UNIVERSITY OF ALBERTA

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American Institute of Steel Construction

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Project Title: **Strength of Transverse Fillet Welds Made with Filler Metals without Specified Toughness**

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Executive Summary

Appendix J2.4 in the AISC Specification permits an increase in fillet weld strength as the angle between the line of action of the load and the orientation of the weld axis increases, based primarily on the work of Miazga and Kennedy (1986) and Lesik and Kennedy (1990). The fact that transverse welds are permitted an increase in strength of 50% has recently been the subject of concern since Miazga and Kennedy performed all their tests using one filler metal (E7014) and a welding process (SMAW) that is used by the steel industry for shop fabrication far less often than other processes such as flux cored arc welding (FCAW). Furthermore, the level of toughness of the filler metal used in the tests was not evaluated.

The objective of the research is to expand the work of Miazga and Kennedy on transverse welds and to assess the influence on strength and ductility of a wide variety of factors. A total of 102 weld tests were conducted to investigate the effect of the following parameters: (1) filler metal classification, both with and without a toughness requirement; (2) flux cored vs. shielded metal arc melding; (3) weld size and number of passes; (4) welding electrode manufacturer; (5) steel fabricator; (6) low temperature; and (7) weldment geometry (lapped vs. cruciform splice). The experimental design included triplicate tests in all cases. An analysis of variance of the test results was used to assess the statistical significance of the test parameters.

The following conclusions can be drawn from the statistical analysis of the test results:

1) The strength and ductility of the E7014 fillet welds tested in this investigation are comparable to those reported by Miazga and Kennedy (1989).
2) Weld toughness, weld size, electrode manufacturer, and fabricator were all found to be influential parameters on weld strength.
3) Testing temperature did not have a significant influence on weld strength.
4) Weld toughness, weld size and testing temperature were all found to be influential on weld ductility.
5) Electrode manufacturer and fabricator did not have a significant effect on weld ductility.
6) Although the strength of the cruciform test specimens was significantly different from the strength of lapped splice specimens, its effect on strength varies depending on whether strength is calculated on the throat area or the fracture surface area.
7) Fillet welds in cruciform splices show a lower ductility than transverse fillet welds in lapped splices.
8) All 102 test results confirm that the fillet weld design equations in both the AISC specification and the Canadian standard—accounting for the 50% increase in strength permitted for transverse welds—give a safe prediction of capacity. The resistance factor used in the AISC specification provides a safety index greater than 4.5.

Acknowledgments

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Strength of Transverse Fillet Welds Made with Filler Metals without Specified Toughness

University of Alberta

1. Introduction

This research program, initiated with a grant from the American Institute of Steel Construction (AISC), consists of three phases. Phase I conforms to the original proposal approved by AISC and deals with transverse fillet welds. Phases II and III were subsequently added to the program, in consultation with AISC, to include welds with other orientations and welded joints with combinations of weld orientations. This significant extension of the program was made possible through additional funding awarded to the researchers by the Natural Sciences and Engineering Research Council of Canada (NSERC). The following is the final report on Phase I of the project. Phases II and III are currently in progress.

Two welding electrode manufacturers and two experienced steel fabricators were used in this research program. In the report, they have each been assigned a letter designation. The electrodes were manufactured by Hobart Brothers Co. (H) and Lincoln Electric Co. (L) and the fabricators were Waiward Steel Fabricators Ltd. (W) and Supreme Steel Ltd. (S), both of Edmonton, Alberta. Throughout the report, for brevity the names have been abbreviated to Hobart, Lincoln, Waiward, and Supreme, respectively. In most tables and graphs, the companies are identified only by the letter designation.

Due to the relatively large number of variables involved, specimens have been given an abbreviated identifier to provide a convenient means of describing the specimen. These identifiers are used only in the appendices, which contain large amounts of data. The identifier takes the form E7XXX(M)F S, where E7XXX is the AWS electrode classification. The letter inside the brackets indicates the electrode manufacturer (H stands for Hobart and L for Lincoln). The letter immediately after the brackets indicates the steel fabricator (S for Supreme and W for Waiward). The specified weld leg size, in inches, follows.

The primary system of units used throughout this report is the Système International (SI). However, for reasons of familiarly and readability, US standard units are used for certain designations, such as those of the American Welding Society (AWS) welding electrode classifications.

On-site shop procedure reviews were made during the fabrication stage by Tom Schlafly of AISC and, with the consent of AISC, James Gilbank of the Lincoln Electric Co. Input at the early stages of the research was provided by members of AISC Task Committee 7.

2. Background

The behavior of fillet welds has been known for several decades to be dependent upon the direction of the load with respect to the weld axis. Research on fillet welds has been conducted primarily on transverse welds (welds with their axes perpendicular to the applied load) and longitudinal welds (welds loaded parallel to their axes). These two orientations have been considered to define both the upper and lower bounds of fillet weld strength and ductility, with transverse welds having the upper bound strength and the lower bound ductility. In comparison, fewer tests have been conducted on fillet welds loaded at intermediate angles. Miazga and Kennedy (1989) presented a review of the literature covering both testing and theoretical analysis of fillet welds starting from the early work of Hankins and Allan (1934).

In order to expand the database of test results for welds loaded at intermediate angles, Miazga and Kennedy (1989) conducted a series of lapped splice fillet weld tests in which seven loading angles, two weld sizes, and three specimens for each combination were tested. The weld angles investigated varied from 0° (longitudinal weld) to 90° (transverse) in increments of 15°. All test specimens were fabricated using shielded metal arc welding (SMAW) with E7014 electrodes, which have no specified toughness requirement. Miazga and Kennedy developed an analytical method for predicting the strength of fillet welds loaded in shear, based on the maximum shear stress failure criterion, that is a function of both the angle of loading and the angle of the fracture surface in the weld. The method was corroborated using their own test results as well as those of others (Butler and Kulak 1971; Clark 1971; Holtz and Hare, *unpublished data*). Lesik and Kennedy (1990) proposed a simplified equation for which predicted weld strength deviates from that predicted by the Miazga and Kennedy equation by less than 1.5%. The equation is a function only of the loading direction and takes the form of a multiplier that is applied to the longitudinal fillet weld strength:

$$[1] \qquad V_{\theta} / V_{l} = 1.0 + 0.50\sin^{1.5}\theta$$

where V_{θ}/V_{l} is the ratio of the strength of the fillet weld (oriented at an angle θ) to that of an equivalent longitudinal fillet weld, and θ is the angle between the weld axis and the line of action of the force. This modifier has been adopted in Appendix J of the American Institute of Steel Construction specification (AISC 1999), as well as the Canadian structural steel design standard, CSA–S16–01 (CSA 2001). Equation 1 predicts an increase in fillet weld strength as the angle between the weld line and the applied load increases from 0°, with an increase in strength of as much as 50% for welds loaded transversely.

The experimental work of Miazga and Kennedy was extended by Lesik and Kennedy (1990) to consider the strength of fillet welds loaded eccentrically in-plane using the method of instantaneous centre of rotation. Simplified expressions to predict the load deformation behavior of fillet welds loaded at various angles were presented.

3. Scope and Objectives

Equation 1 predicts that a transverse fillet weld has a capacity that is 50% larger than that of an equivalent longitudinal weld. The broad applicability of this large increase in strength for transverse welds has recently been questioned since Miazga and Kennedy performed all their tests using one filler metal (E7014) and a welding process (SMAW) that is used by the steel industry for shop fabrication far less often than other processes such as flux cored arc welding (FCAW). The welds were also performed by a welder working primarily in the research field, which is not representative of the industry. E7014 electrodes have no specified toughness requirement; however, the level of toughness was not determined and may have been influential since SMAW generally produces welds with toughness levels that routinely exceed 27 J (20 ft-lbf) at room temperature. Furthermore, the significance of other parameters, such as filler metal classification (with and without specified toughness) and manufacturer, steel fabricator, weld size and number of passes, orientation of the root notch, and ambient temperature, need to be assessed systematically.

The main objective of the research is to expand the body of experimental results on transverse fillet welds to include the FCAW process and to confirm the applicability of the current provisions of Appendix J2.4 of the AISC specification to a broader range of electrode types and other conditions. In particular, the selected filler metals were to possess varying levels of material toughness. Although the experimental program investigates primarily specimens prepared using FCAW, nine test specimens were also prepared using SMAW with E7014 electrodes to provide a direct comparison to the results of Miazga and Kennedy. Two of the FCAW filler metals investigated have no toughness requirement and the other has a specified toughness requirement. Two weld sizes, 6.4 mm (1/4 in.) and 12.7 mm (1/2 in.), have been included in the study, the former being deposited in one pass and the latter in three. Welds with multiple passes were included, in part, to assess the effect of potential tempering of the root pass by the deposition of subsequent passes. Two local steel fabricators and electrodes from two large manufacturers were used in the study to assess the associated resulting variability in weld behavior. A limited number of tests were conducted at -50°C to determine the effect of cold temperature. Six specimens having a cruciform configuration were also tested to assess the need for and nature of future investigations of the effect of the root notch orientation imposed by the weldment geometry. In all cases, tests were conducted in triplicate, so as to provide a means of assessing statistically the variability of the parameters investigated, as well as their relative importance.

4. Test Specimens and Fabrication Procedures

4.1 Filler Metals

Table 1 presents a description of the FCAW filler metals used in this study, including the lot numbers of the spools. Five types of filler metal were tested, namely, E70T-4, E70T-7,

E70T7-K2, E71T8-K6, and E7014 (SMAW), resulting in a total of 102 specimens. (A single electrode designation could not be used in the third case because the two wire manufacturers did not offer products with the same conformance. However, in consultation with AISC Task Committee 7, E70T7-K2 and E71T8-K6 electrodes were deemed to be equivalent for the purposes of this study.) The first two filler metals (E70T-4 and E70T-7; AWS 1995) have no specified toughness requirement, while the electrodes with a toughness requirement selected for this research (E70T7-K2 and E71T8-K6; AWS 1998) have a specified toughness requirement of 27 J (20 ft-lbf) at -29°C (-20°F).

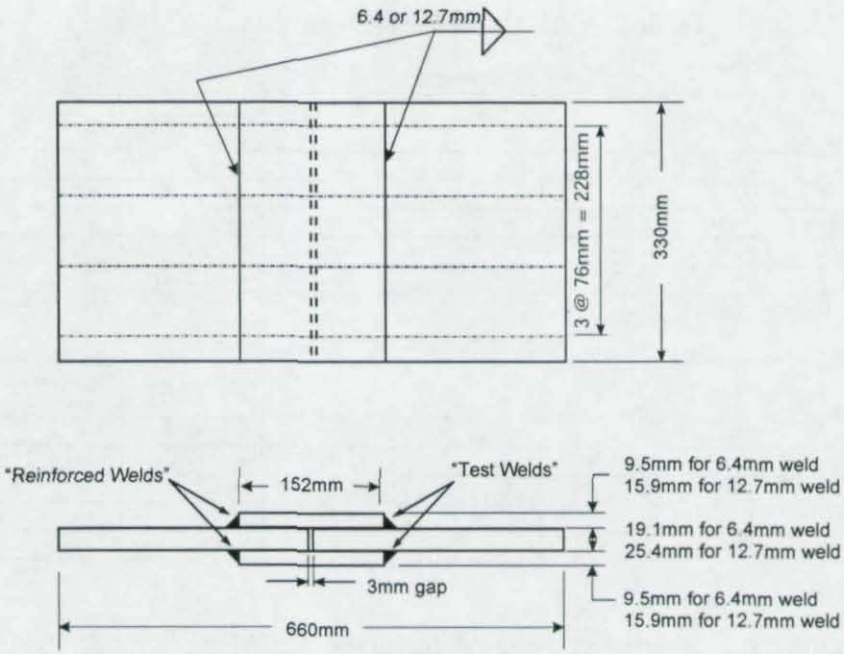
Table 1 – Description of Flux-Cored Arc Welding Wires

AWS Classification	Electrode Manufacturer	Proprietary Designation	Lot No.
E70T-4	Hobart	Fabshield 4	04-24-250C 54208B0661
E70T-4	Lincoln	Innershield NS3M	2A15SA
E70T-7	Hobart	Fabshield 7027	S222729-014 F00836-001
E70T-7	Lincoln	Innershield NR311	11G27AN
E71T8-K6	Hobart	Fabshield 3Ni1	S226625-029 E11187-001
E70T7-K2	Lincoln	Innershield NR311Ni	3A30TG

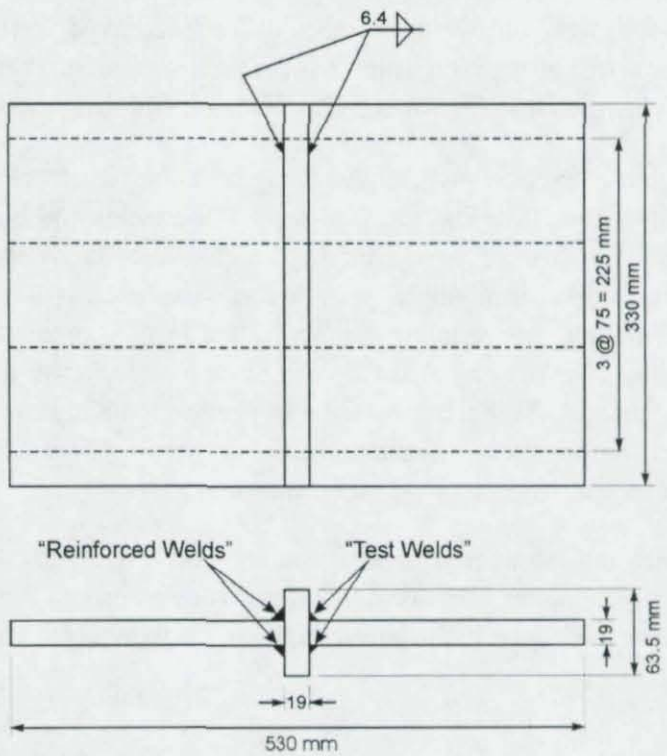
4.2 Transverse Fillet Weld Test Specimens

Ninety-six test specimens were fabricated as double lap splice joints, as shown in Figure 1a, and six specimens were fabricated in a cruciform configuration, as shown in Figure 1b. The latter specimens were prepared to investigate the effect of weldment geometry, as it was believed that the orientation of the root notch might affect fillet weld behavior. Table 2 presents a description of the test matrix for the research.

In order to reduce both the preparation time and the amount of required instrumentation, two welds from each test specimen were reinforced, as shown in Figure 1, to ensure that failure would take place in one of the other two welds (referred to hereafter as the "test welds"). In all cases, fabrication was done in assemblies of three specimens that provided generous run-on and run-off regions in an attempt to provide uniform weld quality within the test specimens. The specimens themselves were then cut from the assemblies and milled to a width of 76 mm.



(a) Lapped splice specimens



(b) Cruciform specimens

Figure 1 – Transverse Fillet Weld Test Specimens

Table 2 – Matrix of Test Specimens

Waiward

AWS Classification	E70T-4				E70T-7				E71T8-K6		E70T7-K2		E7014	
Electrode Manufacturer	H		L		H		L		H		L		L	
Weld Size (mm)	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7
No. of Specimens	12*	3	3	3	3	3	3	3	3	3	6*	3	9	3
No. of Charpy Tests	3 x 2		3 x 2		3 x 2		3 x 2		3 x 2		3 x 2		3 x 2	
No. of Tension Tests	5		2		2		2		2		2		2	

* Includes three cruciform specimens

Supreme

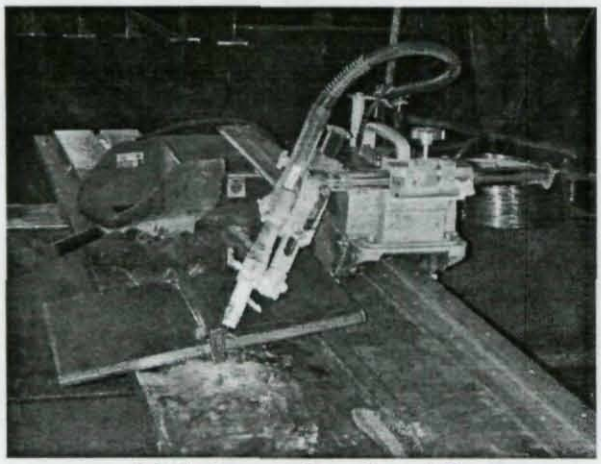
Filler Metal Classification	E70T-4				E70T-7				E71T8-K6		E70T7-K2	
Electrode Manufacturer	H		L		H		L		H		L	
Weld Size (mm)	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7	6.4	12.7
No. of Specimens	3†	3	6	3	3	3	6	3	3	3	3	3
No. of Charpy Tests	3 x 2		—		—		3 x 2		3 x 2		—	
No. of Tension Tests	2		—		—		2		2		—	

† Tested at –50°C

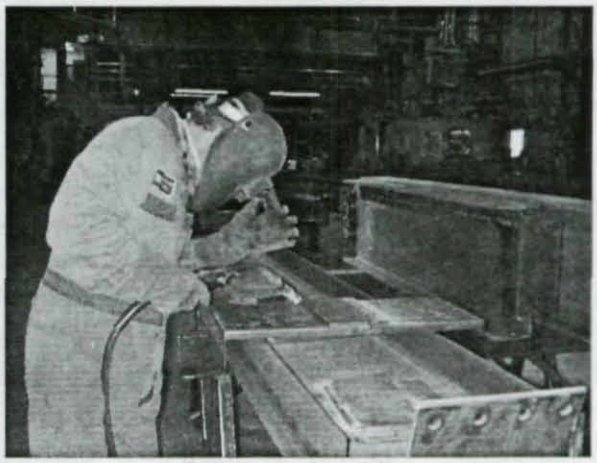
All plates used in the test program met the requirements of ASTM A572 grade 50 steel. Plate thicknesses and heats were selected so that the plates yielded prior to fracture of the welds in order to minimize the amount of lateral restraint to the weld region near the ultimate load. In the case of the E7014 electrodes, plates for the 6.4 mm welds were selected to remain elastic for consistency with the tests conducted by Miazga and Kennedy (1989). All steel plates were supplied by one fabricator, and welds for each filler metal type were made by both fabricators from the same spool of wire to ensure that the fabricator would be the only source of variation for cases having the same filler metal classification and manufacturer.

In order to accentuate the differences that might occur between two fabricators, Waiward used an automated welding track (see Figure 2a) to deposit the welds and Supreme used the standard hand-held semiautomatic process (see Figure 2b). Specimens with fillet welds having 6.4 mm legs were welded in a single weld pass, and specimens with 12.7 mm legs were welded using three passes. All welding was performed in the horizontal position. The welding procedure specifications used by Waiward and Supreme are shown in Tables A1 and A2, respectively, of Appendix A. To determine the root penetration and the extent of fusion, some sections were etched for visual examination, as shown in Appendix B. In general, penetration beyond the root was revealed by the examinations.

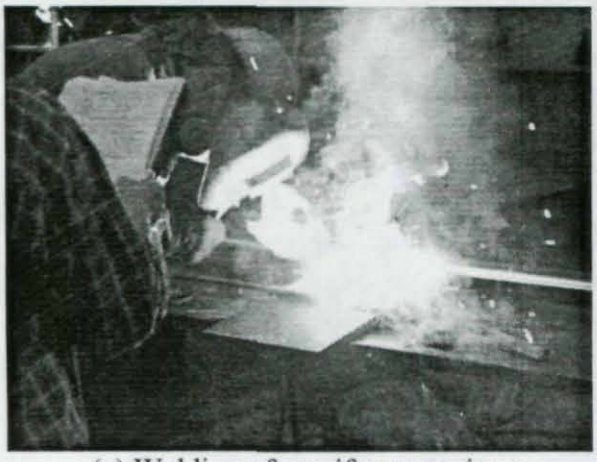
Figure 2c shows the welding of a cruciform specimen and Figure 2d shows the plate assemblies used for the preparation of the weld metal test specimens and the Charpy impact specimens (the preset that can be seen in the photograph offsets the weld shrinkage).



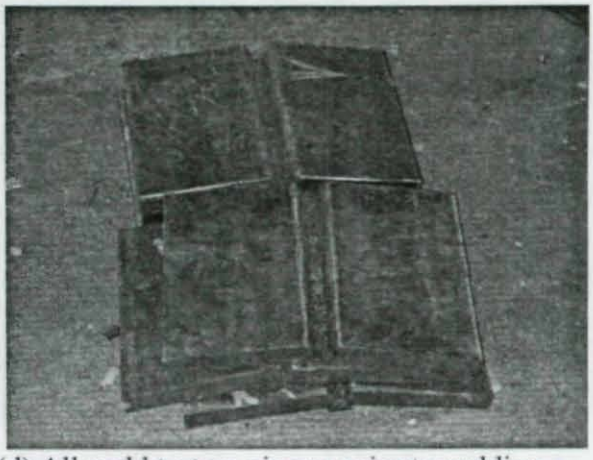
(a) Automated track welding



(b) Manual welding



(c) Welding of cruciform specimen



(d) All-weld test specimens prior to welding

Figure 2 – Fabrication of Test Specimens

4.3 Ancillary Test Specimens

Both tension tests and Charpy impact tests were performed for each filler metal to determine the tensile properties and the fracture toughness of the filler metal. The test specimens were machined from a standard groove welded assembly prepared in accordance with Clause 8 of ANSI/AWS A5.20 (AWS 1995) for the FCAW specimens and Clause 8 of ANSI/AWS A5.1 (AWS 1991) for the SMAW specimens. The ancillary test specimens were prepared using the same wire spools as those used for the fillet weld test specimens.

As shown in Table 2, two tension specimens were tested for each filler metal, with five specimens (three from one assembly and two from another) being used in one case to assess the repeatability of the results. Two Charpy impact tests were conducted at each of three different temperatures, namely, -29°C, 21°C and 100°C. The lowest temperature is the temperature at which the E70T7-K2 and E71T8-K6 weld metals have a toughness requirement in the standard (AWS 1998). The highest temperature provides an estimate of the upper shelf toughness.

In order to characterize the properties of the base metal and confirm the grade, tension coupon tests were also conducted on each plate material used. The tension coupon tests were conducted in accordance with ASTM standard A370-97a (ASTM 1997).

A chemical analysis of each filler metal from each manufacturer was also carried out to determine whether the chemical composition meets the requirements of the applicable AWS specification. In addition, a series of Rockwell hardness tests were done on the fillet welds and the Charpy specimens to investigate whether there is a noticeable difference in hardness—generally considered to be closely associated with tensile strength—between the fillet welds and the all weld metal samples. Figure 3 presents a plot of Rockwell C hardness measurements on the fillet weld versus the hardness measurements on the associated weld metal coupon specimen before and after testing of the fillet welds. The figure shows no obvious correlation between the fillet weld hardness and the weld metal coupon hardness. In general, however, the weld metal coupons showed a lower hardness than the fillet welds. This is attributed to the cooling rate difference between the fillet weld specimens and the weld metal specimens. The multi-pass welding of the weld metal specimens provided a much slower cooling rate than the single pass fillet weld specimens and possibly the ½" multi-pass fillet weld specimens.

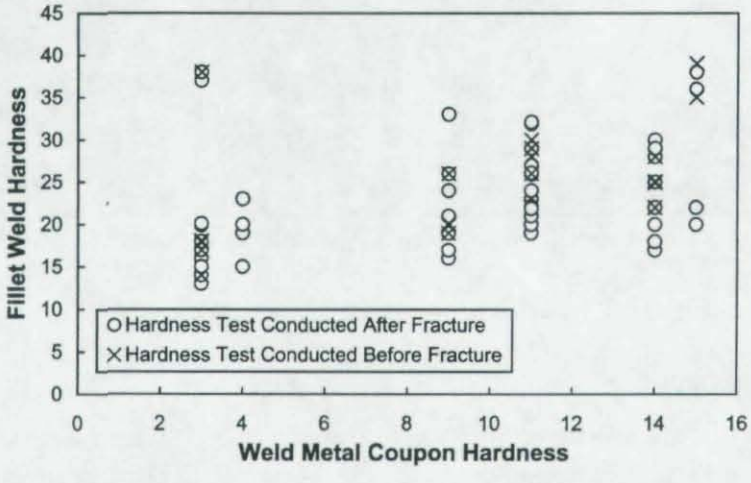


Figure 3 – Fillet Weld Hardness vs. Weld Metal Coupon Hardness

5. Test Procedures and Data Acquisition

5.1 Specimen Preparation

Prior to testing the transverse weld specimens, detailed measurements of the two test welds were taken. The two legs and the throat dimensions (taken at 45°) were measured with a caliper and adjustable fillet weld gauge, respectively, at eight locations along the 76 mm length. A more detailed characterization of the weld profile (amount of reinforcement) of the larger 12.7 mm welds was established by means of two additional measurements parallel to

the throat dimension with the adjustable fillet weld gauge. The values of the individual pre- and post-test weld measurements and the profiles of all the test welds are presented in Appendix C. Each plot shows the profile at each of the eight measurement locations along the length of the weld, giving an indication of the variability of the profile.

5.2 Testing Procedures and Measurements

The test set-up is shown in Figure 4. The tests were conducted in a standard tension testing machine with a 1750 kN capacity. Four linear variable differential transformers (LVDTs)—two on each test weld—were used to measure weld deformations. (While testing the cruciform specimens it was discovered that initial out-of-straightness resulted in appreciable bending that caused unequal loading in the two test welds. To account for this, only two LVDTs were used for the remainder of the tests, one located on each end of the specimen at the test welds. In this way, an averaged response of the two welds is obtained.) The LVDTs were mounted with custom-made brackets developed as part of this research project that were designed to ensure that the displacement measurements include only the deformation within the leg dimension and avoid capturing a significant amount of plate deformation. This was an important test design consideration because the plates were designed to yield prior to weld fracture. Two light punch marks were made at the toe of the weld on the base plate for each LVDT. These punch marks ensured that the two hardened steel anchors of the LVDT brackets sat securely throughout the test. The rear of each bracket had two integrated steel rollers to stabilize the assembly, while at the same time eliminating longitudinal restraint.

The LVDTs were kept in place right up to fracture of the first of the test welds in order to acquire the full load vs. deformation response. The second test weld was then failed to facilitate removal from the testing machine. However, the instrumentation was removed for this final stage because of the non-representative loading on the weld that arises from the severe connection asymmetry introduced by the failure of the first weld. Although only one of the two test welds is instrumented up to fracture, important data are obtained for the other weld to very near the fracture point. The data acquisition system provided a real time plot of the load vs. deformation curve for each of the four LVDT locations that was used in controlling the tests. The tests were conducted quasi-statically, with static readings taken at multiple points during the test.

Following fracture of the welds, the specimen was carefully removed from the testing machine to avoid any damage to the fracture surface. The area of the fracture surface, which includes the weld root penetration, and the angle of the fracture were measured at eight locations along the weld length. The angle of the fracture surface was measured with a vernier bevel protractor. The fracture surfaces of some of the weld specimens were examined under a scanning electron microscope to determine the nature of the fracture process (ductile or brittle) at various locations on the fracture surface.

Three specimens were tested according to the above procedures at –50°C. In order to achieve such a cold environment, a customized cold chamber fabricated from rigid insulation was

fitted to the test specimen. Dry ice was placed in the chamber to lower the temperature and a small fan was used to blow the air toward the specimen. The surface temperatures of the welds on both the near and the far faces of the specimen were monitored throughout the test using thermocouples and the temperature was controlled with a good degree of accuracy by toggling power to the fan.

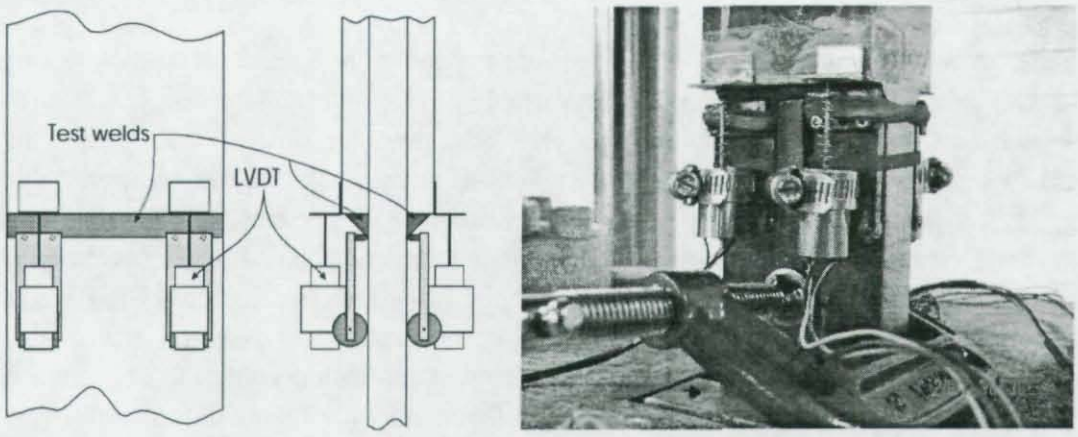


Figure 4 – Test Set-up and Instrumentation

6. Test Results

6.1 Weld Metal Chemical Analysis

A chemical analysis of the weld metal was performed for each filler metal from each manufacturer and the results are shown in Table 3. All tested assemblies were produced by Waiward. The chemical pads for the analyses were prepared in accordance with Clause 9 of ANSI/AWS A5.20 (AWS 1995) and ANSI/AWS A5.1 (AWS 1991). All elements except for Carbon and Sulphur were measured using either the Inductively Coupled Plasma or Atomic Absorption method. Carbon and Sulphur were measured using a LECO Carbon and Sulphur Analyser. In all cases, the element quantities are within the requirements of the applicable AWS filler metal specification (AWS 1991,1995,1998). A comparison of the filler metals with toughness requirement with those without indicates that the former have a significantly higher nickel content and a significantly lower aluminium content. Nickel is known to improve toughness and aluminium, in sufficient quantity (above 1%), decreases toughness.

6.2 Weld Metal Tension Tests

A summary of the results from the 23 weld metal tension tests is presented in Table 4. The values presented in the table represent the mean values of all tests on identical coupons. Detailed weld metal tension test data and all stress vs. strain curves are presented in Appendix D. In three tests, the coupon failed just prior to the ultimate load, as denoted in the table. The mean static tensile strength and elongation values for these cases exclude the

coupon that failed prematurely. The static yield strengths are determined at 0.2% strain offset and the elongations are measured on a 50 mm gauge length. In all cases, the tensile strength exceeds the minimum requirement in the specifications of 480 MPa, but the amount of excess strength varies widely. The specification for the FCAW filler metals with a specified toughness also sets an upper limit on the tensile strength of 620 MPa, and this requirement was also met in all cases. Only the E70T-4(H)W specimens and one of the E71T8-K6 specimens showed a yield strength less than the minimum of 400 MPa required by the specifications. In addition to the three coupons that fractured prematurely, two coupons (both E70T-4 from Hobart) exhibited ductility slightly lower than the specified minimum. The specified minimum elongation for E7014 (SMAW) filler metal is 17%, while the minimum elongations for the FCAW filler metals in this study with and without specified toughness are 20% and 22%, respectively.

Table 3 – Chemical Analysis of Filler Metals

AWS Classification	Electrode Manufacturer	Weight (%)										
		C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu	Al
E7014	L	0.092	0.260	0.369	0.015	0.0130	0.070	0.055	0.069	0.0200	0.039	<0.010
E70T-4	H	0.345	0.295	0.057	0.010	0.0036	0.024	<0.030	<0.050	0.0034	0.016	1.350
E70T-4	L	0.272	0.330	0.258	0.009	0.0041	0.012	<0.030	<0.050	0.0026	0.016	1.170
E70T-7	H	0.313	0.379	0.065	0.009	0.0032	0.017	0.034	<0.050	0.0046	0.019	1.110
E70T-7	L	0.290	0.442	0.093	0.008	0.0037	0.019	<0.030	<0.050	0.0039	0.021	1.140
E70T7-K2	L	0.087	1.180	0.105	0.012	0.0031	1.190	0.042	0.061	0.0044	0.016	0.738
E71T8-K6	H	0.106	0.806	0.088	0.015	0.0043	0.442	0.030	<0.050	0.0052	0.019	0.392

Table 4 – Weld Metal Tension Coupon Test Results

Assembly Designation	No. of Specimens	AWS Classification	Electrode Manufacturer	Steel Fabricator	Mean Static Yield Strength (MPa)	Mean Static Tensile Strength (MPa)	Mean Modulus of Elasticity (MPa)	Mean Elongation (%)
A1	2	E7014	L	W	452	520	210 700	21.7
A2	5	E70T-4	H	W	354	535 *	185 500	23.2 *
A3	2	E70T-4	H	S	472	631	198 600	22.3
A4	2	E70T-4	L	W	407	562	203 400	27.8
A5	2	E70T-7	H	W	468	605	200 800	23.1
A6	2	E70T-7	L	W	445	584 *	205 200	24.7 *
A7	2	E70T-7	L	S	483	652 *	229 400	22.9 *
A8	2	E70T7-K2	L	W	527	592	207 100	24.6
A9	2	E71T8-K6	H	W	414	490	199 900	27.6
A10	2	E71T8-K6	H	S	402	493	207 400	28.4

* Excludes one coupon that fractured prior to reaching the ultimate stress

6.4 Base Metal Tension Tests

All plate material was produced to meet the requirements of ASTM A572 grade 50 (ASTM 2000) structural steel. Although the precise properties of the base metal are not

considered to have had a significant influence on the fillet weld behavior, material tension tests were conducted to confirm compliance with the standard. A summary of the results from the eight base metal tension tests is presented in Table 5. The values presented in the table represent the mean values of the tests conducted on identical coupons. The static yield strengths are determined from three measurements on the yield plateau and the elongations are measured on a 50 mm gauge length. In all cases, the mean yield and tensile strengths exceed the minimum requirements in the standard of 345 MPa and 450 MPa, respectively. The elongations also exceed the minimum requirement of the standard of 21%. Detailed base metal tension test data and the stress vs. strain response curves are presented in Appendix D.

Table 5 – Base Metal Tension Coupon Test Results

Nominal Plate Thickness (mm)	No. of Specimens	Mean Static Yield Strength (MPa)	Mean Static Tensile Strength (MPa)	Mean Modulus of Elasticity (MPa)	Mean Elongation (%)
9.5	2	418	551	207 500	30.5
15.9	2	347	466	201 400	38.2
19.1	2	392	527	195 400	40.5
25.4	2	386	538	201 600	40.9

6.5 Charpy V-notch Impact Tests

A summary of the Charpy V-notch test results is presented in Table 6. Two tests were conducted according to ASTM standard A370 (ASTM 1997) at each of three temperatures. The lowest temperature (-29°C) is the temperature at which the E70T7-K2 and E71T8-K6 filler metals have a minimum specified Charpy impact energy of 27 J. Although these filler metals did tend to have much higher low temperature toughness than the ones that do not have a toughness requirement, one Charpy specimen from assembly A8 did not meet the specification. These filler metals also tended to have much higher energy values at the higher test temperatures. The E7014 (SMAW) filler metal had higher toughness than the FCAW filler metals without a specified toughness.

Table 6 – Charpy V-notch Impact Test Results

Assembly Designation	AWS Classification	Electrode Manufacturer	Steel Fabricator	-29°C			21°C			100°C		
				Energy (J)	Energy (J)	Mean (J)	Energy (J)	Energy (J)	Mean (J)	Energy (J)	Energy (J)	Mean (J)
A1	E7014	L	W	18	23	20	58	79	68	81	77	79
A2	E70T-4	H	W	7	7	7	8	8	8	31	27	29
A3	E70T-4	H	S	9	8	9	15	18	16	57	47	52
A4	E70T-4	L	W	5	5	5	19	15	17	72	76	74
A5	E70T-7	H	W	7	5	6	16	15	16	49	56	52
A6	E70T-7	L	W	11	5	8	24	30	27	62	75	68
A7	E70T-7	L	S	7	7	7	19	20	20	43	49	46
A8	E70T7-K2	L	W	34	14	24	75	89	82	165	180	173
A9	E71T8-K6	H	W	145	140	142	186	186	186	201	214	207
A10	E71T8-K6	H	S	57	34	45	178	220	199	218	205	212

6.6 Transverse Fillet Weld Tests

A summary of the transverse fillet weld test results is presented in Table 7. The numbers reported represent only the weld that fractured and are the mean values of the three test results from a single assembly. The complete set of test data can be found in Appendix E.

The ultimate strength of the weld has been normalized in two ways. In the first normalization method, the ultimate load in the weld (each test weld is assumed to carry one-half of the total force) is divided by the theoretical effective throat area for the mean measured weld leg sizes and the measured length. This area neglects both the penetration and the reinforcement of the weld, as is done in design. In the second normalization method, the ultimate load is divided by the measured area of the fracture surface. This area accounts for both penetration and reinforcement. These capacities are denoted in the tables as P / A_{throat} and $P / A_{fracture}$.

The strain quantity denoted in Table 7 and Appendix E as Δ/D is the measured weld deformation divided by the gauge length (equivalent to the dimension of the leg loaded predominantly in shear) at each LVDT location on the weld that fractured. The mean value of this strain is given at both the ultimate load and at weld fracture. Full response curves at each of the four LVDT locations are presented for each test specimen in Appendix F.

In general, weld fractures did not occur on well-defined planes, as shown in Figure 5. This phenomenon was also observed by Miazga and Kennedy (1989). Therefore, average values of the failure angle (measured from the shear leg) are presented.

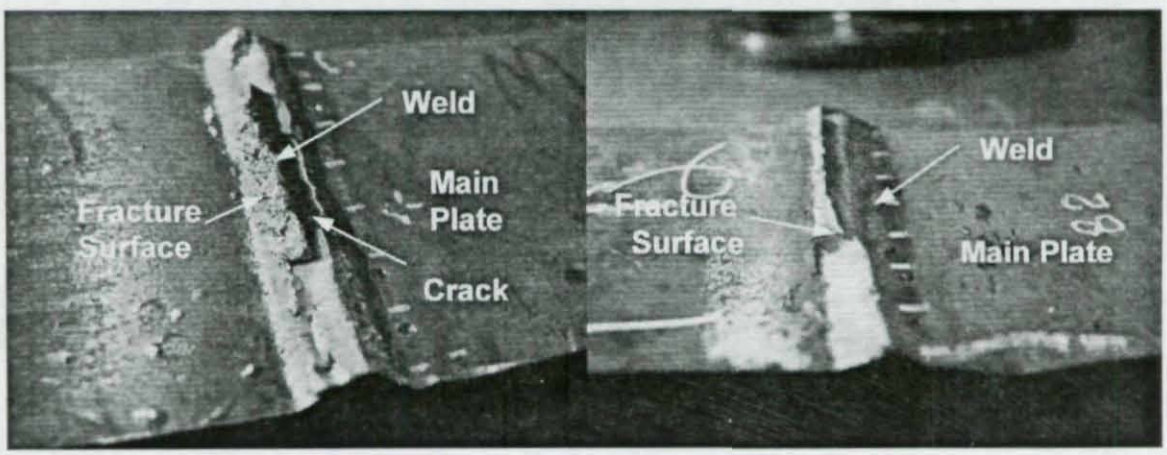


Figure 5 – Non-uniform Failure Angles

Table 7 – Transverse Fillet Weld Test Results

Assembly Designation	Weld Size (mm)	AWS Classification	Electrode Manufacturer	Steel Fabricator	Mean Ultimate Load (kN)	Test/Predicted (S16)		Test/Predicted (AISC)		Mean Ultimate P/A_{throat} (MPa)	Mean Ultimate $P/A_{fracture}$ (MPa)	Mean Δ/D (Ultimate Load)	Mean Δ/D (Fracture)	Average Fracture Angle (°)
						Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength					
T1	6.4	E7014	L	W	510	1.54	1.42	1.72	1.59	738	665	0.09	0.10	10
T2			L	W	473	1.49	1.38	1.67	1.54	721	706	0.10	0.10	11
T3			L	W	520	1.38	1.27	1.54	1.42	666	729	0.09	0.09	15
T4		E70T-4	H	W	642	2.02	1.71	2.26	1.91	976	483	0.08	0.08	0
T5			H	W	636	2.03	1.72	2.26	1.92	978	457	0.09	0.09	0
T6			H	W	707	2.36	2.00	2.64	2.23	1140	846	0.16	0.16	86
T7 *			H	S	635	2.40	2.03	2.68	2.27	1122	714	0.08	0.08	90
T8			L	W	698	1.94	1.65	2.16	1.85	932	613	0.21	0.23	9
T9			L	S	815	2.28	1.94	2.54	2.17	1098	830	0.19	0.19	31
T10			L	S	764	2.05	1.75	2.29	1.96	1012	747	0.11	0.12	2
T11		E70T-7	H	W	677	1.93	1.53	2.15	1.71	930	492	0.10	0.11	0
T12			H	S	699	2.33	1.85	2.60	2.06	1021	808	0.13	0.13	79
T13			L	W	606	2.04	1.59	2.28	1.77	964	697	0.05	0.13	70
T14			L	S	752	1.93	1.50	2.15	1.67	930	521	0.10	0.10	6
T15			L	S	769	2.10	1.63	2.35	1.82	1015	528	0.06	0.06	0
T16		E70T7-K2	L	W	714	2.00	1.62	2.24	1.81	944	693	0.27	0.29	19
T17			L	S	738	2.46	1.99	2.75	2.23	1187	1115	0.09	0.09	82
T18		E71T8-K6	H	W	707	2.36	2.30	2.63	2.57	1137	518	0.34	0.35	0
T19			H	S	769	2.12	2.07	2.37	2.31	1023	787	0.19	0.19	25
T20	12.7	E7014	L	W	870	1.25	1.15	1.39	1.29	602	477	0.15	0.16	14
T21		E70T-4	H	W	966	1.47	1.24	1.64	1.39	708	443	0.13	0.15	0
T22			H	S	936	1.76	1.49	1.96	1.66	849	488	0.13	0.15	0
T23			L	W	935	1.41	1.21	1.58	1.35	682	511	0.16	0.18	14
T24			L	S	1010	1.65	1.41	1.85	1.58	798	666	0.19	0.20	21
T25		E70T-7	H	W	1020	1.63	1.29	1.82	1.44	783	479	0.12	0.13	6
T26			H	S	1063	1.70	1.35	1.90	1.51	822	666	0.20	0.20	23
T27			L	W	910	1.47	1.14	1.64	1.28	710	626	0.10	0.10	17
T28			L	S	993	1.63	1.27	1.83	1.42	788	494	0.12	0.12	6
T29		E70T7-K2	L	W	1069	Plate failed prior to weld fracture								
T30			L	S	1064	1.79	1.45	2.00	1.62	886	703	0.22	0.22	20
T31		E71T8-K6	H	W	1018	1.75	1.71	1.96	1.91	846	469	0.24	0.26	0
T32			H	S	1038	1.66	1.62	1.85	1.81	799	634	0.27	0.26	19
C1	6.4	E70T-4	H	W	643	1.95	1.67	2.18	1.86	942	574	0.03	0.03	5
C2		E70T7-K2	L	W	641	1.92	1.56	2.14	1.74	926	720	0.03	0.03	5

* Specimens tested at -50°C

6.7 Rockwell Hardness Tests

Hardness tests were conducted on a number of fillet welds, both prior and subsequent to failure in the transverse tension tests. Measurements were taken at up to 24 locations on each sample tested, depending, in part, on the area available. For comparison, hardness tests were also performed on some of the Charpy specimens taken from groove welded assemblies. The hardness test results are presented in Appendix G.

It was found that hardness measurements from the Charpy specimens are linearly related to the tensile strength of the weld metal tension coupons made from the same assembly with a strong correlation, as shown in Appendix G. However, no correlation was found between fillet weld hardness measurements and fillet weld strength, whether the hardness was taken before or after weld failure.

7. Analysis and Discussion of Test Results

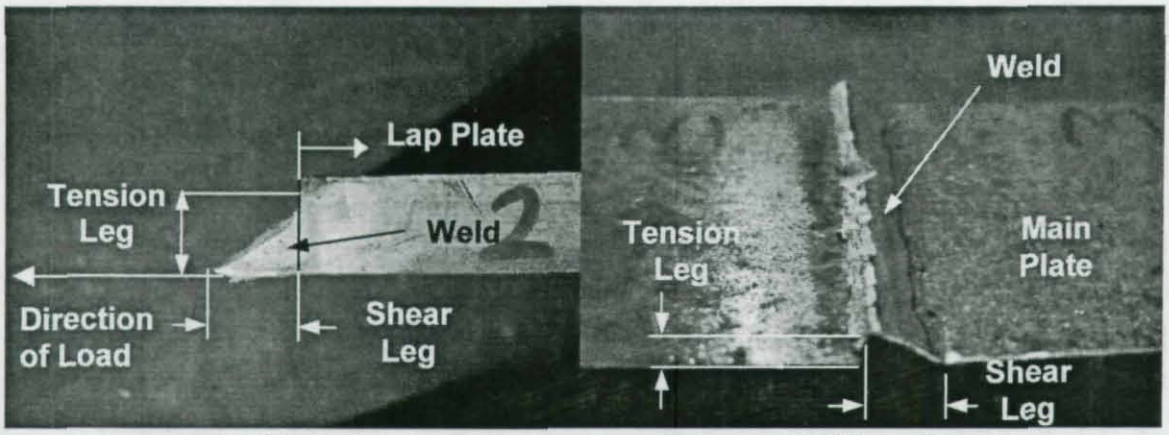
7.1 Strength and Ductility

Although the Charpy impact test results show that the toughness of the E7014 filler metal (SMAW) is higher than that of the other filler metals (FCAW) that have no specified toughness requirement, the weld metal tension coupons and lapped splice tests for E7014 did not exhibit higher strength or ductility. The filler metals that did have a specified toughness showed ductility that was amongst the highest of all the weld metal and lapped splice tests, although in individual cases somewhat lower ductility was also observed.

The lapped splice test results show that the normalized mean ultimate strength of the 6.4 mm welds is always higher than that of the 12.7 mm weld when all other variables are the same. This observation applies to both methods of normalization and is consistent with observations from previous research. Conversely, the weld ductility (Δ/D) does not seem to be directly affected by the leg size. The mean ductility varies widely among assemblies, with values from 0.06 to 0.35 being observed for the lapped splice specimens.

Fillet welds in the cruciform specimens had similar strengths to those in the lapped splice specimens, although the mean value was lower for the cruciform configuration. The mean ductility exhibited by the welds in the cruciform specimens was lower than that of the welds in the lapped splice specimens.

Figure 6 shows the weld and lap plate from a specimen that fractured at an angle of 0° and another specimen (main plate) with the weld fracture at an angle close to 90°. In general, the fillet weld tension leg was somewhat smaller than the shear leg, which can be attributed to the fact that the specimens were welded in the horizontal position. Welds that failed at an angle close to 90° had a tension leg that was significantly smaller than the shear leg.



(a) 0° Angle (b) 90° Angle

Figure 6 – Typical Weld Fracture Surfaces

The specimens tested at -50°C behaved in a manner similar to the equivalent ones tested at room temperature. However, the ductility tended toward the lower end of the observed range. All three specimens tested at -50°C failed with a 90° fracture angle.

Also shown in Table 4 are the mean values of the ratio of the weld capacity (as determined from the test) to that predicted by the AISC Specification (AISC 1999) and Canadian standard CAN/CSA–S16 (CSA 2001). The equation given by the AISC Specification for the factored resistance of fillet welds is:

[2] $$V_r = 0.60\phi A_w F_{EXX}(1.0 + 0.50\sin^{1.5}\theta)$$

where ϕ is the resistance factor, A_w is the effective throat area, F_{EXX} is the minimum specified tensile strength of the filler metal, and θ is the angle of loading with respect to the weld axis. The equation prescribed by standard S16 differs from Equation 2 only in the leading coefficient (0.67 instead of 0.60) and the value of the resistance factor. For the test/predicted ratios given in Table 4, ϕ is taken as 1.0, A_w is taken as the theoretical effective throat area (using the measured leg dimensions, but neglecting the penetration and reinforcement), F_{EXX} is taken as either the minimum specified tensile strength in the specification or the mean measured tensile strength of all the weld metal tension coupon tests having the same electrode designation and manufacturer, as noted in the table, and θ is 90°. The two different definitions of F_{EXX} serve to distinguish between the actual safety margin provided by design Equation 2 for the electrodes used in this study, and that which would exist should electrodes be used that have a tensile strength close to the nominal value. In other words, the latter definition eliminates from the test/predicted ratios the effect that can be attributed directly to overstrength of the weld material itself.

The mean test/predicted ratios, based on the theoretical effective throat area, are greater than 1.0 in all cases. When the nominal filler metal tensile strength of 480 MPa is used to calculate the predicted weld capacity, the mean test/predicted ratios vary from 1.39 (1.25 for

S16) to 2.75 (2.46 for S16). Similarly, when the measured filler metal strength is used, the mean ratios are reduced to 1.28 (1.14 for S16) to 2.57 (2.30 for S16). The E7014 (SMAW) specimens tended to produce strengths closer to the predicted value and the FCAW specimens generally exhibited strengths far in excess of that predicted by the standard. The FCAW filler metals with a specified toughness tended to give higher test/predicted ratios than those without.

7.2 Fracture Surface

Examination of the fracture surface of some of the test specimens was performed to determine whether any unusual features may have initiated premature fracture and to determine the mode of failure. All test specimens were subjected to a visual inspection to identify potential areas of interest. Subsequently, a limited number of weld samples, selected through the visual examination procedure, were cut from the specimens and the fracture surface examined in a scanning electron microscope.

An examination of the fracture plane generally revealed a characteristic ductile fracture surface similar to the one depicted on the left in Figure 7. The fracture surfaces showed elongated microvoids, indicative of a ductile shear failure. The ductile behavior observed on the fracture surfaces is consistent with the ductility observed in the tests. The test specimens that failed on a 90° fracture surface showed signs of combined ductile and brittle fracture, although they exhibited mostly microvoid coalescence. The photomicrograph on the right in Figure 7 shows a typical fracture surface for this combined failure mode. It can be seen that the microvoids on the left half of the photo are not elongated, which indicates a tension fracture surface. For the welds tested at -50°C, close to 50% of the fracture surface consisted of cleavage. None of the test specimens examined visually and microscopically showed unusual features. Photomicrographs from the scanning electron microscope are shown in Appendix H.

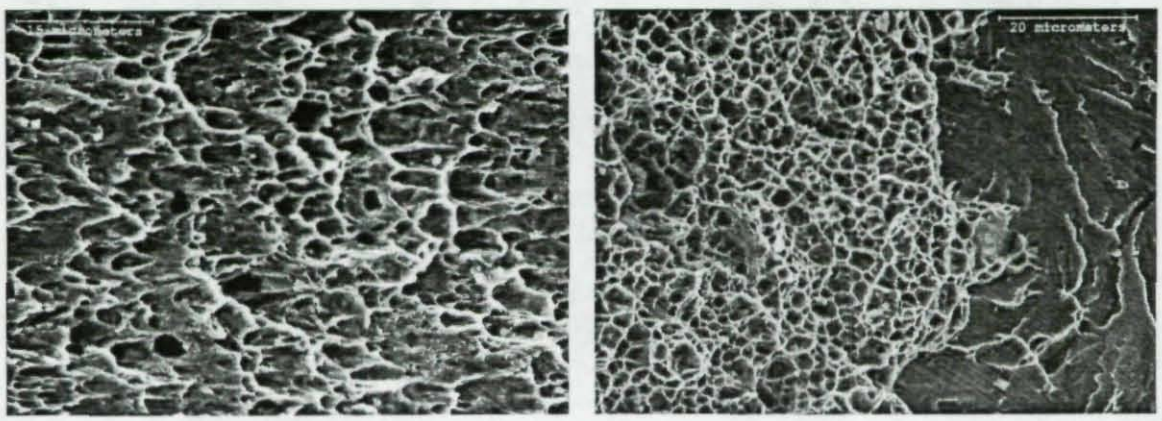


Figure 7 – Photomicrograph of Typical Fracture Surfaces

7.3 Statistical Analysis

The test program made use of triplicate tests so that a reliable determination of the variation within each parameter was possible in order to perform an ANalysis Of VAriance (ANOVA) on the test results to determine the statistical significance of each parameter included in the design of the experiment. The design therefore permits the assessment of the significance of the filler metal (with or without toughness requirement), welding procedure (FCAW and SMAW), weld size/number of weld passes, filler metal manufacturer, and steel fabricator on the strength and ductility of transverse fillet welds. A detailed presentation of this analysis, conducted at a level of confidence of 95%, is presented in Appendix I. The following conclusions can be drawn from the statistical analysis of the test results:

- The strength and ductility of the E7014 fillet welds tested in this investigation are comparable to those reported by Miazga and Kennedy (1989). The difference between the two series of test results is most likely due to differences in welding parameters such as welding speed and current.
- The FCAW with no toughness requirement and the SMAW specimens had similar strength (when calculated on the fracture surface) and ductility. However, since FCAW resulted in greater root penetration, the strength of FCAW was found to be greater than that of SMAW when the strength was calculated based on the throat area.
- Weld toughness, weld size, electrode manufacturer, and fabricator were all found to be influential parameters on weld strength.
- Testing temperature did not have a significant influence on weld strength.
- Weld toughness, weld size and testing temperature were all found to be influential on weld ductility.
- Electrode manufacturer and fabricator did not have a significant effect on weld ductility. (It should be noted that the welding parameters, which were different between manufacturers and fabricators, may explain most of the variation between these parameters.)
- Although the strength of the cruciform test specimens was significantly different from the strength of the lapped splice specimens, the effect of the weldment geometry on strength varies depending on whether strength is calculated on the throat area or the fracture surface area.
- Transverse fillet welds in cruciform splices show a lower ductility than those in lapped splices. The preparation of the cruciform splice specimens introduces undesirable eccentricity in the weldment, which makes the reduction of the test data more difficult and less reliable.

8. Transverse Fillet Weld Strength Reliability Analysis

The test results presented above indicate significantly larger scatter than similar test results presented by Miazga and Kennedy (1989). The implication of the scatter in the test results on the design equation for transverse fillet welds is investigated in the following. The statistical analysis was conducted on two separate sets of data, namely, the tests conducted on specimens fabricated with FCAW filler metal with no toughness requirement (E70T-4 and E70T-7) and all the test specimens pooled in one set.

The factored resistance of a concentrically loaded fillet weld under tension induced shear is given by Equation 2. The resistance factor, ϕ, is determined from (Galambos and Ravindra, 1973):

[3] $$\phi = \Phi_\beta \, \rho_R \, e^{(-\beta \alpha_R V_R)}$$

where the coefficient of separation, α_R, is taken as 0.55, the reliability index, β, reflects the probability of failure, and ρ_R and V_R are the bias coefficient and the coefficient of variation, respectively, of the resistance. These latter two factors are calculated based on the test results presented in this report. The factor Φ_β is a factor used to modify the resistance factor for cases where β is not equal to 3.0, which was assumed in the analysis of the loads. This factor takes values less than one for safety indices greater than 3.0 and greater than one for safety indices less than 3.0. Using the procedure outlined by Fisher *et al.* (1978), values for Φ_β were calculated for safety indices ranging from 1.5 to 5.0 using mean live load to mean dead load ratios ranging from 0.5 to 2. The following relationship between the modification factor, Φ_β, and the safety index, β, was derived using a regression analysis of the calculated Φ_β values (Franchuk *et al.*, 2002):

[4] $$\Phi_\beta = 0.0062\beta^2 - 0.131\beta + 1.338$$

The modification factor calculated using Equation 4 is within 2.0% of the factor calculated using the procedure of Fisher *et al.* (1978) over the full range of live load to dead load ratios and safety indices examined.

The mean value of the bias coefficient is given as,

[5] $$\rho_R = \rho_G \, \rho_{M1} \, \rho_{M2} \, \rho_P$$

and the corresponding coefficient of variation, V_R, is given as,

[6] $$V_R^2 = V_G^2 + V_{M1}^2 + V_{M2}^2 + V_P^2$$

where the subscript G refers to the geometric parameter, namely, the area of the weld throat, M1 is a material parameter related to the tensile strength of the filler metal, M2 is a second material parameter related to the transformation of tensile strength to shear strength, and P is

the professional factor, reflecting the ability of the strength equation to predict the test results.

Table 8 presents a summary of the values for the terms shown in Equations 5 and 6. The geometry factors ρ_G and V_G are obtained as the mean and coefficient of variation of the ratio of the measured weld throat area to the nominal weld throat area. The nominal values were calculated using the weld size specified on the test specimens' drawings. The material factors ρ_{M1} and V_{M1} are the mean and coefficient of variation of the measured-to-nominal ratio of the ultimate tensile strength of the weld metal. The material factors ρ_{M2} and V_{M2} represent the ability of the coefficient used in the design equation to determine the ultimate shear strength from the tensile strength. It is calculated as the ratio of measured (failure load divided by the theoretical throat area for longitudinal fillet welds, generally considered to fail in shear on the throat) to predicted ultimate shear strength (0.6 times the tensile strength obtained from all-weld-metal tension coupons of the same weld metal). The professional factor, ρ_P, is the mean test to predicted ratio, with V_P the associated coefficient of variation. The predicted capacity is calculated using Equation 1 where 0.60 F_{EXX} is replaced by the "measured" ultimate shear strength. The measured shear strength was determined from longitudinal fillet weld tests on specimens having the same electrode classifications. In the cases of the E70T-4, E70T-7 and E71T8-K6 filler metals, the longitudinal welds were made using the same wire spool as the associated transverse specimens. These tests were conducted as part of the second phase of this project (Deng, 2002). In the cases of the E7014 and E70T7-K2 filler metals, no longitudinal weld specimens were produced. For E7014, the results of the longitudinal welds tested by Miazga and Kennedy (1989) were used and for E70T7-K2, the longitudinal weld tests for the E71T8-K6 electrodes were used, but modified in the same ratio as the associated tensile strengths from the tension coupon tests. The mean values of the ultimate shear strength used in the calculations are 411 MPa (obtained from Lesik and Kennedy (1990)), 496 MPa, 545 MPa, 608 MPa and 506 MPa for E7014, E70T-4, E70T-7, E70T7-K2, and E71T8-K6, respectively.

The calculated values for the AISC Specification of ρ_R and V_R, obtained from Equations 5 and 6, are presented in Table 8. The resistance factor, ϕ, can be calculated using Equation 3. For a safety index, β, of 4.5, the resistance factor is therefore:

$\phi = 0.874 \times 1.930\, e^{(-4.5 \times 0.55 \times 0.242)} = 0.93$ based on the welds without toughness alone, and

$\phi = 0.874 \times 1.636\, e^{(-4.5 \times 0.55 \times 0.235)} = 0.80$ based on all the test data pooled into a single data set.

The resistance factor of 0.75 currently implemented in Appendix J2.4(a) of the AISC Specification is therefore adequate.

Table 8 – Statistical Parameters

	FCAW without toughness requirement	All Welds
No. test specimens	54	86
ρ_G	0.998	0.998
V_G	0.100	0.100
ρ_{M1}	1.123	1.123
V_{M1}	0.077	0.077
ρ_{M2}	1.474	1.248
V_{M2}	0.121	0.121
ρ_P	1.168	1.169
V_P	0.168	0.157
ρ_R	1.930	1.636
V_R	0.242	0.235

9. Transverse Fillet Weld Ductility

A measure of weld ductility is given by Lesik and Kennedy (1990) as the weld deformation at ultimate load, Δ_u, and weld deformation at rupture, Δ_f, both normalized with respect to the leg size of the fillet weld. From a regression analysis of 42 test results from Miazga and Kennedy (1989), the following relationships between weld deformation and angle of loading were proposed:

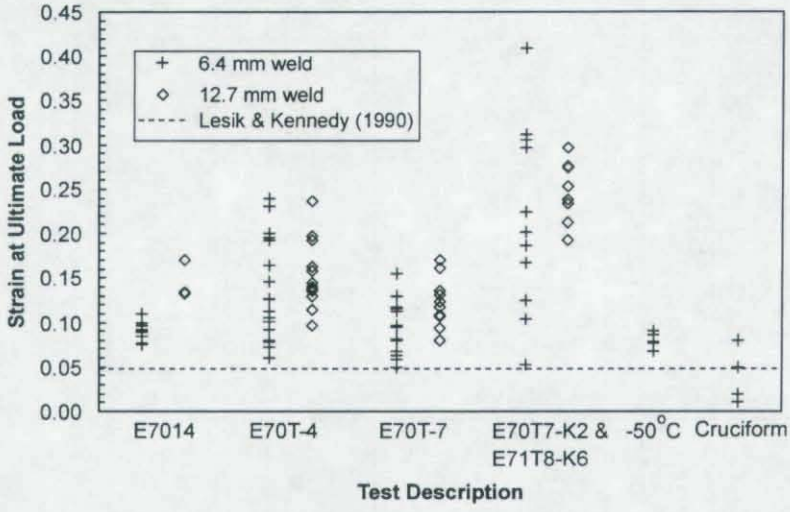
[7] $$\frac{\Delta_u}{d} = 0.209\,(\theta + 2)^{-0.32}$$

and

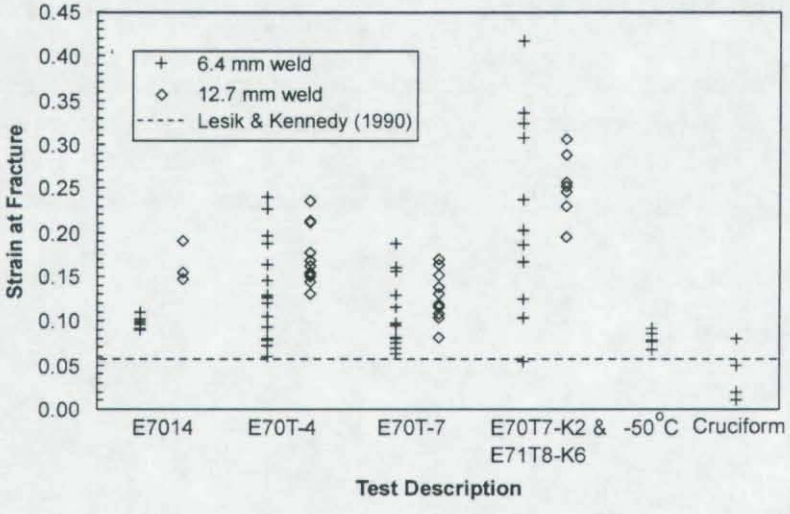
[8] $$\frac{\Delta_f}{d} = 1.087\,(\theta + 6)^{-0.65}$$

Using Equations 7 and 8, the normalized deformation of transverse welds ($\theta = 90°$) at ultimate load and at rupture are 0.049 and 0.056, respectively. An analysis of the test results from the test specimens fabricated using filler metals with no toughness requirement shows an average normalized deformation at ultimate load of 0.116 and an average normalized deformation at rupture of 0.121. Both deformations exceed the values predicted by

Equations 7 and 8. If the test specimens in which the plates did not yield before rupture of the welds are isolated, the values of $\Delta_u/d = 0.108$ and $\Delta_f/d = 0.114$ are obtained. Both deformations exceed the deformations predicted from the work of Lesik and Kennedy. The normalized weld deformations at ultimate for all specimens are presented in Figure 8a. The figure shows that all but two test specimens (cruciform configuration) had a deformation capability superior to the value given by Equation 7. Figure 8b shows a similar situation for the normalized deformation at rupture.



(a) Normalized weld deformations at ultimate



(b) Normalized weld deformations at rupture

Figure 8 – Fillet Weld Ductility Summary

It is difficult to assess the correct magnitude of weld ductility required from fillet welds. This quantity depends upon the objectives to be achieved in the design of the welded connection. Some of these objectives are:

1) to achieve enough ductility to avoid brittle fracture of welds initiated by small weld imperfections;

2) to reach the full capacity of all the welds in joints that combine welds with different orientations.

All the test specimens tested at room temperature showed extensive microvoid coalescence on the fracture surface, indicating ductile fracture. Typically, materials failing by microvoid coalescence have the ability to deform plastically to allow some redistribution of stresses around small stress raisers such as weld imperfections. Although it is difficult to assess exactly the amount of ductility required to avoid brittle fracture from small weld imperfections, the evidence from the fracture surfaces indicate that the ductility observed in the specimens tested in this program was sufficient to avoid brittle fracture.

A common type of joint where welds with more than one orientation are combined together are lap splices with splice plates welded with both transverse welds and longitudinal welds. In such a configuration, the full strength of the transverse weld predicted by Equation 1 may not be additive to the strength of the longitudinal welds. In this situation, it would be desirable for the transverse weld to possess sufficient ductility to mobilize most of the strength of the longitudinal welds before fracture of the transverse weld occurs. This problem is currently being investigated in phases 2 and 3 of the fillet weld test program.

10. Summary and Conclusions

Two sizes of transverse fillet welds from five different filler metal classifications, two filler metal manufacturers, and two arc welding processes deposited by welders at two different fabricators were tested to determine and compare their behavior. In addition, a limited number of low temperature tests and tests on specimens fabricated in a cruciform configuration were conducted. All 102 test results confirm that the fillet weld design equations in both the AISC specification and the Canadian standard—accounting for the 50% increase in strength permitted for transverse welds—give a conservative prediction of capacity. The normalized strength of the 6.4 mm welds was higher than that of the 12.7 mm welds in all cases when the other variables were the same.

Weld metal tension tests on the four filler metal types revealed that all of the weld materials tested had ultimate tensile strengths that exceed the nominal value, but the amount of excess strength varies widely. Filler metals with a specified toughness also showed higher Charpy impact energies than those without. In addition, the E7014 (SMAW) electrodes gave higher Charpy values than the FCAW electrodes that do not have a toughness requirement. However, in the transverse fillet weld tests they showed neither higher strength nor ductility. The electrodes that have a specified toughness tended to show higher ductility than those without.

A statistical analysis of the test results indicated that the SMAW test specimens from the current test series are comparable to the transverse weld specimens tested by Miazga and Kennedy (1989). The FCAW with no toughness requirement and SMAW specimens had similar strength (when calculated on the fracture surface) and ductility. An analysis of variance, conducted at a level of confidence of 95%, indicated that weld toughness, weld size, electrode manufacturer, and fabricator are all influential parameters on weld strength. Testing temperature did not have a significant influence on weld strength. Weld toughness, weld size and testing temperature were all found to be influential on weld ductility. Electrode manufacturer and fabricator did not have a significant effect on weld ductility. (It should be noted that the welding parameters, which were different between manufacturers and fabricators, may explain most of the variation between these two parameters.) Although the strength of the cruciform test specimens was significantly different from the strength of the lapped splice specimens, the effect of the weldment geometry on strength varies depending on whether strength is calculated on the throat area or the fracture surface area. Transverse fillet welds from cruciform splices show a lower ductility than those in lapped splices.

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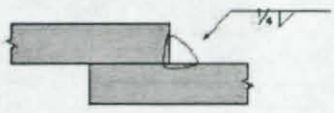
Appendix A

Welding Procedure Specifications

Table A1 – Welding Procedure Specifications prepared by Waiward

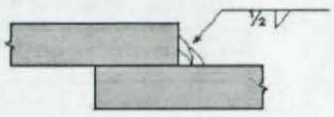
Filler Metal: Fabshield 4				Stick-out: 2.5"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E70T-4	3/32	DC+	221	390/400A	32.5	27

Weld Detail



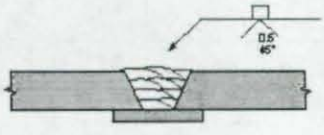
Filler Metal: Fabshield 4				Stick-out: 2.5"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E70T-4	3/32	DC+	221	390/400A	32.5	27
2, 3				221	390/400A	32.5	16, 17

Weld Detail



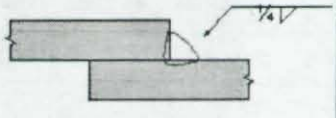
Filler Metal: Fabshield 4				Stick-out: 2.5"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1-10	E70T-4	3/32	DC+	221	390/400A	32.5	16-17

Weld Detail



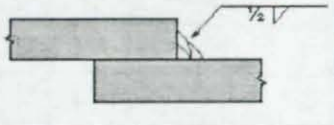
Filler Metal: Innershield NS3M				Stick-out: 2.5"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E70T-4	3/32	DC+	150	310	28-29	18

Weld Detail



Filler Metal: Innershield NS3M				Stick-out: 2.5"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E70T-4	3/32	DC+	150	310	28-29	18
2,3				150	310	28-29	12, 14

Weld Detail



Filler Metal: Innershield NS3M				Stick-out: 2.5"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1-10	E70T-4	3/32	DC+	150	310	28-29	12-14

Weld Detail

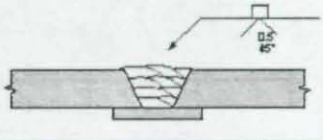
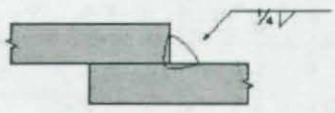
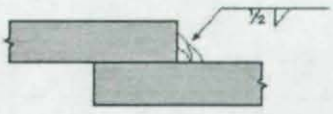
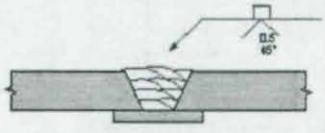
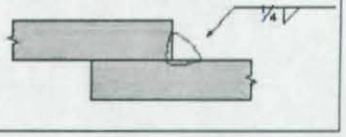


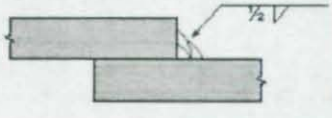
Table A1 – Welding Procedure Specifications prepared by Waiward (cont'd)

Filler Metal: Fabshield 7027			Stick-out: 1.5"				Weld Detail
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1	E70T-7	3/32	DC-	214	410	28.5	21	

Filler Metal: Fabshield 7027			Stick-out: 1.5"				Weld Detail
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1	E70T-7	3/32	DC-	214	410	28.5	21	
2, 3				214	410	28.5	13, 15	

Filler Metal: Fabshield 7027			Stick-out: 1.5"				Weld Detail
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1-10	E70T-7	3/32	DC-	214	410	28.5	13-15	

Filler Metal: Innershield NR311			Stick-out: 1.25"				Weld Detail
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1	E70T-7	3/32	DC-	146	315	28	16	

Filler Metal: Innershield NR311			Stick-out: 1.25"				Weld Detail
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1	E70T-7	3/32	DC-	146	315	28	16	
2, 3				146	315	28	13, 14	

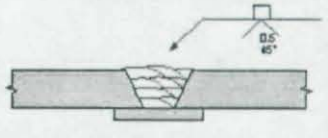
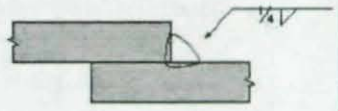
Filler Metal: Innershield NR311			Stick-out: 1.25"				Weld Detail
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1-10	E70T-7	3/32	DC-	146	315	28	13-15	

Table A1 – Welding Procedure Specifications prepared by Waiward (cont'd)

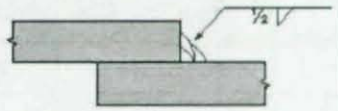
Filler Metal: Fabshield 3Ni1				Stick-out: ¾"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E71T8-K6	5/64	DC-	170	310	23.5	13

Weld Detail



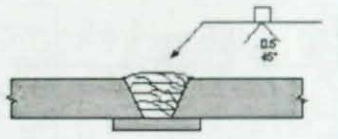
Filler Metal: Fabshield 3Ni1				Stick-out: ¾"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E71T8-K6	5/64	DC-	170	310	23.5	13
2, 3				170	310	23.5	9, 10

Weld Detail



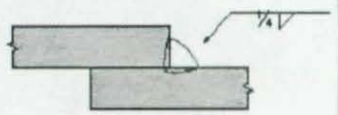
Filler Metal: Fabshield 3Ni1				Stick-out: ¾"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1-15	E71T8-K6	5/64	DC-	170	310	23.5	10-13

Weld Detail



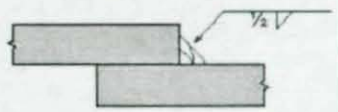
Filler Metal: Innershield NR311Ni				Stick-out: 1"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E70T7-K2	5/64	DC-	196	280	26.5	11

Weld Detail



Filler Metal: Innershield NR311Ni				Stick-out: 1"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1	E70T7-K2	5/64	DC-	196	280	26.5	11
2-3				196	280	26.5	10, 12

Weld Detail



Filler Metal: Innershield NR311Ni				Stick-out: 1"			
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed
1-15	E70T7-K2	5/64	DC-	196	280	26.5	10-12

Weld Detail

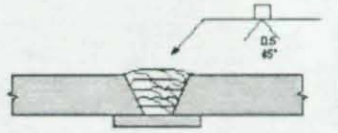
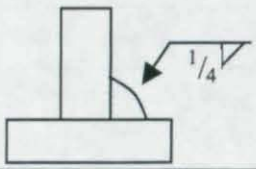
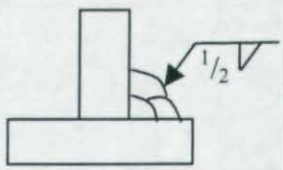
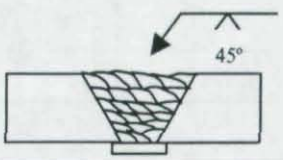


Table A1 – Welding Procedure Specifications prepared by Waiward (cont'd)

Filler Metal: Lincoln E7014								Weld Details
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1	E7014	5/32	DC-	N/A	170	—	10	

Filler Metal: Lincoln E7014								Weld Details
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1-3	E7014	5/32	DC-	N/A	170	—	10	

Filler Metal: Lincoln E7014								Weld Details
Pass #	Class	Dia.	Polarity	Wire Feed Speed	Amperage	Volts	Travel Speed	
1-26	E7014	5/32	DC-	N/A	170	—	10	

Note: All speeds are inches/min.

Table A2 – Welding Procedure Specifications prepared by Supreme

Supreme Steel Data Sheet

Date: 18-Oct-01
Job: 1072
Project: AISC - University of Alberta Fillet Weld Project

Personnel: Welder - Ed Homeniuk (Supreme Steel)
QA/Engineer - Todd Collister (Supreme Steel)

Conditions: Standard Shop Conditions

Material: See Waiward Steel for material specifications and other Information

Equipment:

Welding Machine
Lincoln Electric
Model - DC-600
Code - W383-1
Type - K1288M
Serial No.- 292309

Wire Feeder
Lincoln Electric
LN-7 Wire Feeder
Code - 9168
Serial No.- 186030
Input voltage 115 50/60 Hz current 2.0 Amps

Notes:
-Best welds on same side were choosen based on visual inspection
-Other side of plate was reinforced with small fillet weld
-Groove welded specimen were welded with a maintained temperature of 150 degrees celcius
-Temperature of plate was monitored with a temperature crayon
-High deposit rate with wire speed at 225 made 6mm fillet weld difficult to attain
-Nickel wire was very smokey and was difficult to see puddle and maintain size of fillet

Specimen	Mark	Producer	Filler Metal	Class	Polarity	Stick-out	Wire speed	Amps.	Volts	Date
1/4" fillet	T4-H-S	Hobart	Fabshield 4	E70T-4	DC+	2.5"	225	350	29	21-Aug
1/2" fillet	T4-H-S	Hobart	Fabshield 4	E70T-4	DC+	2.5"	225	350	29	21-Aug
GROOVE	T4-H-S	Hobart	Fabshield 4	E70T-4	DC+	2.5"	225	350	29	21-Aug
1/4" fillet	T4-L-S	Lincoln	Innershield NS3M	E70T-4	DC+	2.5"	150	310	29	16-Oct
1/2" fillet	T4-L-S	Lincoln	Innershield NS3M	E70T-4	DC+	2.5"	150	310	29	16-Oct
1/4" fillet	T7-H-S	Hobart	Fabshield 7027	E70T-7	DC-	1.5"	170	350	26	16-Oct
1/2" fillet	T7-H-S	Hobart	Fabshield 7027	E70T-7	DC-	1.5"	170	350	26	16-Oct
GROOVE	T7-H-S	Hobart	Fabshield 7027	E70T-7	DC-	1.5"	170	350	26	17-Oct
1/4" fillet	T7-L-S	Lincoln	Innershield NR311	E70T-7	DC-	1.25"	160	340	26	17-Oct
1/2" fillet	T7-L-S	Lincoln	Innershield NR311	E70T-7	DC-	1.25"	160	340	26	17-Oct
1/4" fillet	T8-K6-H-S	Hobart	Fabshield 3Ni1	E71T8-K6	DC-	.75"	180	330	24	18-Oct
1/2" fillet	T8-K6-H-S	Hobart	Fabshield 3Ni1	E71T8-K6	DC-	.75"	180	330	24	18-Oct
GROOVE	T8-K6-H-S	Hobart	Fabshield 3Ni1	E71T8-K6	DC-	.75"	180	330	24	18-Oct
1/4" fillet	T7-K2-L-S	Lincoln	Innershield NR311Ni	E70T7-K2	DC-	1"	180	310	25	18-Oct
1/2" fillet	T7-K2-L-S	Lincoln	Innershield NR311Ni	E70T7-K2	DC-	1"	180	310	25	18-Oct

Appendix B

Etched Specimen Cross-Sections

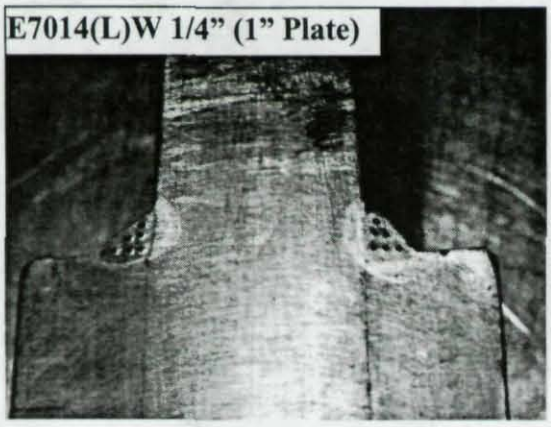


Figure B1 – Specimen T1-3

Figure B2 – Specimen T5-3

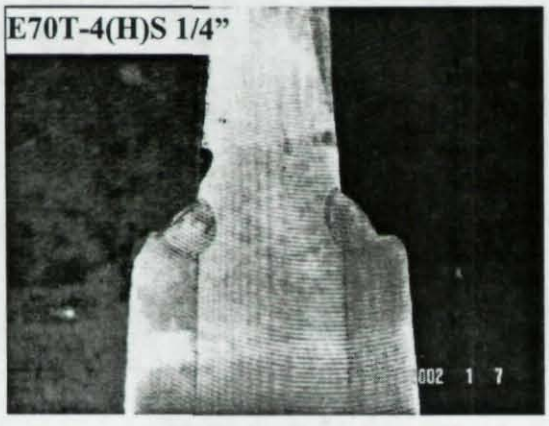


Figure B3 – Specimen T7-1

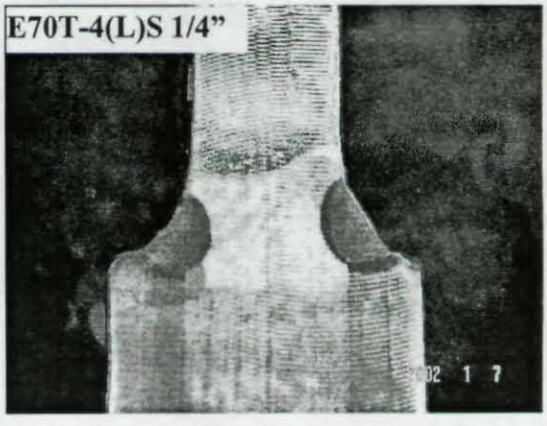


Figure B4 – Specimen T9-1

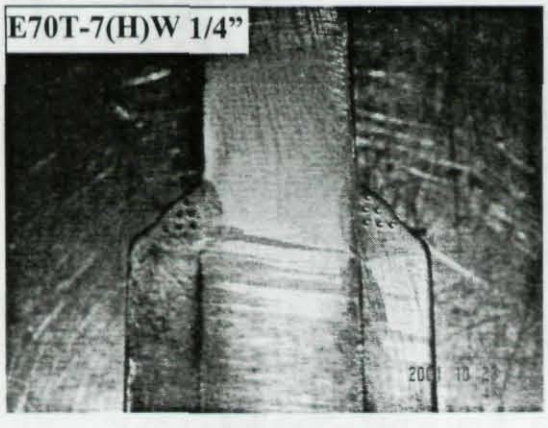


Figure B5 – Specimen T11-2

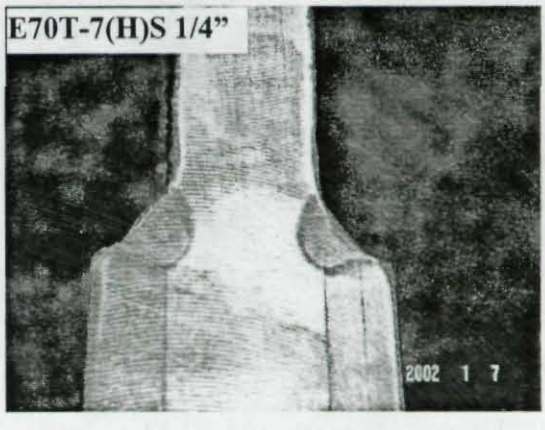


Figure B6 – Specimen T12-1

Figure B7 – Specimen T13-3

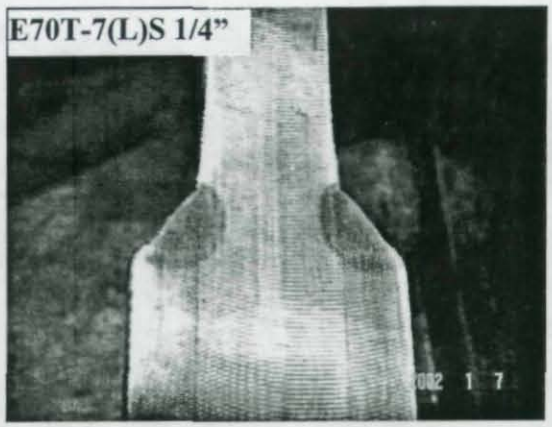


Figure B8 – Specimen T14-1

Figure B9 – Specimen T16-2

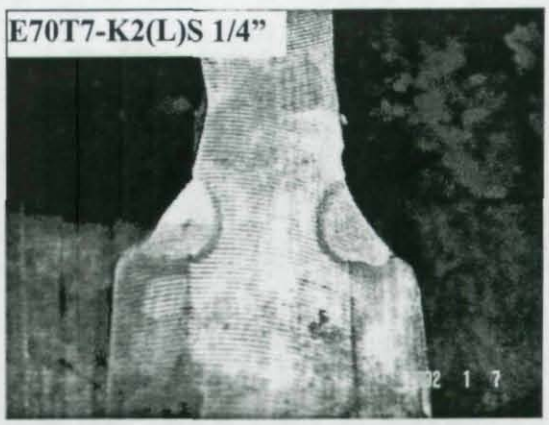


Figure B10 – Specimen T17-1

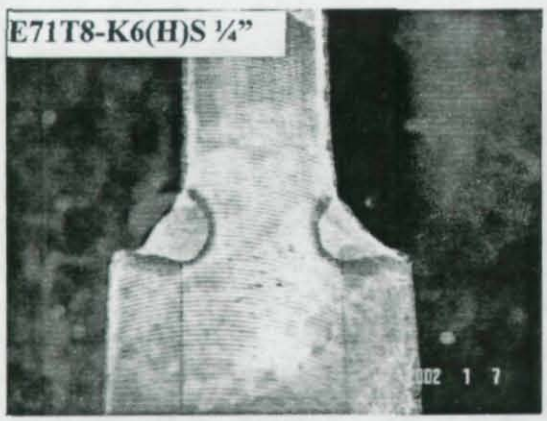


Figure B11 – Specimen T19-1

Figure B12 – Specimen T20-1

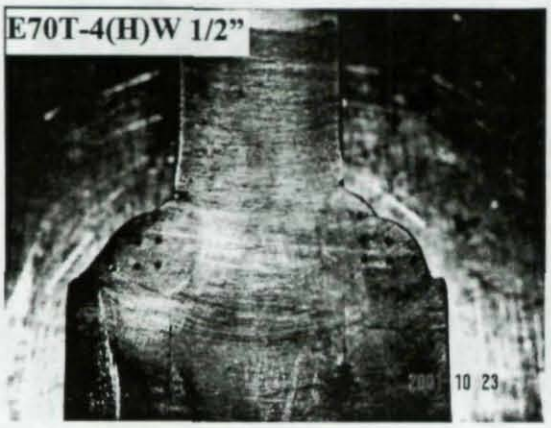


Figure B13 – Specimen T21-1

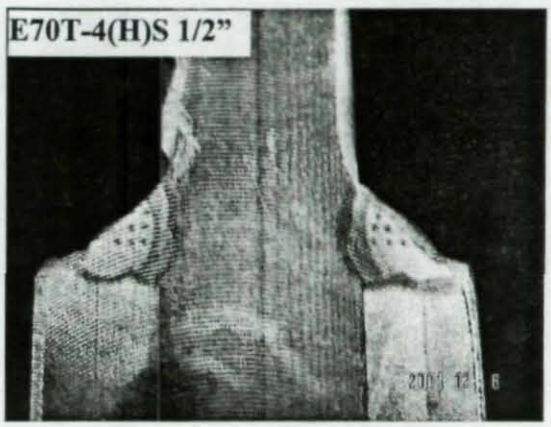


Figure B14 – Specimen T22-2

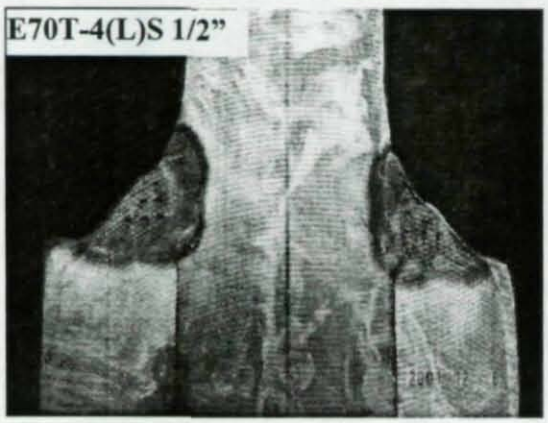


Figure B15 – Specimen T24-3

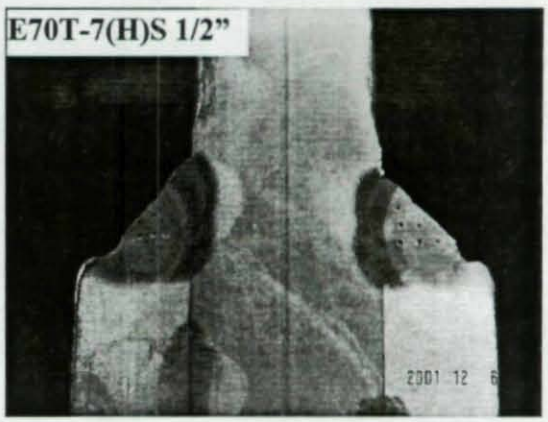


Figure B16 – Specimen T26-1

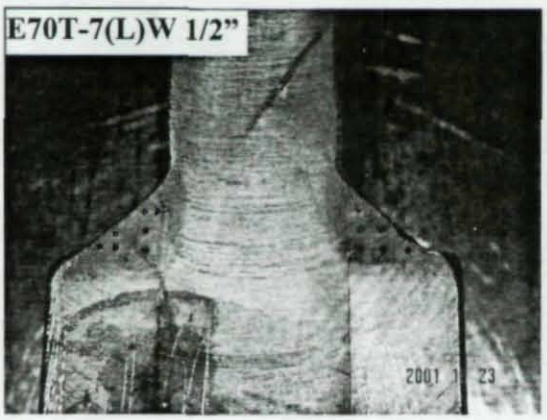


Figure B17 – Specimen T27-2

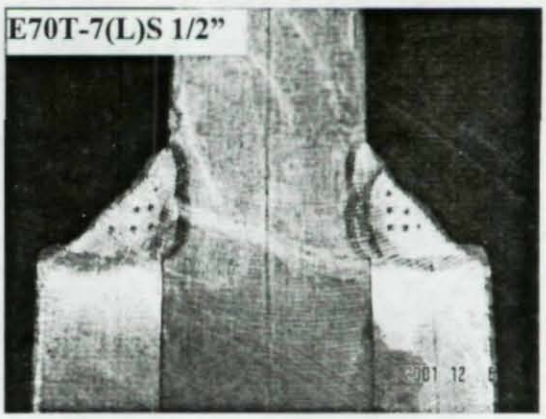


Figure B18 – Specimen T28-3

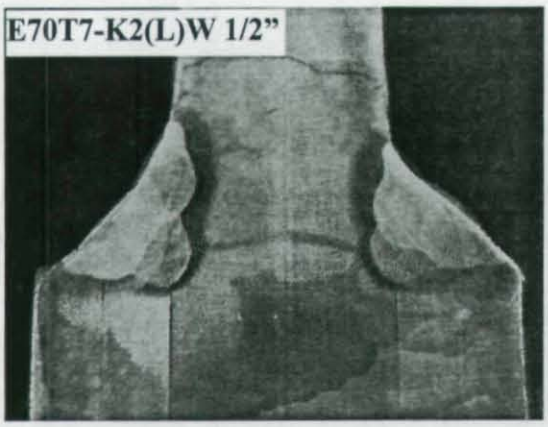


Figure B19 – Specimen T29-2

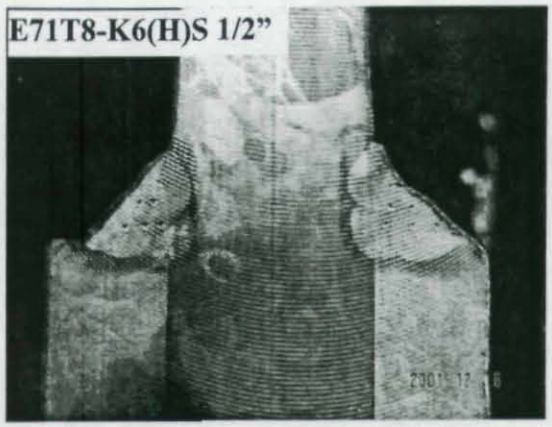


Figure B20 – Specimen T32-2

Appendix C

Weld Measurements and Weld Profiles

Appendix C – Weld Measurements and Weld Profiles

This appendix contains the fillet weld measurements, including the gauge lengths for strain measurements, plots of the weld profiles, and also the out-of-straightness measurements for the cruciform specimens.

Eight tension and shear weld leg measurements were made spaced at 10 mm intervals along the weld length. Measurements of the weld profile, oriented at an angle of 45° to the main plate, were also performed at these same locations. For the 12.7 mm welds, 45° measurements were made at three different points at each location in order to better characterize the profile. The locations of these points are shown in Figure C0a.

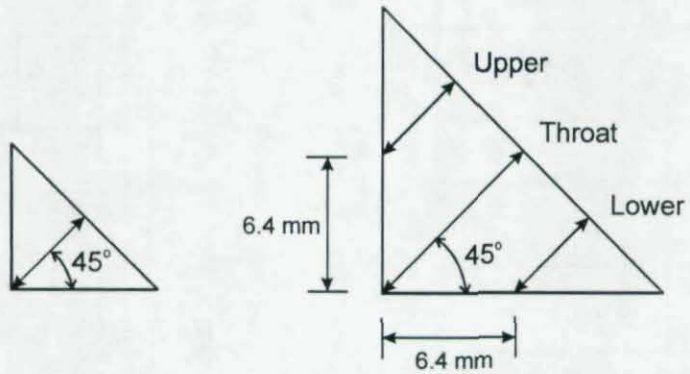


Figure C0a – Pre-test Fillet Weld Measurements

After weld fracture, measurements of the fracture surface, fracture surface angle, and again, the shear leg (called Shear Leg After Fracture in the tables) were made. The Fracture Surface and Shear Leg After Fracture measurements are depicted in Figure C0b.

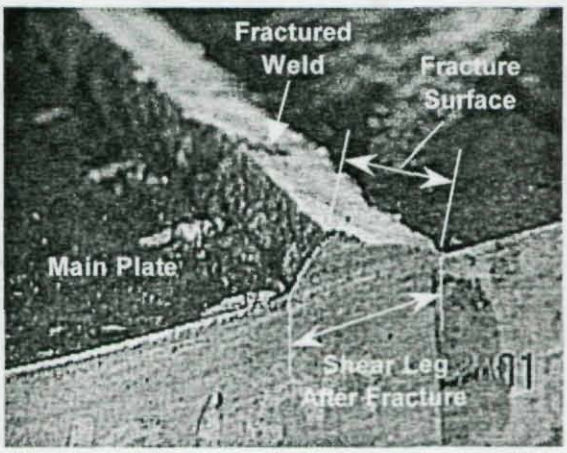


Figure C0b – Shear Leg After Fracture and Fracture Surface Measurements

The Weld Root Penetration values are the difference between the Shear Leg measurement and the Shear Leg After Fracture measurement.

