WELDING TECHNIQUES

Extended Stickout Welding (Cont'd)
Extended stickout welding is best suited to large diameter, high deposition Innershield electrodes, such as 3/32 in. (2.4 mm) and 0.120 in. (3.0 mm) Innershield NS-3M. It is generally limited to 5/16 in. (8.0 mm) and larger flat fillets, multiple pass flat fillets and the fill passes of flat deep groove butt joints.

Extended stickout guides are used to maintain a consistent CTWD (see "Contact Tip to Work Distance" section for more details).

OPERATING GUIDE

Welding Procedures
The suggested welding procedures listed in this publication are not intended to serve as specific procedures for any application. These suggested procedures represent the approximate procedure range of each individual electrode. Arc voltage and/or wire feed speed may need to be adjusted depending upon welding position, type of weld, base steel surface condition or other factors. In general, use the highest voltage possible consistent with porosity-free welds.

For more information on a particular Innershield electrode, see the Lincoln Electric website. Search under "Consumables" – "Flux-Cored Wires, Self-Shielded".

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
3/32 in. (2.4mm) NR-5[1] (DC+) E70T-3, E70T3S 1-1/4 (32) 1.60 lbs/1000 in.	100 (2.5) 150 (3.8) 200 (5.1) 250 (6.4)	22 - 23 23 - 24 24 - 25 25 - 26	340 435 510 575	7.8 (3.5) 12.3 (5.6) 16.9 (7.6) 21.4 (9.7)
0.120 in. (3.0 mm) NR-5[1] (DC+) E70T-3, E70T3S 1-1/4 (32) 2.46 lbs/1000 in.	130 (3.3) 165 (4.2) 205 (5.2) 255 (6.5)	22 - 23 23 - 24 24 - 25 25 - 26	500 600 700 800	16.7 (7.6) 20.9 (9.5) 25.6 (11.6) 31.5 (14.3)
3/32 in. (2.4 mm) NR-131[1] (DC-) E70T-10, E70T10S 1-1/2 (38) 1.58 lbs/1000 in.	150 (3.8) 200 (5.1) 250 (6.4) 350 (8.9) 425 (10.8)	25 - 26 25 - 27 26 - 27 26 - 28 27 - 28	390 490 570 720 810	11.6 (5.3) 15.6 (7.1) 19.6 (8.9) 27.6 (12.5) 33.6 (15.2)
0.045 in. (1.1 mm) NR-152[1] (DC-) E71T-14, E71T14S 5/8 (16) 0.39 lbs/1000 in.	60 (1.5) 90 (2.3) 120 (3.0) 150 (3.8)	14 - 15 15 - 16 16 - 17 17 - 18	95 135 160 180	1.1 (0.5) 1.8 (0.8) 2.5 (1.1) 3.2 (1.4)

(1) Single pass welding only. Key: CTWD = ESO + 1/4 in. (6 mm)

