress cycling was much greater with intact weld bead specimens than with faired weld specimens.

INTRODUCTION

The amount of weld peaking that is encountered in pressure vessel fabrication is unpredictable because of unknown stresses from previous machining operations, forming stresses induced by fixturing and residual stresses from other welds during subassembly fabrication. Excessive peaking adversely affects the structure by reducing the mechanical properties of the joint and by contour changes which make fit-up of subassemblies difficult. When excessive peaking is encountered, it can sometimes be corrected by mechanical means or by using the shrinkage forces resulting from the welding process itself [1]. Basically this is accomplished by selective fusion passes along the back side of a peaked weld.

If repair is to be avoided, the stress analyst must rationalize that the weld will sustain the expected environmental loads by using a higher tensile design allowable. The use of the higher number is normally contingent upon the weld being free of internal as well as external discontinuities. Obviously, the higher allowable exceeds the "A" value (a statistically derived number offering 99 percent probability with 95 percent confidence) that is normally used in aerospace pressure vessel fabrication. However, if this type of analytical procedure results in a satisfactory margin of safety, the pressure vessel is dispositioned as fit-for-purpose.

This program was initiated on the premise that it would be possible to enhance the ultimate strength and ductility of peaked welds by removing the reinforcing bead. This premise was verified in laboratory tests and as a consequence offers greater analytical flexibility and confidence in dispositioning excessively peaked welds. This approach can be considered in lieu of fusion pass or mechanical straightening, particularly for welds with restricted accessibility, subassemblies which contain peaking, but in which mating is not a problem and completed structures where the application of more heat to correct peaking would result in additional residual stress or distortion. Although this program was confined to TIG weld and 2219-T87 plate using 2319 filler wire, the principle should be applicable to other alloy combinations and fusion welding processes.

DISCUSSION

General

Peak weld specimens tend to straighten when the applied load is transverse to the cast bead. The straightening mechanism is confined primarily within the fusion zone (fusion-line to opposite fusion-line). However, due to metallurgical and mechanical considerations, the weld normally fails in tension at one toe (point initiation) of one fusion-line before plastic deformation is sufficient to completely straighten the specimen. This behavior can be generalized in terms of the heterogeneous metallurgy of cast microstructural constituents and the presence of mechanical stress risers at critical locations, both within the weld fusion zone. The principle microstructural constituent in welded 2219 aluminum alloy is $CuAl_2$, a brittle intermetallic compound which is located primarily along the fusion-line, with heavier concentrations at the toes of the weld (points "A" and "B" of Fig. 1). The primary stress risers are located at the weld toes of points "A". A narrow zone along the fusion-line encompasses the smallest cross-sectional area that this plane passes through (points "A" and "B") within the fusion zone. This zone (one on each side) also contains the stress risers (points "A"), and thus is the preferred zone (on each side of the weld) for plastic deformation whenever a load is applied. Within this narrow zone, fibers at point "A" (each side) must elongate much more than the fibers at point "B" (each side) to straighten the specimen. However, point "A" (each side) is rich in $CuAl_2$ and failure initiates at one of the "A" points before the load can be transferred equally across the weld; thus, the specimen fails to plastically deform to the extent of completely straightening. Some plastic

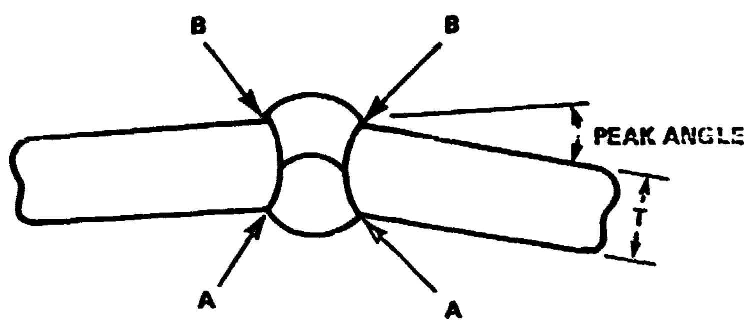

Figure 1. Cross sectional schematic of peak weld.

deformation does occur in the highly ductile central region of the weld [illegible] the two narrow $CuAl_2$-rich zones; however, it is restricted by the weld bead reinforcement which increases the cross-sectional area. It was reasonable to assume, therefore, that greater weld ductility would result if the bead reinforcements were removed and the weld faired to the contour of the adjacent plate. Concurrently, removal of the bead would also eliminate much of the brittle inter-metallic compound ($CuAl_2$) and minimize the stress risers at the toes or point "A". In essence, an applied load would work-harden the cast region as plastic strain increases and the ultimate strength should approach that of a typical flat weld specimen.

Experimental Panel Preparation and Testing

The base material (2219-T87), filler wire, and shielding gas used in this study were procured to appropriate aerospace specifications. The chemical composition limits of each material are given in Table 1 [2].

Preweld sections [6 in. by 24 in. (15.24 cm by 60.96 cm)] [illegible] evaluation were fabricated from two base material thicknesses of plate [illegible] (1.27 cm) and 1 in. (2.54 cm). Preweld joint preparation was in accordance with MSFC-SPEC-504 [3]. The welds were made by the mechanized [illegible] process on standard welding equipment. The work pieces were canted and held by clamping fixtures with target peak angles of 0, 6, 9, 12 and 15 degrees for each base material thickness. The welds were made in the down hand [illegible] position while maintaining conventional and very consistent weld contour.

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 1. CHEMICAL COMPOSITION LIMITS OF BASE MATERIAL AND FILLER METAL

Element	2219 Specification (%)	2319 Specification (%)
Si	0.20	0.20
Fe	0.30	0.30
Cu	5.8 -6.8	5.8 -6.8
Mn	0.20-0.40	0.20-0.40
Mg	0.02	0.02
Zn	0.10	0.10
Ti	0.02-0.10	0.10-0.20
V	0.05-0.15	0.05-0.15
Zr	0.10-0.25	0.10-0.25
Be	—	0.0008
Others, Each	0.05	0.05
Others, Total	0.15	0.15
Al	Remainder	Remainder
(Maximum unless shown as a range)		

Radiographic inspection of the resultant panels followed procedures which usually grade weldments to Class I per MSFC-SPEC-504A [4]. Two panels were fabricated for each thickness and target weld peak angle. The weld bead was removed and faired to the surface for alternate test coupons within each panel. This test coupon selection procedure allowed a reliable comparison between tensile results from intact weld bead specimens and weld bead removed and faired specimens. The surface finish of the weld bead removed and faired specimens was approximately CLA 132.

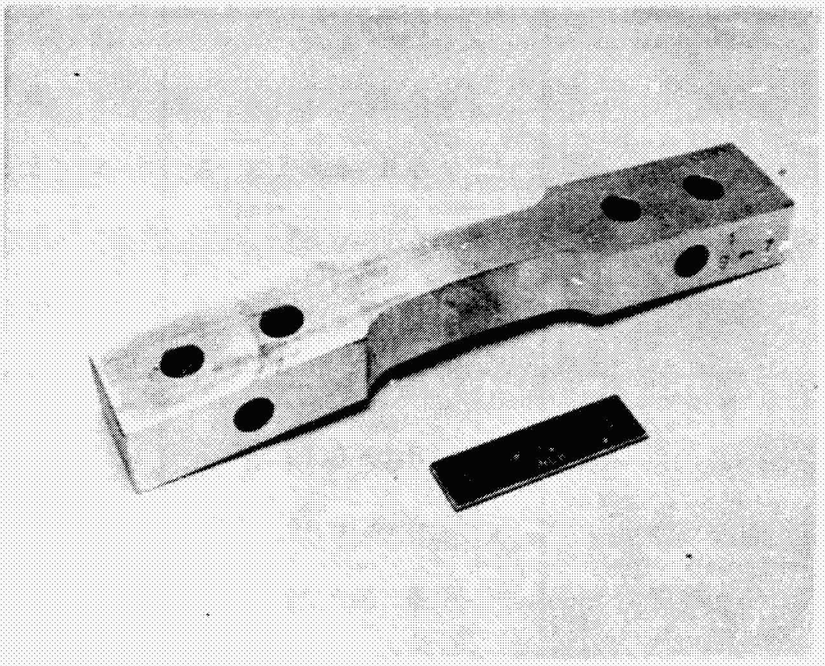

Figure 2. Specimen configuration of a 1-in. (2.54 cm) thick plate weldment (weld bead reinforcement removed and faired).

Figure 2 shows the specimen configuration of a 1-in. (2.54 cm) thick weldment where the weld bead was removed and faired. The clevis used during tensile testing was a couple-type to allow free bending of the peak angle during loading. Tensile tests were conducted at ambient temperature with the test setup shown in Figure 3.