Table C1 – Weld Measurements for Specimen T1-1 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.1	7.2	5.7	76.0	5.6	6.2	5.2	76.3	6.5	6.5	0.5	0
2	7.0	7.0	5.9	76.0	5.8	6.3	5.9	76.2	7.1	4.6	0.1	15
3	6.5	6.9	5.2	76.0	5.5	6.4	5.6	76.2	6.9	4.3	0.4	19
4	7.1	7.5	6.5	76.0	5.6	6.1	5.1	76.2	7.4	5.4	0.3	13
5	6.2	6.7	6.0	76.0	6.1	5.8	5.1	76.3	6.9	5.4	0.7	2
6	6.4	6.7	5.6		5.6	6.3	4.9		7.1	5.3	0.7	15
7	6.3	5.5	5.2		6.1	6.5	5.2		6.8	4.7	0.5	16
8	6.6	5.6	5.1		5.5	6.5	4.9		6.8	4.6	0.2	16
Mean	**6.5**	**6.6**	**5.7**	**76.0**	**5.7**	**6.3**	**5.2**	**76.2**	**6.9**	**5.1**	**0.4**	**12**

Table C2 – Weld Measurements for Specimen T1-2 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure							
	Front Face				Back Face				Front Failure Face				Back Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.3	5.9	5.2	76.1	6.4	6.1	5.6	76.1	7.0	4.7	0.7	19	7.05	5.19	0.70	13.75
2	6.7	6.1	5.7	76.2	6.4	5.8	5.2	76.2	7.4	5.2	0.8	19	7.19	5.38	0.78	14.00
3	7.1	6.0	5.4	76.0	6.5	5.5	4.6	76.2	7.6	4.8	0.6	20	7.08	4.66	0.56	18.70
4	7.3	6.1	5.9	76.1	6.7	5.5	5.2	76.2	7.9	5.0	0.6	15	8.17	4.96	1.50	14.00
5	6.6	6.3	5.6	76.0	6.4	6.0	5.7	76.2	6.7	6.1	0.1	0	6.84	6.39	0.42	0.00
6	5.8	6.4	4.9		5.2	6.0	5.1		6.1	4.5	0.4	12	5.90	5.59	0.71	0.00
7	6.4	6.6	5.4		5.9	6.5	5.4		6.8	4.8	0.4	13	6.87	5.79	0.93	0.00
8	6.1	6.3	5.6		5.8	6.2	5.6		7.0	5.2	0.9	11	6.30	5.36	0.46	7.50
Mean	**6.5**	**6.2**	**5.5**	**76.1**	**6.2**	**5.9**	**5.3**	**76.2**	**7.1**	**5.0**	**0.5**	**14**	**6.93**	**5.42**	**0.76**	**8.49**

Table C3 – Weld Measurements for Specimen T1-3 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure							
	Front Face				Back Face				Front Failure Face				Back Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.9	5.9	5.2	76.2	5.8	7.0	5.4	76.0	6.8	4.9	0.8	9	6.46	6.46	0.69	0.00
2	6.3	6.5	5.4	76.2	6.1	6.8	5.4	76.0	7.1	5.1	0.8	15	6.87	6.25	0.81	0.00
3	6.0	6.3	5.1	76.2	5.7	6.6	4.8	76.0	6.5	4.8	0.5	14	6.41	4.41	0.76	13.00
4	5.9	6.2	5.1	76.2	5.9	6.4	4.8	76.0	6.6	4.7	0.7	14	6.72	4.91	0.80	14.25
5	5.8	6.7	4.6	76.2	5.9	6.9	5.1	76.0	6.7	4.5	0.9	12	6.87	5.01	0.93	15.75
6	6.2	6.7	4.8		6.4	6.5	5.2		6.7	4.8	0.5	15	7.50	6.40	1.07	5.00
7	6.0	7.0	4.9		6.1	6.6	4.4		6.7	5.3	0.7	10	6.94	4.53	0.82	19.25
8	6.1	7.1	5.2		6.5	6.3	5.4		6.7	5.8	0.7	9	7.03	5.89	0.54	12.00
Mean	**6.0**	**6.5**	**5.0**	**76.2**	**6.0**	**6.6**	**5.1**	**76.0**	**6.7**	**5.0**	**0.7**	**12**	**6.85**	**5.48**	**0.80**	**9.91**

Table C4 – Weld Measurements for Specimen T2-1 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.4	5.9	3.7	76.2	6.4	6.0	4.4	76.2	6.0	3.6	0.7	14
2	5.4	6.0	4.0	76.2	6.3	6.0	4.3	76.2	6.1	3.7	0.8	8
3	5.5	6.5	4.3	76.2	6.7	6.5	4.6	76.2	6.3	4.8	0.7	5
4	5.3	6.0	4.0	76.2	6.8	6.2	4.4	76.1	6.9	4.3	1.7	7
5	5.6	6.3	4.1	76.2	6.6	5.8	4.3	76.2	6.4	4.1	0.9	11
6	5.4	5.9	4.0		6.7	6.3	4.3		6.3	4.0	0.9	7
7	5.7	6.3	4.3		6.6	6.0	4.3		6.7	4.6	1.0	9
8	6.1	6.7	4.3		6.7	5.9	4.3		7.2	4.7	1.1	12
Mean	**5.5**	**6.2**	**4.1**	**76.2**	**6.6**	**6.1**	**4.4**	**76.2**	**6.5**	**4.2**	**1.0**	**9**

Table C5 – Weld Measurements for Specimen T2-2 (E7014(L) W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.7	5.7	3.8	76.1	6.2	6.0	4.1	76.1	7.1	3.9	1.4	18
2	5.7	5.8	4.1	76.2	6.2	5.9	4.1	76.2	7.2	3.9	1.5	19
3	5.8	6.7	4.4	76.2	6.4	6.1	4.3	76.1	6.0	3.8	0.3	17
4	5.9	5.8	4.3	76.1	6.1	6.1	4.4	76.2	6.9	4.1	1.1	14
5	6.5	6.4	4.6	76.2	6.5	6.9	4.6	76.2	7.4	4.5	0.9	8
6	6.5	6.2	4.6		6.2	5.9	4.3		6.8	4.4	0.4	12
7	6.1	5.9	4.4		5.7	6.3	4.3		7.0	3.9	1.0	17
8	6.0	6.0	4.6		5.8	6.4	4.3		7.5	5.0	1.5	9
Mean	**6.0**	**6.1**	**4.4**	**76.1**	**6.1**	**6.2**	**4.3**	**76.2**	**7.0**	**4.2**	**1.0**	**14**

Table C6 – Weld Measurements for Specimen T2-3 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.9	6.1	4.4	76.0	6.1	5.7	4.4	76.2	6.9	4.6	1.1	15
2	6.0	6.7	4.4	76.1	6.2	6.2	4.6	76.2	6.8	5.2	0.8	6
3	5.9	6.6	4.6	76.1	6.3	5.5	4.4	76.1	7.1	5.1	1.2	4
4	5.8	6.5	4.6	76.2	6.2	5.8	4.8	76.2	7.0	4.9	1.2	9
5	6.1	6.9	4.9	76.1	6.4	5.6	4.4	76.2	7.4	4.8	1.3	7
6	6.1	6.9	4.9		6.3	5.9	4.6		7.1	5.2	1.0	4
7	6.5	6.9	4.9		6.4	5.6	4.4		7.3	4.2	0.8	15
8	6.6	7.2	5.1		7.0	6.0	4.8		7.2	4.9	0.6	13
Mean	**6.1**	**6.7**	**4.7**	**76.1**	**6.4**	**5.8**	**4.6**	**76.2**	**7.1**	**4.9**	**1.0**	**9**

Table C7 – Weld Measurements for Specimen T3-1 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.6	6.8	5.2	76.0	7.9	7.8	5.2	76.1	6.7	4.7	0.1	11
2	6.8	6.3	4.9	76.0	8.1	8.3	5.2	76.1	6.9	4.5	0.1	16
3	7.5	7.2	5.2	76.0	7.6	6.5	5.1	76.1	7.8	4.6	0.3	18
4	7.4	6.6	5.2	76.1	7.9	6.6	5.1	76.1	7.6	4.5	0.2	13
5	7.4	6.6	5.6	76.1	7.9	7.7	5.2	76.1	7.4	4.7	0.0	14
6	8.0	6.5	5.7		7.5	7.5	5.4		8.0	4.9	0.0	21
7	7.8	6.1	5.4		8.1	7.9	5.4		7.8	4.7	0.0	17
8	8.2	6.9	5.9		7.8	7.1	5.2		8.2	5.2	0.0	12
Mean	**7.5**	**6.6**	**5.4**	**76.0**	**7.9**	**7.4**	**5.2**	**76.1**	**7.5**	**4.7**	**0.1**	**15**

Table C8 – Weld Measurements for Specimen T3-2 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.3	6.4	5.2	76.0	8.8	6.7	5.1	76.0	8.5	4.8	0.3	21
2	8.3	7.0	5.4	76.1	8.2	6.6	5.1	76.0	8.3	4.7	0.1	19
3	7.9	7.0	5.4	76.1	8.6	7.8	5.6	76.0	8.0	4.9	0.1	10
4	7.8	6.9	5.6	76.1	8.4	6.8	6.2	76.0	7.9	3.7	0.0	15
5	8.6	7.1	6.0		7.5	7.2	5.1	76.0	8.2	3.3	-0.4	34
6	7.9	6.3	5.1		7.9	7.1	5.2		7.9	4.4	0.0	12
7	7.9	6.8	5.2		7.9	7.0	4.9		8.0	4.7	0.1	14
8	7.7	7.2	5.4		8.5	8.5	5.4		7.9	5.1	0.1	15
Mean	**8.0**	**6.8**	**5.4**	**76.1**	**8.2**	**7.2**	**5.3**	**76.0**	**8.1**	**4.4**	**0.0**	**18**

Table C9 – Weld Measurements for Specimen T3-3 (E7014(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	7.9	7.0	5.6	76.0	8.0	7.6	5.6	75.9	7.8	5.3	-0.2	14
2	7.3	7.1	5.2	76.0	8.0	7.6	5.6	76.0	7.3	5.0	0.0	8
3	7.3	7.1	5.2	76.0	7.6	7.0	5.4	76.0	7.4	4.4	0.0	13
4	7.7	7.1	5.4	76.1	7.7	7.0	5.1	75.9	7.4	5.2	-0.3	11
5	7.6	7.2	5.4	76.1	7.6	6.4	5.1	76.0	7.5	5.0	-0.2	14
6	7.8	7.5	5.4		8.4	6.6	5.4		7.7	5.0	-0.1	12
7	7.7	7.8	5.6		7.9	6.5	5.2		7.9	5.1	0.1	9
8	7.6	7.4	5.6		7.9	6.7	5.2		7.7	4.6	0.1	10
Mean	**7.6**	**7.3**	**5.4**	**76.0**	**7.9**	**6.9**	**5.3**	**76.0**	**7.6**	**4.9**	**-0.1**	**12**

Table C10 – Weld Measurements for Specimen T4-1 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.8	6.6	5.6	76.1	6.1	6.1	5.4	76.1	8.0	8.0	1.9	0
2	6.0	6.5	5.6	76.2	5.7	5.6	5.2	76.1	8.7	8.7	3.1	0
3	5.9	6.2	5.4	76.2	6.3	6.3	5.4	76.1	9.0	9.0	2.6	0
4	5.6	5.6	5.2	76.2	5.8	6.6	5.6	76.1	7.9	7.9	2.1	0
5	6.2	6.5	5.6	76.2	6.6	5.8	5.6	76.1	9.3	9.3	2.7	0
6	6.4	6.3	5.2		6.3	6.3	5.6		8.4	8.4	2.1	0
7	5.4	6.0	5.4		5.9	5.8	5.6		8.6	8.6	2.7	0
8	5.7	6.1	5.6		6.3	6.2	5.7		8.6	8.6	2.3	0
Mean	**5.9**	**6.2**	**5.4**	**76.2**	**6.1**	**6.1**	**5.5**	**76.1**	**8.6**	**8.6**	**2.4**	**0**

Table C11 – Weld Measurements for Specimen T4-2 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.0	6.6	5.4	76.1	5.7	6.4	5.6	76.0	8.4	8.4	2.7	0
2	6.2	6.3	5.4	76.2	6.3	6.0	5.6	76.1	8.9	8.9	2.6	0
3	5.8	6.1	5.4	76.2	6.9	5.7	5.7	76.1	9.5	9.5	2.6	0
4	6.4	6.3	5.4	76.2	6.6	6.1	5.6	76.1	9.1	9.1	2.5	0
5	6.3	6.5	5.4	76.1	6.4	5.8	5.6	76.1	8.8	8.8	2.4	0
6	6.7	6.1	5.4		6.3	5.6	5.4		9.0	9.0	2.7	0
7	5.6	6.7	5.2		6.1	6.5	5.6		9.5	9.5	3.4	0
8	6.1	6.7	5.6		6.2	6.8	5.7		8.2	8.2	1.9	0
Mean	**6.1**	**6.4**	**5.4**	**76.1**	**6.3**	**6.1**	**5.6**	**76.1**	**8.9**	**8.9**	**2.6**	**0**

Table C12 – Weld Measurements for Specimen T4-3 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.2	6.4	5.4	76.1	6.3	5.8	5.4	76.1	9.0	9.0	2.7	0
2	6.1	6.4	5.2	76.1	6.0	5.8	5.4	76.1	8.5	8.5	2.4	0
3	5.9	6.2	5.1	76.1	6.0	6.0	5.4	76.0	8.8	8.8	2.7	0
4	5.9	6.3	5.2	76.1	6.3	5.4	5.4	76.1	9.5	9.5	3.2	0
5	5.7	6.1	5.1	76.1	5.8	6.4	5.6	76.0	8.2	8.2	2.4	0
6	5.9	6.3	5.2		6.4	6.2	5.7		8.4	8.4	2.1	0
7	6.2	6.4	5.2		5.8	5.6	5.6		8.9	8.9	3.1	0
8	5.9	6.2	5.2		5.7	6.7	5.4		8.6	8.6	2.9	0
Mean	**6.0**	**6.3**	**5.2**	**76.1**	**6.0**	**6.0**	**5.5**	**76.1**	**8.7**	**8.7**	**2.7**	**0**

Table C13 – Weld Measurements for Specimen T5-1 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.2	5.7	4.6	76.0	5.7	5.9	4.8	76.0	8.2	8.2	2.4	0
2	6.7	5.9	4.9	76.1	5.8	6.7	4.9	76.0	8.7	8.7	2.9	0
3	6.4	5.8	4.8	76.1	6.4	5.7	5.1	76.1	8.9	8.9	2.5	0
4	7.0	5.9	4.9	76.1	5.8	6.1	5.1	76.0	8.5	8.5	2.7	0
5	6.6	5.9	4.8	76.1	6.5	5.8	5.1	76.0	8.9	8.9	2.4	0
6	5.5	5.6	4.6		5.6	5.9	5.1		7.9	7.9	2.3	0
7	6.3	5.6	4.8		6.5	6.3	5.2		8.8	8.8	2.4	0
8	6.6	5.9	4.9		5.7	6.4	4.9		7.8	7.8	2.0	0
Mean	**6.4**	**5.8**	**4.8**	**76.1**	**6.0**	**6.1**	**5.0**	**76.0**	**8.5**	**8.5**	**2.5**	**0**

Table C14 – Weld Measurements for Specimen T5-2 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.8	6.1	4.8	75.9	6.2	5.8	4.8	76.0	9.6	9.6	3.4	0
2	6.2	5.5	4.8	75.9	6.1	5.6	4.9	76.0	9.9	9.9	3.8	0
3	6.2	5.7	4.8	75.9	6.0	5.8	4.9	76.0	9.3	9.3	3.3	0
4	6.6	5.6	4.8	75.9	6.7	6.7	5.1	75.9	10.1	10.1	3.5	0
5	6.6	5.8	5.1	75.9	6.0	5.7	4.9	75.9	9.3	9.3	3.3	0
6	6.0	5.7	4.8		6.9	6.7	5.2		10.1	10.1	3.2	0
7	6.9	5.9	5.1		6.4	6.2	5.2		9.5	9.5	3.1	0
8	6.6	5.7	5.1		6.2	6.8	4.9		9.8	9.8	3.7	0
Mean	**6.5**	**5.8**	**4.9**	**75.9**	**6.3**	**6.2**	**5.0**	**76.0**	**9.7**	**9.7**	**3.4**	**0**

Table C15 – Weld Measurements for Specimen T5-3 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.2	5.4	4.9	76.0	5.7	6.1	4.6	76.0	9.6	9.6	3.8	0
2	5.7	5.9	4.8	75.9	5.4	5.9	4.4	76.0	9.6	9.6	4.2	0
3	6.6	6.1	4.9	75.9	5.8	6.0	4.6	76.0	8.9	8.9	3.1	0
4	6.2	5.9	4.8	76.0	5.7	5.7	4.9	75.9	9.1	9.1	3.4	0
5	6.3	5.7	4.8	76.0	6.2	5.8	5.1	76.0	9.9	9.9	3.7	0
6	6.4	5.4	4.9		5.5	6.4	4.8		9.3	9.3	3.8	0
7	6.4	5.4	5.1		6.2	5.7	4.8		9.5	9.5	3.3	0
8	6.8	6.3	5.1		6.2	5.9	4.8		9.4	9.4	3.2	0
Mean	**6.3**	**5.8**	**4.9**	**75.9**	**5.8**	**5.9**	**4.7**	**76.0**	**9.4**	**9.4**	**3.6**	**0**

Table C16 – Weld Measurements for Specimen T6-1 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.6	4.9	4.4	75.9	6.6	5.4	4.6	75.9	9.7	5.2	3.1	90
2	6.4	5.3	4.4	75.9	6.3	5.8	4.6	76.0	9.5	5.8	3.0	90
3	6.4	5.3	4.6	75.9	6.3	5.4	4.6	76.0	9.3	5.4	3.0	90
4	6.9	5.5	4.8	75.9	6.8	5.6	4.8	76.0	10.0	5.7	3.1	90
5	6.9	4.5	4.4	75.9	6.9	5.8	4.8	75.9	9.4	4.6	2.6	90
6	6.4	5.4	4.8		6.4	5.5	4.8		9.9	5.7	3.4	90
7	6.6	4.6	4.6		6.6	5.7	4.8		9.2	5.0	2.6	90
8	6.4	5.1	4.6		6.4	5.0	4.6		9.6	6.2	3.2	90
Mean	**6.6**	**5.1**	**4.6**	**75.9**	**6.5**	**5.5**	**4.7**	**76.0**	**9.6**	**5.4**	**3.0**	**90**

Table C17 – Weld Measurements for Specimen T6-2 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.9	5.6	4.6	76.0	7.0	5.6	4.4	76.0	10.5	5.5	3.5	90
2	6.4	5.2	4.6	76.0	6.7	4.9	4.3	76.0	10.0	5.1	3.4	90
3	6.2	5.6	4.8	76.0	6.6	5.4	4.4	76.0	9.8	5.4	3.1	90
4	6.2	5.8	4.8	76.0	6.5	4.7	4.0	76.0	9.8	4.9	3.3	90
5	6.3	5.5	4.8	76.0	6.8	5.1	4.4	76.0	9.7	5.2	2.9	90
6	6.0	5.9	4.8		7.1	5.4	4.4		10.6	6.0	3.5	33
7	6.5	5.6	4.9		6.8	4.9	4.4		10.1	5.1	3.4	45
8	6.2	6.2	4.8		6.2	4.9	4.4		9.8	5.6	3.6	90
Mean	**6.3**	**5.7**	**4.7**	**76.0**	**6.7**	**5.1**	**4.4**	**76.0**	**10.0**	**5.3**	**3.3**	**77**

Table C18 – Weld Measurements for Specimen T6-3 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	7.1	5.8	4.8	75.9	7.1	6.1	4.8	76.0	10.2	6.1	3.2	90
2	7.1	5.8	4.8	75.8	6.1	5.5	4.3	76.0	9.1	5.7	3.1	90
3	6.6	6.1	4.8	75.9	6.7	5.7	4.4	76.0	10.0	5.7	3.3	90
4	6.1	6.3	4.8	75.9	6.5	5.4	4.4	76.0	9.7	5.4	3.3	90
5	6.9	5.7	4.6	75.9	6.4	5.4	4.4	76.0	9.6	6.1	3.1	90
6	6.0	6.0	4.6		6.6	5.0	4.4		10.0	5.5	3.4	90
7	6.4	5.4	4.8		6.7	4.6	4.4		9.9	5.3	3.2	90
8	6.0	5.5	5.1		6.1	5.6	4.4		10.0	5.9	3.9	90
Mean	**6.5**	**5.8**	**4.8**	**75.9**	**6.5**	**5.4**	**4.5**	**76.0**	**9.8**	**5.7**	**3.3**	**90**

Table C19 – Weld Measurements for Specimen T7-1 (E70T-4(H)S–1/4")

Meas. Number	Before Failure								After Failure							
	Front Face				Back Face				Front Failure Face				Back Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	4.0	4.8	4.0	76.1	6.6	4.6	4.3	76.0	9.0	5.1	5.1	90	7.7	4.9	1.2	90
2	4.7	5.3	4.4	76.1	7.5	5.2	4.6	76.0	9.6	5.7	4.8	90	8.5	4.9	1.0	90
3	5.2	4.8	4.4	76.1	7.4	3.6	4.4	76.0	9.3	5.5	4.1	90	9.3	4.0	1.9	90
4	6.9	5.6	4.6	76.1	6.7	4.1	4.8	76.0	8.6	6.1	1.7	90	10.3	4.3	3.6	90
5	6.0	5.6	4.6	76.1	5.2	6.2	5.2	76.0	7.4	6.0	1.4	90	9.6	6.3	4.4	90
6	4.9	4.9	4.3		7.5	5.4	5.1		10.1	5.5	5.2	90	8.6	5.5	1.1	90
7	5.1	5.2	4.4		6.7	5.5	4.8		10.0	5.9	5.0	90	9.0	6.0	2.2	90
8	5.5	5.1	4.3		6.5	5.4	4.8		8.9	5.6	3.5	90	9.2	5.5	2.8	90
Mean	**5.3**	**5.1**	**4.4**	**76.1**	**6.8**	**5.0**	**4.7**	**76.0**	**9.1**	**5.7**	**3.8**	**90**	**9.0**	**5.2**	**2.3**	**90**

Table C20 – Weld Measurements for Specimen T7-2 (E70T-4(H)S–1/4")

Meas. Number	Before Failure								After Failure							
	Front Face				Back Face				Front Failure Face				Back Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.3	4.2	3.7	76.2	5.9	4.8	4.0	76.1	7.5	7.5	2.2	0	9.2	5.2	3.2	90
2	4.3	5.1	3.7	76.2	5.4	3.7	3.8	76.1	7.3	7.3	3.0	0	8.5	4.3	3.1	90
3	4.5	4.9	4.0	76.3	5.6	4.8	4.2	76.1	7.5	7.5	3.0	0	8.3	5.3	2.6	90
4	4.5	4.6	4.0	76.1	5.8	4.2	4.1	76.1	7.5	4.9	3.0	90	8.3	4.4	2.5	90
5	5.4	4.3	4.1	76.1	5.9	4.0	4.1	76.1	8.4	4.6	3.0	90	8.1	4.1	2.3	90
6	5.8	3.6	4.0		7.0	4.8	4.2		8.1	3.5	2.3	90	9.3	4.7	2.3	90
7	6.1	5.0	4.3		6.0	4.2	3.8		8.2	5.1	2.1	90	7.8	4.0	1.8	90
8	5.1	4.6	3.8		5.9	4.8	3.8		8.0	5.0	2.9	90	8.9	5.2	3.1	90
Mean	**5.1**	**4.5**	**3.9**	**76.2**	**5.9**	**4.4**	**4.0**	**76.1**	**7.8**	**5.7**	**2.7**	**56**	**8.5**	**4.7**	**2.6**	**90**

Table C21 – Weld Measurements for Specimen T7-3 (E70T-4(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.3	4.5	4.0	76.1	5.7	5.3	4.6	76.1	-	5.4	-	0
2	5.0	4.3	4.1	76.1	5.7	5.4	4.6	76.1	-	6.7	-	0
3	4.7	4.7	4.3	76.1	5.5	3.9	4.0	76.1	-	6.0	-	0
4	5.2	3.9	4.0	76.0	5.7	4.8	4.3	76.1	-	6.3	-	0
5	5.3	4.7	4.3	76.1	5.7	4.1	4.1	76.1	-	5.9	-	0
6	5.3	4.6	4.1		5.8	4.0	4.4		-	5.5	-	0
7	5.3	4.5	4.3		5.8	5.2	4.6		-	7.2	-	0
8	5.3	4.7	4.4		5.0	5.1	4.6		-	6.9	-	0
Mean	**5.2**	**4.5**	**4.2**	**76.1**	**5.6**	**4.7**	**4.4**	**76.1**		**6.2**		**0**

Table C22 – Weld Measurements for Specimen T8-1 (E70T-4(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.0	7.0	6.0	75.6	6.4	7.4	6.0	75.4				
2	5.8	7.1	5.7	75.7	6.3	7.3	6.0	75.5				
3	5.9	7.2	5.6	75.6	6.8	7.1	6.4	75.4	Reinforced Weld Failed			
4	5.6	7.2	5.6	75.6	7.0	7.3	6.4	75.4				
5	5.4	7.3	5.9	75.7	6.6	8.0	6.2	75.4				
6	5.6	7.3	5.9		6.6	8.4	6.2					
7	6.6	7.5	6.0		6.6	7.6	6.2					
8	6.0	7.6	6.0		6.1	7.9	6.5					
Mean	**5.9**	**7.3**	**5.8**	**75.6**	**6.5**	**7.6**	**6.2**	**75.4**				

Table C23 – Weld Measurements for Specimen T8-2 (E70T-4(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.5	7.6	5.6	75.3	6.3	7.1	5.9	75.5	8.7	6.5	2.4	18
2	5.9	7.7	6.2	75.6	6.5	7.1	6.0	75.6	8.4	6.2	2.0	15
3	6.1	8.2	6.0	75.6	7.0	7.5	6.2	75.5	9.3	8.4	2.2	0
4	5.9	7.7	6.0	75.6	7.0	7.4	6.2	75.5	8.3	9.0	1.4	0
5	5.9	7.6	6.2	75.5	7.0	7.7	6.2	75.5	8.6	6.2	1.6	14
6	6.4	7.6	6.4		6.1	7.2	6.0		9.1	8.9	3.1	0
7	6.4	7.4	6.2		6.6	7.0	6.0		8.7	8.7	2.1	0
8	6.1	7.7	6.2		5.9	7.2	6.0		7.7	7.7	1.7	0
Mean	**6.0**	**7.7**	**6.1**	**75.5**	**6.5**	**7.3**	**6.1**	**75.5**	**8.6**	**7.7**	**2.1**	**6**

Table C24 – Weld Measurements for Specimen T8-3 (E70T-4(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.2	7.2	6.0	76.3	7.5	7.5	6.5	76.4	8.6	6.3	2.5	15
2	6.7	7.7	6.2	76.2	7.4	7.2	6.2	76.4	9.1	7.7	2.4	9
3	5.7	7.8	6.0	76.3	6.6	7.1	6.4	76.4	8.4	8.4	2.7	0
4	6.2	8.2	6.2	76.2	6.8	7.0	6.2	76.4	8.6	8.3	2.4	0
5	6.4	7.8	6.2	76.3	6.5	7.1	6.0	76.3	8.2	7.9	1.8	0
6	7.0	7.8	6.0		7.2	7.0	5.9		8.9	6.6	1.9	11
7	7.2	7.9	6.4		6.8	7.0	5.6		8.6	6.4	1.4	14
8	7.1	8.0	6.4		6.5	7.2	5.7		9.2	7.0	2.1	10
Mean	**6.5**	**7.8**	**6.2**	**76.3**	**6.9**	**7.1**	**6.1**	**76.4**	**8.7**	**7.3**	**2.1**	**7**

Table C25 – Weld Measurements for Specimen T9-1 (E70T-4(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.8	5.1	4.6	76.0	7.9	5.3	5.2	76.1	10.4	4.9	2.6	90
2	7.4	5.8	5.6	76.0	8.9	5.7	5.6	76.1	10.6	5.4	1.7	60
3	8.1	5.9	5.9	76.0	8.1	6.0	5.4	76.1	9.9	6.0	1.9	27
4	7.8	5.5	5.6	76.1	8.5	6.3	5.4	76.1	10.5	6.8	2.1	20
5	7.1	6.6	6.0	76.1	8.5	6.0	5.4	76.1	9.9	6.9	1.4	15
6	6.4	6.5	5.7		8.9	6.0	5.9		9.9	6.8	1.0	18
7	7.5	6.8	5.7		8.4	5.8	5.6		9.7	5.9	1.3	16
8	7.9	6.1	5.6		9.4	5.8	5.6		11.0	5.3	1.7	75
Mean	**7.4**	**6.0**	**5.6**	**76.0**	**8.6**	**5.8**	**5.5**	**76.1**	**10.3**	**6.0**	**1.7**	**40**

Table C26 – Weld Measurements for Specimen T9-2 (E70T-4(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.2	5.8	5.2	76.1	8.1	6.1	5.6	76.0	9.6	6.9	1.5	21
2	8.2	5.3	5.1	76.0	9.0	6.7	5.9	76.0	11.0	8.3	2.0	13
3	7.3	5.6	4.9	76.0	9.0	6.6	5.4	76.1	10.4	7.0	1.4	18
4	8.4	5.0	5.1	76.1	8.2	6.0	5.2	76.1	10.0	8.4	1.9	11
5	7.8	5.1	5.4	76.1	8.1	5.6	5.2	76.0	9.2	6.5	1.1	19
6	9.3	6.7	5.9		8.4	6.2	5.1		10.3	6.9	2.0	20
7	8.6	5.9	5.6		8.3	5.9	5.2		9.6	6.1	1.3	22
8	8.1	5.7	5.2		7.6	5.5	4.9		9.6	4.8	2.0	90
Mean	**8.2**	**5.6**	**5.3**	**76.1**	**8.3**	**6.1**	**5.3**	**76.0**	**10.0**	**6.9**	**1.6**	**27**

Table C27 – Weld Measurements for Specimen T9-3 (E70T-4(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.6	5.8	5.7	76.0	8.3	5.8	5.7	76.0	10.4	5.8	1.8	33
2	7.3	5.0	5.4	76.0	7.6	6.0	5.6	76.0	8.6	5.1	1.3	35
3	8.7	5.9	5.9	76.0	8.1	6.4	5.6	76.0	10.5	6.4	1.9	27
4	9.0	6.2	6.0	76.0	8.3	6.8	5.4	76.0	10.2	6.9	1.3	23
5	9.1	6.6	6.2	76.0	7.6	5.5	5.4	76.0	10.4	7.1	1.3	21
6	8.0	6.1	6.0		8.2	5.5	5.6		10.5	7.5	2.5	20
7	7.9	6.3	6.2		7.8	6.6	5.7		9.9	7.0	2.1	23
8	8.2	6.7	6.2		8.3	6.5	5.7		9.7	6.6	1.5	21
Mean	**8.3**	**6.1**	**6.0**	**76.0**	**8.0**	**6.1**	**5.6**	**76.0**	**10.0**	**6.5**	**1.7**	**25**

Table C28 – Weld Measurements for Specimen T10-1 (E70T-4(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	9.4	6.7	6.2	76.0	8.5	6.2	6.2	76.1	9.4	6.4	0.0	49
2	7.0	6.0	5.7	76.0	8.3	7.4	6.5	76.0	8.6	5.6	1.6	47
3	7.8	6.6	6.0	76.0	9.6	6.5	6.5	76.0	8.7	6.0	0.9	42
4	7.7	6.9	6.2	76.0	9.0	6.1	6.4	76.1	8.6	6.1	0.9	26
5	7.2	6.7	5.7	76.0	8.9	6.8	6.5	76.0	8.4	8.0	1.2	0
6	7.8	6.9	5.9		8.6	6.4	6.7		9.6	6.5	1.8	15
7	6.8	6.1	5.6		8.5	6.7	6.8		8.2	7.3	1.4	0
8	8.2	6.9	5.7		8.8	6.5	6.4		9.9	6.9	1.7	8
Mean	**7.7**	**6.6**	**5.9**	**76.0**	**8.8**	**6.6**	**6.5**	**76.1**	**8.9**	**6.6**	**1.2**	**23**

Table C29 – Weld Measurements for Specimen T10-2 (E70T-4(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	7.8	6.5	5.7	76.0	7.3	7.0	6.0	76.1	7.8	7.8	0.6	0
2	7.9	5.9	5.6	76.0	7.7	5.7	6.0	76.1	8.4	8.4	0.8	0
3	8.7	6.0	5.9	76.0	8.2	6.1	5.7	76.0	9.1	9.1	0.8	0
4	7.4	6.5	5.9	76.0	8.2	6.2	5.9	76.1	9.1	6.7	0.9	17
5	7.9	6.5	5.6	76.0	8.4	6.0	6.4	76.0	9.0	5.9	0.5	37
6	7.8	6.2	5.9		9.1	6.2	6.2		8.8	5.5	-0.3	27
7	8.2	6.2	5.9		8.2	6.5	6.2		8.1	7.5	-0.1	16
8	7.9	6.3	5.9		8.5	6.5	6.2		9.2	6.7	0.7	18
Mean	**7.9**	**6.3**	**5.8**	**76.0**	**8.2**	**6.3**	**6.1**	**76.1**	**8.7**	**7.2**	**0.5**	**14**

Table C30 – Weld Measurements for Specimen T10-3 (E70T-4(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.7	6.6	6.0	76.0	8.9	7.1	6.2	76.0	10.1	5.3	1.4	75
2	8.5	6.0	6.2	76.0	9.1	6.7	6.2	76.0	9.1	5.0	0.6	51
3	7.9	5.9	6.0	76.0	9.2	6.6	6.0	76.0	9.2	5.9	1.3	30
4	7.8	5.8	5.9	76.0	8.5	6.2	6.0	76.0	8.8	5.6	1.0	27
5	7.7	6.9	6.0	76.1	8.4	6.3	6.2	76.1	8.8	5.8	1.1	31
6	7.8	6.5	6.4		8.7	6.3	6.0		7.9	7.5	0.2	0
7	6.8	6.5	6.0		8.3	6.6	6.2		8.3	8.3	1.4	0
8	7.0	6.4	6.0		7.6	7.1	6.2		7.8	7.8	0.8	0
Mean	**7.8**	**6.3**	**6.1**	**76.0**	**8.6**	**6.6**	**6.1**	**76.0**	**8.7**	**6.4**	**1.0**	**27**

Table C31 – Weld Measurements for Specimen T11-1 (E70T-7(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.0	6.2	5.7	76.1	7.4	6.8	6.2	76.1	8.8	8.8	2.8	0
2	6.4	6.3	6.0	76.1	7.8	7.1	6.2	76.1	8.6	8.6	2.2	0
3	6.3	6.3	6.2	76.1	7.9	7.1	6.4	76.1	8.4	8.4	2.1	0
4	6.6	6.3	6.2	76.1	7.6	7.1	6.4	76.1	9.1	9.1	2.4	0
5	7.0	6.8	6.2	76.1	7.7	6.8	6.4	76.1	9.2	9.2	2.2	0
6	6.2	7.1	6.2		7.5	6.7	6.2		8.6	8.6	2.3	0
7	6.7	7.2	6.4		7.3	6.5	6.4		11.4	11.4	4.7	0
8	6.2	7.2	6.4		8.0	6.5	6.4		8.7	8.7	2.5	0
Mean	**6.4**	**6.7**	**6.2**	**76.1**	**7.6**	**6.8**	**6.3**	**76.1**	**9.1**	**9.1**	**2.7**	**0**

Table C32 – Weld Measurements for Specimen T11-2 (E70T-7(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	7.1	7.0	6.4	76.1	7.3	6.7	5.1	76.0	9.5	9.5	2.3	0
2	6.5	7.2	6.4	76.1	7.7	6.9	4.9	76.0	9.7	9.7	2.0	0
3	6.7	7.1	6.4	76.1	7.1	7.0	6.4	76.0	9.3	9.3	2.2	0
4	6.1	7.4	6.2	76.2	6.8	6.8	6.2	76.0	9.3	9.3	2.5	0
5	6.7	7.4	6.2	76.1	6.8	7.0	6.4	76.0	10.1	10.1	3.3	0
6	6.7	7.0	6.2		6.7	6.9	6.0		10.1	10.1	3.4	0
7	6.8	7.2	6.4		7.1	6.5	6.2		9.8	9.8	2.8	0
8	6.7	7.3	6.0		7.1	6.7	6.4		9.6	9.6	2.5	0
Mean	**6.7**	**7.2**	**6.3**	**76.1**	**7.1**	**6.8**	**5.9**	**76.0**	**9.7**	**9.7**	**2.6**	**0**

Table C33 – Weld Measurements for Specimen T11-3 (E70T-7(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.1	7.3	6.2	76.2	7.2	6.4	6.2	76.2	8.4	8.4	2.3	0
2	6.3	7.2	6.2	76.2	7.2	7.1	6.5	76.1	8.2	8.2	1.9	0
3	6.1	6.9	6.0	76.2	7.7	7.3	6.5	76.1	8.1	8.1	2.0	0
4	6.4	7.3	6.0	76.2	7.1	7.1	6.4	76.1	8.4	8.4	2.1	0
5	6.6	7.1	6.0	76.2	7.3	6.9	6.4	76.1	8.5	8.5	1.9	0
6	6.8	7.2	6.2		6.8	6.6	6.2		8.4	8.4	1.6	0
7	6.7	7.4	6.4		6.6	6.7	6.2		8.4	8.4	1.8	0
8	6.8	7.6	6.2		7.3	6.7	6.2		9.1	9.1	2.2	0
Mean	**6.5**	**7.2**	**6.2**	**76.2**	**7.1**	**6.9**	**6.3**	**76.1**	**8.4**	**8.4**	**2.0**	**0**

Table C34 – Weld Measurements for Specimen T12-1 (E70T-7(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.2	6.2	6.2	76.1	7.5	4.6	5.1	76.1	9.9	5.7	2.4	90
2	7.3	6.1	6.0	76.1	8.0	4.9	4.8	76.1	9.5	4.7	1.5	90
3	8.3	6.4	6.2	76.1	6.9	5.2	5.1	76.1	9.3	5.2	2.4	46
4	7.8	6.1	6.0	76.1	6.6	5.4	4.8	76.1	9.5	7.3	2.9	20
5	8.3	6.4	6.2	76.1	7.9	5.5	5.2	76.1	10.4	6.4	2.5	90
6	7.8	6.6	6.2		8.7	5.4	5.4		10.4	5.6	1.7	90
7	8.1	6.2	6.0		8.6	6.1	5.4		11.3	5.8	2.7	90
8	7.3	6.1	5.7		8.4	6.0	5.1		10.2	5.3	1.8	90
Mean	**7.9**	**6.3**	**6.1**	**76.1**	**7.8**	**5.4**	**5.1**	**76.1**	**10.1**	**5.7**	**2.2**	**76**

Table C35 – Weld Measurements for Specimen T12-2 (E70T-7(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.0	6.6	6.0	76.0	7.8	5.2	5.6	75.9	9.5	6.0	1.7	35
2	8.1	5.8	5.9	75.9	7.6	5.2	5.6	75.9	10.4	4.9	2.8	90
3	7.8	6.0	5.9	75.9	8.0	5.9	5.4	75.9	10.6	5.8	2.7	90
4	7.7	6.1	5.7	76.0	7.8	4.8	4.8	75.9	9.8	4.7	2.0	90
5	8.5	5.8	5.9	76.0	7.4	5.1	4.9	75.9	9.5	4.8	2.1	90
6	8.7	5.6	5.4		7.9	5.3	4.9		9.8	5.6	2.0	32
7	7.4	5.7	5.2		8.3	4.2	4.8		9.4	4.5	1.2	90
8	7.7	5.7	5.4		8.0	4.9	4.9		9.8	5.3	1.8	49
Mean	**8.0**	**5.9**	**5.7**	**75.9**	**7.8**	**5.1**	**5.1**	**75.9**	**9.9**	**5.2**	**2.0**	**71**

Table C36 – Weld Measurements for Specimen T12-3 (E70T-7(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.4	5.5	5.4	76.1	8.9	6.0	5.6	76.1	10.4	5.5	2.0	90
2	7.7	5.3	5.2	76.1	8.4	5.7	5.4	76.1	10.0	5.5	2.2	90
3	7.5	6.0	5.7	76.1	8.4	5.3	5.1	76.0	10.6	6.2	3.2	90
4	7.5	6.3	5.9	76.1	8.3	5.2	4.9	76.0	10.4	6.1	2.9	90
5	7.1	6.4	5.9	76.1	8.2	5.0	4.8	76.0	10.2	6.4	3.0	90
6	6.9	5.9	5.9		8.3	5.3	5.1		10.0	6.5	3.1	90
7	7.8	7.2	5.9		7.6	5.5	5.1		10.8	6.1	3.0	90
8	7.4	6.7	5.7		7.7	5.6	5.2		10.6	6.2	3.2	90
Mean	**7.5**	**6.2**	**5.7**	**76.1**	**8.2**	**5.4**	**5.1**	**76.0**	**10.4**	**6.1**	**2.8**	**90**

Table C37 – Weld Measurements for Specimen T13-1 (E70T-7(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.5	5.8	4.9	75.9	5.7	6.1	4.8	75.8	9.5	5.8	2.9	90
2	6.8	5.1	4.8	75.9	6.8	6.4	4.8	75.9	9.3	4.4	2.5	90
3	6.8	4.8	4.9	75.9	6.6	6.9	4.8	75.9	9.0	4.7	2.1	90
4	6.4	4.9	4.8	75.9	6.7	6.9	5.1	75.8	9.0	4.9	2.6	90
5	7.0	5.0	4.6	75.9	7.2	6.6	5.1	75.9	9.3	4.7	2.3	90
6	6.7	5.3	4.8		7.0	7.2	5.1		9.3	4.9	2.7	90
7	6.7	5.4	4.8		7.2	6.6	4.8		9.5	4.8	2.8	90
8	6.8	5.5	4.8		7.2	6.0	4.4		9.5	4.8	2.6	90
Mean	**6.7**	**5.2**	**4.8**	**75.9**	**6.8**	**6.6**	**4.8**	**75.9**	**9.3**	**4.9**	**2.6**	**90**

Table C38 – Weld Measurements for Specimen T13-2 (E70T-7(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.5	7.5	5.4	76.0	6.5	5.1	5.4	76.1				
2	5.9	6.7	5.2	76.0	7.8	7.1	5.7	76.1				
3	6.4	5.6	5.1	76.0	6.7	5.3	5.2	76.1	Reinforced Weld Failed			
4	6.8	5.4	5.1	76.0	6.8	5.2	5.2	76.1				
5	6.4	5.9	4.9	76.0	7.7	6.1	5.6	76.1				
6	6.9	5.5	4.8		7.5	6.1	5.6					
7	6.8	5.1	5.2		7.2	6.7	5.6					
8	6.2	6.5	4.9		7.8	6.0	5.6					
Mean	**6.5**	**6.0**	**5.1**	**76.0**	**7.3**	**5.9**	**5.5**	**76.1**				

Table C39 – Weld Measurements for Specimen T13-3 (E70T-7(L)W–1/4")

Meas. Number	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.1	5.9	4.8	76.0	5.1	6.1	4.8	75.9	9.1	6.5	4.0	90
2	6.4	5.5	5.1	76.0	5.7	5.8	5.2	76.0	10.4	6.0	4.0	90
3	5.3	6.3	4.8	76.0	4.4	7.3	4.9	75.9	8.6	8.6	3.3	0
4	5.9	6.0	4.8	76.0	5.0	6.0	5.1	75.9	9.5	9.5	3.5	0
5	6.7	5.7	5.1	76.0	5.6	5.2	5.1	76.0	10.1	7.9	3.4	12
6	5.5	5.7	5.1		5.9	4.8	4.8		8.9	6.7	3.5	23
7	6.6	5.6	5.2		6.2	5.4	4.9		9.7	5.9	3.2	90
8	8.2	4.2	4.8		6.1	5.8	5.2		10.4	4.6	2.2	90
Mean	**6.2**	**5.6**	**4.9**	**76.0**	**5.5**	**5.8**	**5.0**	**75.9**	**9.6**	**7.0**	**3.4**	**49**

Table C40 – Weld Measurements for Specimen T14-1 (E70T-7(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.4	6.8	6.0	76.0	8.3	6.5	5.9	76.0	11.3	11.3	3.0	0
2	8.0	6.0	6.0	76.0	8.2	6.6	6.2	76.0	11.4	11.4	3.1	0
3	8.1	6.7	6.2	76.0	8.9	7.3	5.9	76.0	9.9	9.9	1.0	0
4	8.2	6.9	6.4	76.0	9.0	7.0	5.9	76.0	12.6	12.6	3.5	0
5	8.2	6.9	6.5	76.0	8.9	6.7	5.9	76.0	10.1	7.8	1.2	12
6	8.3	7.4	6.4		9.0	6.8	6.0		10.4	7.6	1.4	14
7	8.3	6.8	6.2		8.6	7.1	6.2		10.2	7.6	1.6	16
8	7.9	6.6	5.9		8.5	7.4	6.4		9.4	7.9	0.9	10
Mean	**8.2**	**6.8**	**6.2**	**76.0**	**8.7**	**6.9**	**6.0**	**76.0**	**10.6**	**9.5**	**2.0**	**6**

Table C41 – Weld Measurements for Specimen T14-2 (E70T-7(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.4	6.4	5.7	76.1	8.0	6.9	5.6	76.1	11.4	11.4	3.4	0
2	7.9	6.6	5.7	76.1	8.7	6.7	5.7	76.1	11.9	11.9	3.2	0
3	8.0	6.2	6.0	76.1	8.5	6.5	5.7	76.1	10.3	10.2	1.8	0
4	8.4	7.2	6.4	76.1	8.9	6.8	5.7	76.1	13.4	10.8	4.4	11
5	8.6	7.2	6.0	76.1	8.9	6.5	5.9	76.1	10.3	8.2	1.5	10
6	7.9	6.8	5.9		8.7	6.9	5.9		10.7	8.3	2.0	13
7	8.2	7.0	5.9		8.8	6.9	6.0		10.4	7.8	1.5	15
8	8.6	6.9	5.9		9.1	6.9	6.0		10.3	7.4	1.2	18
Mean	**8.3**	**6.8**	**5.9**	**76.1**	**8.7**	**6.7**	**5.8**	**76.1**	**11.1**	**9.5**	**2.4**	**8**

Table C42 – Weld Measurements for Specimen T14-3 (E70T-7(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.1	6.6	5.9	76.1	8.5	6.3	5.7	76.0	10.0	10.0	1.9	0
2	8.3	7.0	6.7	76.1	8.8	6.6	5.6	76.0	10.0	10.0	1.7	0
3	7.9	7.1	6.5	76.0	8.0	6.1	5.7	76.0	9.7	9.7	1.8	0
4	8.1	7.3	6.0	76.0	8.3	6.5	5.7	76.0	10.3	8.6	2.2	12
5	7.6	7.0	6.0	76.1	8.2	6.3	5.9	76.0	9.8	7.7	2.1	12
6	7.8	6.9	6.0		8.3	7.0	6.0		9.8	8.6	1.9	6
7	7.5	6.7	5.9		8.8	7.2	6.4		9.5	8.7	2.0	5
8	7.8	6.9	6.0		9.3	7.1	6.0		12.6	12.6	4.8	0
Mean	**7.9**	**6.9**	**6.1**	**76.0**	**8.5**	**6.6**	**5.9**	**76.0**	**10.2**	**9.5**	**2.3**	**4**

Table C43 – Weld Measurements for Specimen T15-1 (E70T-7(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.8	6.3	5.4	76.0	7.6	6.9	6.4	76.1	9.8	9.8	3.0	0
2	6.6	6.2	5.4	76.1	6.9	7.3	6.0	76.0	9.1	9.1	2.5	0
3	7.0	7.0	5.4	76.1	6.8	6.6	6.0	76.0	10.0	10.0	3.1	0
4	6.6	7.0	5.6	76.0	8.1	6.4	6.2	76.1	9.8	9.8	3.2	0
5	6.9	6.9	5.6	76.1	7.9	6.0	6.0	76.0	9.5	9.5	2.6	0
6	7.1	6.9	5.4		8.6	6.7	6.5		9.7	9.7	2.7	0
7	6.2	6.5	5.6		7.6	6.9	6.5		8.5	8.5	2.3	0
8	7.1	7.3	6.0		8.1	8.0	6.4		9.5	9.5	2.4	0
Mean	**6.8**	**6.7**	**5.5**	**76.1**	**7.7**	**6.8**	**6.3**	**76.1**	**9.5**	**9.5**	**2.7**	**0**

Table C44 – Weld Measurements for Specimen T15-2 (E70T-7(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	7.3	7.5	6.2	76.0	7.5	7.4	6.5	76.0	10.4	10.4	3.1	0
2	6.7	7.6	6.2	76.0	7.6	7.5	6.4	76.0	9.7	9.7	3.1	0
3	7.8	7.8	5.9	76.0	7.7	7.6	6.0	76.0	10.8	10.8	3.0	0
4	7.9	7.5	5.6	76.0	7.5	7.3	6.0	76.1	9.9	9.9	2.0	0
5	7.1	6.3	5.7	76.0	8.0	7.3	6.2	76.0	9.0	9.0	1.9	0
6	7.9	7.5	5.9		8.0	7.0	6.2		10.5	10.5	2.6	0
7	7.0	7.1	5.7		7.6	6.9	5.7		9.9	9.9	2.9	0
8	7.6	7.1	6.0		8.1	7.2	6.4		9.7	9.7	2.1	0
Mean	**7.4**	**7.3**	**5.9**	**76.0**	**7.7**	**7.3**	**6.2**	**76.0**	**10.0**	**10.0**	**2.6**	**0**

Table C45 – Weld Measurements for Specimen T15-3 (E70T-7(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	7.3	7.3	6.0	76.2	7.3	7.3	6.0	76.1	10.3	10.3	3.0	0
2	6.5	7.4	6.0	76.1	7.4	7.3	6.2	76.1	8.7	8.7	2.2	0
3	6.9	8.0	6.0	76.1	7.3	6.5	6.4	76.1	9.2	9.2	2.3	0
4	6.9	7.2	5.7	76.2	7.6	7.0	6.5	76.2	8.8	8.8	1.9	0
5	7.7	7.3	5.6	76.1	7.8	7.3	6.4	76.1	9.8	9.8	2.1	0
6	7.9	6.2	5.6		7.4	7.1	6.0		9.3	9.3	1.4	0
7	6.8	5.4	5.4		7.7	6.9	6.0		8.6	8.6	1.8	0
8	7.2	6.9	6.0		7.2	7.1	6.4		9.4	9.4	2.2	0
Mean	**7.2**	**7.0**	**5.8**	**76.1**	**7.5**	**7.1**	**6.2**	**76.1**	**9.3**	**9.3**	**2.1**	**0**

Table C46 – Weld Measurements for Specimen T16-1 (E70T7-K2(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.1	6.0	4.9	76.2	7.2	7.7	6.4	76.2	9.7	7.1	2.4	18
2	5.7	6.9	5.9	76.2	7.9	7.3	6.4	76.2	9.9	6.7	2.0	20
3	8.0	7.9	5.7	76.2	7.6	7.2	6.5	76.2	10.1	7.5	2.5	16
4	8.0	7.7	5.7	76.2	7.5	7.6	6.7	76.2	10.1	7.0	2.5	20
5	7.3	7.5	5.4	76.2	8.0	7.7	6.7	76.2	10.3	7.4	2.3	16
6	6.7	7.0	5.1		7.8	7.4	6.5		10.5	8.0	2.7	14
7	6.5	6.9	5.2		7.8	7.5	6.4		10.6	7.0	2.8	19
8	6.5	7.0	5.2		7.8	8.0	6.7		10.5	7.1	2.7	21
Mean	**6.7**	**7.1**	**5.4**	**76.2**	**7.7**	**7.5**	**6.5**	**76.2**	**10.2**	**7.2**	**2.5**	**18**

Table C47 – Weld Measurements for Specimen T16-2 (E70T7-K2(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.8	7.2	5.6	76.2	7.9	7.8	6.7	76.2				
2	6.6	7.0	5.2	76.2	7.8	8.0	6.5	76.2				
3	6.7	6.3	5.2	76.2	8.0	7.6	6.7	76.2		Main Plate Failed		
4	6.8	6.9	5.4	76.2	8.1	8.0	6.7	76.2				
5	7.1	6.7	5.4	76.2	8.0	7.9	6.5	76.3				
6	6.6	6.7	5.2		8.3	8.5	6.4					
7	6.4	6.9	5.7		8.1	8.3	6.4					
8	7.1	7.1	5.2		8.2	7.4	6.7					
Mean	**6.7**	**6.8**	**5.4**	**76.2**	**8.1**	**7.9**	**6.5**	**76.2**				

Table C48 – Weld Measurements for Specimen T16-3 (E70T7-K2(L)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	6.8	7.0	5.6	71.7	6.7	5.9	5.4	71.6	9.4	6.3	2.8	22
2	6.8	7.1	5.4	71.7	6.5	6.0	5.7	71.7	9.4	6.3	2.9	22
3	7.3	6.9	5.6	71.7	7.2	6.4	5.9	71.6	9.4	6.9	2.2	22
4	6.9	7.2	5.6	71.8	7.9	6.8	6.0	71.6	10.3	6.7	2.4	20
5	6.7	7.2	5.6	71.7	7.8	6.9	5.9	71.7	10.1	6.6	2.3	20
6	7.1	7.0	5.6		7.2	6.9	5.9		10.0	6.6	2.9	20
7	6.7	7.2	5.4		7.4	6.0	5.9		9.8	6.8	2.4	20
8	6.6	7.4	4.8		7.1	7.0	5.9		10.0	7.3	2.8	19
Mean	**6.9**	**7.1**	**5.4**	**71.7**	**7.2**	**6.5**	**5.8**	**71.6**	**9.8**	**6.7**	**2.6**	**21**

Table C49 – Weld Measurements for Specimen T17-1 (E70T7-K2(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	9.4	5.7	5.6	76.1	9.0	5.7	5.6	76.0	10.5	7.3	1.1	21
2	8.1	4.8	4.8	76.1	8.8	5.7	5.6	76.1	9.6	7.1	1.5	20
3	8.2	5.2	4.8	76.1	8.3	4.9	5.6	76.1	9.8	6.9	1.7	25
4	9.0	5.5	5.2	76.2	9.8	5.7	5.6	76.1	12.1	4.5	3.1	90
5	9.1	4.9	4.9	76.1	9.7	5.6	5.2	76.1	12.1	4.3	3.0	90
6	9.1	5.2	5.1		9.4	5.0	5.2		11.7	4.8	2.6	90
7	9.4	5.1	4.9		9.8	5.4	5.4		12.2	4.7	2.8	90
8	10.0	4.0	4.6		9.4	5.3	5.2		13.0	3.6	3.1	90
Mean	**9.0**	**5.1**	**5.0**	**76.1**	**9.2**	**5.4**	**5.4**	**76.1**	**11.4**	**5.4**	**2.4**	**64**

Table C50 – Weld Measurements for Specimen T17-2 (E70T7-K2(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	10.6	3.5	4.4	76.2	9.8	6.0	5.9	76.1	12.4	2.9	1.9	90
2	9.2	5.0	4.8	76.1	10.2	6.0	6.4	76.1	12.4	4.9	3.2	90
3	9.1	4.0	4.4	76.1	9.2	7.4	6.4	76.2	11.9	3.7	2.9	90
4	9.1	3.9	4.0	76.2	8.3	6.7	6.2	76.2	11.9	3.5	2.8	90
5	9.8	3.7	4.1	76.1	8.1	6.6	6.2	76.1	12.2	3.7	2.5	90
6	8.6	3.4	4.4		8.7	6.9	5.7		10.9	3.1	2.3	90
7	10.4	5.3	5.2		9.5	5.9	5.6		12.6	4.5	2.2	90
8	10.2	4.8	4.8		8.7	5.1	5.2		11.7	4.5	1.4	90
Mean	**9.6**	**4.2**	**4.5**	**76.2**	**9.1**	**6.3**	**5.9**	**76.1**	**12.0**	**3.8**	**2.4**	**90**

Table C51 – Weld Measurements for Specimen T17-3 (E70T7-K2(L)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	9.7	3.9	4.4	76.1	8.9	5.9	6.2	76.2	12.3	3.9	2.6	90
2	9.7	5.1	4.8	76.1	8.8	7.6	6.4	76.1	12.0	4.2	2.3	90
3	9.5	4.2	4.8	76.3	8.0	6.8	6.2	76.0	12.0	3.9	2.5	90
4	9.8	4.5	4.8	76.2	8.2	7.1	6.0	76.1	12.0	4.2	2.2	90
5	10.1	4.1	4.6	76.1	8.0	6.4	6.0	76.2	12.9	4.0	2.9	90
6	9.9	4.5	4.8		8.6	6.6	5.9		12.5	4.2	2.6	90
7	9.2	3.7	4.6		8.1	6.2	5.6		11.2	3.3	2.0	90
8	10.3	5.1	5.1		8.3	6.0	5.7		12.2	4.6	1.9	90
Mean	**9.8**	**4.4**	**4.7**	**76.2**	**8.4**	**6.6**	**6.0**	**76.1**	**12.1**	**4.0**	**2.4**	**90**

Table C52 – Weld Measurements for Specimen T18-1 (E71T8-K6(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.3	6.0	4.6	75.9	5.8	6.7	5.1	75.8	9.9	9.9	4.6	0
2	5.2	5.4	4.4	75.9	5.7	6.3	5.1	75.8	9.6	9.6	4.4	0
3	5.8	6.7	5.1	75.9	6.0	6.1	5.2	75.8	9.7	9.7	3.9	0
4	5.6	6.6	5.1	75.9	5.7	6.3	5.2	75.8	9.3	9.3	3.7	0
5	5.7	6.1	5.1	75.9	5.7	6.7	5.2	75.8	9.3	9.3	3.6	0
6	5.7	6.8	5.1		5.5	6.1	5.4		9.4	9.4	3.7	0
7	5.2	7.3	5.2		5.8	6.0	5.4		9.7	9.7	4.5	0
8	5.7	7.5	5.2		5.5	6.8	5.2		9.6	9.6	3.9	0
Mean	**5.5**	**6.5**	**5.0**	**75.9**	**5.7**	**6.4**	**5.2**	**75.8**	**9.6**	**9.6**	**4.0**	**0**

Table C53 – Weld Measurements for Specimen T18-2 (E71T8-K6(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	4.6	7.2	4.8	75.9	5.1	7.0	4.9	75.9	9.1	9.1	4.0	0
2	4.8	6.9	4.8	75.9	5.1	5.2	4.8	76.0	8.5	8.5	3.4	0
3	5.0	6.7	5.2	75.9	5.1	5.8	5.1	75.9	8.6	8.6	3.6	0
4	5.1	6.7	5.1	76.0	5.4	6.3	5.2	76.0	9.1	9.1	3.7	0
5	5.5	6.8	4.8	75.9	5.6	5.1	5.1	75.9	9.0	9.0	3.4	0
6	5.7	6.9	5.1		5.2	6.1	5.1		8.5	8.5	3.3	0
7	5.5	7.3	5.1		5.3	6.6	5.4		8.6	8.6	3.3	0
8	5.5	6.9	5.2		5.3	6.9	5.1		9.1	9.1	3.9	0
Mean	**5.2**	**6.9**	**5.0**	**75.9**	**5.3**	**6.1**	**5.1**	**75.9**	**8.8**	**8.8**	**3.6**	**0**

Table C54 – Weld Measurements for Specimen T18-3 (E71T8-K6(H)W–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	5.2	6.5	5.2	75.9	5.1	6.7	4.8	75.9	8.6	8.6	3.5	0
2	6.0	7.2	5.2	75.8	5.7	6.1	5.2	75.9	9.1	9.1	3.4	0
3	6.1	7.4	5.2	75.9	4.8	6.6	5.1	75.9	8.3	8.3	3.6	0
4	5.6	7.9	5.2	75.9	5.3	6.5	4.9	75.9	8.7	8.7	3.5	0
5	6.3	7.1	5.1	76.0	5.7	6.2	5.1	75.9	8.8	7.6	3.1	0
6	5.8	7.3	5.1		5.4	6.4	5.4		8.6	8.6	3.3	0
7	5.1	6.6	4.9		5.1	6.4	5.1		9.1	9.1	4.0	0
8	5.9	6.3	4.8		5.4	6.5	5.2		9.0	9.0	3.6	0
Mean	**5.7**	**7.0**	**5.1**	**75.9**	**5.3**	**6.4**	**5.1**	**75.9**	**8.8**	**8.6**	**3.5**	**0**

Table C55 – Weld Measurements for Specimen T19-1 (E71T8-K6(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.0	5.8	5.1	76.1	8.3	7.5	6.0	76.1	10.5	7.3	2.2	19
2	8.0	7.0	5.2	76.1	8.0	6.2	5.4	76.1	9.9	6.3	1.9	22
3	8.0	7.4	5.4	76.1	7.8	6.1	5.4	76.0	9.5	6.1	1.7	22
4	8.1	6.6	5.2	76.1	8.5	6.7	5.6	76.0	10.6	6.6	2.1	24
5	8.3	6.9	5.4	76.1	7.5	7.1	6.0	76.1	10.0	7.2	2.5	20
6	8.4	6.3	5.4		7.5	7.6	5.9		10.3	6.6	2.8	22
7	8.2	6.7	5.6		7.3	6.0	5.4		9.5	5.8	2.2	30
8	8.1	8.5	5.9		7.4	6.9	5.4		9.4	4.9	2.0	37
Mean	**8.1**	**6.9**	**5.4**	**76.1**	**7.8**	**6.8**	**5.6**	**76.1**	**10.0**	**6.3**	**2.2**	**24**

Table C56 – Weld Measurements for Specimen T19-2 (E71T8-K6(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	8.5	8.0	5.9	76.0	7.6	6.2	5.2	76.1	10.6	6.9	3.1	22
2	9.0	7.2	5.7	76.0	7.9	6.2	5.6	76.0	10.5	6.8	2.7	23
3	8.9	7.7	5.9	76.0	7.7	6.5	5.6	76.0	10.1	6.8	2.4	23
4	8.9	8.0	5.7	76.0	8.2	5.8	5.2	76.0	9.6	6.0	1.3	27
5	8.4	7.8	5.7	76.0	7.9	5.9	5.7	76.0	9.3	6.4	1.5	25
6	8.9	8.1	5.7		8.8	5.4	5.6		10.5	6.0	1.8	30
7	8.8	6.8	5.6		8.4	6.1	5.6		10.2	6.4	1.8	27
8	8.7	7.0	5.9		8.4	5.7	5.4		10.0	5.7	1.6	33
Mean	**8.8**	**7.6**	**5.8**	**76.0**	**8.1**	**6.0**	**5.5**	**76.0**	**10.1**	**6.4**	**2.0**	**26**

Table C57 – Weld Measurements for Specimen T19-3 (E71T8-K6(H)S–1/4")

Meas. Number	Before Failure								After Failure			
	Front Face				Back Face				Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	9.0	7.3	5.6	75.9	8.2	5.2	5.1	76.0	10.3	5.9	2.1	32
2	8.7	7.0	5.6	75.9	8.9	5.6	5.9	76.1	10.8	6.9	1.9	29
3	8.9	7.1	5.6	75.9	8.3	5.5	5.7	76.0	10.6	6.5	2.3	28
4	9.5	7.4	5.4	75.9	7.7	6.5	5.9	76.0	10.4	6.1	2.6	28
5	8.9	7.4	5.9	75.9	8.3	7.2	5.9	76.1	10.5	6.8	2.2	21
6	7.9	7.4	5.6		8.2	7.6	5.9		11.0	8.0	2.7	20
7	8.9	7.1	5.7		6.8	5.9	5.2		9.4	6.4	2.5	22
8	7.9	7.1	5.7		7.2	6.5	4.9		9.7	6.3	2.5	22
Mean	**8.7**	**7.2**	**5.6**	**75.9**	**8.0**	**6.2**	**5.6**	**76.0**	**10.3**	**6.6**	**2.3**	**25**

Table C58 – Weld Measurements for Specimen T20-1 (E7014(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.1	13.6	4.5	9.5	4.8	75.9	13.4	12.5	4.5	10.2	6.0	75.8	14.5	9.3	1.4	29
2	12.9	14.7	4.4	9.7	5.2	75.8	12.2	13.1	4.2	10.0	5.9	75.8	15.2	9.4	2.2	30
3	13.0	14.2	4.5	9.7	5.4	75.9	12.5	13.4	4.2	9.8	5.9	75.8	14.9	9.6	1.9	31
4	13.0	14.2	4.7	9.8	5.9	75.8	12.9	13.9	4.8	10.0	5.9	75.8	16.3	11.0	3.3	24
5	13.6	14.3	5.0	10.2	6.0	75.8	13.3	14.2	4.8	10.2	6.2	75.8	16.3	10.3	2.7	27
6	13.5	13.8	4.8	9.8	6.0		13.5	14.6	5.3	10.6	6.4		15.8	10.4	2.3	25
7	13.9	13.9	4.8	9.7	5.9		14.7	13.9	6.1	11.0	7.1		16.1	10.4	2.2	26
8	14.6	15.0	4.8	10.2	5.9		14.0	14.1	5.0	10.6	6.8		18.1	10.6	3.5	23
Mean	**13.4**	**14.2**	**4.7**	**9.8**	**5.6**	**75.8**	**13.3**	**13.7**	**4.9**	**10.3**	**6.3**	**75.8**	**15.9**	**10.1**	**2.4**	**27**

Table C59 – Weld Measurements for Specimen T20-2 (E7014(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.0	13.1	3.7	9.0	4.9	76.0	13.9	14.5	4.7	9.5	5.7	75.9	14.2	14.2	1.2	0
2	13.1	12.5	3.7	9.0	5.1	76.0	13.4	14.9	4.5	9.4	5.6	75.9	13.5	13.5	0.4	29
3	12.9	13.0	3.7	8.9	4.8	75.9	13.2	14.5	4.8	9.5	5.7	75.9	13.3	13.3	0.4	26
4	12.6	13.1	4.0	9.2	5.1	76.0	13.1	15.2	4.7	9.7	5.9	76.0	13.5	13.5	0.9	0
5	12.4	13.6	4.2	9.2	5.1	76.0	13.1	14.2	4.8	9.7	5.7	75.9	13.3	13.3	1.0	0
6	12.5	14.0	4.0	9.2	5.2		13.2	14.3	4.7	9.5	5.9		13.3	13.3	0.8	0
7	13.2	13.0	4.0	9.4	5.2		13.5	14.8	4.7	9.8	6.0		14.3	14.3	1.1	0
8	12.7	13.1	4.5	9.5	5.1		13.5	14.7	4.8	9.8	6.0		14.2	14.2	1.5	0
Mean	**12.8**	**13.2**	**4.0**	**9.2**	**5.1**	**76.0**	**13.4**	**14.6**	**4.7**	**9.6**	**5.8**	**75.9**	**13.7**	**13.7**	**0.9**	**7**

Table C60 – Weld Measurements for Specimen T20-3 (E7014(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.2	14.3	4.4	9.7	4.9	75.9	13.9	13.3	4.0	9.4	5.1	76.2	13.6	13.6	1.4	0
2	13.1	14.2	4.7	10.0	5.2	76.0	13.9	13.4	4.0	9.2	5.4	76.2	14.7	14.7	1.6	0
3	13.6	14.3	5.1	10.8	6.0	76.0	13.6	13.8	4.5	9.5	5.6	76.2	15.1	15.1	1.5	0
4	13.8	15.0	6.1	11.7	7.0	76.0	14.3	14.0	4.2	9.5	5.6	76.1	13.6	13.6	-0.2	0
5	14.0	13.8	6.7	10.0	6.8	76.1	13.7	13.5	4.5	9.8	5.9	76.2	15.6	14.9	1.6	0
6	13.2	13.9	5.5	9.7	4.9		13.8	13.1	4.2	9.5	5.9		15.3	9.8	2.1	20
7	13.4	13.3	5.3	9.4	4.8		13.9	13.7	4.4	9.5	5.7		15.3	8.8	1.8	20
8	13.4	14.0	5.3	9.2	4.4		14.1	13.6	4.4	9.0	5.4		15.3	9.1	1.9	20
Mean	**13.3**	**14.1**	**5.4**	**10.1**	**5.5**	**76.0**	**13.9**	**13.6**	**4.3**	**9.4**	**5.6**	**76.2**	**14.8**	**12.4**	**1.5**	**7.4**

Table C61 – Weld Measurements for Specimen T21-1 (E70T-4(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.1	13.4	6.4	11.3	5.1	76.3	12.4	12.7	7.1	10.8	6.0	76.3	14.3	14.3	2.2	0
2	12.2	14.0	6.6	11.1	4.8	76.2	12.4	13.1	6.9	11.4	6.0	76.3	14.7	14.7	2.6	0
3	11.9	13.9	6.6	11.1	4.8	76.2	12.1	13.6	7.4	11.7	5.9	76.2	14.0	14.0	2.1	0
4	11.3	13.7	6.7	11.1	4.8	76.3	11.5	13.1	7.2	11.7	5.7	76.2	13.2	13.2	1.9	0
5	10.6	14.3	6.7	11.3	4.6	76.2	11.8	13.3	7.4	11.6	5.9	76.2	12.9	12.9	2.3	0
6	11.2	14.2	6.7	10.8	4.6		12.1	12.8	7.4	11.9	5.6		13.4	13.4	2.2	0
7	10.7	14.1	6.6	11.0	4.8		12.5	12.9	7.4	11.7	5.9		12.8	12.8	2.1	0
8	10.7	14.1	6.4	10.8	4.6		13.2	13.2	7.4	11.7	6.0		12.9	12.9	2.3	0
Mean	**11.3**	**14.0**	**6.6**	**11.1**	**4.7**	**76.3**	**12.2**	**13.1**	**7.3**	**11.6**	**5.9**	**76.2**	**13.5**	**13.5**	**2.2**	**0**

Table C62 – Weld Measurements for Specimen T21-2 (E70T-4(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.7	14.0	6.4	11.4	4.8	76.3	12.7	13.7	7.2	11.9	6.0	76.0	16.2	16.2	3.5	0
2	12.3	13.7	6.4	11.1	4.9	76.3	12.2	13.6	7.7	11.9	5.9	76.1	14.9	14.9	2.8	0
3	12.8	14.0	6.4	11.4	5.2	76.3	11.9	13.6	7.7	12.1	5.9	76.1	14.3	14.3	2.4	0
4	11.8	13.2	6.4	11.3	5.2	76.3	12.2	13.7	7.7	12.2	5.9	76.1	15.3	15.3	3.2	0
5	12.4	13.6	6.4	11.3	5.4	76.3	11.9	13.5	7.5	12.1	5.7	76.1	15.0	15.0	3.1	0
6	12.3	13.7	6.4	11.1	5.4		12.2	13.4	7.4	12.2	5.7		14.9	14.9	2.7	0
7	12.3	13.8	6.4	11.1	5.4		11.6	14.4	7.7	12.2	5.6		14.5	14.5	2.9	0
8	12.5	13.6	6.6	11.3	5.1		11.9	13.7	7.8	12.2	5.6		14.7	14.7	2.8	0
Mean	**12.2**	**13.7**	**6.4**	**11.3**	**5.2**	**76.3**	**12.1**	**13.7**	**7.6**	**12.1**	**5.8**	**76.1**	**15.0**	**15.0**	**2.9**	**0**

Table C63 – Weld Measurements for Specimen T21-3 (E70T-4(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.2	11.5	5.5	10.0	5.9	76.2	12.3	14.4	7.7	12.2	5.9	76.1	14.6	14.6	2.3	0
2	12.9	12.4	6.1	10.6	5.4	76.2	12.2	13.8	7.4	11.6	5.9	76.2	14.5	14.5	2.3	0
3	13.0	14.1	6.9	11.4	5.6	76.2	12.1	13.8	7.4	11.4	5.7	76.1	14.6	14.6	2.5	0
4	12.2	14.1	6.7	11.1	5.4	76.3	12.4	13.5	7.4	11.6	5.7	76.1	14.8	14.8	2.5	0
5	11.6	14.3	6.7	11.1	5.1	76.2	12.3	13.1	7.1	11.7	5.7	76.1	14.7	14.7	2.5	0
6	11.7	13.8	6.6	10.8	4.9		11.7	13.6	6.9	11.7	5.6		13.7	13.7	2.0	0
7	11.2	14.0	6.4	10.8	4.4		12.2	13.1	6.7	11.7	5.9		14.2	14.2	1.9	0
8	11.4	13.7	6.4	11.1	4.8		12.3	12.3	6.4	11.4	5.9		14.9	14.9	2.6	0
Mean	**12.1**	**13.5**	**6.4**	**10.9**	**5.2**	**76.2**	**12.2**	**13.5**	**7.1**	**11.7**	**5.8**	**76.1**	**14.5**	**14.5**	**2.3**	**0**

Table C64 – Weld Measurements for Specimen T22-1 (E70T-4(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	9.8	10.0	3.4	7.8	3.2	76.3	10.3	11.3	4.4	9.2	4.0	76.1	12.2	12.2	2.4	0
2	9.5	10.9	3.6	7.9	3.0	76.2	10.9	11.6	4.7	9.0	4.1	76.1	12.2	12.2	2.8	0
3	9.3	10.6	3.4	7.8	2.9	76.2	10.9	12.0	5.0	9.4	4.1	76.1	12.2	12.2	3.0	0
4	8.9	10.7	3.4	7.8	2.9	76.2	10.5	12.2	5.0	9.4	4.1	76.1	12.5	12.5	3.6	0
5	9.8	10.3	3.7	7.6	3.2	76.2	11.8	12.1	4.7	9.2	4.4	76.1	12.8	12.8	3.0	0
6	9.3	11.3	4.0	8.3	3.5		11.0	12.2	4.8	8.9	4.4		10.9	10.9	1.6	0
7	9.5	10.7	3.6	7.9	3.7		12.2	12.0	5.0	9.2	4.4		12.5	12.5	3.0	0
8	9.6	10.6	3.4	7.6	3.2		11.0	12.0	4.7	9.2	4.3		12.0	12.0	2.5	0
Mean	**9.4**	**10.6**	**3.6**	**7.8**	**3.2**	**76.2**	**11.1**	**11.9**	**4.8**	**9.2**	**4.2**	**76.1**	**12.2**	**12.2**	**2.7**	**0**

Table E65 – Weld measurements for Specimen T22-2 (E70T-4(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	9.9	9.4	2.9	7.0	3.2	76.1	10.5	11.4	4.8	8.7	3.8	76.1	12.4	12.4	2.5	0
2	10.5	10.5	3.6	7.9	3.8	76.1	11.3	11.4	4.8	8.9	4.3	76.1	13.2	13.2	2.7	0
3	10.2	10.1	3.1	7.6	3.8	76.1	11.2	11.3	4.8	9.0	4.3	76.1	12.4	12.4	2.2	0
4	8.5	10.2	3.4	8.1	3.0	76.1	11.0	11.6	4.8	9.0	3.8	76.1	10.3	10.3	1.9	0
5	10.4	10.0	3.2	8.3	3.7	76.1	11.9	10.9	4.8	8.9	4.3	76.1	13.2	13.2	2.7	0
6	9.7	9.9	3.1	8.4	3.2		10.2	11.9	5.1	9.2	3.7		12.0	12.0	2.3	0
7	11.4	10.0	3.4	8.4	3.7		10.6	11.6	5.0	8.9	3.8		13.7	13.7	2.3	0
8	12.2	10.4	3.4	8.6	4.3		9.9	11.9	4.8	9.0	3.8		14.4	14.4	2.3	0
Mean	**10.3**	**10.0**	**3.3**	**8.0**	**3.6**	**76.1**	**10.8**	**11.5**	**4.9**	**9.0**	**4.0**	**76.1**	**12.7**	**12.7**	**2.4**	**0**

Table C66 – Weld Measurements for Specimen T22-3 (E70T-4(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.7	9.7	3.2	8.3	4.6	76.0	10.0	11.6	4.4	8.3	3.2	76.1	14.2	14.2	2.5	0
2	11.5	10.4	3.7	8.4	4.6	76.0	10.7	11.1	4.0	8.3	3.5	76.1	13.8	13.8	2.3	0
3	11.6	10.3	3.4	8.4	4.3	76.0	10.1	11.4	4.2	7.9	3.3	76.1	13.9	13.9	2.3	0
4	9.5	10.6	3.4	8.1	3.2	76.1	9.5	11.5	4.5	8.6	3.0	76.2	11.5	11.5	2.0	0
5	11.1	9.9	3.1	8.1	4.0	76.1	10.2	11.7	4.0	8.4	3.2	76.1	13.0	13.0	1.9	0
6	10.6	9.6	3.2	8.3	4.1		9.5	11.1	4.5	8.1	3.2		11.9	11.9	1.3	0
7	10.4	9.8	3.4	9.0	4.3		10.3	12.0	4.8	9.0	3.7		11.4	11.4	1.0	0
8	12.3	10.6	3.4	8.4	4.4		10.9	12.1	4.7	9.0	3.7		13.9	13.9	1.5	0
Mean	**11.1**	**10.1**	**3.4**	**8.4**	**4.2**	**76.0**	**10.1**	**11.6**	**4.4**	**8.5**	**3.3**	**76.1**	**12.9**	**12.9**	**1.8**	**0**

Table C67 – Weld Measurements for Specimen T23-1 (E70T-4(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.2	13.8	5.6	10.0	4.8	76.1	13.6	13.3	5.3	10.2	5.1	76.1	17.2	12.7	5.0	16
2	12.1	13.5	5.3	10.0	4.6	76.1	13.6	13.1	5.1	9.8	5.1	76.1	16.2	12.5	4.1	15
3	13.1	13.1	5.3	10.0	4.8	76.1	13.1	12.8	5.0	9.8	5.1	76.1	17.5	13.5	4.4	12
4	13.2	12.5	5.1	10.0	4.8	76.1	13.4	12.7	5.0	10.0	5.1	76.0	17.1	12.9	4.0	13
5	12.4	12.7	5.1	10.3	4.8	76.1	13.6	13.3	5.0	10.2	5.1	76.1	14.6	12.0	2.3	11
6	12.7	12.1	5.1	10.5	5.1		13.7	13.0	5.1	10.2	5.2		16.2	13.1	3.4	10
7	12.1	12.7	5.1	10.3	4.6		13.0	13.3	5.3	10.2	5.1		15.0	11.4	2.9	12
8	12.7	12.1	5.0	10.5	5.2		13.9	12.4	5.1	10.0	5.2		15.8	11.3	3.1	12
Mean	**12.6**	**12.8**	**5.2**	**10.2**	**4.8**	**76.1**	**13.5**	**13.0**	**5.1**	**10.0**	**5.1**	**76.1**	**16.2**	**12.4**	**3.6**	**12**

Table C68 – Weld Measurements for Specimen T23-2 (E70T-4(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.9	12.2	5.0	10.5	5.1	75.9	13.0	12.9	5.1	10.0	5.1	76.1	15.6	12.2	2.7	15
2	12.5	12.7	5.1	10.5	5.2	75.9	13.4	13.2	5.3	10.3	5.2	76.1	15.1	12.5	2.6	13
3	12.3	12.5	5.3	10.6	5.1	75.9	14.0	13.2	5.1	10.2	5.1	76.2	15.3	12.8	3.1	12
4	12.9	13.0	5.5	10.6	5.2	75.9	13.4	12.1	5.1	10.0	5.1	76.3	15.4	12.4	2.5	14
5	12.4	12.9	5.5	10.6	5.2	75.9	13.1	13.0	5.3	10.2	4.8	76.2	14.7	12.0	2.3	13
6	12.4	12.7	5.3	10.6	5.2		13.6	13.3	5.3	10.2	4.9		15.1	12.4	2.7	13
7	12.3	12.9	5.5	10.5	4.9		13.3	13.4	5.3	10.2	4.9		15.2	11.8	2.9	15
8	12.6	12.8	5.5	10.3	4.8		13.3	12.7	5.1	10.3	5.1		15.0	11.8	2.4	15
Mean	**12.5**	**12.7**	**5.3**	**10.5**	**5.1**	**75.9**	**13.4**	**13.0**	**5.2**	**10.2**	**5.0**	**76.2**	**15.2**	**12.2**	**2.6**	**14**

Table C69 – Weld Measurements for Specimen T23-3 (E70T-4(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.3	13.0	5.3	10.5	5.1	76.0	13.3	13.1	5.1	9.8	5.1	76.2	15.0	11.9	2.7	15
2	12.3	13.3	5.5	10.5	5.1	76.0	13.3	13.1	5.0	9.8	5.1	75.8	14.7	11.3	2.4	15
3	12.0	13.2	5.5	10.3	5.1	76.1	13.0	12.8	5.0	9.8	4.9	75.8	14.8	11.5	2.8	16
4	13.0	12.8	5.5	10.6	5.1	76.2	13.4	12.4	5.0	9.8	4.9	75.8	14.8	11.4	1.9	16
5	12.0	13.2	5.6	10.5	5.1	76.2	13.7	12.3	5.0	9.8	4.9	75.8	14.4	11.1	2.4	18
6	13.3	13.5	5.6	10.5	5.2		13.0	12.6	5.0	9.8	4.8		16.0	11.8	2.7	17
7	13.2	13.3	5.8	10.5	5.2		12.9	12.7	5.0	10.0	4.8		15.4	11.3	2.2	18
8	13.3	13.8	5.6	10.5	5.2		12.7	13.2	5.1	10.0	5.1		15.9	11.7	2.6	19
Mean	**12.7**	**13.3**	**5.5**	**10.5**	**5.1**	**76.1**	**13.2**	**12.8**	**5.0**	**9.9**	**4.9**	**75.9**	**15.1**	**11.5**	**2.4**	**17**

Table C70 – Weld Measurements for Specimen T24-1 (E70T-4(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.0	11.2	3.4	7.9	3.5	76.2	11.0	11.8	4.2	8.7	3.5	76.1	14.2	10.3	3.2	21
2	11.4	10.8	3.4	7.9	3.5	76.1	11.7	11.9	4.0	8.1	3.7	76.1	13.9	8.9	2.1	21
3	11.6	11.0	3.7	8.1	3.8	76.2	11.8	12.3	4.5	8.6	4.0	76.2	14.5	10.1	2.8	21
4	11.3	11.0	3.7	8.1	3.8	76.2	12.2	11.5	4.0	9.0	4.3	76.1	16.7	10.3	4.5	21
5	11.0	11.3	3.7	8.4	3.5	76.2	12.3	11.7	4.2	8.7	4.3	76.1	14.0	9.3	1.7	21
6	11.8	11.2	3.6	8.4	3.8		11.3	12.0	4.2	8.9	4.3		13.3	9.6	2.0	21
7	12.4	10.7	3.4	8.3	4.0		11.2	11.7	4.4	8.6	4.3		13.3	8.7	2.1	24
8	12.1	10.3	3.2	8.1	3.8		12.5	11.8	4.0	8.4	4.4		14.7	9.3	2.2	24
Mean	**11.6**	**10.9**	**3.5**	**8.2**	**3.7**	**76.2**	**11.7**	**11.8**	**4.2**	**8.6**	**4.1**	**76.1**	**14.3**	**9.6**	**2.6**	**22**

Table C71 – Weld Measurements for Specimen T24-2 (E70T-4(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.3	10.6	3.4	8.4	4.0	76.1	11.6	10.9	3.7	8.3	4.1	76.0	15.2	9.3	3.6	23
2	12.4	10.7	3.6	8.6	4.1	76.0	11.9	11.3	4.2	9.0	4.1	76.0	14.6	10.1	2.7	20
3	12.5	10.2	3.1	8.1	4.0	76.0	12.5	11.5	4.5	9.0	4.4	76.0	15.2	10.2	2.7	21
4	13.5	10.2	3.2	8.1	4.3	76.1	12.5	11.3	4.5	8.9	4.3	76.0	14.8	9.3	2.3	23
5	13.3	10.2	3.2	8.4	4.3	76.1	12.2	11.5	4.7	9.0	4.4	76.1	15.0	10.1	2.8	23
6	13.0	10.9	3.6	8.1	4.3		12.1	11.6	4.5	9.2	4.4		14.5	10.0	2.5	23
7	12.6	10.4	3.4	8.7	4.3		12.0	11.7	4.8	9.0	4.3		14.9	10.3	2.9	23
8	12.2	10.5	3.4	8.4	4.1		11.3	11.9	4.4	8.7	4.0		14.5	9.8	3.2	23
Mean	**12.7**	**10.5**	**3.4**	**8.4**	**4.2**	**76.1**	**12.0**	**11.4**	**4.4**	**8.9**	**4.3**	**76.0**	**14.8**	**9.9**	**2.8**	**22**

Table C72 – Weld Measurements for Specimen T24-3 (E70T-4(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.8	10.7	3.4	8.4	3.8	76.0	12.1	11.6	4.2	8.3	4.1	76.2	16.1	11.0	3.2	17
2	13.0	10.8	3.4	8.1	4.0	76.1	12.3	11.4	3.7	7.9	4.1	76.0	15.6	10.0	2.6	17
3	13.1	10.6	3.2	8.3	4.3	76.0	12.3	11.0	3.7	7.8	4.1	76.2	15.6	9.6	2.5	20
4	13.2	10.9	3.4	8.4	4.1	76.0	12.1	11.1	3.7	8.3	4.0	76.1	15.6	10.6	2.5	17
5	13.4	10.9	3.6	8.6	4.3	76.0	11.6	11.0	3.7	8.3	4.0	76.1	15.7	11.0	2.4	16
6	13.5	10.6	3.4	8.6	4.3		11.6	10.7	3.7	8.4	4.0		15.6	10.7	2.2	16
7	13.6	10.6	3.4	8.4	4.4		12.2	11.1	3.7	8.4	4.1		15.6	10.6	2.0	18
8	14.2	10.2	3.1	8.3	4.6		12.2	10.9	3.7	8.4	4.3		16.3	10.5	2.1	19
Mean	**13.4**	**10.7**	**3.4**	**8.4**	**4.2**	**76.0**	**12.0**	**11.1**	**3.8**	**8.2**	**4.1**	**76.1**	**15.8**	**10.5**	**2.4**	**17**

Table C73 – Weld Measurements for Specimen T25-1 (E70T-7(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.3	11.4	4.7	9.5	5.4	76.0	14.6	10.7	4.2	10.2	5.9	76.1				
2	13.7	11.5	4.7	9.5	5.4	76.0	14.9	10.8	4.2	10.2	5.9	76.1				
3	13.4	11.4	4.4	9.5	5.4	76.0	14.5	10.4	4.2	10.2	5.9	76.0	Reinforced Weld Failed			
4	13.4	11.2	4.4	9.5	5.6	76.1	14.5	10.6	4.2	10.0	5.9	76.0				
5	13.9	11.5	4.7	9.5	5.6	76.0	15.4	10.6	4.2	10.2	5.9	76.1				
6	14.6	11.6	4.7	9.5	5.9		15.1	10.7	4.4	10.3	6.0					
7	14.0	11.3	4.5	9.5	5.9		14.5	10.6	4.4	10.3	6.0					
8	14.1	11.1	4.7	9.5	5.9		14.7	10.9	4.8	10.5	6.0					
Mean	**13.8**	**11.4**	**4.6**	**9.5**	**5.6**	**76.0**	**14.8**	**10.7**	**4.3**	**10.2**	**5.9**	**76.1**				

Table C74 – Weld Measurements for Specimen T25-2 (E70T-7(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.4	11.4	4.4	9.4	4.9	76.0	12.9	11.1	4.4	9.4	4.9	76.1	15.9	15.9	3.5	0
2	12.5	11.5	4.4	9.2	4.9	76.0	12.2	11.2	4.5	9.4	4.9	76.1	15.6	15.6	3.1	0
3	12.8	11.6	4.4	9.0	4.9	76.1	12.2	11.1	4.7	9.4	4.9	76.1	15.7	15.7	2.8	0
4	12.8	11.7	4.4	9.0	4.9	76.0	12.4	11.9	4.8	9.5	4.9	76.2	15.4	15.4	2.6	0
5	12.4	11.9	4.5	8.7	4.6	76.0	12.8	11.5	4.7	9.5	5.1	76.1	15.4	15.4	3.0	0
6	12.2	11.9	4.7	9.0	4.6		12.7	11.3	4.7	9.5	4.9		14.8	14.8	2.6	0
7	11.8	12.3	4.8	9.2	4.8		12.6	11.8	4.8	9.4	4.8		15.0	15.0	3.2	0
8	11.5	12.1	4.8	9.2	4.8		11.9	11.7	4.8	9.4	4.8		14.5	14.5	2.9	0
Mean	**12.3**	**11.8**	**4.5**	**9.1**	**4.8**	**76.0**	**12.4**	**11.4**	**4.7**	**9.4**	**4.9**	**76.1**	**15.3**	**15.3**	**3.0**	**0**

Table C75 – Weld Measurements for Specimen T25-3 (E70T-7(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.5	11.5	4.8	9.5	5.1	75.9	11.9	11.3	4.5	9.8	4.4	76.0	14.5	14.5	2.6	0
2	13.8	11.8	4.8	9.5	5.2	75.9	12.1	11.3	4.4	9.5	4.4	76.1	14.2	14.2	2.2	0
3	13.9	11.5	4.5	9.5	5.2	76.0	12.9	10.9	4.4	9.5	5.1	76.0	15.0	15.0	2.1	0
4	13.6	11.2	4.4	9.5	5.2	75.9	13.8	11.1	4.4	9.5	5.4	76.0	15.9	15.9	2.1	0
5	14.0	11.3	4.7	9.7	5.2	76.0	14.1	10.4	4.2	9.5	5.4	76.0	16.3	10.4	2.2	24
6	13.2	11.6	5.0	9.8	5.2		13.8	10.6	4.2	9.5	5.6		16.1	10.6	2.3	22
7	13.5	12.2	5.3	9.8	5.4		13.8	11.0	4.2	9.5	5.4		16.3	10.4	2.5	23
8	14.1	12.3	5.1	10.0	5.2		14.1	10.8	4.0	9.4	5.4		16.6	10.7	2.5	23
Mean	**13.7**	**11.7**	**4.8**	**9.7**	**5.2**	**75.9**	**13.3**	**10.9**	**4.3**	**9.5**	**5.1**	**76.0**	**15.6**	**12.7**	**2.3**	**11**

Table C76 – Weld Measurements for Specimen T26-1 (E70T-7(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.2	11.7	4.4	9.8	4.6	76.0	13.7	10.8	4.2	9.0	4.9	76.2	16.5	10.9	2.8	24
2	12.9	11.5	4.5	9.5	4.9	76.0	13.7	10.7	3.7	8.7	4.8	76.2	15.7	9.5	2.0	27
3	12.2	11.9	4.8	9.4	4.8	76.0	13.1	10.7	3.6	9.0	4.6	77.0	14.4	9.3	1.3	25
4	13.1	11.7	4.8	9.5	5.1	76.0	13.2	10.4	3.6	9.2	4.6	76.0	15.1	10.0	1.8	22
5	12.6	11.4	5.0	9.4	5.1	76.0	12.0	10.5	3.4	9.0	4.4	76.1	14.3	9.9	2.3	21
6	11.7	11.9	5.0	9.7	4.9		13.1	10.6	3.7	9.0	4.8		15.3	10.1	2.1	22
7	12.2	11.6	4.8	9.4	4.9		13.4	10.7	3.6	9.0	5.1		15.4	10.0	2.0	23
8	12.4	11.4	4.7	9.4	4.8		13.4	10.2	3.7	8.6	5.4		14.9	8.9	1.6	30
Mean	**12.4**	**11.6**	**4.8**	**9.5**	**4.9**	**76.0**	**13.2**	**10.6**	**3.7**	**9.0**	**4.8**	**76.3**	**15.2**	**9.8**	**2.0**	**24**

Table C77 – Weld Measurements for Specimen T26-2 (E70T-7(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.5	11.6	4.8	9.5	4.8	75.9	12.6	11.3	4.5	9.4	5.1	76.2	15.1	11.7	3.6	23
2	12.9	11.9	4.8	9.4	4.9	75.9	13.0	11.2	4.5	9.2	5.1	76.1	16.7	11.7	3.8	23
3	13.0	12.0	5.0	9.4	5.1	75.9	12.4	10.9	4.2	9.0	4.9	76.1	16.8	11.4	3.8	23
4	11.2	11.5	4.8	9.5	4.8	76.0	11.7	11.0	4.0	9.0	4.3	76.2	14.7	11.6	3.5	23
5	12.7	12.2	5.0	9.7	5.1	75.9	13.0	10.8	4.2	9.2	4.8	76.2	15.4	11.1	2.8	23
6	13.5	12.2	5.0	9.5	5.2		12.4	11.3	4.5	9.4	4.6		17.3	11.7	3.8	22
7	12.3	11.9	4.8	9.7	5.1		12.9	11.5	4.5	9.4	4.8		14.9	11.3	2.6	23
8	12.3	11.7	4.8	9.5	4.9		13.6	11.7	4.5	9.2	5.1		15.1	11.3	2.9	21
Mean	**12.4**	**11.9**	**4.9**	**9.5**	**5.0**	**75.9**	**12.7**	**11.2**	**4.4**	**9.2**	**4.8**	**76.1**	**15.8**	**11.4**	**3.3**	**23**

Table C78 – Weld Measurements for Specimen T26-3 (E70T-7(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.2	11.5	4.2	9.4	4.6	76.2	12.1	12.3	5.0	9.2	4.8	76.2	14.9	10.2	2.7	24
2	12.7	11.6	4.2	9.2	4.6	76.1	13.1	11.7	4.5	9.2	4.9	76.2	15.1	10.6	2.4	20
3	12.6	11.5	4.2	9.0	4.9	76.2	13.3	11.3	4.4	9.2	4.8	76.2	14.8	10.0	2.2	24
4	13.7	11.6	4.8	9.5	5.2	76.1	13.0	11.3	4.4	9.5	5.1	76.3	16.8	11.9	3.1	22
5	13.0	11.9	4.5	9.4	5.1	76.2	13.2	11.3	4.4	9.5	5.1	76.2	15.3	9.9	2.3	24
6	13.1	11.7	4.5	9.2	5.1		13.6	11.7	4.4	9.7	5.1		14.5	9.8	1.3	23
7	12.8	11.7	4.8	9.2	5.2		12.9	11.4	4.2	9.2	4.9		14.5	9.8	1.7	25
8	13.8	11.9	5.1	9.5	5.7		13.0	11.5	4.2	9.0	5.2		16.4	10.6	2.6	26
Mean	**13.0**	**11.7**	**4.6**	**9.3**	**5.1**	**76.2**	**13.0**	**11.6**	**4.4**	**9.3**	**5.0**	**76.2**	**15.3**	**10.3**	**2.3**	**24**

Table C79 – Weld Measurements for Specimen T27-1 (E70T-7(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.4	11.1	2.8	7.6	3.5	76.2	11.8	12.3	4.0	8.4	4.0	76.0	16.1	8.9	3.7	34
2	12.8	11.1	2.9	7.6	3.7	76.3	12.1	12.0	4.0	8.4	4.1	76.1	16.6	9.2	3.8	34
3	13.2	10.9	3.2	7.9	3.7	76.2	11.3	11.8	4.0	8.4	3.8	76.1	16.1	8.5	2.9	35
4	13.4	11.4	3.2	7.9	3.8	76.2	11.4	11.9	4.0	8.4	3.8	76.1	17.4	9.1	4.0	28
5	12.9	11.5	3.2	8.1	3.7	76.3	11.1	12.2	4.0	8.4	3.7	76.1	16.3	9.2	3.4	24
6	12.6	11.7	3.6	8.1	3.7		11.3	12.3	4.0	8.4	3.8		16.4	9.2	3.8	20
7	12.9	11.8	3.6	8.3	3.5		11.9	11.9	4.0	8.3	4.0		16.9	11.1	4.0	6
8	12.4	11.9	3.6	8.3	3.7		11.8	12.0	4.0	8.4	4.3		15.1	10.1	2.7	17
Mean	**12.8**	**11.4**	**3.3**	**8.0**	**3.6**	**76.3**	**11.6**	**12.1**	**4.0**	**8.4**	**3.9**	**76.1**	**16.4**	**9.4**	**3.5**	**25**

Table C80 – Weld Measurements for Specimen T27-2 (E70T-7(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.8	11.9	3.4	8.4	3.8	76.3	11.6	12.3	3.7	8.1	3.7	76.2	13.7	9.4	2.1	15
2	12.7	12.0	3.6	8.4	3.8	76.3	12.0	12.2	3.7	8.1	3.7	76.3	13.5	9.6	1.5	12
3	12.8	11.8	3.7	8.4	4.0	76.3	12.0	11.9	3.7	8.3	3.7	76.2	13.3	10.2	1.3	9
4	12.2	12.2	3.7	8.4	3.8	76.3	11.3	11.9	3.7	8.3	3.5	76.2	12.4	9.0	1.1	13
5	11.9	11.6	3.7	8.3	3.8	76.3	11.4	11.9	3.7	8.4	3.7	76.3	13.4	9.8	2.0	11
6	12.5	11.8	3.7	8.3	3.8		11.5	12.2	3.9	8.6	3.7		12.7	9.2	1.2	14
7	12.5	11.7	3.7	8.1	3.7		11.8	12.0	3.7	8.4	3.5		13.0	8.5	1.3	16
8	12.6	11.6	3.7	8.1	3.7		12.3	11.9	3.7	8.3	3.7		14.0	9.2	1.7	18
Mean	**12.5**	**11.8**	**3.7**	**8.3**	**3.8**	**76.3**	**11.8**	**12.0**	**3.7**	**8.3**	**3.6**	**76.2**	**13.2**	**9.3**	**1.5**	**13**

Table C81 – Weld Measurements for Specimen T27-3 (E70T-7(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.0	12.0	3.9	8.3	3.7	76.0	12.1	12.2	3.6	8.7	3.5	76.2	13.8	10.1	1.7	13
2	12.4	12.1	3.9	8.3	3.8	76.1	11.5	11.5	3.4	8.4	3.5	76.1	13.1	10.4	1.6	11
3	12.1	12.9	3.9	8.4	3.7	76.1	11.4	11.6	3.6	8.3	3.2	76.1	12.7	9.9	1.3	11
4	12.4	12.3	3.9	8.4	3.8	76.1	11.5	11.4	3.4	8.3	3.2	76.2	13.3	10.8	1.8	11
5	12.3	12.1	4.0	8.6	3.8	76.0	11.3	11.5	3.4	8.3	3.3	76.2	13.8	10.5	2.5	13
6	11.9	11.2	3.6	8.3	4.0		11.7	11.6	3.4	8.3	3.5		12.7	8.6	1.0	16
7	12.0	12.5	4.0	8.4	3.7		11.6	12.3	3.7	8.3	3.5		12.9	8.9	1.3	13
8	12.3	11.5	3.9	8.6	3.8		12.1	12.3	3.7	8.6	3.5		13.5	9.6	1.4	15
Mean	**12.2**	**12.1**	**3.9**	**8.4**	**3.8**	**76.1**	**11.6**	**11.8**	**3.5**	**8.4**	**3.4**	**76.2**	**13.2**	**9.9**	**1.6**	**13**

Table C82 – Weld Measurements for Specimen T28-1 (E70T-7(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.2	11.2	3.7	9.0	4.4	76.1	12.5	10.4	3.6	7.9	4.0	76.2	15.7	11.2	2.5	18
2	13.2	10.6	3.6	8.9	4.8	76.0	12.1	10.7	3.7	7.8	4.0	76.2	15.0	10.2	1.8	20
3	13.6	10.0	3.4	8.7	4.8	76.1	12.8	11.0	3.7	8.3	4.1	76.2	15.8	10.6	2.2	20
4	13.8	10.2	3.4	8.6	4.8	76.1	12.8	10.4	3.4	8.3	4.1	76.2	15.7	10.0	1.8	20
5	14.1	10.1	3.4	9.0	4.8	76.1	13.2	10.4	3.4	8.6	4.3	76.2	16.3	9.9	2.2	20
6	14.4	10.9	3.7	9.0	5.1		12.4	10.7	3.7	8.7	4.3		16.2	9.8	1.7	20
7	13.7	11.1	3.7	9.0	4.8		12.6	10.7	3.7	8.6	4.3		16.2	10.4	2.6	17
8	14.0	10.7	3.7	8.6	4.8		12.0	11.0	3.7	8.6	4.3		16.6	10.2	2.6	17
Mean	**13.8**	**10.6**	**3.6**	**8.9**	**4.8**	**76.1**	**12.5**	**10.7**	**3.6**	**8.3**	**4.2**	**76.2**	**15.9**	**10.3**	**2.2**	**19**

Table C83 – Weld Measurements for Specimen T28-2 (E70T-7(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.5	10.4	3.7	8.7	5.1	76.2	12.5	11.1	4.0	8.7	4.0	76.1	15.1	15.1	2.6	0
2	13.9	10.3	3.7	8.7	4.9	76.2	12.4	11.2	4.0	8.4	4.1	76.1	15.2	15.2	2.8	0
3	13.4	10.6	3.7	9.0	4.8	76.2	12.2	11.1	3.9	8.3	4.1	76.1	14.4	14.4	2.3	0
4	13.1	10.6	3.7	9.2	4.9	76.2	12.1	10.8	3.6	8.1	4.0	76.1	15.0	15.0	2.9	0
5	13.4	10.6	3.9	9.2	5.1	76.2	12.5	10.2	3.4	7.8	4.0	76.1	14.8	14.8	2.3	0
6	13.2	11.0	4.4	9.2	5.4		12.3	10.2	3.4	8.3	4.3		14.8	14.8	2.5	0
7	12.8	10.9	4.4	9.5	5.1		12.1	11.0	3.6	8.6	4.0		14.7	14.7	2.6	0
8	12.8	11.1	4.4	9.2	4.9		11.9	10.8	3.6	8.4	4.3		15.0	15.0	3.1	0
Mean	**13.3**	**10.7**	**4.0**	**9.1**	**5.0**	**76.2**	**12.2**	**10.8**	**3.7**	**8.3**	**4.1**	**76.1**	**14.9**	**14.9**	**2.6**	**0**

Table C84 – Weld Measurements for Specimen T28-3 (E70T-7(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.1	11.2	4.4	9.0	4.9	76.1	12.5	10.7	3.4	8.3	4.1	76.0	16.2	16.2	3.7	0
2	13.1	11.1	4.2	8.6	5.2	76.1	13.7	10.9	3.7	8.6	4.3	76.0	17.0	17.0	3.3	0
3	13.2	11.1	4.0	9.0	4.9	76.1	13.1	11.2	3.9	8.7	4.0	76.0	16.0	16.0	2.9	0
4	13.1	11.2	4.0	9.0	4.8	76.1	12.9	11.3	3.9	8.6	4.0	76.0	16.6	16.6	3.7	0
5	13.1	11.3	4.0	9.2	4.9	76.1	12.3	10.9	3.7	8.4	4.1	76.1	15.1	15.1	2.7	0
6	13.1	11.2	4.2	9.2	4.8		12.8	10.8	3.4	8.3	4.1		15.2	15.2	2.4	0
7	12.8	11.3	4.0	9.5	4.6		12.8	10.8	3.6	8.3	4.1		15.8	15.8	3.0	0
8	12.7	11.5	4.0	8.6	4.8		13.1	11.1	4.0	8.4	4.4		15.9	15.9	2.9	0
Mean	**13.0**	**11.2**	**4.1**	**9.0**	**4.9**	**76.1**	**12.9**	**10.9**	**3.7**	**8.4**	**4.1**	**76.0**	**16.0**	**16.0**	**3.1**	**0**

Table C85 – Weld Measurements for Specimen T29-1 (E70T7-K2(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.3	12.1	5.0	10.0	4.3	76.2	15.5	12.1	4.5	9.2	5.6	76.1				
2	11.3	12.7	5.1	10.0	4.8	76.1	16.2	12.2	4.8	9.4	5.7	76.1				
3	12.5	12.3	5.0	10.2	5.2	76.1	16.4	12.7	5.0	9.5	5.9	76.1		Main Plate Failed		
4	13.3	11.2	5.0	10.5	5.2	76.2	16.9	12.8	4.8	9.5	6.0	76.0				
5	13.2	11.5	5.3	10.6	5.2	76.1	16.3	12.8	5.0	9.4	5.7	76.1				
6	13.7	12.4	5.3	10.2	5.2		16.0	13.1	5.0	9.2	5.7					
7	13.4	12.2	5.3	10.0	5.1		16.3	12.6	4.5	9.0	5.7					
8	13.0	12.0	5.6	10.3	5.1		16.5	12.8	5.0	8.9	5.7					
Mean	**12.7**	**12.0**	**5.2**	**10.2**	**5.0**	**76.1**	**16.3**	**12.6**	**4.8**	**9.3**	**5.8**	**76.1**				

Table C86 – Weld Measurements for Specimen T29-2 (E70T7-K2(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.2	13.0	5.5	10.3	5.2	76.0	17.1	12.2	4.7	9.4	5.7	76.2				
2	13.6	12.8	5.5	10.5	5.1	76.0	17.2	12.3	4.8	9.4	5.7	76.2				
3	13.9	12.5	5.6	10.5	5.2	76.1	17.3	12.3	4.5	9.4	5.9	76.1		Main Plate Failed		
4	13.3	13.0	5.3	10.3	5.1	76.0	17.2	12.2	4.5	9.4	5.7	76.1				
5	13.0	12.6	5.3	10.2	5.1	76.0	16.3	12.2	4.5	9.4	5.7	76.1				
6	13.2	12.6	5.3	10.0	4.9		16.4	12.3	4.5	9.2	5.6					
7	13.4	12.7	5.8	10.3	5.1		16.3	12.0	4.5	9.2	5.6					
8	13.6	13.5	5.8	10.6	5.2		16.4	12.3	4.7	9.2	5.6					
Mean	**13.4**	**12.8**	**5.5**	**10.3**	**5.1**	**76.0**	**16.8**	**12.2**	**4.6**	**9.3**	**5.7**	**76.1**				

Table C87 – Weld Measurements for Specimen T29-3 (E70T7-K2(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	16.0	10.8	4.0	9.4	6.0	76.0	13.1	13.6	6.3	11.0	5.2	76.1				
2	15.2	11.2	4.0	9.4	5.7	76.0	13.1	14.5	6.1	10.8	5.4	76.0				
3	15.9	12.1	5.0	9.8	5.9	76.0	13.4	13.7	5.9	10.5	5.4	76.1		Main Plate Failed		
4	15.7	12.5	5.0	9.8	5.7	76.0	13.2	12.9	5.8	10.5	5.2	76.0				
5	16.0	12.3	5.0	9.8	5.9	76.0	13.4	13.1	6.1	10.8	5.4	76.0				
6	16.5	12.3	5.1	9.8	5.6		13.5	13.5	6.3	11.0	5.6					
7	16.4	12.4	5.0	9.7	5.9		13.5	13.9	6.1	10.6	5.6					
8	16.6	12.3	5.1	9.7	6.0		14.1	14.2	5.8	10.3	5.6					
Mean	**16.0**	**12.0**	**4.8**	**9.7**	**5.8**	**76.0**	**13.4**	**13.7**	**6.0**	**10.7**	**5.4**	**76.0**				

Table C88 – Weld Measurements for Specimen T30-1 (E70T7-K2(L)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	13.2	11.9	4.0	9.4	4.6	76.2	12.6	9.6	2.9	8.4	4.8	76.2				
2	12.9	11.4	3.6	8.3	4.4	76.2	12.9	10.5	2.9	8.4	4.6	76.2				
3	13.3	10.6	3.2	8.6	4.4	76.2	13.0	9.9	3.2	8.6	4.6	76.2		Main Plate Failed		
4	13.3	10.5	3.4	8.9	4.4	76.2	12.7	10.6	3.7	8.7	4.4	76.2				
5	13.3	10.7	4.0	8.9	4.6	76.2	12.7	10.7	3.7	8.7	4.6	76.3				
6	11.6	11.6	4.2	9.4	4.3		14.2	10.8	3.7	8.3	5.1					
7	11.4	11.7	4.0	8.9	4.3		13.4	10.3	3.4	8.4	4.9					
8	12.5	11.0	3.7	8.1	4.4		13.2	10.2	3.2	8.1	4.6					
Mean	**12.7**	**11.2**	**3.8**	**8.8**	**4.4**	**76.2**	**13.1**	**10.3**	**3.4**	**8.5**	**4.7**	**76.2**				