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

OPERATING GUIDE

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
0.062 in. (1.6 mm) NR-152[1] (DC+) E71T-14, E71T14S 5/8 (16) 0.74 lbs/1000 in.	30 (0.8) 40 (1.0) 50 (1.3) 70 (1.8) 110 (2.8)	13 - 14 13 - 14 15 - 16 16 - 17 19 - 20	90 115 140 185 265	1.2 (0.5) 1.6 (0.7) 2.0 (0.9) 2.8 (1.3) 4.4 (2.0)
0.068 in. (1.7 mm) NR-152[1] (DC-) E71T-14, E71T14S 3/4 (20) 0.91 lbs/1000 in.	30 (0.8) 40 (1.0) 50 (1.3) 60 (1.5) 80 (2.0) 110 (2.8)	13 - 14 13 - 14 14 - 15 15 - 16 16 - 17 20 - 21	68 95 120 145 190 240	1.4 (0.6) 1.9 (0.9) 2.4 (1.1) 2.9 (1.3) 3.9 (1.8) 5.4 (2.4)
0.068 in. (1.7 mm) NR-203MP (DC-) E71T-8J, E71T8-A4-CS3-H16 1 (25) 0.78 lbs/1000 in.	70 (1.8) 90 (2.3) 120 (3.0) 140 (3.5) 150 (3.8)	16 - 17 18 - 19 20 - 21 21 - 22 23 - 24	145 180 225 255 265	2.3 (1.0) 3.2 (1.5) 4.3 (2.0) 4.8 (2.2) 5.1 (2.3)
5/64 in. (2.0 mm) NR-203MP (DC-) E71T-8J, E71T8-A4-CS3-H16 1 (25) 1.03 lbs/1000 in.	50 (1.3) 70 (1.8) 90 (2.3) 110 (2.8) 120 (3.0) 140 (3.5)	16 - 17 18 - 19 19 - 20 20 - 21 21 - 22 22 - 23	130 180 220 260 280 310	1.9 (0.9) 2.9 (1.3) 4.2 (1.9) 5.3 (2.4) 5.9 (2.7) 6.8 (3.1)
5/64 in. (2.0 mm) Pipeliner NR-208-P (DC-) E81T8-G, E81T8-A4G 3/4 (20) 1.04 lbs/1000 in.	70 (1.8) 90 (2.3) 110 (2.8) 130 (3.3)	18 - 19 19 - 20 19 - 20 20 - 21	210 240 270 305	3.6 (1.6) 4.8 (2.2) 6.0 (2.7) 6.7 (3.0)
5/64 in. (2.0 mm) NR-203 Nickel (1%) (DC-) E71T8-Ni1, E71T8-A2-Ni1-H16 1 (25) 1.02 lbs/1000 in.	50 (1.3) 70 (1.8) 90 (2.3) 110 (2.8) 120 (3.0) 140 (3.5)	16 - 17 18 - 19 19 - 20 20 - 21 21 - 22 22 - 23	145 195 240 275 290 310	2.3 (1.0) 3.3 (1.5) 4.3 (2.0) 5.3 (2.4) 5.8 (2.6) 6.9 (3.0)
5/64 in. (2.0 mm) NR-203 Ni C Plus-H (DC-) E71T8-K2, E71T8-A2-K2-H8 1 (25) 1.09 lbs/1000 in.	50 (1.3) 70 (1.8) 90 (2.3) 110 (2.8)	16 - 17 17 - 18 19 - 20 20 - 21	115 170 210 245	2.3 (1.0) 3.3 (1.5) 4.4 (2.0) 5.5 (2.5)
0.068 in. (1.7 mm) NR-207[2] (DC-) E71T8-K6, E71T8-A2-K6-H16 1 (25) 0.78 lbs/1000 in.	80 (2.0) 90 (2.3) 105 (2.7) 120 (3.0) 145 (3.7) 170 (4.3)	17 - 18 17 - 18 18 - 19 19 - 20 21 - 22 21 - 22	190 205 230 245 275 295	3.0 (1.4) 3.4 (1.5) 4.0 (1.8) 4.5 (2.0) 5.5 (2.5) 6.4 (2.9)

(1) Single pass welding only. Key: CTWD = ESO + 1/4 in. (6 mm)
(2) Electrode designed for pipe welding.