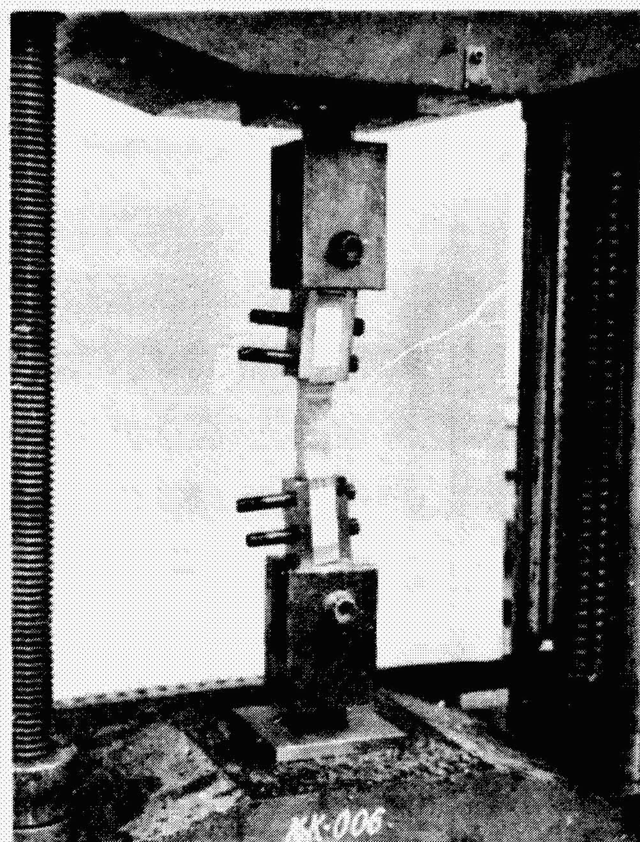

Figure 3. Tensile test setup.

Effect of Bead Removal on Tensile Strength

Flat weld specimens (zero peak) were included in this evaluation to provide baseline data. These tensile results showed a very slight decrease in ultimate tensile strength when testing with the weld bead removed and faired with the surface contour of each equal-thickness plate. The yield strengths were virtually identical when compared with results between specimens with intact weld beads and removed and faired weld beads. Those specimens with removed and faired weld beads displayed higher elongation values than specimens with intact weld beads (Table 2).

Comparisons were made between peaked weld tensile results of intact weld bead specimens and weld bead removed and faired specimens. The comparisons were limited to results from weldments of equal thickness and approximately

TABLE 2. TRANSVERSE ULTIMATE STRENGTH OF TIG/2319 WELD (ZERO PEAK) IN ALUMINUM ALLOW 2219-T87 PLATE

Welds in 1/2-Inch (1.27 cm) Plate

	Weld Bead Intact					Weld Bead Removed/Faired				
	UTS		UYS (0.2% Offset)		El 2" (5.08 cm) Gage	UTS		UYS (0.2% Offset)		El 2" (5.08 cm) Gage
	Ksi	MN/m^2	Ksi	MN/m^2	Percent	Ksi	MN/m^2	Ksi	MN/m^2	Percent
	43.5	300	24.1	166	3.5	42.0	290	24.5	169	4.5
	43.9	302	25.8	178	3.5	42.8	295	25.6	176	4.0
	44.1	304	25.8	178	3.5	43.1	297	26.3	181	5.0
	44.4	306	24.7	170	3.0	41.9	289	22.9	158	5.0
	44.7	308	25.1	173	4.0	42.6	294	24.6	169	4.5
	44.2	305	24.7	170	4.0	42.9	296	25.8	178	4.0
	41.7	288	24.5	169	3.0	43.3	299	23.6	162	5.0
	42.5	293	24.7	170	3.5	43.8	302	23.7	163	5.0
	42.3	292	24.2	167	3.5	42.3	292	25.4	175	4.0
	42.0	290	23.9	164	3.5	42.6	294	25.7	177	4.5
						43.2	298	25.3	174	4.0
						42.2	291	24.5	169	4.0
						42.4	292	24.0	165	4.0
Avg	43.3	299	24.8	171	3.5	42.7	295	24.8	171	4.5

TABLE 2. (CONCLUDED)

Welds in 1-Inch (2.54 cm) Plate

	Weld Bead Intact					Weld Bead Removed/Faired				
	UTS		UYS (0.2% Offset)		El 2" (5.08 cm) Gage	UTS		UYS (0.2% Offset)		El 2" (5.08 cm) Gage
	Ksi	MN/m^2	Ksi	MN/m^2	Percent	Ksi	MN/m^2	Ksi	MN/m^2	Percent
	45.5	314	25.0	172	6.0	44.2	305	26.2	181	7.0
	44.8	309	25.9	178	5.0	43.8	302	24.5	169	8.0
	46.2	319	25.5	176	6.0	44.1	304	25.8	178	8.0
	45.3	312	25.4	175	6.0	43.5	300	26.0	179	7.0
	41.1	283	24.8	171	5.0	42.7	295	25.1	173	7.0
	41.0	283	25.9	178	4.0	39.6	273	25.8	178	5.0
	45.2	312	25.5	176	7.0	44.0	303	24.0	165	7.0
						43.9	303	25.7	177	7.0
						42.8	295	24.3	167	6.0
						43.5	300	24.9	172	6.0
Avg	44.2	305	25.5	175	5.6	43.2	298	25.2	174	6.8

Note: Results for each weld thickness are from tensile specimens removed from two weld panels.

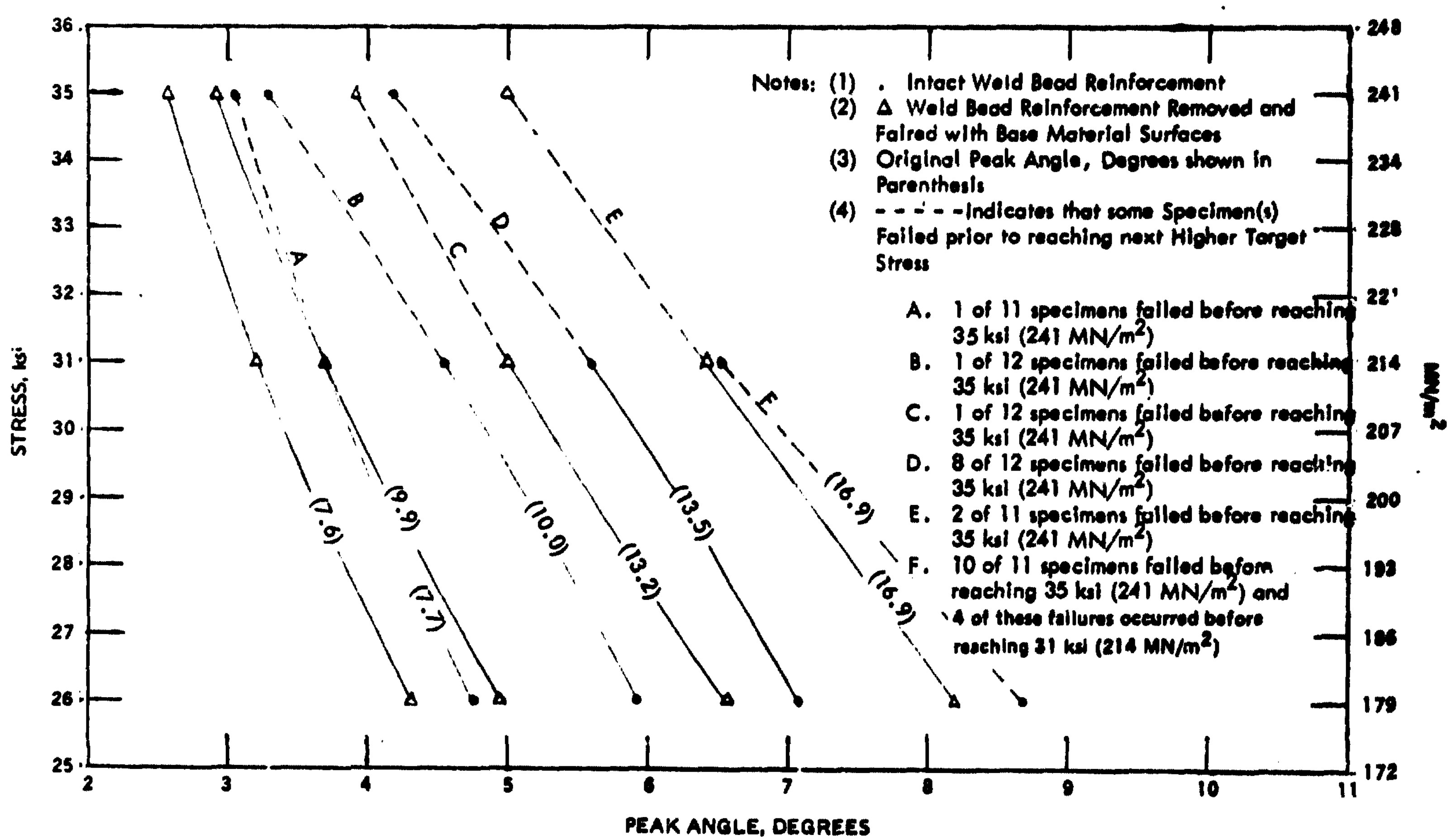

Figure 4. Weld joint straightening tendencies as determined by measuring the resultant peak angle after releasing each target stress of 26 ksi (179 MN/m²), 31 ksi (214 MN/m²), and 35 ksi (241 MN/m²) [TIG weldments in 1/2-in. (127 cm) plate].