Table C89 – Weld Measurements for Specimen T30-2 (E70T7-K2(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.8	11.6	4.0	8.9	4.8	76.1	14.1	9.1	2.4	8.1	4.6	76.0	16.4	10.8	2.3	64-45
2	12.9	9.9	3.4	9.2	4.8	76.1	14.1	9.9	2.9	7.9	4.4	76.0	15.9	8.7	1.8	19
3	11.7	10.4	3.4	8.9	4.6	76.1	14.7	9.7	2.9	8.3	4.4	76.0	16.2	9.8	1.6	19
4	12.8	10.3	3.4	8.6	4.6	76.1	13.7	9.4	2.9	8.7	4.8	76.1	16.2	10.6	2.5	19
5	13.1	11.0	3.7	9.0	4.9	76.1	13.1	9.5	2.6	8.9	4.6	76.0	15.4	10.4	2.2	19
6	13.4	10.3	3.1	8.4	4.9		12.6	9.6	3.2	8.4	4.3		15.0	9.5	2.4	19
7	12.4	9.6	2.8	8.4	4.8		13.1	10.1	3.4	8.9	4.4		16.0	10.4	2.9	19
8	11.9	9.8	2.9	8.7	4.4		14.0	9.8	3.2	9.0	4.4		17.2	11.5	3.2	18
Mean	**12.6**	**10.3**	**3.3**	**8.8**	**4.7**	**76.1**	**13.7**	**9.6**	**3.0**	**8.5**	**4.5**	**76.0**	**16.0**	**10.2**	**2.4**	**19**

Table C90 – Weld Measurements for Specimen T30-3 (E70T7-K2(L)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.2	9.7	2.9	8.4	4.8	76.0	12.7	10.6	3.7	8.6	4.4	76.0	15.1	10.1	2.9	21
2	12.4	10.0	3.4	8.4	5.1	76.0	12.4	10.5	3.4	8.4	4.4	76.0	14.7	9.2	2.2	21
3	11.7	10.5	3.6	8.3	4.6	76.0	13.1	10.6	3.6	8.3	4.6	76.0	13.7	8.9	2.0	21
4	10.9	10.9	3.9	8.1	4.1	76.1	13.6	10.3	3.4	8.4	4.6	76.0	14.1	9.4	3.1	21
5	12.5	11.4	3.7	8.3	4.4	76.1	13.0	10.2	2.9	7.9	4.6	76.0	15.6	10.3	3.1	21
6	12.0	10.5	3.2	7.9	4.4		13.0	9.8	2.9	8.3	4.9		14.9	9.9	2.9	21
7	13.1	10.2	2.9	7.9	4.8		13.8	9.8	2.9	8.4	5.1		14.4	10.0	1.3	21
8	13.8	9.8	3.2	8.4	5.1		13.9	10.3	3.2	8.3	4.9		15.4	9.8	1.6	24
Mean	**12.3**	**10.4**	**3.4**	**8.2**	**4.7**	**76.0**	**13.2**	**10.3**	**3.3**	**8.3**	**4.7**	**76.0**	**14.7**	**9.7**	**2.4**	**21**

Table C91 – Weld Measurements for Specimen T31-1 (E71T8-K6(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.2	10.8	3.7	7.8	4.0	76.1	10.4	11.8	5.0	9.8	4.3	76.2	14.4	14.4	4.0	0
2	11.3	10.7	3.9	9.0	3.8	76.1	10.1	12.8	5.0	9.5	4.1	76.2	14.5	14.5	4.4	0
3	11.4	10.7	3.7	8.7	4.3	76.1	10.5	12.0	4.8	9.4	4.0	76.3	14.1	14.1	3.7	0
4	12.4	10.1	3.7	8.9	4.3	76.1	10.4	12.5	4.8	9.5	4.6	76.3	15.3	15.3	5.0	0
5	11.8	10.4	3.7	8.6	4.3	76.1	10.1	12.2	4.7	9.0	4.3	76.2	13.8	13.8	3.8	0
6	11.5	10.3	4.0	8.7	4.3		9.8	12.6	4.8	9.5	4.0		14.5	14.5	4.7	0
7	11.1	11.1	4.2	9.0	4.3		11.1	12.4	5.0	9.5	4.4		15.1	15.1	4.0	0
8	11.2	11.7	4.4	9.0	4.3		12.0	12.6	5.0	9.2	4.8		15.3	15.3	11.9	14
Mean	**11.5**	**10.7**	**3.9**	**8.7**	**4.2**	**76.1**	**10.5**	**12.4**	**4.9**	**9.4**	**4.3**	**76.2**	**14.6**	**14.6**	**5.2**	**2**

Table C92 – Weld Measurements for Specimen T31-2 (E71T8-K6(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.4	12.0	4.4	8.9	4.4	76.2	10.7	12.1	4.8	9.2	4.0	76.1	14.7	14.7	4.0	0
2	11.4	11.4	4.2	9.0	4.4	76.2	10.8	11.8	4.7	9.5	4.1	76.1	15.0	15.0	4.2	0
3	11.2	11.9	4.2	8.6	4.1	76.2	10.8	11.9	4.5	8.7	4.1	76.1	14.5	14.5	3.6	0
4	11.2	11.8	4.2	8.4	4.1	76.2	10.8	12.3	4.5	9.2	4.3	76.2	14.6	14.6	3.8	0
5	11.3	11.9	4.2	9.0	4.4	76.2	10.6	12.5	5.0	9.2	4.3	76.2	14.1	14.1	3.5	0
6	11.9	12.1	4.4	8.7	4.6		11.1	12.2	5.0	9.8	4.6		14.5	14.5	3.4	0
7	11.4	11.7	4.5	8.9	4.4		10.2	11.6	4.8	9.5	4.0		13.5	13.5	3.3	0
8	11.4	11.6	4.5	9.0	4.1		10.6	12.4	5.0	9.5	4.0		13.8	13.8	3.2	0
Mean	**11.4**	**11.8**	**4.3**	**8.8**	**4.3**	**76.2**	**10.7**	**12.1**	**4.8**	**9.3**	**4.2**	**76.2**	**14.3**	**14.3**	**3.6**	**0**

Table C93 – Weld Measurements for Specimen T31-3 (E71T8-K6(H)W–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	11.1	11.7	4.2	9.2	4.0	76.1	10.2	11.5	4.2	9.4	4.0	76.1	14.2	14.2	3.9	0
2	11.0	12.2	4.5	9.2	4.0	76.1	10.6	11.4	4.2	9.2	4.1	76.1	14.3	14.3	3.7	0
3	11.5	12.5	5.0	9.2	4.6	76.1	10.6	11.2	4.2	9.0	4.0	76.1	14.5	14.5	3.8	0
4	11.9	12.2	5.0	9.5	4.6	76.1	9.1	11.4	4.7	9.4	3.0	76.1	13.2	13.2	4.1	0
5	11.3	12.2	5.0	9.4	4.6	76.1	10.7	10.9	4.5	9.4	4.4	76.2	14.3	14.3	3.6	0
6	11.2	12.7	5.0	9.8	4.4		10.8	11.6	4.5	9.4	4.1		14.2	14.2	3.4	0
7	11.2	12.8	5.0	9.5	4.3		10.3	11.8	4.5	9.2	4.0		14.4	14.4	4.1	19
8	11.8	12.5	5.0	9.5	4.3		10.1	11.6	4.7	9.7	4.0		14.4	11.5	4.3	16
Mean	**11.4**	**12.4**	**4.8**	**9.4**	**4.3**	**76.1**	**10.3**	**11.4**	**4.4**	**9.3**	**3.9**	**76.1**	**14.2**	**13.8**	**3.9**	**4**

Table C94 – Weld Measurements for Specimen T32-1 (E71T8-K6(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.5	11.3	4.0	9.0	4.4	76.0	12.6	12.7	4.5	8.6	4.6	76.2	15.9	10.2	3.4	25
2	12.5	11.0	4.0	9.0	4.3	76.0	12.9	12.7	4.7	8.6	4.6	76.2	16.3	10.2	3.4	25
3	12.7	11.4	4.2	8.9	4.4	76.0	12.8	12.4	4.7	8.9	4.6	76.2	16.5	10.7	3.6	25
4	12.0	11.7	4.2	8.7	4.0	76.0	12.0	12.6	5.0	9.2	4.3	76.2	15.4	11.3	3.4	25
5	12.3	11.4	4.0	7.9	4.3	76.0	11.5	12.3	4.8	9.4	4.3	76.2	13.8	10.6	2.3	25
6	12.2	11.7	4.0	8.7	4.6		12.4	13.2	5.3	9.0	4.3		15.8	11.5	3.5	25
7	12.3	10.1	3.9	9.0	4.3		12.0	13.1	4.7	8.7	4.4		16.3	10.2	4.3	23
8	11.6	11.2	4.0	8.7	4.4		11.5	12.4	4.4	8.7	4.4		15.4	10.3	3.9	25
Mean	**12.3**	**11.2**	**4.1**	**8.8**	**4.3**	**76.0**	**12.2**	**12.7**	**4.8**	**8.9**	**4.4**	**76.2**	**15.7**	**10.6**	**3.5**	**25**

Table C95 – Weld Measurements for Specimen T32-2 (E71T8-K6(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	12.1	11.8	4.0	8.9	4.6	76.0	12.1	12.6	4.5	9.4	4.8	76.1	15.0	10.7	2.9	21
2	11.1	11.6	4.4	9.0	4.6	76.1	11.8	11.9	4.5	9.4	4.4	76.1	14.6	10.5	2.8	21
3	12.1	11.5	4.0	9.0	4.8	76.1	12.7	12.2	4.5	9.2	4.8	76.1	15.9	10.7	3.2	21
4	11.4	10.4	4.2	9.4	4.6	76.1	11.7	13.6	4.7	8.9	4.6	76.1	15.1	10.5	3.4	22
5	10.8	12.4	4.7	9.4	4.6	76.1	13.0	12.7	5.0	9.2	4.8	76.1	16.3	10.5	3.3	22
6	11.1	11.8	4.8	9.7	4.6		11.7	12.3	5.0	9.2	4.8		15.1	10.2	3.4	23
7	11.1	11.7	4.7	8.7	4.6		11.8	12.7	4.8	8.6	4.9		15.3	9.8	3.5	26
8	11.3	12.3	4.7	8.6	4.4		11.7	13.2	4.8	8.4	4.6		15.0	8.7	3.3	31
Mean	**11.4**	**11.7**	**4.4**	**9.1**	**4.6**	**76.1**	**12.1**	**12.7**	**4.7**	**9.0**	**4.7**	**76.1**	**15.3**	**10.2**	**3.2**	**23**

Table C96 – Weld Measurements for Specimen T32-3 (E71T8-K6(H)S–1/2")

Meas. Number	Before Failure												After Failure			
	Front Face						Back Face						Failure Face			
	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Measurements Upper (mm)	Throat (mm)	Lower (mm)	Weld Length (mm)	Shear Leg After Fracture (mm)	Fracture Surface (mm)	Weld Root Penetration (mm)	Fracture Angle (°)
1	10.8	12.7	5.3	10.5	4.4	76.0	11.6	11.6	3.9	8.7	4.1	76.1	14.8	11.6	4.0	12
2	11.6	13.9	5.3	9.0	4.6	76.0	12.7	11.4	3.9	8.4	4.4	76.1	15.7	11.9	4.1	14
3	10.6	12.1	5.1	9.0	4.0	76.0	12.6	11.1	3.9	8.6	4.6	76.0	14.3	10.2	3.7	17
4	10.0	13.7	4.8	7.9	3.8	76.0	12.6	11.1	4.2	8.7	4.6	76.1	13.0	9.6	3.0	16
5	9.9	12.6	4.8	8.4	4.0	76.0	12.4	11.6	4.7	9.5	4.9	76.1	13.7	13.7	3.8	0
6	10.4	12.2	4.8	8.4	4.3		12.3	12.0	4.8	9.5	4.8		13.8	13.7	3.4	0
7	10.1	12.8	4.8	7.9	3.8		11.4	12.8	4.8	9.4	4.6		13.2	12.2	3.1	0
8	10.3	13.0	4.8	8.6	4.1		11.8	12.4	4.8	9.2	4.8		13.2	9.3	2.9	20
Mean	**10.5**	**12.9**	**5.0**	**8.7**	**4.1**	**76.0**	**12.2**	**11.8**	**4.4**	**9.0**	**4.6**	**76.1**	**13.9**	**11.5**	**3.5**	**10**

Table C97 – Weld Measurements for Specimen C1-1 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure	
	Front Face				Back Face				Failure Face	
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Fracture Surface (mm)	Fracture Angle (°)
1	6.9	5.3	3.7	75.6	7.8	5.9	4.9	75.5	7.9	0
2	7.3	5.0	3.7	75.6	7.8	5.5	4.9	75.5	8.1	0
3	6.7	4.8	3.7	75.5	8.3	6.2	5.1	75.6	7.4	0
4	7.3	5.4	3.7	75.5	8.0	6.4	4.8	75.5	7.9	0
5	7.5	5.3	4.0	75.6	7.6	6.0	4.8	75.6	7.6	0
6	7.1	5.5	3.8		7.5	6.2	4.8		7.5	0
7	7.7	4.9	3.7		8.0	6.3	4.9		6.7	32
8	6.8	4.9	3.7		7.4	6.6	4.8		7.6	90
Mean	**7.2**	**5.1**	**5.5**	**75.5**	**7.8**	**6.1**	**5.6**	**75.5**	**7.6**	**15**

Table C98 – Weld Measurements for Specimen C1-2 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure	
	Front Face				Back Face				Failure Face	
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Fracture Surface (mm)	Fracture Angle (°)
1	7.1	5.2	4.3	76.1	7.3	6.4	5.7	76.1	7.6	0
2	7.9	5.2	4.6	76.1	7.8	6.5	5.7	76.1	8.2	0
3	7.4	5.5	4.6	76.1	7.5	6.5	5.7	76.1	7.9	0
4	7.2	5.0	4.4	76.1	7.9	6.6	5.9	76.1	7.7	0
5	7.5	5.6	4.6	76.1	7.9	6.9	5.9	76.2	7.9	0
6	6.8	4.8	4.3		8.1	6.3	5.6		7.1	0
7	7.2	5.8	4.6		7.8	6.5	5.1		8.0	0
8	7.2	4.3	4.1		7.7	5.7	4.9		7.6	0
Mean	**7.3**	**5.1**	**5.5**	**76.1**	**7.7**	**6.4**	**5.6**	**76.1**	**7.8**	**0**

Table C99 – Weld Measurements for Specimen C1-3 (E70T-4(H)W–1/4")

Meas. Number	Before Failure								After Failure	
	Front Face				Back Face				Failure Face	
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Fracture Surface (mm)	Fracture Angle (°)
1	7.4	5.7	4.6	75.0	8.6	7.4	6.0	75.2	7.9	0
2	7.0	5.2	4.6	74.9	7.4	6.1	5.2	75.1	7.3	0
3	6.7	5.8	4.6	75.0	8.1	5.6	5.4	75.1	7.3	0
4	7.2	5.6	4.4	74.9	8.2	6.4	5.7	75.0	7.2	0
5	6.1	5.3	4.4	75.1	7.7	5.9	5.6	75.0	6.4	0
6	6.6	5.5	4.6		7.3	6.8	5.4		6.6	0
7	6.0	5.5	4.4		7.0	6.3	5.6		6.3	0
8	6.3	5.5	4.1		7.7	6.4	5.6		6.3	0
Mean	**6.7**	**5.5**	**5.5**	**75.0**	**7.7**	**6.4**	**5.6**	**75.1**	**6.9**	**0**

Table C100 – Weld Measurements for Specimen C2-1 (E70T7-K2(L)W–1/4")

Meas. Number	Before Failure								After Failure	
	Front Face				Back Face				Failure Face	
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Fracture Surface (mm)	Fracture Angle (°)
1	5.6	5.9	5.2	75.8	7.8	6.2	5.9	75.8	5.9	0
2	5.6	6.2	5.6	75.9	7.7	6.6	5.4	75.9	5.6	0
3	5.9	6.5	5.6	75.8	7.5	6.3	5.4	75.8	6.2	0
4	5.4	6.6	5.4	75.8	8.2	6.6	5.4	75.8	5.7	0
5	6.1	6.7	5.4	75.8	7.4	6.4	5.2	75.8	6.4	0
6	5.5	6.2	5.4		7.2	6.8	5.9		5.8	0
7	5.6	6.9	5.6		6.9	6.5	5.4		5.6	0
8	6.4	6.8	5.6		6.5	6.6	5.9		6.4	0
Mean	**5.8**	**6.5**	**5.5**	**75.8**	**7.4**	**6.5**	**5.6**	**75.8**	**6.0**	**0**

Table C101 – Weld Measurements for Specimen C2-2 (E70T7-K2(L)W–1/4")

Meas. Number	Before Failure								After Failure	
	Front Face				Back Face				Failure Face	
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Fracture Surface (mm)	Fracture Angle (°)
1	8.0	5.3	5.9	75.9	6.3	6.6	5.2	75.8	6.1	0
2	7.6	5.7	5.9	75.9	5.9	6.9	5.4	75.8	5.5	0
3	8.0	5.4	6.0	75.9	5.3	6.8	5.2	75.8	5.0	0
4	7.2	5.9	6.0	75.9	5.8	7.0	5.2	75.8	5.5	0
5	7.5	5.6	6.0	76.0	6.2	7.0	5.2	75.8	5.9	0
6	7.7	6.2	5.9		5.3	7.2	5.4		5.0	0
7	7.9	5.9	6.0		6.3	7.5	5.4		6.0	0
8	7.9	5.9	6.2		6.3	7.1	5.2		6.3	0
Mean	**7.7**	**5.7**	**5.5**	**75.9**	**5.9**	**7.0**	**5.6**	**75.8**	**5.7**	**0**

Table C102 – Weld Measurements for Specimen C2-3 (E70T7-K2(L)W–1/4")

Meas. Number	Before Failure								After Failure	
	Front Face				Back Face				Failure Face	
	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Shear Leg (mm)	Tension Leg (mm)	45° Meas. (mm)	Weld Length (mm)	Fracture Surface (mm)	Fracture Angle (°)
1	7.3	6.0	4.9	76.2	5.9	7.4	5.7	76.2	6.1	0
2	7.3	5.0	5.1	76.2	6.0	7.4	5.9	76.2	6.3	0
3	7.3	5.7	5.4	76.2	5.5	7.6	5.6	76.2	5.7	0
4	7.4	5.8	5.6	76.2	5.4	7.8	5.7	76.3	5.6	0
5	7.3	6.1	5.2	76.2	6.0	7.6	5.7	76.3	6.0	0
6	7.1	5.7	5.4		5.5	7.5	5.9		6.0	0
7	7.3	5.3	5.2		6.0	7.5	6.5		6.5	0
8	7.1	5.4	5.2		6.2	8.7	6.8		5.8	0
Mean	**7.3**	**5.6**	**5.5**	**76.2**	**5.8**	**7.7**	**5.6**	**76.2**	**6.0**	**0**

Table C103 – Gauge Lengths For Strain Measurements

Specimen Designation	Identifier	LVDT 1 (mm)	LVDT 2 (mm)	LVDT 3 (mm)	LVDT 4 (mm)
T1-1	E7014(L)W–1/4"	6.7	6.9	5.8	5.7
T1-2		6.8	6.1	5.6	6.4
T1-3		6.1	6.1	6.0	5.4
T2-1	E7014(L)W–1/4"	5.4	5.6	6.8	6.7
T2-2		5.9	6.3	5.8	6.2
T2-3		6.1	6.5	6.6	6.2
T3-1	E7014(L)W–1/4"	6.9	7.9	7.7	8.0
T3-2		8.0	7.7	7.6	8.4
T3-3		7.1	7.7	8.0	7.5
T4-1	E70T-4(H)W–1/4"	6.1	5.9	6.2	5.9
T4-2		5.9	6.0	6.3	6.5
T4-3		6.0	6.0	5.9	5.6
T5-1	E70T-4(H)W–1/4"	6.3	6.0	6.1	6.0
T5-2		6.1	6.3	6.2	6.1
T5-3		6.5	6.1	5.8	5.5
T6-1	E70T-4(H)W–1/4"	6.3	6.6	6.2	6.3
T6-2		6.7	6.4	6.6	6.9
T6-3		6.6	6.4	6.6	6.2
T7-1	E70T-4(H)S–1/4"	5.0	5.8	6.3	7.1
T7-2		4.6	5.8	6.6	5.1
T7-3		5.2	5.4	5.6	5.9
T8-1	E70T-4(L)W–1/4"	5.9	6.4	6.4	7.0
T8-2		6.7	6.0	7.0	6.9
T8-3		6.7	6.0	7.0	6.9
T9-1	E70T-4(L)S–1/4"	7.7	7.2	8.8	8.3
T9-2		8.0	8.5	7.9	8.9
T9-3		8.3	8.4	7.9	8.1
T10-1	E70T-4(L)S–1/4"	7.6	7.6	8.8	8.9
T10-2		8.3	7.8	8.4	7.8
T10-3		8.3	7.0	8.6	8.8
T11-1	E70T-7(H)W–1/4"	6.4	6.3	7.3	7.5
T11-2		6.4	6.8	7.0	7.3
T11-3		6.1	6.8	7.0	7.5
T12-1	E70T-7(H)S–1/4"	8.0	7.5	8.4	7.6
T12-2		8.1	8.3	8.2	7.9
T12-3		7.7	7.5	8.0	8.8
T13-1	E70T-7(L)W–1/4"	6.8	6.7	7.2	6.3
T13-2		6.2	6.4	7.3	7.3
T13-3		5.9	7.1	6.0	5.0
T14-1	E70T-7(L)S–1/4"	8.0	8.3	8.5	9.0
T14-2		8.1	8.6	9.0	8.4
T14-3		8.3	7.7	8.7	8.4
T15-1	E70T-7(L)S–1/4"	6.7	6.9	7.9	7.0
T15-2		7.3	7.2	7.6	7.6
T15-3		6.9	7.5	7.4	7.5

Table C103 – Gauge Lengths For Strain Measurements (Cont.)

Specimen Designation	Identifier	LVDT 1 (mm)	LVDT 2 (mm)	LVDT 3 (mm)	LVDT 4 (mm)
T16-1	E70T7-K2(L)W–1/4"	6.5	6.6	7.6	7.7
T16-2		6.5	6.6	8.1	8.1
T16-3		7.1	6.8	7.3	6.6
T17-1	E70T7-K2(L)S–1/4"	8.9	9.5	9.8	9.1
T17-2		9.4	9.7	9.0	10.0
T17-3		9.1	9.8	7.8	8.4
T18-1	E71T8-K6(H)W–1/4"	4.9	5.8	6.0	5.8
T18-2		4.8	5.3	5.4	5.0
T18-3		5.6	5.6	5.3	5.4
T19-1	E71T8-K6(H)S–1/4"	7.8	8.1	7.4	7.6
T19-2		9.2	8.4	7.9	7.6
T19-3		8.6	8.8	7.1	8.8
T20-1	E7014(L)W–1/2"	12.9	13.9	14.3	12.5
T20-2		13.2	12.6	13.6	13.6
T20-3		13.5	13.7	13.9	12.5
T21-1	E70T-4(H)W–1/2"	12.0	11.3	12.4	12.3
T21-2		12.0	12.4	11.8	12.1
T21-3		13.0	11.5	12.0	12.0
T22-1	E70T-4(H)S–1/2"	9.5	9.7	11.4	10.9
T22-2		10.5	10.2	10.5	11.1
T22-3		12.1	11.5	10.1	10.4
T23-1	E70T-4(L)W–1/2"	13.2	12.4	13.5	13.5
T23-2		12.7	12.3	13.0	13.3
T23-3		12.3	13.0	12.9	13.3
T24-1	E70T-4(L)S–1/2"	11.2	12.4	11.5	11.4
T24-2		12.3	12.9	12.1	11.7
T24-3		12.6	13.7	11.7	12.1
T25-1	E70T-7(H)W–1/2"	13.5	14.2	14.6	14.6
T25-2		12.7	12.1	12.2	12.3
T25-3		13.1	13.4	13.7	13.8
T26-1	E70T-7(H)S–1/2"	11.9	12.5	13.2	13.7
T26-2		12.4	12.9	12.7	12.8
T26-3		12.3	13.3	12.9	12.9
T27-1	E70T-7(L)W–1/2"	12.6	12.8	11.5	11.7
T27-2		12.8	12.7	11.8	12.0
T27-3		12.3	12.0	11.4	11.5
T28-1	E70T-7(L)S–1/2"	13.4	13.8	12.6	12.7
T28-2		13.7	12.9	12.2	12.4
T28-3		12.6	13.0	12.9	13.5
T29-1	E70T7-K2(L)W–1/2"	11.8	13.1	16.2	16.2
T29-2		13.7	13.3	17.1	16.4
T29-3		13.4	13.4	16.1	15.4
T30-1	E70T7-K2(L)S–1/2"	13.0	11.5	13.8	13.2
T30-2		12.9	12.6	13.0	14.6
T30-3		12.4	13.1	13.6	12.8

Table C103 – Gauge Lengths For Strain Measurements (Cont.)

Specimen Designation	Identifier	LVDT 1 (mm)	LVDT 2 (mm)	LVDT 3 (mm)	LVDT 4 (mm)
T31-1	E71T8-K6(H)W–1/2"	11.3	11.1	10.6	10.2
T31-2		10.9	11.3	10.3	10.4
T31-3		11.3	11.3	10.4	10.7
T32-1	E71T8-K6(H)S–1/2"	12.3	12.2	11.9	12.5
T32-2		11.4	11.0	12.0	12.4
T32-3		10.7	9.7	11.8	12.5
C1-1	E70T-4(H)W–1/4"	—	8.4	—	8.3
C1-2		—	7.7	—	7.8
C1-3		—	7.4	—	9.0
C2-1	E70T7-K2(L)W–1/4"	5.7	6.0	7.2	7.6
C2-2		—	7.8	—	8.1
C2-3		7.0	7.2	6.0	5.9