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

OPERATING GUIDE

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
5/64 in. (2.0 mm) NR-207[2] (DC-) E71T-8-K6, E71T8-A2-K6-H16 1 (25) 1.04 lbs/1000 in.	70 (1.8) 80 (2.0) 90 (2.3) 110 (2.8) 130 (3.3)	17 - 18 18 - 19 18 - 19 20 - 21 20 - 21	205 225 240 275 300	3.4 (1.5) 3.9 (1.8) 4.5 (2.0) 5.5 (2.5) 6.5 (2.9)
5/64 in. (2.0 mm) NR-208-H[2] (DC-) E91T8-G-H8, E91T8-AG-G-H8 1 (25) 1.04 lbs/1000 in.	70 (1.8) 80 (2.0) 90 (2.3) 110 (2.8) 130 (3.3)	16 - 17 17 - 18 18 - 19 19 - 20 19 - 20	195 220 235 275 295	3.2 (1.5) 3.9 (1.8) 4.5 (2.0) 5.5 (2.5) 6.5 (2.9)
5/64 in. (2.0 mm) Pipeliner NR-207+[2] (DC-) E71T8-K6, E71T8-A2-K6 3/4 (20) 1.04 lbs/1000 in.	70 (1.8) 90 (2.3) 110 (2.8) 130 (3.3)	17 - 18 18 - 19 20 - 21 20 - 21	205 240 275 300	3.4 (1.5) 4.5 (2.0) 5.5 (2.5) 6.5 (2.9)
5/64 in. (2.0 mm) Pipeliner NR-208-XP[2] (DC-) E81T8-G, E81T8-A4-G 3/4 (20) 1.04 lbs/1000 in.	70 (1.8) 90 (2.3) 110 (2.8) 130 (3.3)	17 - 18 18 - 19 19 - 20 19 - 20	195 235 265 295	4.0 (1.8) 4.8 (2.2) 6.0 (2.7) 7.6 (3.5)
0.030 in. (0.8 mm) NR-211-MP[3] (DC-) E71T-11, E71T11-AZ-CS3 1/2 (13) 0.250 lbs/1000 in.	50 (1.3) 100 (2.5) 150 (3.8) 200 (5.1) 250 (6.4) 300 (7.6)	13 - 14 13 - 14 14 - 15 14 - 15 15 - 16 18 - 19	30 60 80 100 130 140	0.4 (0.2) 0.8 (0.4) 1.2 (0.5) 1.7 (0.8) 2.1 (1.0) 2.6 (1.2)
0.035 in. (0.9 mm) NR-211-MP[3] (DC-) E71T-11, E71T11-AZ-CS3 1/2 - 5/8 (13 - 16) 0.250 lbs/1000 in.	50 (1.3) 70 (1.8) 110 (2.8) 150 (3.8) 200 (5.1)	14 - 15 15 - 16 16 - 17 17 - 18 18 - 19	30 60 115 130 155	0.7 (0.3) 1.0 (0.5) 1.3 (0.6) 1.7 (0.8) 2.5 (1.1)
0.045 in. (1.1 mm) NR-211-MP[3] (DC-) E71T-11, E71T11-AZ-CS3 5/8 (16) 0.39 lbs/1000 in.	70 (1.8) 90 (2.3) 110 (2.8) 130 (3.3)	15 - 16 16 - 17 17 - 18 18 - 19	120 140 160 170	1.1 (0.5) 1.7 (0.8) 2.3 (1.0) 2.7 (1.2)
0.068 in. (1.7 mm) NR-211-MP[3] (DC-) E71T-11, E71T11-AZ-CS3 3/4 - 1-1/4 (19 - 32) 0.89 lbs/1000 in.	40 (1.0) 75 (1.9) 130 (3.3) 175 (4.4)	15 - 16 18 - 19 20 - 21 23 - 24	125 190 270 300	1.7 (0.8) 3.4 (1.5) 6.1 (2.8) 8.4 (3.8)
5/64 in. (2.0 mm) NR-211-MP[4] (DC-) E71T-11, E71T11-AZ-CS3 3/4 - 1-1/4 (19 - 32) 1.17 lbs/1000 in.	50 (1.3) 75 (1.9) 120 (3.0) 160 (4.1)	16 - 17 18 - 19 20 - 21 22 - 23	180 235 290 325	2.9 (1.3) 4.5 (2.0) 7.4 (3.4) 10.0 (4.5)

(2) Electrode designed for pipe welding. Key: CTWD = ESO + 1/4 in. (6 mm)
(3) Electrode limited to maximum 5/16 in. (7.9 mm) plate thickness.
(4) Electrode limited to maximum 1/2 in. (12.7 mm) plate thickness.