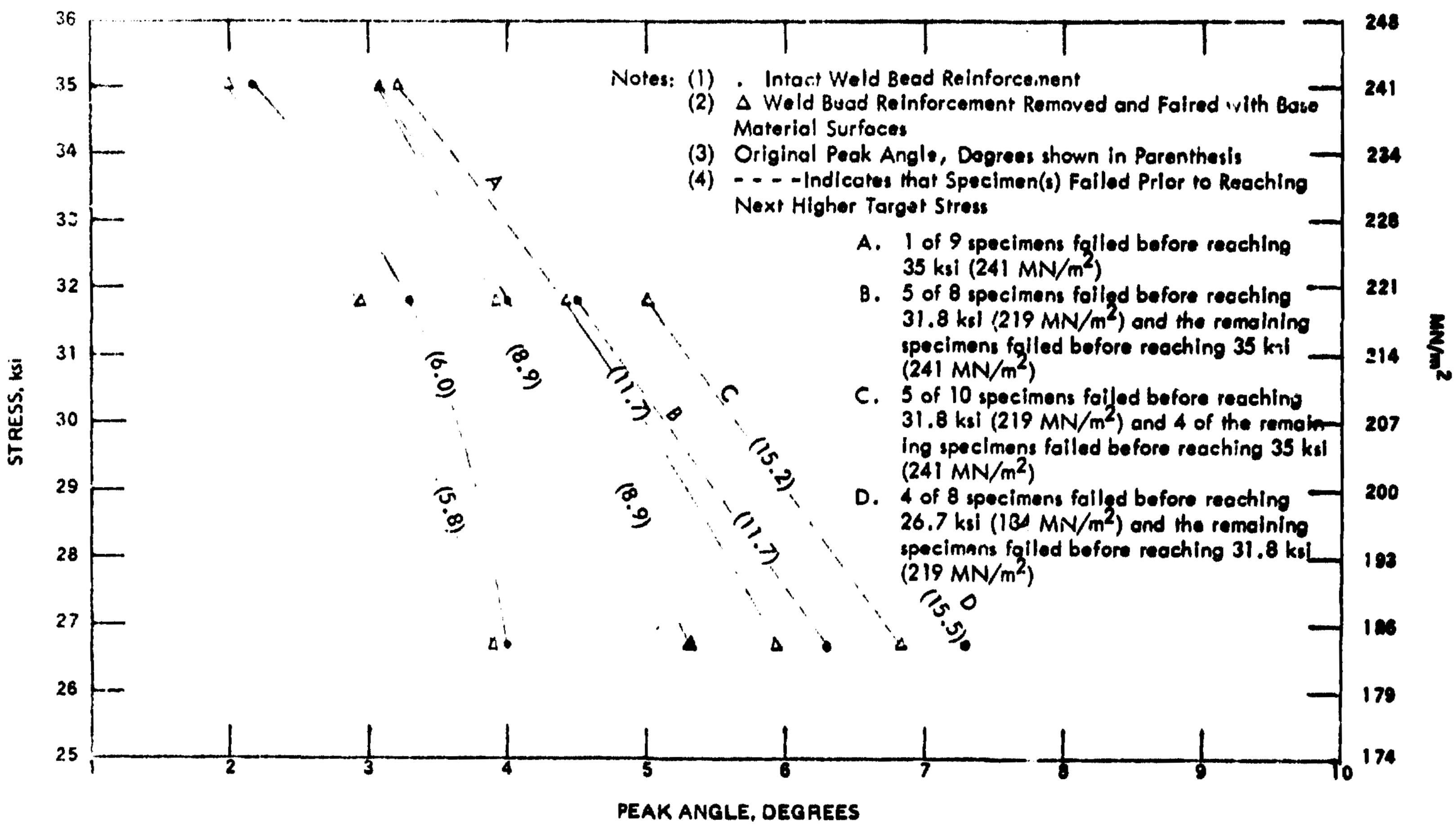

Figure 5. Weld joint straightening tendencies as determined by measuring the resultant peak angle after releasing each target stress of 26.7 ksi (184 MN/m²), 31.8 ksi (219 MN/m²), and 35 ksi (241 MN/m²) [TIG weldments in 1-in. (2.54 cm) plate].

TABLE 3. TRANSVERSE ULTIMATE TENSILE STRENGTH OF TIG/2319 WELDS IN ALUMINUM ALLOY 2219-T87 PLATE, 1/2 in. (1.27 cm) THICK, AND THE CORRESPONDING WELD PEAK ANGLE

	Weld Bead Intact			Weld Bead Removed/[illegible]		
	UTS Ksi	UTS MN/m^2	Peak Angle Degrees	UTS Ksi	UTS MN/m^2	Peak Angle Degrees
	41.8	288	8.0	42.1	290	6.7
	40.3	278	7.7	40.8	281	7.5
	39.8	274	7.7	41.2	284	7.3
	40.1	276	7.5	40.0	276	7.6
	40.3	278	7.5	40.4	279	7.0
	40.5	279	7.5	40.2	277	6.[illegible]
	39.7	274	8.0	40.0	276	7.[illegible]
	39.5	272	8.0	40.0	276	8.0
	37.2	256	7.8	38.9	268	8.0
	34.8	240	7.7	39.0	269	[illegible]
	36.4	251	7.5	38.6	266	8.0
				39.8	274	8.0
Avg	39.1	270	7.7*	40.1	276	7.6*
	38.4	265	9.0	36.3	250	8.6
	38.2	263	9.4	39.2	270	9.1
	38.0	262	9.6	38.9	268	9.2
	40.0	276	9.4	40.1	276	9.[illegible]
	41.2	284	8.9	39.6	273	9.7
	36.1	249	10.6	40.5	279	9.1
	33.7	232	11.4	39.2	270	10.0
	37.3	257	11.0	39.4	272	10.8
	38.5	265	11.0	39.2	270	10.9
	40.0	276	10.2	38.7	267	10.5
	38.4	265	9.4	38.8	268	9.9
Avg	38.2	263	10.0**	39.1	269	9.8**

TABLE 3. (CONCLUDED)

	Weld Bead Intact			Weld Bead Removed/Faired		
	UTS Ksi	UTS MN/m^2	Peak Angle Degrees	UTS Ksi	UTS MN/m^2	Peak Angle Degrees
	33.5	231	12.8	34.5	239	12.0
	34.0	234	13.6	36.2	250	13.4
	33.3	229	14.2	36.8	254	13.7
	31.0	214	14.8	36.6	252	13.4
	31.1	214	14.4	36.0	248	14.6
	33.4	230	14.0	36.6	252	14.0
	36.6	252	13.0	37.9	261	12.5
	33.9	233	13.4	39.9	275	12.7
	32.9	227	13.4	38.6	266	13.2
	36.3	250	13.4	39.1	270	13.2
	35.9	247	13.0	40.5	279	12.8
	36.1	249	12.3	38.5	265	12.8
Avg	34.1	234	13.5***	37.6	259	13.2***
	35.8	247	15.8	36.7	253	15.5
	32.4	223	16.7	36.1	249	16.3
	32.8	226	17.2	37.4	258	17.0
	30.9	213	17.5	37.3	257	17.3
	33.5	231	17.6	36.1	249	17.3
	33.3	229	17.0	35.0	241	17.3
	30.8	212	17.1	32.7	226	16.3
	29.8	205	16.8	34.5	239	17.2
	30.2	208	17.0	37.3	257	17.2
	31.4	217	16.5	35.1	242	17.0
	32.1	221	17.0	35.9	247	17.2
Avg	32.1	221	16.9****	35.8	247	16.9****

Notes:

(1) Results are grouped according to the target peak angle.

* Target peak angle 6 degrees

** Target peak angle 9 degrees

*** Target peak angle 12 degrees

**** Target peak angle 15 degrees

(2) Results in each group represent tensile specimens removed from two weld panels.

TABLE 4. TRANSVERSE ULTIMATE TENSILE STRENGTH OF TIG/2319 WELDS IN ALUMINUM ALLOY 2219-T87 PLATE, 1 in. (2.54 cm) THICK, AND THE CORRESPONDING WELD PEAK ANGLE

	Weld Bead Intact			Weld Bead Removed/Faired		
	UTS Ksi	UTS MN/m^2	Peak Angle Degrees	UTS Ksi	UTS MN/m^2	Peak Angle Degrees
	41.1	283	5.7	43.4	299	5.6
	40.5	279	5.8	42.8	295	5.6
	42.1	290	5.8	43.1	297	6.0
	41.1	283	6.2	45.3	312	5.9
	42.8	295	5.8	44.3	305	5.9
	43.1	297	6.1	43.6	301	5.9
	42.3	292	6.1	43.0	296	5.6
	43.5	300	6.1	44.2	305	6.0
				40.0	276	6.0
Avg	42.1	290	6.0*	43.3	298	5.8*
	41.6	287	8.7	43.1	297	8.6
	41.7	288	8.6	41.3	285	8.8
	42.4	292	8.7	43.4	299	8.6
	43.0	296	8.9	41.5	286	9.0
	37.4	258	9.2	43.4	299	9.1
	40.4	279	8.9	42.5	293	9.2
	41.1	283	9.0	42.4	292	9.0
	38.0	262	8.9	42.1	290	9.1
				38.5	265	9.0
Avg	40.7	281	8.9**	42.0	290	8.9**

TABLE 4. (CONCLUDED)

	Weld Bead Intact			Weld Bead Removed/Faired		
	UTS Ksi	UTS MN/m²	Peak Angle Degrees	UTS Ksi	UTS MN/m²	Peak Angle Degrees
	34.7	239	11.9	38.4	265	12.0
	29.3	202	11.9	40.0	276	12.0
	29.2	201	11.9	36.5	253	11.9
	34.9	241	11.8	36.3	250	11.9
	33.8	233	11.4	32.7	226	11.4
	30.3	209	11.6	37.4	258	11.2
	31.0	214	11.6	40.0	276	11.4
	30.0	207	11.6	39.7	274	11.8
				35.9	247	11.3
Avg	31.6	218	11.7***	37.4	258	11.7***
	27.2	188	15.3	30.0	207	15.1
	23.0	159	15.6	30.9	213	15.2
	23.4	161	15.6	33.7	232	15.2
	23.3	161	15.7	34.1	235	14.9
	26.5	183	14.8	34.4	237	16.0
	28.0	193	15.8	32.3	223	15.5
	27.7	191	15.2	29.2	201	15.0
	28.1	194	15.2	36.4	251	14.9
				27.4	189	15.2
				29.3	202	14.9
Avg	25.9	179	15.5****	31.8	219	15.2****

Notes:

(1) Results are grouped according to the target peak angle.
* Target peak angle 6 degrees
** Target peak angle 9 degrees
*** Target peak angle 12 degrees
**** Target peak angle 15 degrees

(2) Results in each group represent tensile specimens removed from two weld panels.