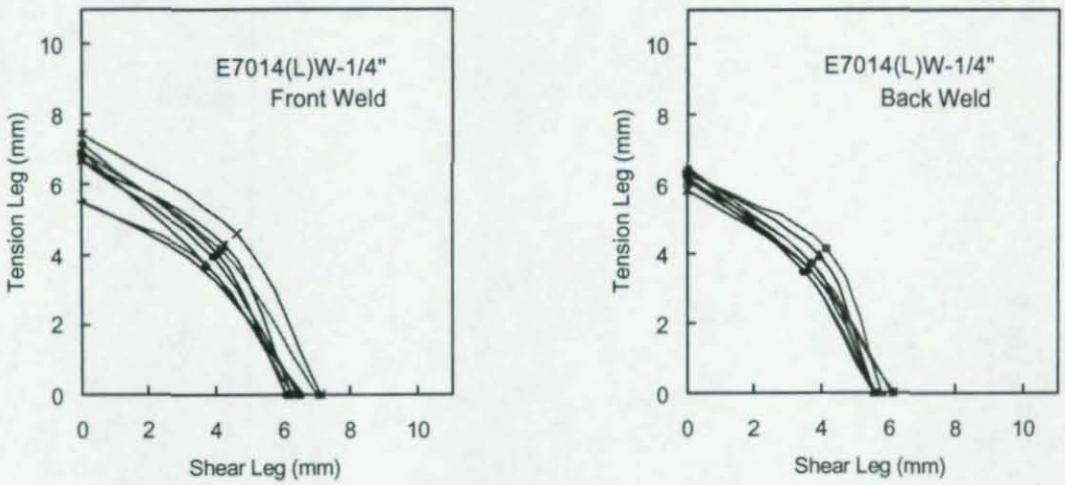


Figure C1 – Weld Profile for Specimen T1-1

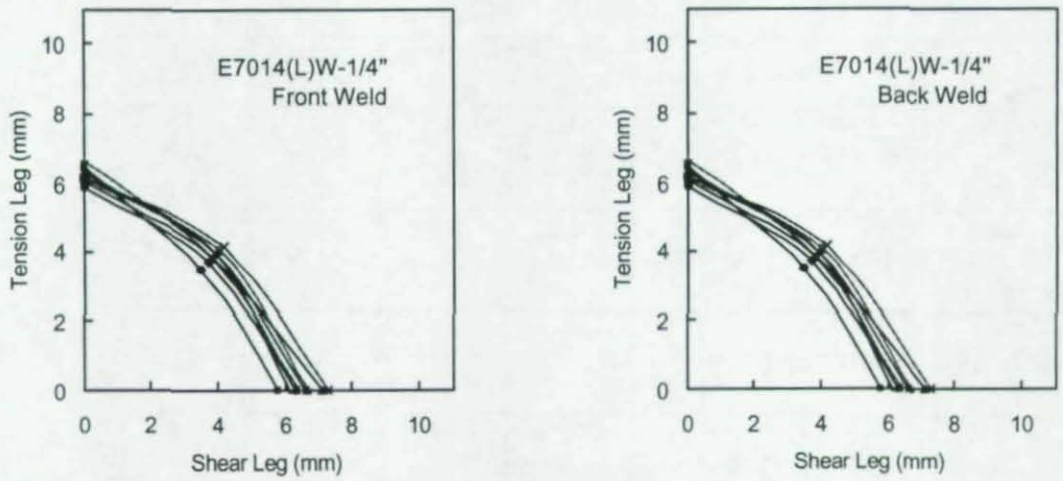


Figure C2 – Weld Profile for Specimen T1-2

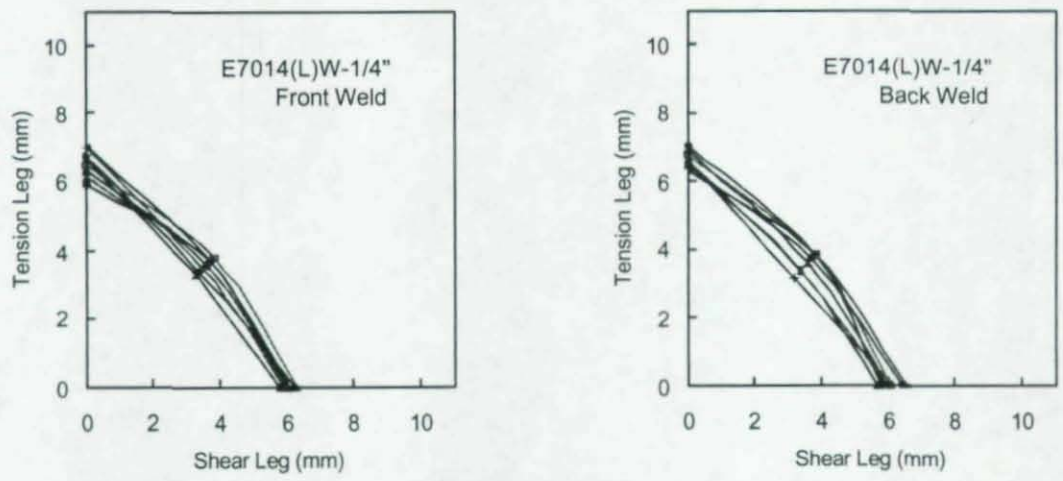


Figure C3 – Weld Profile for Specimen T1-3

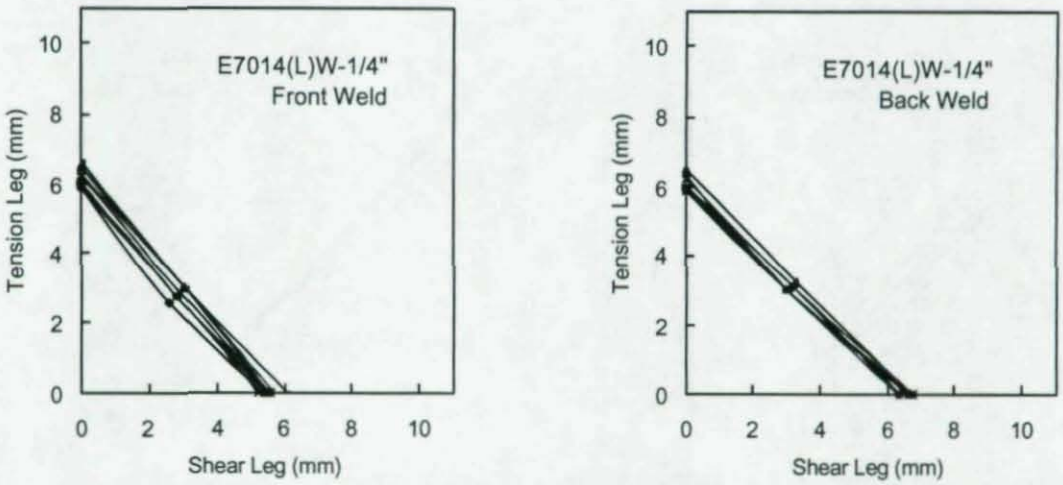


Figure C4 – Weld Profile for Specimen T2-1

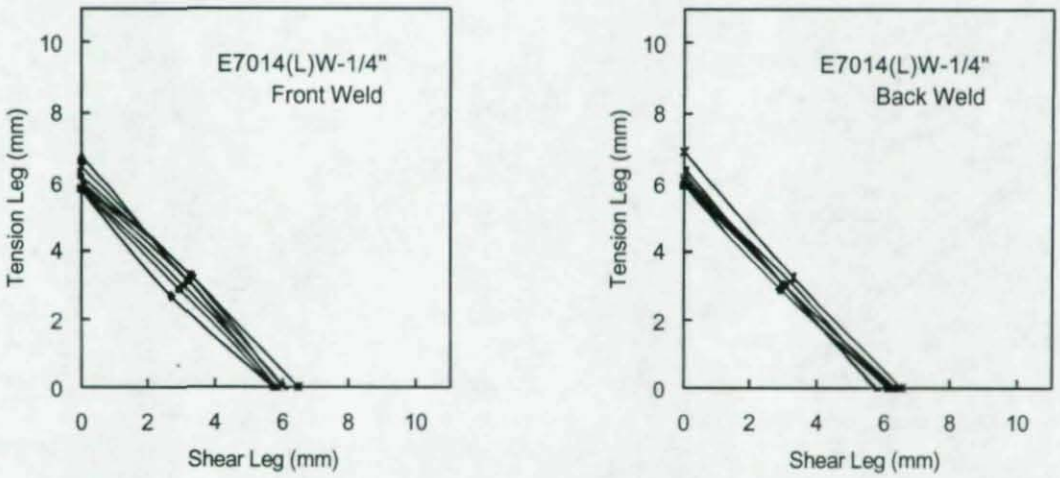


Figure C5 – Weld Profile for Specimen T2-2

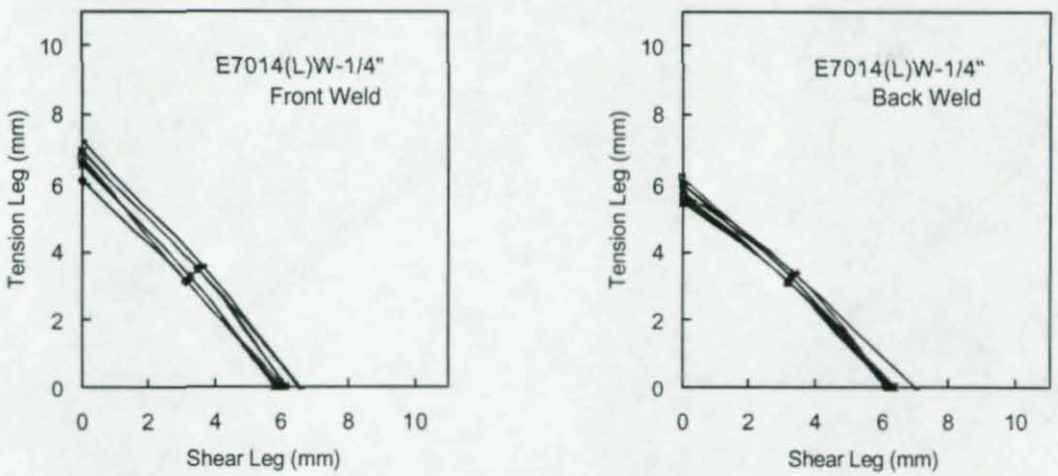


Figure C6 – Weld Profile for Specimen T2-3

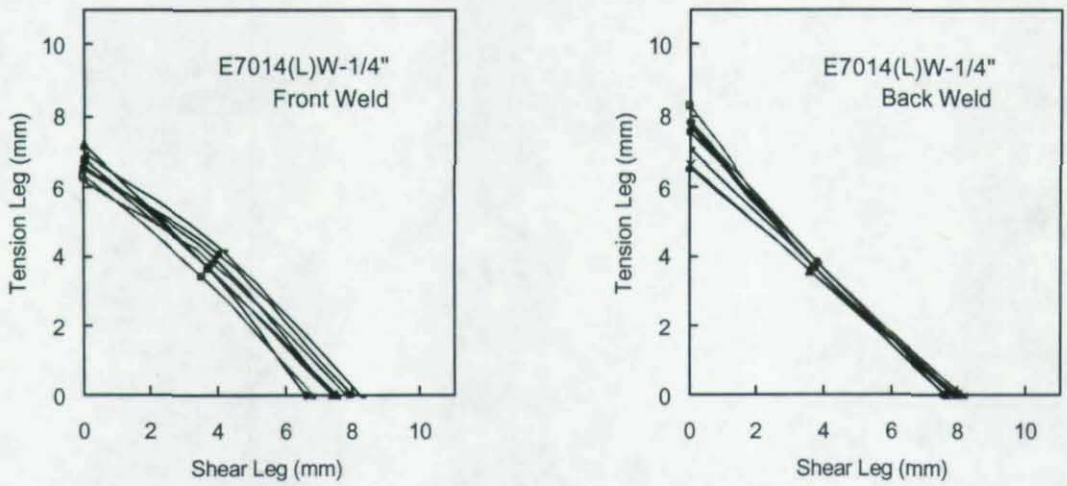


Figure C7 – Weld Profile for Specimen T3-1

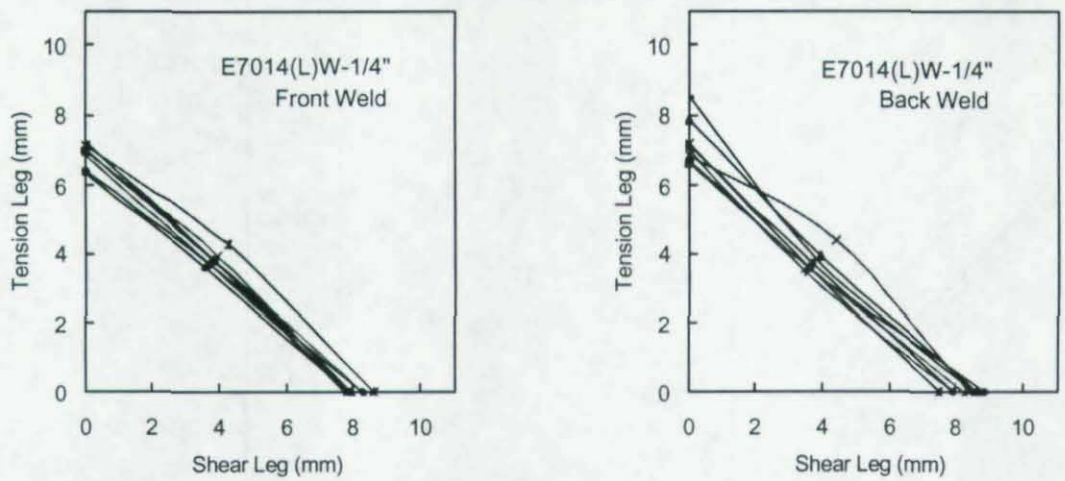


Figure C8 – Weld Profile for Specimen T3-2

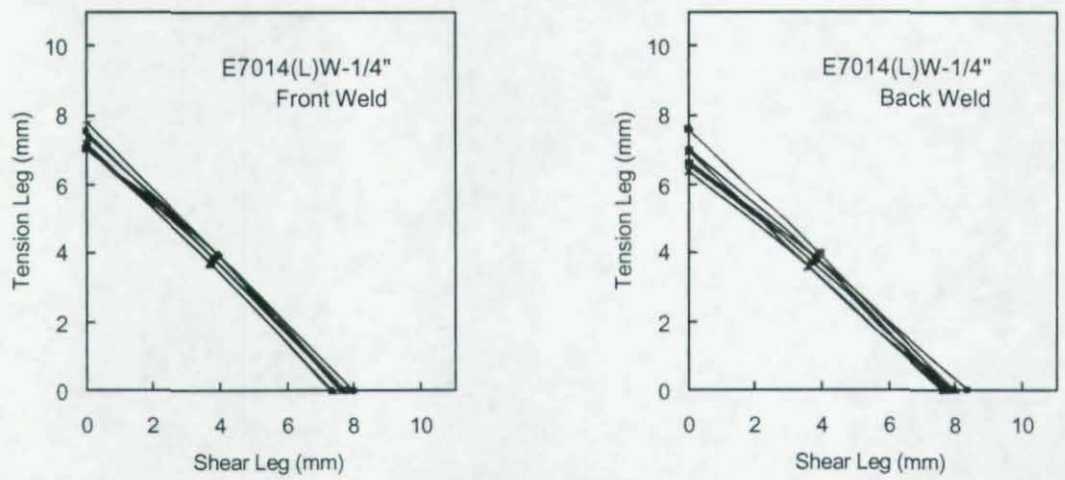


Figure C9 – Weld Profile for Specimen T3-3

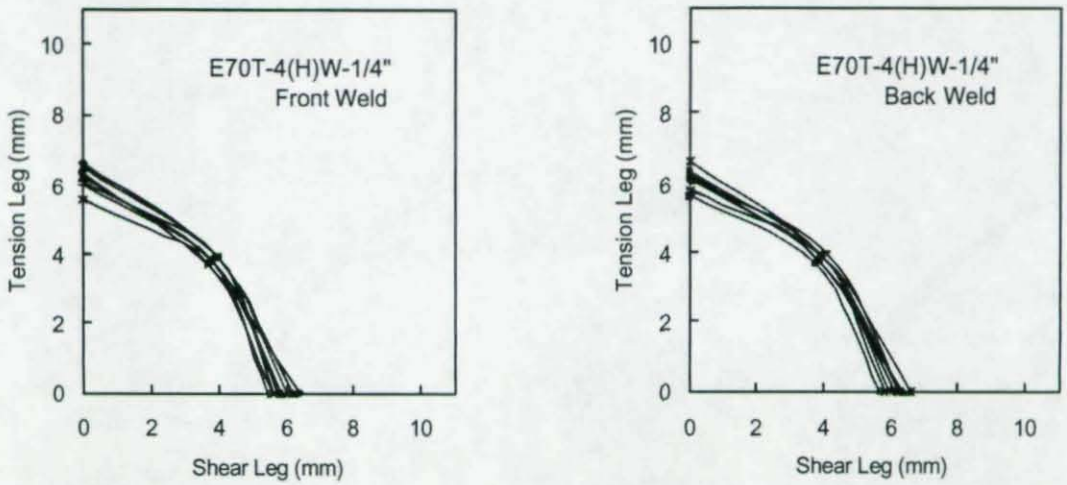


Figure C10 – Weld Profile for Specimen T4-1

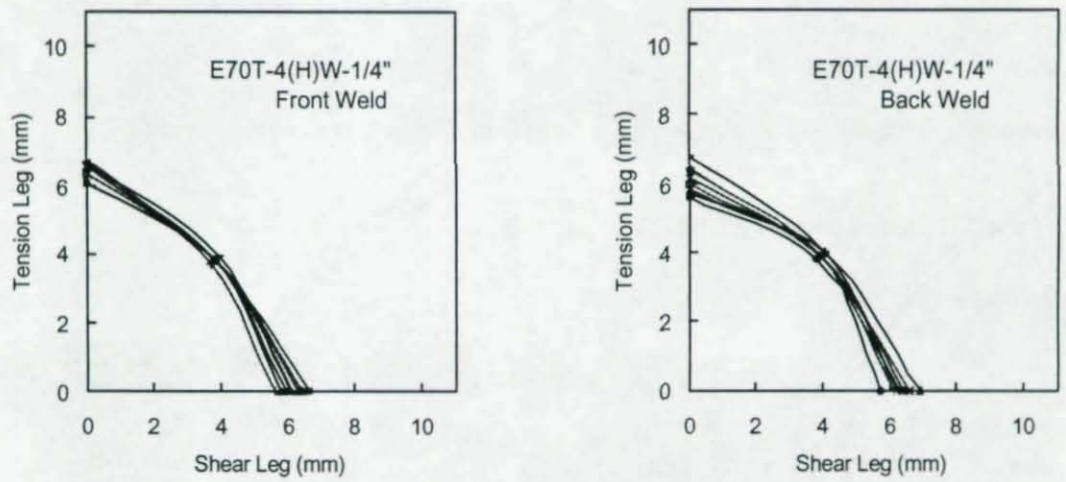


Figure C11 – Weld Profile for Specimen T4-2

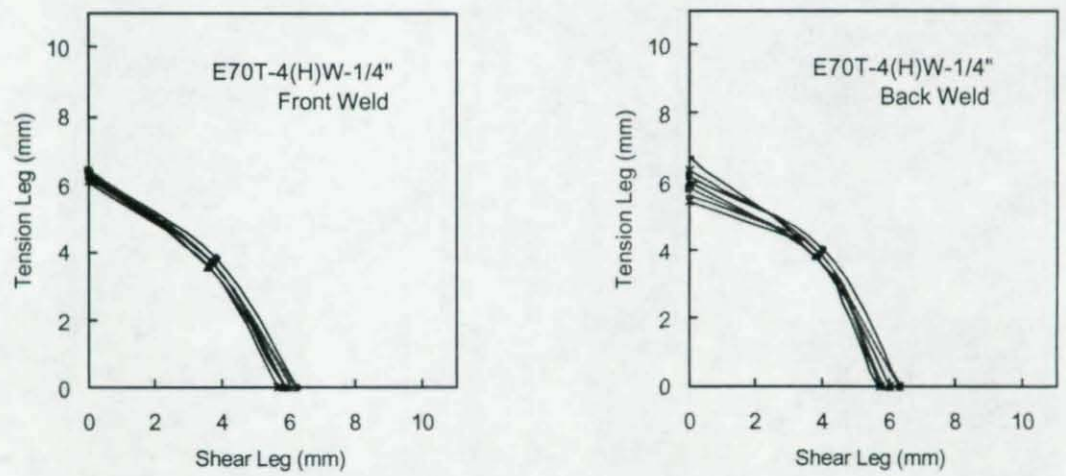


Figure C12 – Weld Profile for Specimen T4-3

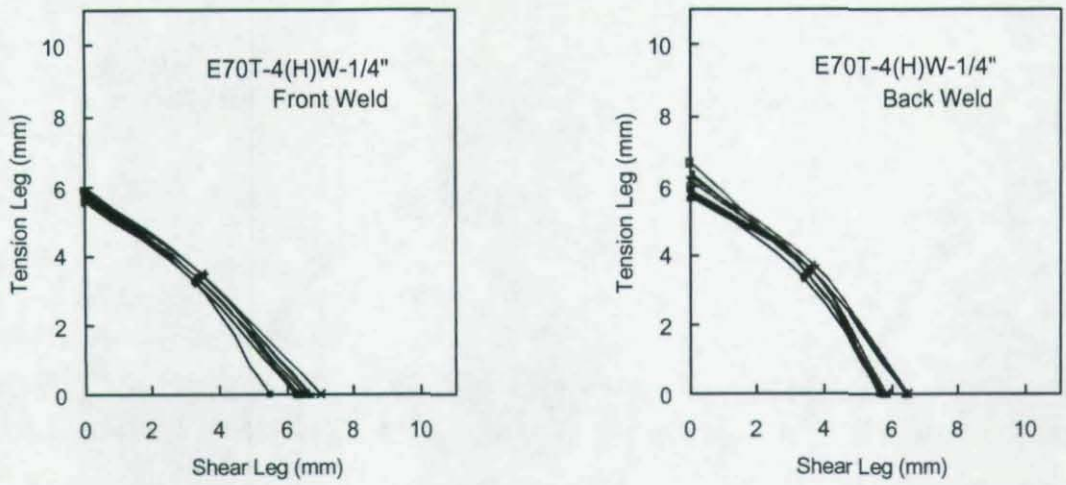


Figure C13 – Weld Profile for Specimen T5-1

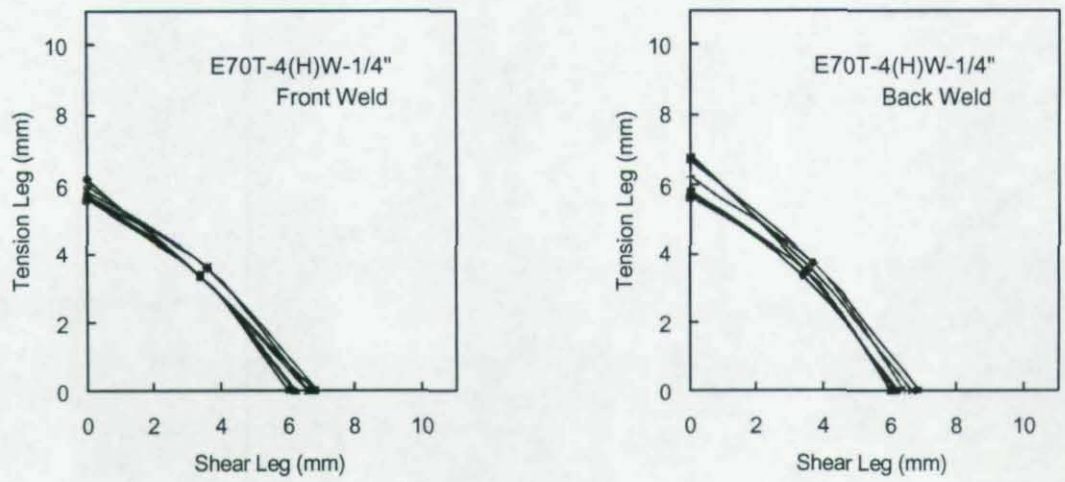


Figure C14 – Weld Profile for Specimen T5-2

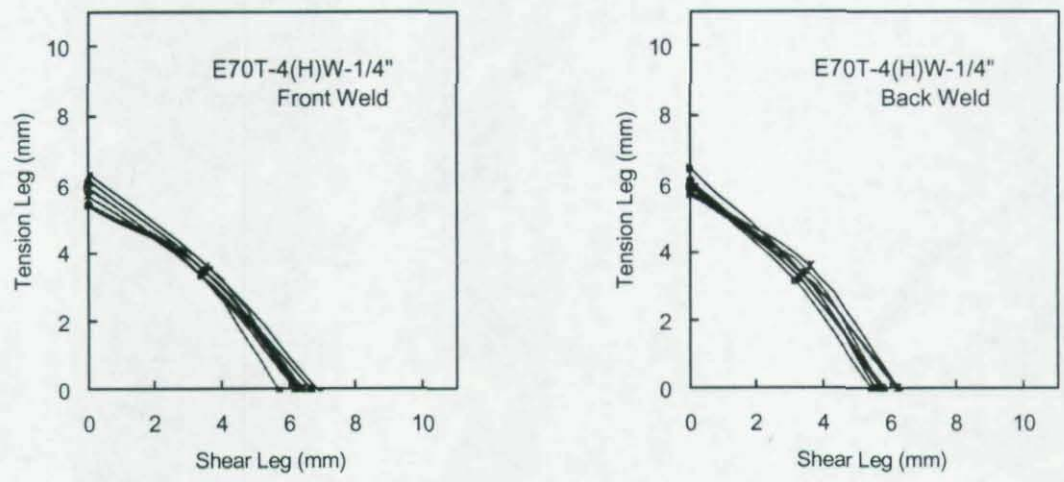


Figure C15 – Weld Profile for Specimen T5-3

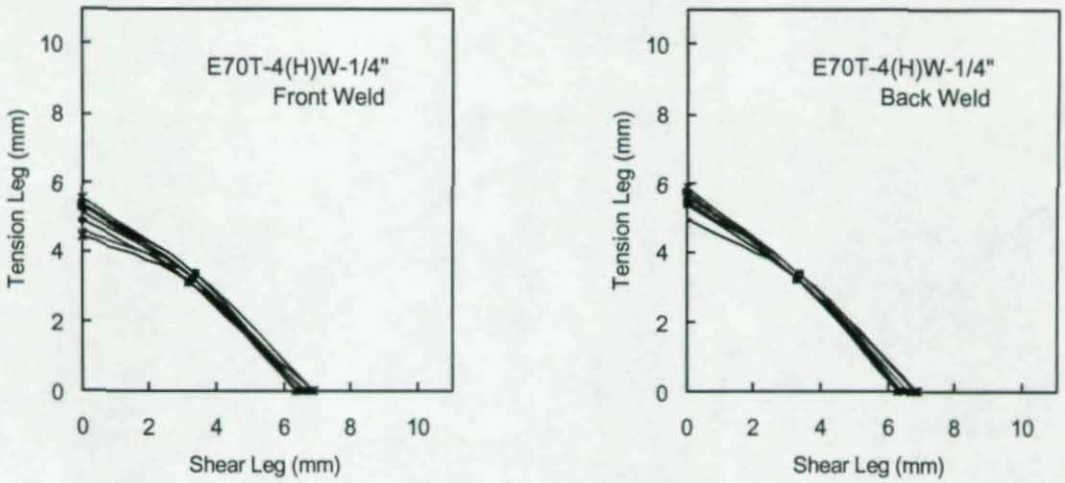


Figure C16 – Weld Profile for Specimen T6-1

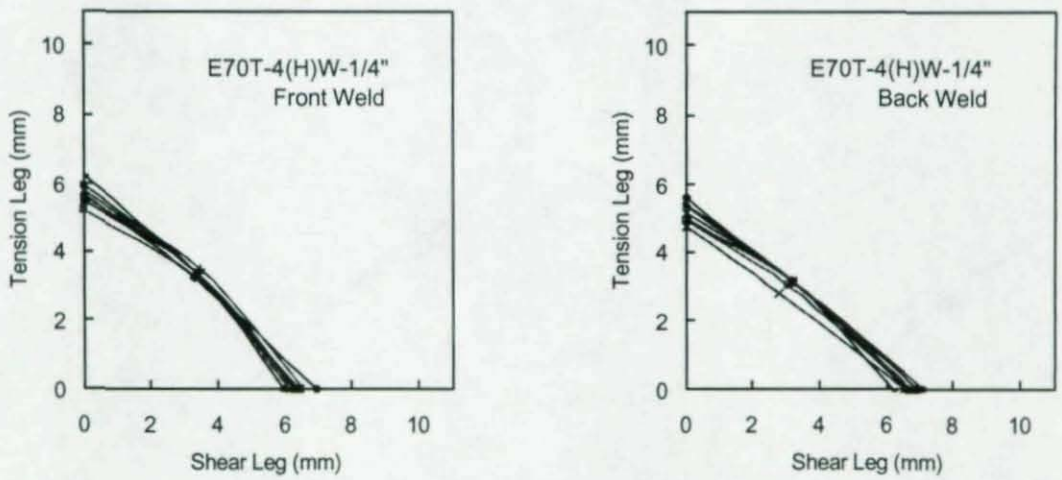


Figure C17 – Weld Profile for Specimen T6-2

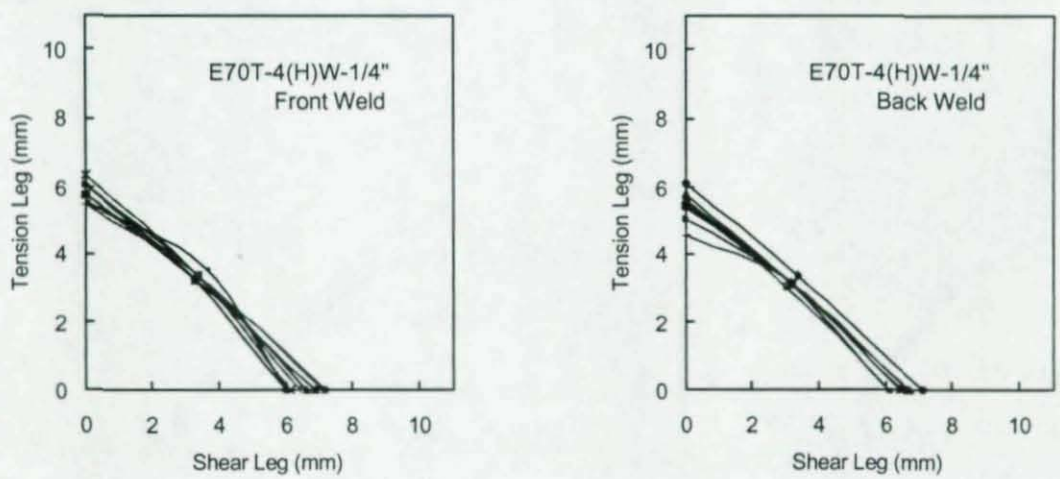


Figure C18 – Weld Profile for Specimen T6-3

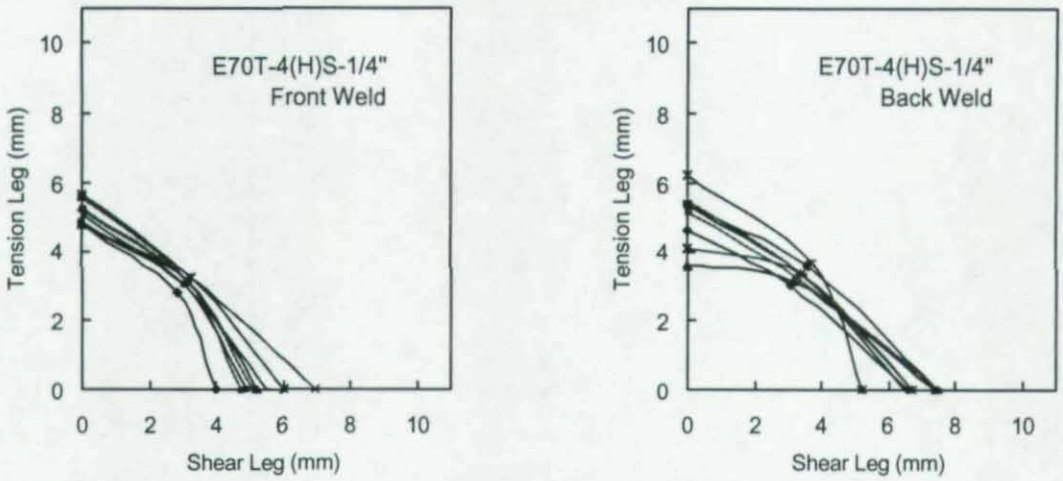


Figure C19 – Weld Profile for Specimen T7-1

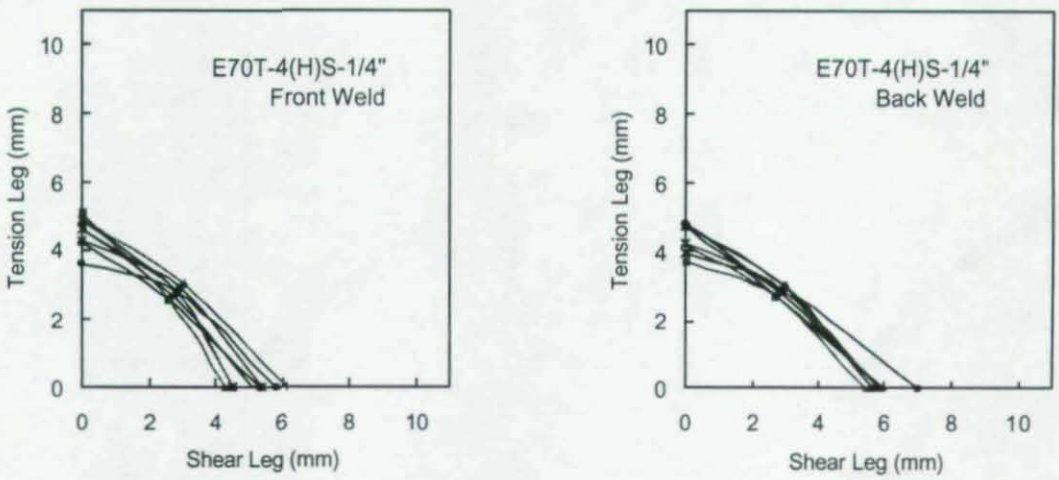


Figure C20 – Weld Profile for Specimen T7-2

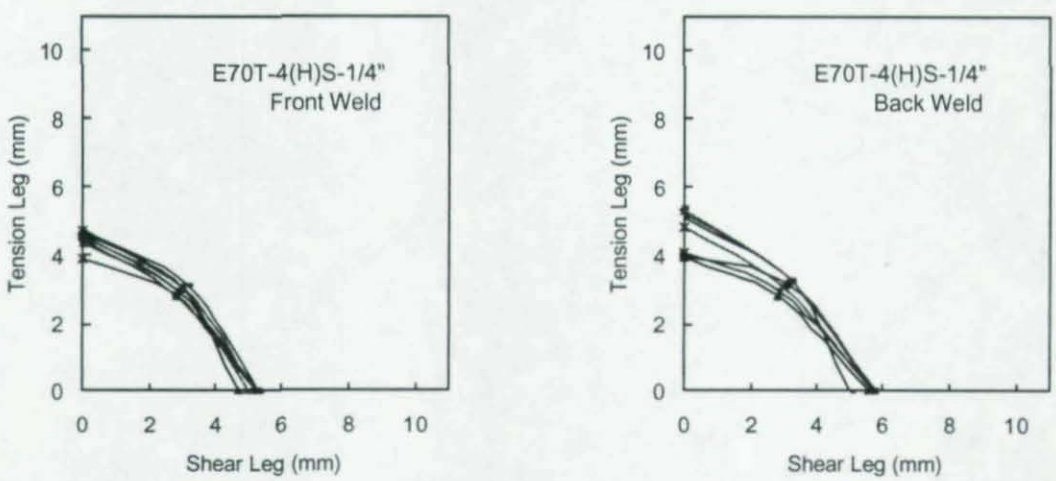


Figure C21 – Weld Profile for Specimen T7-3

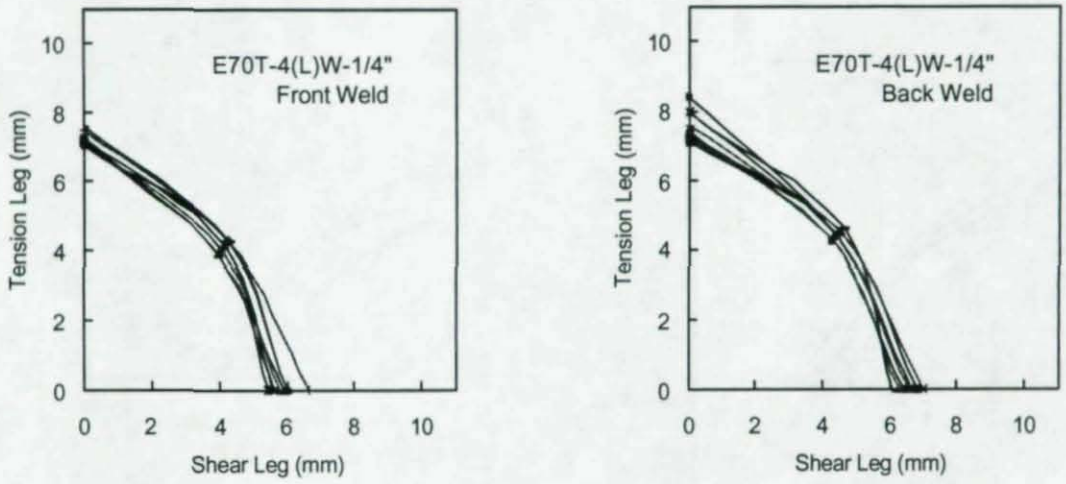


Figure C22 – Weld Profile for Specimen T8-1

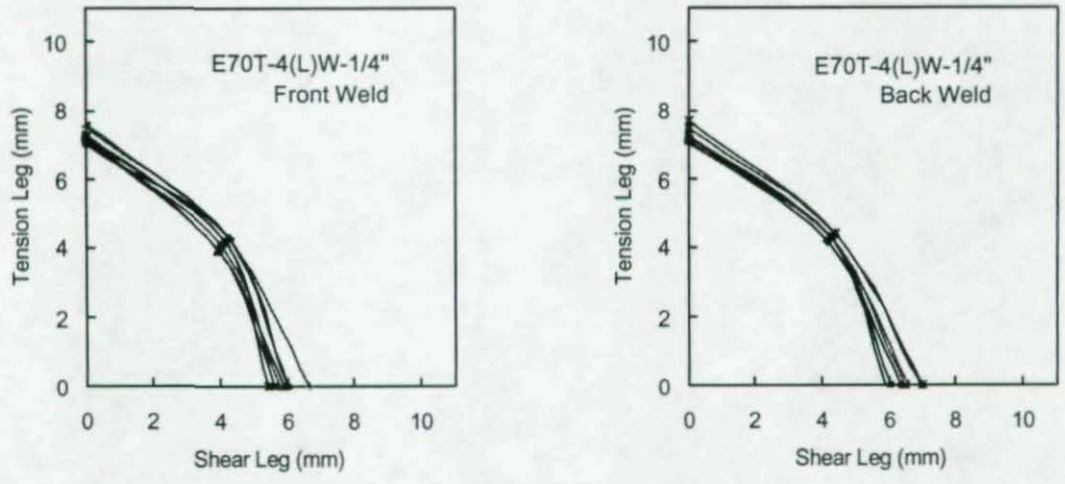


Figure C23 – Weld Profile for Specimen T8-2

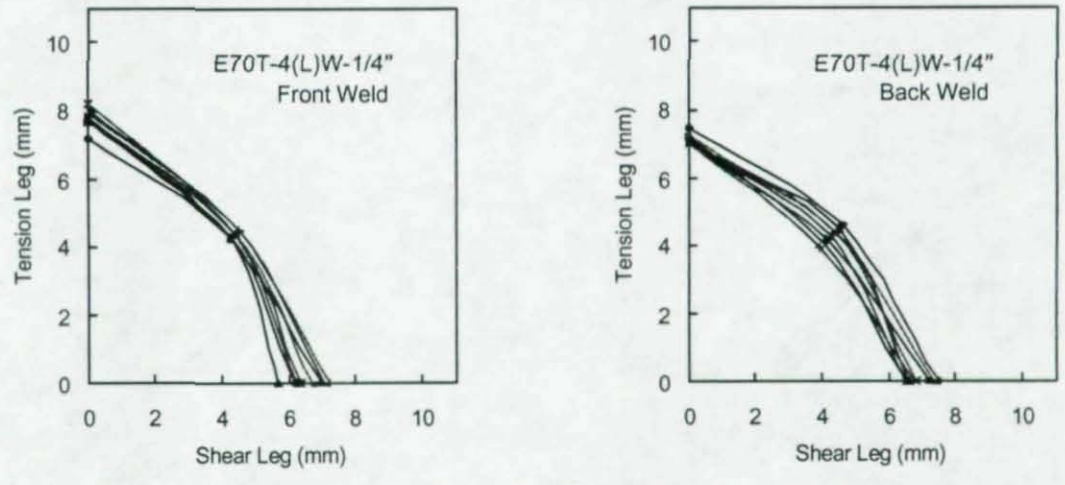


Figure C24 – Weld Profile for Specimen T8-3

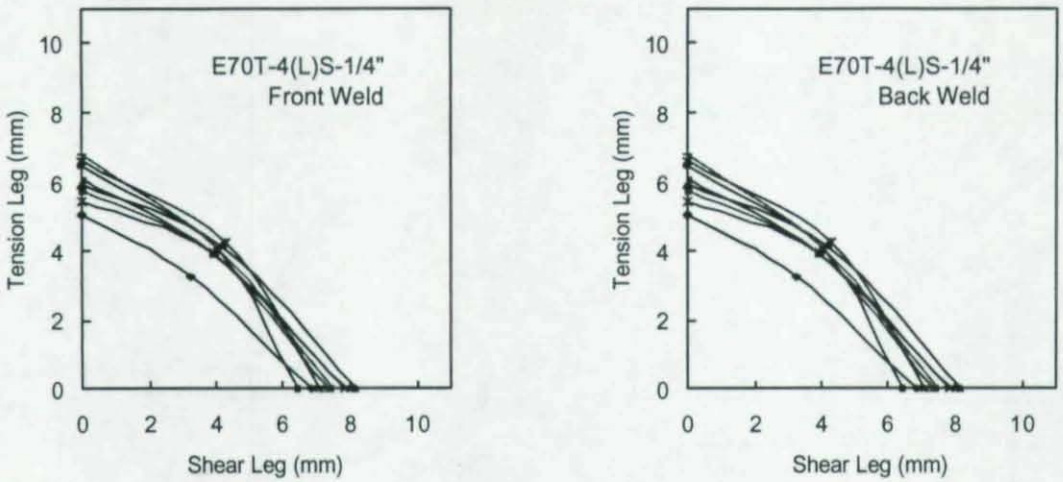


Figure C25 – Weld Profile for Specimen T9-1

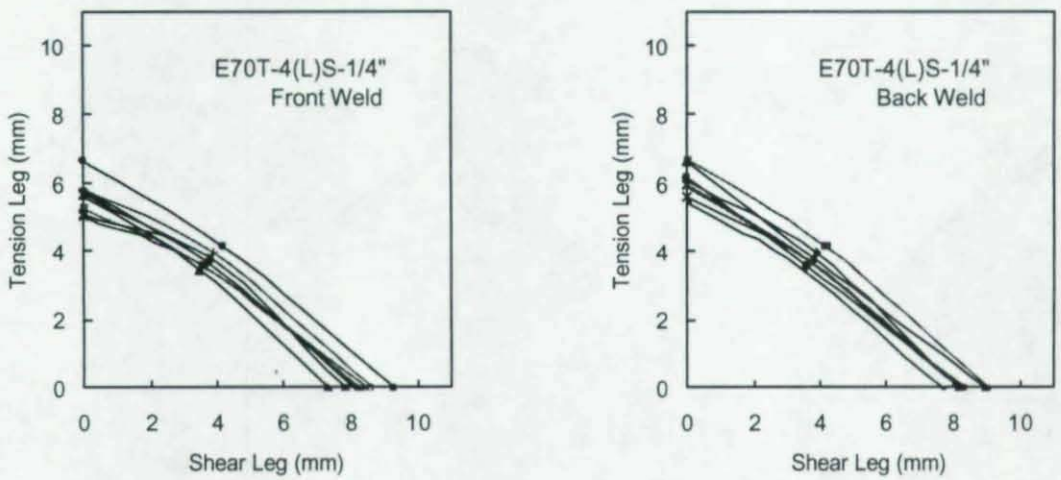


Figure C26 – Weld Profile for Specimen T9-2

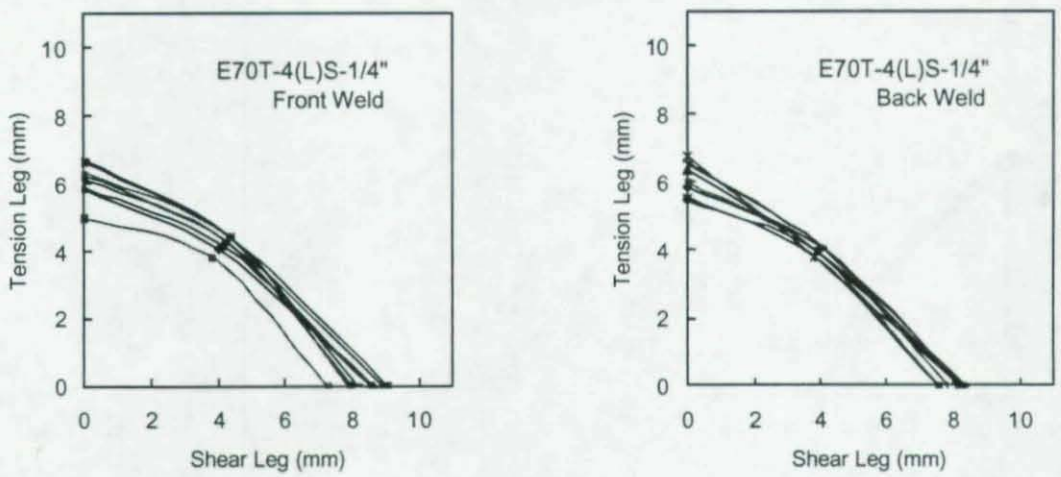


Figure C27 – Weld Profile for Specimen T9-3

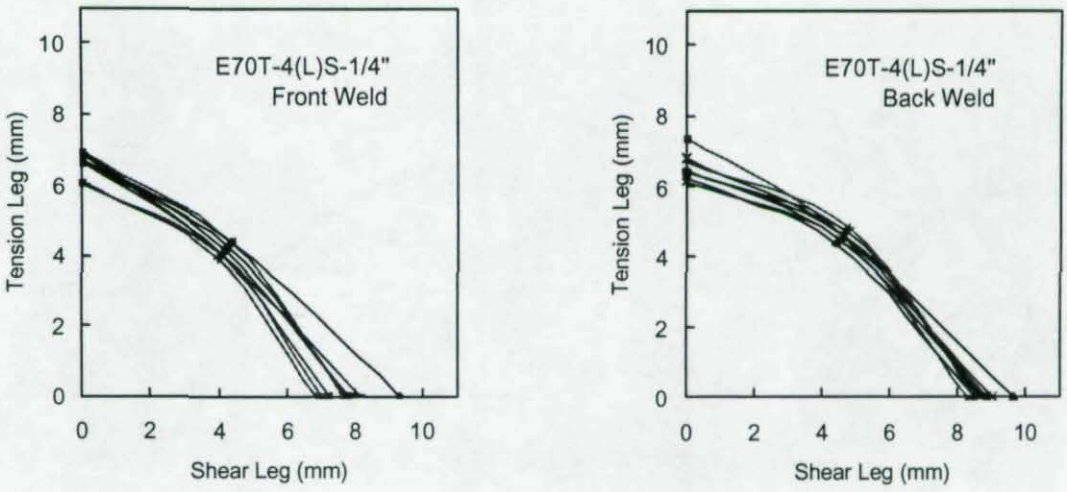


Figure C28 – Weld Profile for Specimen T10-1

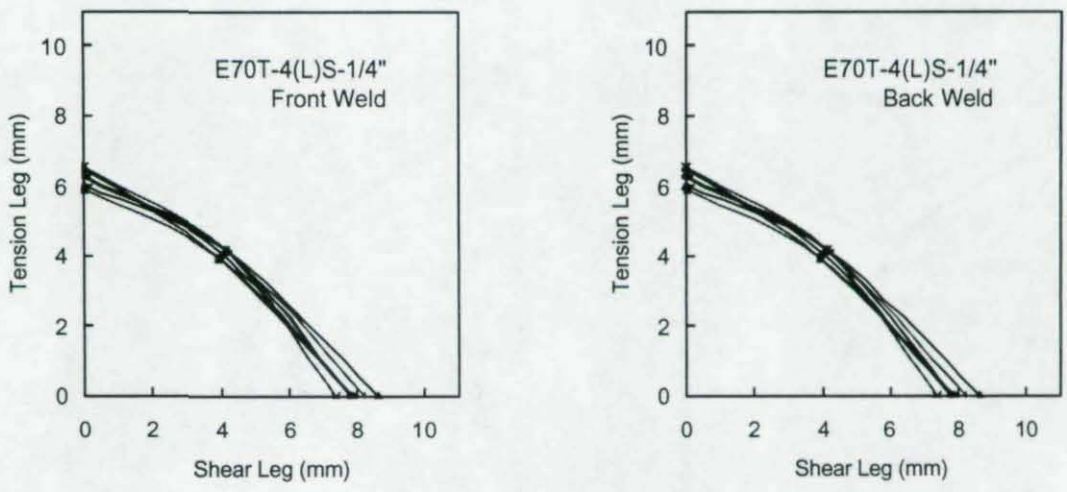


Figure C29 – Weld Profile for Specimen T10-2

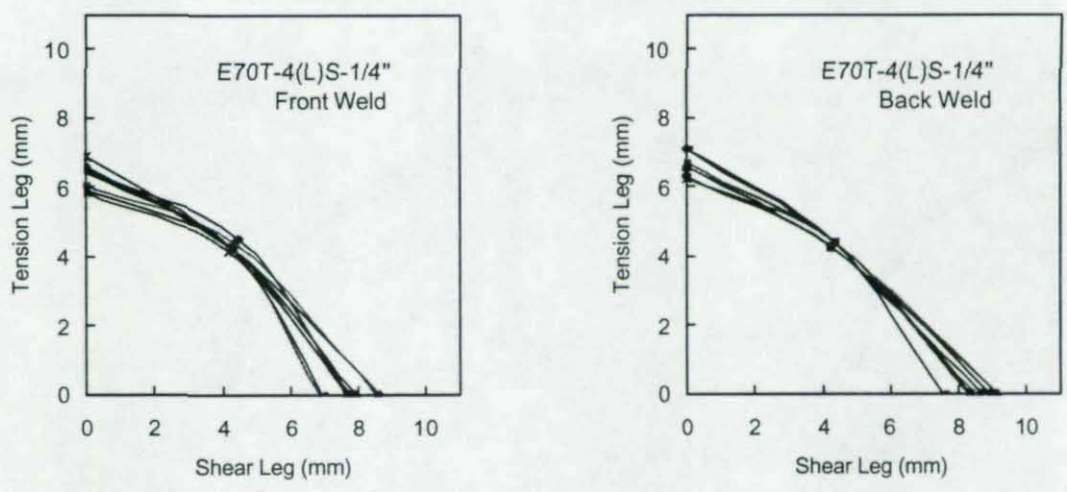


Figure C30 – Weld Profile for Specimen T10-3

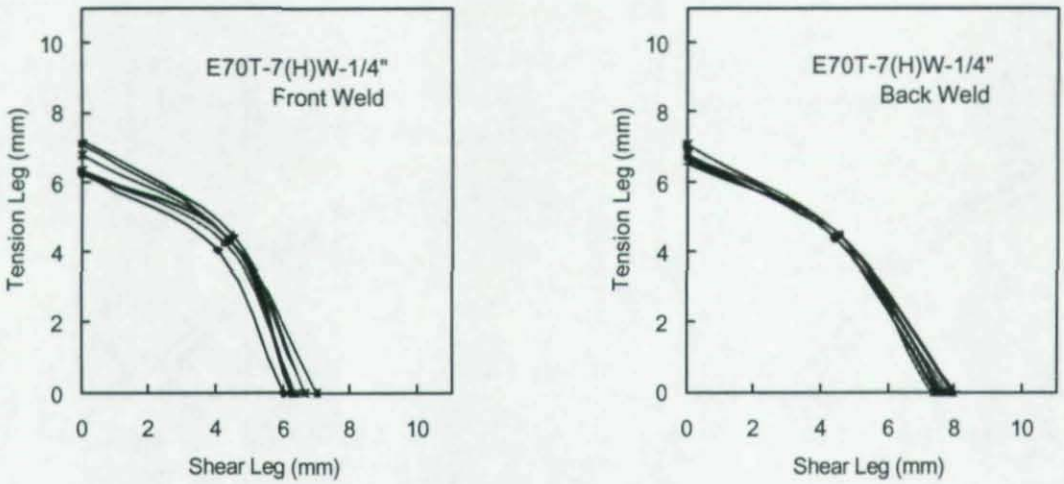


Figure C31 – Weld Profile for Specimen T11-1

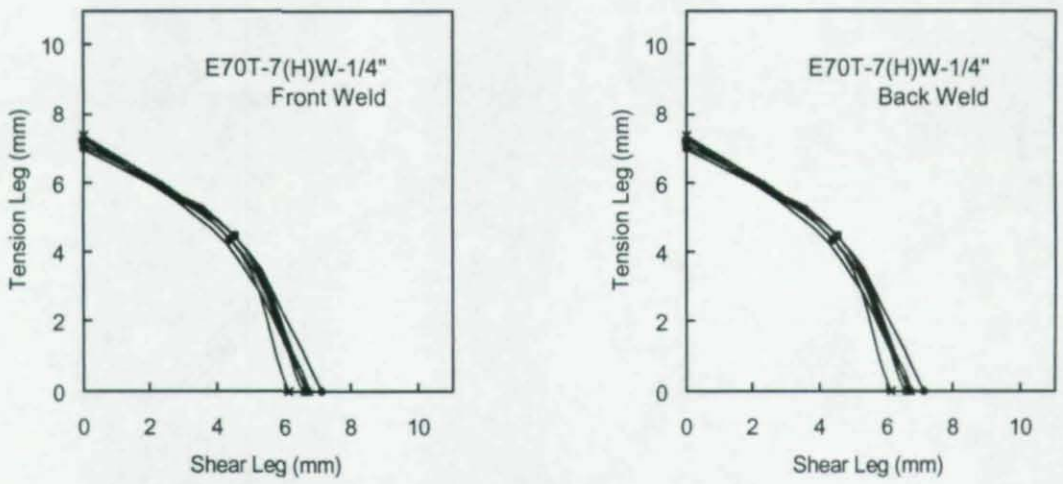


Figure C32 – Weld Profile for Specimen T11-2

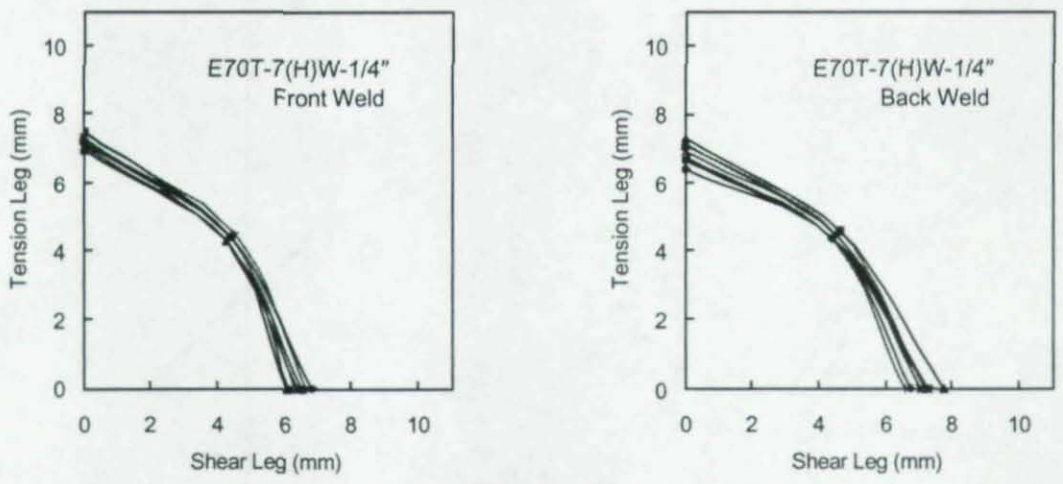


Figure C33 – Weld Profile for Specimen T11-3

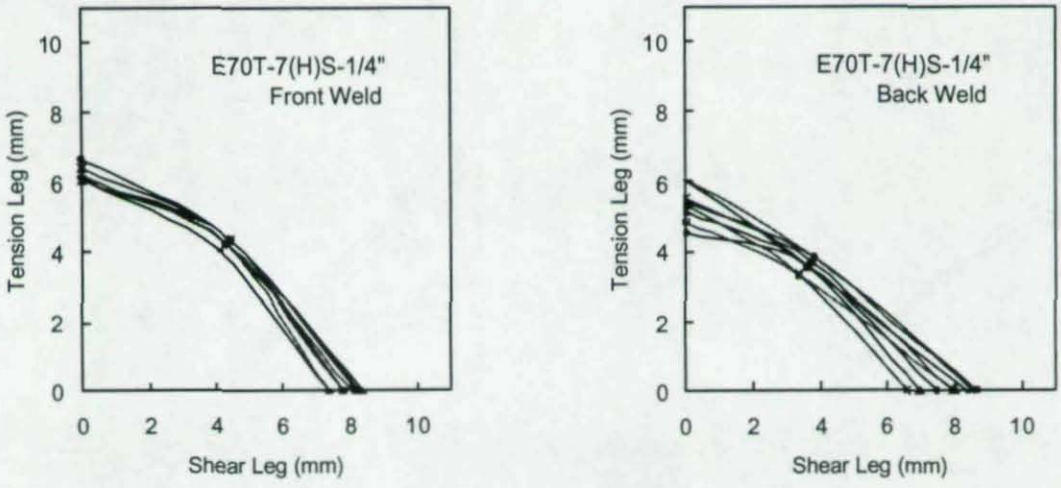


Figure C34 – Weld Profile for Specimen T12-1

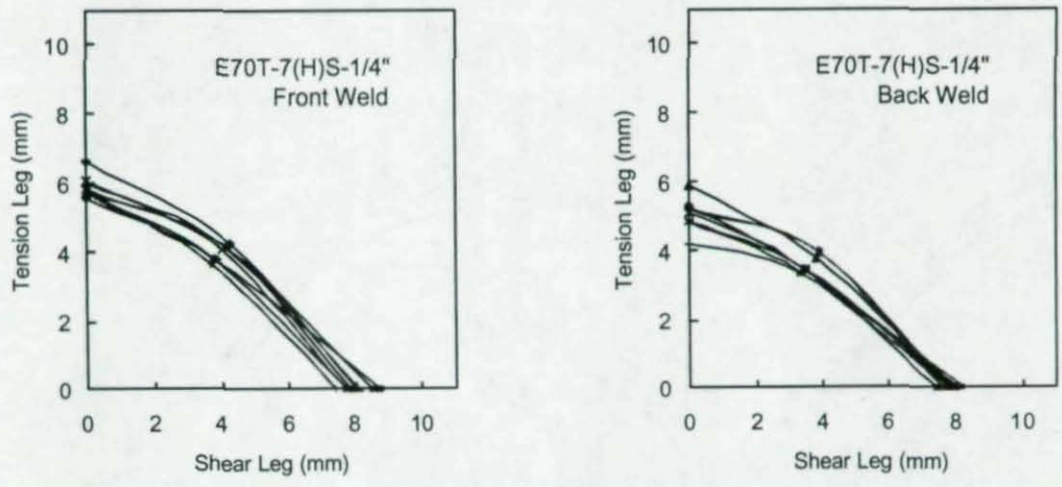


Figure C35 – Weld Profile for Specimen T12-2

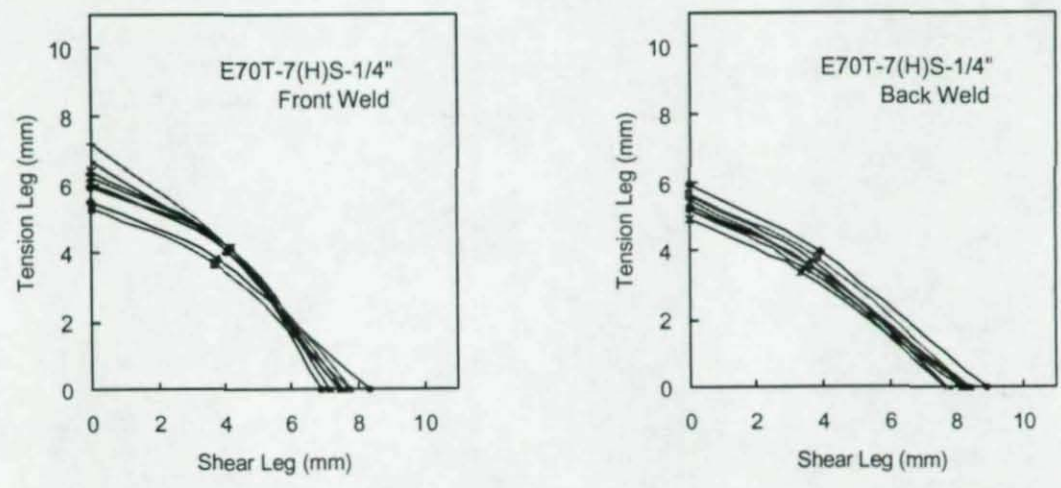


Figure C36 – Weld Profile for Specimen T12-3

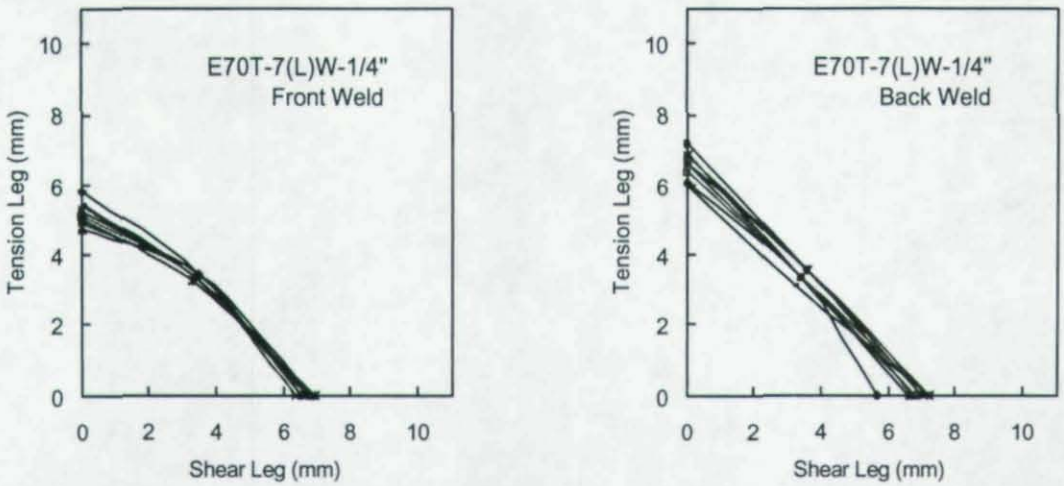


Figure C37 – Weld Profile for Specimen T13-1

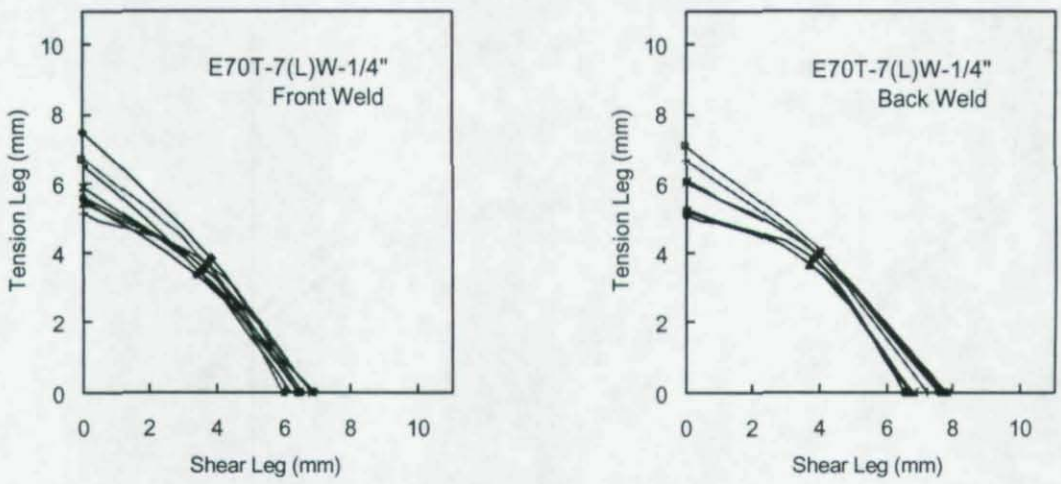


Figure C38 – Weld Profile for Specimen T13-2

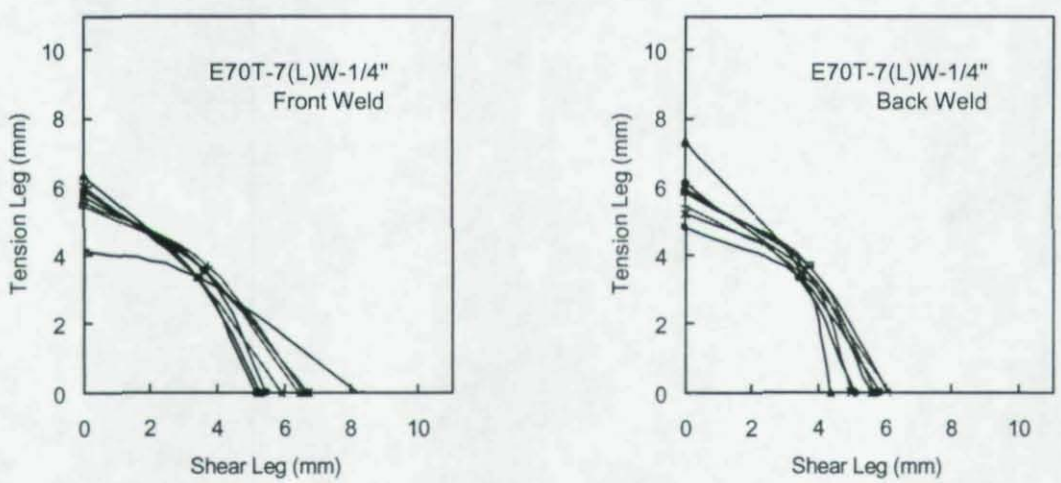


Figure C39 – Weld Profile for Specimen T13-3

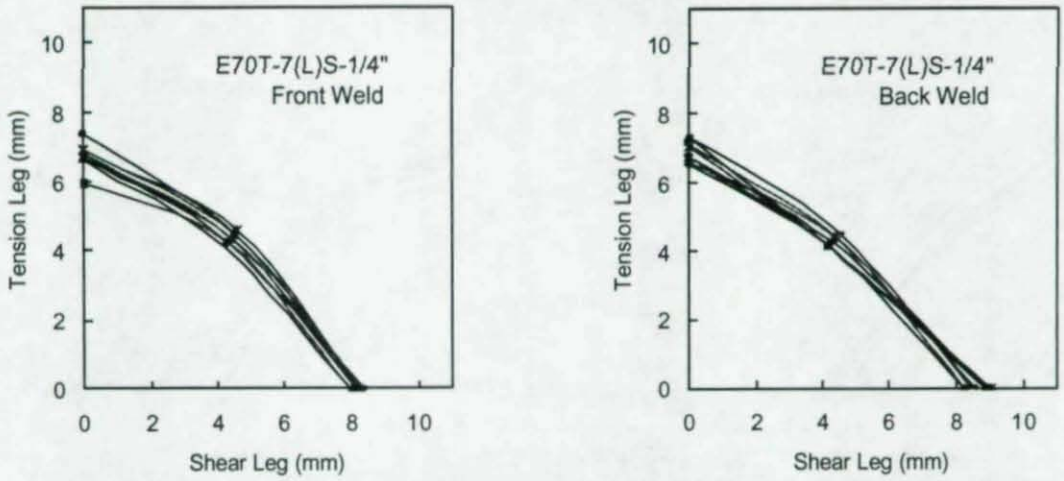


Figure C40 – Weld Profile for Specimen T14-1

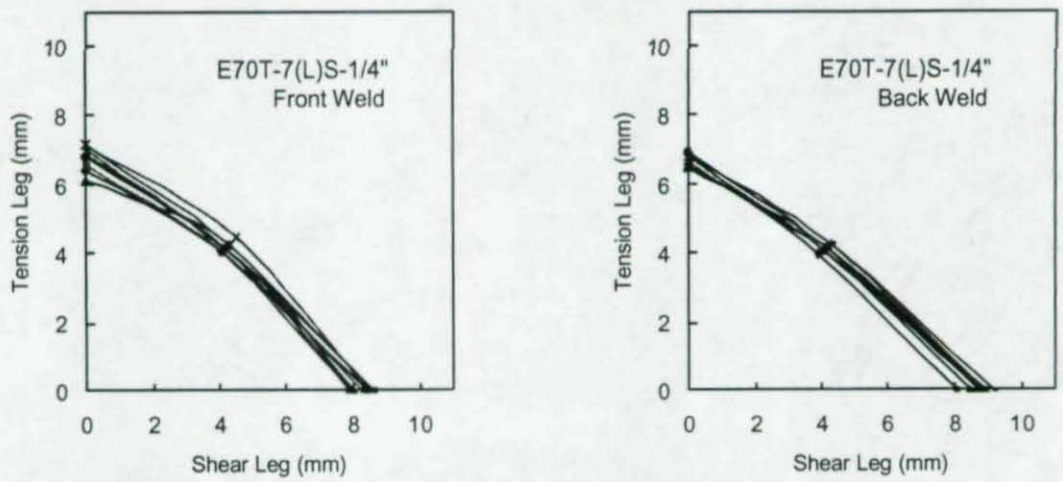


Figure C41 – Weld Profile for Specimen T14-2

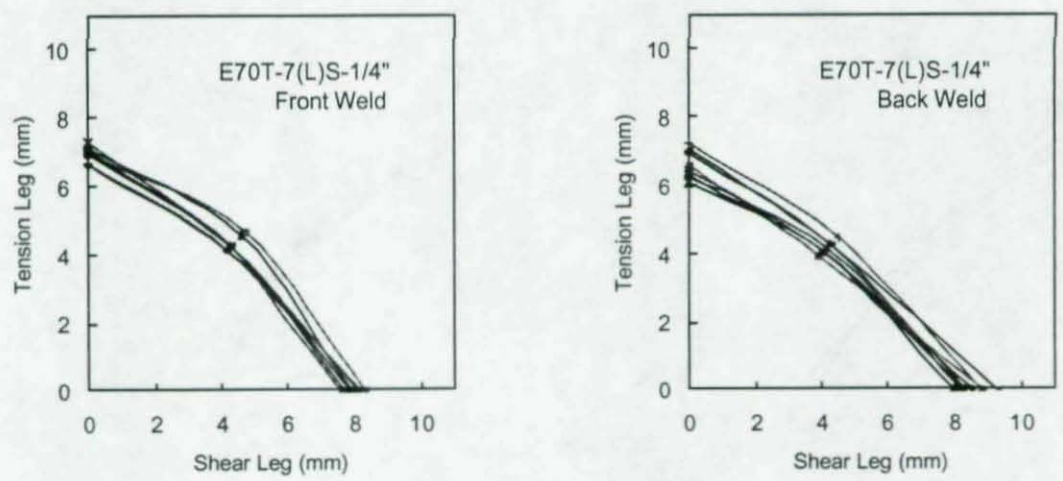


Figure C42 – Weld Profile for Specimen T14-3

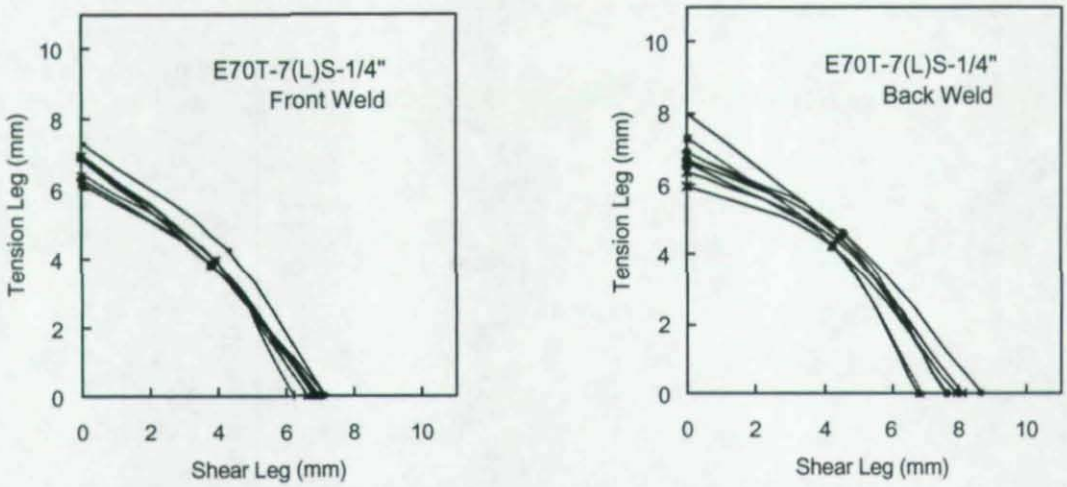


Figure C43 – Weld Profile for Specimen T15-1

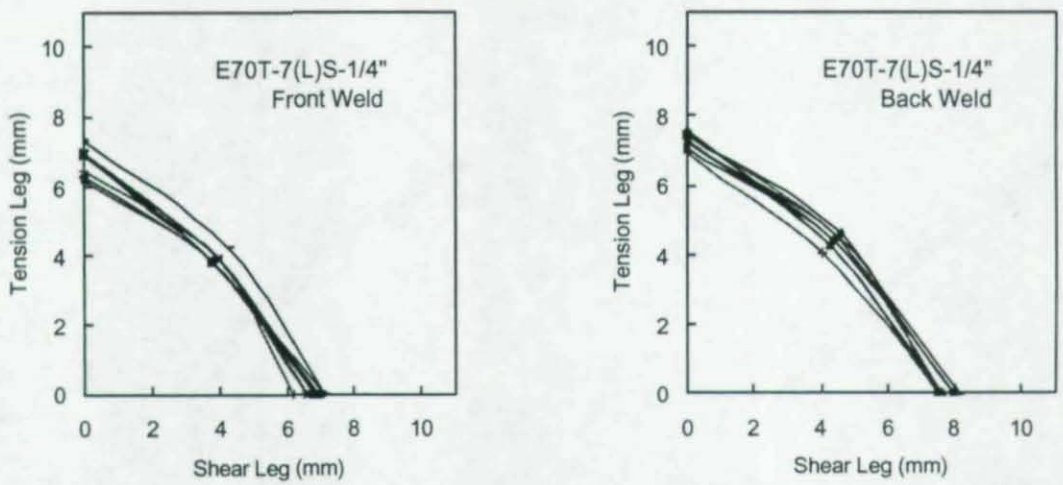


Figure C44 – Weld Profile for Specimen T15-2

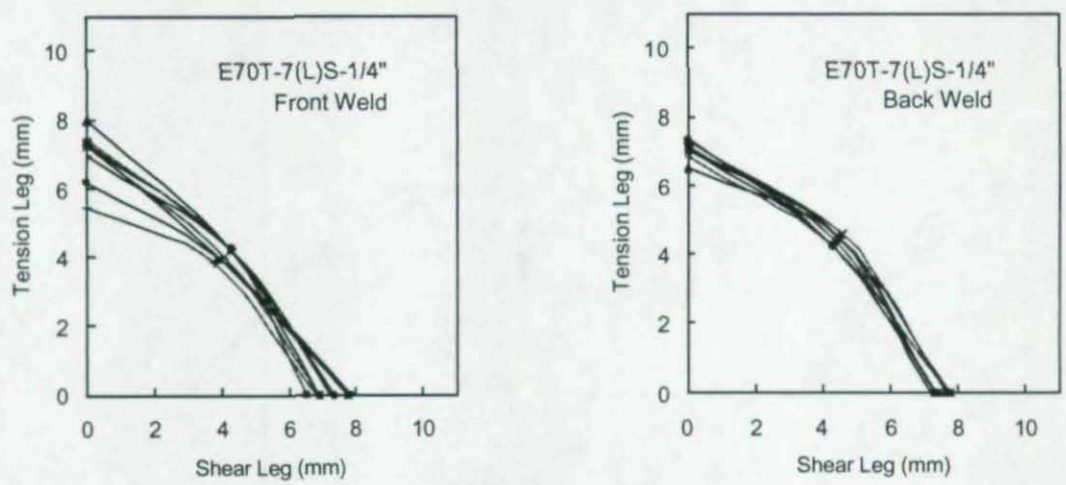


Figure C45 – Weld Profile for Specimen T15-3

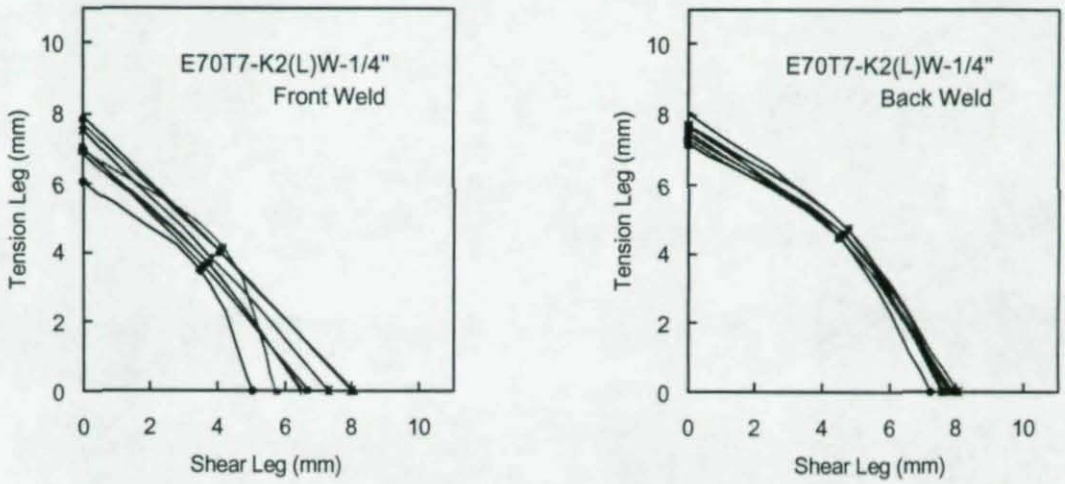


Figure C46 – Weld Profile for Specimen T16-1

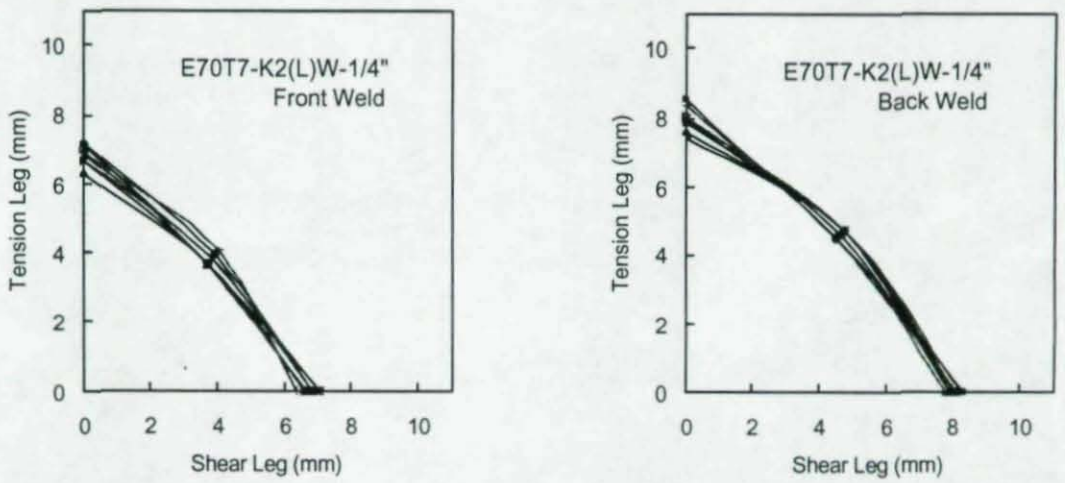


Figure C47 – Weld Profile for Specimen T16-2

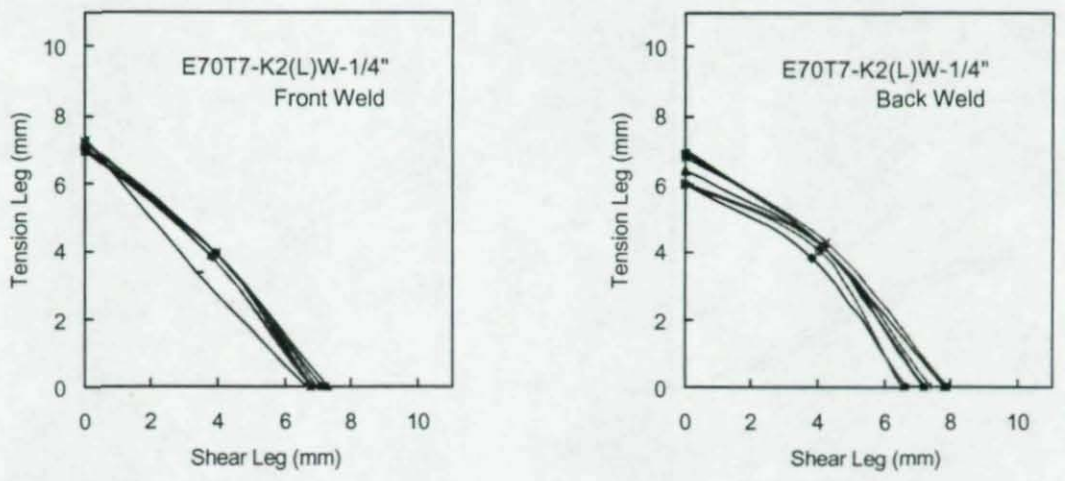


Figure C48 – Weld Profile for Specimen T16-3

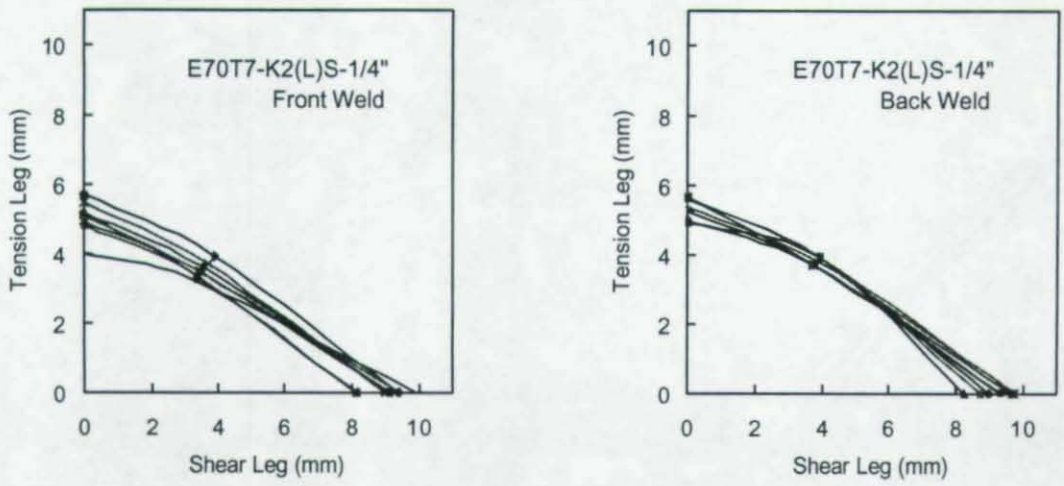


Figure C49 – Weld Profile for Specimen T17-1

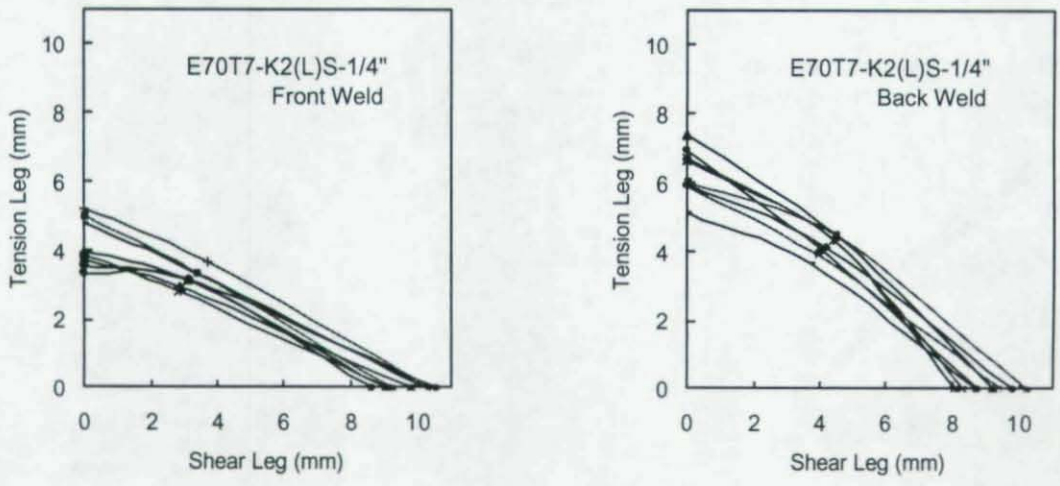


Figure C50 – Weld Profile for Specimen T17-2

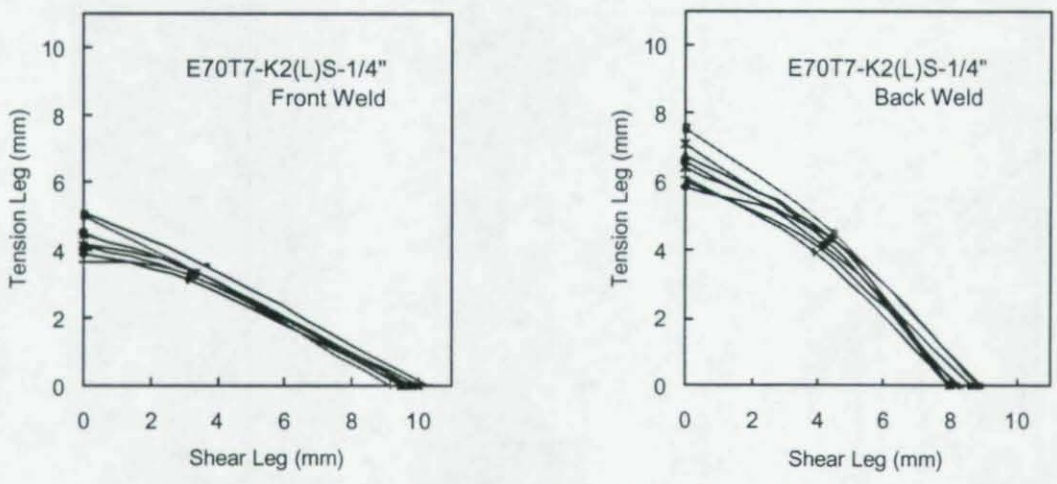


Figure C51 – Weld Profile for Specimen T17-3

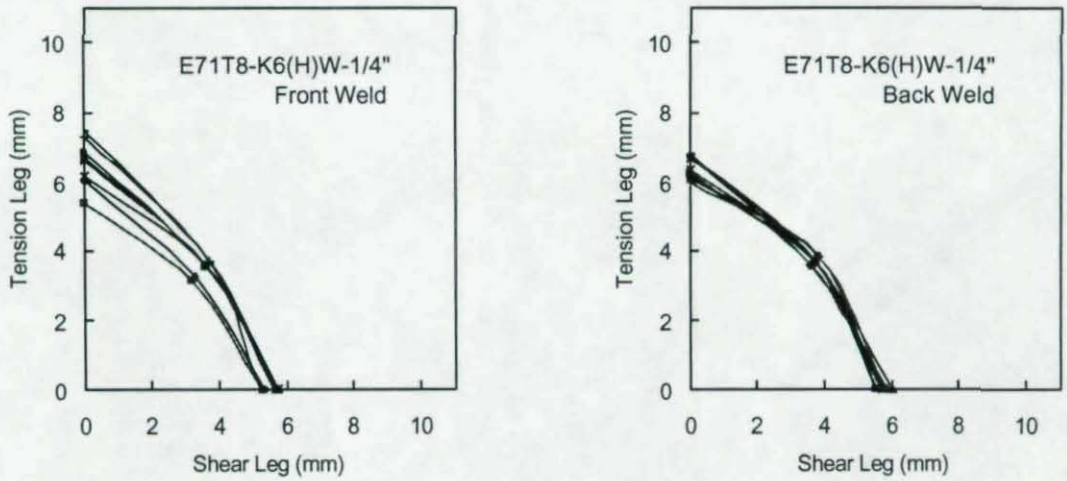


Figure C52 – Weld Profile for Specimen T18-1

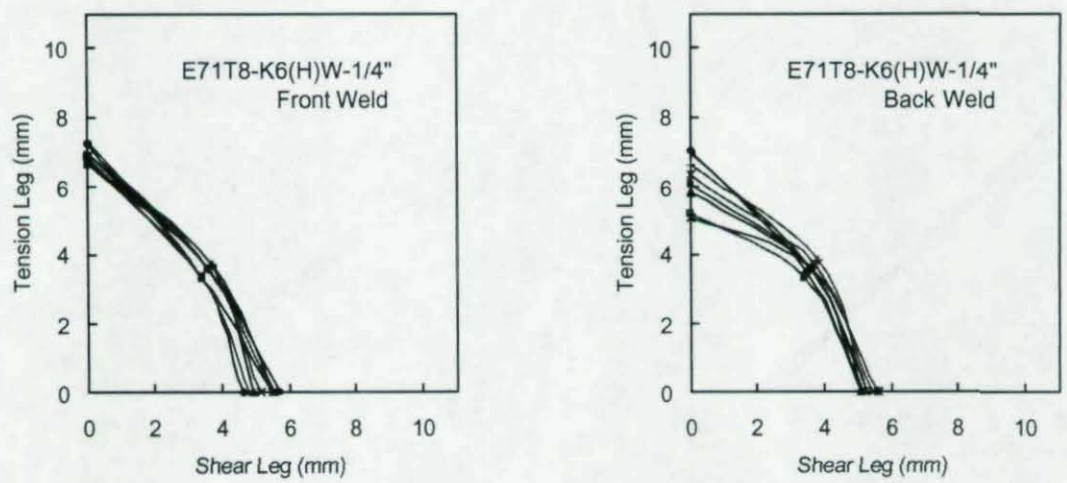


Figure C53 – Weld Profile for Specimen T18-2

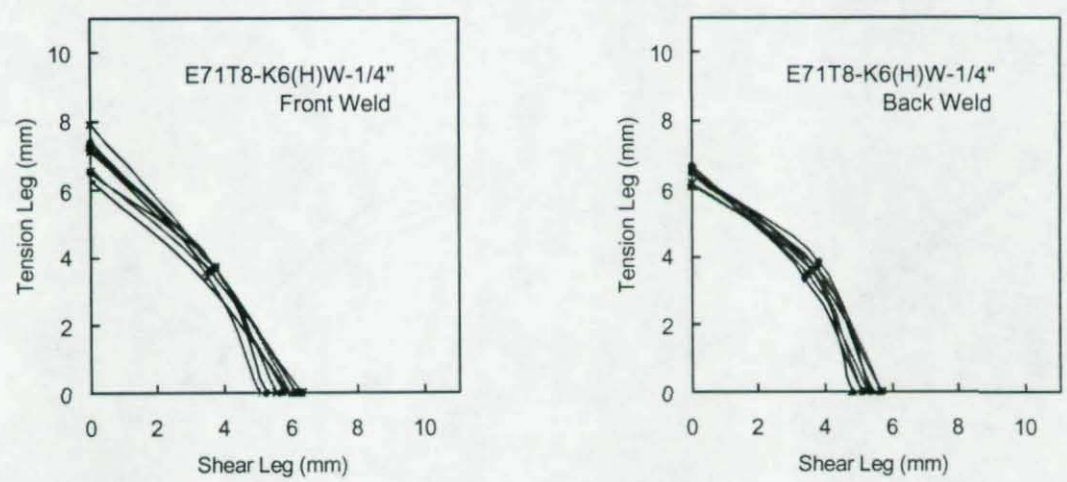


Figure C54 – Weld Profile for Specimen T18-3

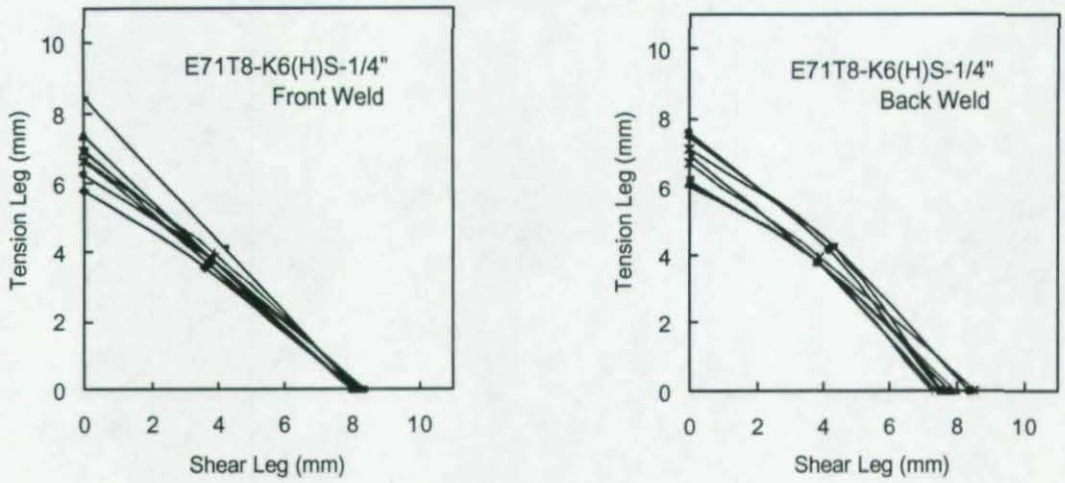


Figure C55 – Weld Profile for Specimen T19-1

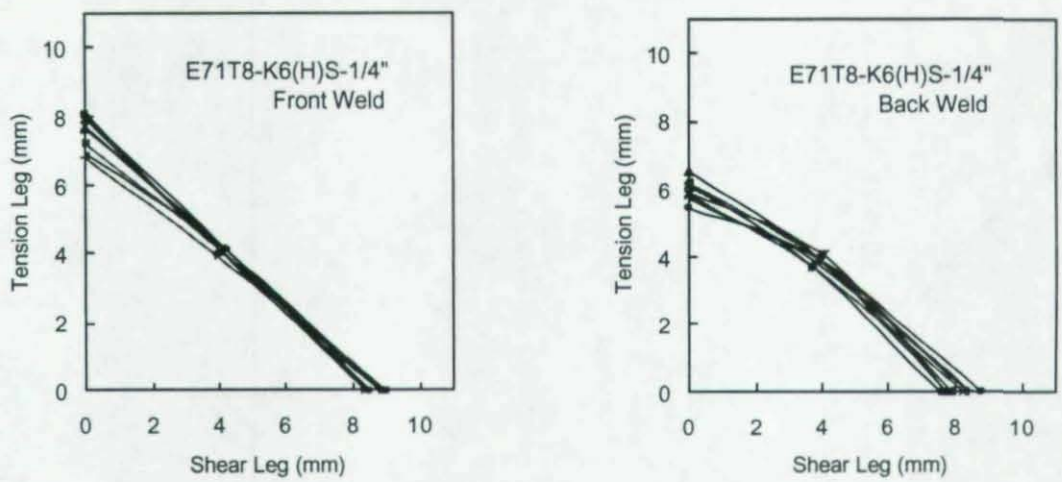


Figure C56 – Weld Profile for Specimen T19-2

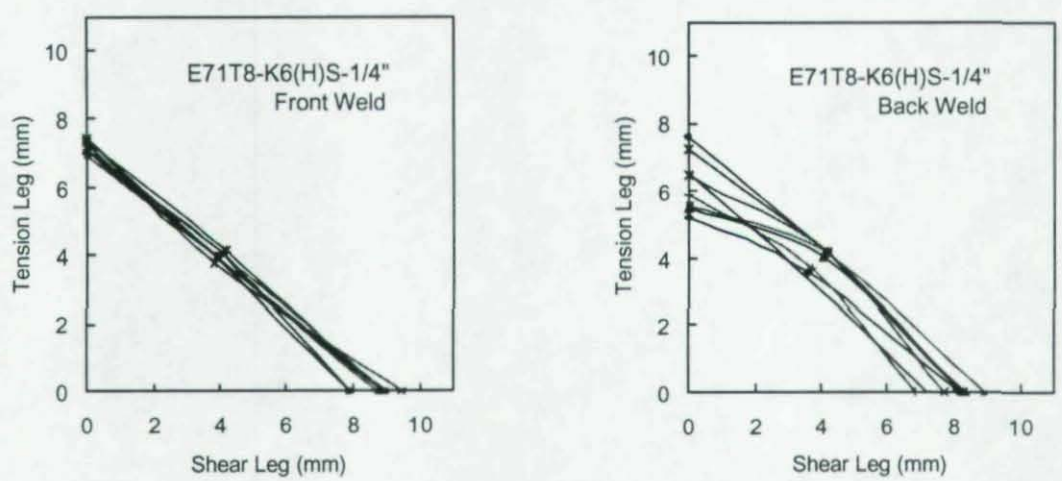


Figure C57 – Weld Profile for Specimen T19-3

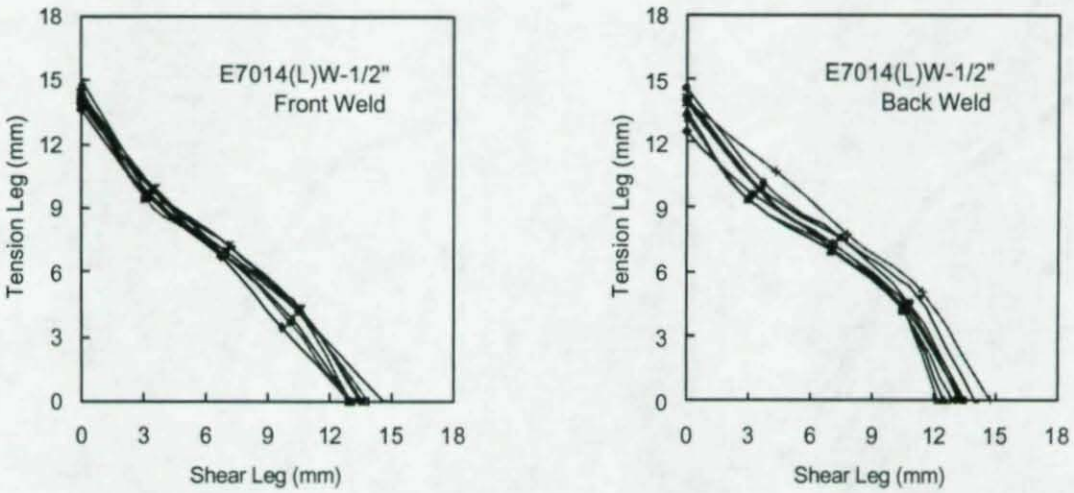


Figure C58 – Weld Profile for Specimen T20-1

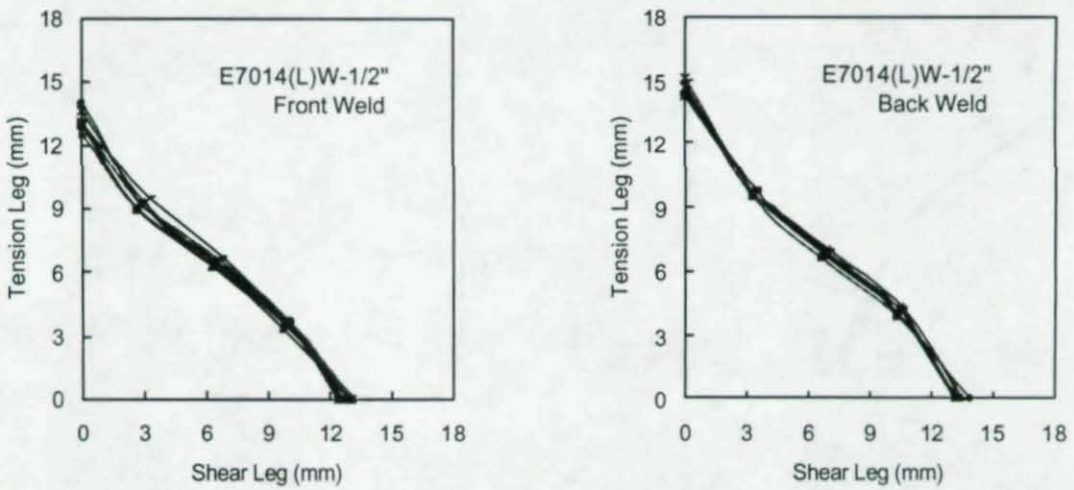


Figure C59 – Weld Profile for Specimen T20-2

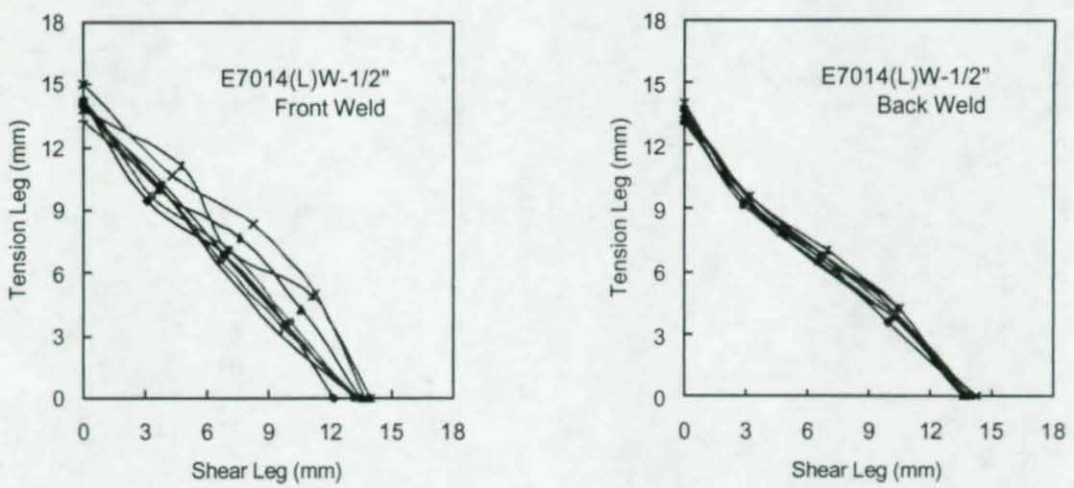


Figure C60 – Weld Profile for Specimen T20-3

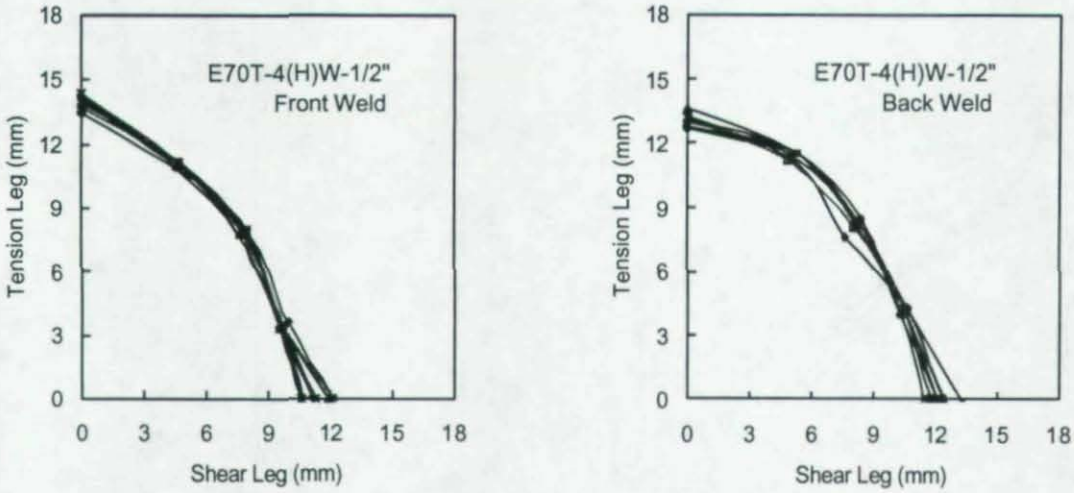


Figure C61 – Weld Profile for Specimen T21-1

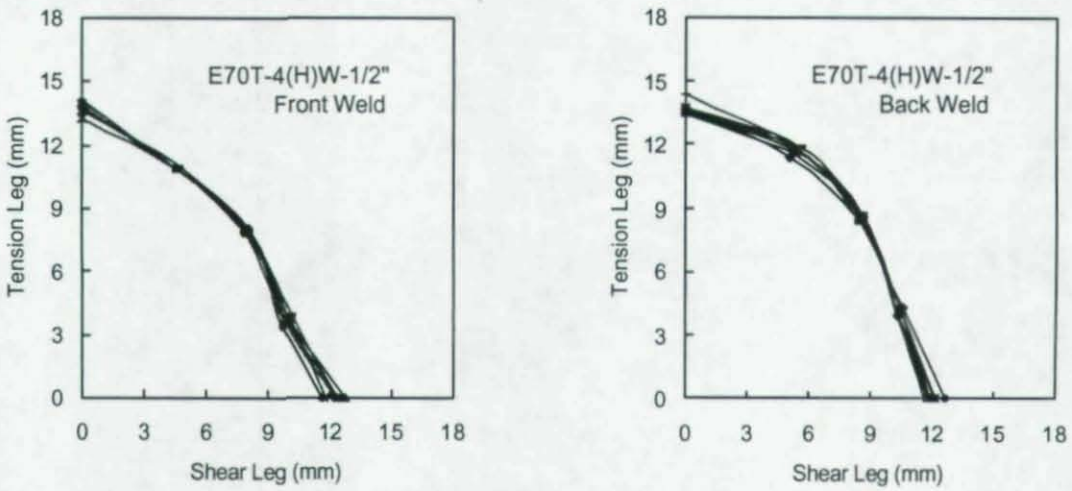


Figure C62 – Weld Profile for Specimen T21-2

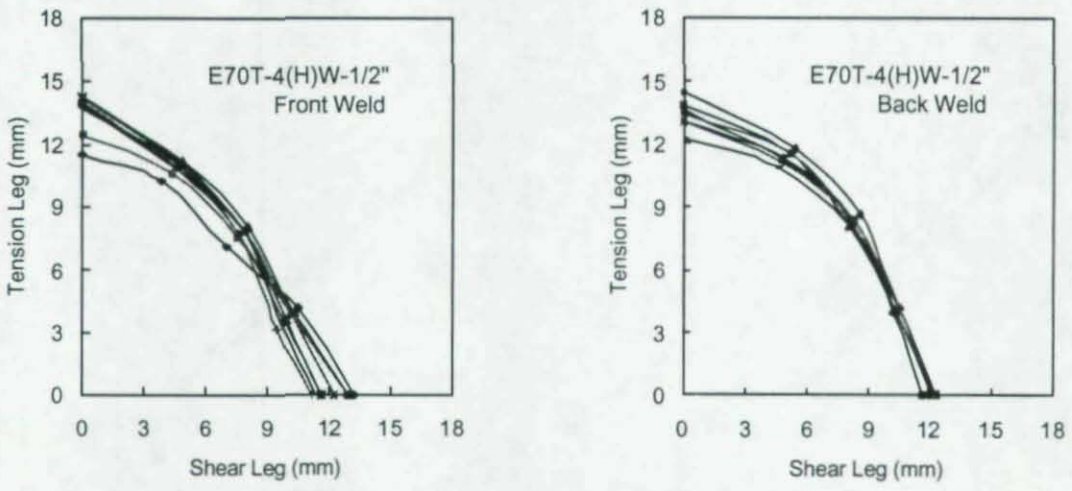


Figure C63 – Weld Profile for Specimen T21-3

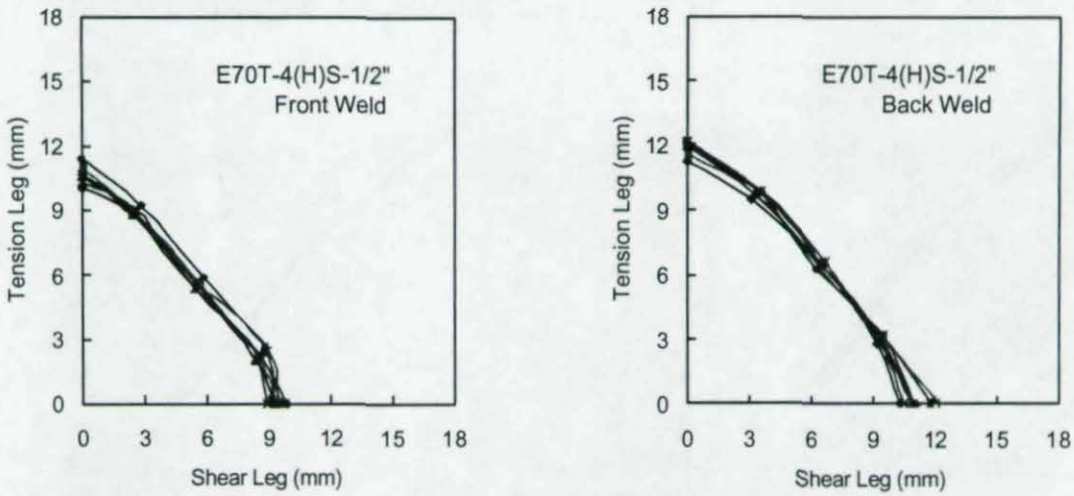


Figure C64 – Weld Profile for Specimen T22-1

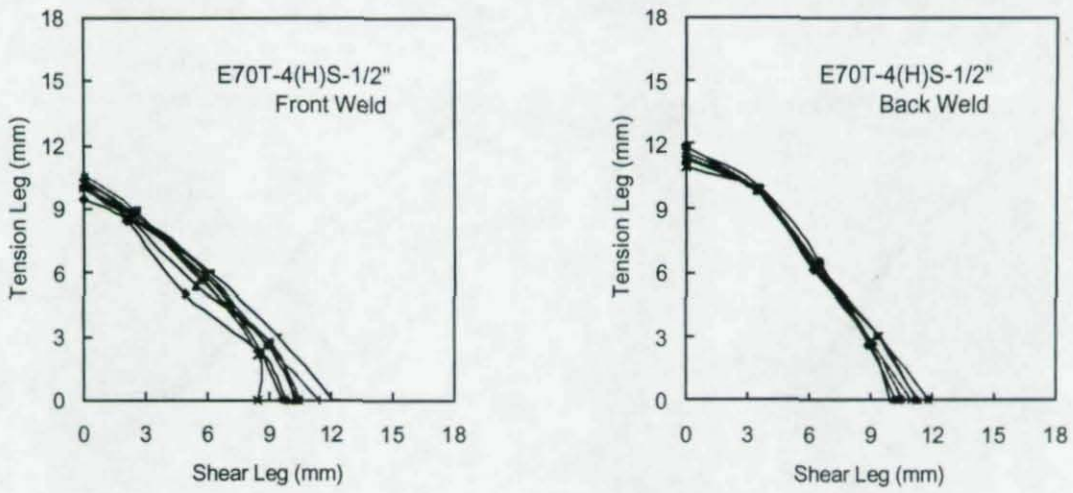


Figure C65 – Weld Profile for Specimen T22-2

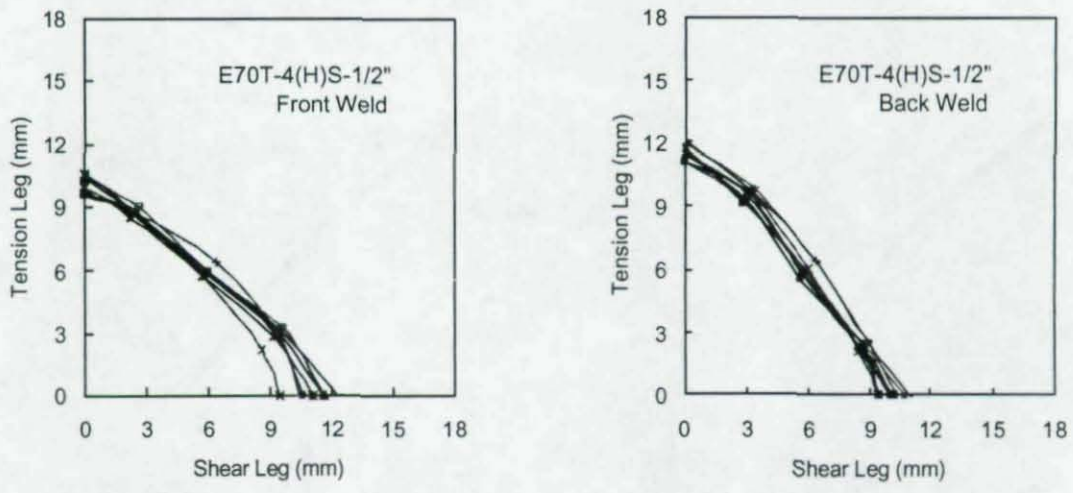


Figure C66 – Weld Profile for Specimen T22-3

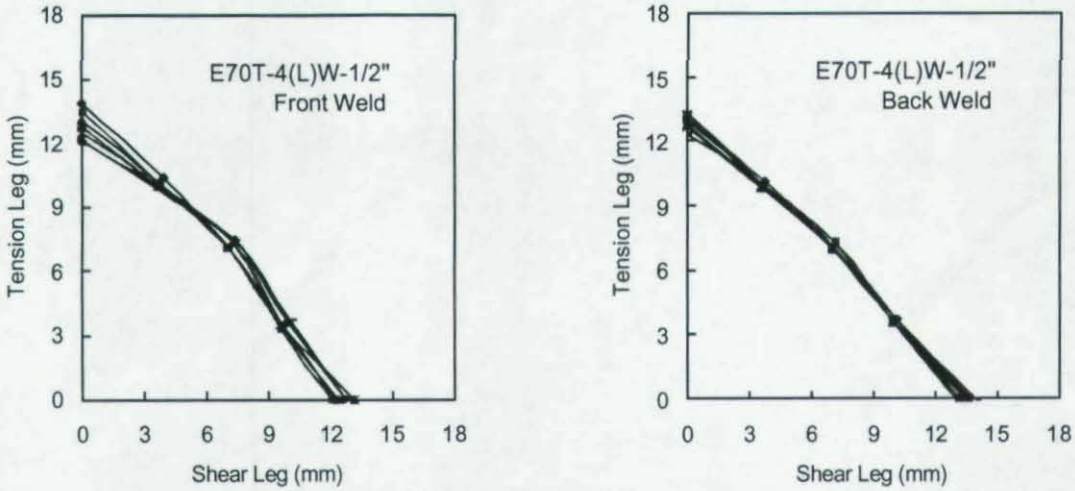


Figure C67 – Weld Profile for Specimen T23-1

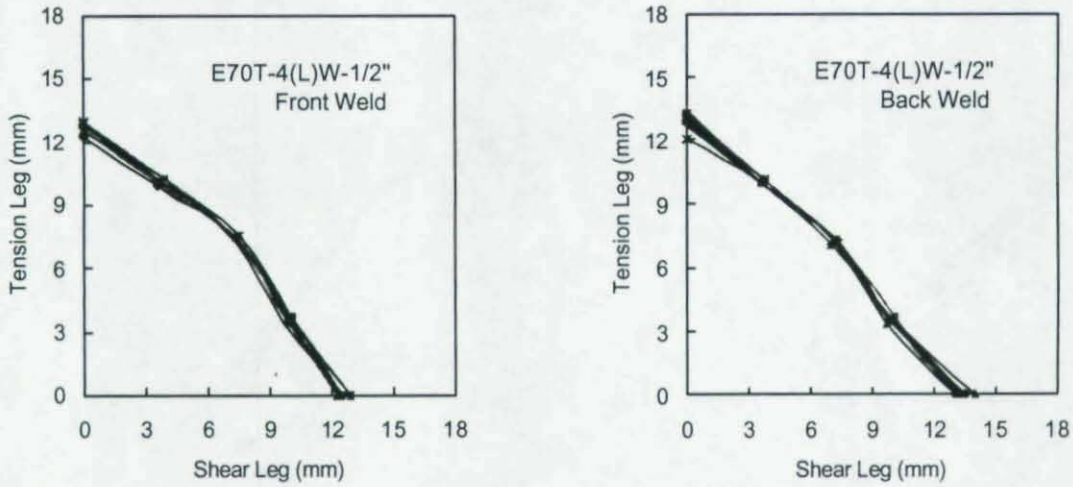


Figure C68 – Weld Profile for Specimen T23-2

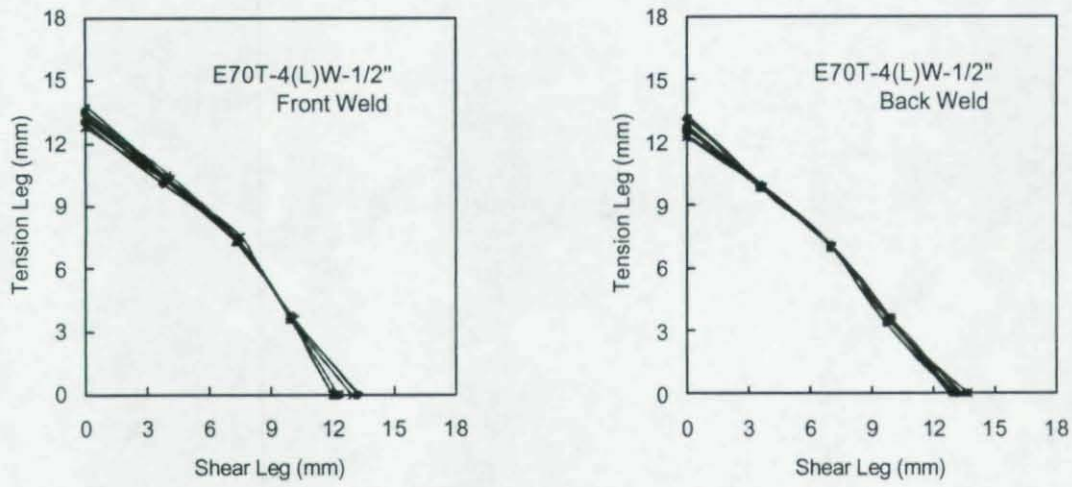


Figure C69 – Weld Profile for Specimen T23-3

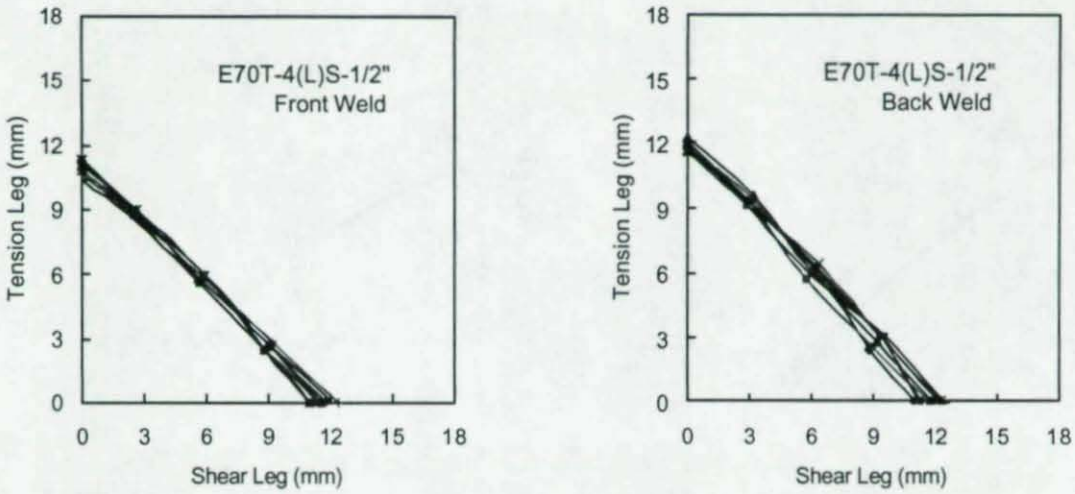


Figure C70 – Weld Profile for Specimen T24-1

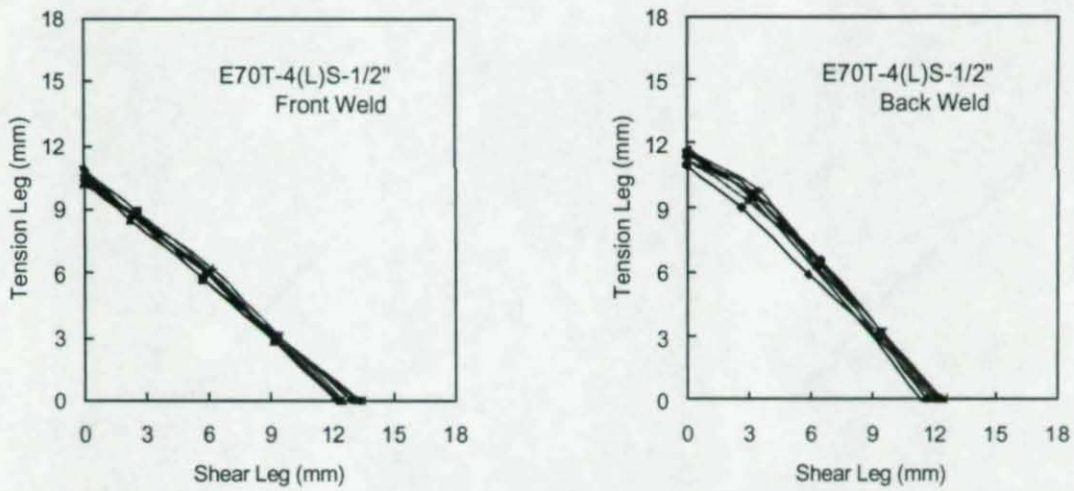


Figure C71 – Weld Profile for Specimen T24-2

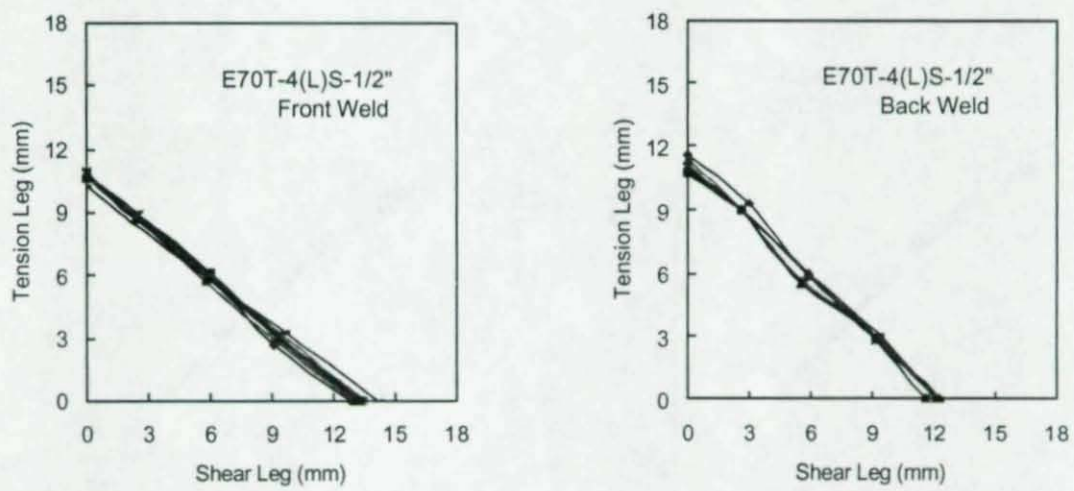


Figure C72 – Weld Profile for Specimen T24-3

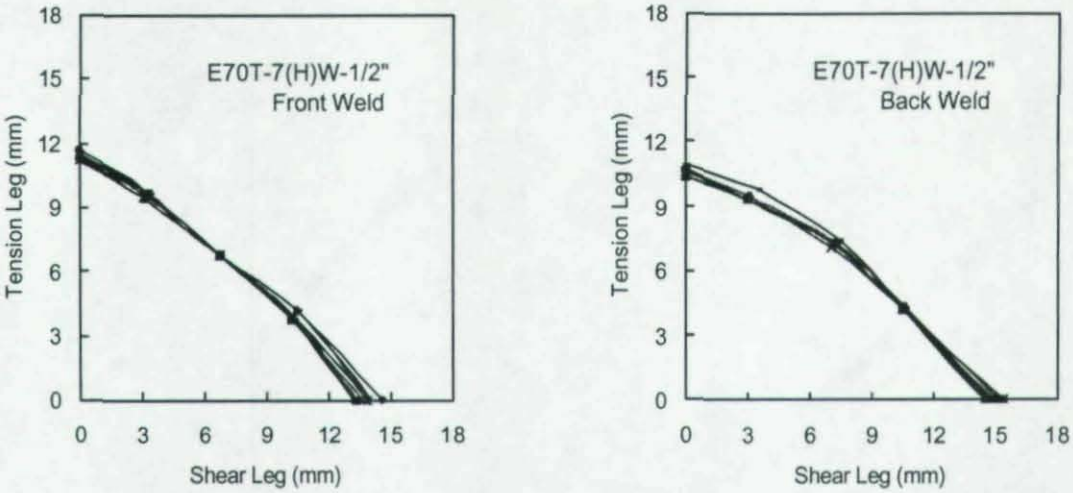


Figure C73 – Weld Profile for Specimen T25-1

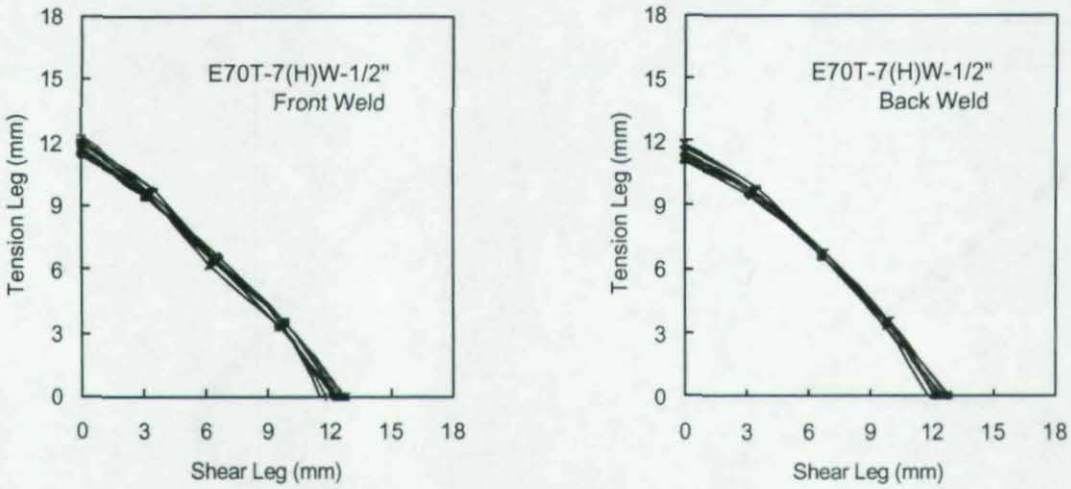


Figure C74 – Weld Profile for Specimen T25-2

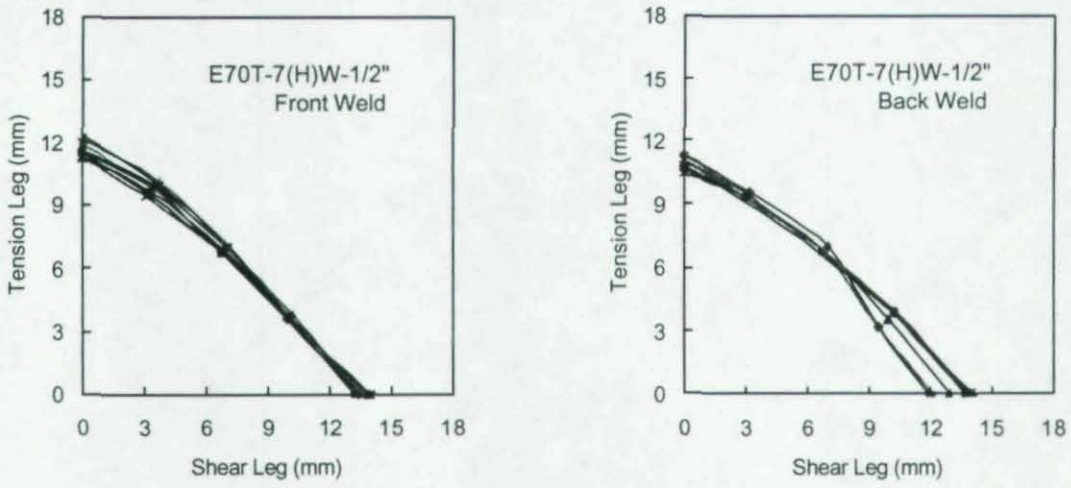


Figure C75 – Weld Profile for Specimen T25-3

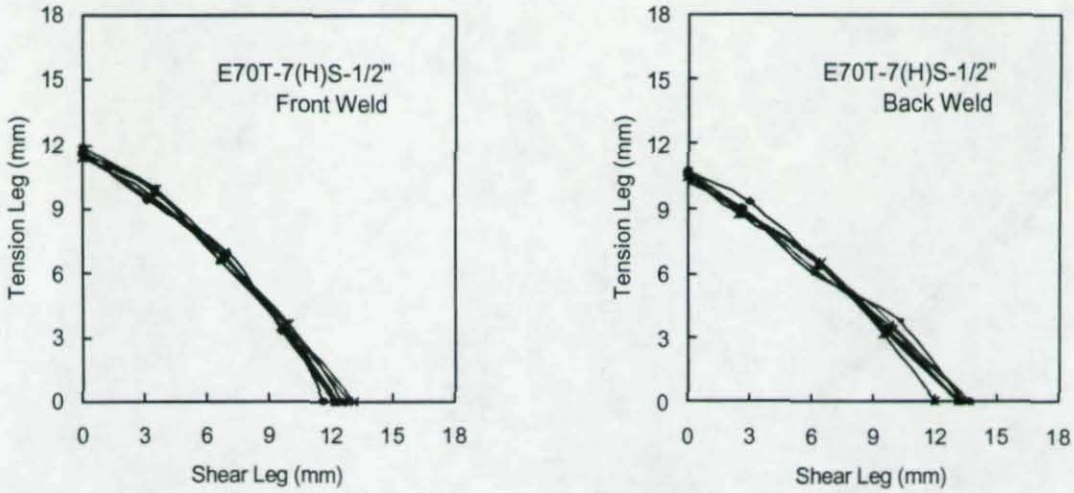


Figure C76 – Weld Profile for Specimen T26-1

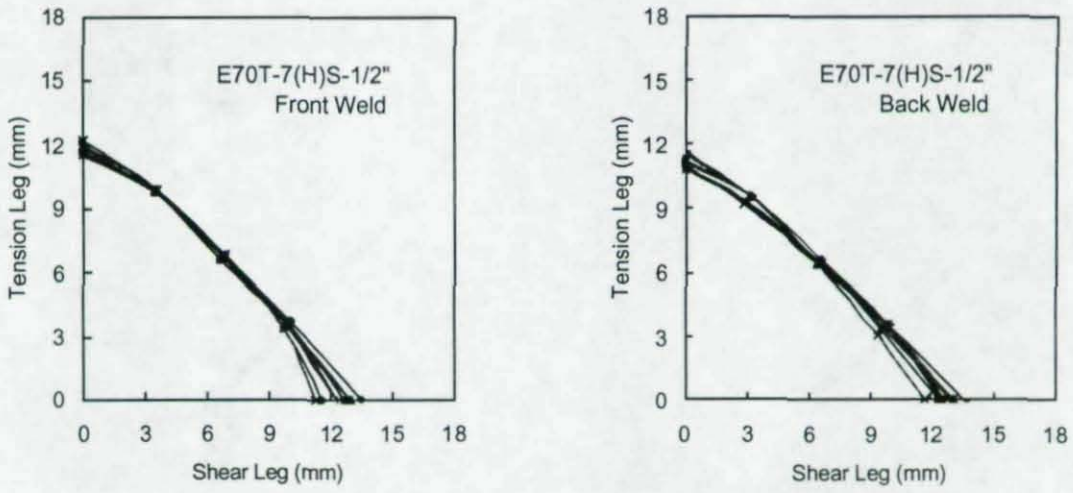


Figure C77 – Weld Profile for Specimen T26-2

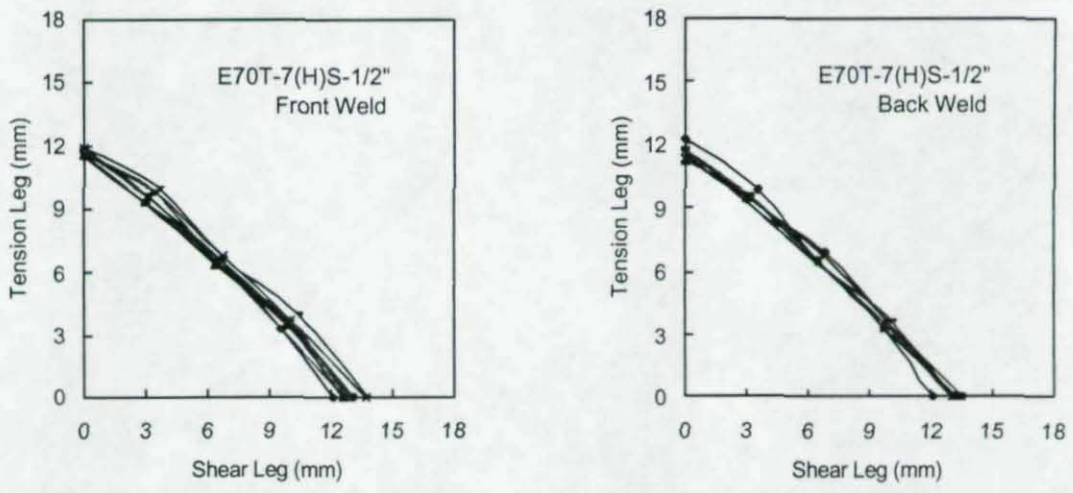


Figure C78 – Weld Profile for Specimen T26-3

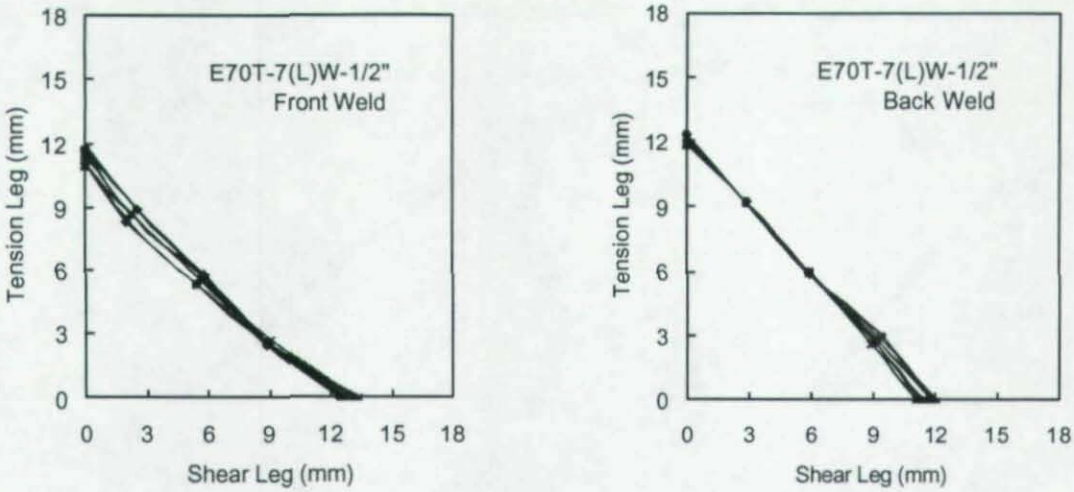


Figure C79 – Weld Profile for Specimen T27-1

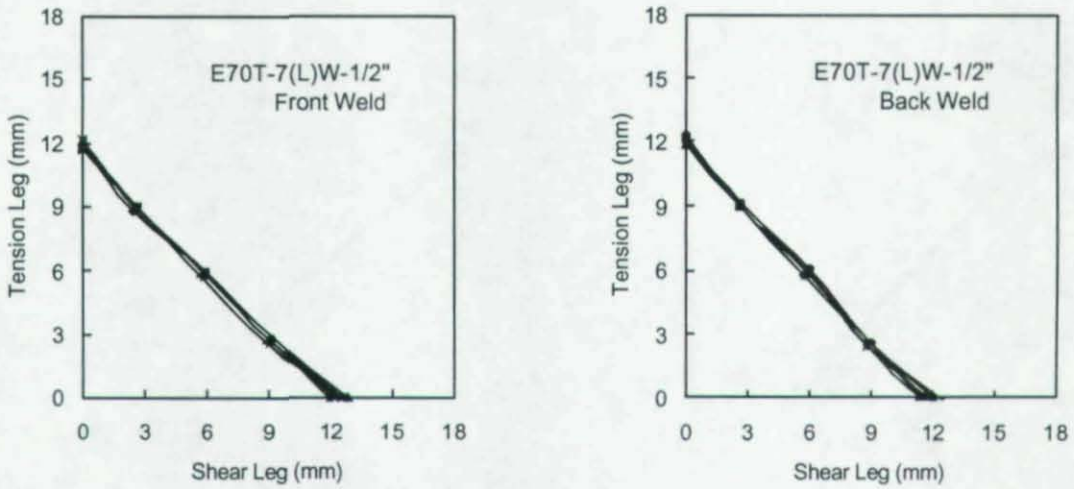


Figure C80 – Weld Profile for Specimen T27-2

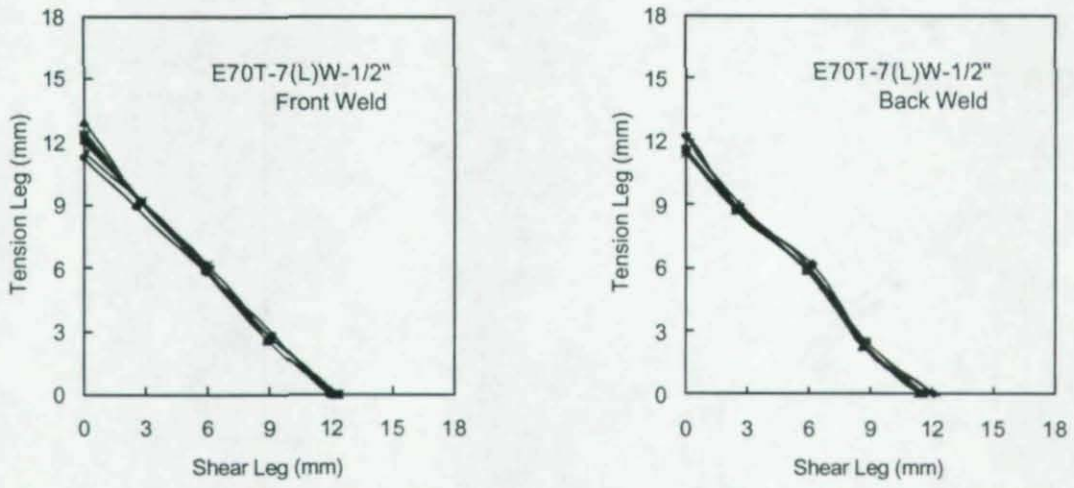


Figure C81 – Weld Profile for Specimen T27-3

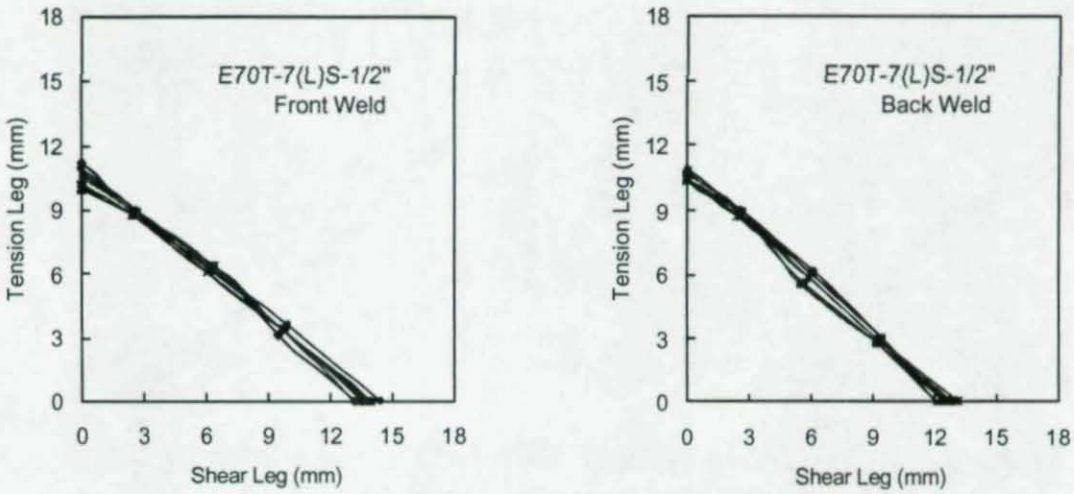


Figure C82 – Weld Profile for Specimen T28-1

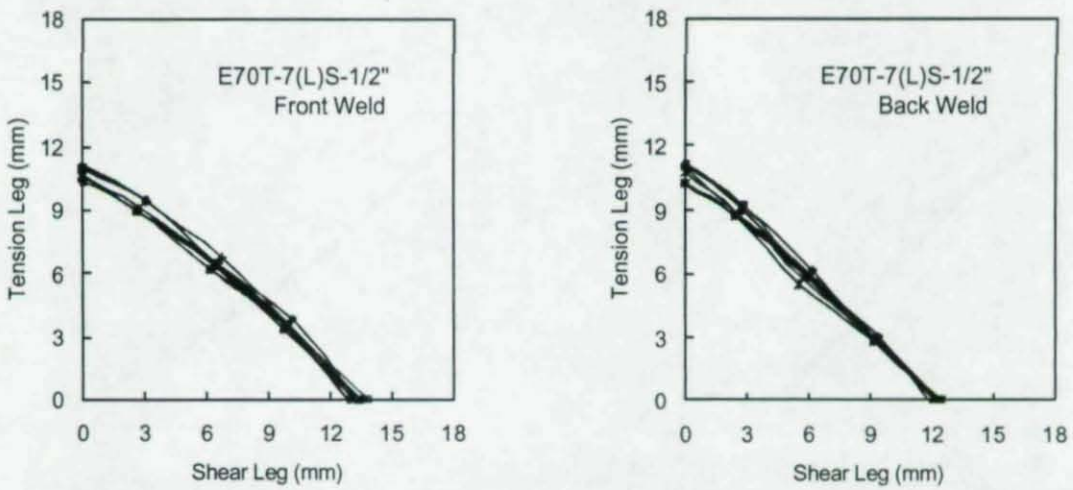


Figure C83 – Weld Profile for Specimen T28-2

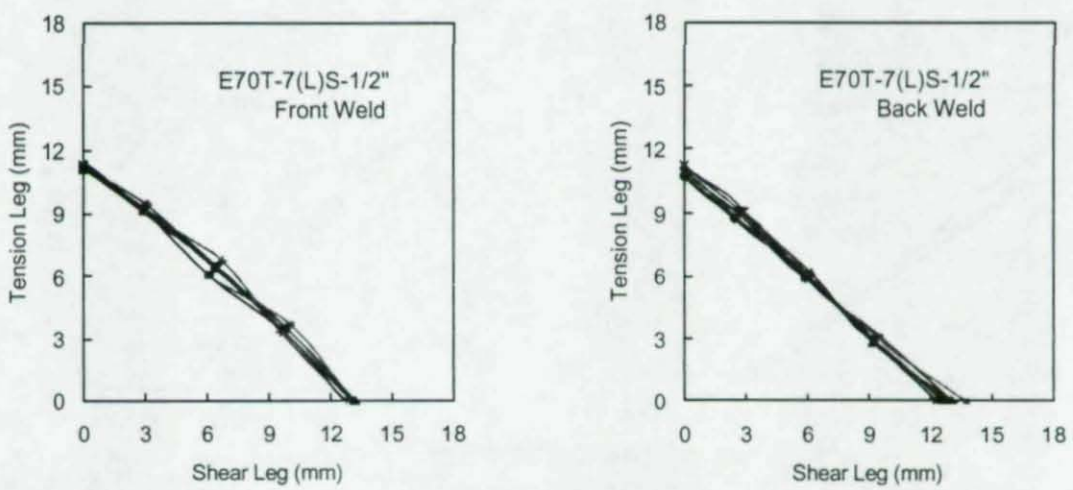


Figure C84 – Weld Profile for Specimen T28-3

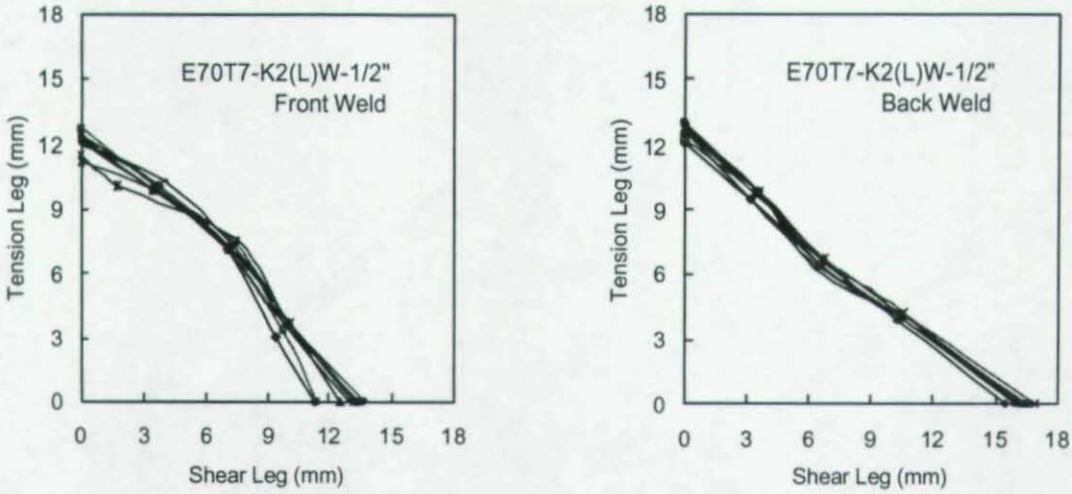


Figure C85 – Weld Profile for Specimen T29-1

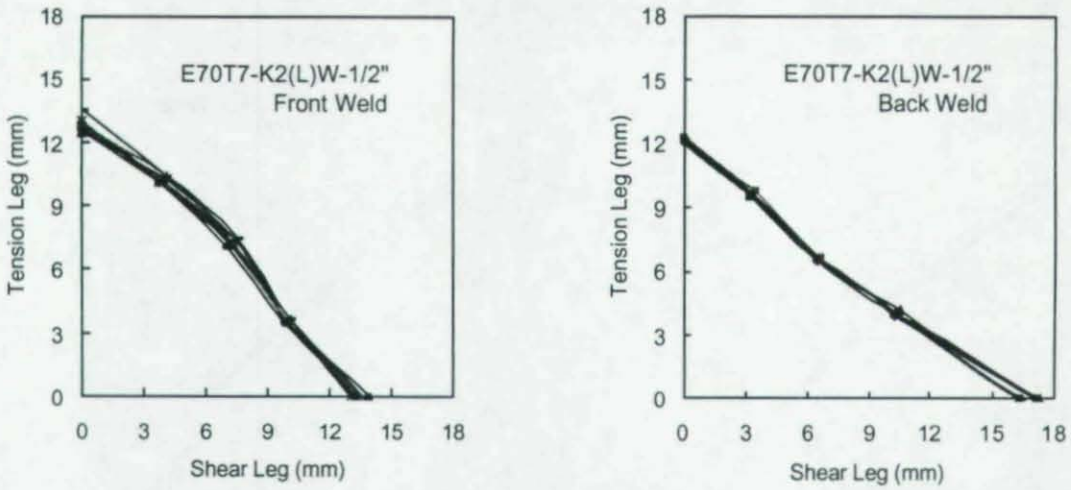


Figure C86 – Weld Profile for Specimen T29-2

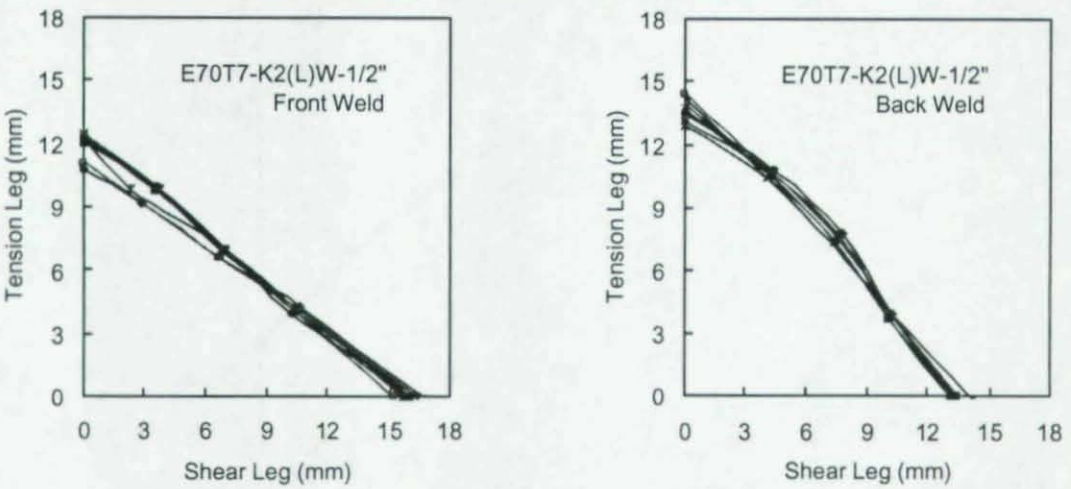


Figure C87 – Weld Profile for Specimen T29-3

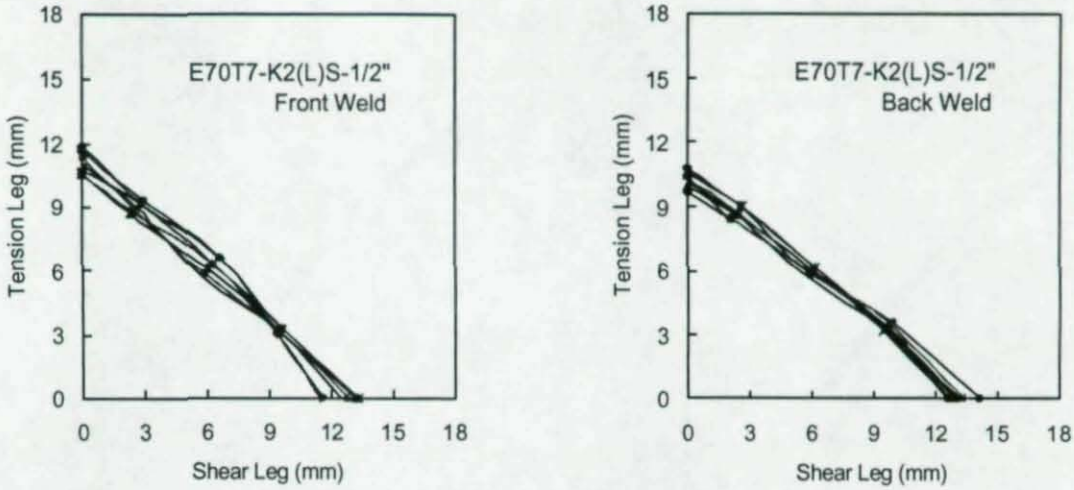


Figure C88 – Weld Profile for Specimen T30-1

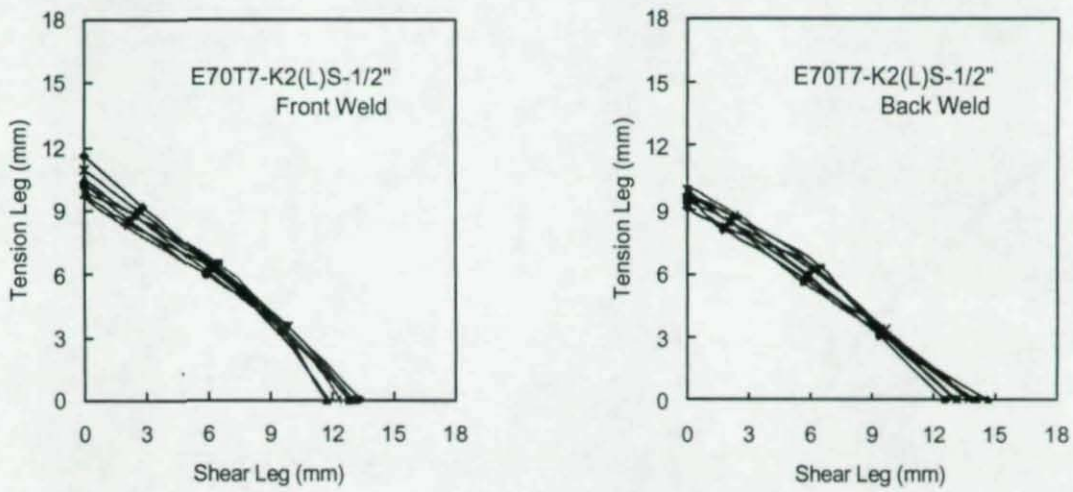


Figure C89 – Weld Profile for Specimen T30-2

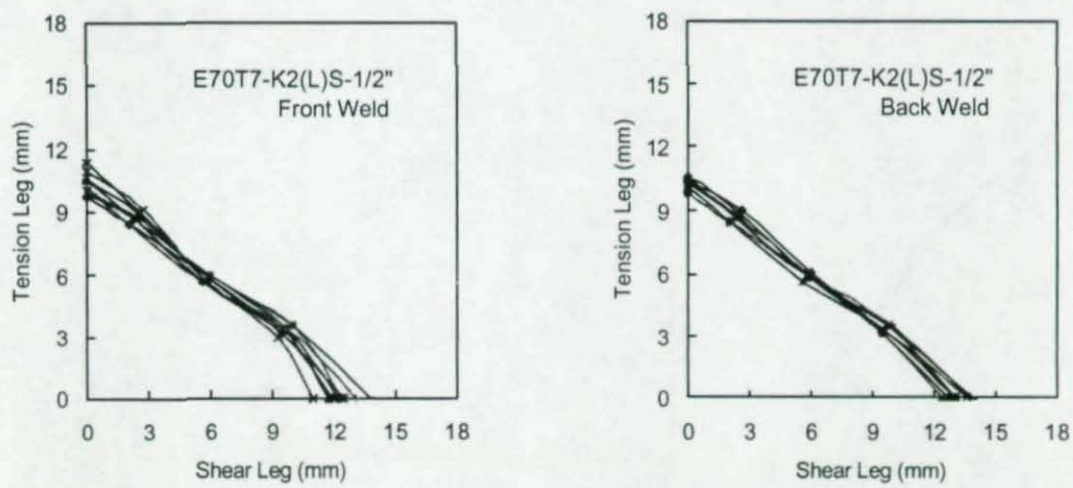


Figure C90 – Weld Profile for Specimen T30-3

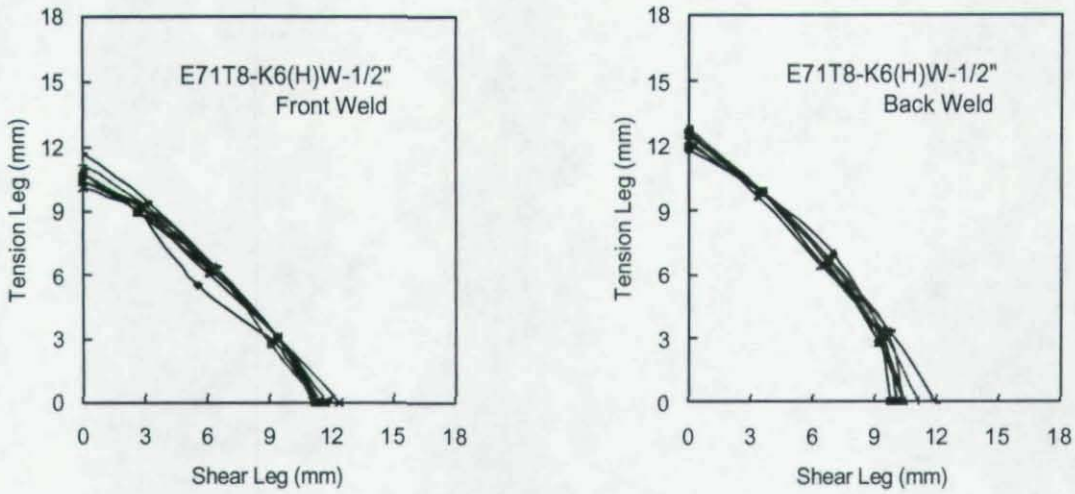


Figure C91 – Weld Profile for Specimen T31-1

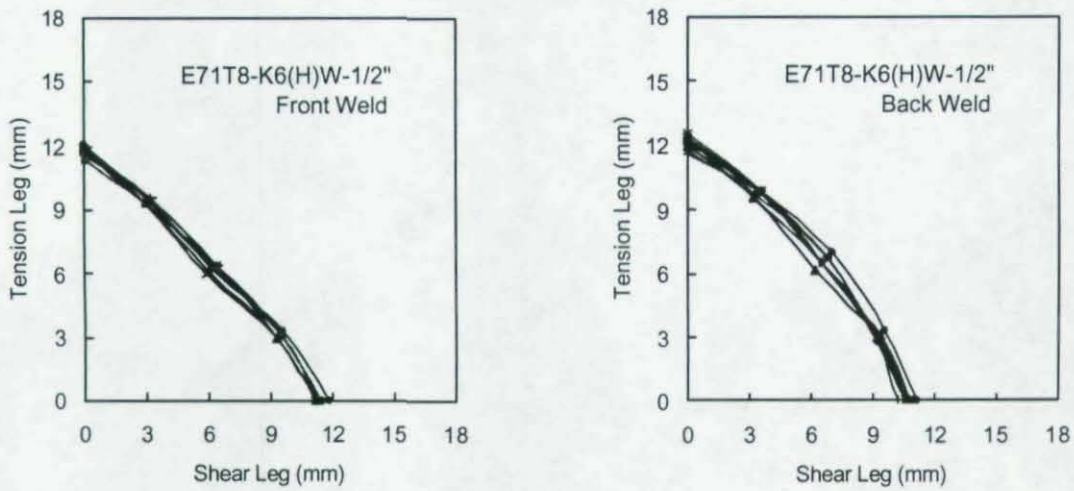


Figure C92 – Weld Profile for Specimen T31-2

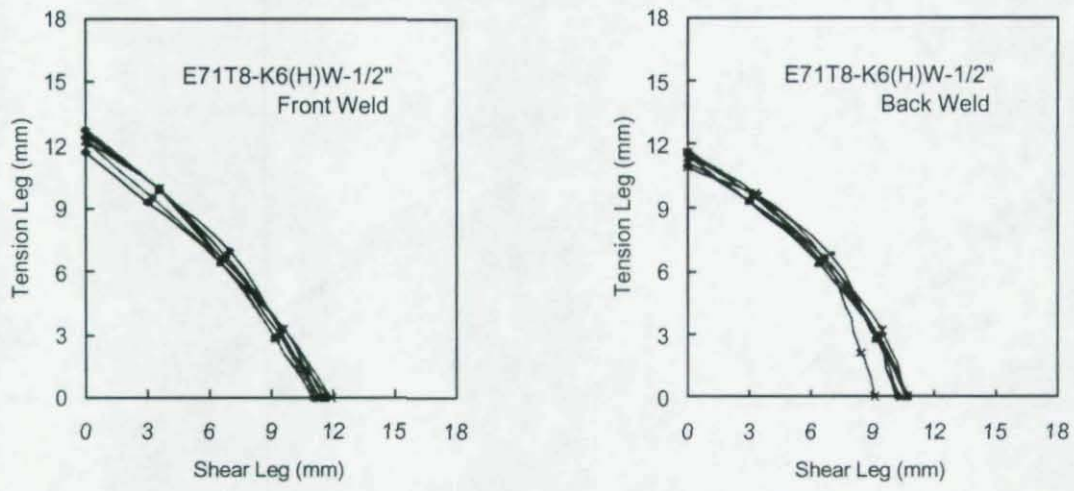


Figure C93 – Weld Profile for Specimen T31-3

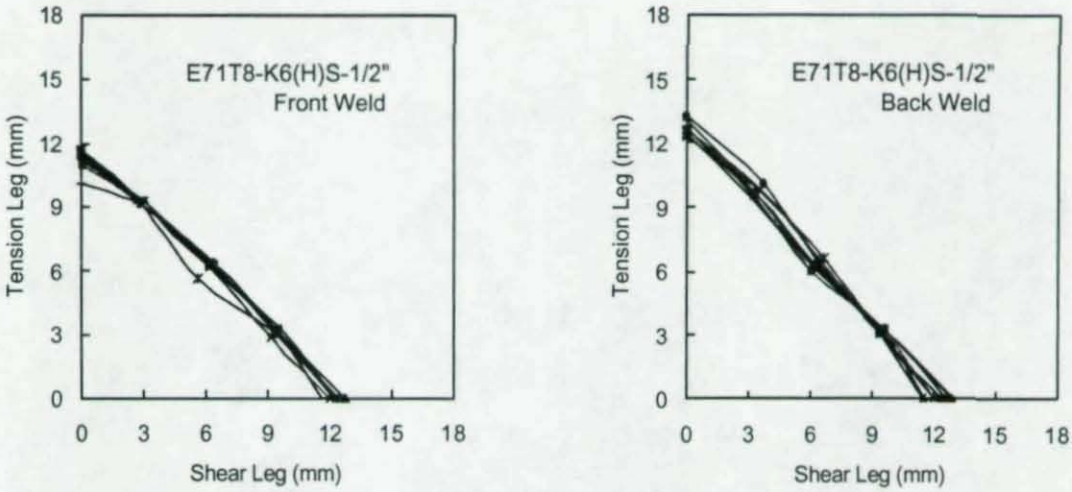


Figure C94 – Weld Profile for Specimen T32-1

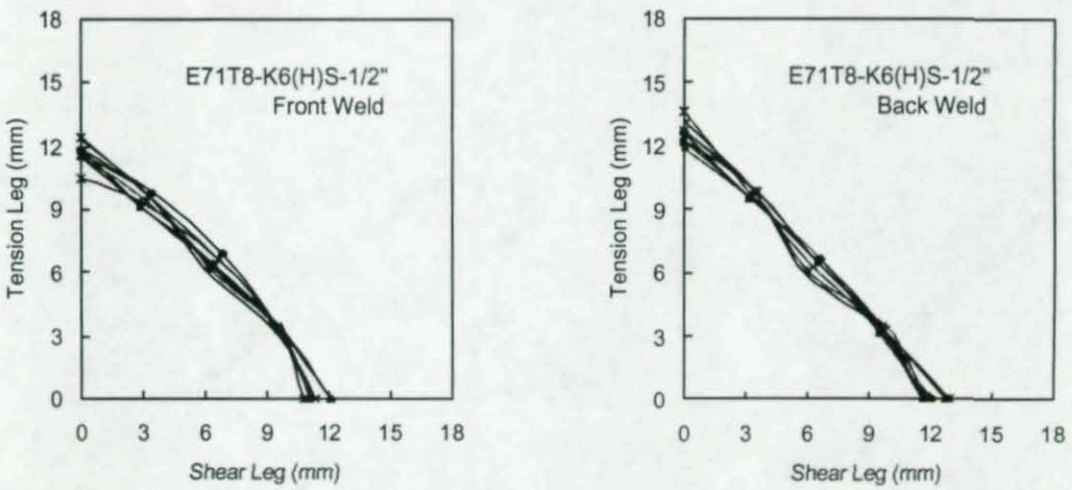


Figure C95 – Weld Profile for Specimen T32-2

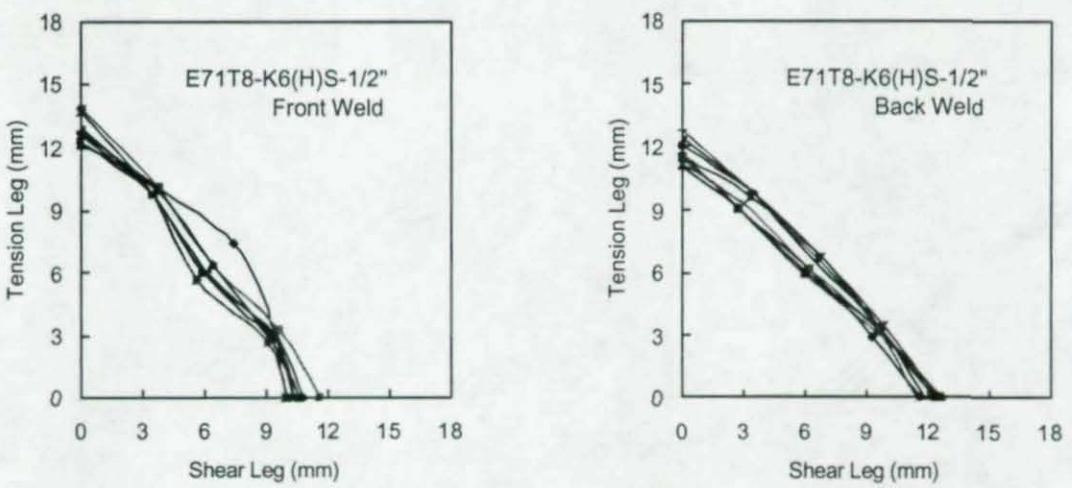


Figure C96 – Weld Profile for Specimen T32-3

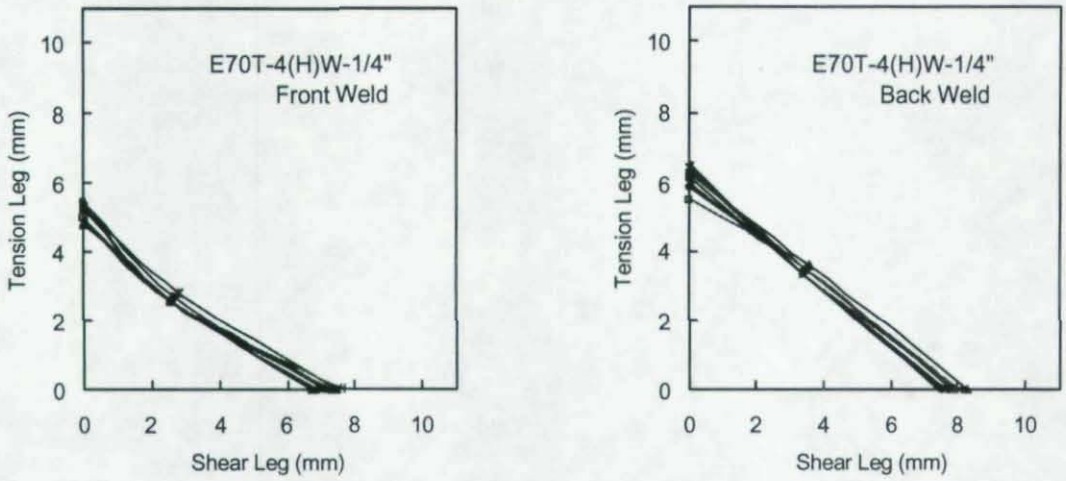


Figure C97 – Weld Profile for Specimen C1-1

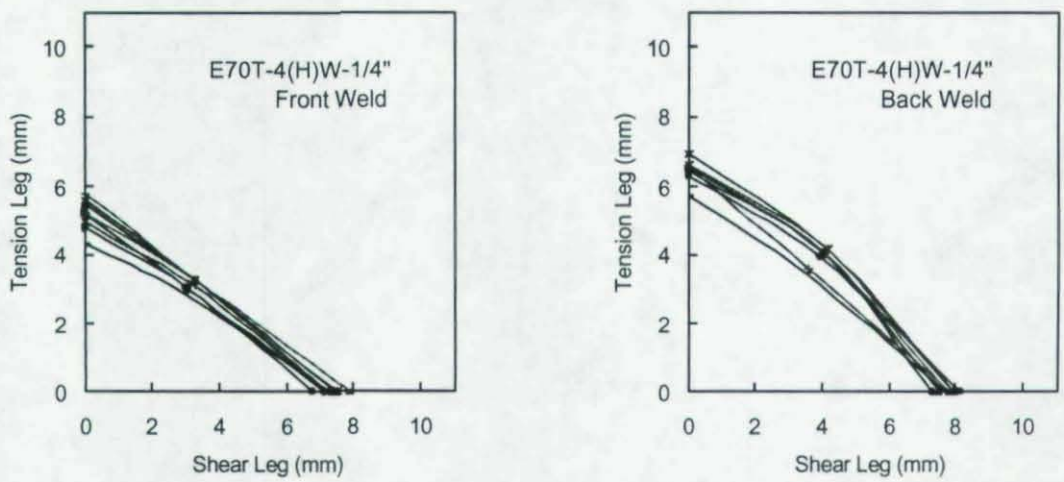


Figure C98 – Weld Profile for Specimen C1-2

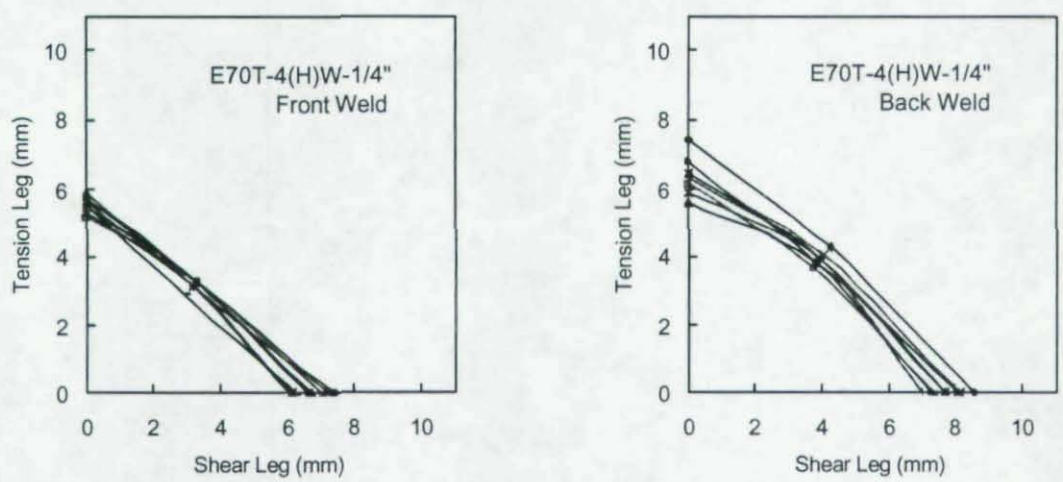


Figure C99 – Weld Profile for Specimen C1-3

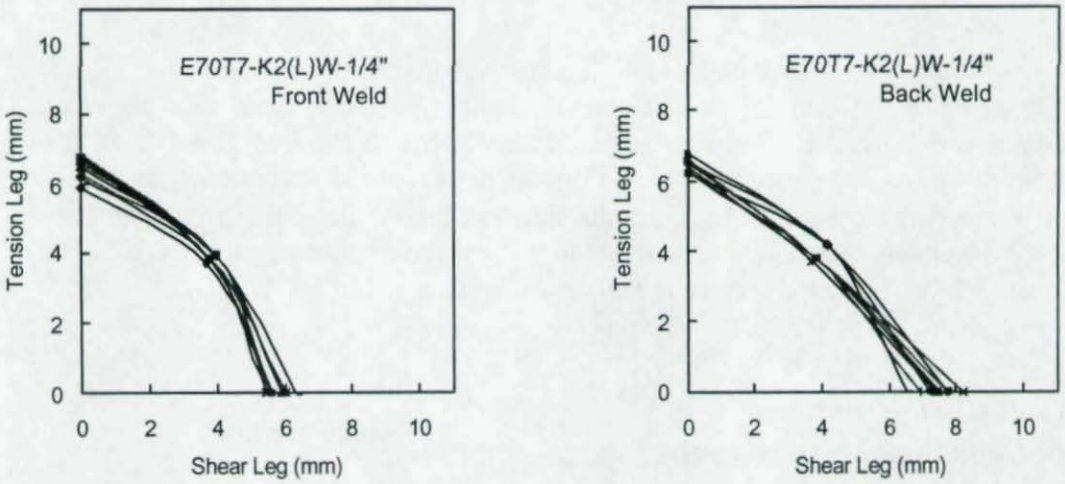


Figure C100 – Weld Profile for Specimen C2-1

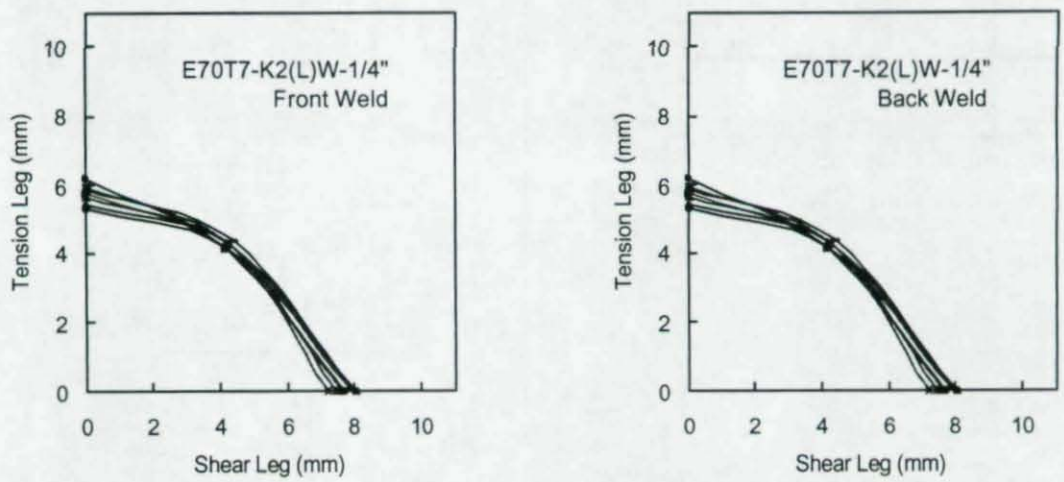


Figure C101 – Weld Profile for Specimen C2-2

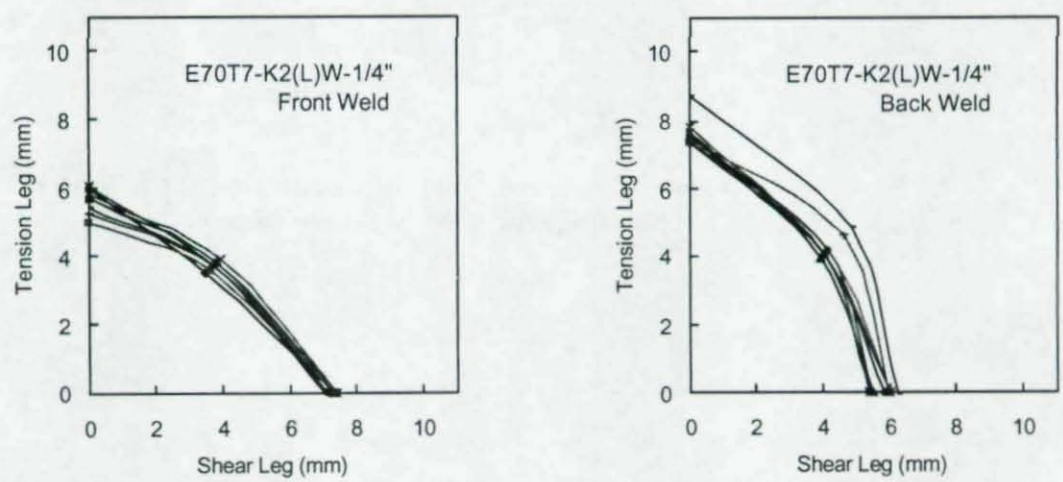


Figure C102 – Weld Profile for Specimen C2-3

Cruciform Specimen Measurements

The out-of-straightness of the cruciform specimens was measured as indicated in Figure C103. Measurements t and b are the perpendicular distances from the projected centerlines of the top and bottom base plates, respectively, to the line of action of the load. These distances were measured at the midlength, L, of the specimen. The line of action of the load is assumed to be along the line that bisects the thickness of the base plates at the specimen ends and is shown as the vertical dashed line in Figure C103. For all specimens, the offsets t and b were in the same direction.