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

OPERATING GUIDE

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
3/32 in. (2.4 mm) NR-211-MP[4] (DC-) E71T-11, E71T11-AZ-CS3 3/4 - 1-1/4 (19 - 32) 1.66 lbs/1000 in.	50 (1.3) 75 (1.9) 100 (2.5) 130 (3.3)	16 - 17 19 - 20 20 - 21 22 - 23	245 305 365 400	4.2 (1.9) 6.4 (2.9) 8.7 (3.9) 11.3 (5.1)
0.045 in. (1.1 mm) NR-212[5] (DC-) E71TG-G, E71TG-AZ-G-H16 5/8 (16) 0.39 lbs/1000 in.	55 (1.4) 70 (1.8) 90 (2.3) 110 (2.8) 130 (3.3) 150 (3.8)	14 - 15 15 - 16 16 - 17 17 - 18 18 - 19 19 - 20	75 95 115 135 155 170	1.1 (0.5) 1.4 (0.6) 1.8 (0.8) 2.2 (1.0) 2.6 (1.2) 3.0 (1.4)
0.068 in. (1.7 mm) NR-212[5] (DC-) E71TG-G, E71TG-AZ-G-H16 1 (25) 0.82 lbs/1000 in.	60 (1.5) 75 (1.9) 90 (2.3) 120 (3.0) 150 (3.8) 175 (4.4)	16 - 17 18 - 19 19 - 20 20 - 21 21 - 22 22 - 23	145 180 200 230 255 275	2.4 (1.1) 3.2 (1.4) 3.8 (1.7) 5.2 (2.4) 6.4 (2.9) 7.5 (3.4)
5/64 in. (2.0 mm) NR-212[5] (DC-) E71TG-G, E71TG-AZ-G-H16 1 (25) 1.06 lbs/1000 in.	60 (1.5) 75 (1.9) 90 (2.3) 110 (2.8) 130 (3.3) 150 (3.8)	16 - 17 18 - 19 19 - 20 20 - 21 21 - 22 22 - 23	200 225 245 275 300 325	3.3 (1.5) 4.1 (1.9) 5.0 (2.3) 6.2 (2.8) 7.3 (3.3) 8.4 (3.8)
0.068 (1.7 mm) NR-232 (DC-) E71T-8, E71T8-A2-CS3-H16 1 (25) 0.75 lbs/1000 in.	110 (2.8) 130 (3.3) 150 (3.8) 170 (4.3) 195 (5.0) 250 (6.4) 320 (8.1)	18 - 20 19 - 21 19 - 21 20 - 22 23 - 24 23 - 24 25 - 27	195 225 250 270 300 350 400	3.9 (1.8) 4.6 (2.1) 5.3 (2.4) 6.1 (2.8) 7.0 (3.2) 9.0 (4.1) 11.4 (5.2)
0.072 in. (1.8 mm) NR-232 (DC-) E71T-8, E71T8-A2-CS3-H16 1 (25) 0.78 lbs/1000 in.	80 (2.0) 140 (3.6) 155 (3.9) 170 (4.3) 250 (6.4) 290 (7.4)	16 - 18 18 - 21 19 - 22 20 - 23 22 - 24 23 - 25	130 225 240 255 315 350	3.3 (1.5) 5.5 (2.5) 6.0 (2.7) 6.5 (3.0) 9.6 (4.4) 11.0 (5.0)
5/64 in. (2.0 mm) NR-232 (DC-) E71T-8, E71T8-A2-CS3-H16 1 (25) 1.00 lbs/1000 in.	60 (1.5) 70 (1.8) 115 (2.9) 120 (3.0) 130 (3.3) 150 (3.8) 180 (4.6)	16 - 17 16 - 17 19 - 20 19 - 20 20 - 21 20.5 - 21.5 22 - 23	145 170 260 270 285 320 365	2.7 (1.2) 3.2 (1.5) 5.5 (2.5) 5.7 (2.6) 6.2 (2.8) 7.2 (3.3) 8.7 (4.0)
1/16 in. (1.6 mm) NR-233 (DC-) E71T-8, E71T8-A2-CS3-H16 1 (25) 0.59 lbs/1000 in.	150 (3.8) 200 (5.1) 250 (6.4) 300 (7.6) 350 (8.9)	17 - 19 19 - 21 21 - 23 23 - 25 25 - 27	220 245 270 295 315	4.2 (1.9) 5.4 (2.5) 6.6 (3.0) 7.7 (3.5) 9.4 (4.3)