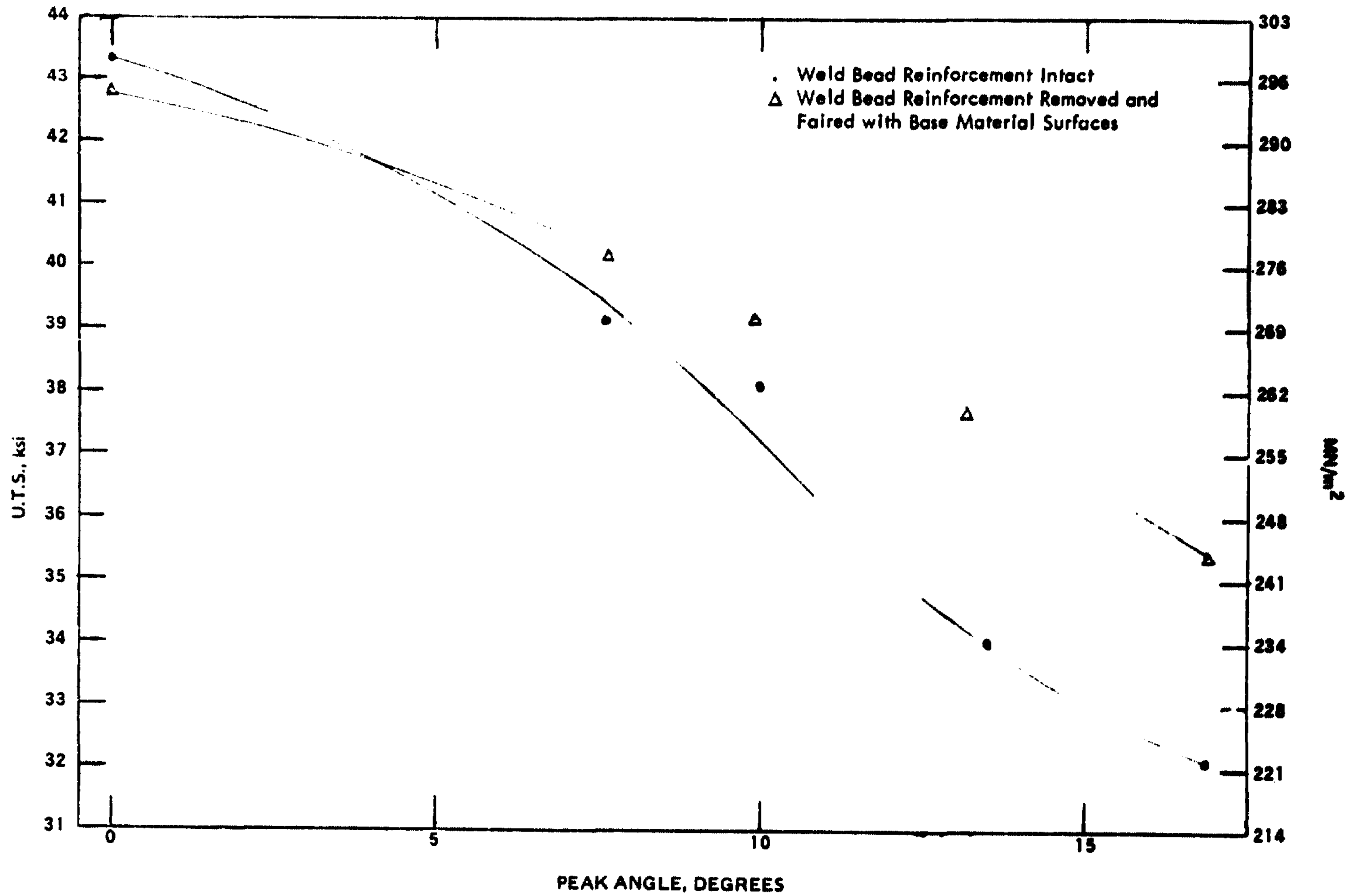

Figure 6. Transverse ultimate tensile strength of weldments plotted as a function of weld peak angle [TIG weldments in 1/2-in. (1.27 cm) plate].

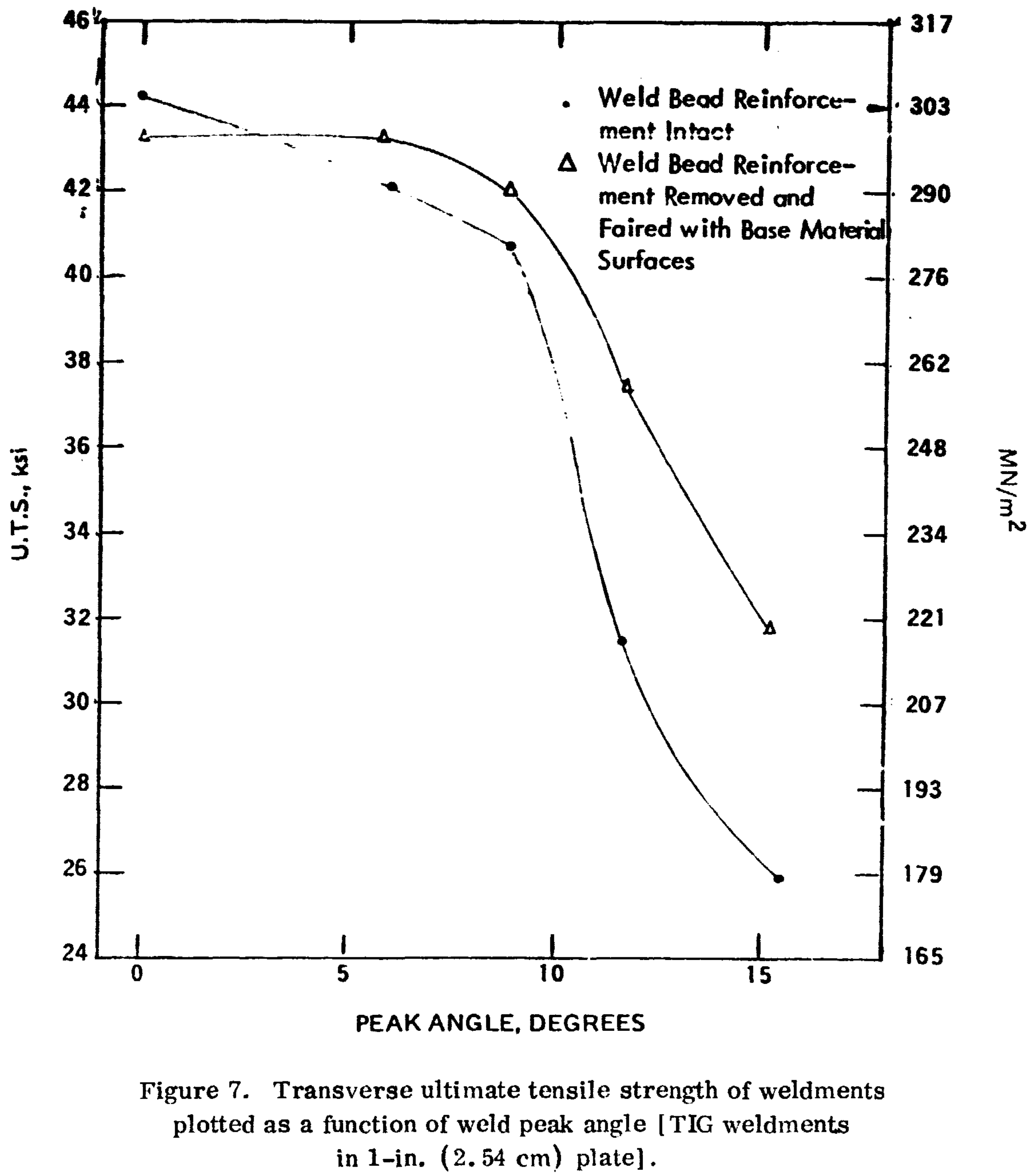

Figure 7. Transverse ultimate tensile strength of weldments plotted as a function of weld peak angle [TIG weldments in 1-in. (2.54 cm) plate].

the same weld peak angle. All the peak welds displayed strength increases as a result of the bead removal and fairing process. These increases were in the 2 to 3 percent range for peak angles of 5.8 to 10.0 degrees. The strength increases were more pronounced for peak angles of 11.7 to 16.9 degrees, showing tensile improvements of 10 to 22 percent. In general, the 1-in. (2.54 cm) plate peaked welds achieved greater strength improvements on a percentage basis than the 1/2-in. (1.27 cm) plate peaked welds. Conversely, the 1-in. (2.54 cm) plate peaked welds displayed much greater decreases in strength than 1/2-in. (1.27 cm) plate peak welds when tested with intact weld beads and peak angles greater than 9 degrees.