Table C104 – Cruciform Out-of-Straightness Measurements

Specimen Designation	t* (mm)	b* (mm)	L (mm)
C1-1	1	2	262
C1-2	2	2	261
C1-3	3	1	261
C2-1	Not measured		
C2-2	-2	-2	265
C2-3	Not measured		

* Measurement values are positive as shown on Figure C103

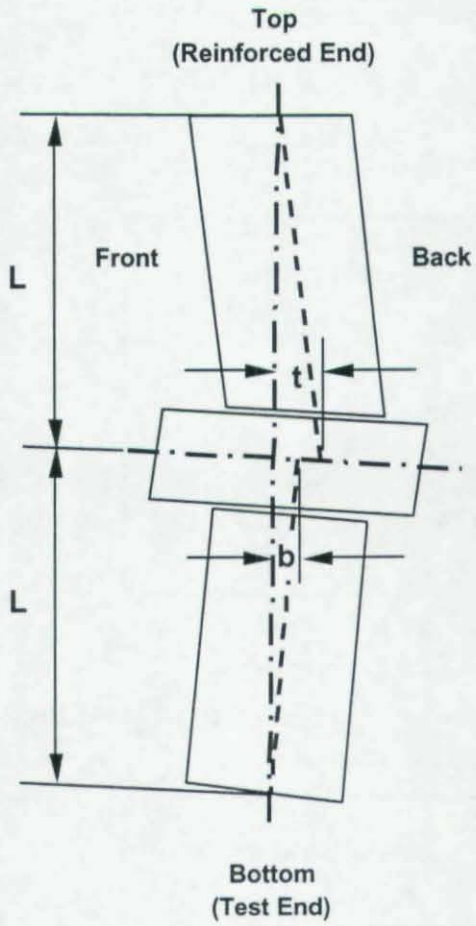


Figure C103 – Side View of Cruciform (Not to Scale)
Showing Out-of-Straightness Measurements

Appendix D

Material Tension Coupon Test Results

Table D1 – Plate Tension Coupon Test Results

Nominal Thickness	Coupon Number	Static Yield Strength (MPa)	Static Tensile Strength (MPa)	Modulus of Elasticiy (MPa)	Elongation [2] (%)	Reduction of Area (%)
9.5 mm	1	416	550	215 900	29.5	52.5
	2	419	551	199 000	31.4	51.9
	Mean	**418**	**551**	**207 500**	**30.5**	**52.2**
15.9 mm	1	347	466	202 700	38.2	66.6
	2	347	465	200 100	38.2	67.2
	Mean	**347**	**466**	**201 400**	**38.2**	**66.9**
19.1 mm	1	392	528	194 700	40.6	64.2
	2	392	526	196 100	40.4	65.1
	Mean	**392**	**527**	**195 400**	**40.5**	**64.6**
25.4 mm	1	388	538	201 800	40.9	62.8
	2	385	538	201 300	40.9	64.1
	Mean	**386**	**538**	**201 600**	**40.9**	**63.4**

Table D2 – Weld Metal Tension Coupon Test Results

Assembly Designation	Identifier	Coupon Number	Static Yield Strength (MPa)	Static Tensile Strength (MPa)	Modulus of Elasticiy (MPa)	Elongation [2] (%)	Reduction of Area (%)
A1	E7014(L)W	1	448	517	200 400	20.6	51.7
		2	456	523	221 000	22.8	54.5
		Mean	**452**	**520**	**210 700**	**21.7**	**53.1**
A2	E70T-4(H)W	1	315	513	173 500	25.2	35.0
		2	312	513	214 500	25.0	45.3
		3	376	557	181 200	22.5	34.1
		4	383	— [3]	175 000	9.4 [3]	9.0
		5	383	557	183 200	19.9	40.4
		Mean	**354**	**535**	**185 500**	**23.2**	**32.7**
A3	E70T-4(H)S	1	470	630	206 100	21.1	36.5
		2	473	631	191 100	23.4	51.0
		Mean	**472**	**631**	**198 600**	**22.3**	**43.8**
A4	E70T-4(L)W	1	407	562	200 900	26.1	54.9
		2	407	563	205 900	29.5	55.2
		Mean	**407**	**562**	**203 400**	**27.8**	**55.0**
A5	E70T-7(H)W	1	465	609	201 300	23.6	49.2
		2	471	600	200 200	22.5	49.4
		Mean	**468**	**605**	**200 800**	**23.1**	**49.3**
A6	E70T-7(L)W	1	437	584	207 500	24.7	52.2
		2	453	— [3]	202 900	7.2 [3]	15.2
		Mean	**445**	**584**	**205 200**	**24.7**	**33.7**
A7	E70T-7(L)S	1	493	652	245 500	22.9	42.6
		2	473	— [3]	213 300	11.8 [3]	23.7
		Mean	**483**	**652**	**229 400**	**22.9**	**33.2**
A8	E70T7-K2(L)W	1	530	592	199 900	23.9	69.6
		2	523	591	214 200	25.3	68.8
		Mean	**527**	**592**	**207 100**	**24.6**	**69.2**
A9	E71T8-K6(H)W	1	413	485	199 400	32.1	71.4
		2	414	494	200 400	23.0	47.9
		Mean	**414**	**490**	**199 900**	**27.6**	**59.7**
A10	E71T8-K6(H)S	1	409	495	207 800	25.9	59.0
		2	395	491	206 900	30.8	74.1
		Mean	**402**	**493**	**207 400**	**28.4**	**66.6**

[1] Measured at 0.2% offset
[2] Measured on 50 mm gauge length
[3] Specimen fractured prior to reaching ultimate load

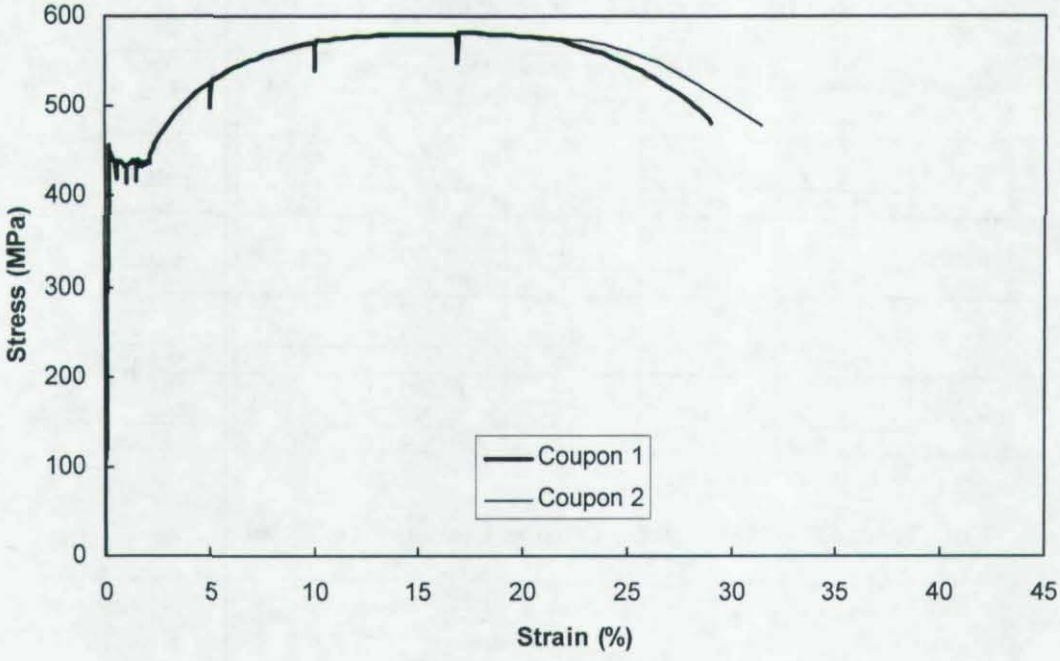


Figure D1 – Stress vs. Strain Curves for 9.5 mm Thick Plate

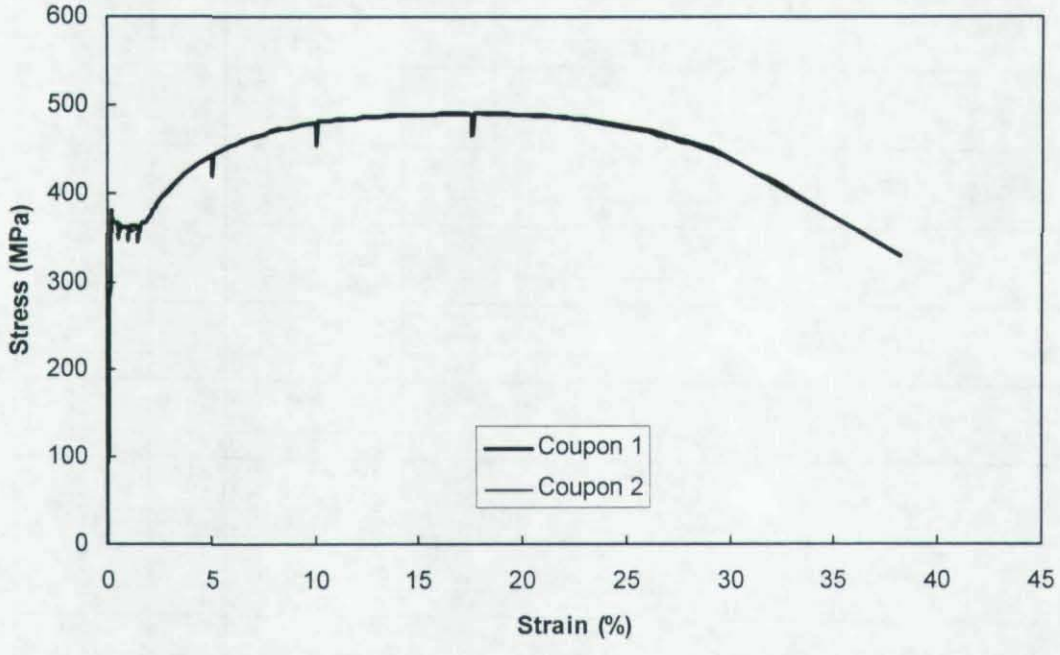


Figure D2 – Stress vs. Strain Curves for 15.9 mm Thick Plate

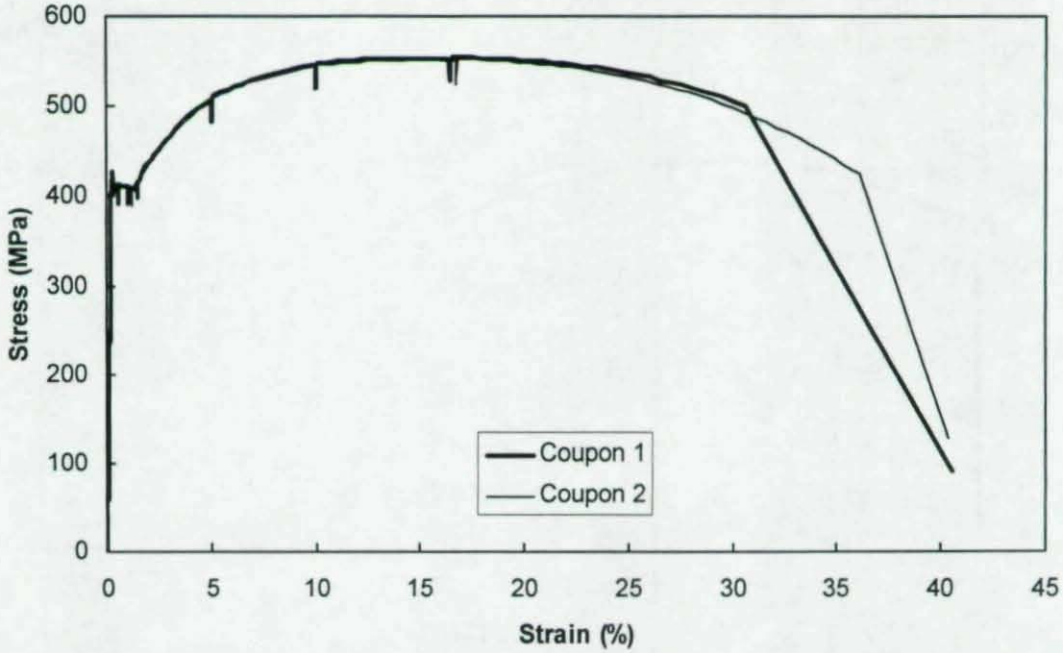


Figure D3 – Stress vs. Strain Curves for 19.1 mm Thick Plate

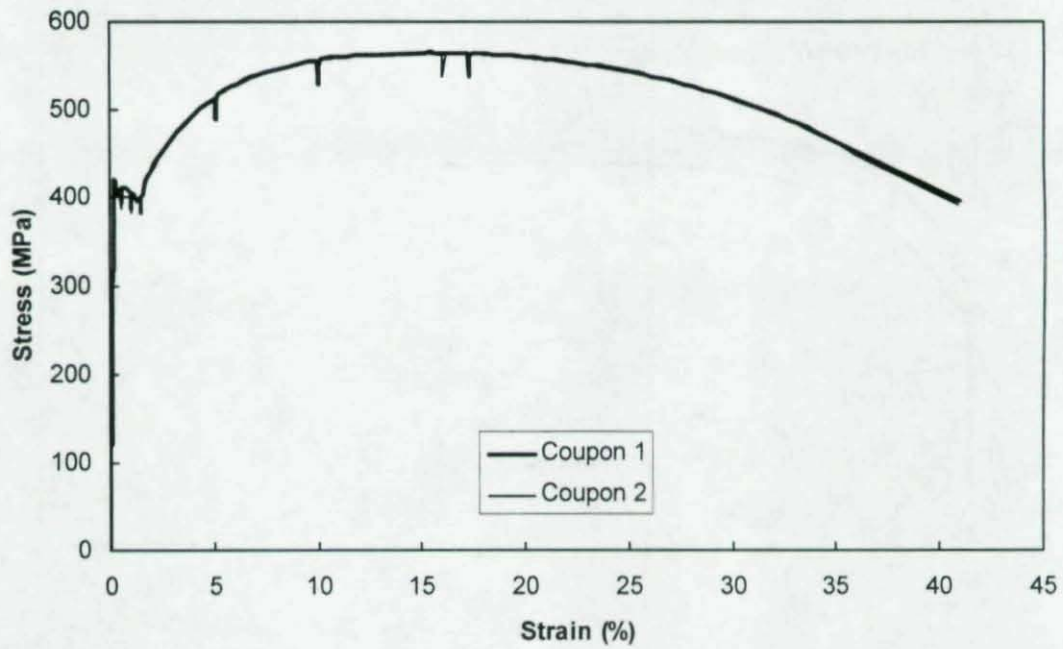


Figure D4 – Stress vs. Strain Curves for 25.4 mm Thick Plate

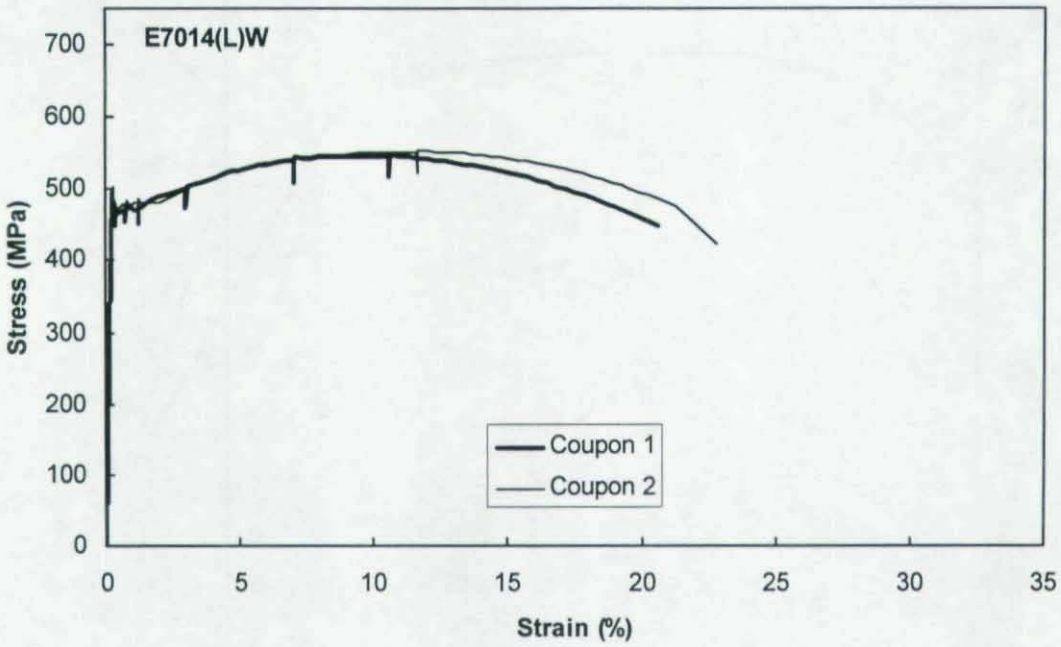


Figure D5 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A1

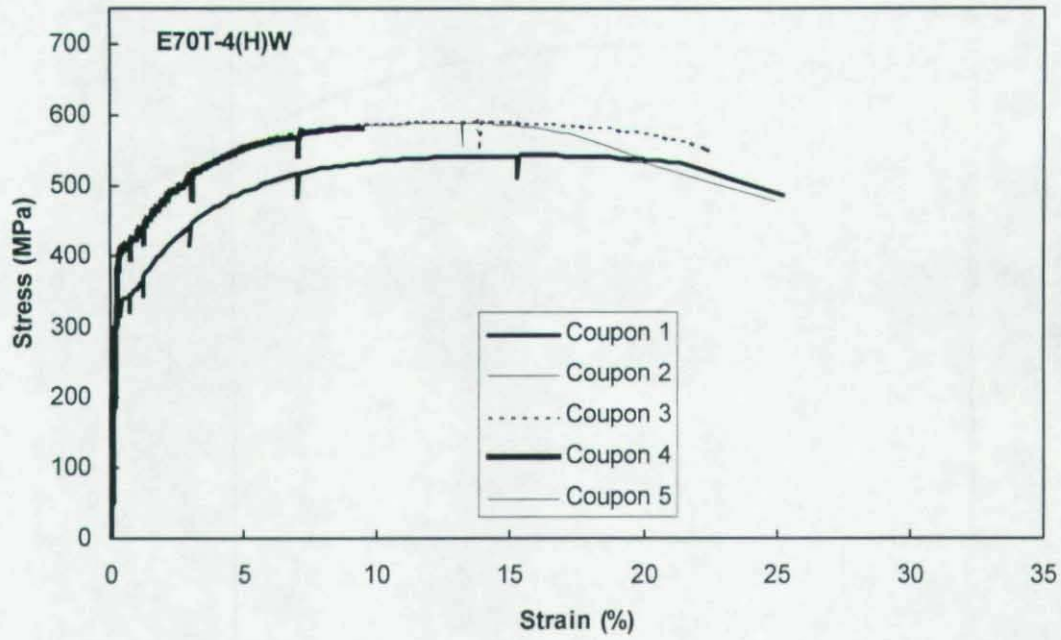


Figure D6 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A2

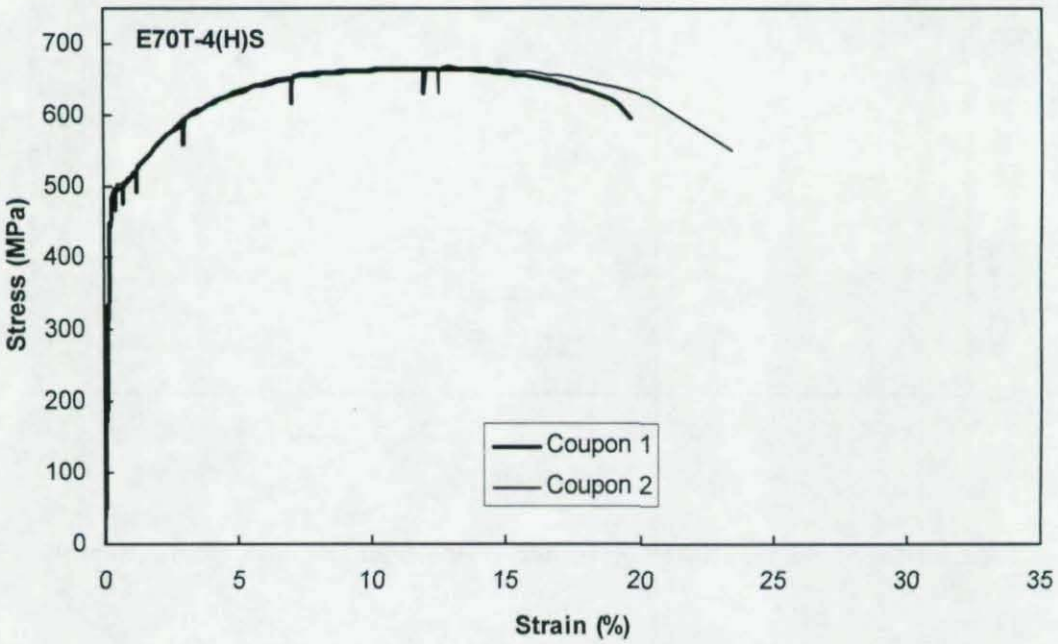


Figure D7 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A3

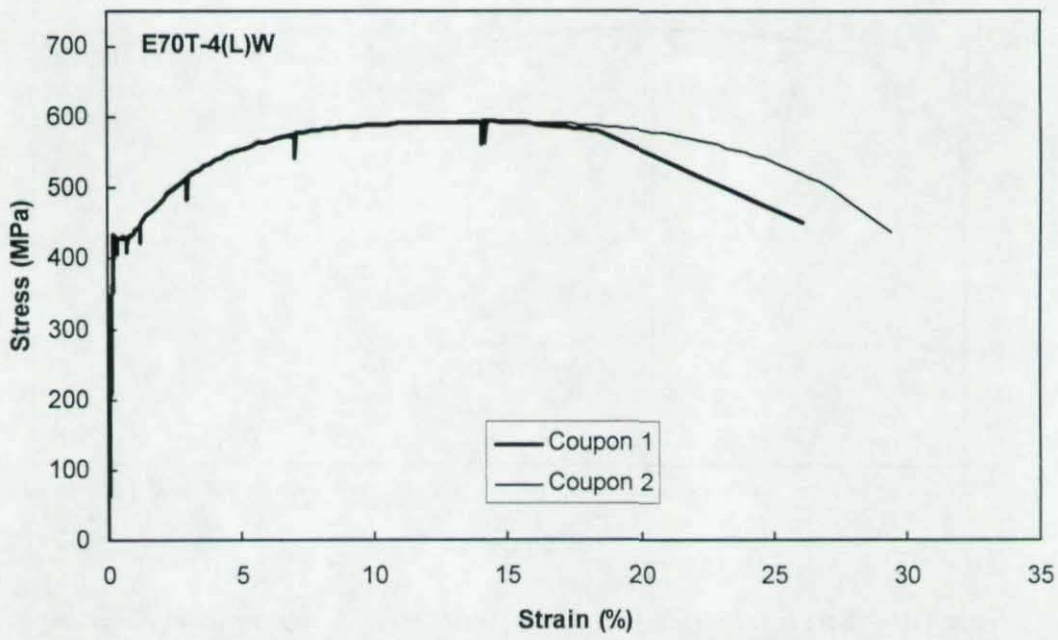


Figure D8 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A4

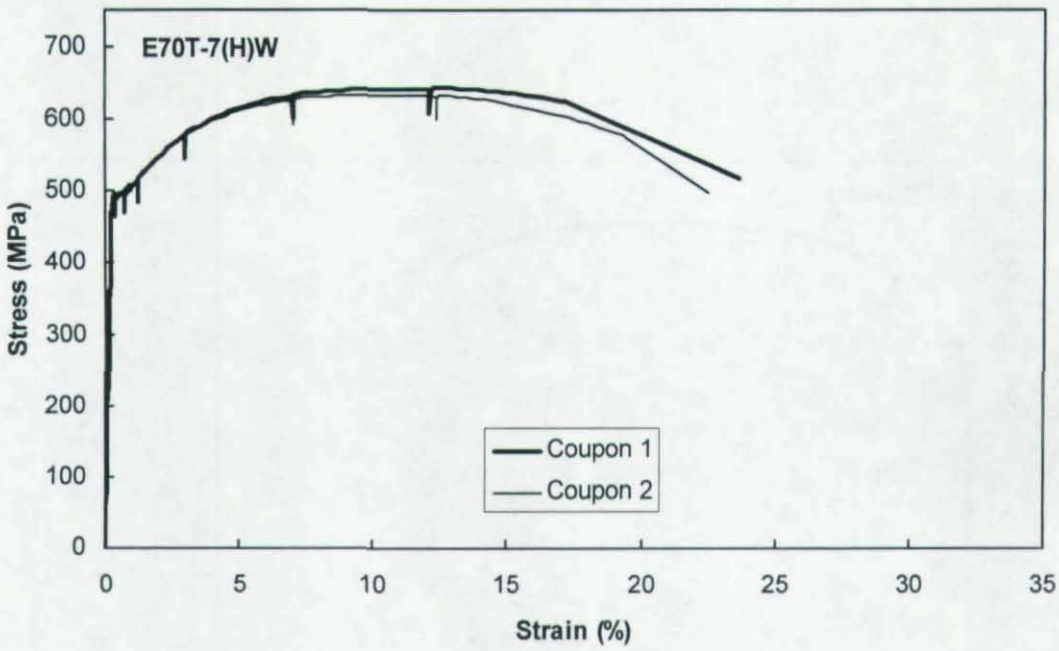


Figure D9 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A5

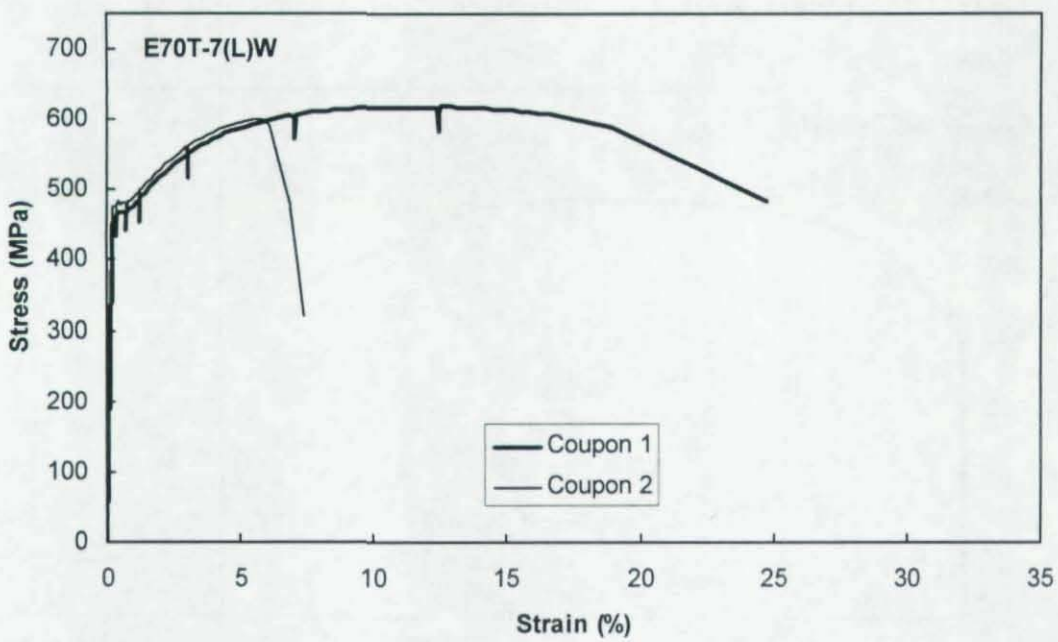


Figure D10 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A6

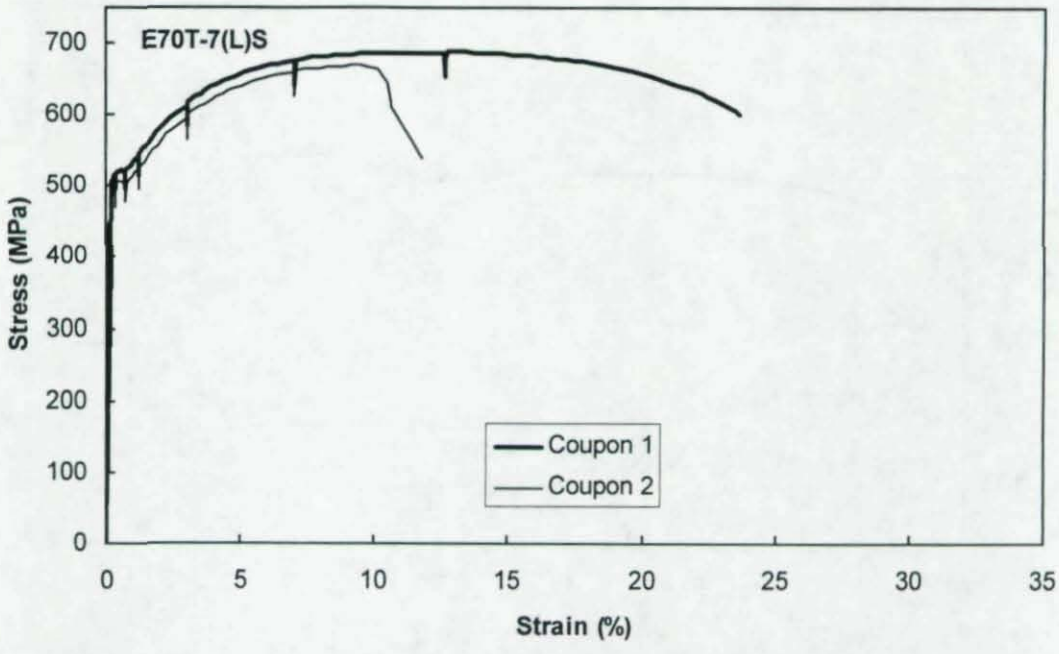


Figure D11 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A7

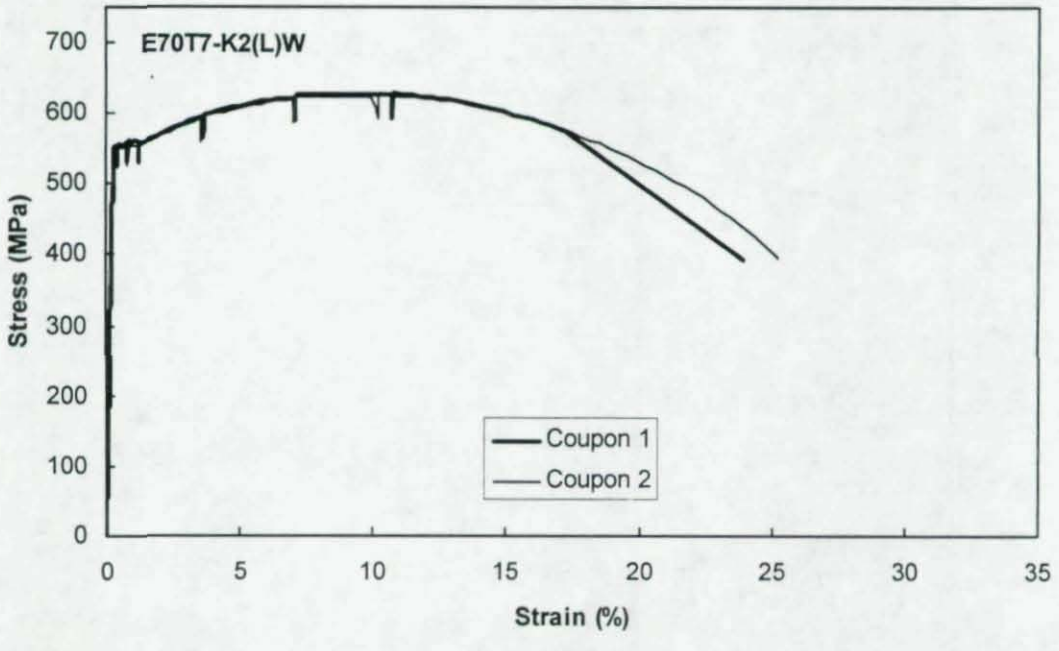


Figure D12 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A8

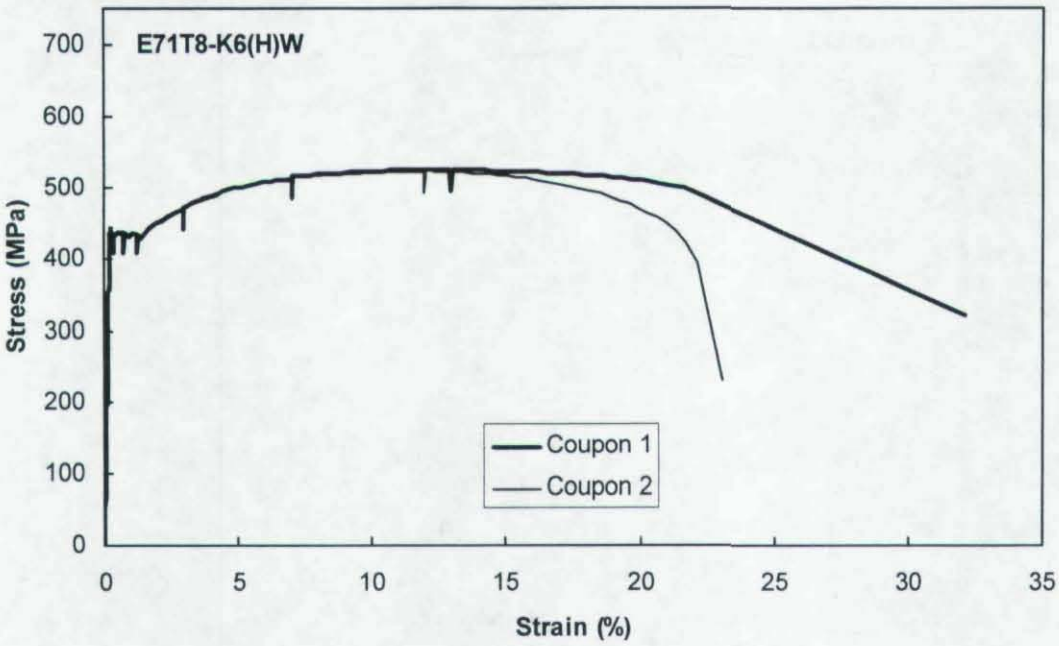


Figure D13 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A9

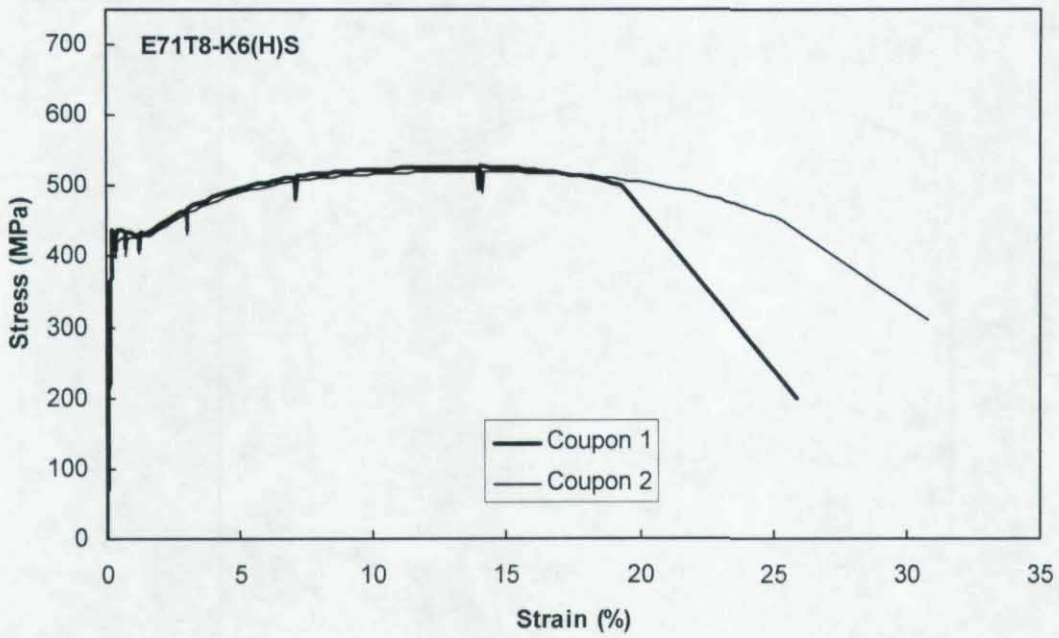


Figure D14 – Stress vs. Strain Curves for Weld Metal Coupons from Assembly A10

Appendix E

Transverse Fillet Weld Test Results

Appendix E – Transverse Fillet Weld Test Results

Explanatory Notes:

- Test/Predicted Ratios are calculated from two different steel design standards: CAN/CSA–S16, Limit States Design of Steel Structures, and AISC Load and Resistance Factor Design Specification for Structural Steel Buildings. Values using both the nominal weld strength and the weld strength measured from weld metal tension coupon tests are shown. The resistance factor is taken equal to 1.0. A more complete description of these calculations, and the rationale on which they are based, can be found in section 4.6 of the main body of the report.

- Effective Throat Area is the product of the minimum theoretical throat dimension, calculated using the mean value of the measurements of each weld leg, and the weld length.

- Facture Surface Area is the product of the mean fracture surface width, based on measurements at eight locations along the weld, and the weld length.

- Ultimate P/A_{throat} and Ultimate $P/A_{fracture}$ are calculated as one-half of the maximum load applied to the specimen divided by the effective throat area or the fracture surface area, respectively.

- Average Δ/D is the mean value of the two strain measurements on the same weld. The strain is calculated as the LVDT displacement measurement divided by the original gauge length. Results at both the ultimate load and at fracture are reported.

- Fracture Angle is the angle between the fracture surface and the main plate. The reported fracture angles are the mean value of eight measurements along the weld length.

- Maximum Main Plate Stress is the ultimate load divided by the measured cross-sectional area of the main plate.

Table E1 – Lapped Splice Specimen Test Results

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T1-1	6.4	E7014	L	W	513	Front	1.51	1.39	1.68	1.55	353	726	387	662	0.08	0.09	12	258
						Back	1.65	1.52	1.84	1.70	322	797	—	—	0.09	0.09	—	
T1-2	6.4	E7014	L	W	502	Front	1.52	1.40	1.70	1.57	342	733	383	656	0.08	0.10	8	251
						Back	1.60	1.47	1.78	1.65	326	770	—	—	0.09	0.11	—	
T1-3	6.4	E7014	L	W	513	Front	1.58	1.46	1.76	1.63	337	761	379	677	0.09	0.10	12	257
						Back	1.57	1.45	1.75	1.61	339	756	417	616	0.10	0.11	7	
T2-1	6.4	E7014	L	W	462	Front	1.52	1.41	1.70	1.57	314	735	321	720	0.10	0.10	9	291
						Back	1.41	1.30	1.57	1.45	341	678	—	—	0.07	0.07	—	
T2-2	6.4	E7014	L	W	474	Front	1.51	1.40	1.69	1.56	325	730	318	746	0.11	0.11	14	298
						Back	1.48	1.37	1.65	1.53	332	714	—	—	0.09	0.09	—	
T2-3	6.4	E7014	L	W	482	Front	1.45	1.34	1.62	1.49	345	699	369	652	0.09	0.10	9	303
						Back	1.53	1.42	1.71	1.58	326	740	—	—	0.07	0.07	—	
T3-1	6.4	E7014	L	W	523	Front	1.44	1.33	1.61	1.48	377	695	360	727	0.10	0.10	15	332
						Back	1.32	1.22	1.48	1.36	410	637	—	—	0.10	0.10	—	
T3-2	6.4	E7014	L	W	518	Front	1.35	1.25	1.51	1.40	396	654	338	766	0.07	0.09	18	331
						Back	1.30	1.20	1.45	1.34	412	628	—	—	0.07	0.07	—	
T3-3	6.4	E7014	L	W	520	Front	1.35	1.24	1.50	1.39	400	650	375	693	0.09	0.09	12	333
						Back	1.37	1.26	1.52	1.41	395	659	—	—	0.48	0.48	—	
T4-1	6.4	E70T-4	H	W	646	Front	2.06	1.74	2.30	1.95	325	994	—	—	0.11	0.11	—	410
						Back	2.04	1.72	2.27	1.93	329	982	651	496	0.08	0.08	0	
T4-2	6.4	E70T-4	H	W	651	Front	2.00	1.69	2.24	1.89	337	966	—	—	0.09	0.09	—	412
						Back	2.02	1.71	2.25	1.91	334	973	679	479	0.07	0.07	0	
T4-3	6.4	E70T-4	H	W	629	Front	1.98	1.68	2.21	1.87	329	956	—	—	0.07	0.07	—	401
						Back	2.01	1.71	2.25	1.90	324	972	663	474	0.08	0.08	0	

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T5-1	6.4	E70T-4	H	W	648	Front	2.06	1.74	2.30	1.94	326	992	—	—	0.07	0.07	—	404
						Back	2.07	1.75	2.31	1.96	325	998	643	504	0.08	0.08	0	
T5-2	6.4	E70T-4	H	W	632	Front	2.00	1.70	2.24	1.90	327	967	—	—	0.04	0.04	—	395
						Back	1.96	1.66	2.18	1.85	335	943	737	429	0.09	0.09	0	
T5-3	6.4	E70T-4	H	W	628	Front	2.01	1.70	2.25	1.90	324	970	—	—	0.04	0.04	—	394
						Back	2.06	1.74	2.30	1.95	316	993	715	439	0.10	0.10	0	
T6-1	6.4	E70T-4	H	W	717	Front	2.44	2.06	2.72	2.30	305	1175	413	869	0.16	0.16	90	459
						Back	2.32	1.97	2.59	2.19	320	1120	—	—	0.12	0.12	—	
T6-2	6.4	E70T-4	H	W	663	Front	2.14	1.81	2.39	2.02	321	1032	—	—	0.08	0.08	—	423
						Back	2.22	1.88	2.48	2.10	309	1073	406	816	0.13	0.13	77	
T6-3	6.4	E70T-4	H	W	741	Front	2.33	1.97	2.60	2.20	330	1124	—	—	0.14	0.14	—	473
						Back	2.43	2.06	2.71	2.30	316	1172	434	854	0.20	0.20	90	
T7-1*	6.4	E70T-4	H	S	679	Front	2.51	2.12	2.80	2.37	281	1209	431	788	0.08	0.08	90	435
						Back	2.30	1.95	2.57	2.18	305	1112	392	866	0.09	0.09	90	
T7-2*	6.4	E70T-4	H	S	601	Front	2.40	2.04	2.68	2.27	259	1160	433	694	0.07	0.07	90	384
						Back	2.31	1.96	2.58	2.18	270	1115	433	694	0.09	0.09	90	
T7-3*	6.4	E70T-4	H	S	627	Front	2.52	2.14	2.82	2.38	258	1217	475	660	0.65	0.65	90	399
						Back	2.36	2.00	2.64	2.23	275	1139	475	660	0.08	0.08	90	
T8-1	6.4	E70T-4	L	W	673	Front	2.02	1.72	2.25	1.92	346	973	Reinforced Weld Failed	—	0.20	—	—	431
						Back	1.86	1.59	2.08	1.78	374	899		—	0.14	—	—	
T8-2	6.4	E70T-4	L	W	683	Front	1.98	1.69	2.21	1.89	357	956	—	—	0.16	0.17	—	438
						Back	1.93	1.65	2.15	1.84	367	930	581	588	0.20	0.23	6	
T8-3	6.4	E70T-4	L	W	713	Front	1.94	1.65	2.16	1.85	382	934	558	639	0.23	0.24	12	453
						Back	1.95	1.67	2.18	1.86	379	942	—	—	0.16	0.16	—	

* Specimen tested at -50°C

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T9-1	6.4	E70T-4	L	S	806	Front	2.35	2.01	2.63	2.24	355	1135	—	—	0.19	0.19	—	507
						Back	2.28	1.94	2.54	2.17	367	1098	457	882	0.15	0.15	40	
T9-2	6.4	E70T-4	L	S	809	Front	2.37	2.02	2.65	2.26	354	1143	—	—	0.19	0.18	—	510
						Back	2.25	1.92	2.51	2.14	373	1084	522	775	0.19	0.19	27	
T9-3	6.4	E70T-4	L	S	829	Front	2.30	1.97	2.57	2.20	373	1111	498	833	0.24	0.24	25	523
						Back	2.32	1.98	2.59	2.21	370	1120	—	—	0.21	0.21	—	
T10-1	6.4	E70T-4	L	S	740	Front	2.01	1.72	2.25	1.92	381	970	501	739	0.10	0.12	23	373
						Back	1.92	1.64	2.14	1.83	400	925	—	—	0.06	0.06	—	
T10-2	6.4	E70T-4	L	S	794	Front	2.20	1.88	2.46	2.10	374	1063	—	—	0.12	0.13	—	401
						Back	2.17	1.86	2.43	2.07	379	1049	547	725	0.11	0.13	14	
T10-3	6.4	E70T-4	L	S	757	Front	2.11	1.80	2.35	2.01	373	1016	—	—	0.11	0.11	27	383
						Back	1.97	1.69	2.20	1.88	398	952	487	777	0.06	0.06	—	
T11-1	6.4	E70T-7	H	W	695	Front	2.05	1.62	2.28	1.81	352	987	691	503	0.13	0.16	0	438
						Back	1.86	1.48	2.08	1.65	387	898	—	—	0.09	0.09	—	
T11-2	6.4	E70T-7	H	W	680	Front	1.89	1.50	2.11	1.68	372	914	—	—	0.08	0.08	—	437
						Back	1.89	1.50	2.11	1.67	373	912	735	463	0.08	0.08	0	
T11-3	6.4	E70T-7	H	W	655	Front	1.85	1.47	2.06	1.64	368	891	642	510	0.09	0.09	0	411
						Back	1.80	1.43	2.02	1.60	376	871	—	—	0.06	0.06	—	
T12-1	6.4	E70T-7	H	S	745	Front	2.07	1.64	2.31	1.83	373	999	—	—	0.09	0.09	—	467
						Back	2.29	1.82	2.56	2.03	337	1106	436	854	0.12	0.12	76	
T12-2	6.4	E70T-7	H	S	769	Front	2.21	1.75	2.47	1.96	361	1066	—	—	0.10	0.10	—	483
						Back	2.46	1.95	2.75	2.18	324	1188	394	976	0.12	0.12	71	
T12-3	6.4	E70T-7	H	S	783	Front	2.23	1.77	2.49	1.98	363	1078	461	849	0.16	0.16	90	490
						Back	2.35	1.87	2.63	2.08	345	1135	—	—	0.15	0.15	—	

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T13-1	6.4	E70T-7	L	W	607	Front	2.01	1.56	2.25	1.74	313	971	370	821	0.06	0.07	90	384
						Back	1.75	1.36	1.96	1.52	359	845	—	—	0.04	0.06	—	
T13-2	6.4	E70T-7	L	W	689	Front	2.12	1.65	2.37	1.84	336	1024	Reinforced Weld Failed	—	0.14	—	—	434
						Back	2.04	1.59	2.28	1.77	349	986		—	0.13	—	—	
T13-3	6.4	E70T-7	L	W	605	Front	1.98	1.54	2.22	1.72	316	957	528	572	0.05	0.19	49	384
						Back	2.07	1.61	2.32	1.80	302	1000	—	—	0.07	0.12	—	
T14-1	6.4	E70T-7	L	S	769	Front	2.01	1.56	2.24	1.74	396	970	—	—	0.10	0.10	—	481
						Back	1.94	1.51	2.17	1.68	411	936	722	533	0.08	0.08	6	
T14-2	6.4	E70T-7	L	S	778	Front	2.02	1.57	2.26	1.75	399	976	—	—	0.13	0.13	—	509
						Back	1.99	1.54	2.22	1.72	406	959	723	538	0.11	0.13	8	
T14-3	6.4	E70T-7	L	S	709	Front	1.86	1.44	2.07	1.61	396	895	722	491	0.10	0.10	4	442
						Back	1.85	1.44	2.07	1.61	397	894	—	—	0.08	0.08	—	
T15-1	6.4	E70T-7	L	S	781	Front	2.23	1.73	2.49	1.93	364	1074	722	541	0.06	0.06	0	395
						Back	2.08	1.62	2.32	1.81	389	1004	—	—	0.04	0.04	—	
T15-2	6.4	E70T-7	L	S	760	Front	1.99	1.55	2.23	1.73	395	962	760	500	0.07	0.07	0	384
						Back	1.96	1.52	2.18	1.70	403	944	—	—	0.05	0.05	—	
T15-3	6.4	E70T-7	L	S	766	Front	2.09	1.62	2.33	1.81	380	1007	706	542	0.06	0.06	0	386
						Back	2.03	1.58	2.27	1.76	391	980	—	—	0.04	0.04	—	
T16-1	6.4	E70T7-K2	L	W	769	Front	2.14	1.74	2.39	1.94	372	1034	—	—	0.27	0.27	-	481
						Back	1.94	1.57	2.17	1.76	411	936	550	699	0.31	0.34	18	
T16-2	6.4	E70T7-K2	L	W	782	Front	2.22	1.80	2.47	2.01	366	1069	Lap Plate Failed	—	0.25	—	—	491
						Back	1.88	1.52	2.10	1.70	431	907		—	0.20	—	—	
T16-3	6.4	E70T7-K2	L	W	658	Front	1.92	1.56	2.15	1.74	355	928	—	—	0.16	0.16	—	439
						Back	1.97	1.60	2.20	1.79	345	952	478	688	0.22	0.24	21	

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T17-1	6.4	E70T7-K2	L	S	777	Front	2.40	1.95	2.68	2.17	335	1158	410	947	0.12	0.12	64	491
						Back	2.27	1.84	2.54	2.06	355	1095	—	—	0.12	0.12	—	
T17-2	6.4	E70T7-K2	L	S	715	Front	2.53	2.05	2.83	2.29	293	1222	292	1222	0.05	0.05	90	451
						Back	1.87	1.52	2.09	1.70	396	904	—	—	0.06	0.06	—	
T17-3	6.4	E70T7-K2	L	S	721	Front	2.45	1.98	2.73	2.22	305	1180	307	1175	0.10	0.10	90	453
						Back	1.90	1.54	2.12	1.72	393	917	—	—	0.08	0.08	—	
T18-1	6.4	E71T8-K6	H	W	711	Front	2.30	2.25	2.57	2.51	320	1110	726	490	0.41	0.42	0	449
						Back	2.29	2.23	2.55	2.49	322	1103	—	—	0.23	0.25	—	
T18-2	6.4	E71T8-K6	H	W	699	Front	2.29	2.24	2.56	2.50	316	1107	—	—	0.45	0.46	—	443
						Back	2.39	2.33	2.67	2.61	303	1153	670	522	0.30	0.31	0	
T18-3	6.4	E71T8-K6	H	W	711	Front	2.19	2.13	2.44	2.38	337	1054	—	—	0.40	0.40	—	449
						Back	2.38	2.32	2.66	2.59	310	1148	654	543	0.31	0.32	0	
T19-1	6.4	E71T8-K6	H	S	780	Front	2.02	1.97	2.26	2.20	400	975	—	—	0.15	0.15	—	490
						Back	2.08	2.03	2.32	2.27	389	1003	481	810	0.17	0.17	24	
T19-2	6.4	E71T8-K6	H	S	784	Front	1.87	1.82	2.09	2.04	435	901	—	—	0.15	0.15	—	493
						Back	2.22	2.17	2.48	2.42	366	1070	484	810	0.20	0.20	26	
T19-3	6.4	E71T8-K6	H	S	744	Front	1.83	1.78	2.04	1.99	422	882	—	—	0.15	0.15	—	468
						Back	2.06	2.01	2.30	2.25	374	995	502	741	0.19	0.19	25	
T20-1	12.7	E7014	L	W	782	Front	1.09	1.01	1.22	1.13	741	528	767	510	0.13	0.15	27	396
						Back	1.12	1.03	1.25	1.15	724	540	—	—	0.05	0.06	—	
T20-2	12.7	E7014	L	W	949	Front	1.41	1.30	1.58	1.46	697	681	1040	456	0.17	0.19	7	481
						Back	1.31	1.21	1.47	1.35	749	633	—	—	0.13	0.13	—	
T20-3	12.7	E7014	L	W	878	Front	1.24	1.14	1.38	1.27	736	596	946	464	0.13	0.15	7	443
						Back	1.23	1.14	1.37	1.27	739	594	—	—	0.09	0.09	—	

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T21-1	12.7	E70T-4	H	W	996	Front	1.54	1.30	1.72	1.45	671	742	1033	482	0.16	0.18	0	499
						Back	1.51	1.28	1.69	1.43	682	731	—	—	0.11	0.12	—	
T21-2	12.7	E70T-4	H	W	981	Front	1.46	1.24	1.63	1.38	697	704	—	—	0.10	0.10	—	494
						Back	1.48	1.25	1.65	1.39	689	712	1139	431	0.14	0.15	0	
T21-3	12.7	E70T-4	H	W	921	Front	1.39	1.17	1.55	1.31	688	669	—	—	0.08	0.09	—	463
						Back	1.39	1.18	1.55	1.31	687	670	1105	417	0.10	0.13	0	
T22-1	12.7	E70T-4	H	S	912	Front	1.76	1.49	1.96	1.66	538	848	928	491	0.13	0.15	0	460
						Back	1.53	1.30	1.71	1.45	617	739	—	—	0.08	0.08	—	
T22-2	12.7	E70T-4	H	S	903	Front	1.71	1.45	1.91	1.61	548	823	966	467	0.11	0.13	0	455
						Back	1.56	1.32	1.74	1.47	601	752	—	—	0.08	0.08	—	
T22-3	12.7	E70T-4	H	S	994	Front	1.81	1.54	2.03	1.71	568	875	983	506	0.16	0.17	0	481
						Back	1.78	1.50	1.98	1.68	580	857	—	—	0.14	0.14	—	
T23-1	12.7	E70T-4	L	W	966	Front	2.02	1.72	2.25	1.92	683	707	945	511	0.19	0.21	13	488
						Back	1.86	1.59	2.08	1.78	712	678	—	—	0.12	0.13	—	
T23-2	12.7	E70T-4	L	W	920	Front	1.98	1.69	2.21	1.89	677	679	928	495	0.14	0.16	14	465
						Back	1.93	1.65	2.15	1.84	710	648	—	—	0.08	0.08	—	
T23-3	12.7	E70T-4	L	W	919	Front	1.94	1.65	2.16	1.85	697	659	874	526	0.14	0.15	17	464
						Back	1.95	1.67	2.18	1.86	696	660	—	—	0.10	0.10	—	
T24-1	12.7	E70T-4	L	S	1014	Front	2.35	2.01	2.63	2.24	605	838	—	—	0.17	0.18	—	513
						Back	2.28	1.94	2.54	2.17	634	799	729	696	0.20	0.21	22	
T24-2	12.7	E70T-4	L	S	1020	Front	2.37	2.02	2.65	2.26	614	830	—	—	0.15	0.15	—	516
						Back	2.25	1.92	2.51	2.14	630	810	751	679	0.24	0.24	22	
T24-3	12.7	E70T-4	L	S	995	Front	2.30	1.97	2.57	2.20	634	785	797	624	0.14	0.14	17	503
						Back	2.32	1.98	2.59	2.21	621	801	—	—	0.15	0.15	—	

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T25-1	12.7	E70T-7	H	W	1040	Front	1.62	1.28	1.80	1.43	667	780	Reinforced Weld Failed	—	0.10	—	—	525
						Back	1.64	1.30	1.83	1.45	657	791		—	0.10	—	—	
T25-2	12.7	E70T-7	H	W	999	Front	1.60	1.27	1.79	1.42	648	771	1161	430	0.11	0.11	0	504
						Back	1.62	1.28	1.80	1.43	641	779	—	—	0.11	0.11	—	
T25-3	12.7	E70T-7	H	W	1020	Front	1.57	1.24	1.75	1.39	674	756	—	—	0.11	0.11	—	515
						Back	1.65	1.31	1.84	1.46	641	795	966	528	0.14	0.15	11	
T26-1	12.7	E70T-7	H	S	1060	Front	1.70	1.35	1.90	1.51	645	822	749	708	0.17	0.17	—	536
						Back	1.74	1.38	1.95	1.55	630	842	—	—	0.17	0.17	24	
T26-2	12.7	E70T-7	H	S	1068	Front	1.70	1.35	1.90	1.51	651	821	—	—	0.20	0.21	23	541
						Back	1.73	1.37	1.94	1.54	639	836	868	615	0.16	0.16	—	
T26-3	12.7	E70T-7	H	S	1062	Front	1.67	1.32	1.86	1.48	661	804	—	—	0.22	0.22	24	537
						Back	1.67	1.33	1.87	1.48	658	807	787	675	0.13	0.13	—	
T27-1	12.7	E70T-7	L	W	841	Front	1.34	1.04	1.50	1.16	650	647	718	586	0.09	0.10	25	423
						Back	1.37	1.07	1.53	1.19	635	662	—	—	0.06	0.07	—	
T27-2	12.7	E70T-7	L	W	943	Front	1.49	1.16	1.66	1.29	656	719	—	—	0.11	0.11	—	473
						Back	1.53	1.18	1.70	1.32	641	736	712	662	0.12	0.13	13	
T27-3	12.7	E70T-7	L	W	945	Front	1.50	1.17	1.68	1.30	652	725	—	—	0.12	0.12	—	416
						Back	1.55	1.20	1.73	1.35	631	748	751	630	0.08	0.08	13	
T28-1	12.7	E70T-7	L	S	990	Front	1.61	1.25	1.79	1.39	639	775	782	633	0.14	0.14	19	500
						Back	1.66	1.29	1.85	1.44	619	800	—	—	0.11	0.11	—	
T28-2	12.7	E70T-7	L	S	999	Front	1.63	1.27	1.82	1.42	634	788	—	—	0.12	0.12	—	504
						Back	1.68	1.30	1.87	1.46	617	810	1132	441	0.12	0.12	0	
T28-3	12.7	E70T-7	L	S	991	Front	1.59	1.23	1.77	1.38	647	766	—	—	0.10	0.10	—	500
						Back	1.62	1.26	1.81	1.40	635	781	1214	408	0.11	0.12	0	

Table E1 – Lapped Splice Specimen Test Results (cont.)

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
T29-1	12.7	E70T7-K2	L	W	1083	Front	1.69	1.37	1.88	1.53	666	813	Main Plate Failed	—	0.17	—	—	547
						Back	1.48	1.20	1.65	1.34	758	714		—	0.14	—	—	
T29-2	12.7	E70T7-K2	L	W	1073	Front	1.58	1.28	1.76	1.43	705	761	Main Plate Failed	—	0.19	—	—	543
						Back	1.48	1.20	1.65	1.34	751	714		—	0.15	—	—	
T29-3	12.7	E70T7-K2	L	W	1082	Front	1.54	1.25	1.72	1.39	729	742	Main Plate Failed	—	0.20	—	—	547
						Back	1.54	1.25	1.72	1.40	727	744		—	0.20	—	—	
T30-1	12.7	E70T7-K2	L	S	1057	Front	1.71	1.39	1.92	1.55	639	827	Main Plate Failed	—	0.22	—	—	532
						Back	1.78	1.44	1.98	1.61	617	856		—	0.18	—	—	
T30-2	12.7	E70T7-K2	L	S	1073	Front	1.83	1.48	2.04	1.65	609	881	—	—	0.24	0.25	—	542
						Back	1.86	1.51	2.07	1.68	599	896	777	690	0.19	0.20	19	
T30-3	12.7	E70T7-K2	L	S	1056	Front	1.81	1.47	2.03	1.64	603	875	737	716	0.25	0.25	21	534
						Back	1.78	1.44	1.99	1.61	615	858	—	—	0.20	0.20	—	
T31-1	12.7	E71T8-K6	H	W	1036	Front	1.80	1.76	2.01	1.97	596	869	—	—	0.22	0.23	—	522
						Back	1.76	1.72	1.96	1.92	611	847	1116	464	0.27	0.29	0	
T31-2	12.7	E71T8-K6	H	W	1004	Front	1.67	1.63	1.86	1.82	624	805	—	—	0.17	0.18	—	507
						Back	1.70	1.66	1.90	1.86	611	822	1092	459	0.23	0.26	0	
T31-3	12.7	E71T8-K6	H	W	1014	Front	1.65	1.61	1.84	1.80	637	796	—	—	0.19	0.21	—	511
						Back	1.80	1.76	2.01	1.97	583	870	1051	482	0.21	0.25	0	
T32-1	12.7	E71T8-K6	H	S	1044	Front	1.72	1.68	1.92	1.87	630	829	—	—	0.21	0.21	—	528
						Back	1.62	1.58	1.80	1.76	670	779	811	644	0.27	0.23	25	
T32-2	12.7	E71T8-K6	H	S	1049	Front	1.75	1.71	1.96	1.91	620	846	—	—	0.27	0.28	—	530
						Back	1.64	1.60	1.83	1.78	665	789	776	676	0.24	0.26	23	
T32-3	12.7	E71T8-K6	H	S	1022	Front	1.72	1.68	1.92	1.87	617	828	876	583	0.30	0.31	10	516
						Back	1.57	1.54	1.76	1.72	673	759	—	—	0.18	0.19	—	

Table E2 – Cruciform Specimen Test Results

Specimen Designation	Weld Size (mm)	Electrode Classification	Electrode Manufacturer	Steel Fabricator	Ultimate Load (kN)	Weld Location	Test/Predicted (S16) Ratio		Test/Predicted (AISC) Ratio		Effective Throat Area - A_{throat} (mm^2)	Ultimate P/A_{throat} (MPa)	Fracture Surface Area - $A_{fracture}$ (mm^2)	Ultimate $P/A_{fracture}$ (MPa)	Average Δ/D (Ultimate Load)	Average Δ/D (Fracture)	Fracture Angle (°)	Maximum Main Plate Stress (MPa)
							Nominal Weld Strength	Measured Weld Strength	Nominal Weld Strength	Measured Weld Strength								
C1-1	6.4	E70T-4	H	W	672	Front	2.21	1.89	2.47	2.11	315	1067	573	586	0.05	0.05	15	422
						Back	1.91	1.63	2.14	1.82	364	923	—	—			—	
C1-2	6.4	E70T-4	H	W	658	Front	2.13	1.82	2.38	2.03	320	1028	590	558	0.02	0.02	0	410
						Back	1.81	1.55	2.02	1.73	376	874	—	—			—	
C1-3	6.4	E70T-4	H	W	600	Front	1.95	1.67	2.18	1.86	318	943	518	580	0.01	0.01	0	380
						Back	1.69	1.44	1.88	1.61	369	814	—	—			—	
C2-1	6.4	E70T7-K2	L	W	650	Front	2.07	1.68	2.31	1.87	326	997	451	720	0.08	0.08	15	422
						Back	1.82	1.48	2.03	1.65	370	878	—	—	0.00	0.00	—	
C2-2	6.4	E70T7-K2	L	W	655	Front	1.94	1.57	2.17	1.76	350	937	—	—	0.02	0.02	—	410
						Back	1.98	1.60	2.21	1.79	343	954	430	762			0	
C2-3	6.4	E70T7-K2	L	W	618	Front	1.89	1.53	2.11	1.71	339	911	—	—	-0.01	-0.01	—	380
						Back	1.82	1.47	2.03	1.65	352	877	456	677	0.05	0.05	0	

Appendix F

Transverse Fillet Weld Stress vs. Strain Response

Appendix F – Transverse Fillet Weld Stress vs. Strain Response

Figure F0 shows a sample stress vs. strain plot for the transverse fillet weld test specimens. A description of several key elements of the plots, identified by number, is provided below.

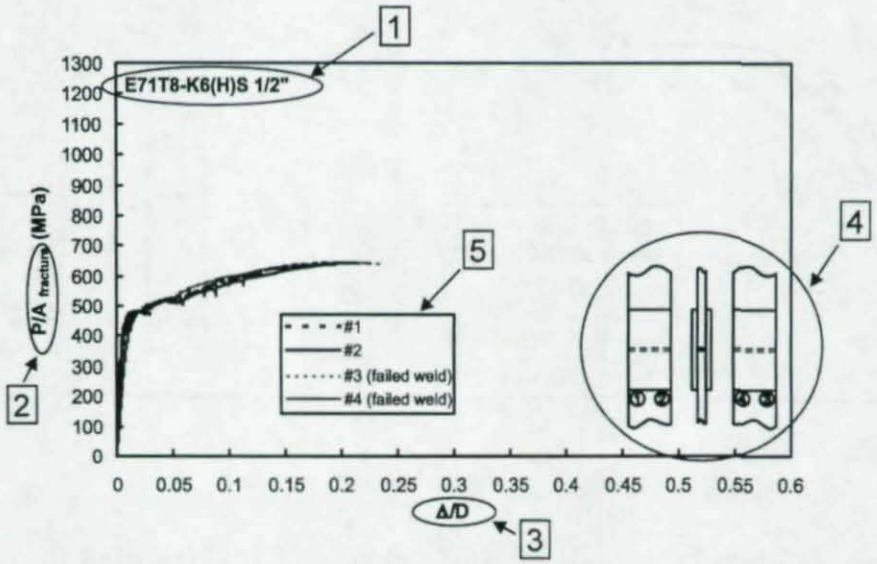


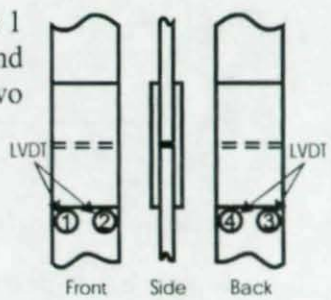
Figure F0 – Sample Stress vs. Strain Plot

1. The elements of the specimen identifier nomenclature are described in section 1 of the main body of the report.

2. The subscripts indicate upon which area the plotted stress values are based. In general, the area is that of the measured fracture surface, which accounts for both weld penetration and reinforcement. It is implicitly assumed that the test weld that did not fail would have had a fracture surface with a similar area. In the few cases where the base plate fractured just prior to reaching the weld capacity, the area of the theoretical throat, based upon the measured weld leg sizes, is substituted. Stresses measured in these two different ways cannot be compared directly.

3. The weld strain was calculated as the measured weld deformation, Δ, divided by the initial measured weld leg size, D.

4. The diagram shows the locations of the LVDTs. LVDTs 1 and 2 are at the front of the test specimen and LVDTs 3 and 4 are at the back. Some cruciform specimens had only two LVDTs that were located at the sides of the specimen to eliminate the effects of bending. See section 5.2 of the main body of the report for details.



5. The legend identifies for each curve the location where displacements were measured and indicates where failure took place.

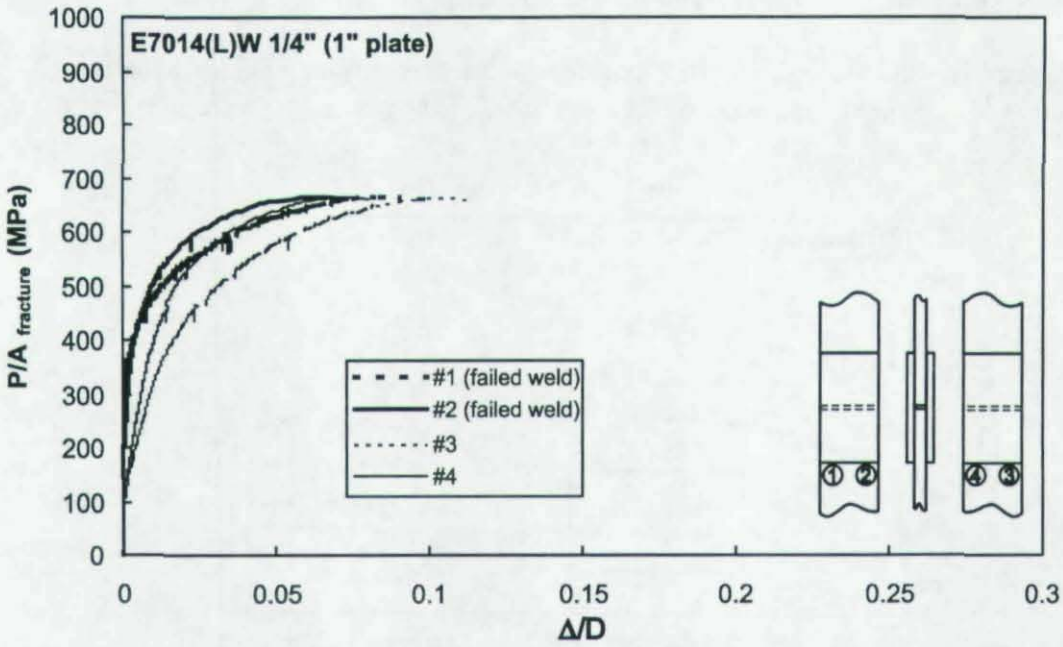


Figure F1 – Specimen T1-1 with 1/4" weld from E7014 electrode

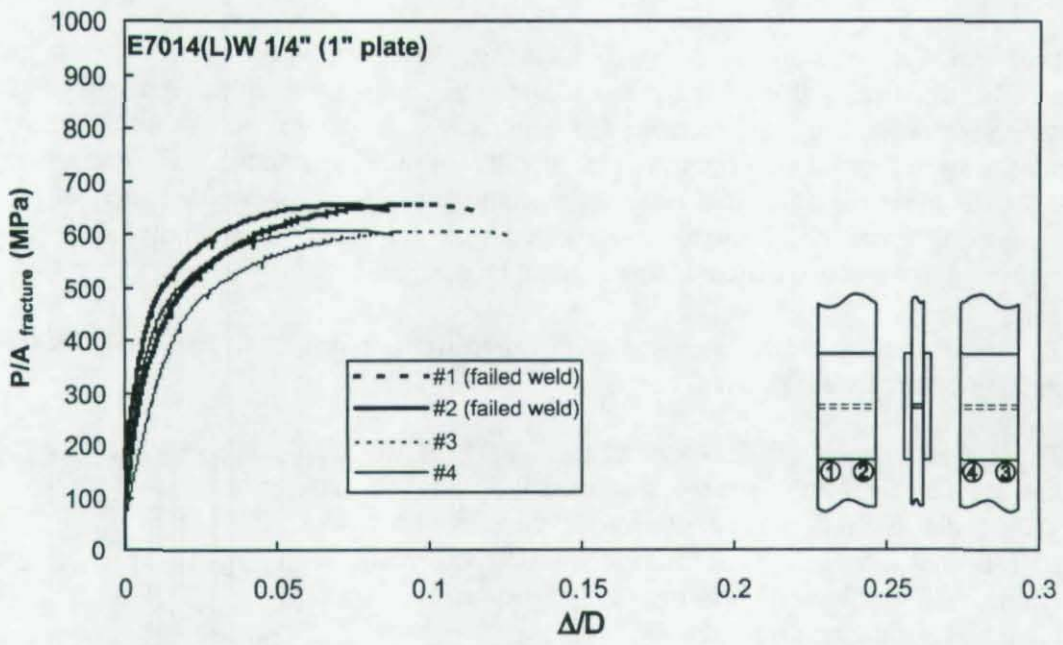


Figure F2 – Specimen T1-2 with 1/4" weld from E7014 electrode

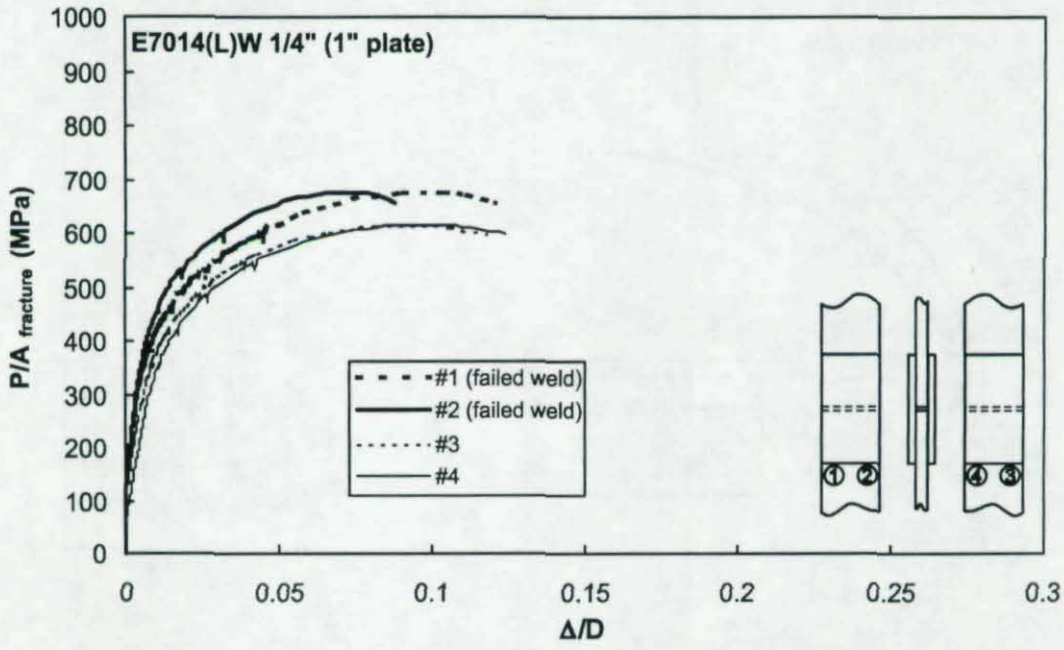


Figure F3 – Specimen T1-3 with 1/4" weld from E7014 electrode

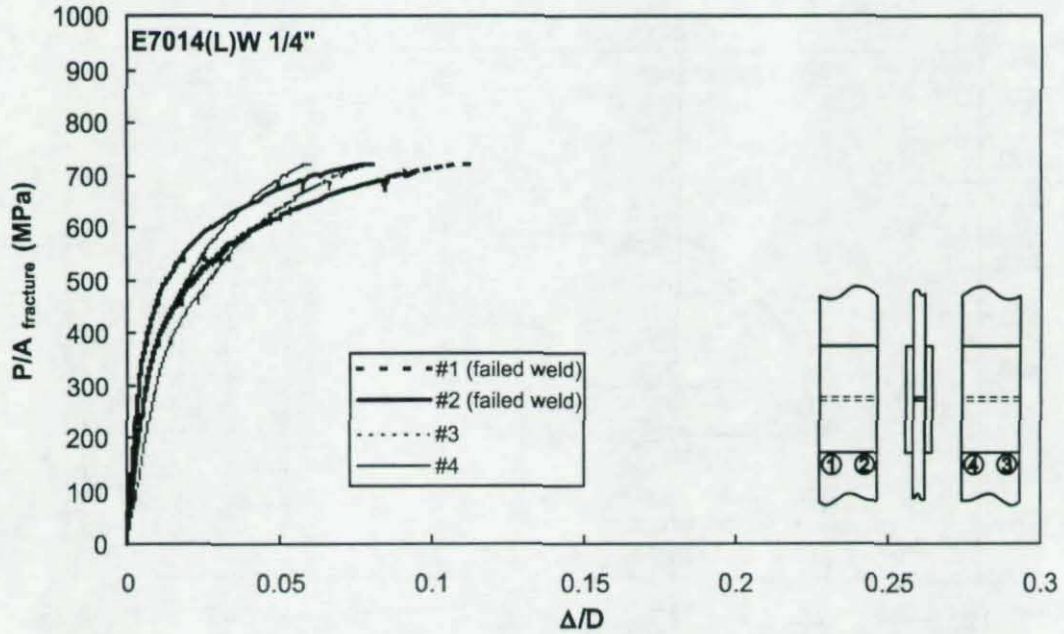


Figure F4 – Specimen T2-1 with 1/4" weld from E7014 electrode

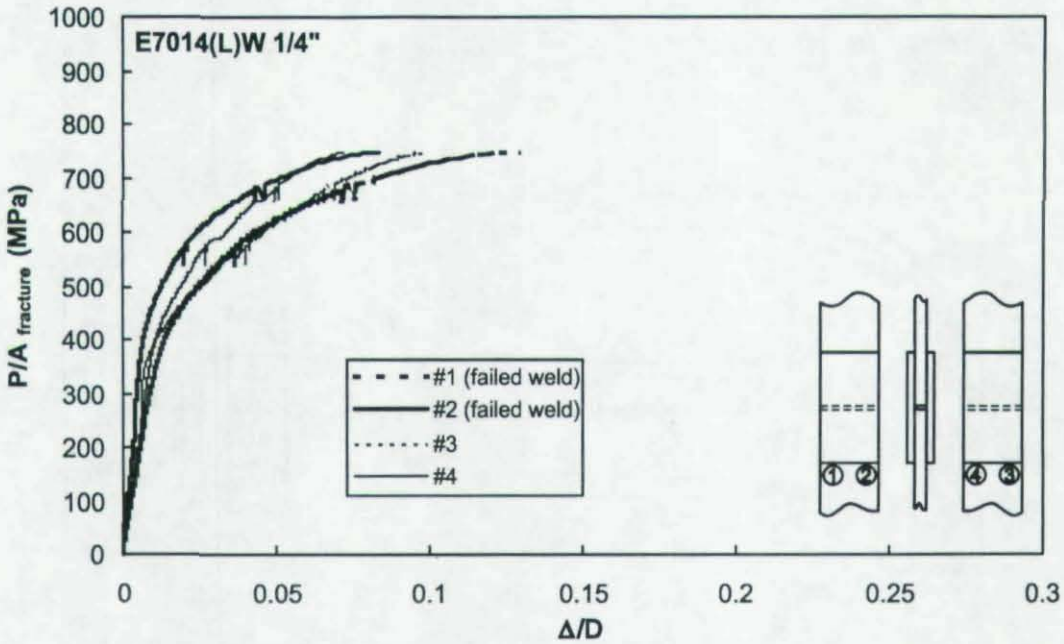


Figure F5 – Specimen T2-2 with 1/4" weld from E7014 electrode

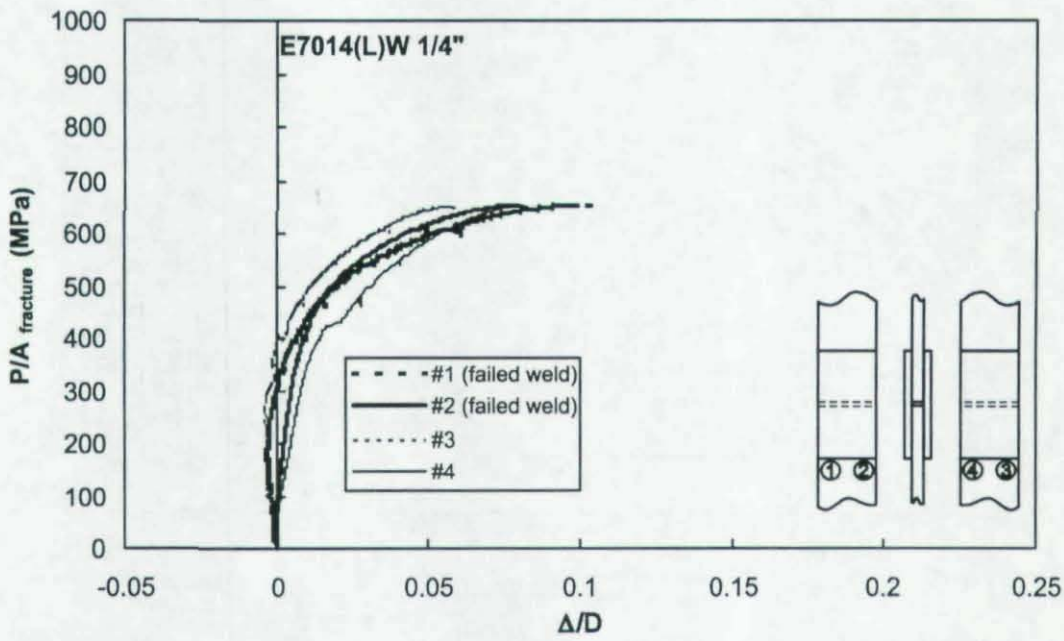


Figure F6 – Specimen T2-3 with 1/4" weld from E7014 electrode

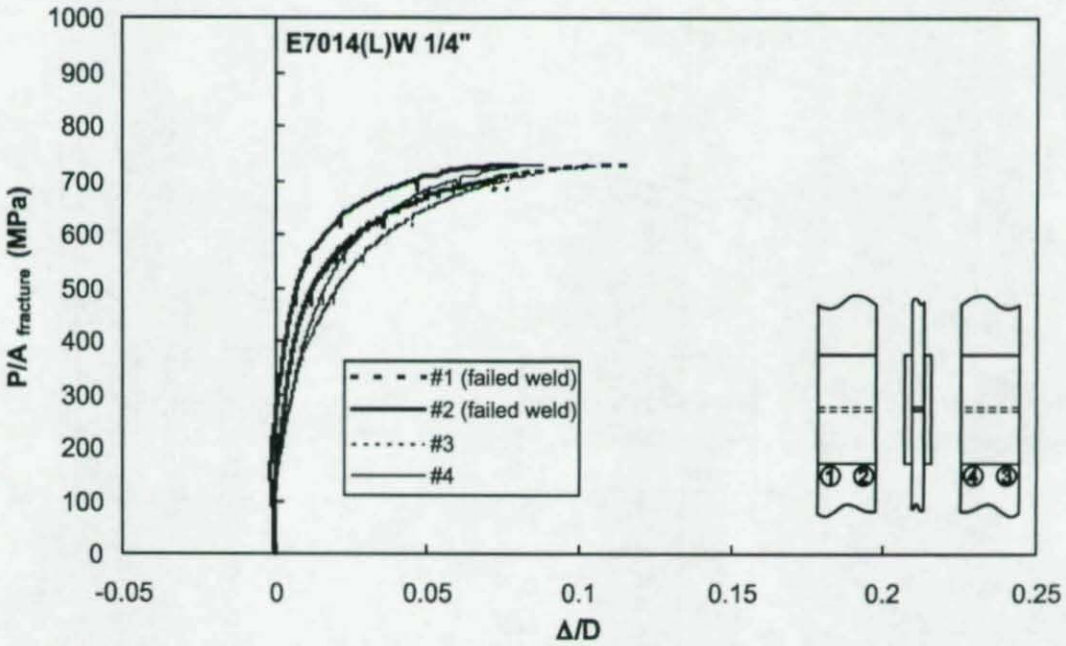


Figure F7 – Specimen T3-1 with 1/4" weld from E7014 electrode

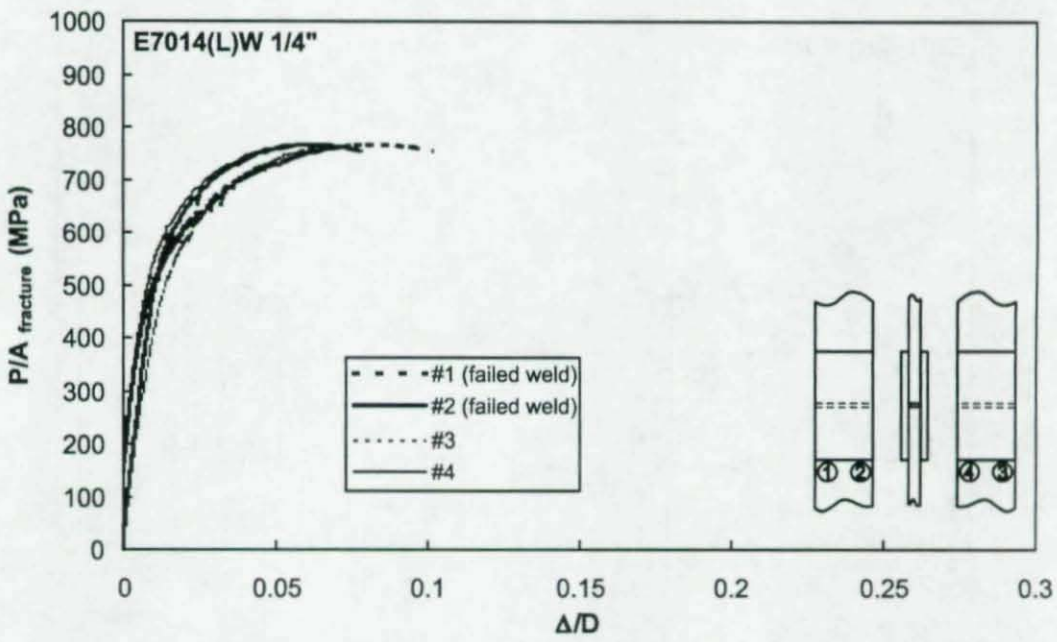


Figure F8 – Specimen T3-2 with 1/4" weld from E7014 electrode

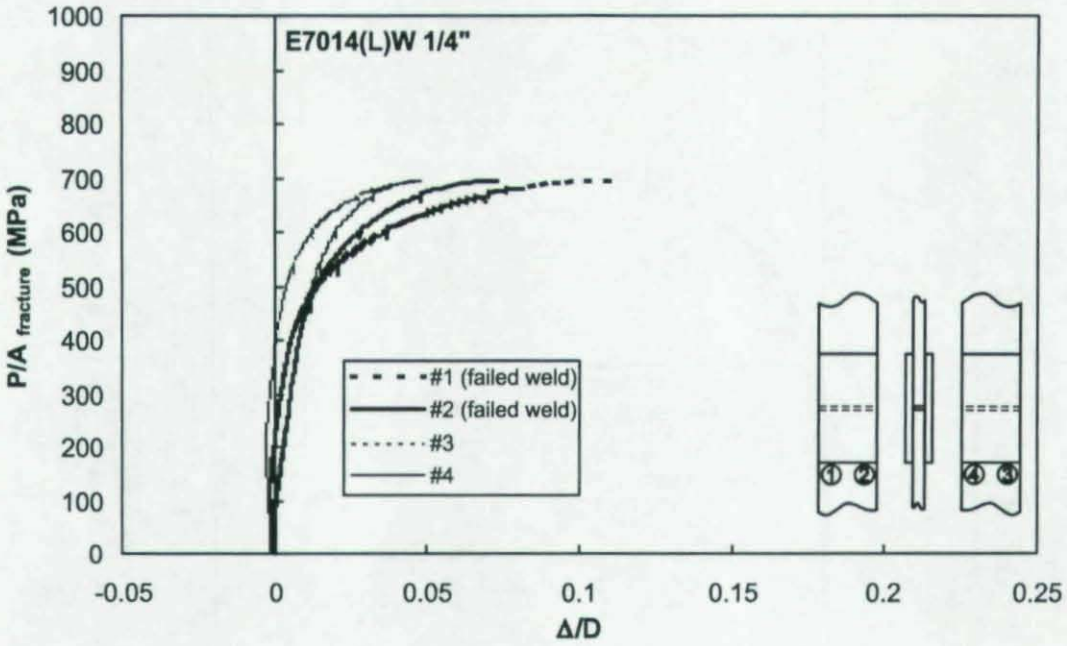


Figure F9 – Specimen T3-3 with 1/4" weld from E7014 electrode

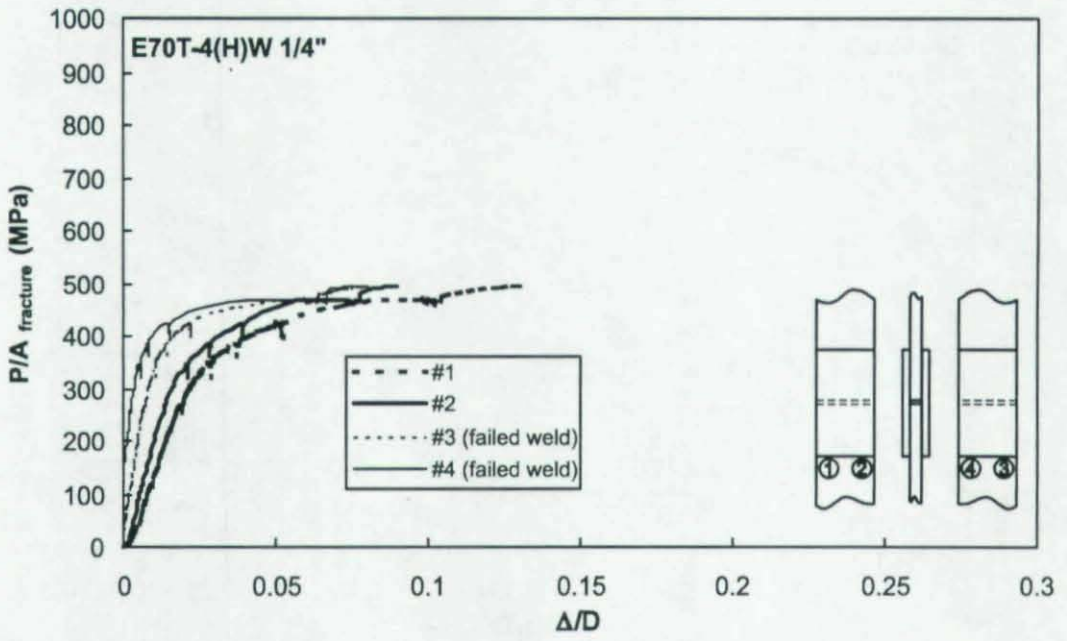


Figure F10 – Specimen T4-1 with 1/4" weld from E70T-4 electrode

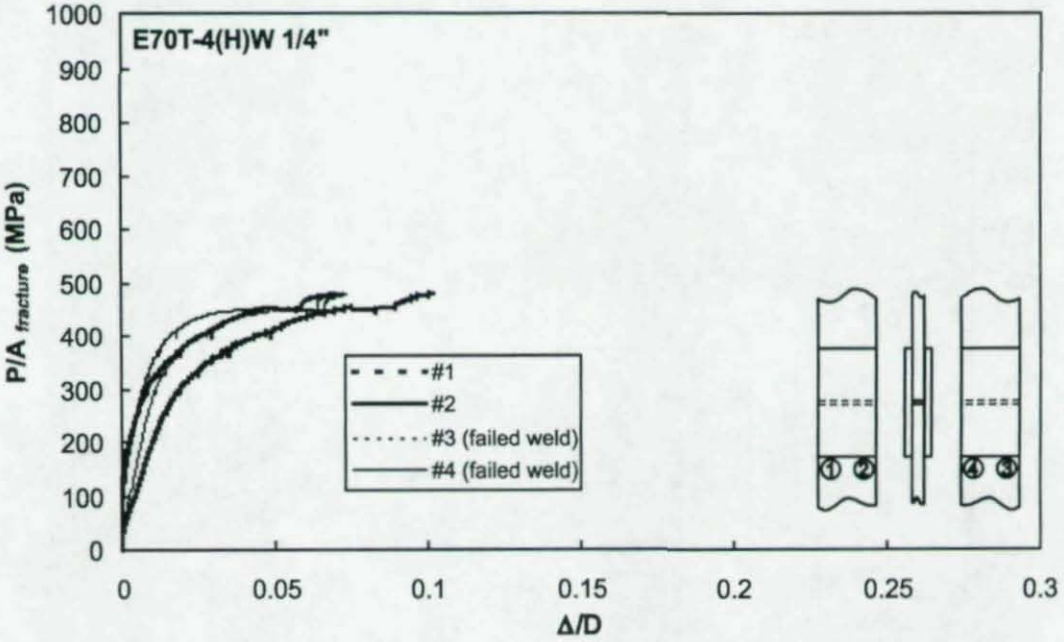


Figure F11 – Specimen T4-2 with 1/4" weld from E70T-4 electrode

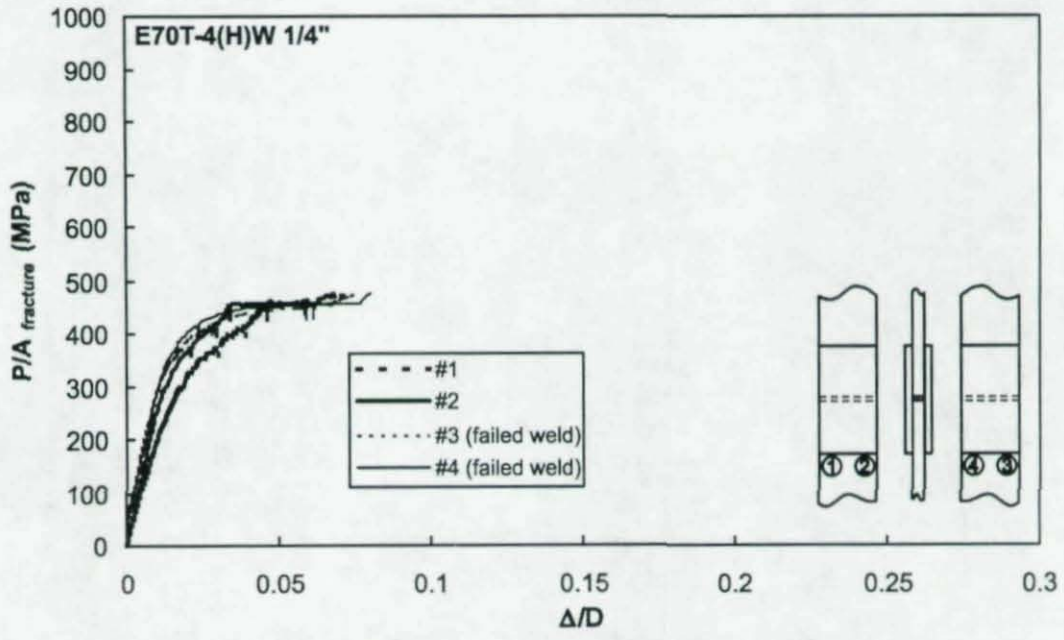


Figure F12 – Specimen T4-3 with 1/4" weld from E70T-4 electrode

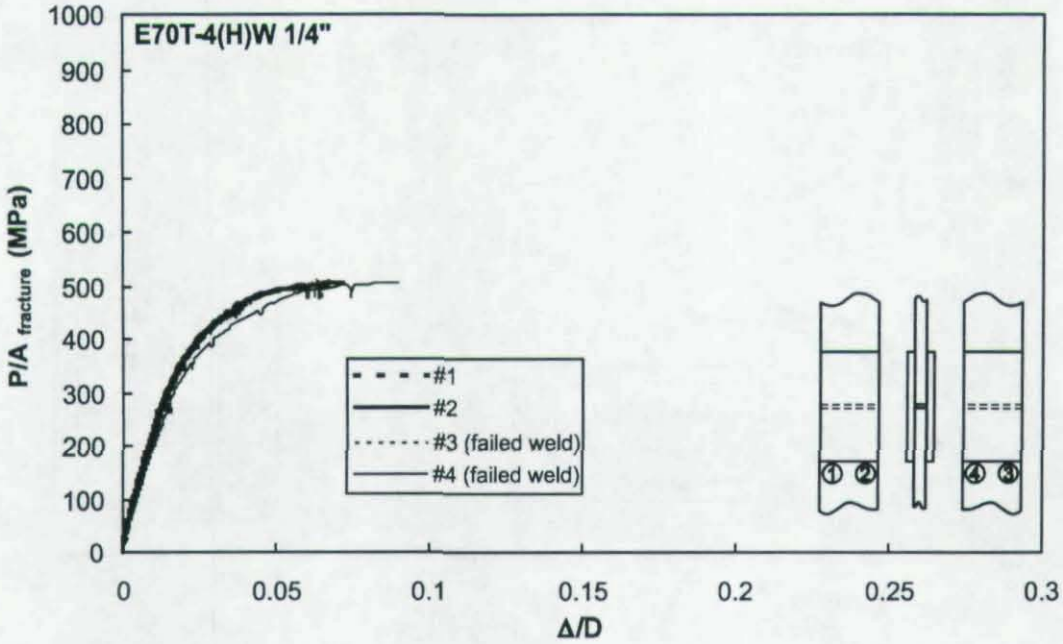


Figure F13 – Specimen T5-1 with 1/4" weld from E70T-4 electrode

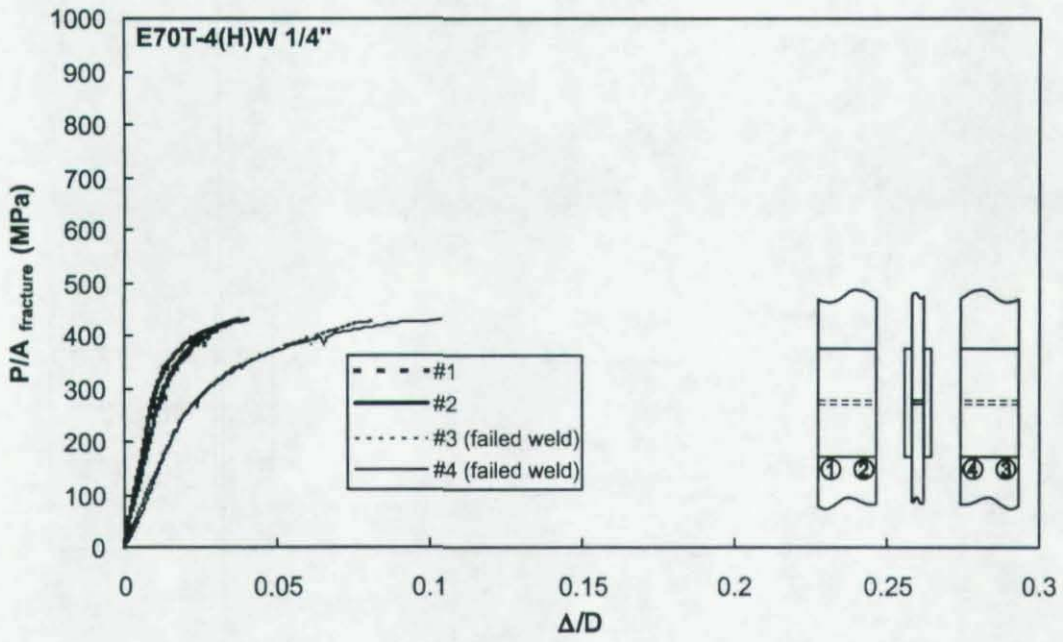


Figure F14 – Specimen T5-2 with 1/4" weld from E70T-4 electrode

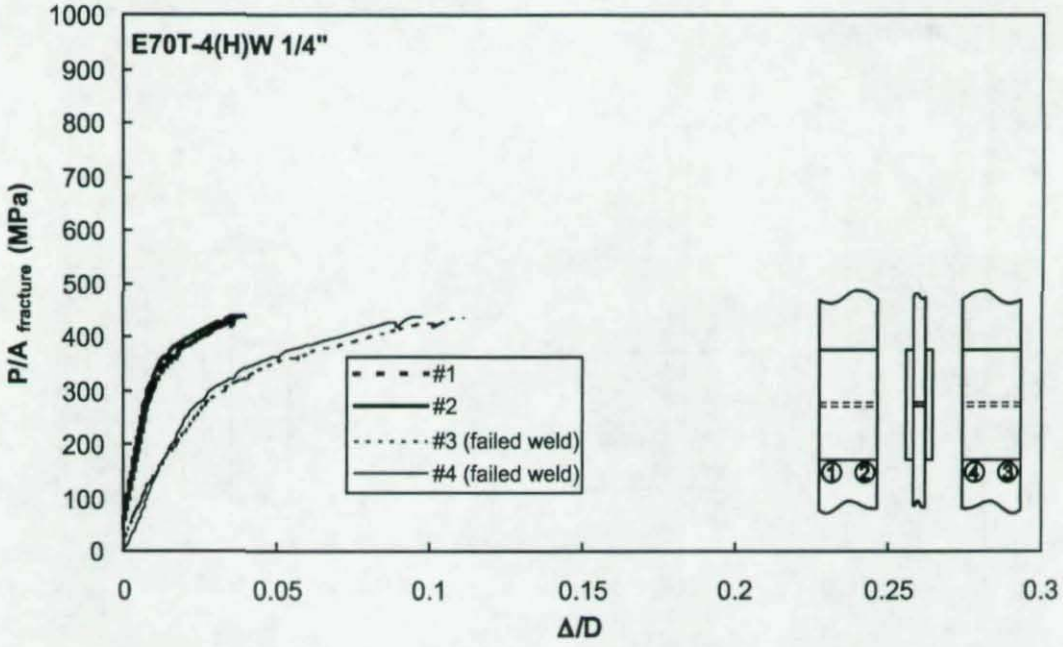


Figure F15 – Specimen T5-3 with 1/4" weld from E70T-4 electrode

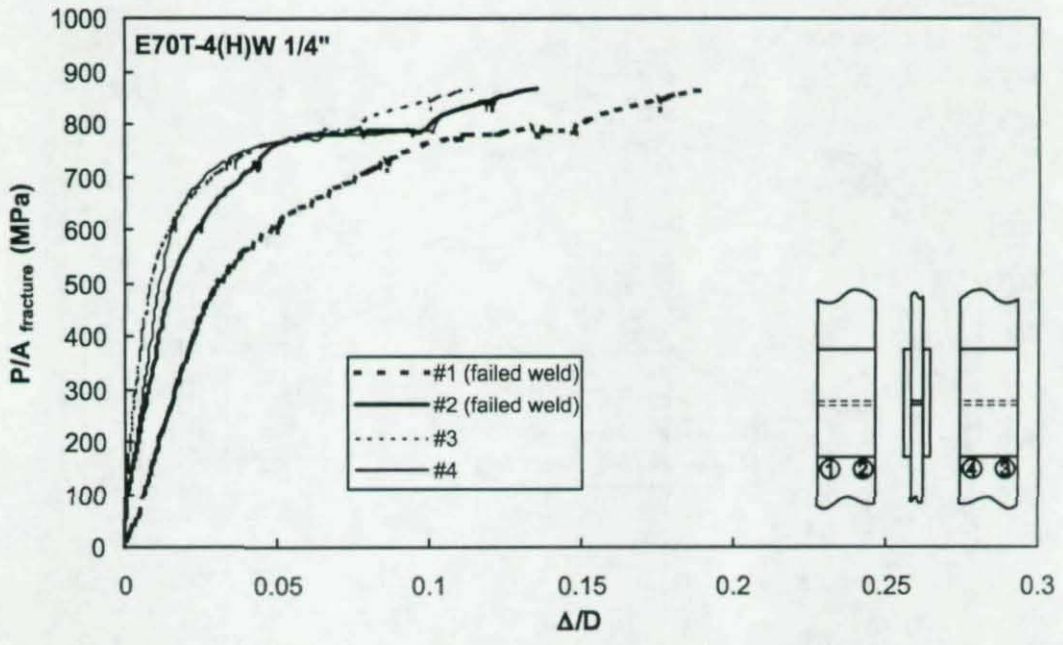


Figure F16 – Specimen T6-1 with 1/4" weld from E70T-4 electrode

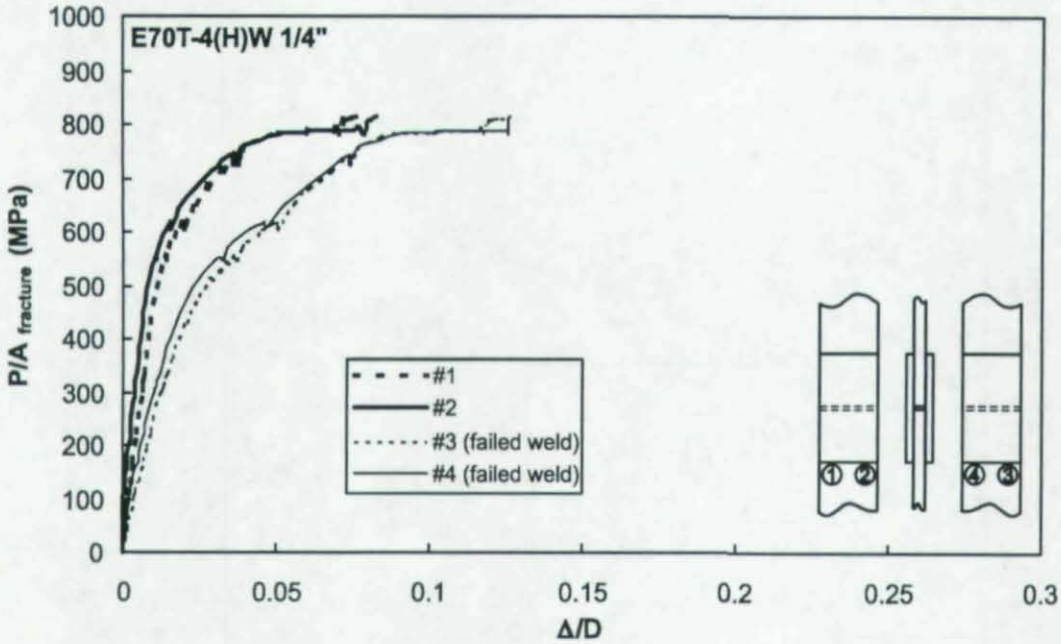


Figure F17 – Specimen T6-2 with 1/4" weld from E70T-4 electrode

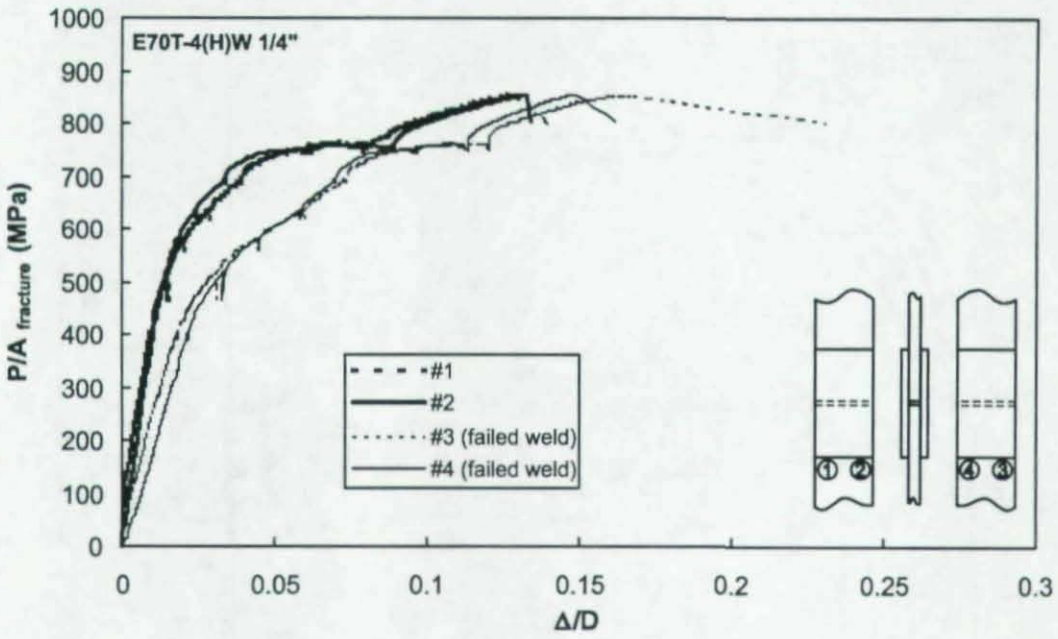


Figure F18 – Specimen T6-3 with 1/4" weld from E70T-4 electrode

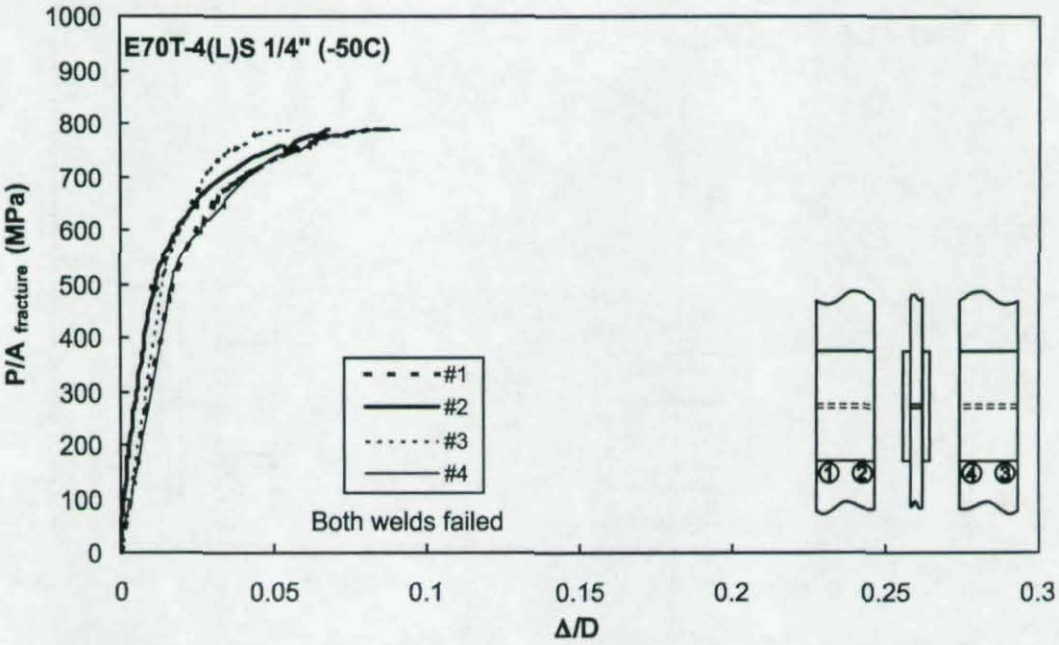


Figure F19 – Specimen T7-1 with 1/4" weld from E70T-4 electrode

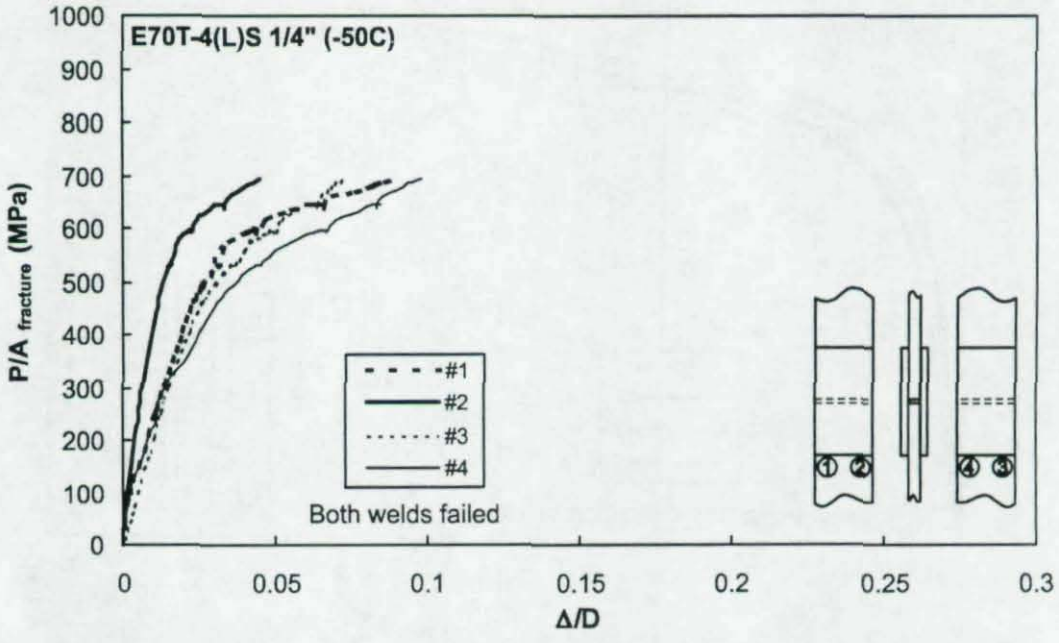


Figure F20 – Specimen T7-2 with 1/4" weld from E70T-4 electrode

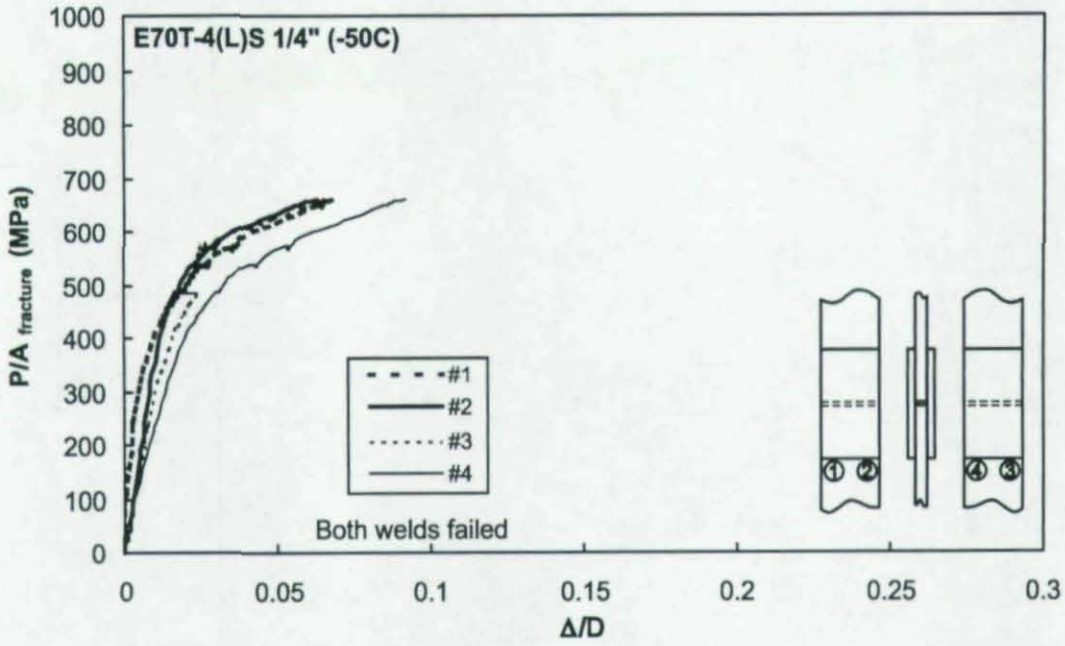


Figure F21 – Specimen T7-3 with 1/4" weld from E70T-4 electrode

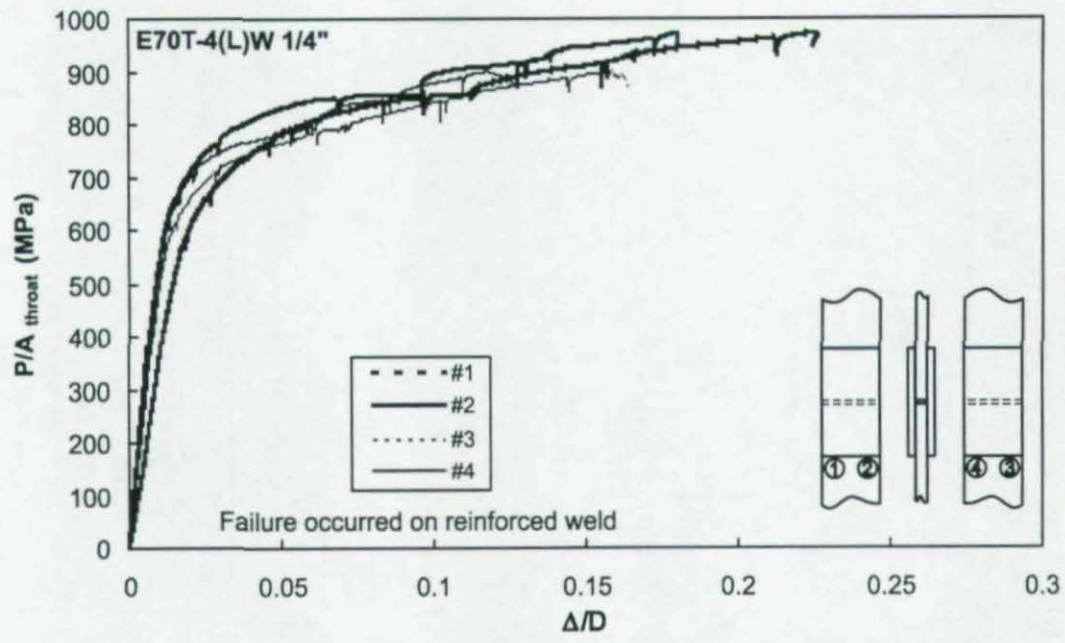


Figure F22 – Specimen T8-1 with 1/4" weld from E70T-4 electrode

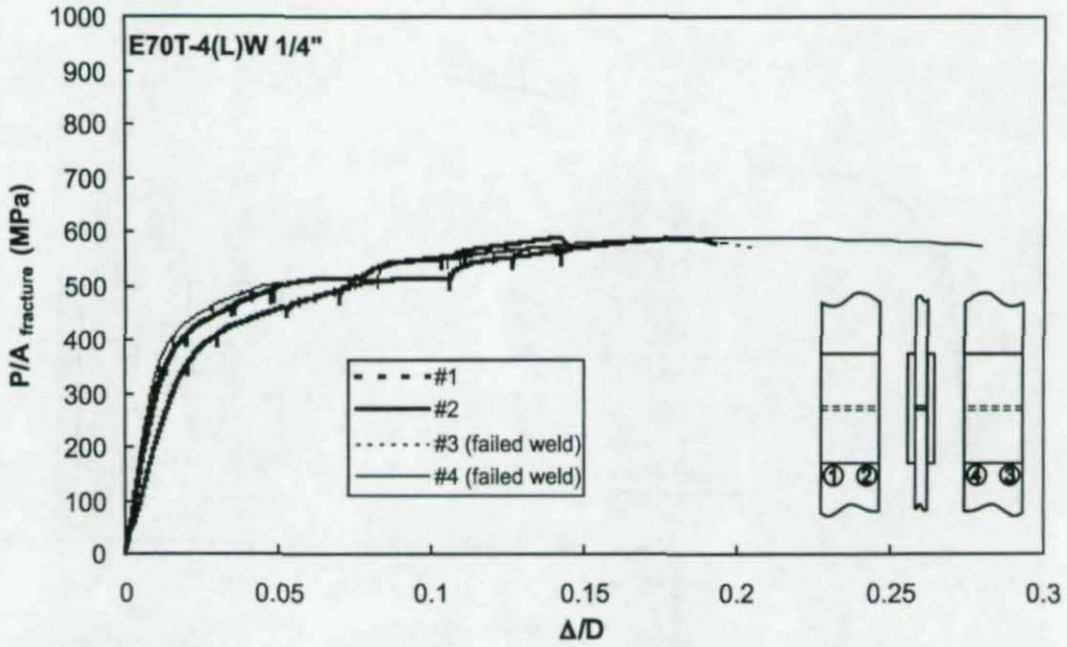


Figure F23 – Specimen T8-2 with 1/4" weld from E70T-4 electrode

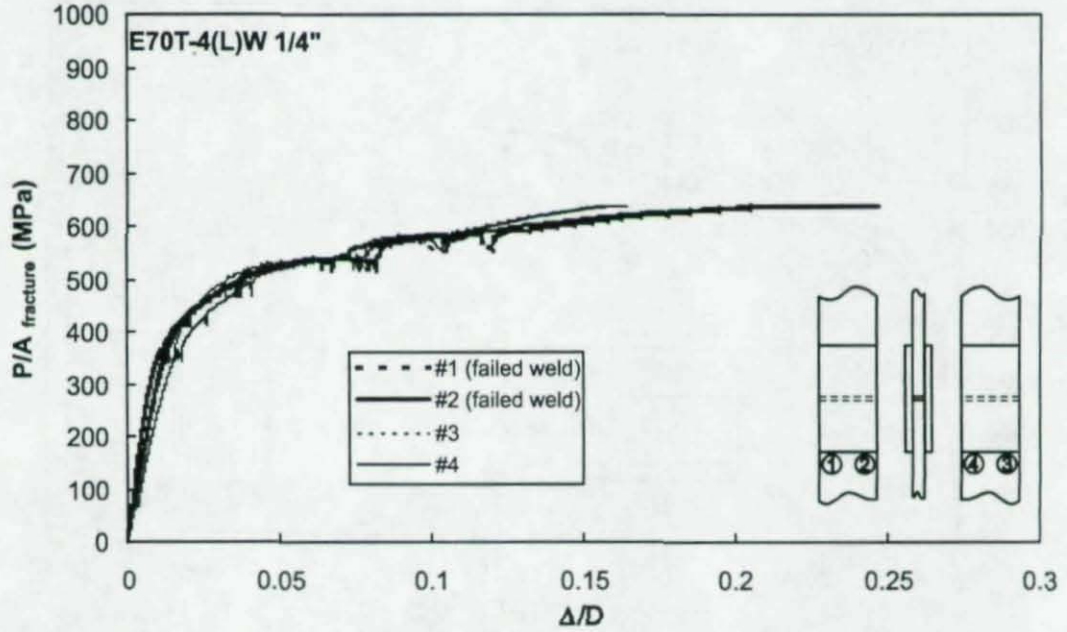


Figure F24 – Specimen T8-3 with 1/4" weld from E70T-4 electrode

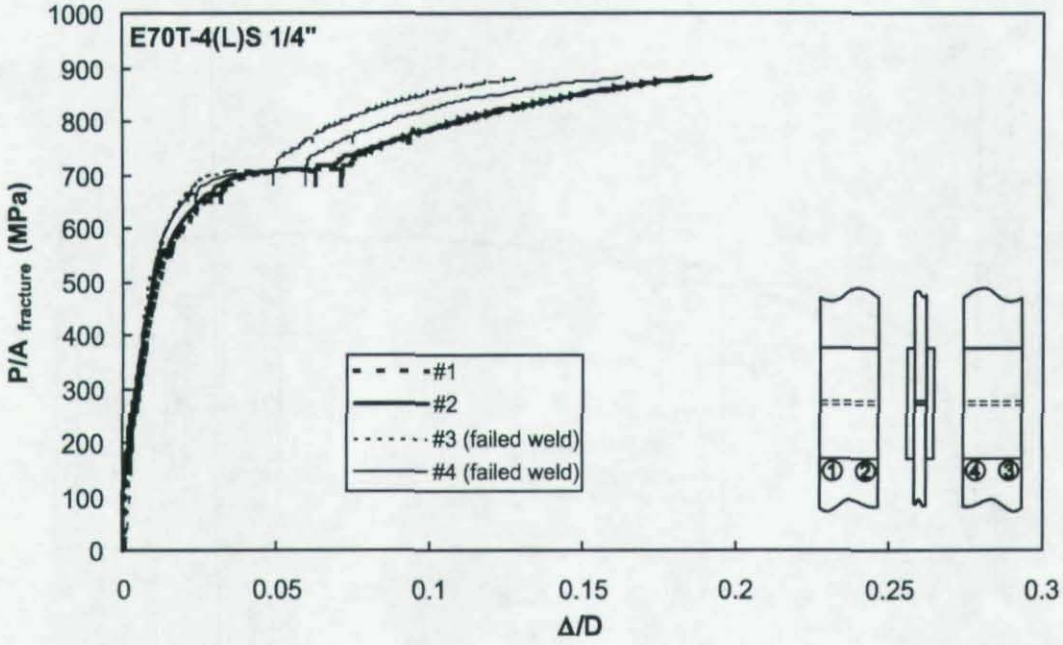


Figure F25 – Specimen T9-1 with 1/4" weld from E70T-4 electrode

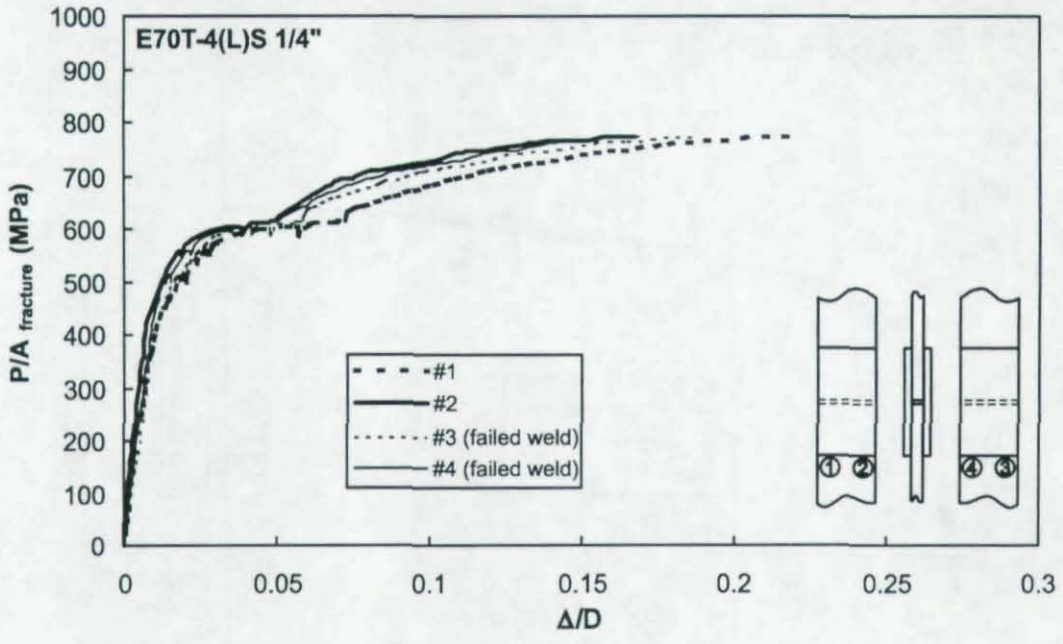


Figure F26 – Specimen T9-2 with 1/4" weld from E70T-4 electrode

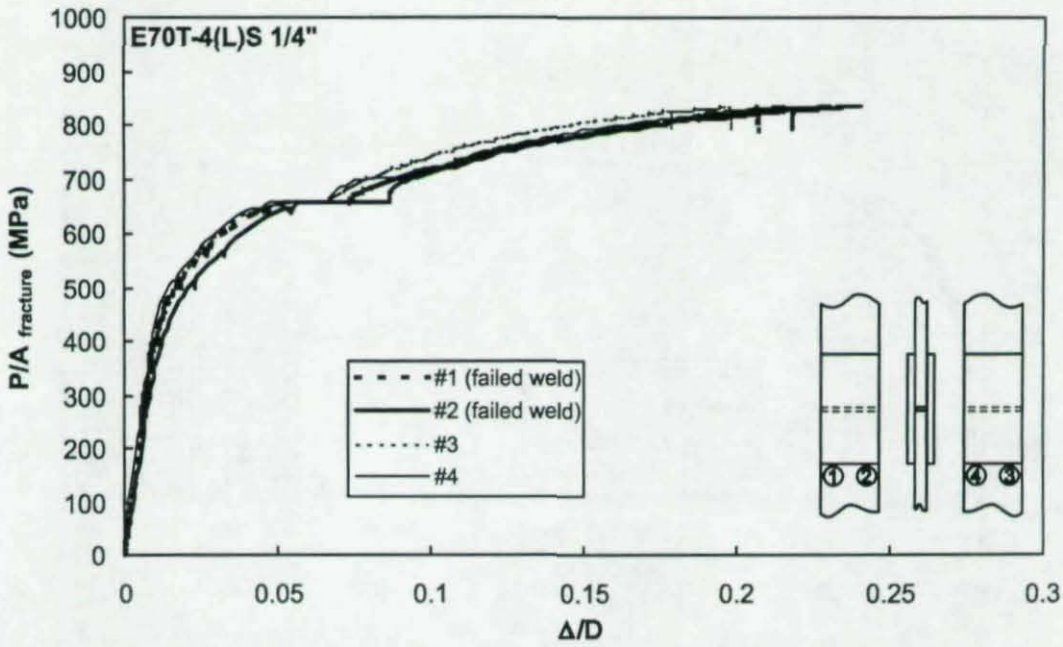


Figure F27 – Specimen T9-3 with 1/4" weld from E70T-4 electrode

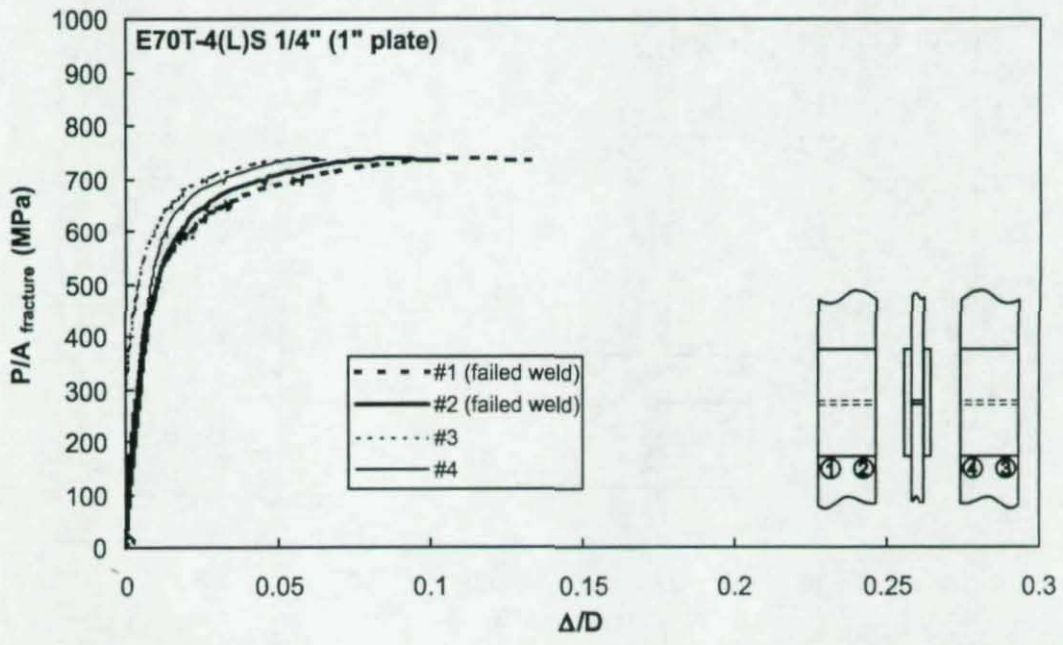


Figure F28 – Specimen T10-1 with 1/4" weld from E70T-4 electrode

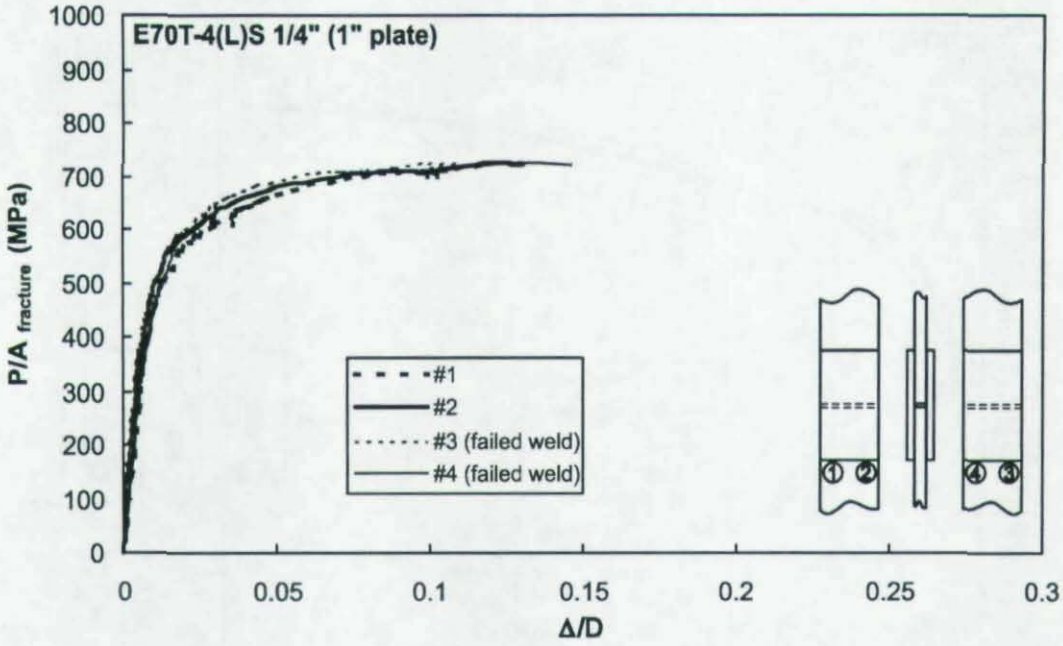


Figure F29 – Specimen T10-2 with 1/4" weld from E70T-4 electrode

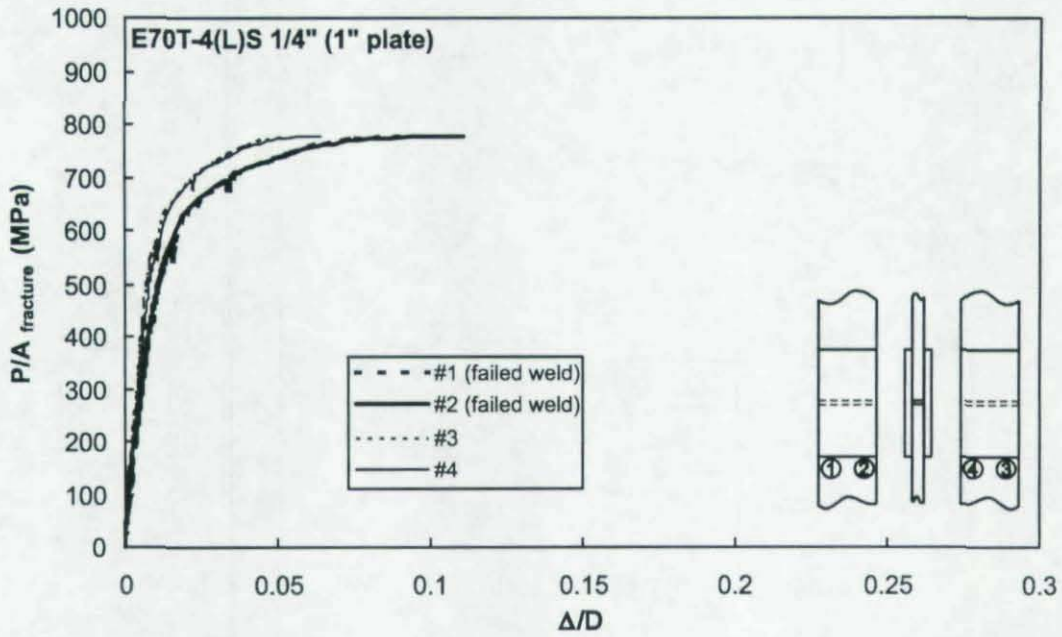


Figure F30 – Specimen T10-3 with 1/4" weld from E70T-4 electrode

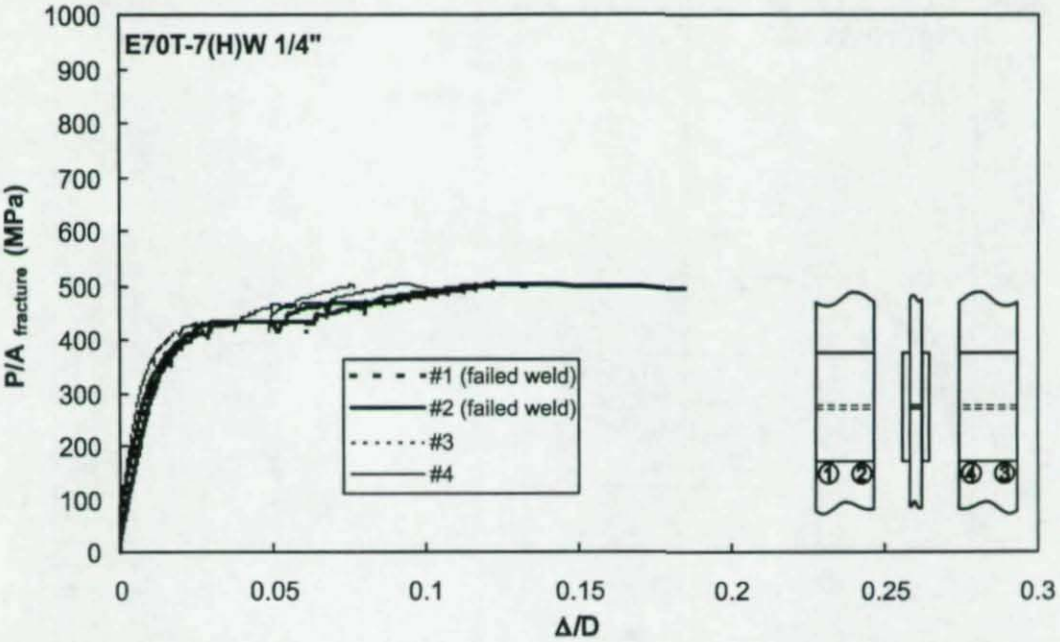


Figure F31 – Specimen T11-1 with 1/4" weld from E70T-7 electrode

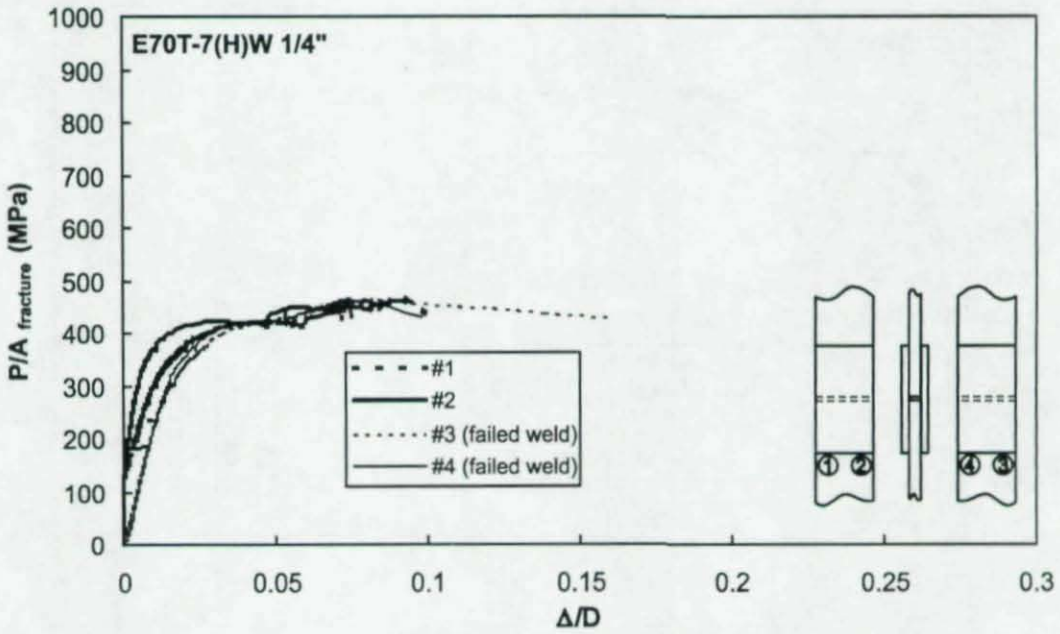


Figure F32 – Specimen T11-2 with 1/4" weld from E70T-7 electrode

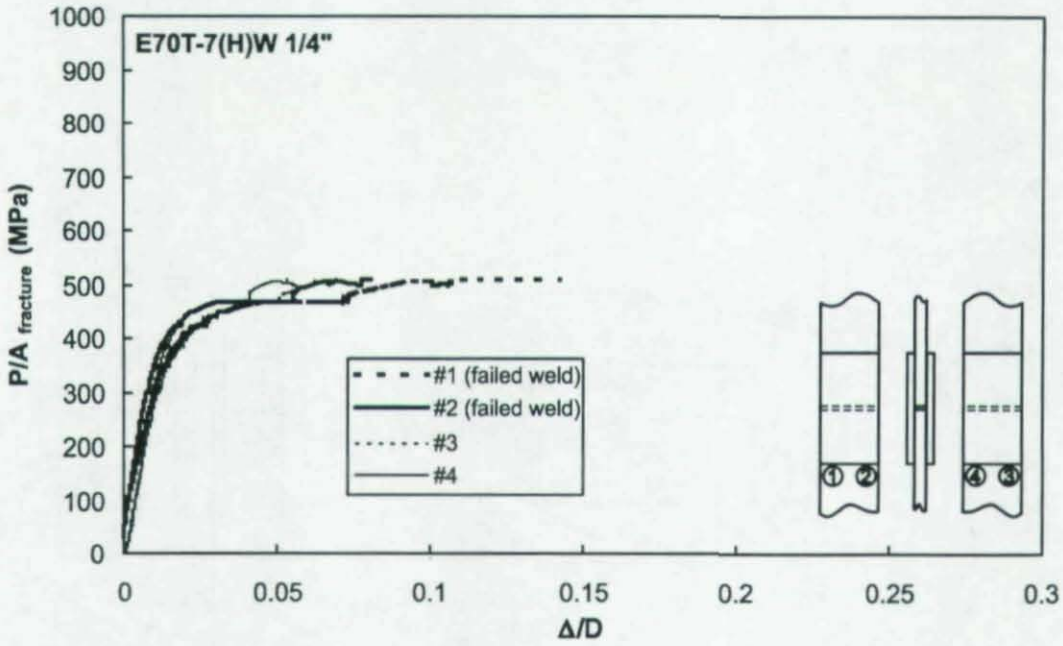


Figure F33 – Specimen T11-3 with 1/4" weld from E70T-7 electrode

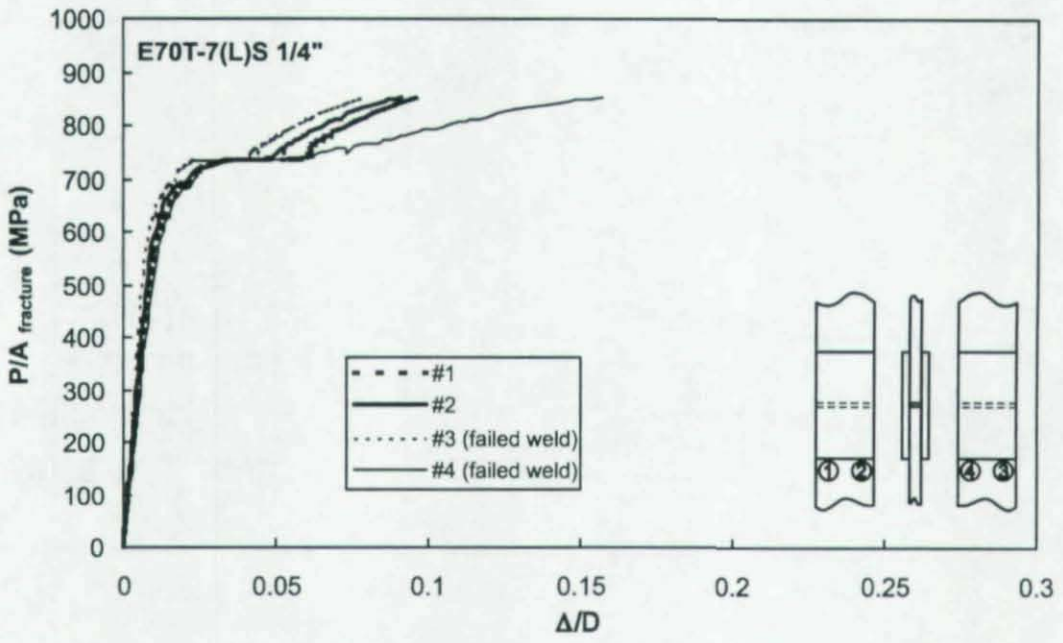


Figure F34 – Specimen T12-1 with 1/4" weld from E70T-7 electrode

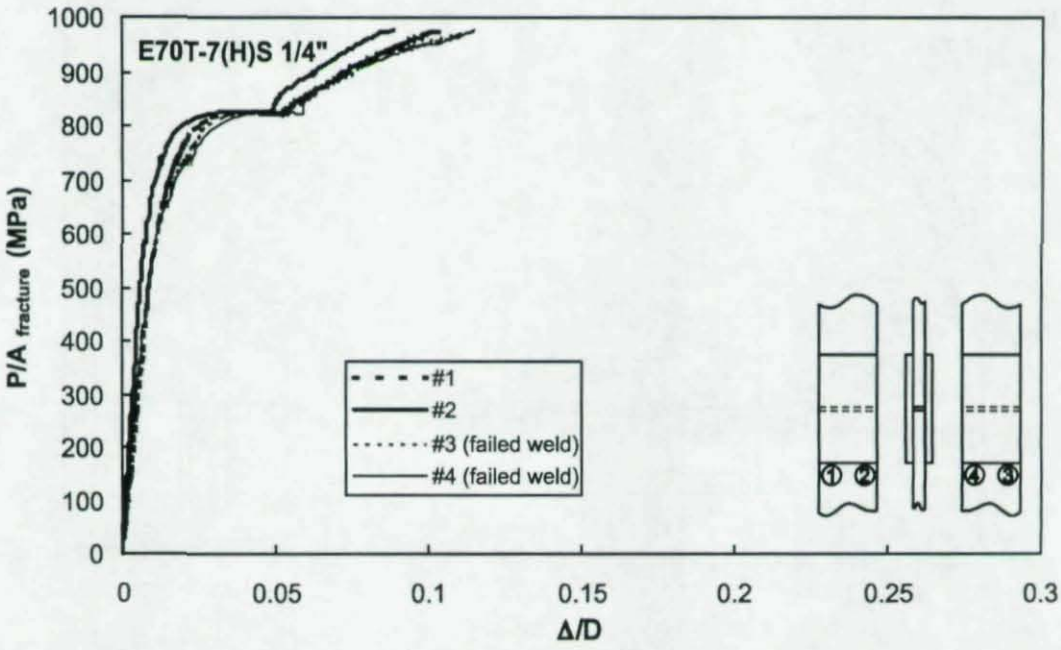


Figure F35 – Specimen T12-2 with 1/4" weld from E70T-7 electrode

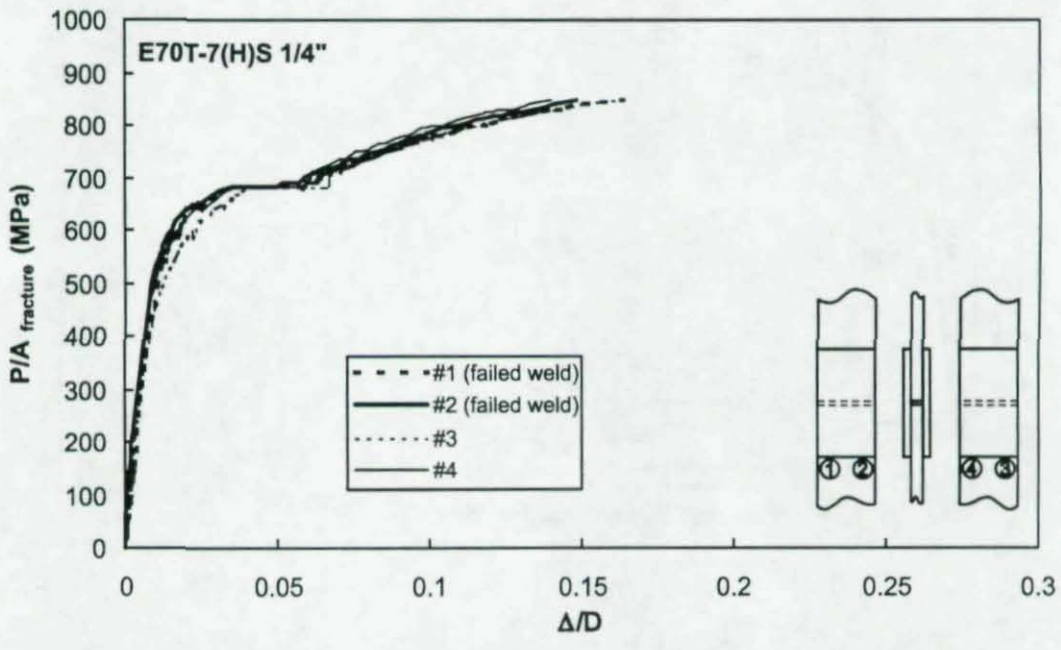


Figure F36 – Specimen T12-3 with 1/4" weld from E70T-7 electrode

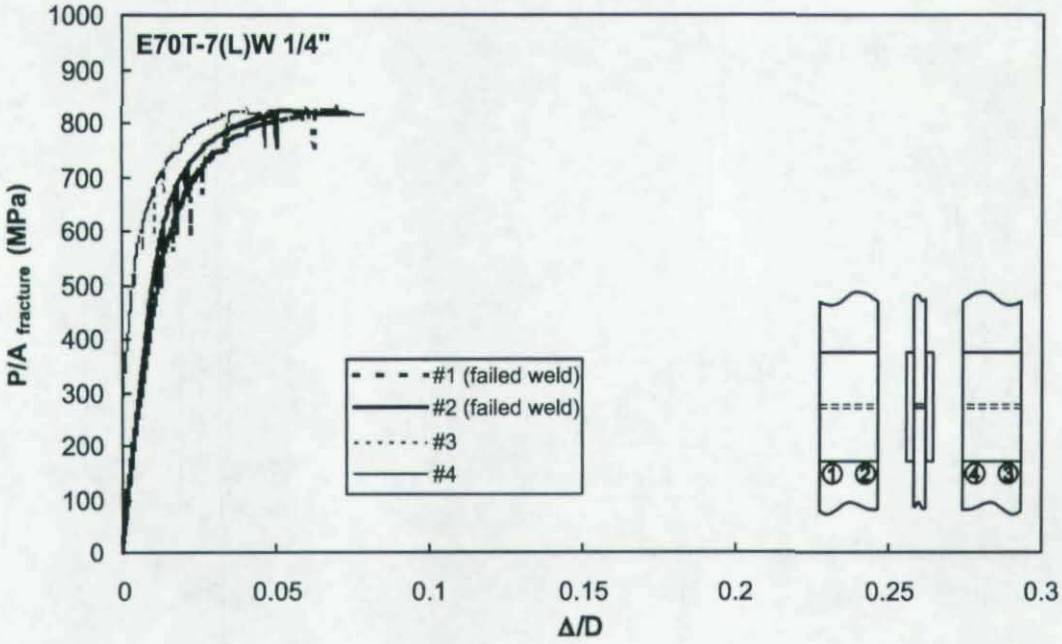


Figure F37 – Specimen 13-1 with 1/4" weld from E70T-7 electrode

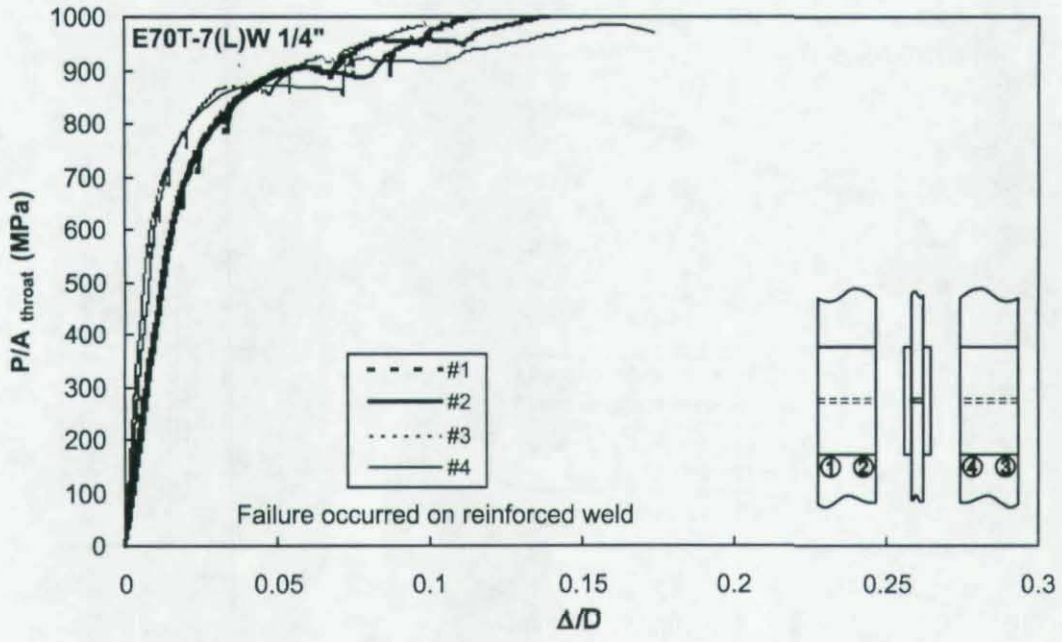


Figure F38 – Specimen 13-2 with 1/4" weld from E70T-7 electrode

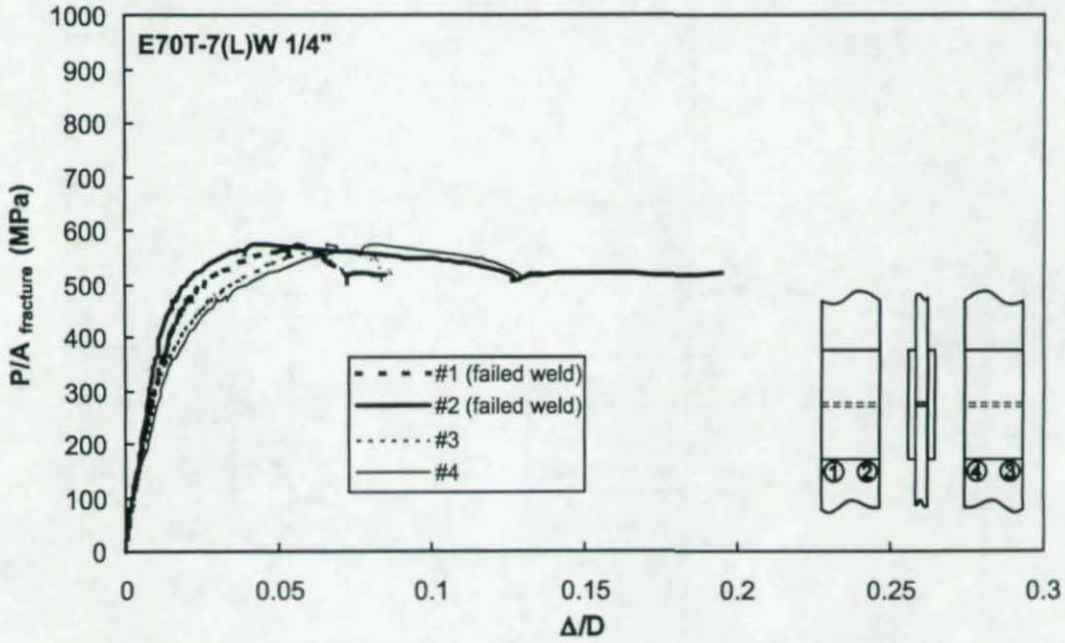


Figure F39 – Specimen T13-3 with 1/4" weld from E70T-7 electrode

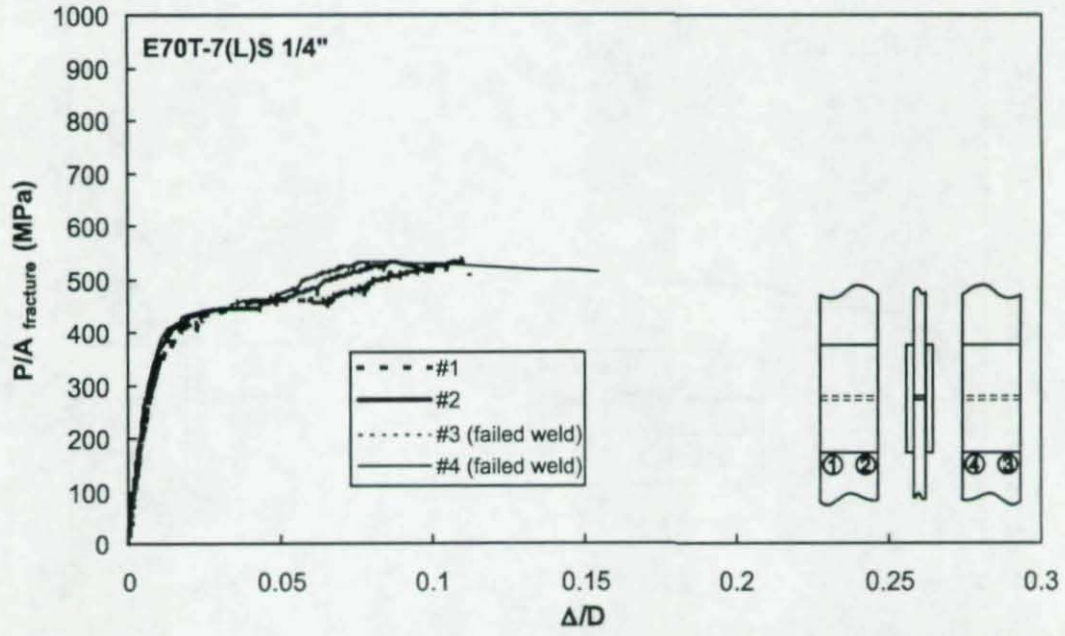


Figure F40 – Specimen T14-1 with 1/4" weld from E70T-7 electrode

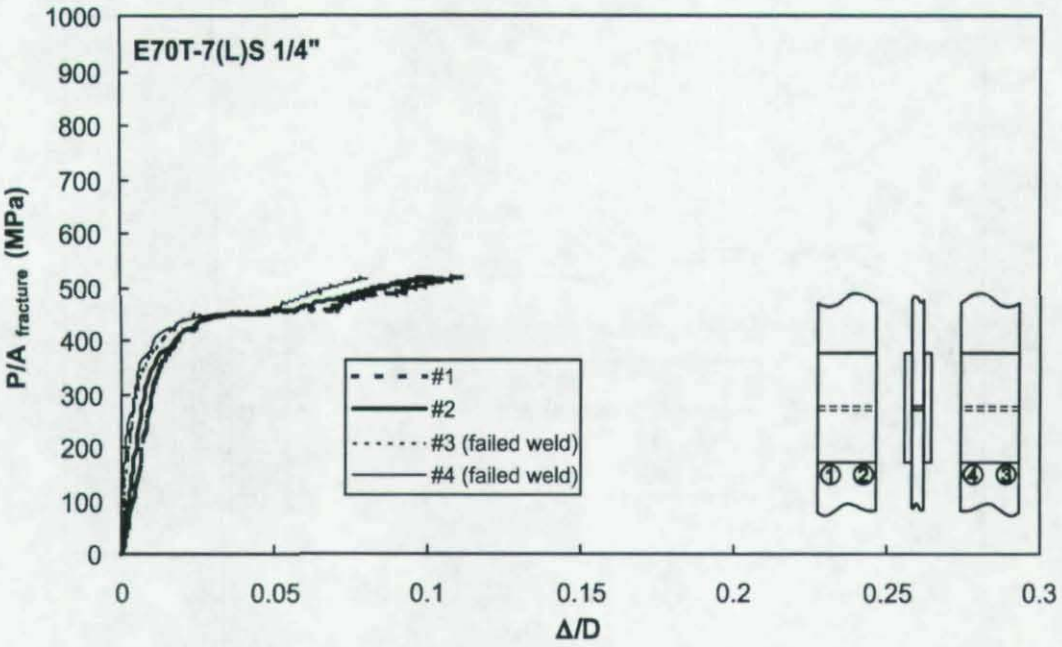


Figure F41 – Specimen T14-2 with 1/4" weld from E70T-7 electrode

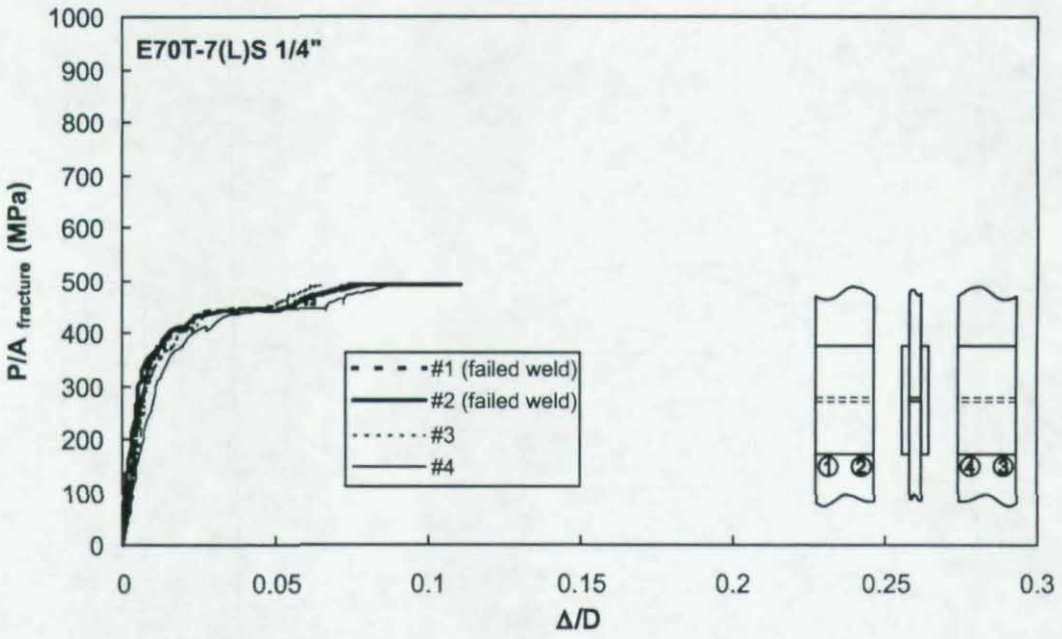


Figure F42 – Specimen T14-3 with 1/4" weld from E70T-7 electrode

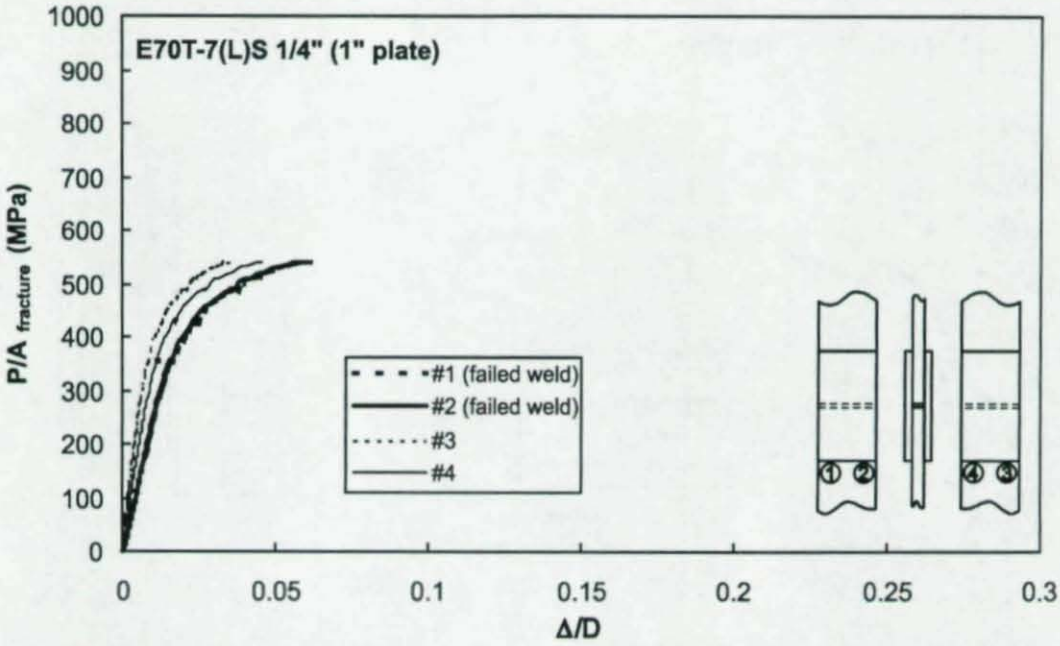


Figure F43 – Specimen T15-1 with 1/4" weld from E70T-7 electrode

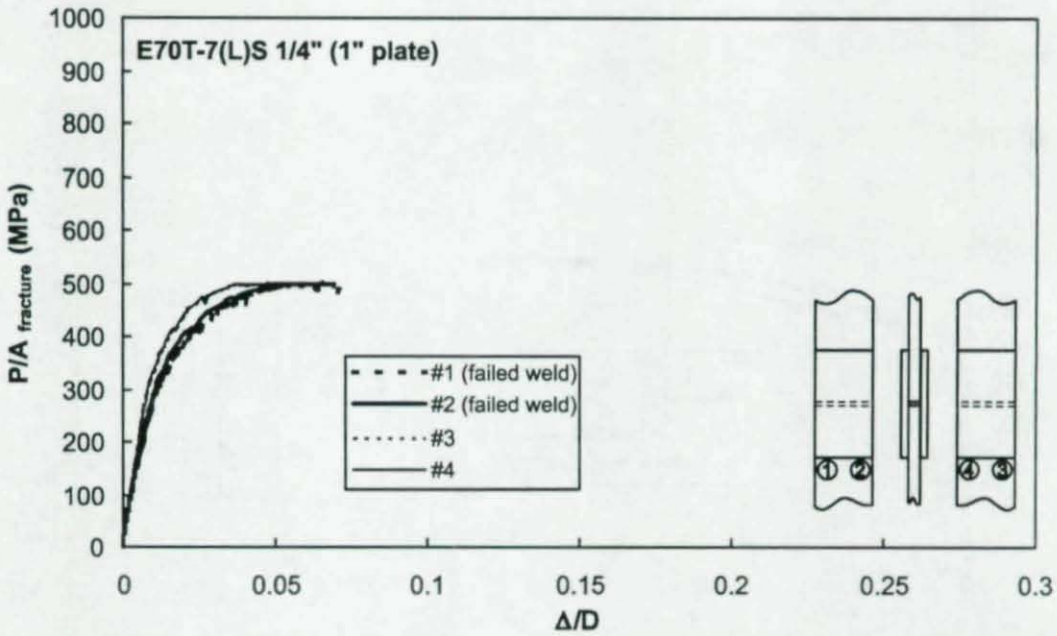


Figure F44 – Specimen T15-2 with 1/4" weld from E70T-7 electrode

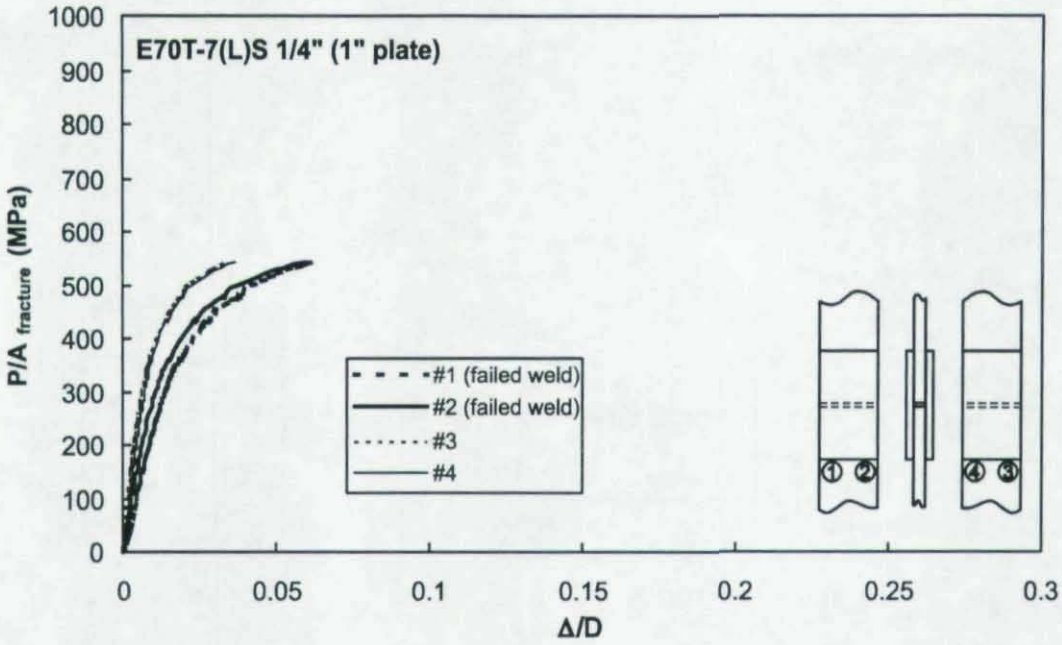


Figure F45 – Specimen T15-3 with 1/4" weld from E70T-7 electrode

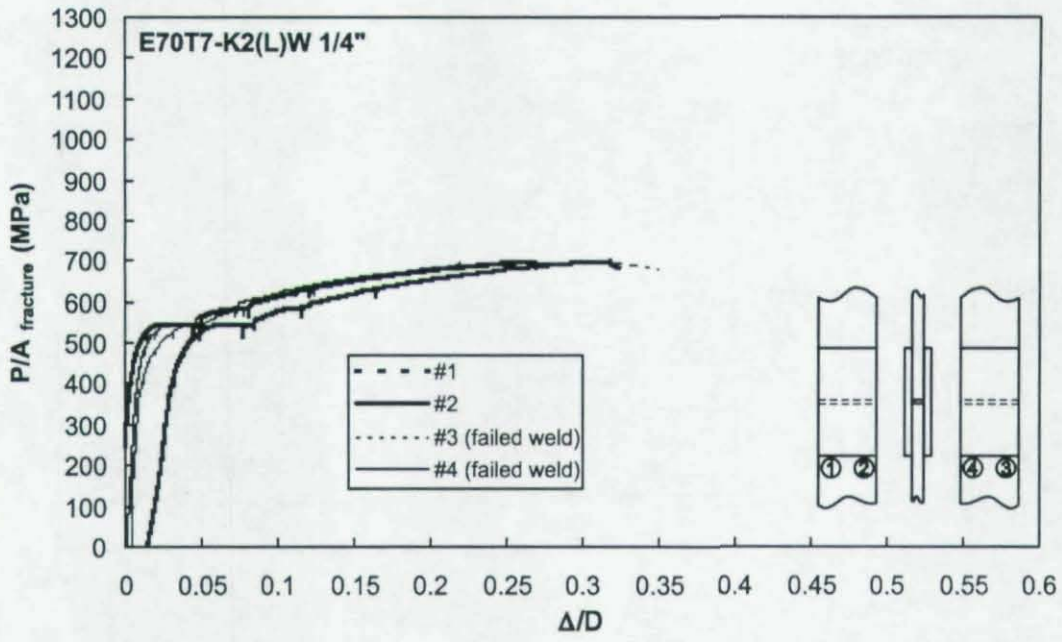


Figure F46 – Specimen T16-1 with 1/4" weld from E70T7-K2 electrode

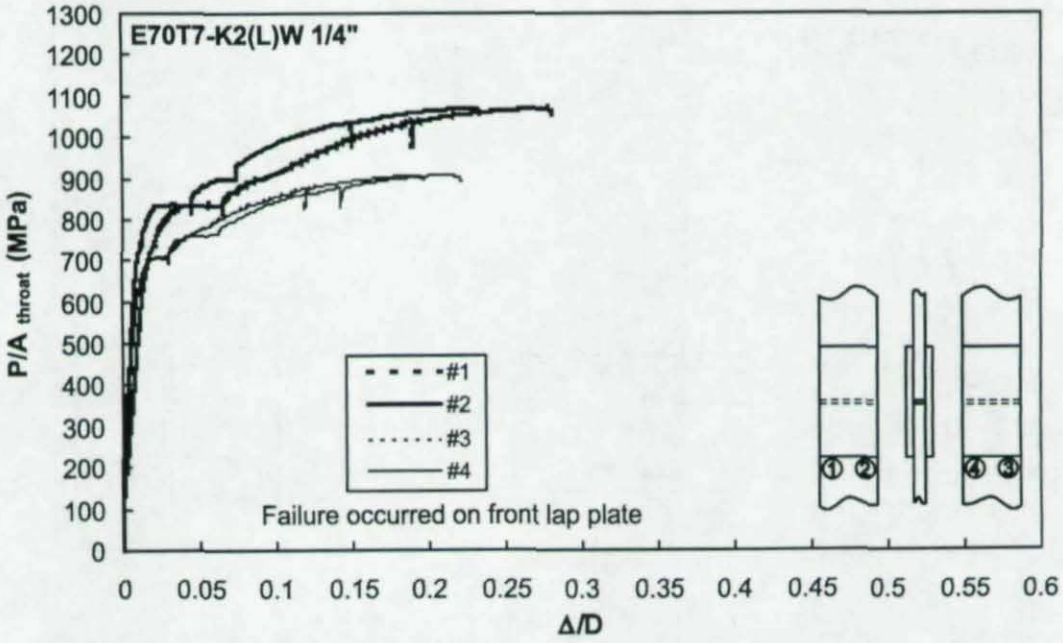


Figure F47 – Specimen T16-2 with 1/4" weld from E70T7-K2 electrode

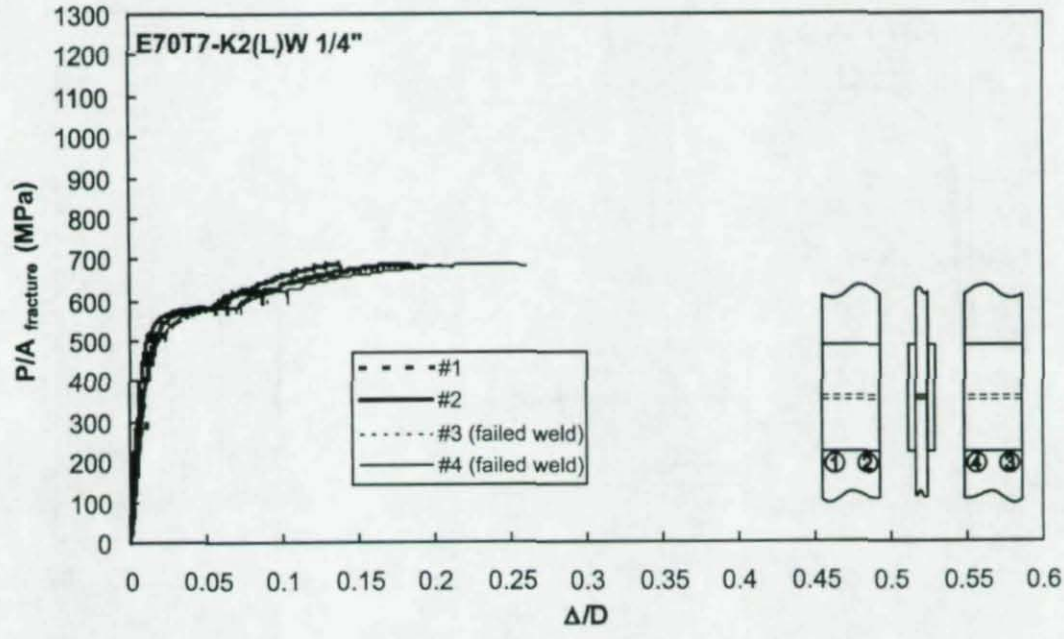


Figure F48 – Specimen T16-3 with 1/4" weld from E70T7-K2 electrode

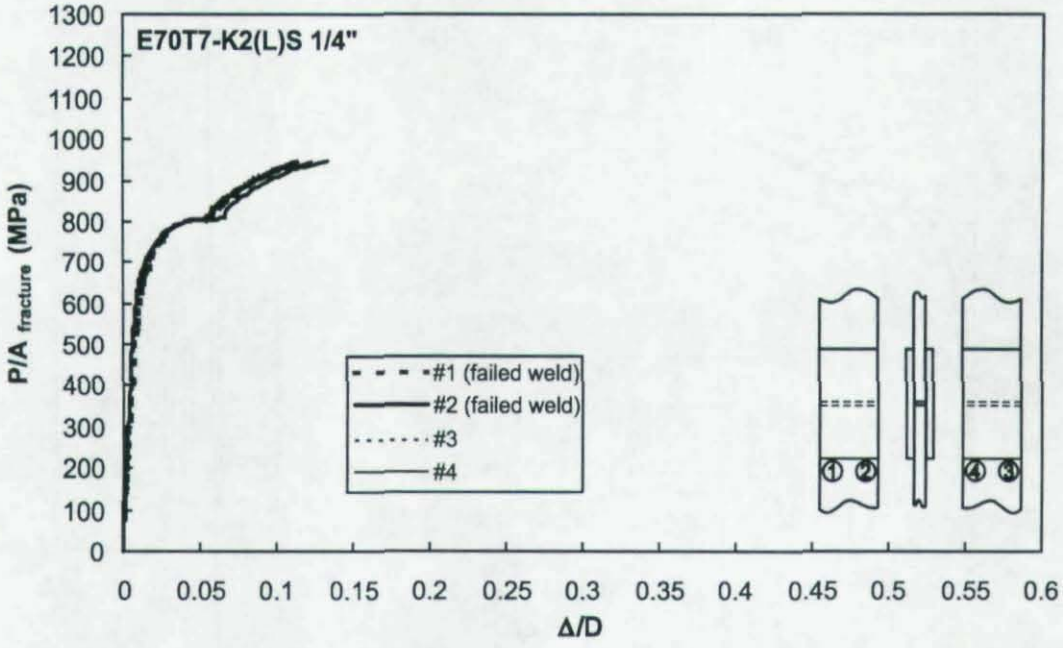


Figure F49 – Specimen T17-1 with 1/4" weld from E70T7-K2 electrode

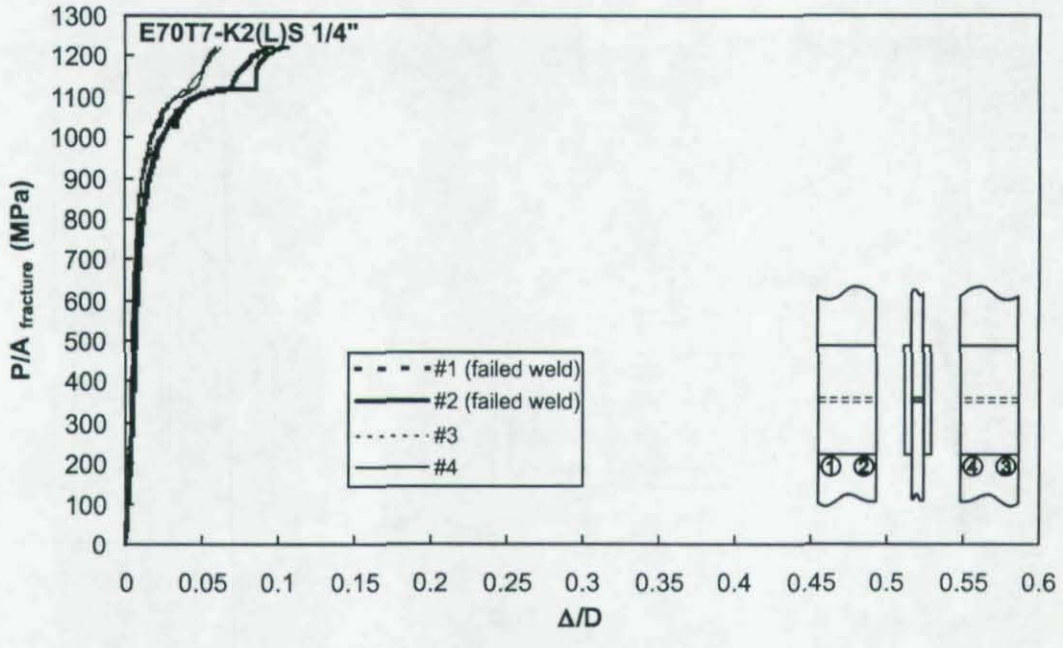


Figure F50 – Specimen T17-2 with 1/4" weld from E70T7-K2 electrode

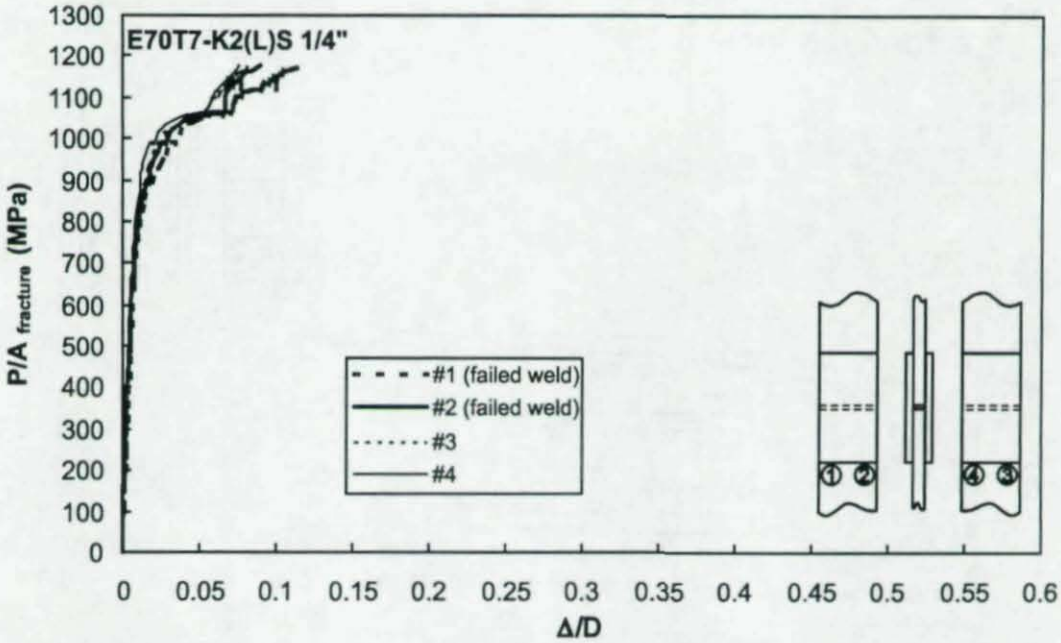


Figure F51 – Specimen T17-3 with 1/4" weld from E70T7-K2 electrode

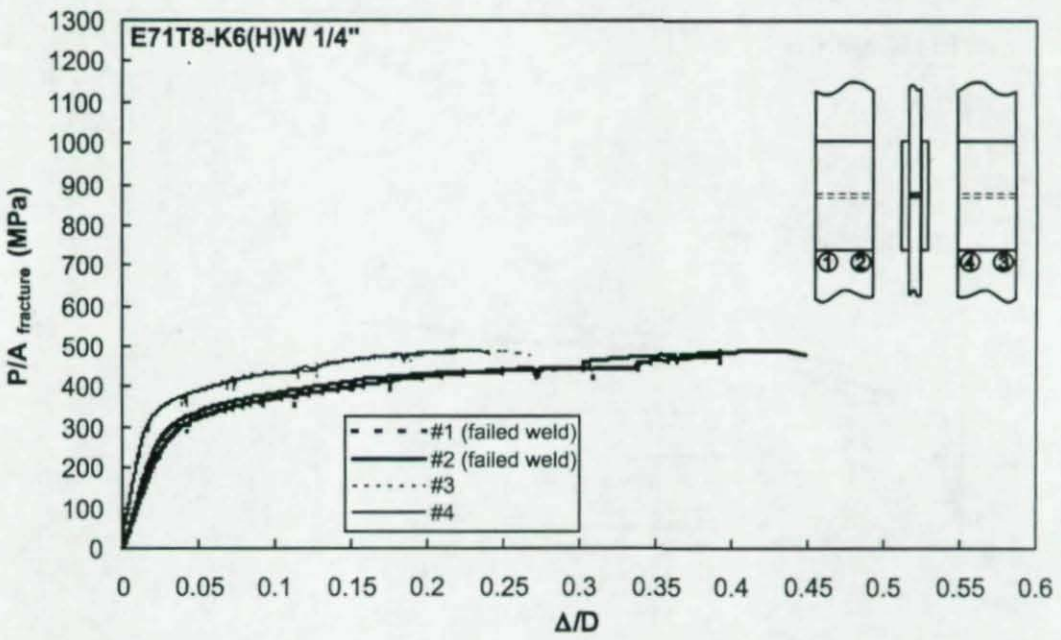


Figure F52 – Specimen T18-1 with 1/4" weld from E71T8-K6 electrode

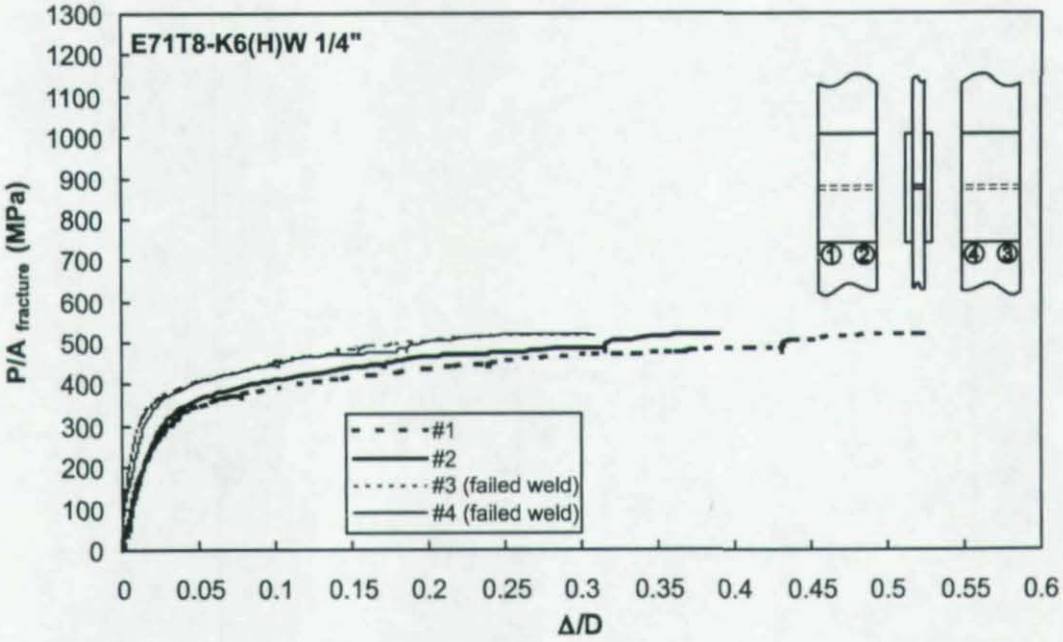


Figure F53 – Specimen T18-2 with 1/4" weld from E71T8-K6 electrode

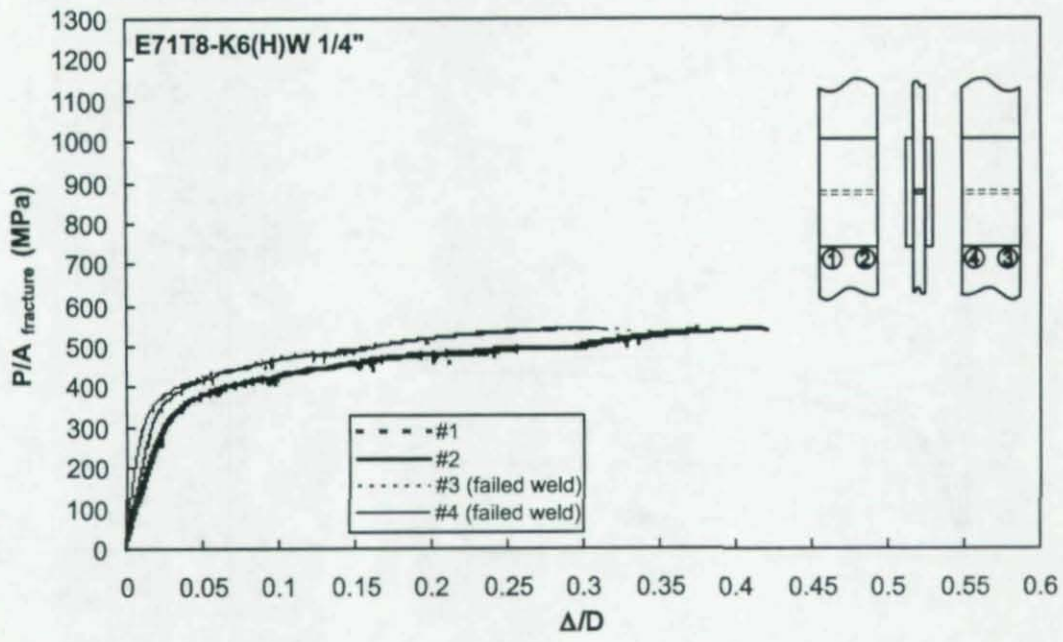


Figure F54 – Specimen T18-3 with 1/4" weld from E71T8-K6 electrode

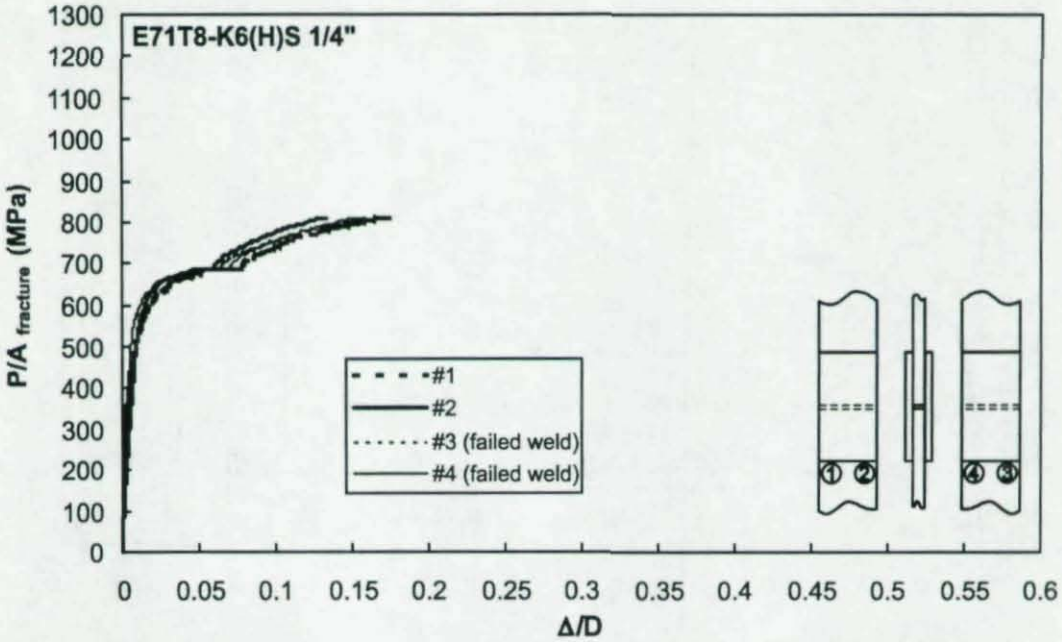


Figure F55 – Specimen T19-1 with 1/4" weld from E71T8-K6 electrode

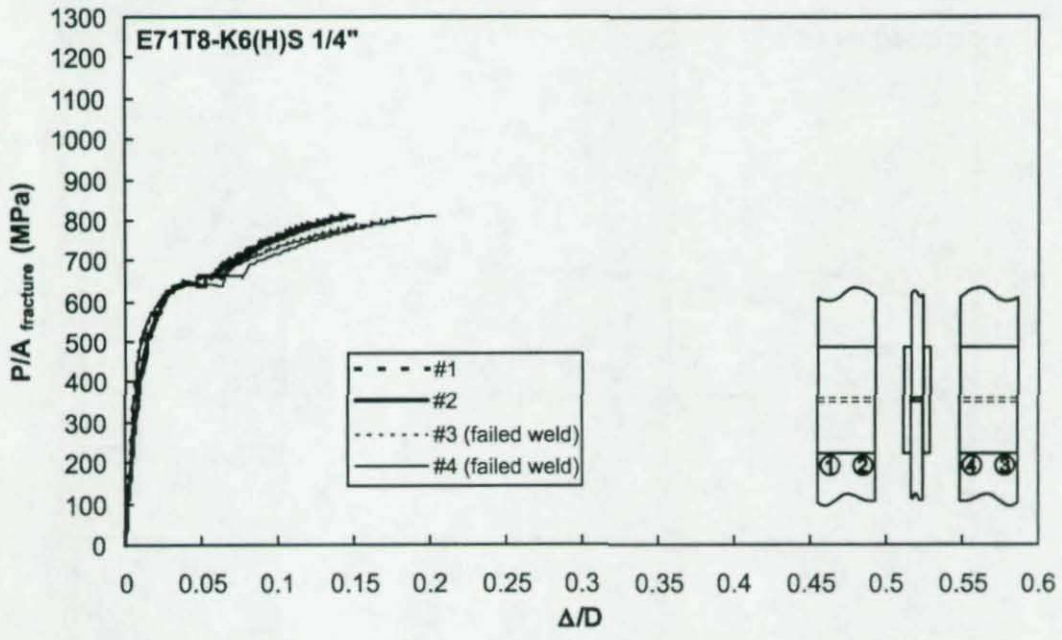


Figure F56 – Specimen T19-2 with 1/4" weld from E71T8-K6 electrode

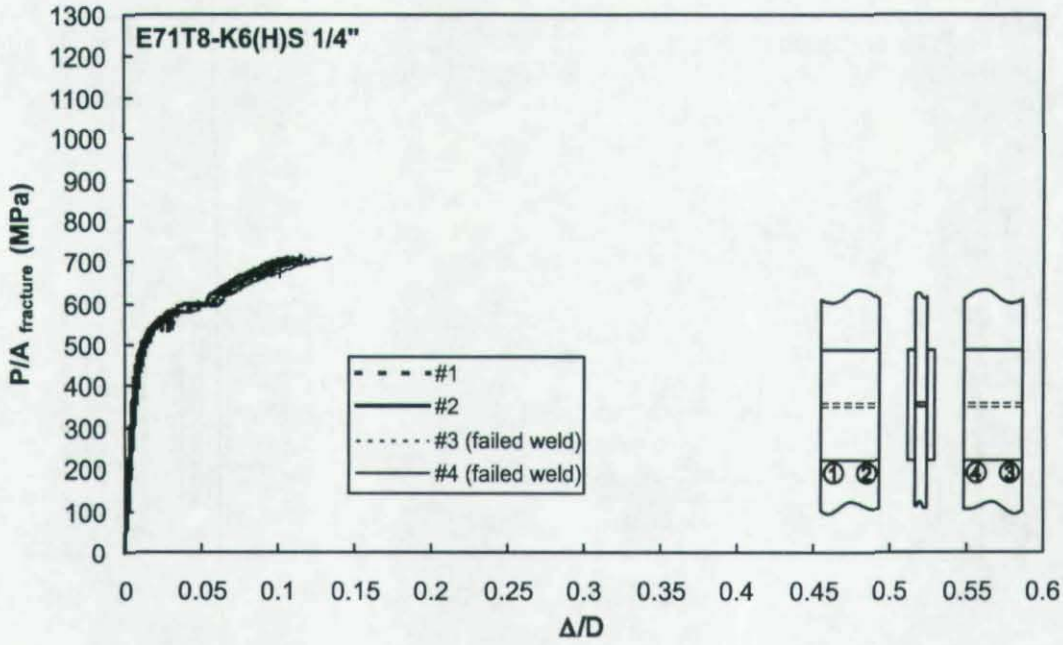


Figure F57 – Specimen T19-3 with 1/4" weld from E71T8-K6 electrode

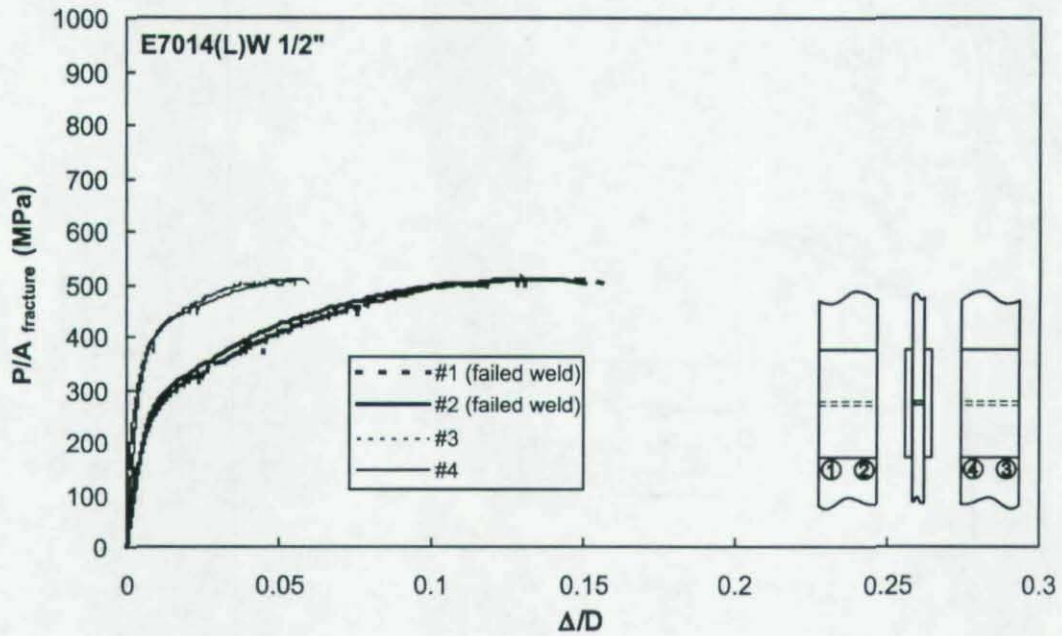


Figure F58 – Specimen T20-1 with 1/2" weld from E7014 electrode

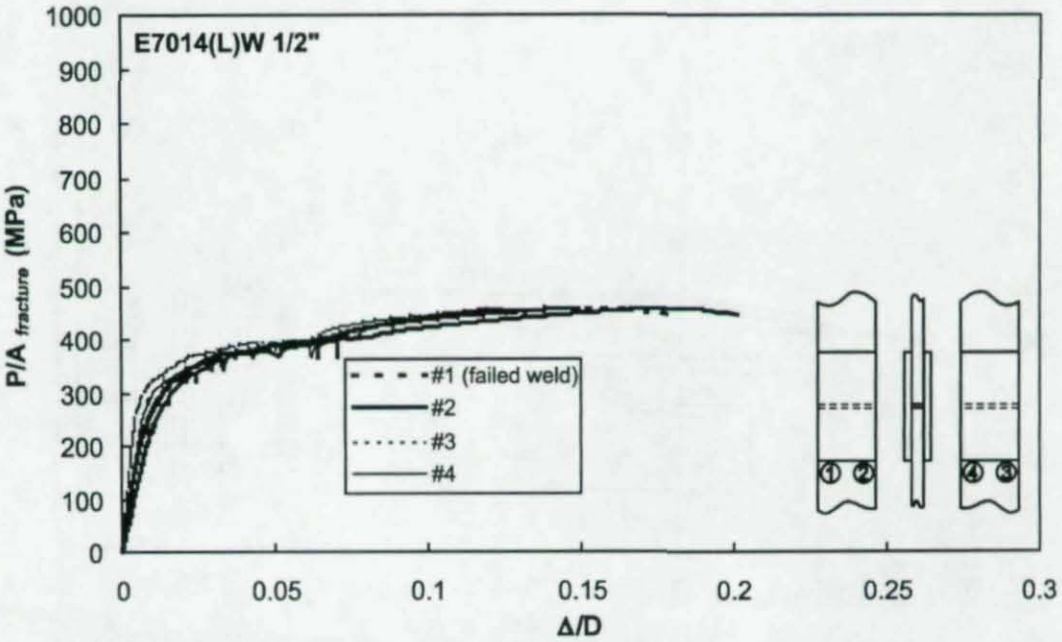


Figure F59 – Specimen T20-2 with 1/2" weld from E7014 electrode

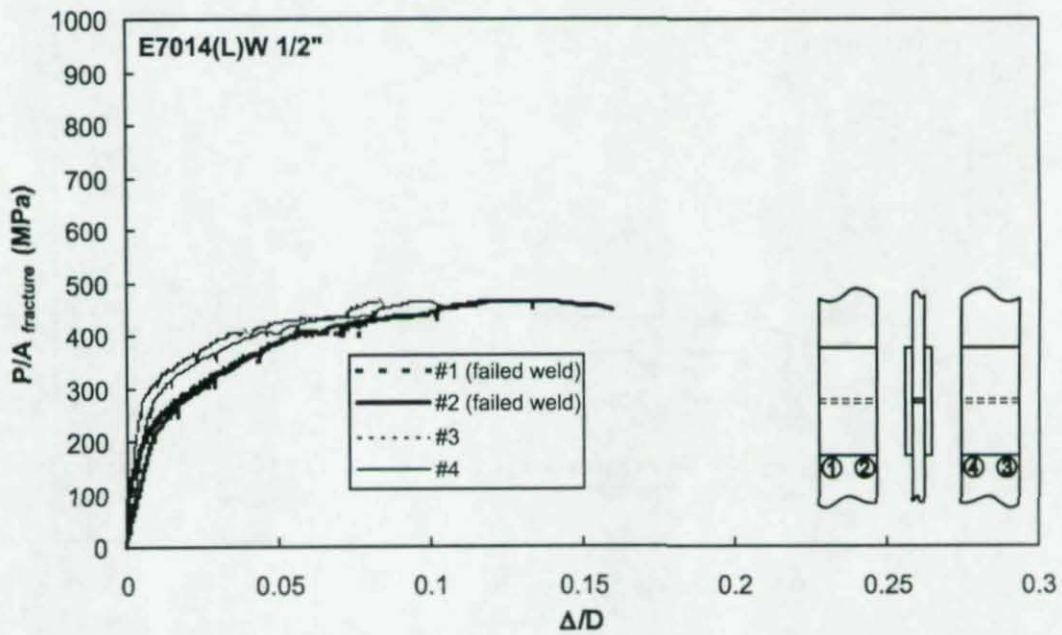


Figure F60 – Specimen T20-3 with 1/2" weld from E7014 electrode

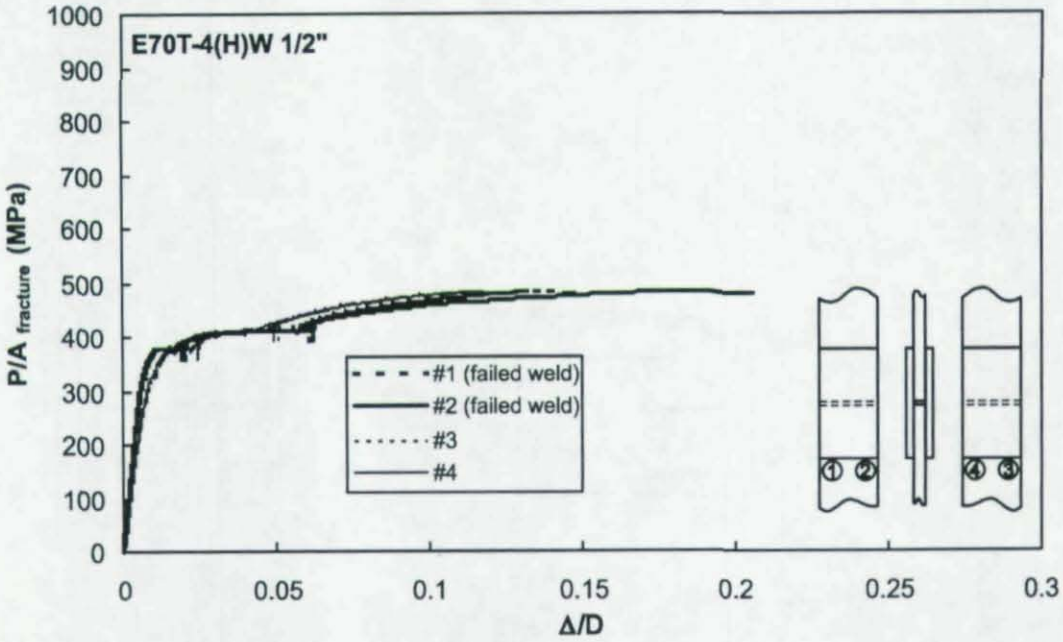


Figure F61 – Specimen T21-1 with 1/2" weld from E70T-4 electrode

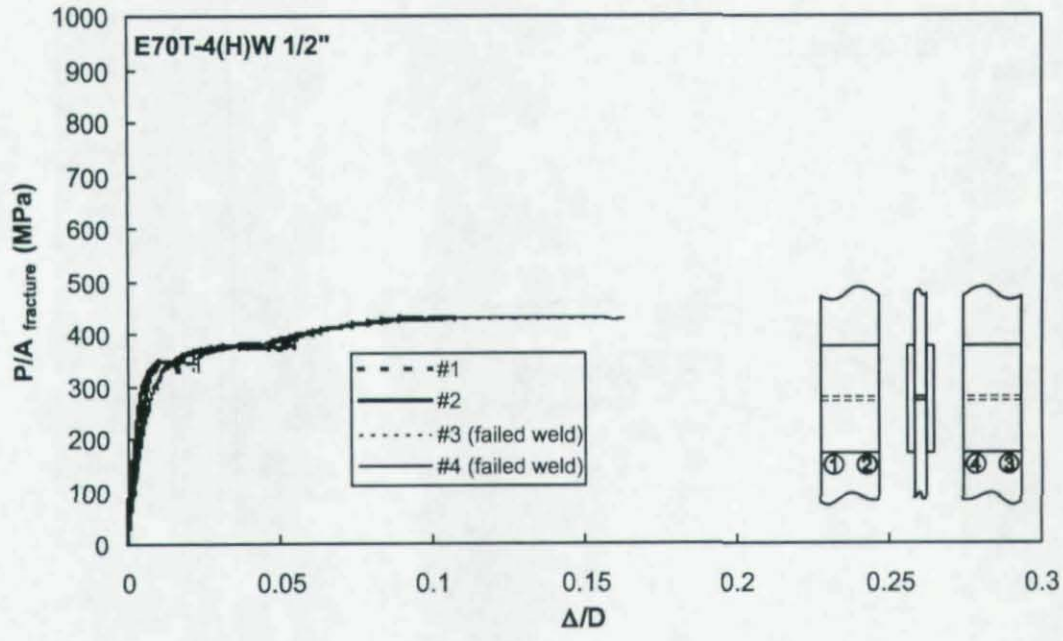


Figure F62 – Specimen T21-2 with 1/2" weld from E70T-4 electrode

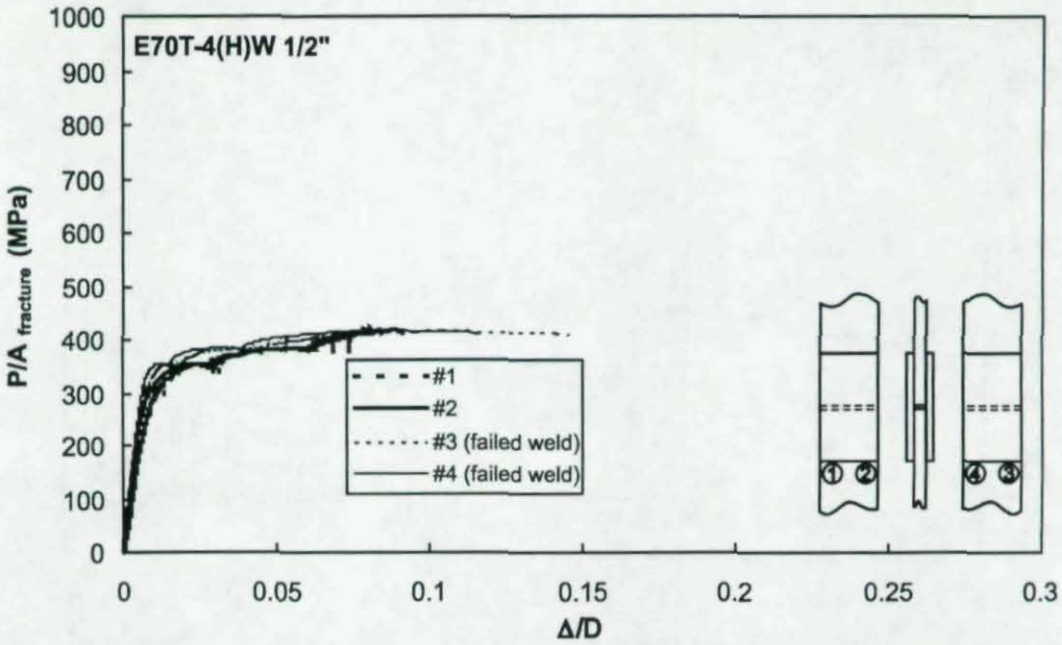


Figure F63 – Specimen T21-3 with 1/2" weld from E70T-4 electrode

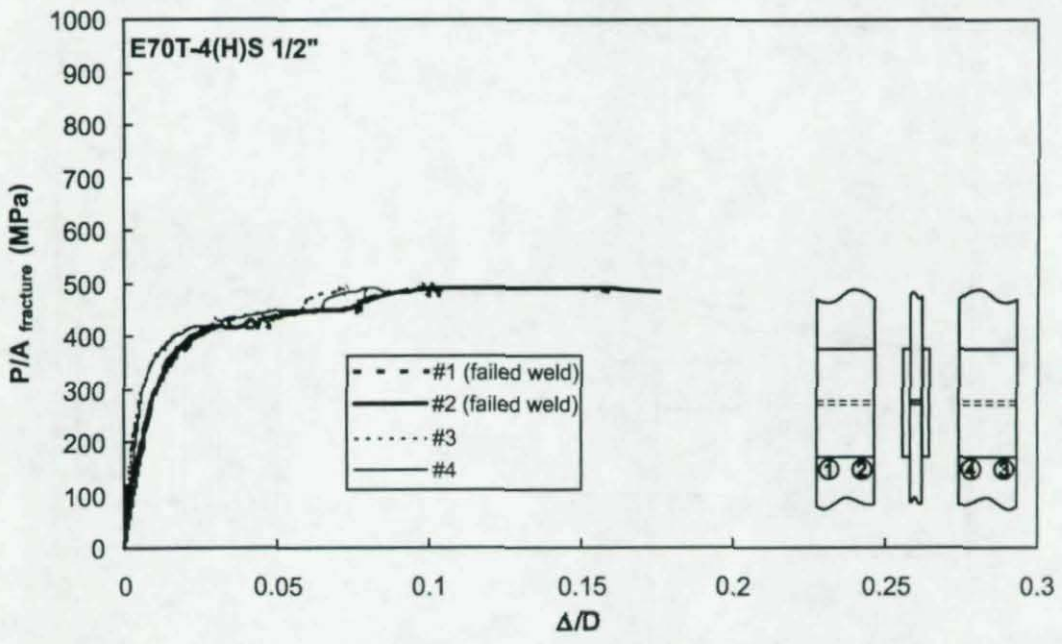


Figure F64 – Specimen T22-1 with 1/2" weld from E70T-4 electrode

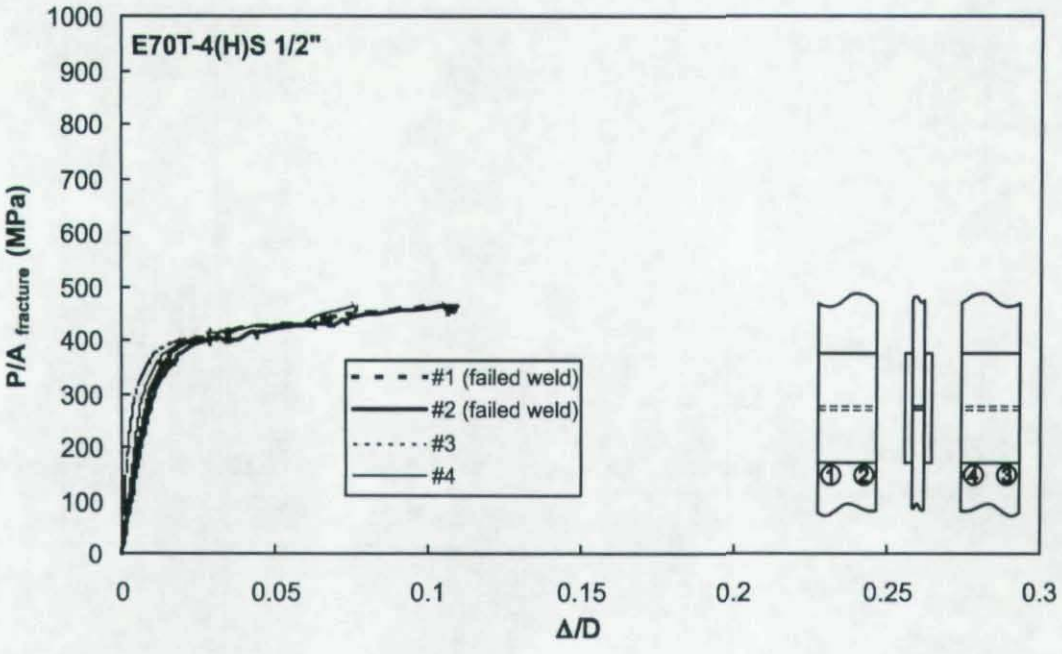


Figure F65 – Specimen T22-2 with 1/2" weld from E70T-4 electrode

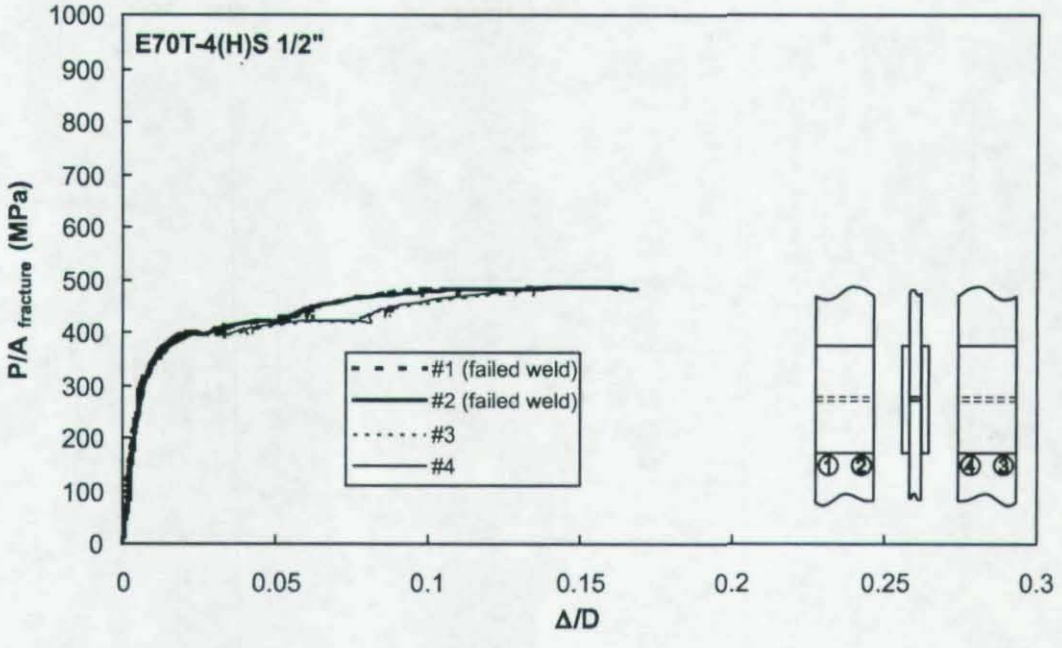


Figure F66 – Specimen T22-3 with 1/2" weld from E70T-4 electrode

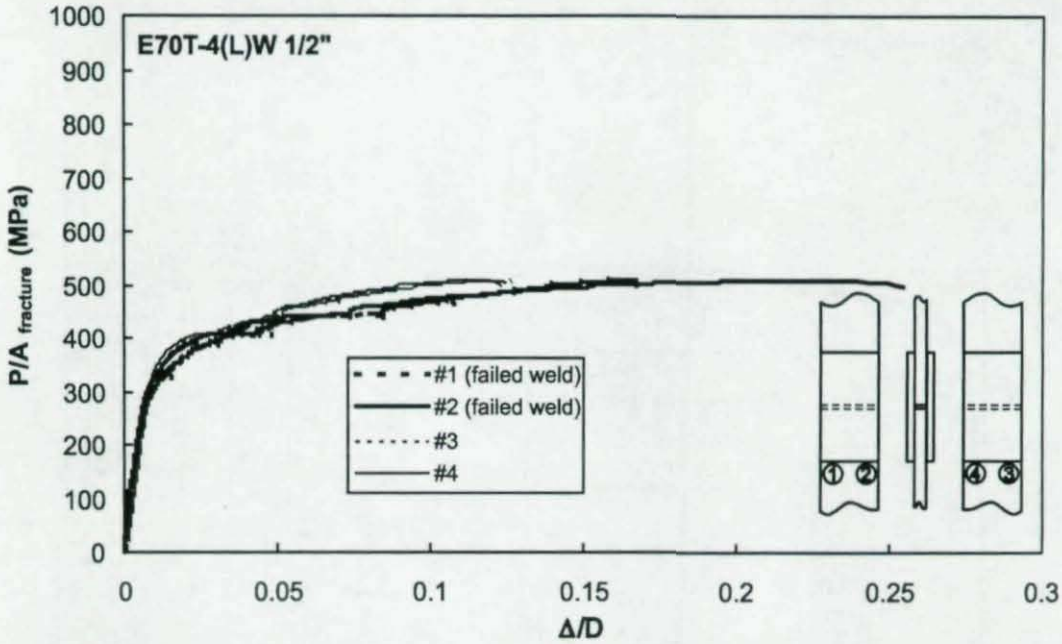


Figure F67 – Specimen T23-1 with 1/2" weld from E70T-4 electrode

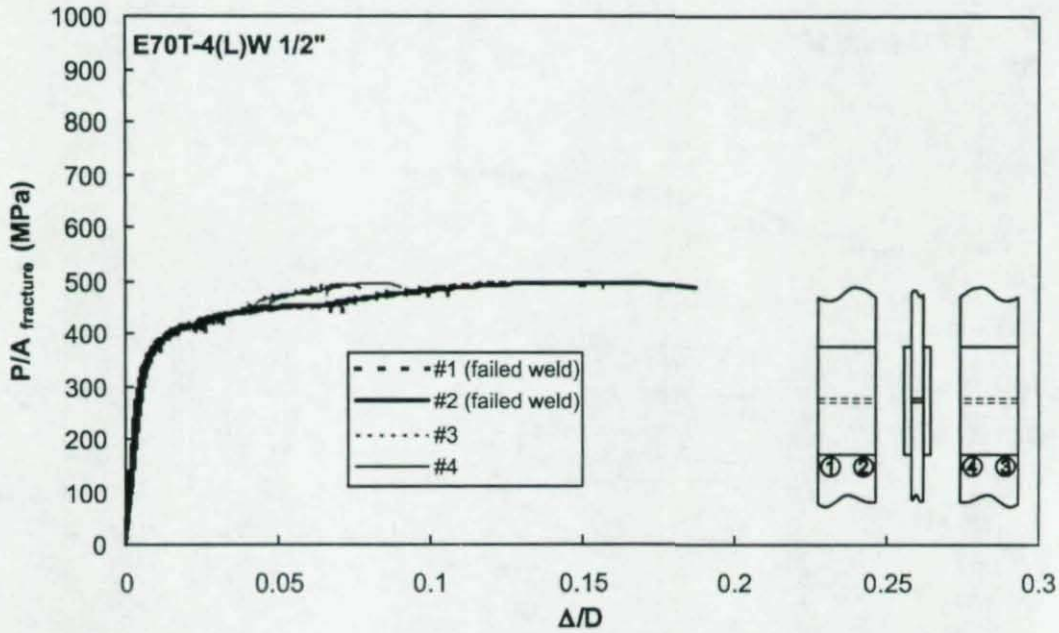


Figure F68 – Specimen T23-2 with 1/2" weld from E70T-4 electrode

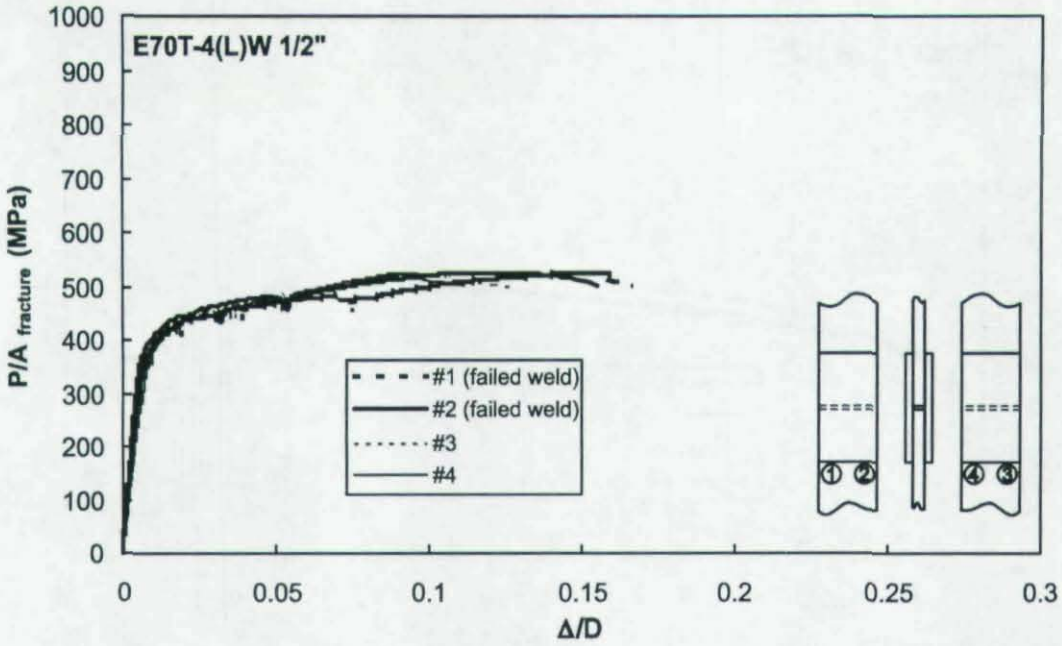


Figure F69 – Specimen T23-3 with 1/2" weld from E70T-4 electrode