Welds that were tested with intact beads showed an average tensile value greater than 35 ksi (241 MN/m^2) at peak angles of 10 and 8.9 degrees, respectively, for 1/2-in. (1.27 cm) and 1-in. (2.54 cm) plate welds. Removal and fairing of the weld bead allow the 35-ksi average tensile value to be surpassed by welds with peak angles of 16.9 and 11.7 degrees, respectively, in 1/2-in. (1.27 cm) and 1-in. (2.54 cm) plates. It should be noted that these tensile results are average values above 35 ksi (241 MN/m^2) and should not be confused with the weld allowable (F_{tu}) of 35 ksi (241 MN/m^2) [5]. Some of the specimens failed below 35 ksi (241 MN/m^2) (Figs. 4 and 5). Nevertheless, it is evident from the tensile results that it is a good fabrication practice to remove the weld bead reinforcement and fair the fusion zone surfaces to those of the adjacent base material whenever out-of-tolerance weld peaking is not corrected. The tensile results and corresponding peak angles are shown in Tables 3 and 4. Figures 6 and 7 show ultimate tensile strength plotted as a function of peak angle.

Effect of Bead Removal on Peak Weld Straightening

A companion evaluation was conducted to determine the straightening tendencies of peak weld specimens after cyclic loading at progressive stress levels of 105 percent of yield strength, 125 percent of yield strength, and at the F_{tu} of 35 ksi (241 MN/m^2). Measurements of the peak angle were taken after releasing each specified stress. A stress level of 105 percent yield strength results in 26 ksi (179 MN/m^2) for 1/2-in. (1.27 cm) plate welds and 26.7 ksi (184 MN/m^2) for 1-in. (2.54 cm) plate welds; whereas, a stress level of 125 percent yield strength results in 31 ksi (214 MN/m^2) and 31.8 ksi (219 MN/m^2), respectively, for 1/2-in. (1.27 cm) and 1-in. (2.54 cm) plate welds.

None of the specimens completely straightened, including those specimens which were cycled at the 35 ksi (241 MN/m²) level. Most of the straightening took place after stress cycling at 105 percent of yield strength (Figs. 4, 5, and 8 through 15). In addition, these same figures reveal the more favorable straightening tendencies of the faired weld bead specimens as opposed to the intact weld bead specimens. Most notably, the tensile failure rate was much greater with intact weld bead specimens than with faired weld bead specimens during progressive stress cycling. In general, these results also indicate the advantages of the weld bead removal and fairing process as opposed to intact weld beads whenever out-of-tolerance weld peaking is not corrected.

CONCLUSIONS

The ultimate tensile strength of peaked 2219-T87 plate welds increased whenever the weld bead reinforcement was removed and the joint surfaces faired to the adjacent base material surfaces. These strength increases were in the 2 to 3 percent range for peak angles of 5.8 to 10.0 degrees. Tensile strength increases were more pronounced for peak angles in the 11.7 to 16.9 degree range, showing strength improvements of 10 to 22 percent. The 1-in. (2.54 cm) plate peak welds achieved greater strength improvements on a percentage basis than the 1/2-in. (1.27 cm) plate peaked welds as a result of the weld bead fairing process. Conversely, the 1-in. (2.54 cm) plate peaked welds displayed much greater degradation in strength than 1/2-in. (1.27 cm) peaked welds when tested with intact weld beads combined with peak angles greater than 9 degrees.

None of the peaked weld specimens completely straightened as a result of stress cycling; this included those specimens that were cycled at the maximum target stress of 35 ksi (241 MN/m²). Most of the straightening occurred on the initial stress cycle of 105 percent of yield strength. The more favorable straightening tendencies were observed with the faired weld bead specimens as opposed to the intact weld bead specimens. Most notably, the tensile failure rate was much greater with intact weld bead specimens than with faired weld bead specimens during progressive stress cycling.

Weld joint tensile results as well as the joint straightening tendencies after stress cycling indicate the advantages of the weld bead fairing process. Therefore, it is concluded to be a good fabrication practice to remove the weld bead reinforcement and fair the joint with the adjacent base material surfaces whenever out-of-tolerance peaking is not corrected by either mechanical techniques or rework.

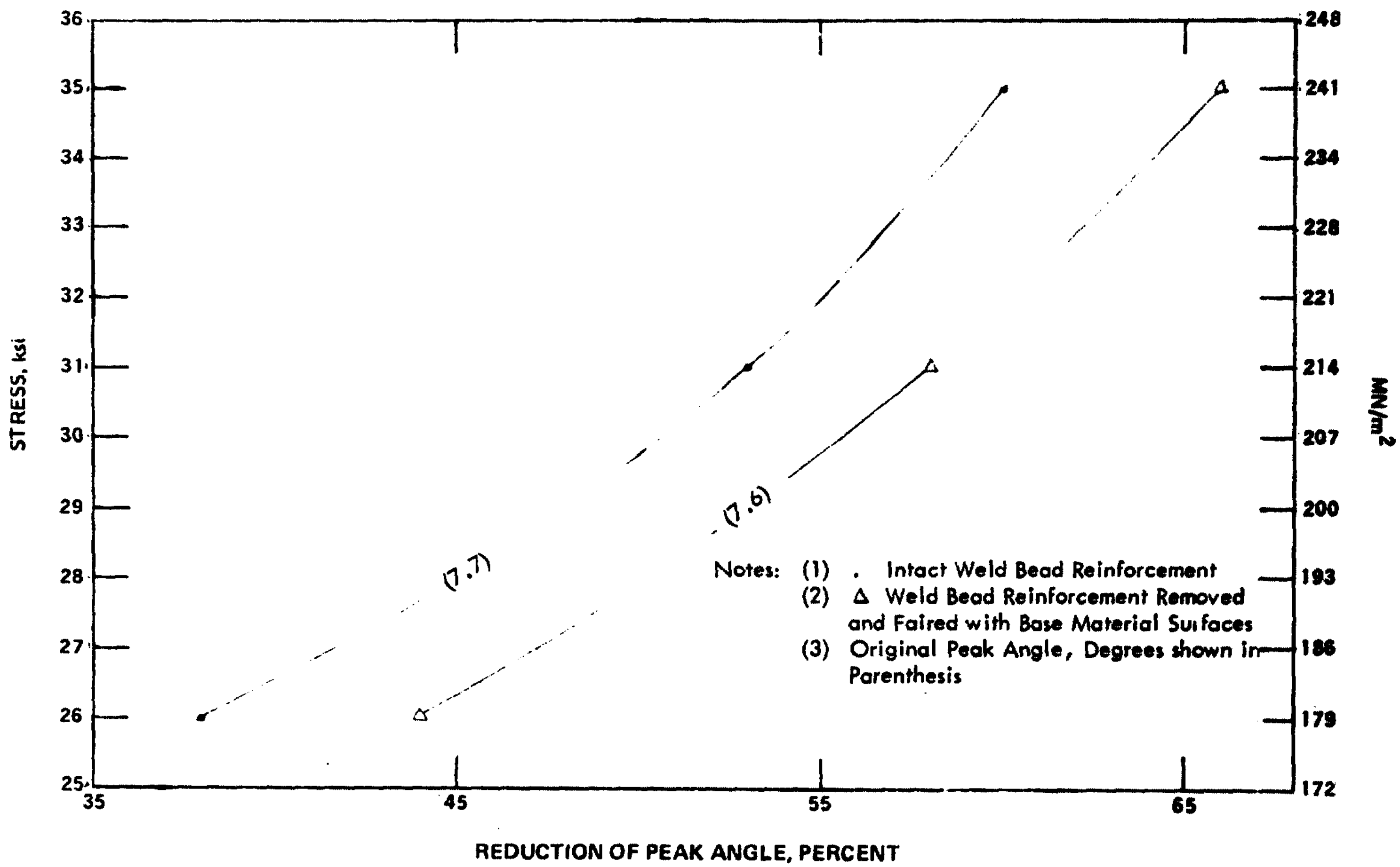

Figure 8. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m^2) [1/2-in. (1.27 cm) plate weldments with a fabrication target peak angle of 6 degrees].