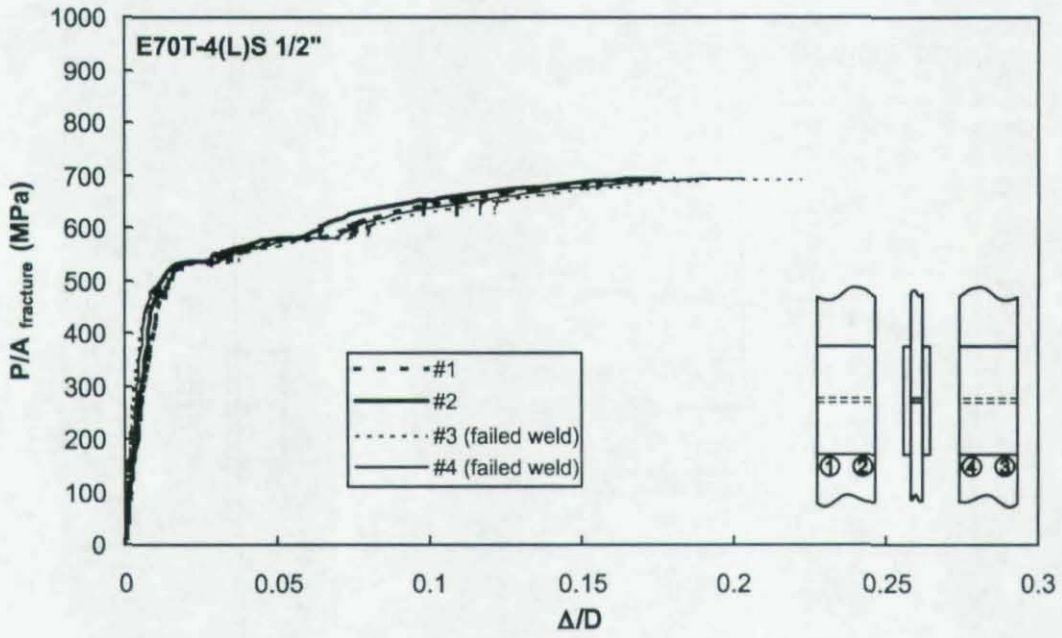


Figure F70 – Specimen T24-1 with 1/2" weld from E70T-4 electrode

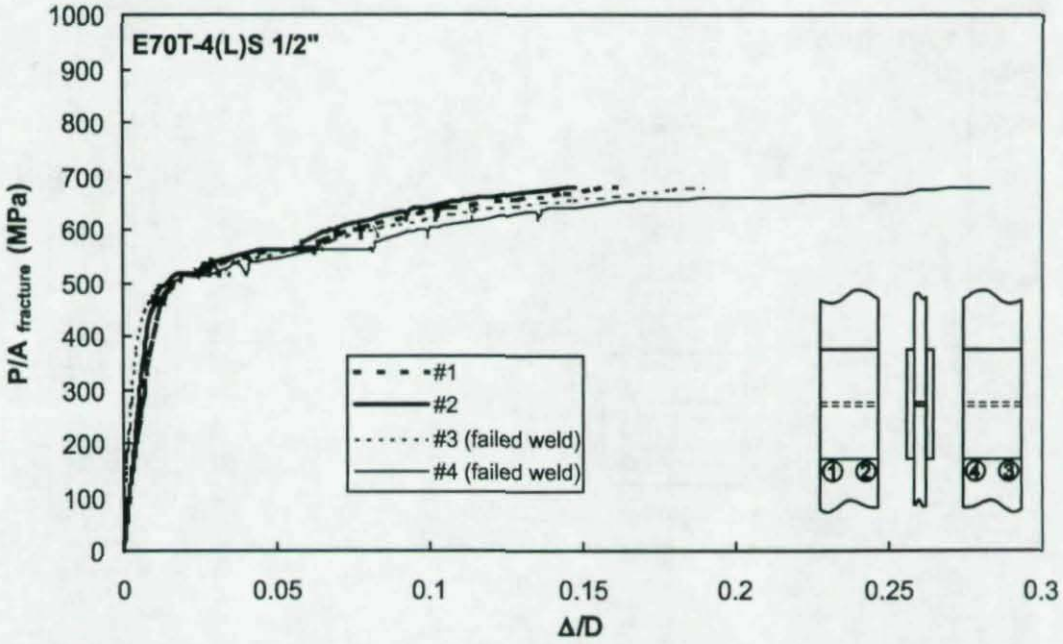


Figure F71 – Specimen T24-2 with 1/2" weld from E70T-4 electrode

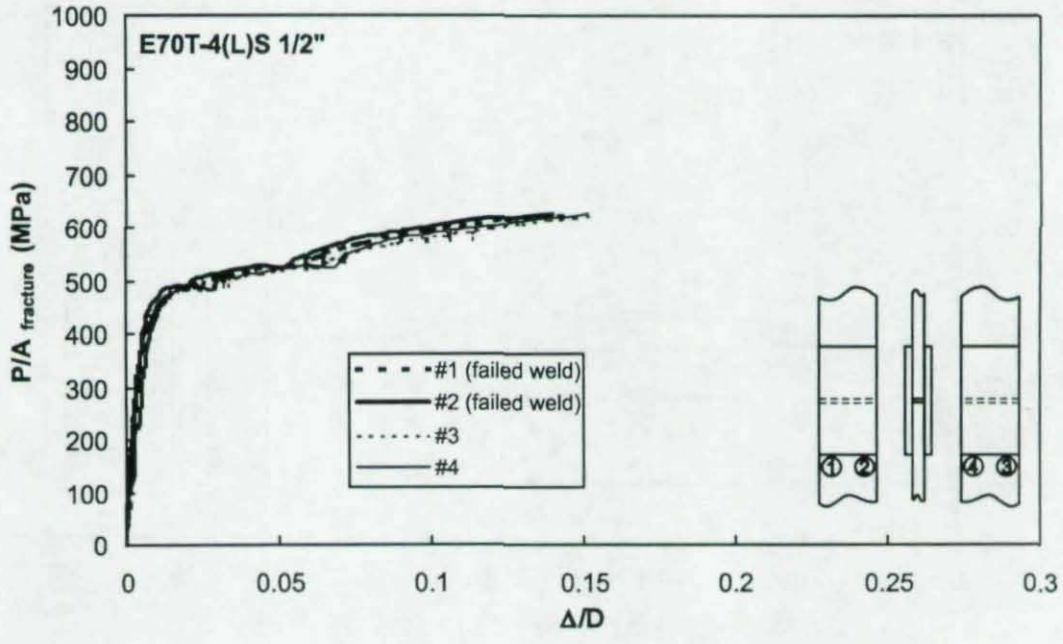


Figure F72 – Specimen T24-3 with 1/2" weld from E70T-4 electrode

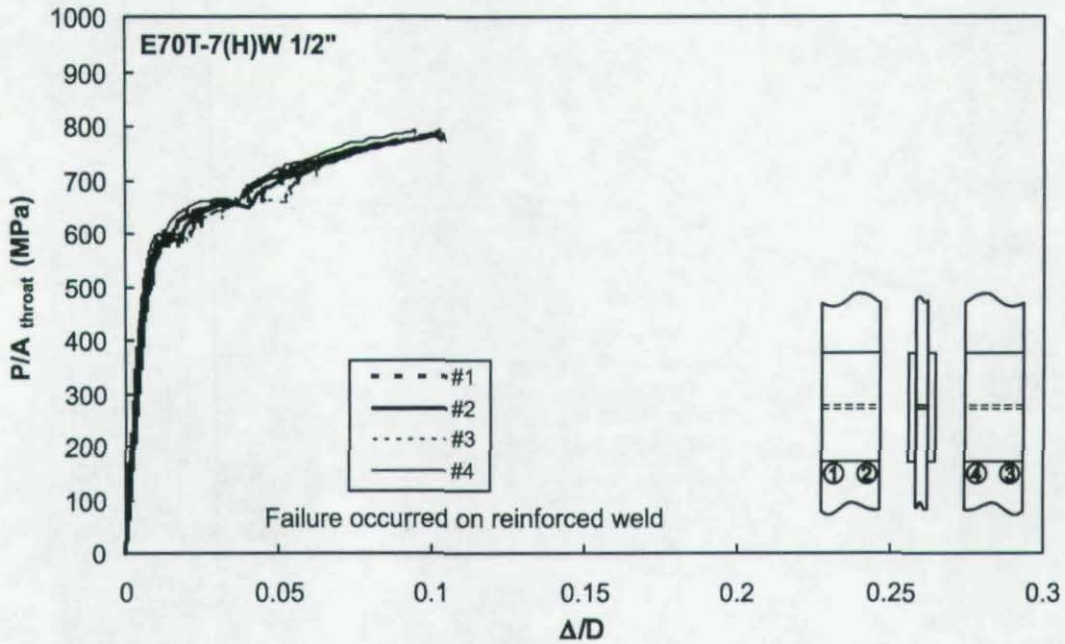


Figure F73 – Specimen T25-1 with 1/2" weld from E70T-7 electrode

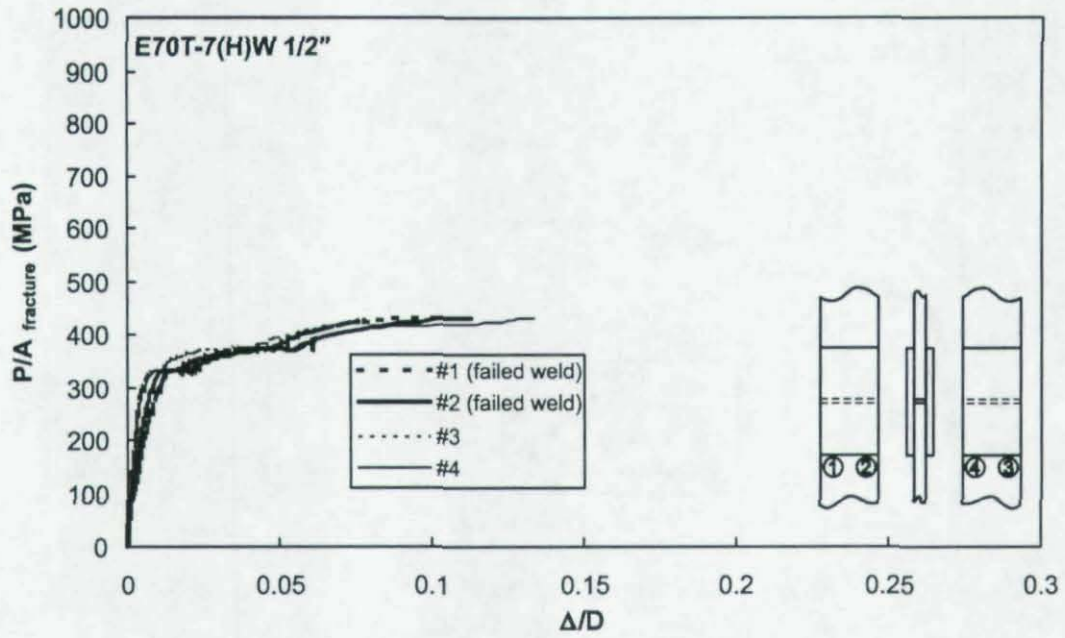


Figure F74 – Specimen T25-2 with 1/2" weld from E70T-7 electrode

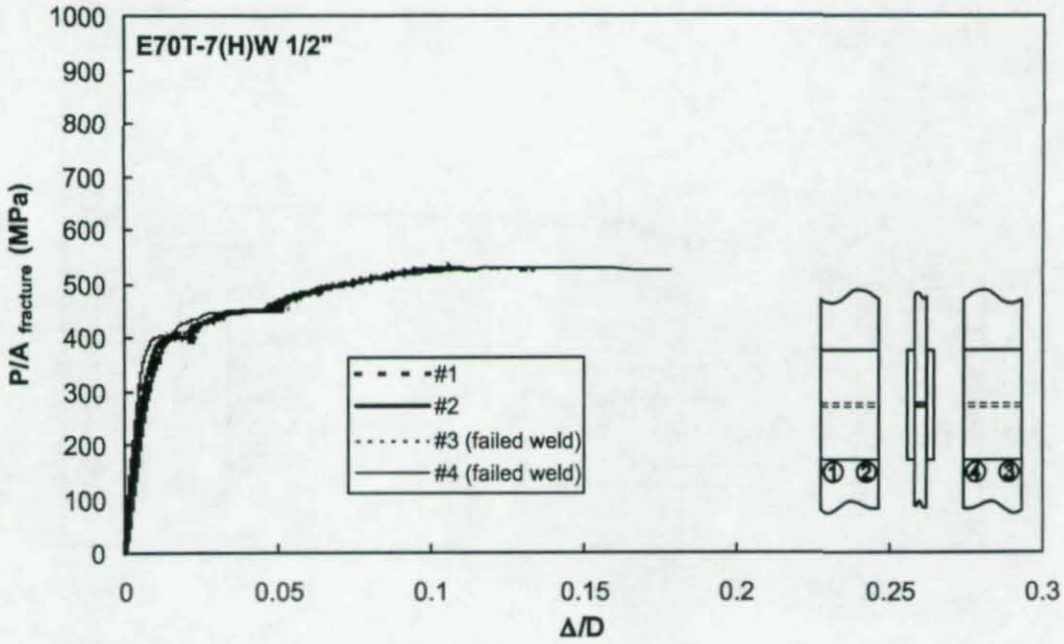


Figure F75 – Specimen T25-3 with 1/2" weld from E70T-7 electrode

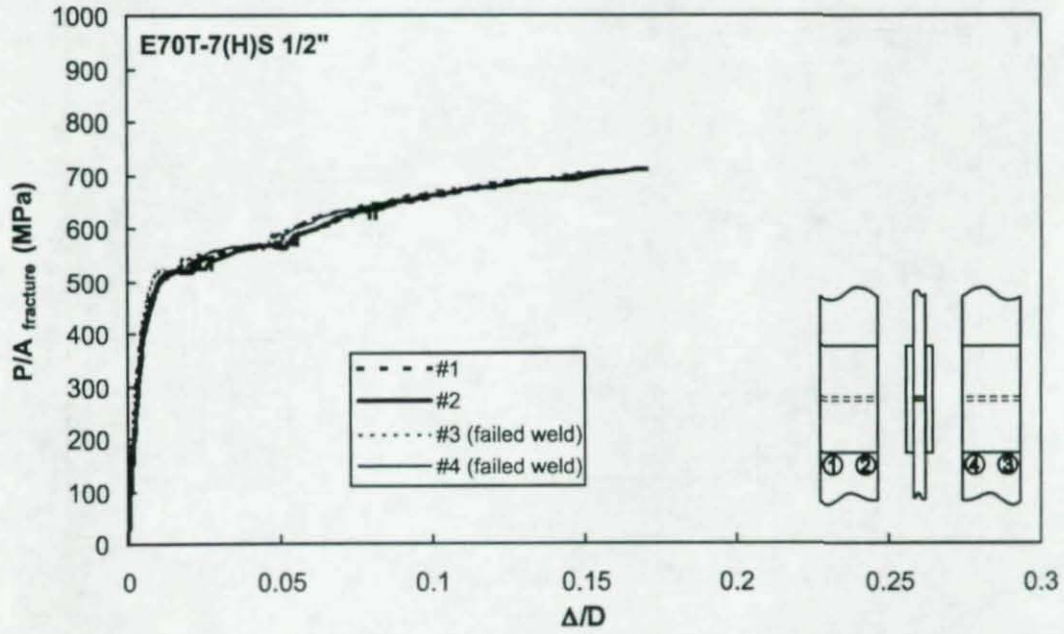


Figure F76 – Specimen T26-1 with 1/2" weld from E70T-7 electrode

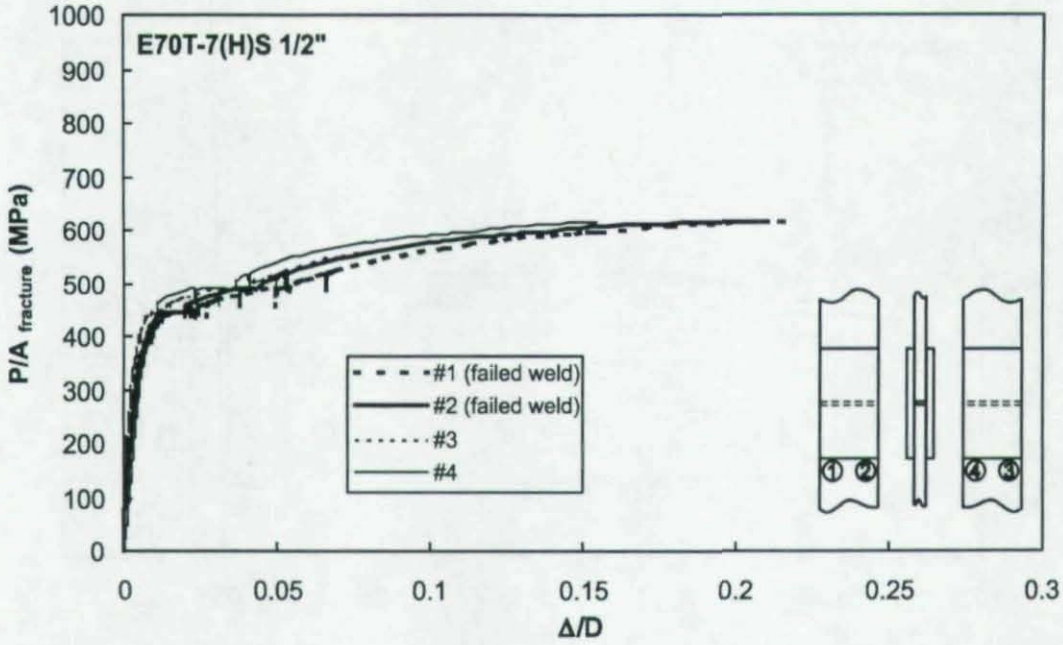


Figure F77 – Specimen T26-2 with 1/2" weld from E70T-7 electrode

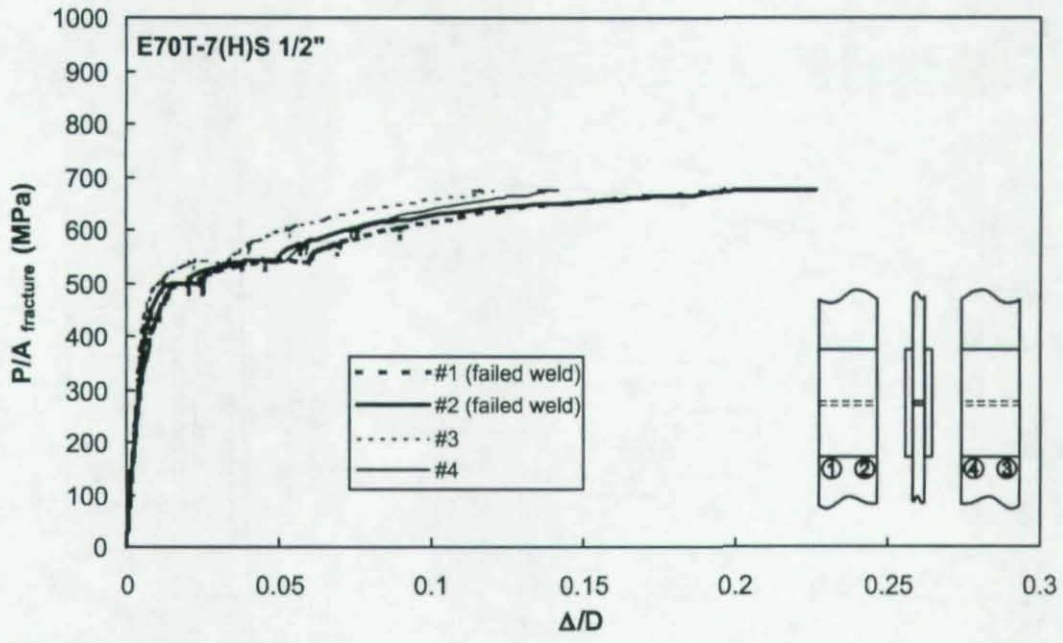


Figure F78 – Specimen T26-3 with 1/2" weld from E70T-7 electrode

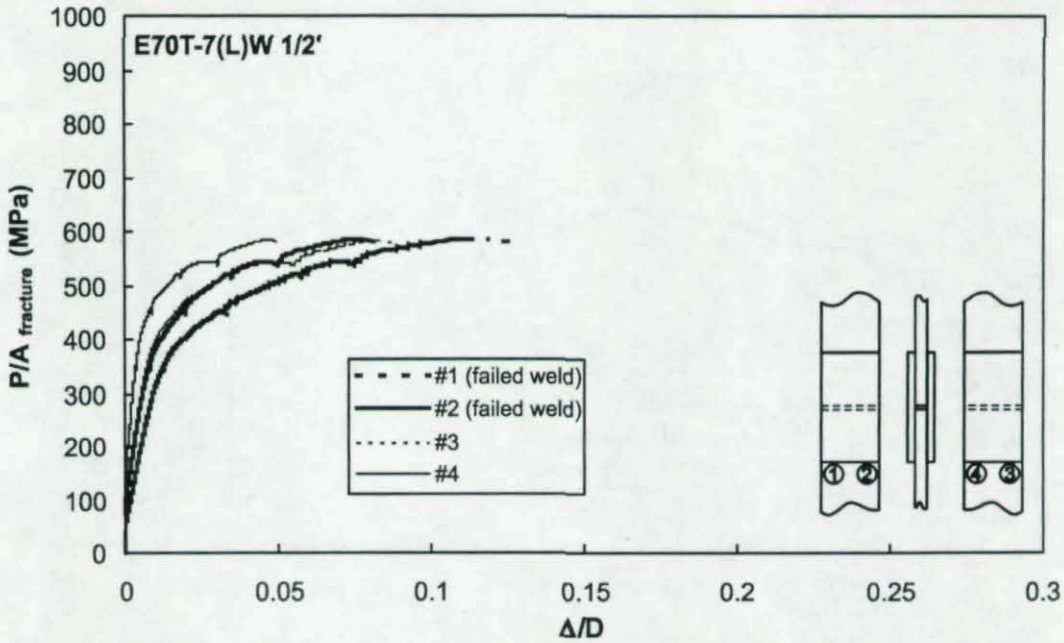


Figure F79 – Specimen T27-1 with 1/2" weld from E70T-7 electrode

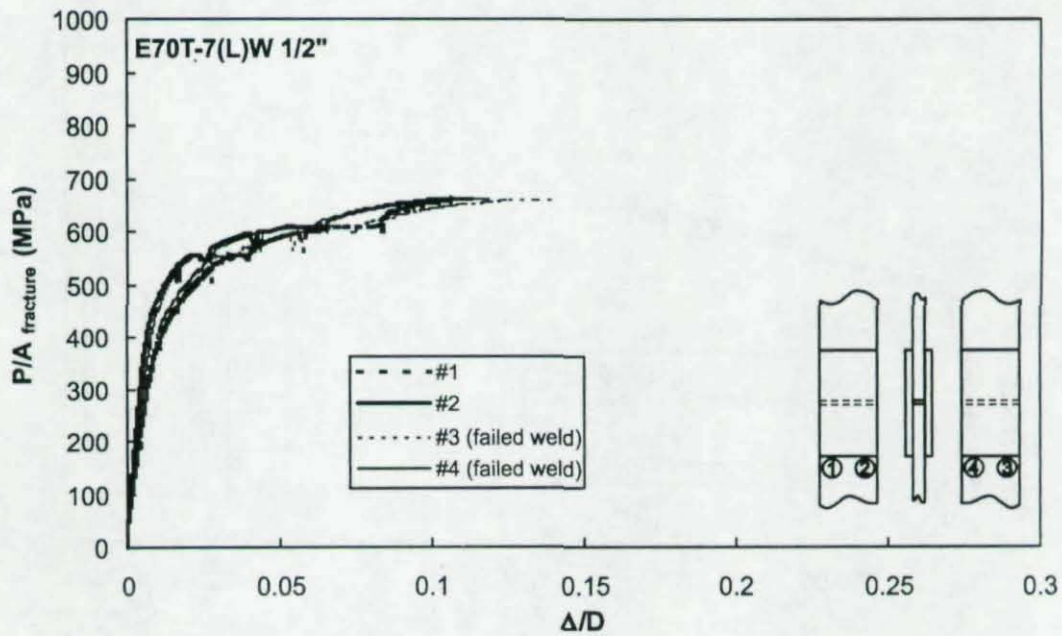


Figure F80 – Specimen T27-2 with 1/2" weld from E70T-7 electrode

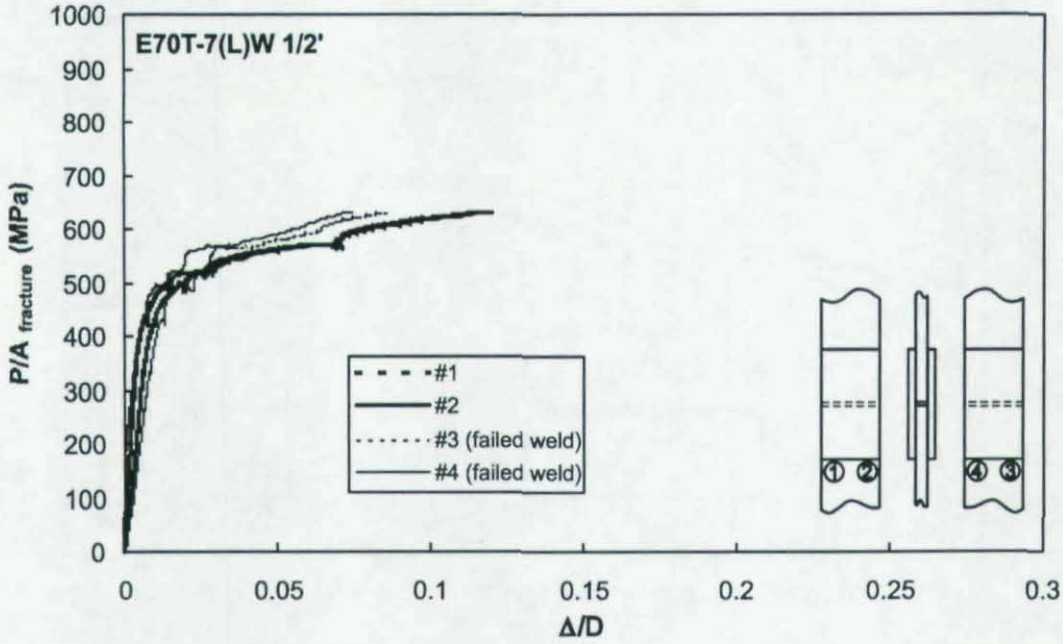


Figure F81 – Specimen T27-3 with 1/2" weld from E70T-7 electrode

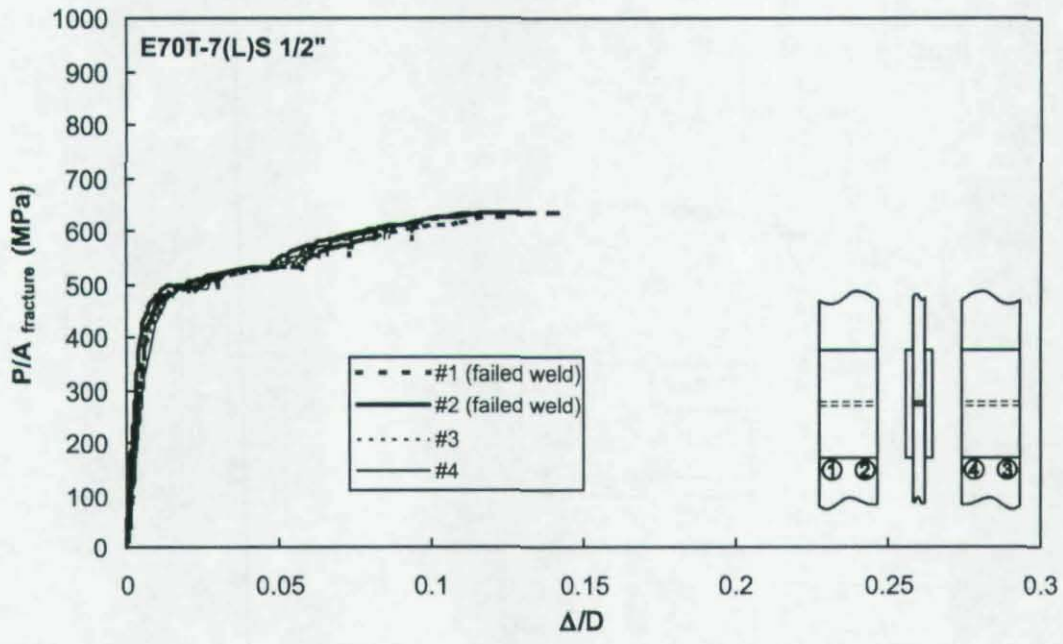


Figure F82 – Specimen T28-1 with 1/2" weld from E70T-7 electrode

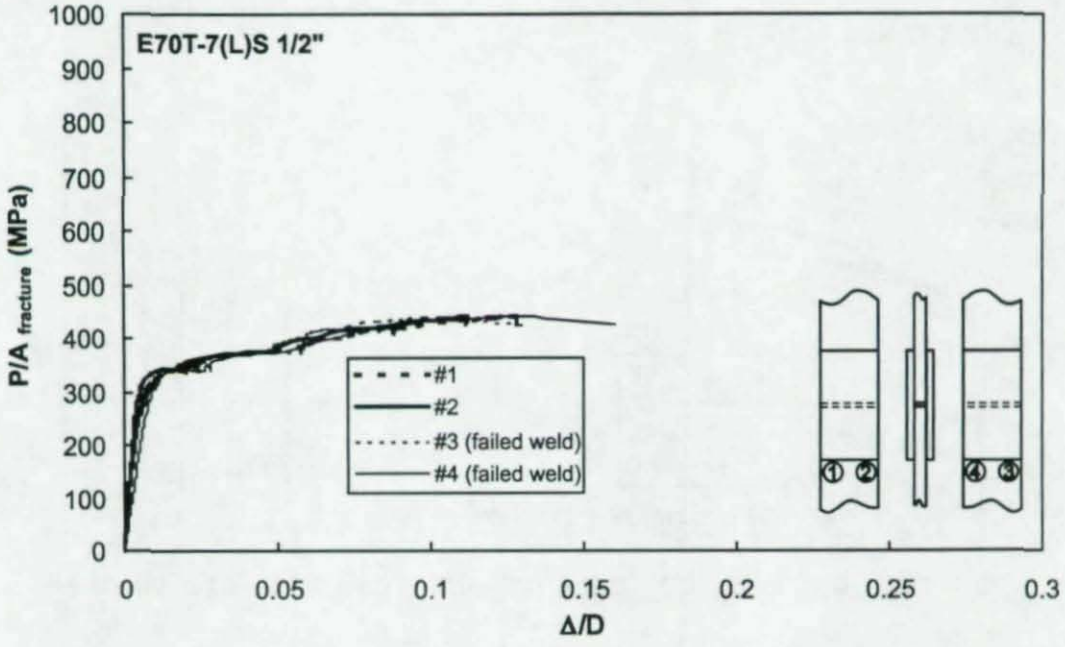


Figure F83 – Specimen T28-2 with 1/2" weld from E70T-7 electrode

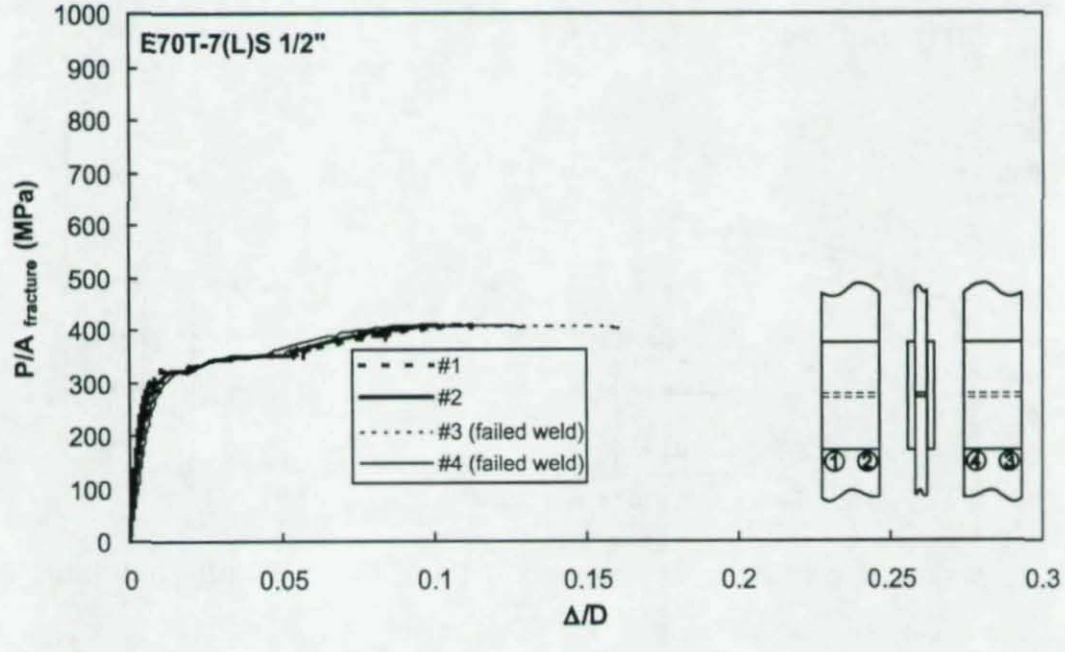


Figure F84 – Specimen T28-3 with 1/2" weld from E70T-7 electrode

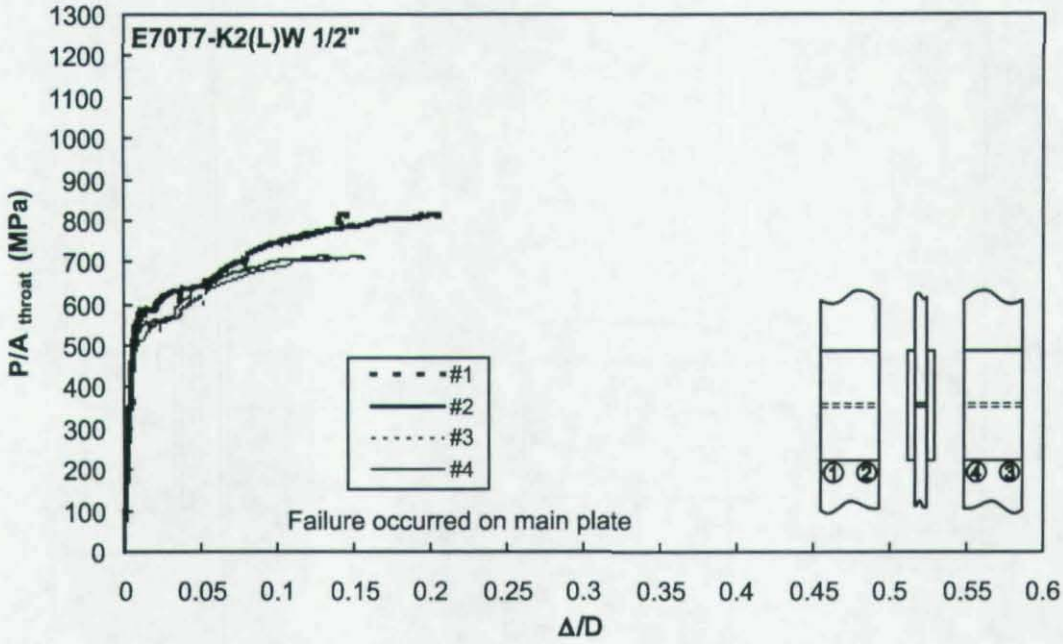


Figure F85 – Specimen T29-1 with 1/2" weld from E70T7-K2 electrode

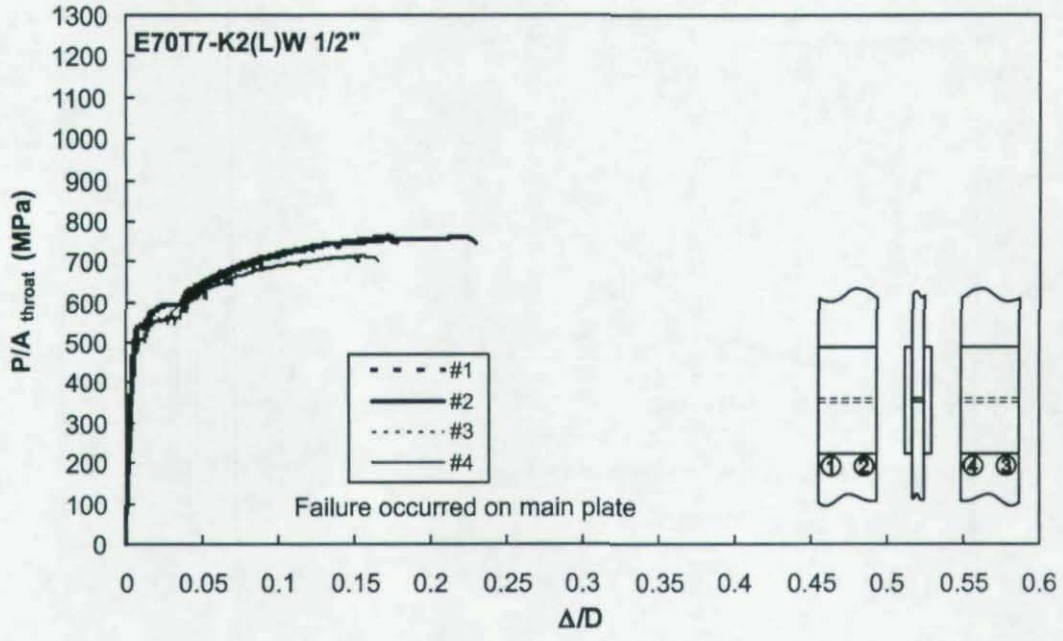


Figure F86 – Specimen T29-2 with 1/2" weld from E70T7-K2 electrode

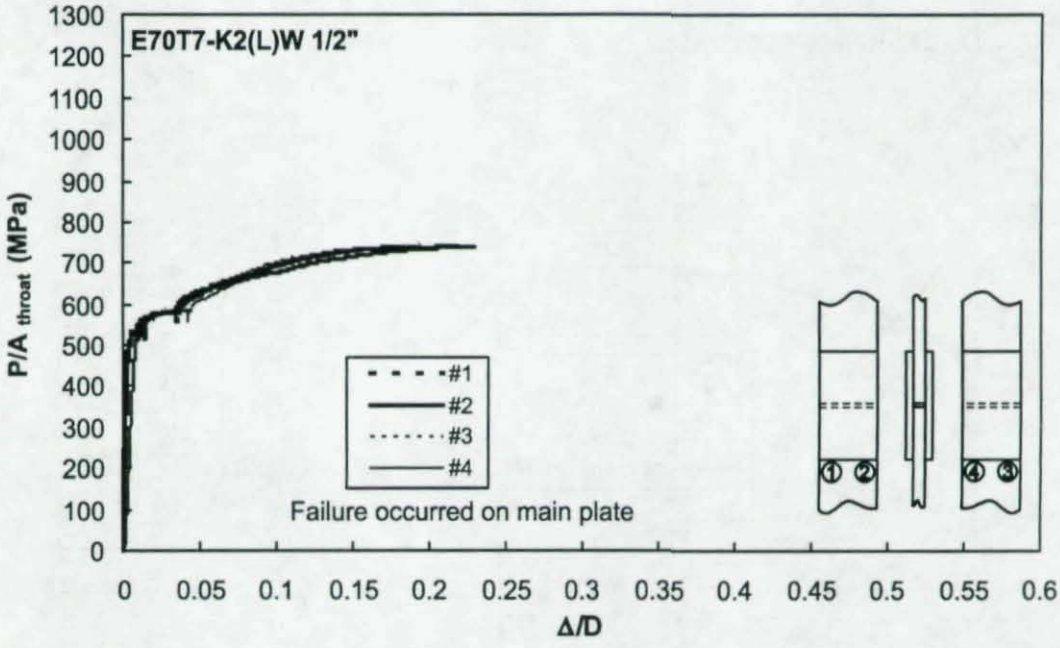


Figure F87 – Specimen T29-3 with 1/2" weld from E70T7-K2 electrode

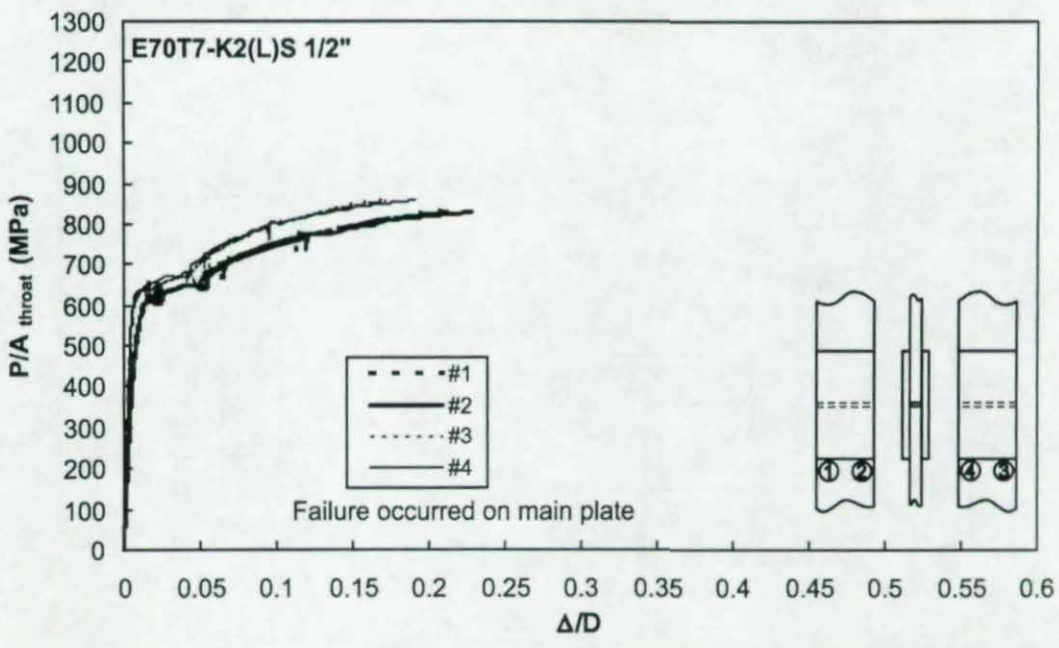


Figure F88 – Specimen T30-1 with 1/2" weld from E70T7-K2 electrode

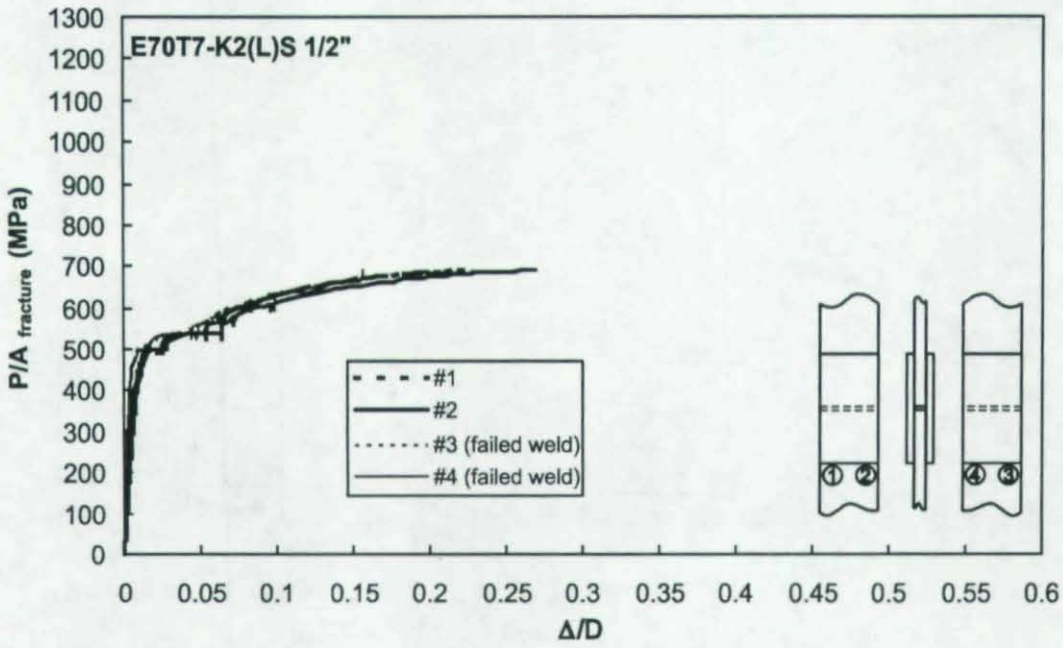


Figure F89 – Specimen T30-2 with 1/2" weld from E70T7-K2 electrode

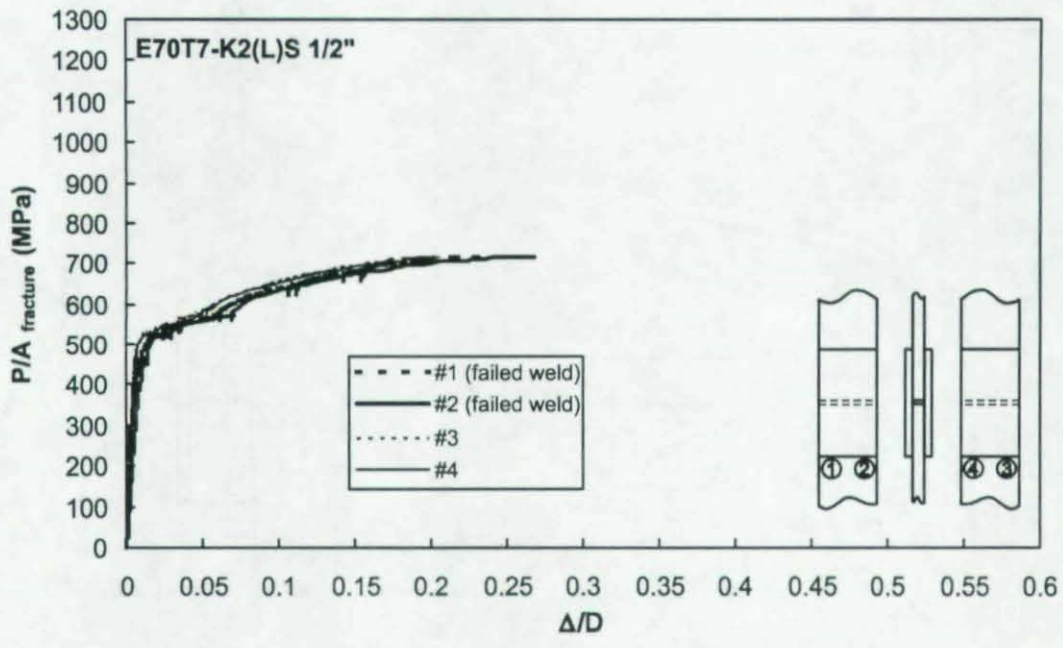


Figure F90 – Specimen T30-3 with 1/2" weld from E70T7-K2 electrode

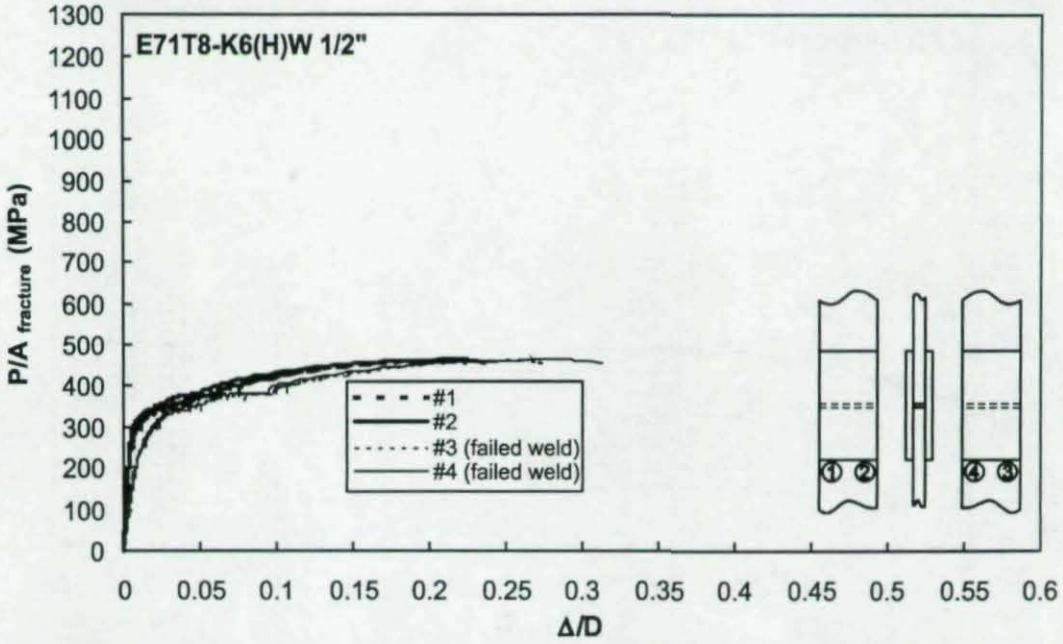


Figure F91 – Specimen T31-1 with 1/2" weld from E71T8-K6 electrode

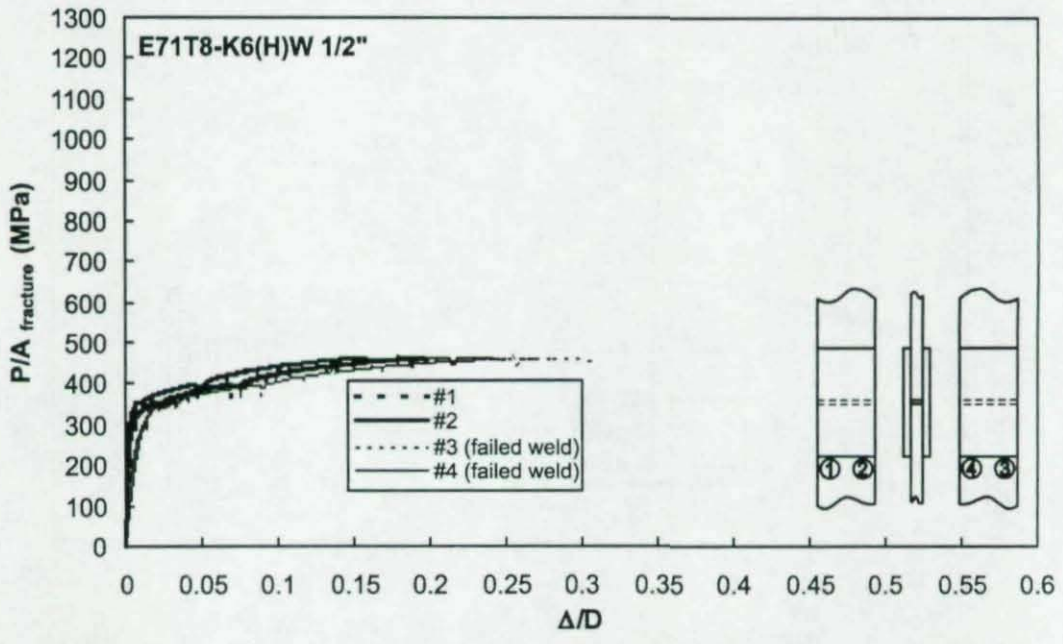


Figure F92 – Specimen T31-2 with 1/2" weld from E71T8-K6 electrode

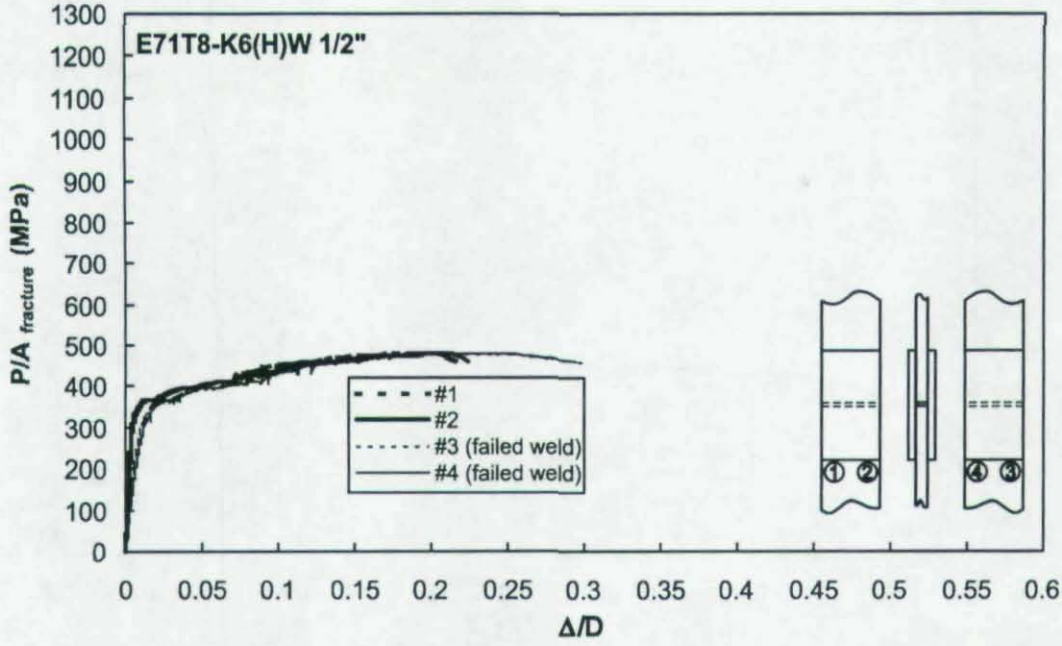


Figure F93 – Specimen T31-3 with 1/2" weld from E71T8-K6 electrode

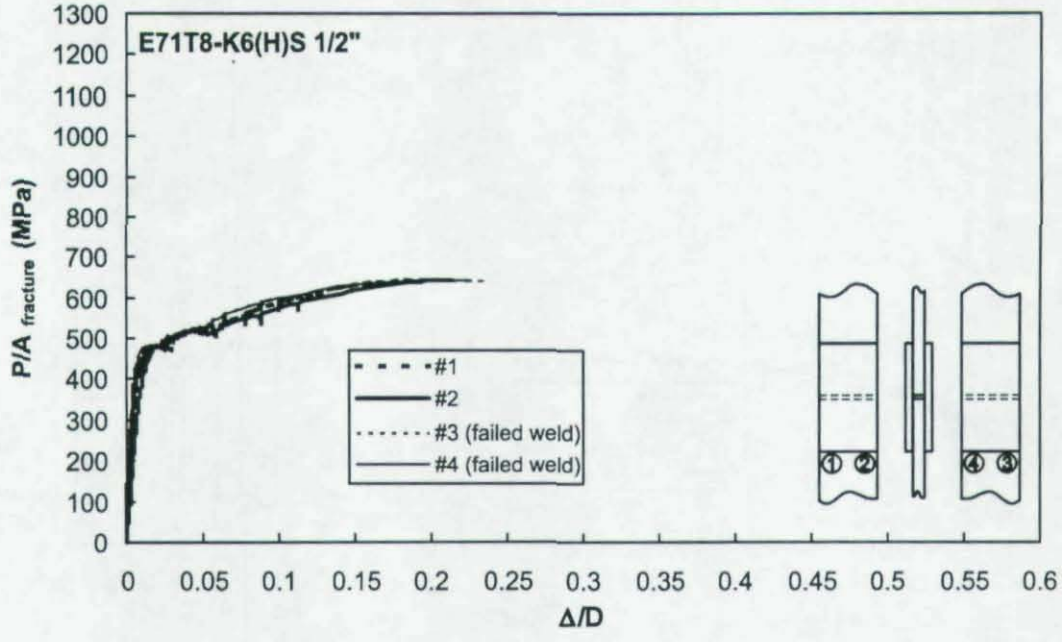


Figure F94 – Specimen T32-1 with 1/2" weld from E71T8-K6 electrode

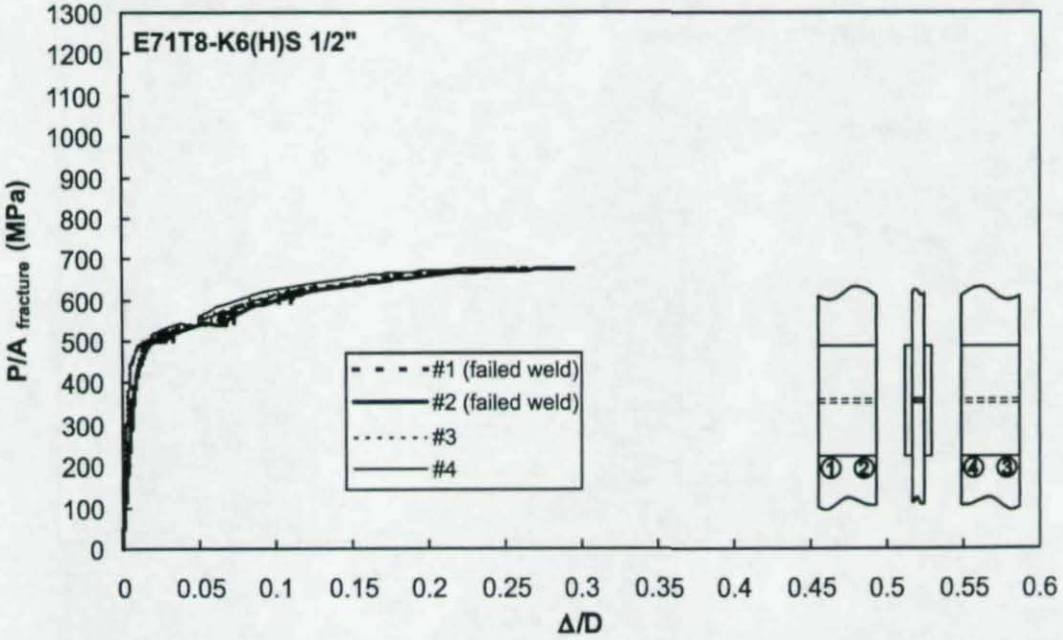


Figure F95 – Specimen T32-2 with 1/2" weld from E71T8-K6 electrode

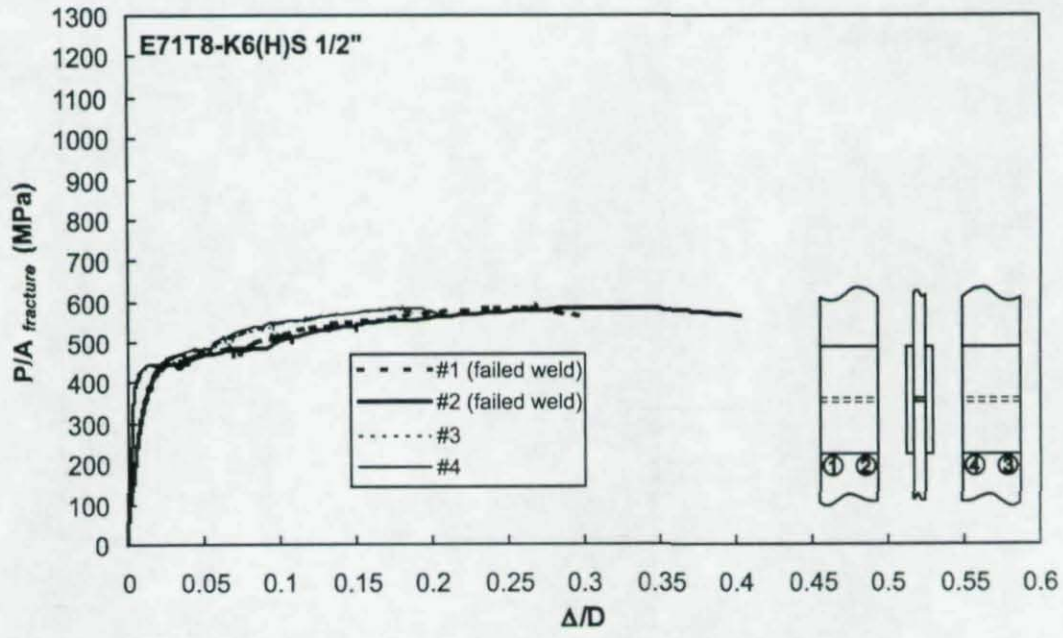


Figure F96 – Specimen T32-3 with 1/2" weld from E71T8-K6 electrode

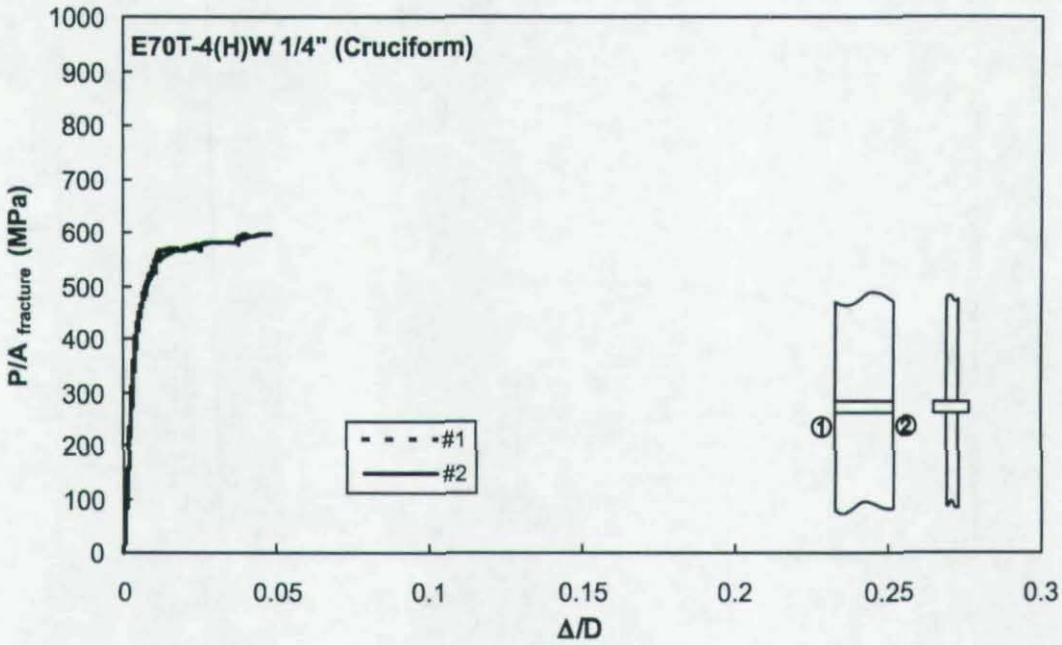


Figure F97 – Specimen C1-1 with 1/4" weld from E70T-4 electrode

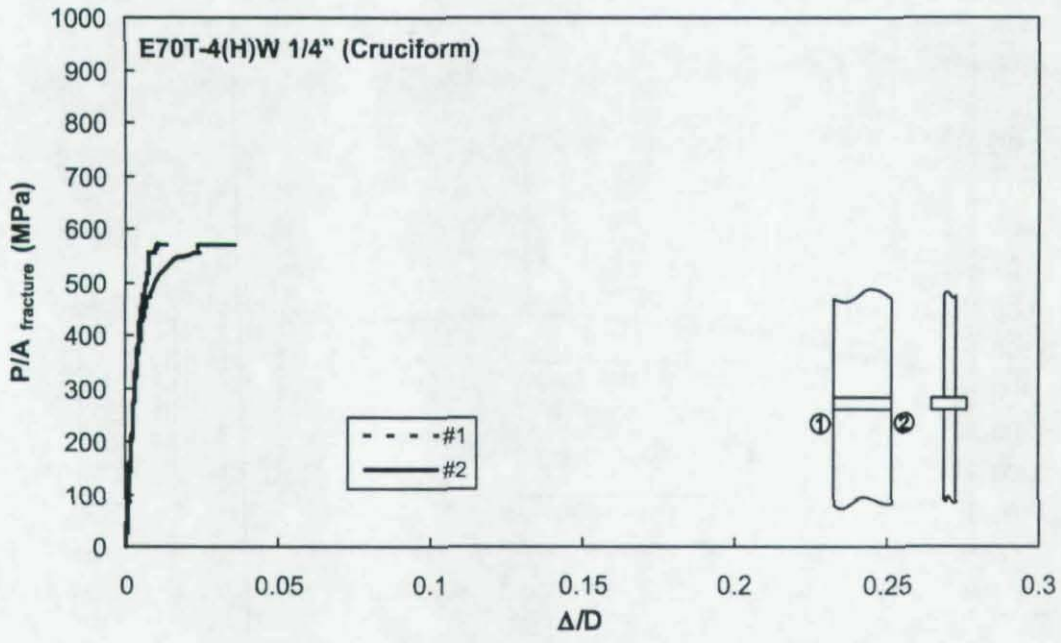


Figure F98 – Specimen C1-2 with 1/4" weld from E70T-4 electrode

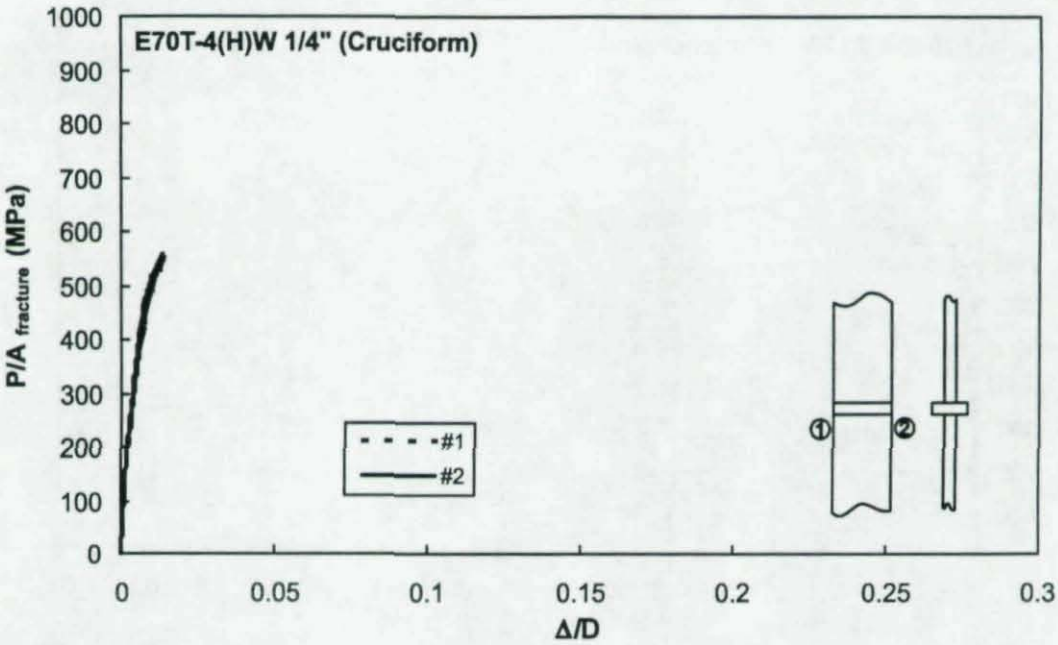


Figure F99 – Specimen C1-3 with 1/4" weld from E70T-4 electrode

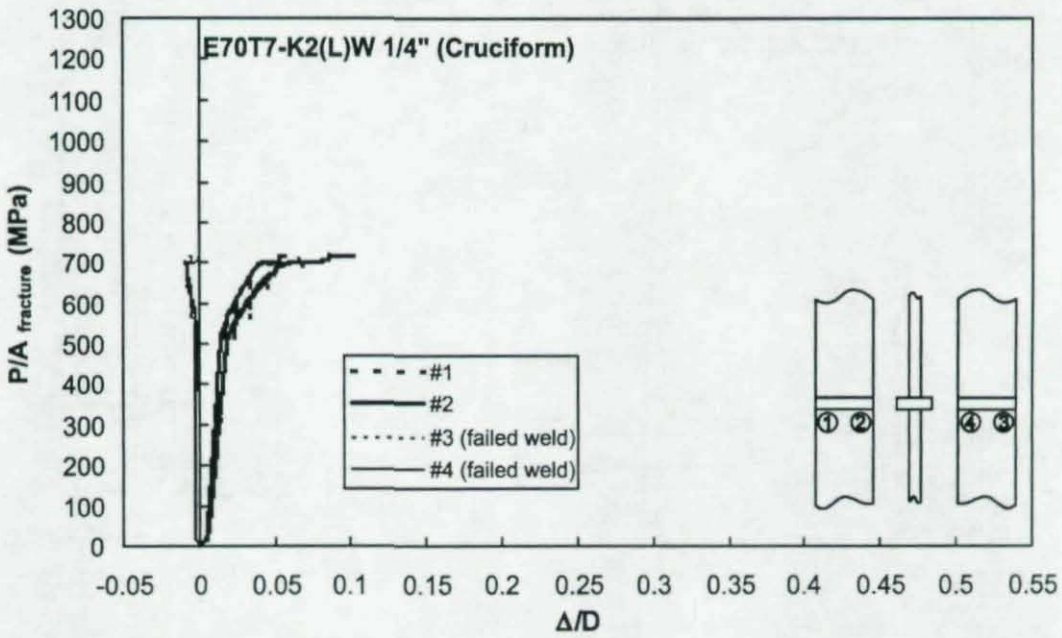


Figure F100 – Specimen C2-1 with 1/4" weld from E70T7-K2 electrode

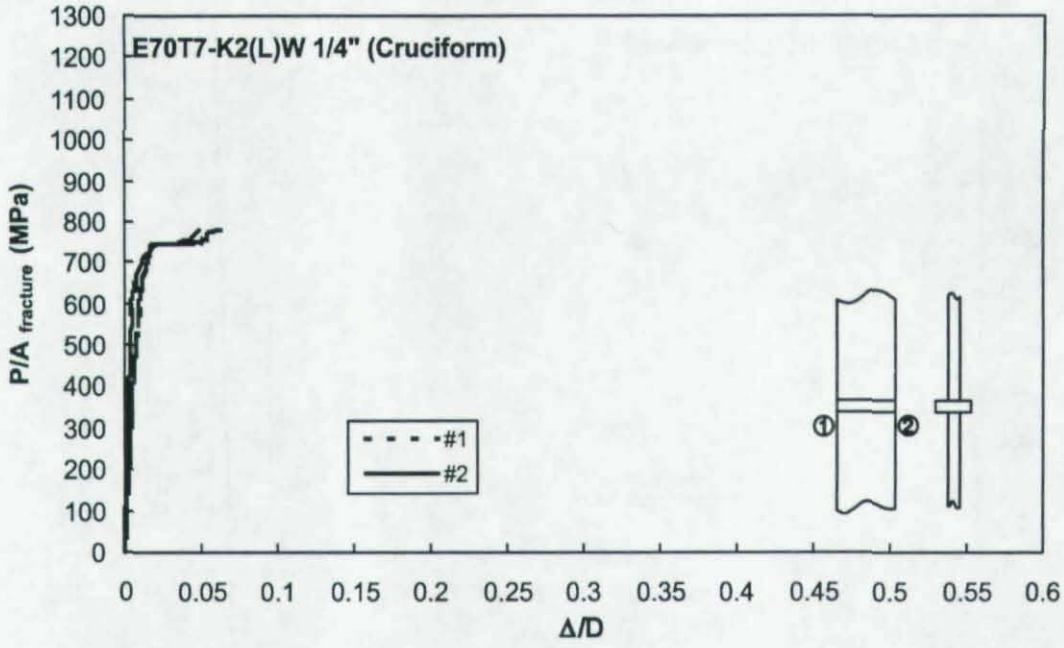


Figure F101 – Specimen C2-2 with 1/4" weld from E70T7-K2 electrode

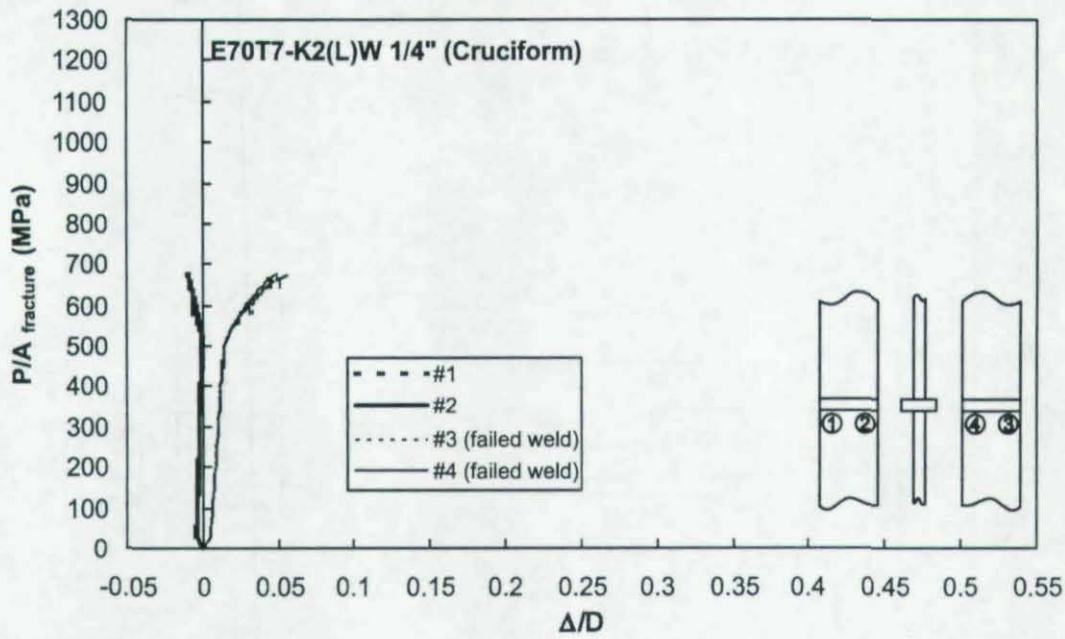


Figure F102 – Specimen C2-3 with 1/4" weld from E70T7-K2 electrode

Appendix G

Weld Hardness Test Results

Table G1 – All-Weld Metal Hardness Test Results

AWS Classification	Electrode Manufacturer	Steel Fabricator	Tensile Strength from Tension Coupon (MPa)	Rockwell C Hardness						Mean	Standard Deviation	Coefficient of Variation
				1	2	3	4	5	6			
E7014	L	W	520	5	4	1	3	2	4	3	1.47	0.46
E70T-4	H	W	513	3	4	4	4	2		3	0.89	0.26
	H	S	631	15	13	10	16	16	17	15	2.59	0.18
	L	W	562	7	10	8	10	8	10	9	1.33	0.15
E70T-7	H	W	605	10	9	15	12	9	8	11	2.59	0.25
	L	S	652	13	14	15	14	13	13	14	0.82	0.06
E70T7-K2	L	W	592	13	13	13	11	11	13	12	1.03	0.08
	L	W	584	9	10	9	11	6	12	10	2.07	0.22
E71T8-K6	H	W	490	2	6	4	4	3	2	4	1.52	0.43
	H	S	493	3	4	3	2	1		3	1.14	0.44

Table G2 - Lapped Splice Specimen Hardness Test Results and Weld Stress at Fracture

Specimen Designation	Identifier	Measurement End	Rockwell C Hardness						Mean	Standard Deviation	Coefficient of Variation	Ultimate P/A_{throat} (MPa)	Ultimate $P/A_{fracture}$ (MPa)
			1	2	3	4	5	6					
T2-1	E7014(L)W 1/4"	Front End 1	5	16	15				13	4.17	0.32	735	720
		Front End 2	12	16	13								
		Back End 1	13	14	18	14			14	1.70	0.12	678	
		Back End 2	13	14	14								
T20-2	E7014(L)W 1/2"	Front End 1	15	12	14	16	18	20	15	2.38	0.16	681	456
		Front End 2	13	13	14	14	17	17					
		Back End 1	13	15	13	19	18	19	16	2.64	0.17	633	
		Back End 2	11	14	14	16	17	18					
T5-3	E70T-4(H)W 1/4"	Front End 1*	36	38	40	35	39	38	38	1.67	0.04	970	
		Front End 2*	37	40	37	40	38						
		Back End 1*	38	41	42	40	42	40	38	3.46	0.09	993	439
		Back End 2*	31	36	36	33	38	37					
		Front End 1	36	39	39	37			37	1.41	0.04	970	
		Front End 2	35	37	38	38							
		Back End 1	36	37	38	37	39		38	1.01	0.03	993	439
		Back End 2	37	39	37	38							

*** Rows marked with an asterisk contain hardness test results obtained before tension testing.**

Table G2 - Lapped Splice Specimen Hardness Test Results and Weld Stress at Fracture (Cont.)

Specimen Designation	Identifier	Measurement End	Rockwell C Hardness						Mean	Standard Deviation	Coefficient of Variation	Ultimate P/A_{throat} (MPa)	Ultimate $P/A_{fracture}$ (MPa)
			1	2	3	4	5	6					
T7-1	E70T-4(H)S 1/4"	Front End 1*	37	35	29	34			35	3.23	0.09	1209	
		Front End 2*	32	37	39	35	40	35					
		Back End 1*	33	38	42	34	40	36	39	3.96	0.10	1112	788
		Back End 2*	37	43	45	40	45	40					
		Front End 1	37	36	34	36			36	1.25	0.03	1209	
		Front End 2	37	36	35	38							
		Back End 1	36	35	32	39	36		38	3.81	0.10	1112	788
		Back End 2	43	41	40	43							
T21-2	E70T-4(H)W 1/2"	Front End 1	15	19	20	15	20	19	17	2.26	0.13	704	
		Front End 2	13	19	16	16	18	17					
		Back End 1	12	14	15	12	14	16	14	1.98	0.14	712	431
		Back End 2	11	13	14	14	18	16					
T22-1	E70T-4(H)S 1/2"	Front End 1	16	21	22	20	23	23	22	2.19	0.10	848	491
		Front End 2	20	22	23	23	24	23					
		Back End 1	16	19	22	19	21	19	20	1.95	0.10	739	
		Back End 2	18	21	22	20	23	20					
T8-2	E70T-4(L)W 1/4"	Front End 1*	19	21	22	21	22	19	19	3.54	0.19	956	
		Front End 2*	12	19	20	12	20						
		Back End 1*	27	29	29	25	28	28	26	2.23	0.09	930	588
		Back End 2*	24	26	24	23	27	23					
		Front End 1	32	34	33	35	34		33	1.61	0.05	956	
		Front End 2	29	33	34	32	34	33					
		Back End 1	24	20	18	24	17	23	19	4.07	0.22	930	588
		Back End 2	10	17	19	16	19						
T9-1	E70T-4(L)S 1/4"	Front End 1*	13	20	20	19			20	2.88	0.15	1135	
		Front End 2*	18	22	23	20	21						
		Back End 1*	6	23	21	27	23		20	5.65	0.28	1098	882
		Back End 2*	14	20	23	20	23	21					
		Front End 1	23	25	25	25			24	1.85	0.08	1135	
		Front End 2	22	22	27	26							
		Back End 1	24	27	28	25	25	23	26	2.02	0.08	1098	882
		Back End 2	26	26	26	29	30	27					
T23-2	E70T-4(L)W 1/2"	Front End 1	14	16	17	17	20	18	16	1.96	0.12	679	495
		Front End 2	13	15	14	17	17	17					
		Back End 1	14	18	18	16	19	19	17	1.98	0.11	648	
		Back End 2	14	18	18	16	19	20					

* Rows marked with an asterisk contain hardness test results obtained before tension testing.