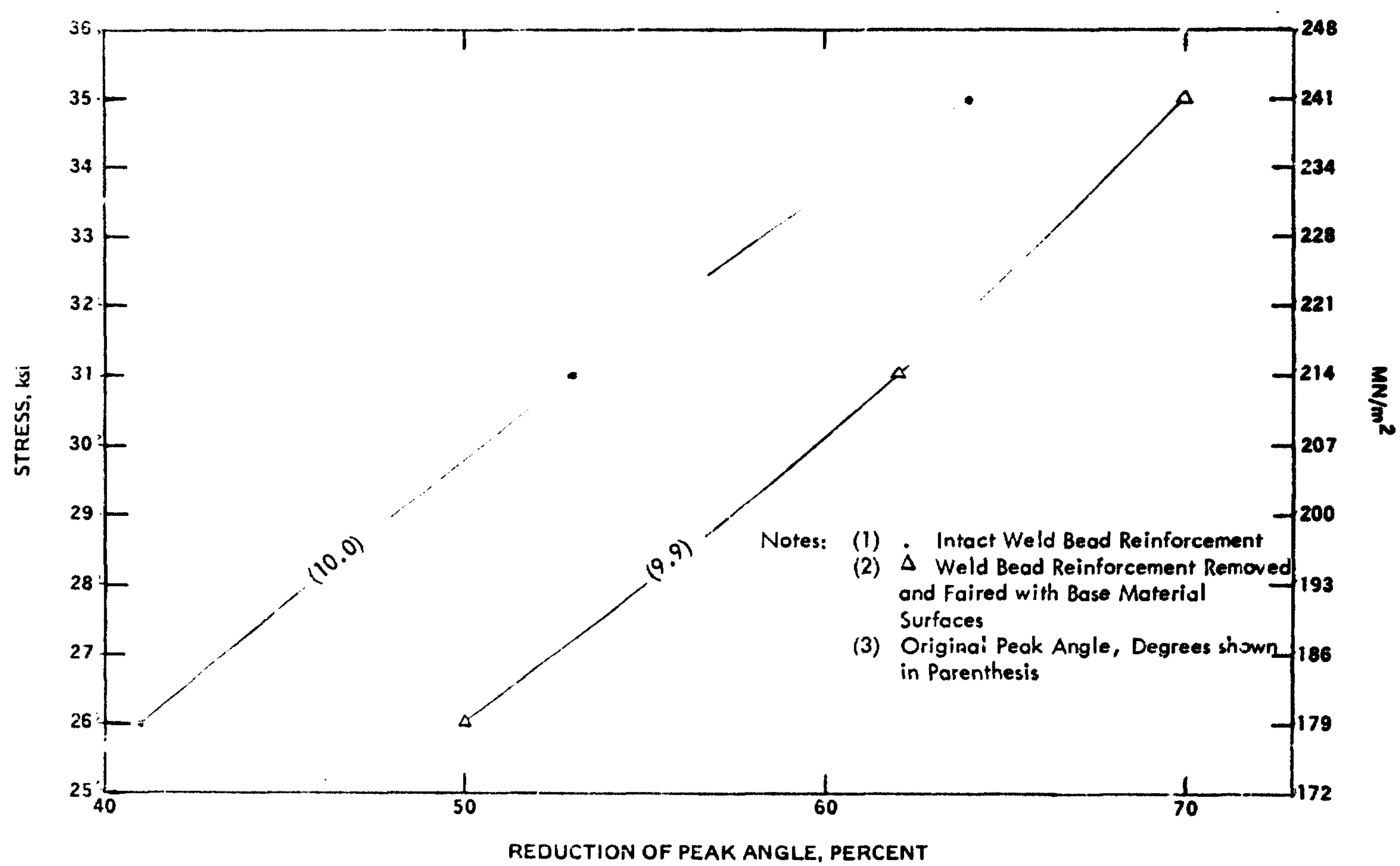

Figure 9. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m²) [1/2-in. (1.27 cm) plate weldments with a fabrication target peak angle of 9 degrees].

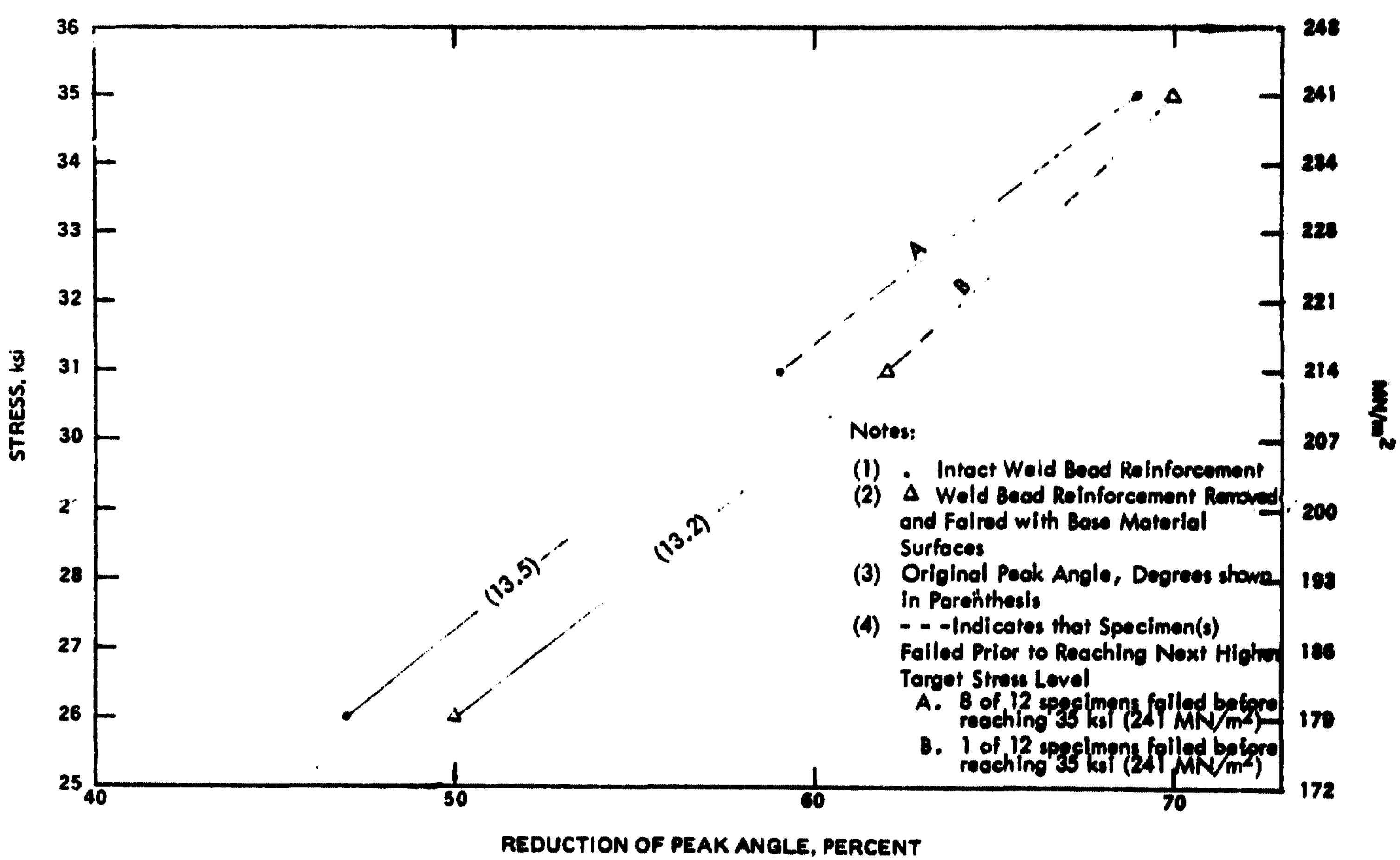

Figure 10. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m^2) [1/2-in. (1.27 cm) plate weldments with a fabrication target peak angle of 12 degrees].

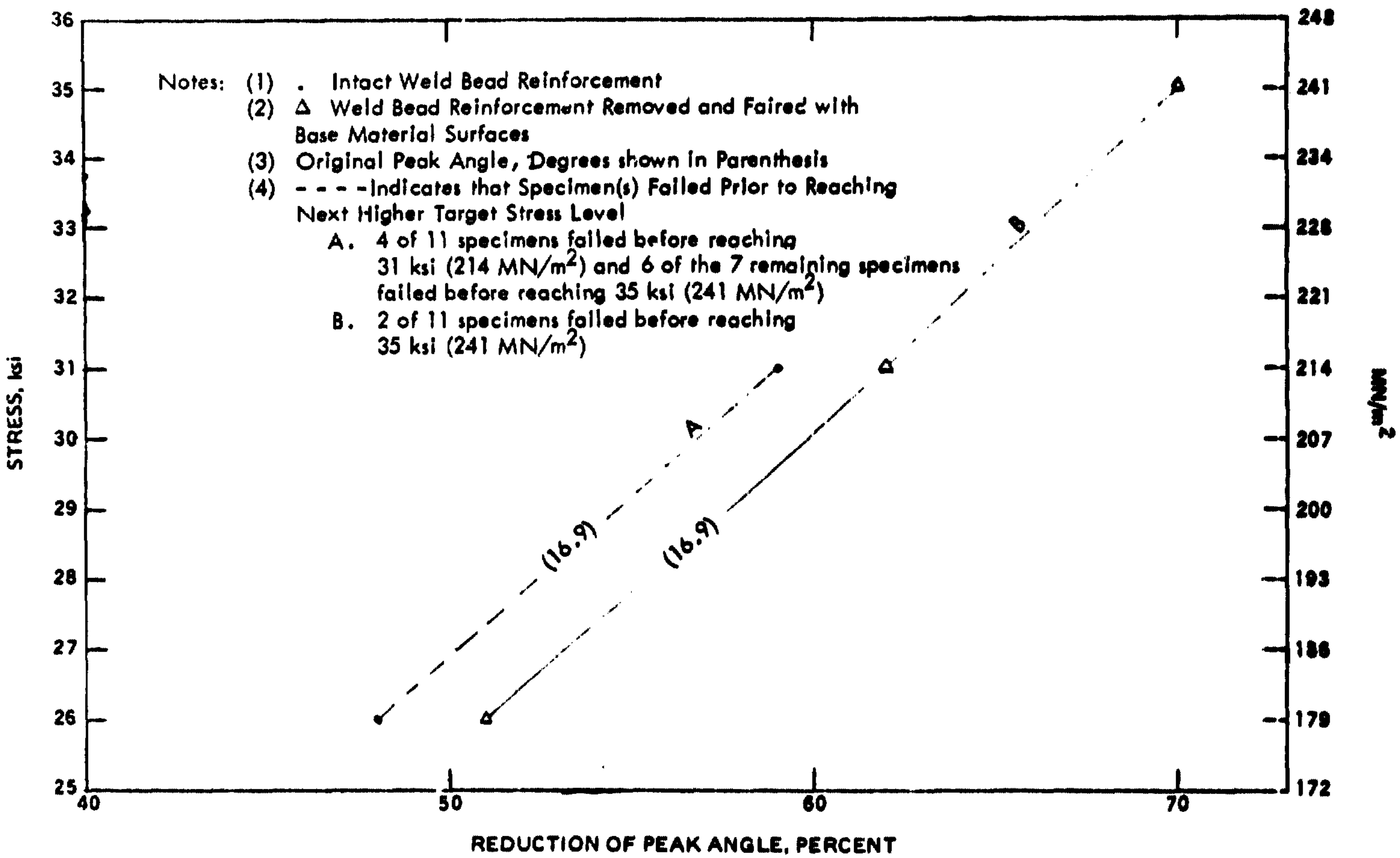

Figure 11. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m²) [1/2-in. (1.27 cm) plate weldments with a fabrication target peak angle of 15 degrees].

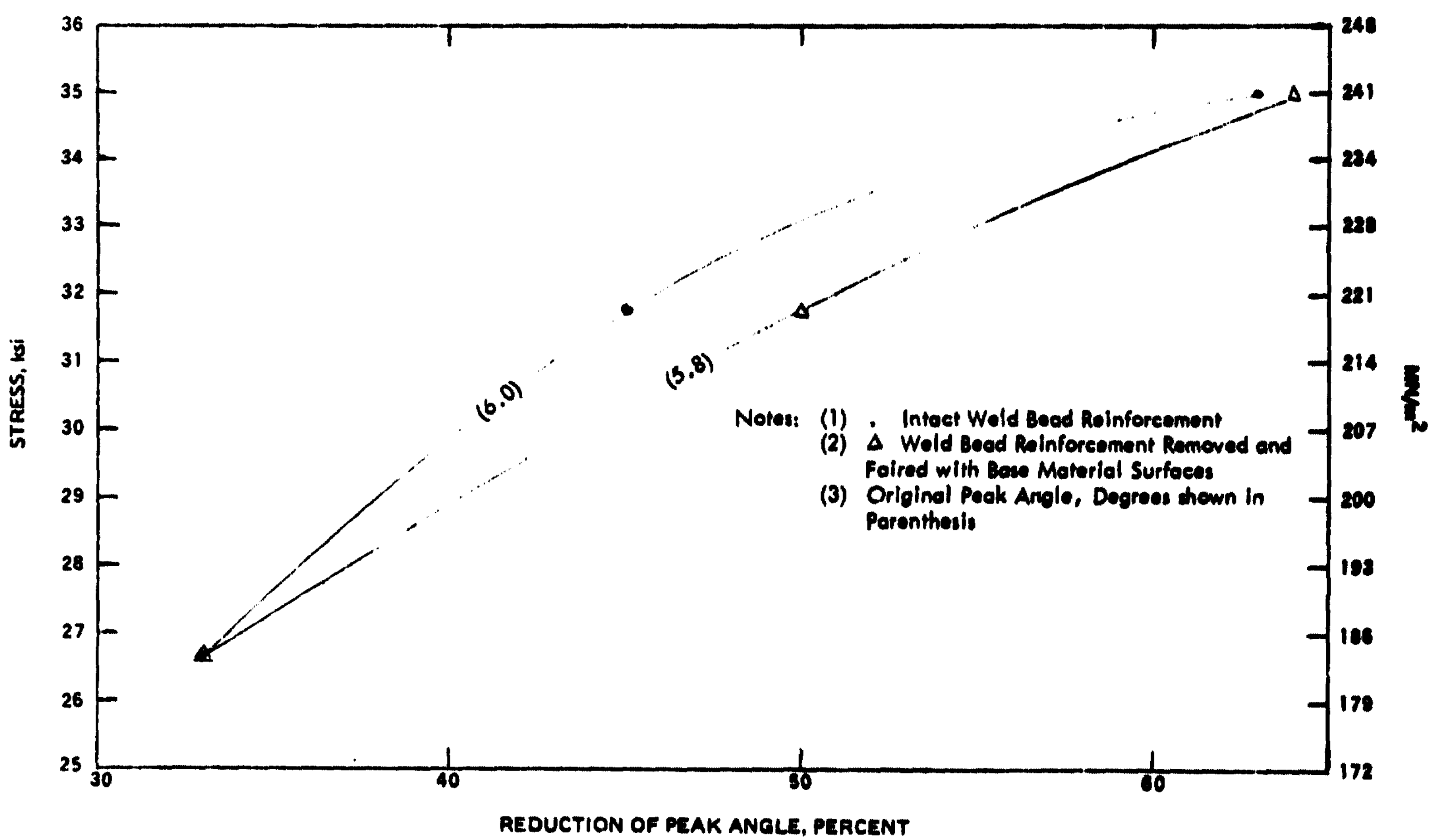

Figure 12 Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m^2) [1-in. (2.54 cm) plate weldments with a fabrication target peak angle of 6 degrees].

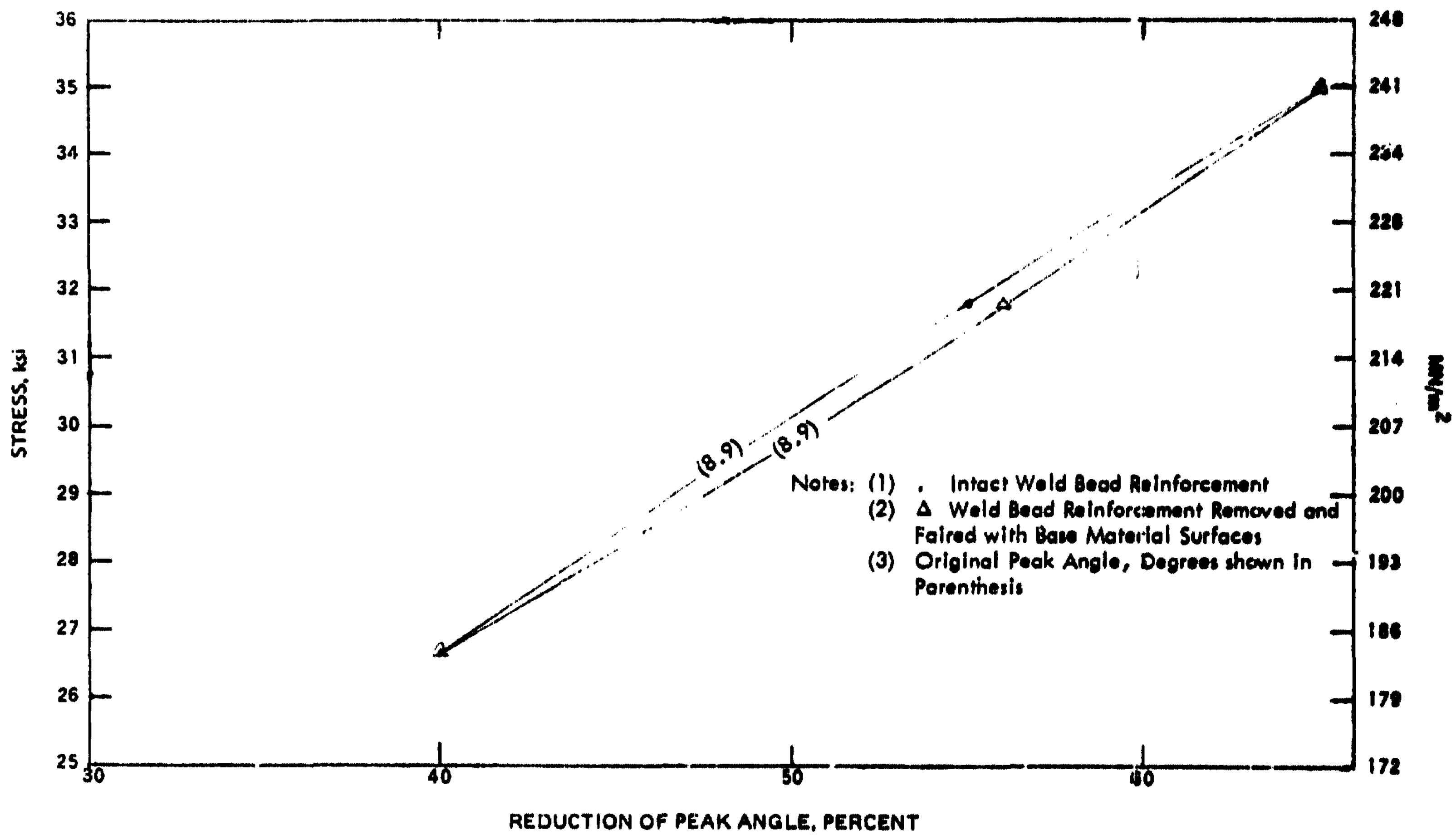

Figure 13. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m^2) [1-in. (2.54 cm) plate weldments with a fabrication target peak angle of 9 degrees].