Table G2 - Lapped Splice Specimen Hardness Test Results and Weld Stress at Fracture (Cont.)

Specimen Designation	Identifier	Measurement End	Rockwell C Hardness 1	2	3	4	5	6	Mean	Standard Deviation	Coefficient of Variation	Ultimate P/A_{throat} (MPa)	Ultimate $P/A_{fracture}$ (MPa)
T24-2	E70T-4(L)S 1/2"	Front End 1	17	20	20	19	20	20	19	1.42	0.08	830	
		Front End 2	18	19	20	16	19	17					
		Back End 1	24	26	23	27	20	20	21	3.53	0.17	810	679
		Back End 2	16	18	21	16	20	20					
T11-1	E70T-7(H)W 1/4"	Front End 1	25	26	32	30	30	30	27	2.68	0.10	987	503
		Front End 2	24	25	27	25	26	25					
		Back End 1	25	30	31	29	32	32	29	2.50	0.09	898	
		Back End 2	25	26	27	28	29	30					
T12-2	E70T-7(H)S 1/4"	Front End 1*	16	28	30	26	31	31	28	4.61	0.17	1066	
		Front End 2*	24	31	31	26	33	27					
		Back End 1*	31	30	32	29	34	34	30	3.15	0.10	1188	976
		Back End 2*	23	29	30	26	32	31					
		Front End 1	31	30	29	31	33	31	32	1.50	0.05	1066	
		Front End 2	32	31	33	34	33						
		Back End 1	28	31	32	30			32	2.99	0.09	1188	976
		Back End 2	36	35	35								
T25-1	E70T-7(H)W 1/2"	Front End 1	17	21	22	23	25	25	22	2.34	0.11	Reinforced Weld Failed	
		Front End 2	20	21	22	23	23	19					
		Back End 1	20	23	22	24	24	26	23	2.22	0.10		
		Back End 2	20	21	21	22	23	27					
T26-2	E70T-7(H)S 1/2"	Front End 1	15	19	21	18	22	21	19	2.15	0.11	821	868
		Front End 2	17	21	20	19	22	18					
		Back End 1	17	21	23	19	24	23	22	2.44	0.11	836	
		Back End 2	20	22	24	20	24	25					
T13-3	E70T-7(L)W 1/4"	Front End 1*	22	26	30	24	28	26	28	3.45	0.12	957	572
		Front End 2*	27	31	31	30	34	31					
		Back End 1*	22	25	27	24	28	24	22	4.85	0.22	1000	
		Back End 2*	12	21	23	14	22	18					
		Front End 1	32	32	32	30			30	2.13	0.07	957	572
		Front End 2	28	27	28	28							
		Back End 1	23	28	26	28	28		25	2.77	0.11	1000	
		Back End 2	21	23	24	22							

* Rows marked with an asterisk contain hardness test results obtained before tension testing.

Table G2 - Lapped Splice Specimen Hardness Test Results and Weld Stress at Fracture (Cont.)

Specimen Designation	Identifier	Measurement End	Rockwell C Hardness 1	2	3	4	5	6	Mean	Standard Deviation	Coefficient of Variation	Ultimate P/A_{throat} (MPa)	Ultimate $P/A_{fracture}$ (MPa)
T14-1	E70T-7(L)S 1/4"	Front End 1*	20	26	27	25	27	24	25	2.39	0.10	970	
		Front End 2*	22	26	27	23	28	26					
		Back End 1*	20	23	25	26	27	25	25	2.35	0.09	936	533
		Back End 2*	22	25	27	24	27	28					
		Front End 1	23	26	27	27	28	26	28	2.32	0.08	970	
		Front End 2	26	28	30	31	27	31					
		Back End 1	26	29	32	28	31	30	29	2.04	0.07	936	533
		Back End 2	25	29	28	30	31	29					
T27-3	E70T-7(L)W 1/2"	Front End 1	15	16	19	17	18	17	17	1.34	0.08	725	
		Front End 2	15	17	17	18	18	15					
		Back End 1	14	17	18	19	20	19	18	2.12	0.12	748	630
		Back End 2	15	17	20	18	21	20					
T28-2	E70T-7(L)S 1/2"	Front End 1	12	19	23	19	23	19	20	2.94	0.15	788	
		Front End 2	20	22	21	20	22	21					
		Back End 1	17	22	23	24	25	25	22	2.49	0.11	810	441
		Back End 2	19	20	21	21	23	24					
T16-1	E70T7-K2(L)W 1/4"	Front End 1	23	25	22	27			24	1.71	0.07	1034	
		Front End 2	22	24	24	26	26	25					
		Back End 1	19	19	21	21	18	20	20	1.75	0.09	936	699
		Back End 2	16	18	21	22	20						
T17-1	E70T7-K2(L)S 1/4"	Front End 1*	22	28	29	28	30	29	29	3.11	0.11	1158	947
		Front End 2*	26	33	31	33	30	32					
		Back End 1*	24	27	25	27	26	27	26	1.29	0.05	1095	
		Back End 2*	27	28	25	28	26						
		Front End 1	30	30	28	22			26	3.09	0.12	1158	947
		Front End 2	25	25	24								
		Back End 1	22	27	27				26	2.21	0.08	1095	
		Back End 2	27	25	27	29							
T29-1	E70T7-K2(L)W 1/2"	Front End 1	15	18	21	19	22	22	20	2.42	0.12	Main Plate Failed	
		Front End 2	17	18	20	19	23	22					
		Back End 1	19	22	23	22	24	18	21	2.41	0.11		
		Back End 2	16	20	22	22	23	23					
T30-1	E70T7-K2(L)S 1/2"	Front End 1	14	18	20	21	22	22	22	3.42	0.16	Main Plate Failed	
		Front End 2	20	23	26	25	26	22					
		Back End 1	20	21	21	23	23	23	22	1.62	0.07		
		Back End 2	19	21	23	22	25	22					

*** Rows marked with an asterisk contain hardness test results obtained before tension testing.**

Table G2 - Lapped Splice Specimen Hardness Test Results and Weld Stress at Fracture (Cont.)

Specimen Designation	Identifier	Measurement End	Rockwell C Hardness						Mean	Standard Deviation	Coefficient of Variation	Ultimate P/A_{throat} (MPa)	Ultimate $P/A_{fracture}$ (MPa)
			1	2	3	4	5	6					
T18-1	E71T8-K6(H)W 1/4"	Front End 1	19	23	23				23	2.99	0.13	1110	490
		Front End 2	18	24	25	26							
		Back End 1	19	21	21				19	2.07	0.11	1103	
		Back End 2	16	17	18								
T19-1	E71T8-K6(H)S 1/4"	Front End 1*	16	19	19	17	19	18	17	2.14	0.13	975	
		Front End 2*	12	16	18	14	17	16					
		Back End 1*	8	15	15	15	18	12	14	2.88	0.20	1003	810
		Back End 2*	13	16	13	18	16						
		Front End 1	20	22	24				20	2.33	0.12	975	
		Front End 2	16	19	18	21	21	21					
		Back End 1	16	16	20				18	1.92	0.11	1003	810
		Back End 2	15	18	17	18	20	20					
T19-2	E71T8-K6(H)S 1/4"	Front End 1*	18	18	16	19	17		18	1.21	0.07	901	810
		Front End 2*	16	18	19	18	19	16					
		Back End 1*	16	20	19	19	21	18	18	1.68	0.09	1070	
		Back End 2*	15	18	19	18	20	18					
		Front End 1	17	19	18	18	19		20	2.15	0.11	901	810
		Front End 2	21	22	23	22							
		Back End 1	19	21	19	18	16	21	20	2.55	0.13	1070	
		Back End 2	17	20	21	18	23	25					
T31-2	E71T8-K6(H)W 1/2"	Front End 1	20	23	22	18	20		20	2.59	0.13	805	
		Front End 2	21	20	19	24	16	16					
		Back End 1	8	13	16	12	16	17	15	2.94	0.20	822	460
		Back End 2	12	14	15	15	17	19					
T32-1	E71T8-K6(H)S 1/2"	Front End 1	14	18	19	20	19	17	18	1.78	0.10	829	
		Front End 2	19	20	19	17	19	16					
		Back End 1	13	17	17	21	3	17	15	4.57	0.31	779	644
		Back End 2	11	15	16	19	14	15					

* Rows marked with an asterisk contain hardness test results obtained before tension testing.

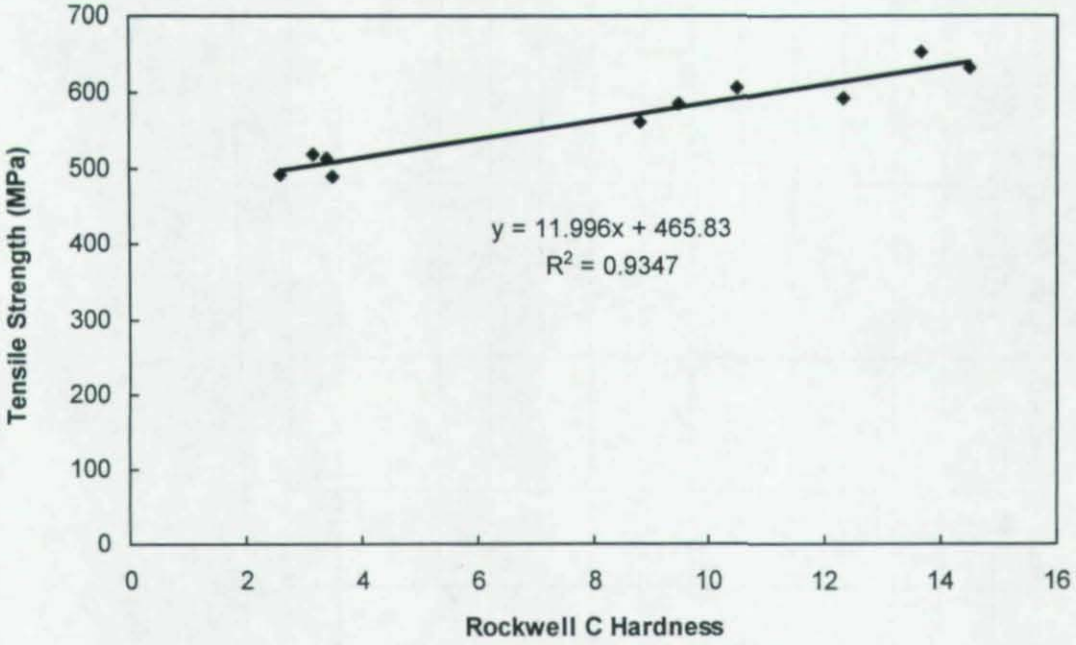


Figure G1 - Relationship between all-weld metal hardness and tensile strength

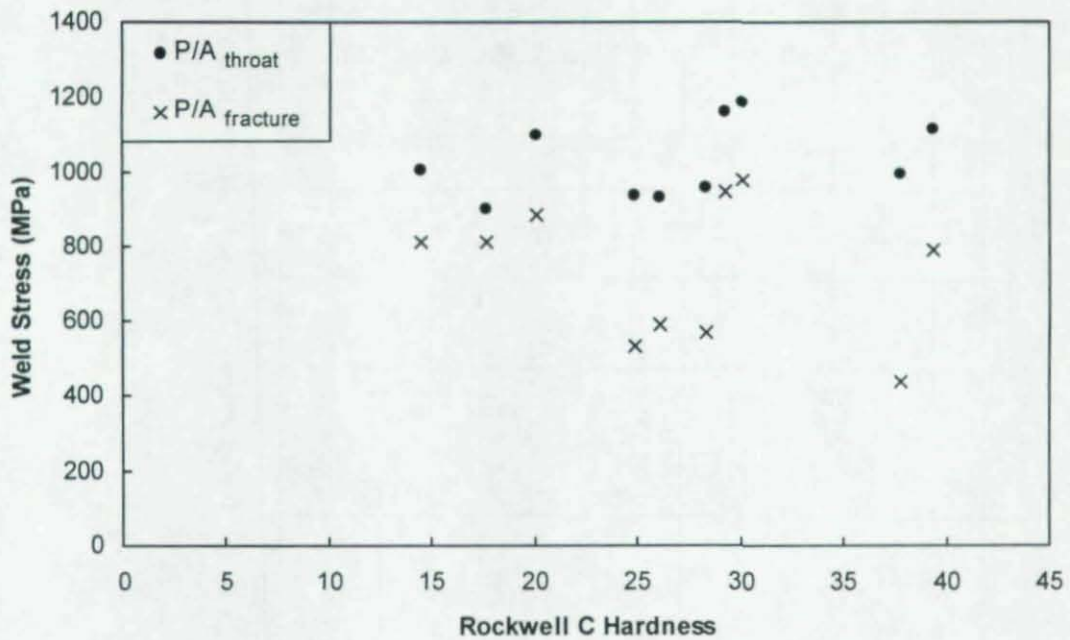


Figure G2 - Relationship between weld strength and weld hardness before fracture.

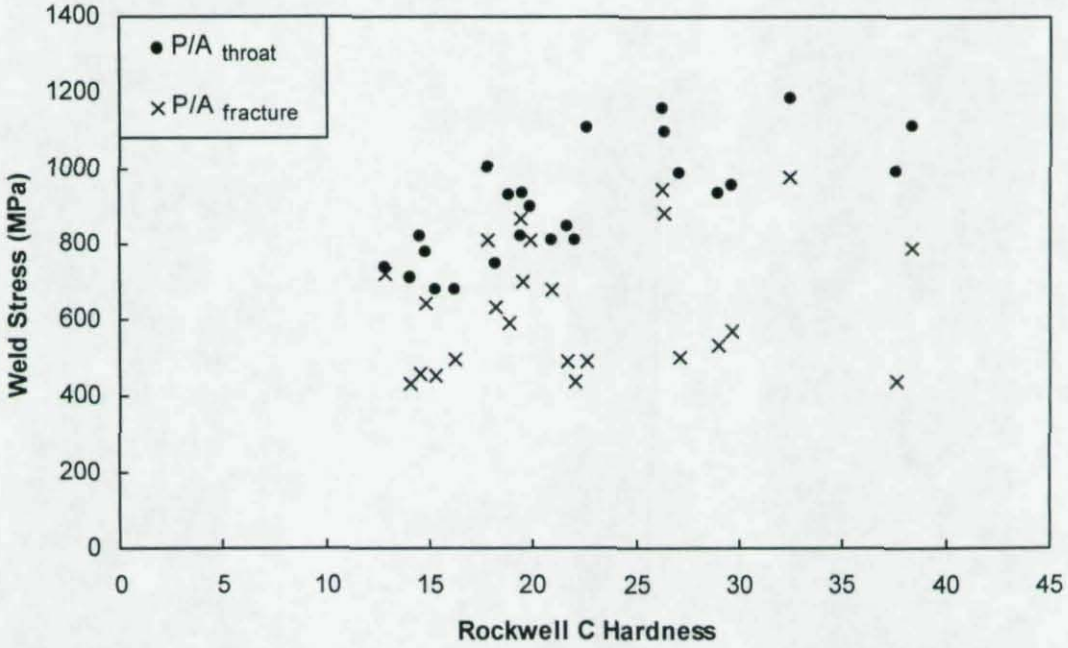


Figure G3 – Relationship between weld strength and weld hardness after fracture.

Appendix H

Examination of Fracture Surfaces

Appendix H – Examination of Fracture Surfaces

The fracture surface of representative test specimens was examined under a scanning electron microscope to determine the mode of fracture of welds that failed on the shear plane (angle of failure surface of 0°), on the tension plane (angle of failure surface of 90°), and intermediate fracture surface angles.

Figures H1 and H2 show a typical shear fracture surface in the weld metal from specimen T2-3 (E7014(L)W-1/4") where the fracture angle was 9°. The fracture surface shows elongated microvoids, indicative of ductile shear failure.

Specimen T13-1 (E70T-7(L)W-1/4") failed on a plane at 90° to the load axis. The fracture surface, shown in Figure H3, showed some areas of microvoid coalescence and some areas of cleavage fracture. Figures H4 and H5 show the fracture surface at increased magnification. The equiaxed (rounded) shape of the microvoids indicates failure in tension.

Test specimen T6-2 (E70T-4(H)W-1/4") showed some porosity (see Figure H6). The average angle of the fracture surface for this specimen was 77°. The fracture surface showed some signs of cleavage fracture, as shown in Figure H7, and some microvoid coalescence, as shown in Figure H8. Since the microvoids are equiaxed, the fracture was therefore a tension fracture. Another specimen that failed at a similar angle showed extensive microvoid coalescence on the fracture surface. This was the case for specimen T12-1 (E70T-7(H)S-1/4") shown in Figures H9 and H10, for which the fracture surface was at an angle of 76°.

Specimen T22-2 (E70T-4(H)S-1/2") failed in shear (angle of failure surface of 0°). As expected for this mode of failure, the fracture surface showed elongated microvoids (refer to Figures H11 and H12).

Several test specimens failed on a fracture surface close to 20°. The fracture surface for these specimens was typically ductile, as shown in Figures H13 and H14 for specimen T32-2 (E71T8-K6(H)S-1/2"). Similar features were also observed in specimen T28-1 (E70T-7(L)S-1/2"), as shown in Figures H15 and H16. Specimen T30-3, which also failed in the weld at a fracture surface angle of 21°, showed both microvoids and cleavage on the fracture surface (refer to Figures H17 to H19).

Specimen T17-2 (E70T7-K2(L)S-1/4") failed at the front weld at 90° because of a significantly shorter tension leg than the shear leg (the length of the tension leg was only about 40% of the shear leg). Failure took place in the base metal. Microvoid coalescence characterized the fracture surface as shown in Figures H20 and H21.

Fracture of all specimens tested at low temperature took place on a plane at 90° from the axis of the load. The fracture surface, shown in Figures H22 and H23 for specimen T7-2 (E70T-4(H)S-1/4") show a mixture of cleavage and microvoid coalescence.

Figure H1 – Fracture Surface of Test Specimen T2-3

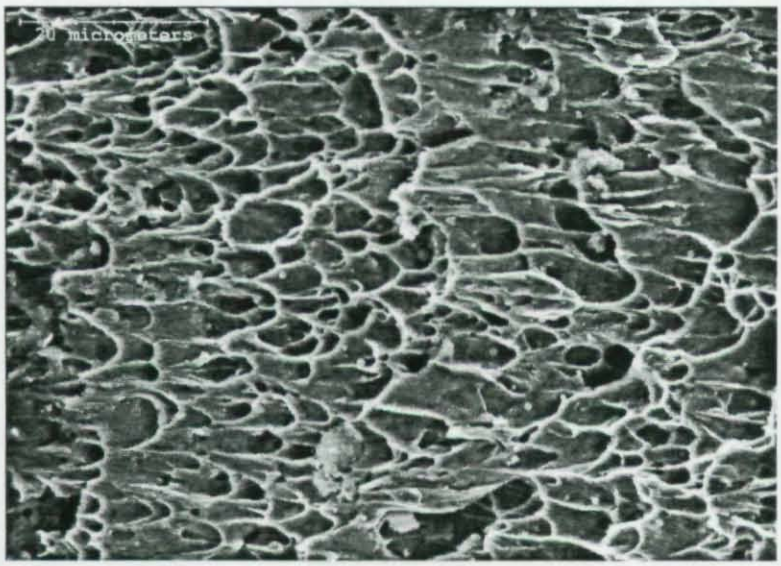


Figure H2 – Microvoid Coalescence on Fracture Surface of Test Specimen T2-3

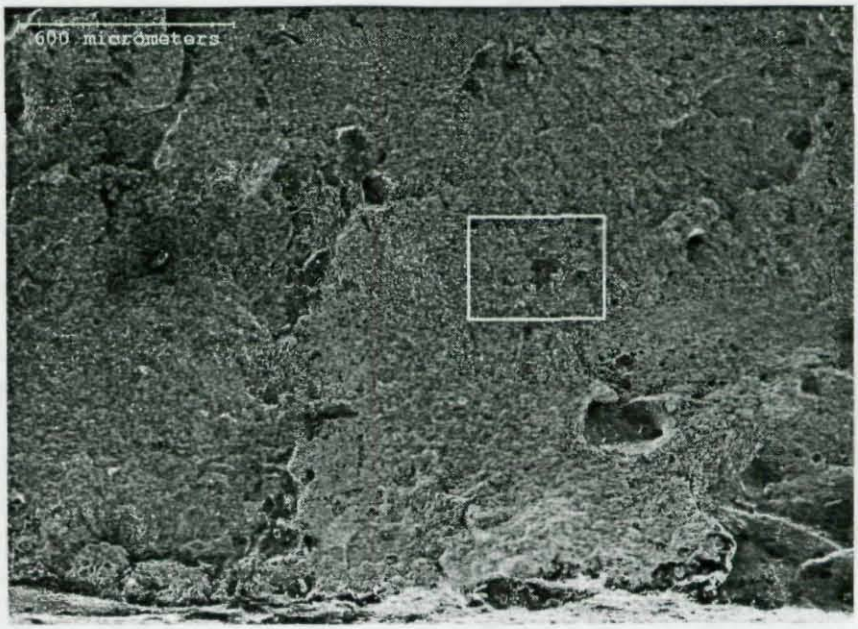


Figure H3 – Fracture Surface of Test Specimen T13-1

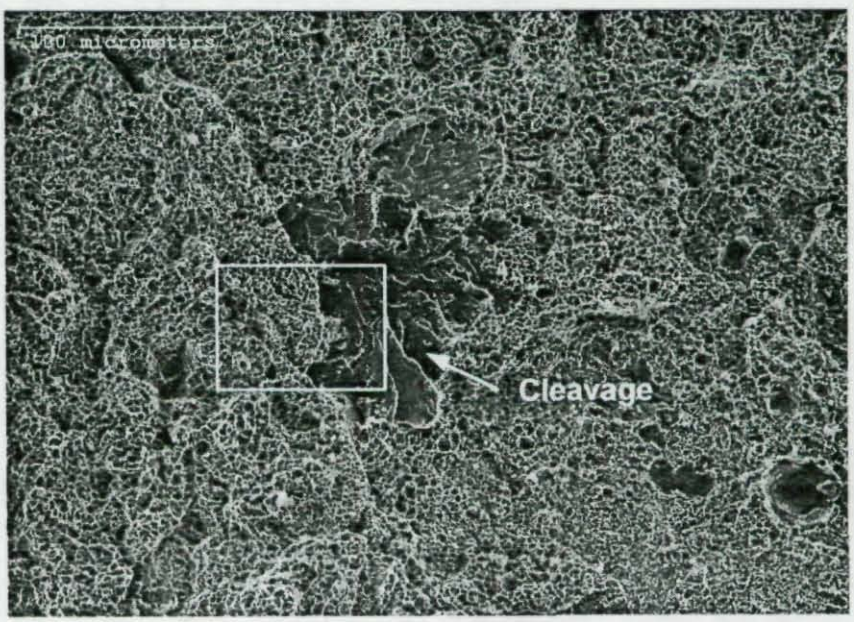


Figure H4 – Cleavage and Microvoid Coalescence on Fracture Surface of Test Specimen T13-1

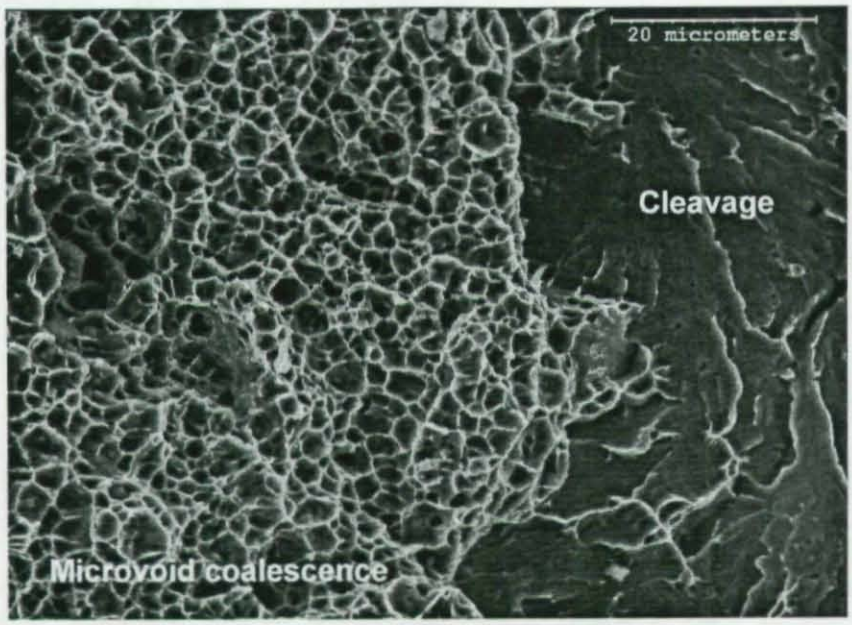


Figure H5 – Cleavage and Microvoid Coalescence on Fracture Surface of Test Specimen T13-1

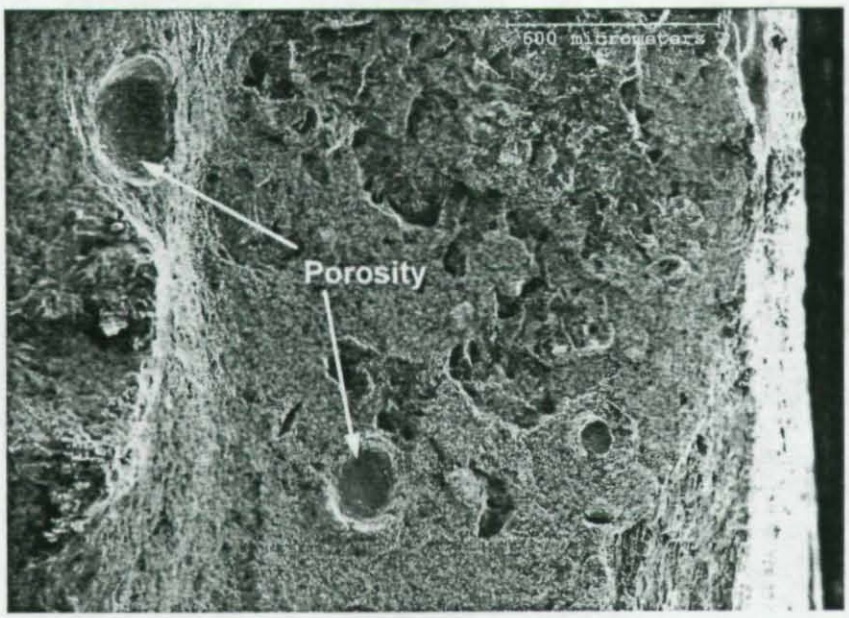


Figure H6 – Fracture Surface of Test Specimen T6-2

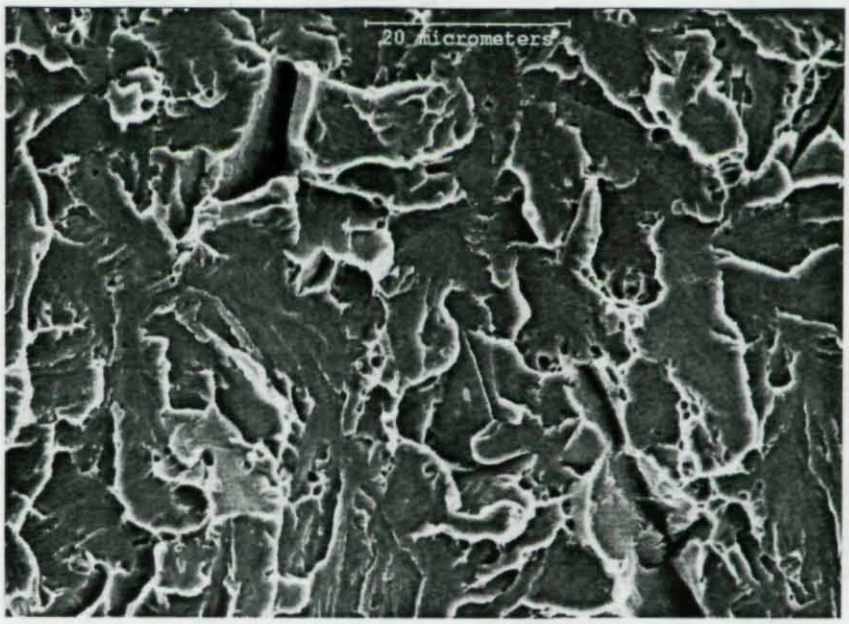


Figure H7 – Cleavage Fracture on Test Specimen T6-2

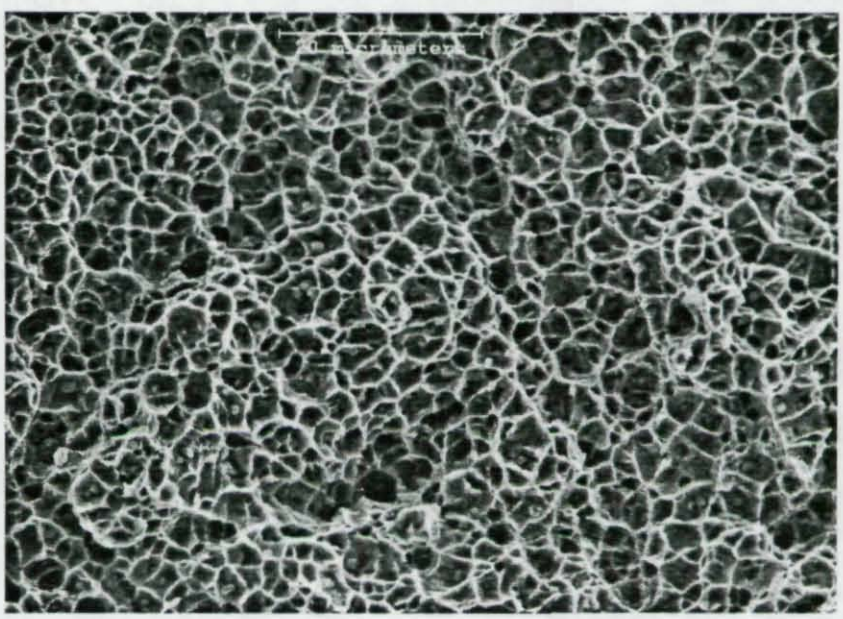


Figure H8 – Microvoid Coalescence on Fracture Surface of Test Specimen T6-2

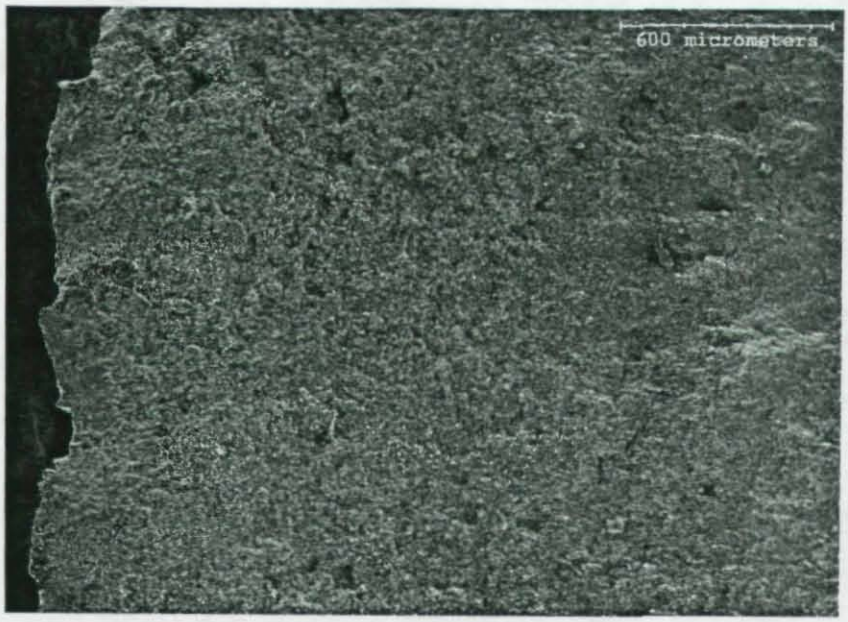


Figure H9 – Fracture Surface of Test Specimen T12-1

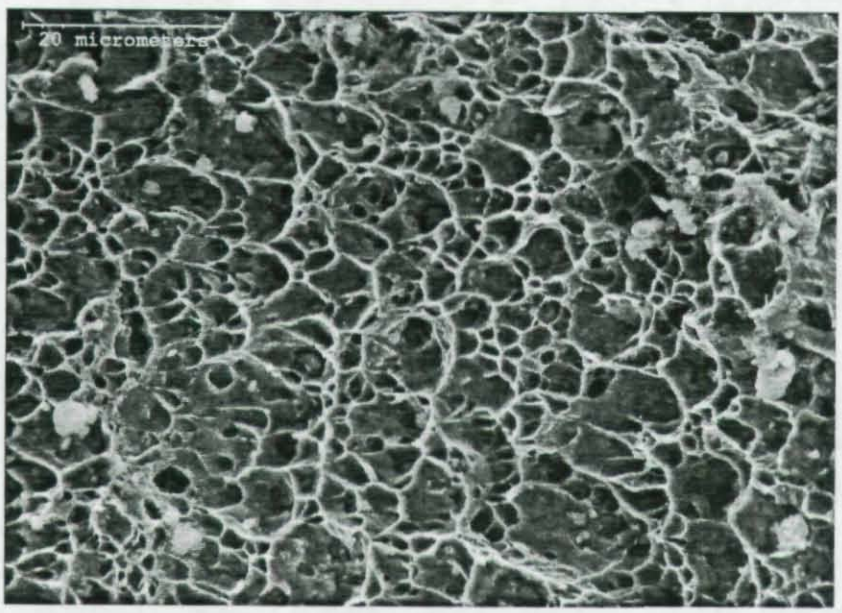


Figure H10 – Microvoids on Fracture Surface of Test Specimen T12-1

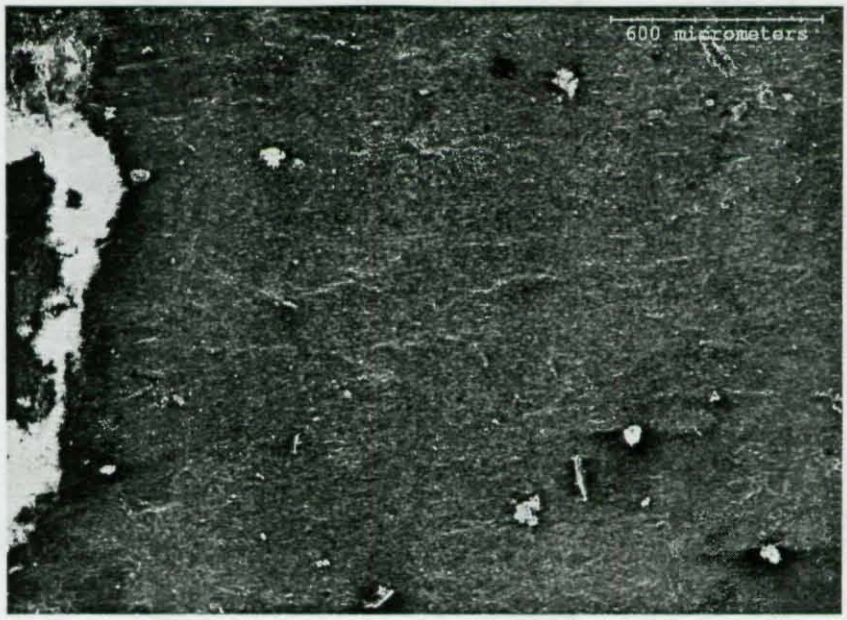


Figure H11 –Fracture Surface of Test Specimen T22-2

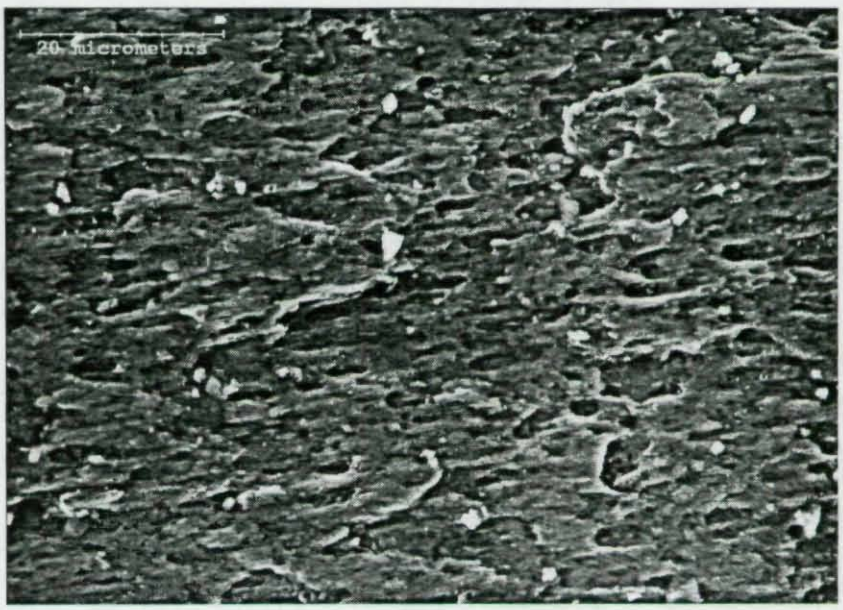


Figure H12 – Microvoid Coalescence on Fracture Surface of Test Specimen T22-2

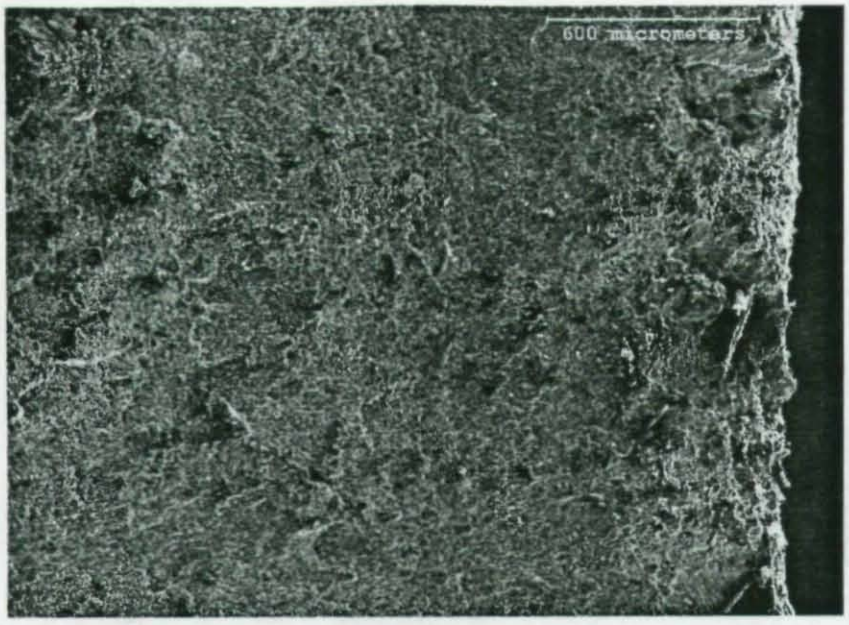


Figure H13 – Fracture Surface of Test Specimen T32-2

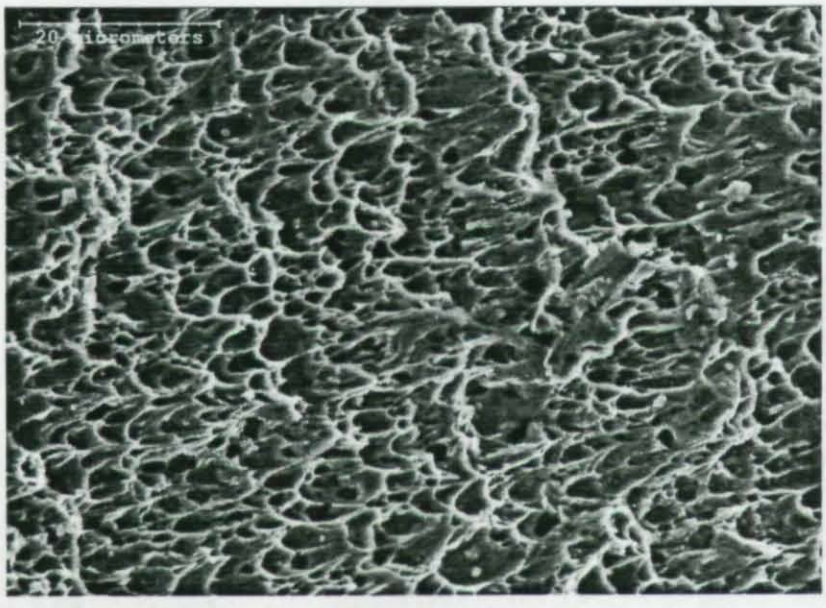


Figure H14 – Elongated Microvoids on Fracture Surface of Test Specimen T32-2

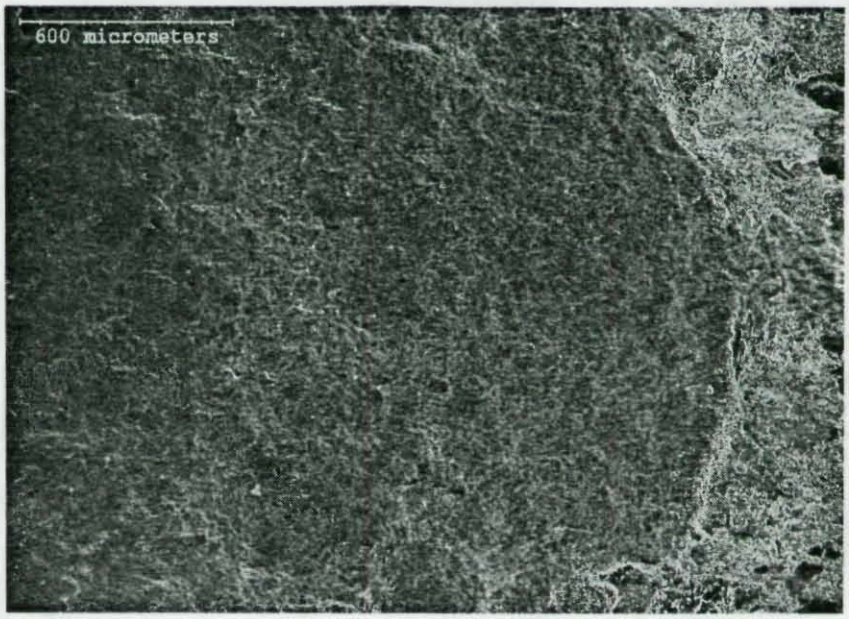


Figure H15 – Fracture Surface of Test Specimen T28-1

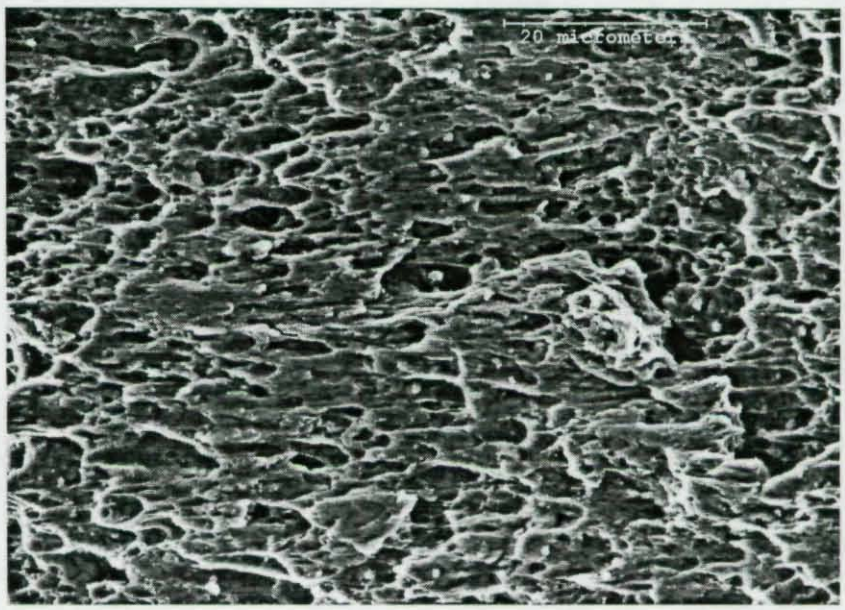


Figure H16 – Elongated Microvoids on Fracture Surface of Test Specimen T28-1

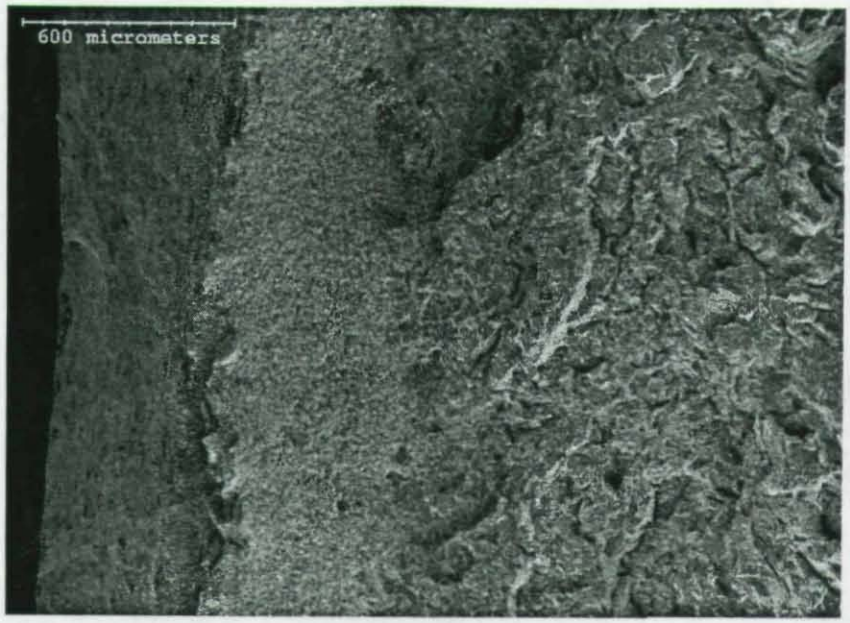


Figure H17 – Fracture Surface of Test Specimen T30-3

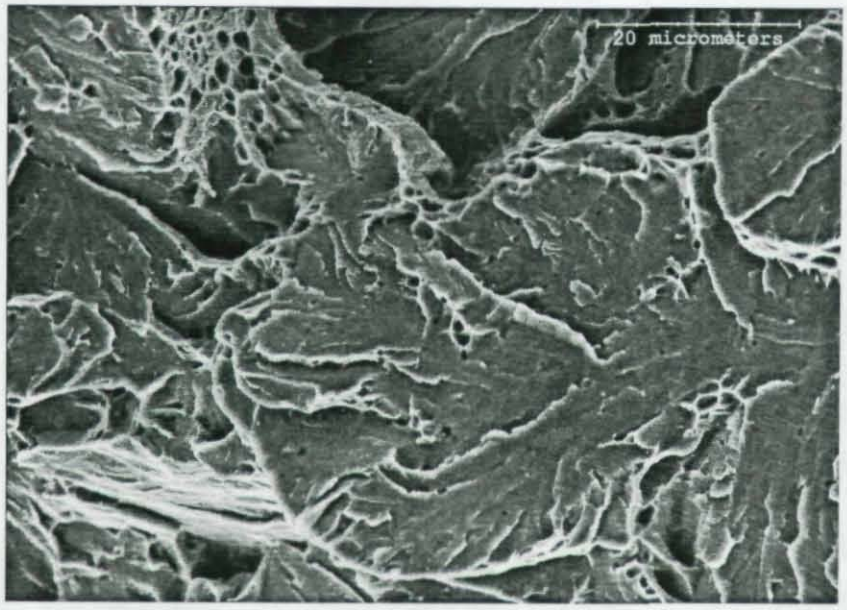


Figure H18 – Cleavage on Fracture Surface of Test Specimen T30-3

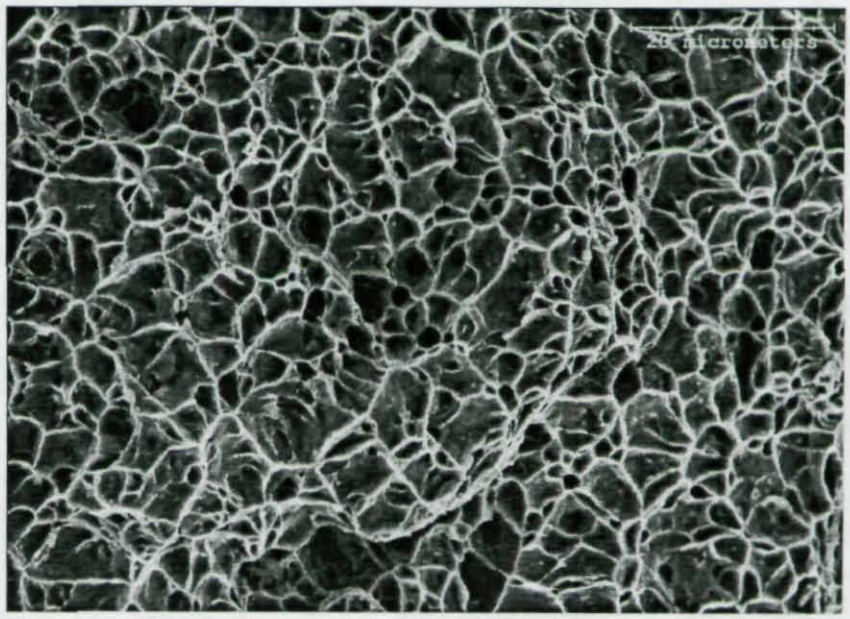


Figure H19 – Microvoids on Fracture Surface of Test Specimen T30-3

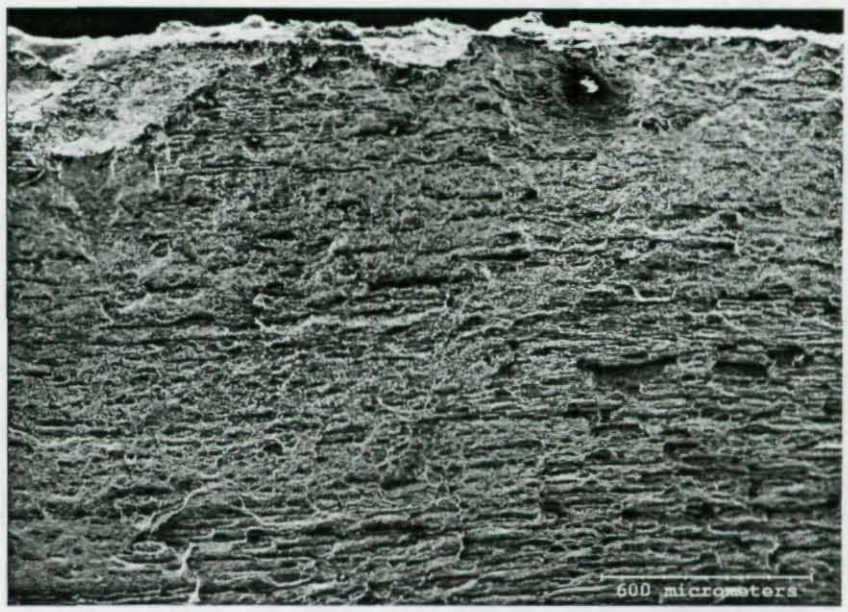


Figure H20 – Fracture Surface of Test Specimen T17-2

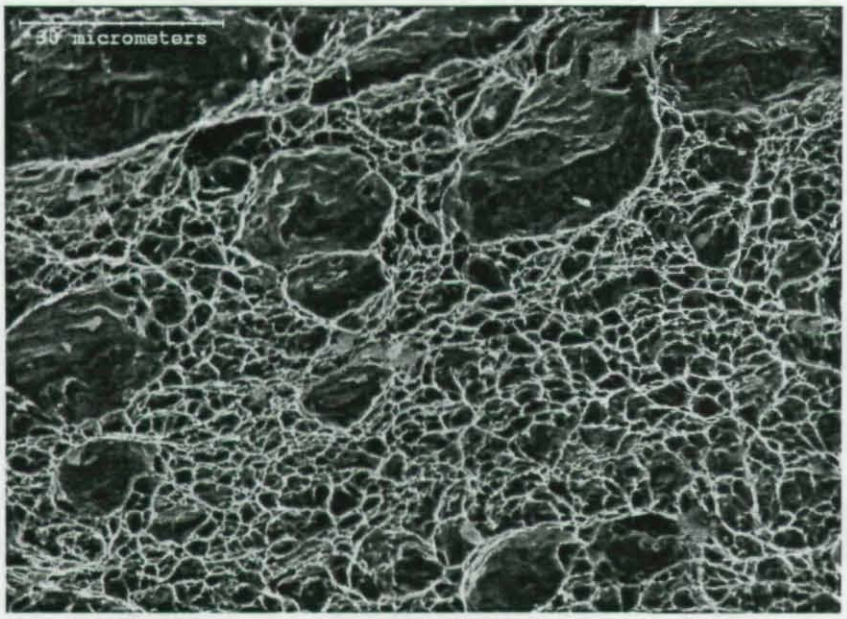


Figure H21 – Microvoids on Fracture Surface of Test Specimen T17-2

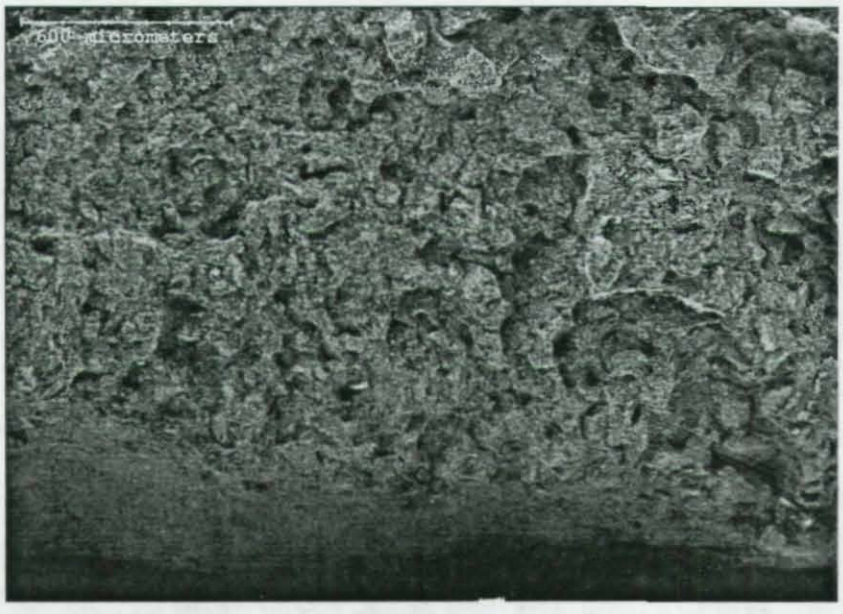


Figure H22 – Fracture Surface of Test Specimen T7-2 (Low temperature test)

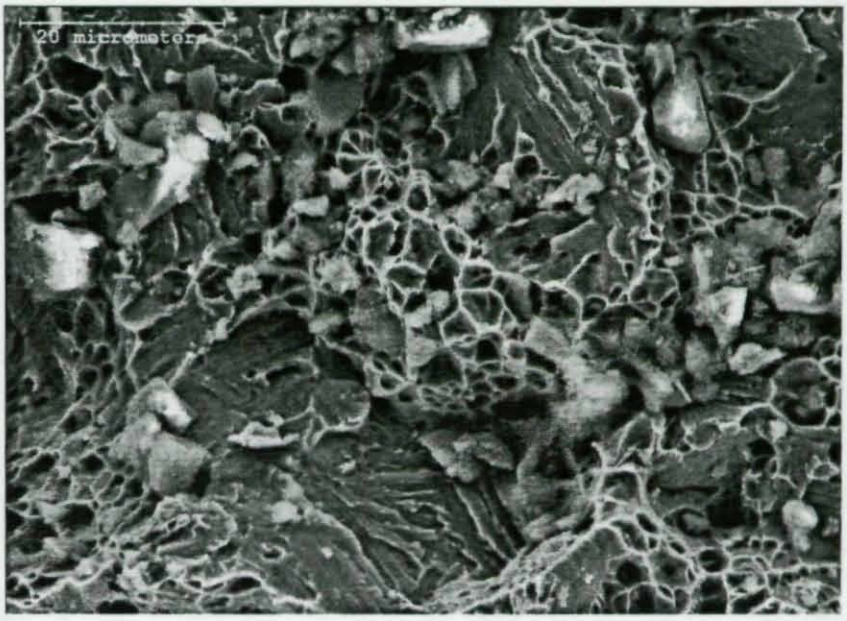


Figure H23 – Microvoid Coalescence and Cleavage on Fracture Surface of Test Specimen T7-2

Appendix I

Statistical Analysis of Test Data

Appendix I – Statistical Analysis of Test Data

This section presents a comparison of the results obtained in this test program with the results from the test program by Miazga and Kennedy (1989). It also presents the results of an ANalysis Of VAriance (ANOVA) conducted to assess the significance of the various factors included in the research program on transverse fillet welds. The ANOVA provides a method of estimating how much of the total variation in a set of data can be attributed to certain causes of variation, such as weld electrode manufacturer, fabricator, etc., and how much can be attributed to chance. The procedure therefore consists of comparing the variation between different treatments, such as the variation between fabricators, to the variation within the treatments, which reflects the variability of weld strength per se. The statistical analysis software SPSS® was used for this analysis. The following presents a discussion of the effect of the various parameters incorporated in the test program on the strength and ductility of transverse fillet welds.

I.1 Comparison of Current Study with the work of Miazga and Kennedy (1989)

Some of the test specimens in the current study were fabricated using E7014 electrodes to provide a means of comparing the test results from this investigation with the test results obtained by Miazga and Kennedy (1989). Table I1 presents a comparison of the welding parameters and properties of the material used to fabricate the test specimens in the Miazga and Kennedy research with those used in the present research program. Miazga and Kennedy tested three each of specimens with 5 mm and 9 mm fillet welds. The present research includes nine test specimens with 6.4 mm welds and three specimens with 12.7 mm welds from E7014 electrodes. An examination of Table I1 indicates that the welding parameters in the Miazga and Kennedy investigation are somewhat different from those used in the current investigation. Although Miazga and Kennedy used different parameters for their two weld sizes, the same parameters were used for the two weld sizes in the present investigation. Since the heat input is inversely proportional to welding speed and directly proportional to current, an estimate of heat input for all four weld sizes listed in Table I1 would indicate that the heat input for the 5 mm weld is significantly lower than that for the 9 mm weld for equal arc voltage. On the other hand, the heat input for the 6.4 mm and 12.7 mm welds was the same, but slightly higher than for the 9 mm weld. Another factor that would affect the strength of welds would be the number of passes used to deposit the weld. The tempering effect of subsequent weld passes will decrease weld strength.

The weld material properties obtained from the weld metal tension coupon tests in each investigation are similar. Although the welding parameters used to prepare the weld material specimens are not reported by Miazga and Kennedy, it is expected that the variation in weld metal strength would be smaller than the variation in fillet weld strength because the preparation of the weld metal coupon specimens follows stringent rules with respect to interpass temperature, thus ensuring a more consistent cooling rate among test specimens. The cooling rate, and hence the strength, of the fillet weld specimens would be affected by parameters such as initial temperature, heat input, and plate thickness.

These factors were not the same in both investigations. This could result in differences between the two investigations.

A description of the test specimens and the results of the transverse fillet weld tests from the Miazga and Kennedy test program and the present one are summarized in Table I2. A total of 18 test results, six from Miazga and Kennedy and 12 from this test program, are available for comparison. A visual comparison of the test results from both sources is presented in Figure I1. The following observations can be made from the figure:

- The scatter in the test results of Miazga and Kennedy, whose specimens were fabricated in a university laboratory by a welder working primarily in research, is significantly smaller than that in the results from the present research.
- In the current research program the small weld (6.4 mm) seems to have higher unit strength than the large weld (12.7 mm). This is attributed to the fact that the 12.7 mm weld was deposited in three passes, while the 6.4 mm weld was deposited in a single pass.
- In the Miazga and Kennedy test program the small weld (5 mm) seems to have a lower strength than the large weld (9 mm). This is not expected since the heat input in the 5 mm weld was lower than in the 9 mm weld and the 9 mm weld was deposited in three passes rather than in one for the 5 mm weld.
- The larger weld size from the two test programs seem to have similar strength. This can be explained, in part, by noting that the heat input for these two welds was similar, compared to the two smaller welds, and that both welds were deposited in three passes, so the cooling rate would have also been similar.

Table I1 – Comparison of Welding Parameters and Material Properties

Parameter	Miazga & Kennedy		Present Research	
	5 mm weld	9 mm weld	6.4 mm weld	12.7 mm weld
No. of Specimens	3	3	9	3
Welding Parameters				
Speed (mm/min)	250	205	254	254
Current (A)	125	125	170	170
Weld Material Properties				
Modulus of elasticity (MPa)	207 600	207 600	210 700	210 700
Yield strength (MPa)	465	465	452	452
Tensile strength (MPa)	538	538	520	520
Rupture strain (%)	25	25	22	22
Splice Plates Material Properties			*	
Yield strength (MPa)	364	346	418	347
Tensile strength (MPa)	522	513	551	466
Rupture strain (%)	23	27	31	38
Main Plates Material Properties				
Yield strength (MPa)	346	324	392	386
Tensile strength (MPa)	513	493	527	538
Rupture strain (%)	27	32	40	41

* The plates listed for the 12.7 mm weld specimens were used in three of the nine cases.

Table I2 – Summary of Test Results

	Miazga and Kennedy						Present Research											
Specimen Designation	90.1	90.2	90.3	90.11	90.12	90.13	T1-1	T1-2	T1-3	T2-1	T2-2	T2-3	T3-1	T3-2	T3-3	T20-1	T20-2	T20-3
Nominal Weld Size (mm)	5.0	5.0	5.0	9.0	9.0	9.0	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	12.7	12.7	12.7
Average Leg Size (mm)	5.3	5.3	5.3	9.1	9.3	9.2	6.6	6.4	6.3	5.9	6.1	6.4	7.1	7.4	7.5	13.8	13.0	13.7
Total weld length (mm)	200	200	201	197	200	200	152	152	152	152	152	152	152	152	152	152	152	152
Test capacity (kN)	421	431	407	789	807	791	513	502	513	462	474	482	523	518	520	782	949	878
Strain at rupture (%)	6.1	3.8	6.7	5.8	5.2	5.6	9.0	10.0	10.0	8.5	10.0	8.5	10.0	8.0	8.5	10.5	16.0	12.0
Angle of fracture surface	10	13	10	16	21	20	12	8	9	9	14	9	15	18	12	27	7	7
Throat area (mm^2)	742	754	752	1267	1309	1295	704	684	673	630	651	689	758	796	801	1479	1397	1474
Maximum stress on throat (MPa)	567	572	541	623	616	611	729	734	762	733	728	700	690	651	650	529	679	596

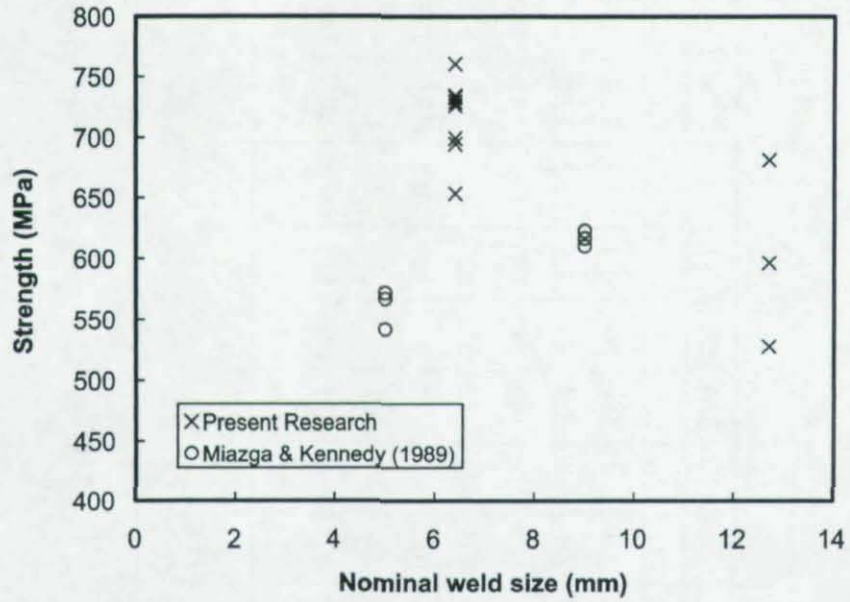


Figure I1 – Comparison of Test Results for E7014 Electrode

Although differences in strength do exist between the test specimens from the Miazga and Kennedy test program and the present test program, the differences can generally be attributed to differences in welding parameters. Insufficient data is available to explain the anomaly observed between the 5 mm and the 9 mm welds from the Miazga and Kennedy test program.

I.2 Analysis of Test Results from Lapped Splice Specimens

The parameters that were investigated experimentally in this study were:

1) Filler Metal — Five different weld electrode classifications were incorporated in this test program, two with a toughness requirement and three without. A total of 72 lapped splice specimens were fabricated with electrodes without a toughness requirement and 24 were fabricated with electrodes with a toughness requirement.
2) Electrode manufacturer — Electrodes were supplied by two manufacturers, namely, Lincoln and Hobart. A total of 54 specimens were prepared with electrodes from Lincoln and 42 from filler metal by Hobart.
3) Weld size — Two weld sizes were tested, namely, 6.4 mm and 12.7 mm. A total of 57 specimens were fabricated using 6.4 mm welds and 39 were fabricated with 12.7 mm welds.
4) Steel fabricator — The specimens were fabricated by Supreme and Waiward. Supreme fabricated 42 test specimens and Waiward fabricated 54.
5) Test temperature — All the specimens were tested at room temperature except for three that were tested at –50°C.

Although some of the weld specimens were tested with plates that yielded before fracture, while others were tested with plates that did not yield, an analysis of variation

on this parameter is not possible because the parameter was not isolated in the test program. Only the test specimens fabricated with E7014 electrodes were designed to remain elastic and within this electrode group, the specimens that yielded in the plates were fabricated with a different weld size. All test specimens prepared with FCAW failed after plate yielding. The yield effect is therefore left out of the analysis of variance.

I.2.1 Effect of filler metal classification

Although an analysis of variance can be performed to determine whether the strength of transverse fillet welds is significantly affected by the electrode classification, such an analysis does not provide a good estimate of the variation in strength between the different electrode classifications used in this investigation. This effect is better visualized from a plot of strength versus electrode classification. Figures I2 and I3 present plots of weld strength, calculated on the throat area and the fracture surface area, respectively, versus electrode classification. The mean strength, indicated by a solid square, and the associated 95% confidence interval are plotted. A comparison of Figure I2 with Figure I3 indicates that the variation in test results tends to be larger when the stress is calculated on the fracture surface. The electrode classification that shows the largest scatter in strength is E70T7-K2. As expected, because the area on the fracture surface is generally larger than the throat area, the stresses calculated based on the area of the fracture surface are generally lower than those calculated on the throat area. When the stress is calculated based on the throat area, the E7014 electrode shows a significantly lower strength than any of the flux cored electrodes. On the other hand, when the stress is calculated based on the fracture surface area, the E70T7-K2 electrode gives a distinctly higher strength, while the other four electrodes yield essentially the same strength. An examination of the electrodes with no toughness requirement indicates that there is no significant difference between the FCAW process and the SMAW process when the stress is calculated on the fracture surface. Because FCAW generally give greater root penetration, the FCAW gives a higher strength when calculated on the throat area.

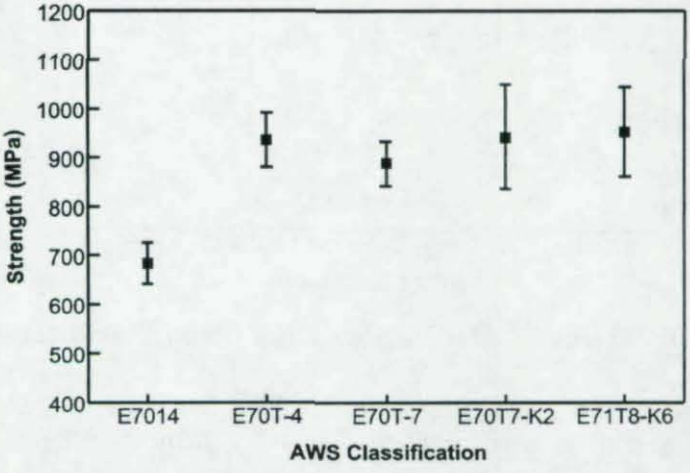


Figure I2 – Weld Strength Calculated on Throat Area for Various Filler Metal Classifications

The ductility of the welds was found to vary among electrodes. Figure I4 presents a plot of mean ductility, taken as the strain at rupture, for each electrode classification. The 95% confidence interval is also plotted for each electrode classification. Once again, electrode E70T7-K2 shows a greater variability than any of the other tested electrodes. The figure shows a distinctly higher ductility for the two electrodes with a toughness requirement, E70T7-K2 and E71T8-K6. The large variation observed for E70T7-K2, however, renders the higher ductility for this electrode statistically insignificant.

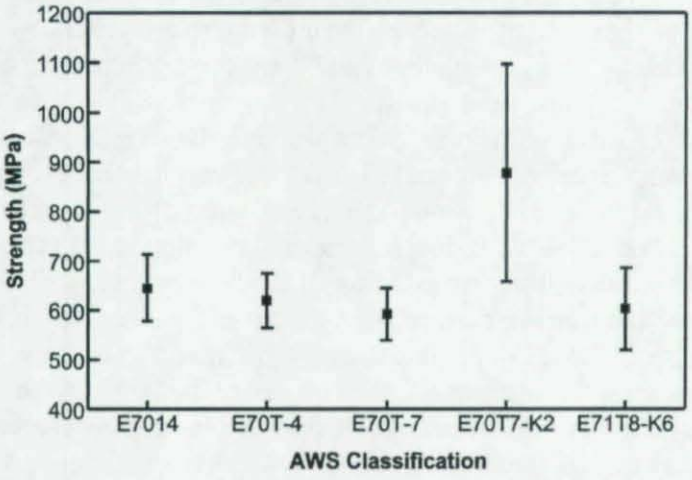


Figure I3 – Weld Strength Calculated on Fracture Surface for Various Filler Metal Classifications

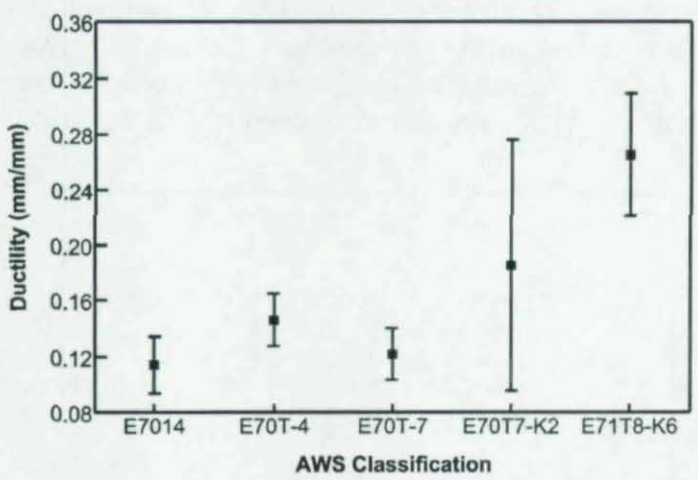


Figure I4 – Weld Ductility for Various Filler Metal Classifications

Now that the significance of the filler metal classification has been examined, the filler metals are grouped into two groups for further analysis, namely, filler metals with a toughness requirement and those without. (It should be noted here that, as discussed in section 6.5 of the main body of the report, the filler metals that have a toughness requirement did exhibit markedly higher Charpy impact energy values, as expected.) The effect of the test parameters, with weld toughness requirement taken as one of the

parameters, was investigated on three different variables, namely, the strength of the weld calculated using the throat area, the strength of the weld calculated using the fracture surface area, and the ductility of the weld.

I.2.2 ANOVA on the strength calculated using the throat area

The results of the analysis of variance on the weld strength calculated using the measured throat area are presented in Table I3. The first column of the summary table lists the source of variation, also called treatment, in the test program. Within the source of variation, two interactions are of interest, namely, the interaction between weld electrode manufacturer and electrode toughness requirement (designated as Manufacturer x Toughness) and the interaction between fabricator and toughness requirement. This latter parameter is of particular interest since the fabricators reported having more difficulty using the electrodes that have a toughness requirement than those that have no toughness requirement. The second to fourth columns in the summary tables present the sum of squares, number of degrees of freedom, and mean square calculated to assess the variance within the different treatments and variance between treatments. The F-ratio reported in the fifth column, which is the ratio of variance between treatments to the variance within treatments is the parameter used to assess the significance of the variance between treatments. The probability that the null hypothesis is correct (i.e., that the variance between treatments is not significantly different from the variance within treatments) is presented in the sixth column of the summary tables. At a 95% confidence level, any probability less than 5% (0.05) would indicate that null hypothesis is not correct, i.e., that the source of variation is significant. This essentially indicates that the parameter under consideration affects significantly the strength or ductility of the transverse fillet welds. The last column of the summary tables indicates the conclusion that is supported by the statistical analysis. The conclusion is either that the source of variation is influential or is not influential.

Table I3 – Analysis of Variation on Weld Strength
(Strength Calculated on Throat)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	Probability	Conclusion (95% confidence level)
Weld toughness	110120	1	110120	13.9	0.000	Influential
Weld size	1106480	1	1106480	139.5	0.000	Influential
Manufacturer	63380	1	63380	8.0	0.006	Influential
Fabricator	139330	1	139330	17.6	0.000	Influential
Test temperature	1297	1	1297	0.2	0.687	Not influential
Manufacturer x Toughness	43870	1	43870	5.5	0.021	Influential
Fabricator x Toughness	30498	1	30498	3.8	0.053	Influential*
Error	698130	88	7933			

* Influential at 94.7% confidence level

The ANOVA Table I3 includes weld toughness, weld size, electrode manufacturer, fabricator, test temperature as the main factors. As discussed above, the two-way

interaction terms "manufacturer x toughness" and "fabricator x toughness" are also included in the analysis.

Effect of weld toughness requirement

The results of the ANOVA indicate that the weld toughness requirement is an influential factor on the strength of transverse fillet welds. Figure I5 plots the mean strength for welds with no toughness requirement (NT) and welds with a toughness requirement (T) and the corresponding 95% confidence interval. The figure indicates that welds with a toughness requirement have a higher strength and somewhat higher variability than welds with no toughness requirement.

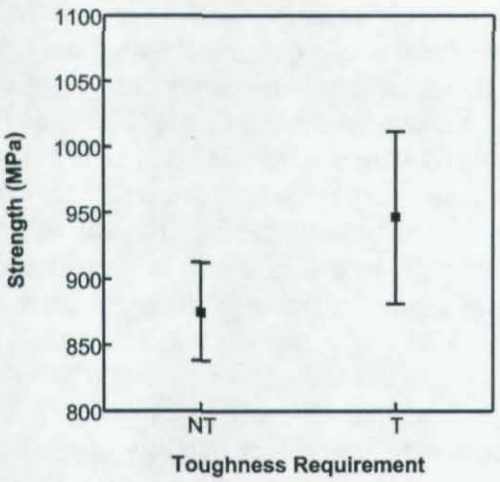


Figure I5 – Effect of Toughness Requirement on Transverse Fillet Weld Strength

Effect of weld size

The results of the ANOVA indicate that the weld size is an influential factor on the strength of transverse fillet welds. Figure I6 shows that the 6.4 mm weld specimens had a significantly higher strength than the 12.7 mm weld specimens. The 95% confidence interval shown in Figure I6 shows that the 6.4 mm welds also had a slightly larger variation in strength than the 12.7 mm welds. This increase in strength observed in the smaller weld is attributed to the faster cooling rate of small welds and the lack of tempering effect offered by subsequent passes in multi-pass welds.

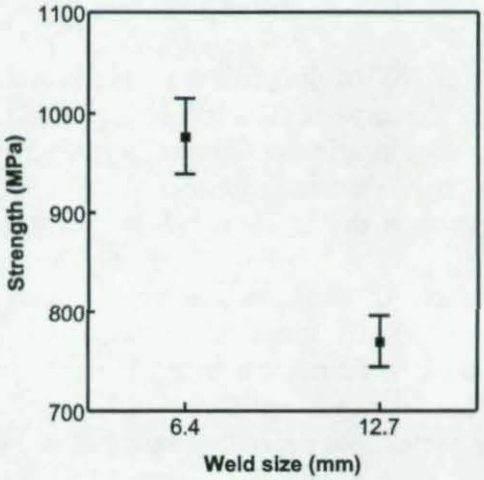


Figure I6 – Effect of Weld Size on Transverse Fillet Weld Strength

Effect of electrode manufacturer

The results of the ANOVA indicate that the electrode manufacturer is also an influential factor on the strength of transverse fillet welds. Figure I7 shows a plot of mean strength and the corresponding 95% confidence interval for the two manufacturers included in this study. The figure indicates that weld electrodes manufactured by Hobart produced fillet welds with higher strength than those manufactured by Lincoln. (It should be emphasized, however, that all electrodes included in the study from both sources exceeded the material strength required by their respective AWS electrode classifications.) It is noted that different welding parameters were used in the fabrication of the test specimens with electrodes of the same AWS classification, but from different manufacturers. This in itself can explain part, if not all, of the variation observed between manufacturers.

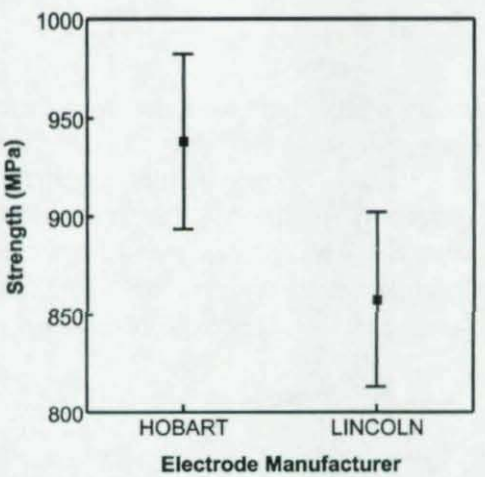


Figure I7 – Effect of Electrode Manufacturer on Transverse Fillet Weld Strength

Effect of fabricator

Once again, the results of the ANOVA indicate that this source of variation is an influential factor on the strength of transverse fillet welds. Figure I8 shows a plot of mean strength and the corresponding 95% confidence interval for the two fabricators used to fabricate the test specimens. The figure indicates that test specimens fabricated by Supreme had a higher strength than those fabricated by Waiward. The variation in strength between the two fabricators is attributable mostly to the different welding parameters used by the fabricators. Although both fabricators used welding parameters that fell within the manufacturers' specifications, there was a fairly significant variation in the parameters selected by the two fabricators (refer to Appendix A for the welding parameters used for the fabrication of the test specimens). The strengths of the test specimens from each fabricator show about the same amount of scatter.

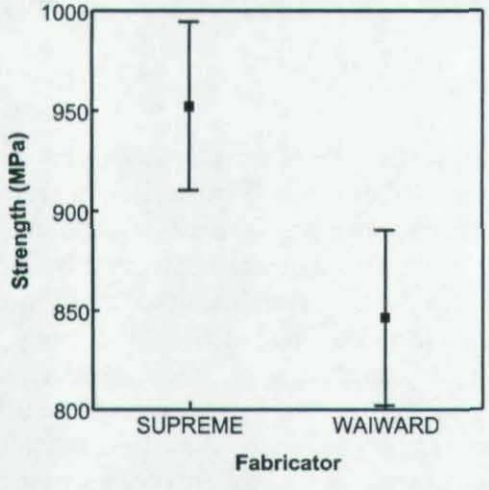
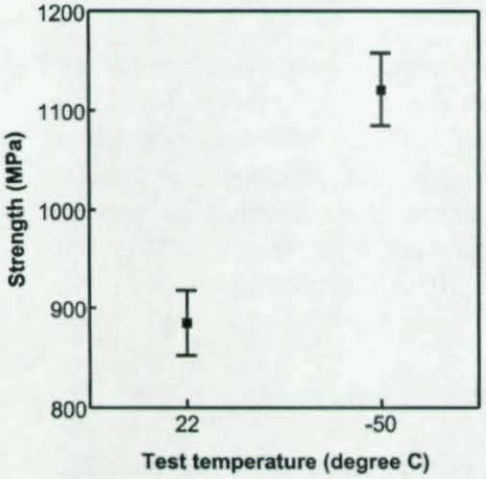


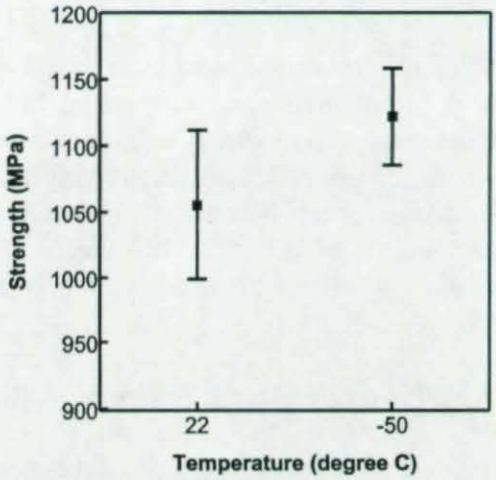
Figure I8 – Effect of Steel Fabricator on Transverse Fillet Weld Strength

Effect of test temperature

The ANOVA found that the testing temperature was the only main factor that did not show a significant effect on the strength of the test specimens. This conclusion, however, is not supported by Figure I9a, which shows a plot of mean strength and the corresponding 95% confidence interval for the two test temperatures used in the test program. The discrepancy between the ANOVA table and Figure I9 is attributed to the unbalanced nature of the experimental design with respect to this parameter. Only three tests were conducted at –50°C, whereas 93 specimens were tested at room temperature.



(a) All test specimens included



(b) E70T-4 with 6.4 mm welds only

Figure I9 – Effect of Test Temperature on Transverse Fillet Weld Strength

In order to investigate the effect of the unbalanced design, the test specimens that were fabricated with the same electrode classification (E70T-4) and with the same weld size as the low temperature test specimens were isolated for the statistical analysis. Figure I9b shows the modified mean strength and 95% confidence interval as a function of the testing temperature. The difference in strength is now not as significant as that shown in Figure I9a. The ANOVA was repeated and the results are presented in Table I4. Although the probability of the null hypothesis being correct has decreased substantially, the temperature is still seen to have an insignificant effect on strength at a 95% confidence level. An inconsistency between Figures I9a and I9b and the analysis of variance shown in Tables I3 and I4 is apparent. Although Figure I9 seems to indicate that the effect of temperature is more significant when all the data is pooled than when only a small group from the data set is used for the analysis, Tables I3 and I4 indicate that the significance of the temperature effect is stronger on the small sample (probability of accepting the null hypothesis is much smaller in Table I4 than in Table I3). This apparent inconsistency is partially explained by the largely unbalanced design for this factor and the large reduction in sample size from Table I3 to Table I4. The number of sources of variation selected for the ANOVA also influences the probability value. Nevertheless, the conclusion is the same for both analyses.

Table I4 – Analysis of Variance for the Effect of Test Temperature

Source of variation	Sum of squares	Degrees of Freedom	Mean Square	F-ratio	Probability	Conclusion (95% confidence level)
Test temperature	8960	1	8960	4.2	0.080	Not influential
Error	14977	7	2140			

Effect of Interaction

Two different interactions were examined, namely, interaction between manufacturer and toughness requirement, and interaction between fabricator and toughness. The latter interaction was chosen because fabricators often have difficulty welding with filler metals that contain nickel as an alloying element. The ANOVA indicates that there is significant interaction between manufacturer and toughness requirement. This may be explained by the fact that the two electrodes with required toughness selected for this investigation were not an exact match, which could affect the conclusion from this analysis.

I.2.3 ANOVA on the strength calculated using the fracture surface area

The ANOVA table for the strength of the welds calculated using the weld fracture surface area is presented in Table I6. The number of data points available for this analysis is slightly smaller since eight test specimens fractured either in the plates or in the reinforced welds and are not included in this analysis. A comparison of Table I3 and Table I5 indicates that all the sources of variation have the same effect as determined based on the stress calculated on the throat area. The two interaction effects that were found to be influential when the stress was calculated using the throat area are once again found to be significant when the stress is calculated based on the fracture area.

Table I5 – Analysis of Variation on Weld Strength
(Strength calculated on fracture surface)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	Probability	Conclusion (95% confidence level)
Weld toughness	141896	1	141896	10.2	0.002	Influential
Weld size	325936	1	325936	23.5	0.000	Influential
Manufacturer	177674	1	177674	12.8	0.001	Influential
Fabricator	320040	1	320040	23.0	0.000	Influential
Test temperature	4804	1	4804	0.3	0.558	Not influential
Manufacturer x Toughness	80572	1	80572	5.8	0.018	Influential
Fabricator x Toughness	121526	1	121526	8.7	0.004	Influential
Error	1111505	80	13894			

I.2.4 ANOVA on weld ductility

The effect on weld ductility of the parameters investigated in this study was also investigated using ANOVA. Weld ductility is taken as the measured weld strain at fracture. Since only the test welds that fractured could be included in this analysis, the number of data points is 88, as opposed to the 96 specimens tested. Table I6 shows a summary of the ANOVA on weld ductility.

Table I6 – Analysis of Variation on Weld Ductility

Source of Variation	Sum of Squares x 10^3	Degrees of Freedom	Mean Square x 10^3	F-ratio	Probability	Conclusion (95% confidence level)
Weld toughness	141.0	1	141.0	45.7	0.000	Influential
Weld size	26.6	1	26.6	8.6	0.004	Influential
Manufacturer	3.5	1	3.5	1.1	0.292	Not influential
Fabricator	5.0	1	5.0	1.6	0.206	Not influential
Test temperature	2.7	1	2.7	0.9	0.350	Not influential
Error	253	82	3.1			

Effect of weld toughness

The results of the ANOVA indicate that the weld toughness requirement is an influential factor on the ductility of transverse fillet welds. Figure I10 shows a plot of the mean ductility for welds with no toughness requirement (NT) and welds with a toughness requirement (T) and the corresponding 95% confidence interval. The figure indicates that welds with a toughness requirement have substantially more ductility than welds with no toughness requirement. The welds with toughness requirement also show more variability.

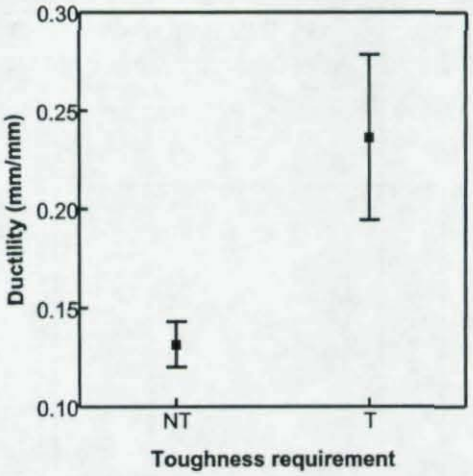


Figure I10 – Effect of Toughness Requirement on Transverse Fillet Weld Ductility

Effect of weld size

The results of the ANOVA indicate that the weld size is an influential factor on the ductility of transverse fillet welds. Figure I11 shows a plot of mean ductility and the corresponding 95% confidence interval for the two weld sizes included in this study. The figure indicates that the 6.4 mm weld specimens have a lower ductility than the 12.7 mm weld specimens. This is consistent with the earlier observation that the 6.4 mm welds are stronger than the 12.7 mm welds, since an increase in strength is often accompanied by a loss of ductility.

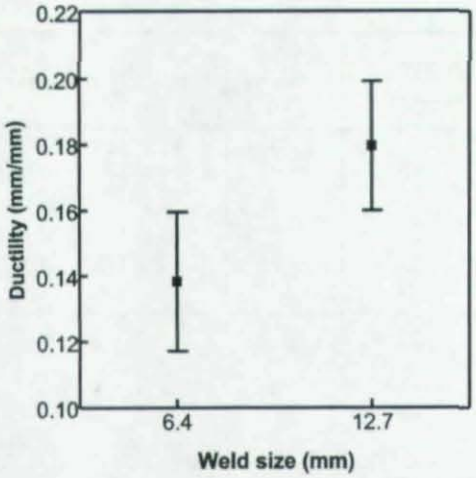


Figure I11 – Effect of Weld Size on Transverse Fillet Weld Ductility

Effect of electrode manufacturer

The results of the ANOVA indicate that the electrode manufacturer is not an influential factor on the ductility of transverse fillet welds. Figure I12 indicates that, although the Lincoln electrodes had a slightly lower ductility than the Hobart electrodes, the scatter in the test results is sufficiently large to make this parameter insignificant. The observed difference in ductility could be the direct consequence of the different welding parameters selected to fabricate the specimens.

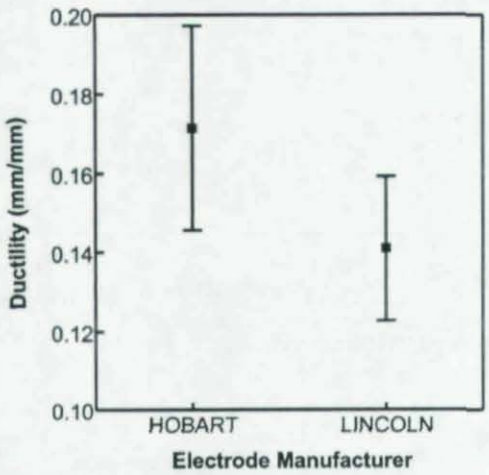


Figure I12 – Effect of Electrode Manufacturer on Transverse Fillet Weld Ductility

Effect of fabricator

The results of the ANOVA indicate that this source of variation is not an influential factor on the ductility of transverse fillet welds. Figure I13 shows a plot of mean ductility

and the corresponding 95% confidence interval for the two fabricators. The plot concurs with the results of the analysis of variance.

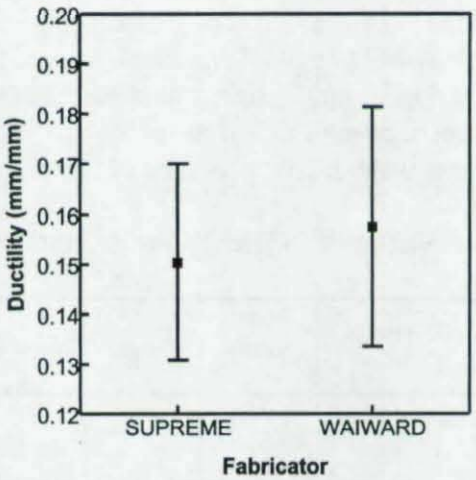
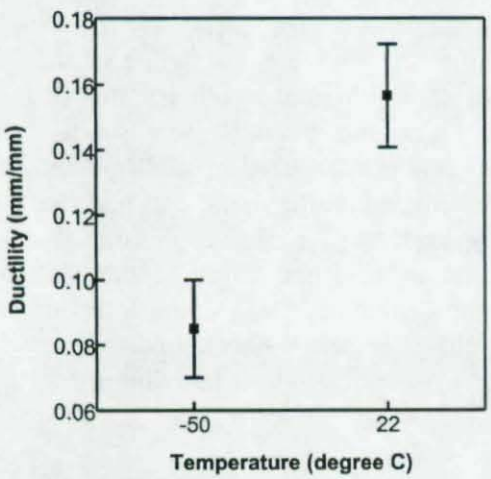


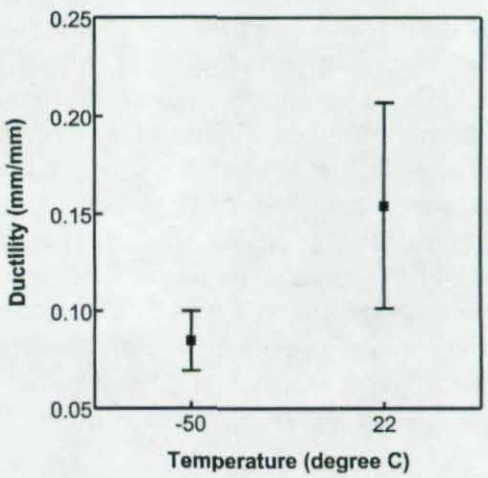
Figure I13 – Effect of Steel Fabricator on Transverse Fillet Weld Ductility

Effect of test temperature

The ANOVA found that the testing temperature does not have a significant effect on the ductility of the test specimens. This conclusion, however, is not supported by Figure I14a, which shows a plot of mean ductility and the corresponding 95% confidence interval for the two test temperatures. As for the strength parameter investigated above, the discrepancy between the ANOVA table and Figure I14a can be attributed to the unbalanced experimental design with respect to this parameter.



(a) All test specimens included



(b) E70T-4 with 6.4 mm welds only

Figure I14 – Effect of Test Temperature on Transverse Fillet Weld Ductility

In order to investigate the effect of the unbalanced design, the test specimens that were fabricated with the same electrode classification as the low temperature test specimens (E70T-4) and with the same weld size were isolated for the statistical analysis. Figure I14b shows the mean ductility and 95% confidence interval as a function of the testing temperature for the reduced sample size. The difference in strength is now not as significant as shown in Figure I14a. The ANOVA was repeated and the results are presented in Table I7. For this reduced sample size, where sources of variation not related to temperature effects have been minimized, it is seen that the temperature has a significant effect on the transverse weld ductility for a confidence level of 94.6%.

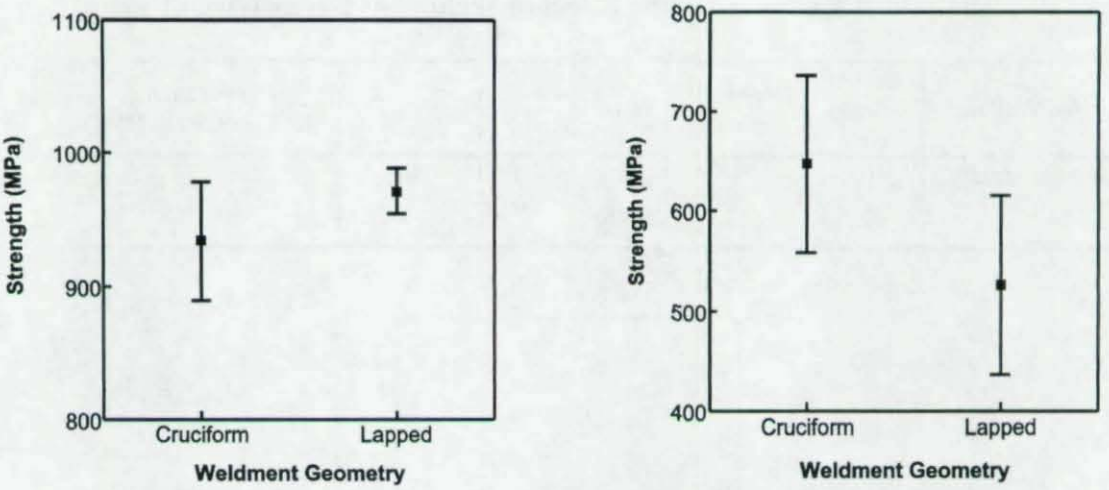
Table I7 – Analysis of Variance for the Effect of Test Temperature

Source of Variation	Sum of Squares x 10^3	Degrees of Freedom	Mean Square x 10^3	F-ratio	Probability	Conclusion (95% confidence level)
Test temperature	9.7	1	9.7	5.4	0.054	Influential*
Error	12.7	7	1.8			

* Influential at 94.6% confidence level

I.3 Effect of Weldment Geometry

Although most of the test program was conducted using lapped splice test specimens, a limited number of cruciform splice specimens were tested, namely, three specimens fabricated using E70T-4 filler metal, and three specimens fabricated using E70T7-K2 filler metal. All cruciform splice test specimens were welded with 6.4 mm fillet welds. A statistical analysis is conducted on the test data from this series of tests and the corresponding test specimens from the lapped splice test specimens so that a direct comparison between the two geometries can be made. Figure I15 presents the test results of the limited data in terms of strength versus test specimen geometry. The strength is calculated on the throat area in Figure I15a and on the fracture surface area in Figure I15b. Both figures indicate a small effect of the weldment geometry on the strength of transverse fillet welds. The test results show significantly more scatter, indicated by the 95% confidence interval, when the stress is calculated on the fracture surface area. An analysis of variance for the strength calculated on the throat area and the strength calculated on the fracture surface area is presented in Tables I8 and I9, respectively. The analysis of variance shows that the significance value of the test specimen design is about 0.04 in both cases, which shows that the weld strength in the cruciform splice specimen is different from the weld strength in the lapped splice specimen. The geometry that gives the higher weld strength seems to be a function of the area used, however, as illustrated in Figure I15.



(a) Strength calculated on throat (b) Strength calculated on fracture surface

Figure I15 – Effect of Weldment Geometry on Transverse Fillet Weld Strength

Table I8 – Analysis of Variance for the Effect of Weldment Geometry on Strength
(stress calculated on the throat area)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	Probability	Conclusion (95% confidence level)
Weldment Geometry	5004	1	5004	5.1	0.042	Influential
Error	12833	13	987			

Table I9 – Analysis of Variance for the Effect of Weldment Geometry on Strength
(stress calculated on the fracture surface area)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	Probability	Conclusion (95% confidence level)
Weldment Geometry	50342	1	50342	5.3	0.041	Influential
Error	115030	12	9586			

The effect of weldment geometry on weld ductility is also of interest, so a statistical analysis of the test data was therefore conducted to determine this effect. The results of the analysis of variance are presented in Table I10 and the trend between ductility and weldment geometry is presented in Figure I16. The analysis of variance indicates that weldment geometry has a significant effect on weld ductility and Figure I16 shows that the cruciform splice design results in lower weld ductility.

Table I10 – Analysis of Variance for the Effect of Weldment Geometry on Ductility

Source of Variation	Sum of Squares x 10^3	Degrees of Freedom	Mean Square x 10^3	F-ratio	Probability	Conclusion (95% confidence level)
Weldment Geometry	40.0	1	15.8	7.1	0.021	Influential
Error	67.7	12	5.6			

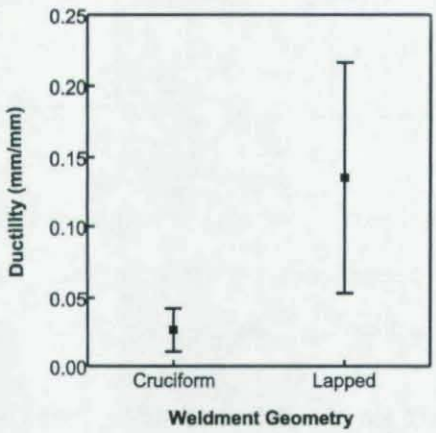


Figure I16 – Effect of Weldment Geometry on Transverse Fillet Weld Ductility

I.4 Summary

The results obtained in the present test program for E7014 electrodes and the test program conducted by Miazga and Kennedy (1989) show reasonably good agreement. Because of the close similarity between the weld metal tension coupon test results from the two research programs, it is believed that the any difference in fillet weld specimen behavior is most likely attributable to the differences in the welding parameters used.

An analysis of variance was conducted on the test data to assess the effect of the test parameters on weld strength and ductility. Table I11 summarizes the main findings from this analysis.

Table I11 – Summary of Statistical Analysis of Test Results

Factor	Effect on Weld Strength	Effect on Weld Ductility
Weld toughness	Influential	Influential
Weld size	Influential	Influential
Manufacturer	Influential	Not influential
Fabricator	Influential	Not influential
Test temperature	Not influential	Influential
Cruciform	Influential	Influential