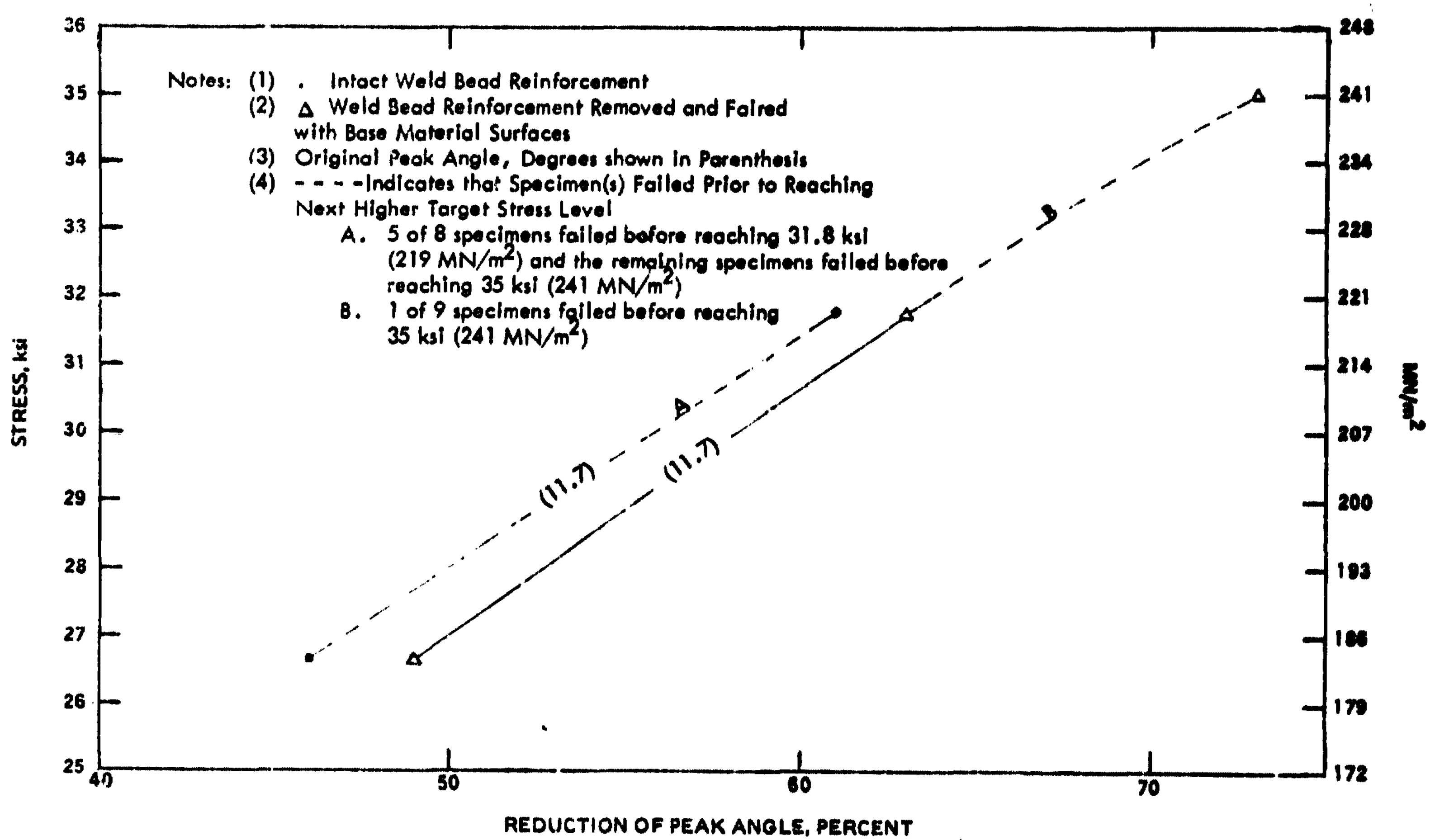

Figure 14. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m^2) [1-in. (2.54 cm) plate weldments with a fabrication target peak angle of 12 degrees].

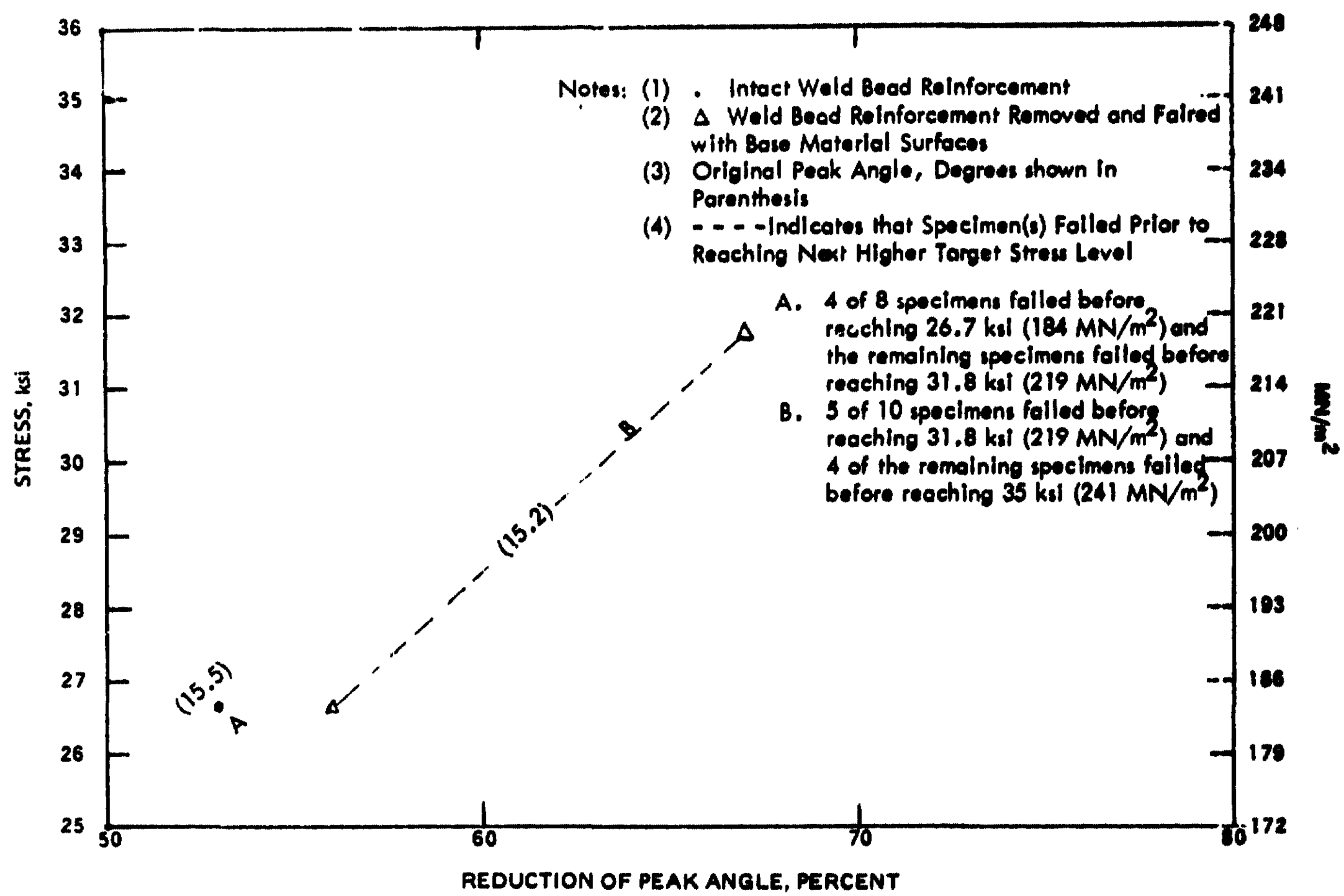

Figure 15. Reduction of peak angle in percent after releasing each stress of 105 percent yield strength, 125 percent yield strength, and 35 ksi (241 MN/m^2) [1-in. (2.54 cm) plate weldments with fabrication target peak angle of 15 degrees].

REFERENCES

1. Bayless, E., Poorman, R., and Sexton, J.: Weld Peaking on Heavy Aluminum Structures. NASA TM-78176, June 1978.

2. Mayer, L. W.: Alcoa Aluminum Alloy 2219. Alcoa Green Letter, January 1962.

3. MSFC-SPEC-504: Welding, Aluminum and Aluminum Alloys. Marshall Space Flight Center, AL, March 25, 1970.

4. MSFC-SPEC-504A: Welding, Aluminum Alloys. Marshall Space Flight Center, AL, 1977.

5. Davis, R. A.: Evaluation of Welded 2219-T87 Aluminum Alloy. MPT-P&VE-M-62-16, December 19, 1962.

APPROVAL

WELD BEAD REINFORCEMENT REMOVAL – A METHOD OF IMPROVING THE STRENGTH AND DUCTILITY OF PEAKED WELDS IN 2219-T87 ALUMINUM ALLOY PLATE

By Charles V. Lovoy

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

R. J. Schwinghamer
Director
Materials and Processes Laboratory

U.S. GOVERNMENT PRINTING OFFICE 1979–640-081/479 REGION NO. 4