(4) Electrode limited to maximum 1/2 in. (12.7 mm) plate thickness. Key: CTWD = ESO + 1/4 in. (6 mm)
(5) Electrode limited to maximum 3/4 in. (19 mm) plate thickness.

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

OPERATING GUIDE

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
0.072 in. (1.8 mm) NR-233 (DC-) E71T-8, E71T8-A2-CS3-H16 1 (25) 0.74 lbs/1000 in.	100 (2.5) 150 (3.8) 200 (5.1) 250 (6.4) 300 (7.6)	17 - 18 18 - 19 20 - 21 22 - 23 23 - 24	185 250 295 330 355	3.6 (1.6) 5.4 (2.5) 7.1 (3.2) 8.9 (4.0) 10.6 (4.8)
5/64 in. (2.0 mm) NR-233 (DC-) E71T-8, E71T8-A2-CS3-H16 1 (25) 0.93 lbs/1000 in.	90 (2.3) 125 (3.2) 150 (3.8) 200 (5.1) 240 (6.1)	18 - 19 19 - 20 20 - 21 21- 22 22 - 23	210 260 300 340 380	4.1 (1.9) 5.6 (2.5) 6.7 (3.0) 9.0 (4.1) 10.8 (4.9)
5/64 in. (2.0 mm) NS-3M (DC+) E70T-4, E70T4-AZ-CS3 2-1/4 (57)[6] 1.03 lbs/1000 in.	200 (5.1) 240 (6.1) 260 (6.6) 300 (7.6)	29 - 31 30 - 32 30 - 32 31 - 33	280 315 330 350	10.1 (4.6) 12.1 (5.5) 13.2 (6.0) 15.2 (6.9)
3/32 in. (2.4 mm) NS-3M (DC+) E70T-4, E70T4-AZ-CS3 3 (76)[6] 1.53 lbs/1000 in.	110 (2.8) 150 (3.8) 185 (4.7) 230 (5.8) 275 (7.0)	28 - 30 29 - 31 30 - 32 31 - 33 32 - 34	250 300 350 400 450	8.2 (3.7) 11.7 (5.3) 14.6 (6.6) 18.3 (8.3) 22.0 (10.0)
0.120 in. (3.0 mm) NS-3M (DC+) E70T-4, E70T4-AZ-CS3 3 (76)[6] 2.34 lbs/1000 in.	140 (3.6) 175 (4.4) 200 (5.1) 225 (5.7)	28 - 30 29 - 31 30 - 32 31 - 33	380 450 500 550	15.5 (7.0) 20.0 (9.1) 23.2 (10.5) 26.2(11.9)
0.120 in. (3.0 mm) NS-3M (DC+) E70T-4, E70T4-AZ-CS3 4 (102)[6] 2.34 lbs/1000 in.	210 (5.3) 250 (6.4) 300 (7.6) 355 (9.0)	35 - 37 36 - 38 37 - 39 38 - 40	450 500 550 600	25.0 (11.3) 29.0 (13.2) 34.0 (15.4) 39.5 (18.0)
5/64 in. (2.0 mm) NR-305 (DC+) E70T-6, E70T6-A2-CS3-H16 1-1/2 (38) 1.07 lbs/1000 in.	175 (4.4) 220 (5.6) 260 (6.6) 300 (7.6) 325 (8.3)	20 - 22 21 - 23 22 - 24 24 - 26 25 - 27	300 330 360 375 400	8.8 (4.0) 11.1 (5.0) 13.1 (5.9) 15.2 (6.9) 16.4 (7.4)
3/32 in. (2.4 mm) NR-305 (DC+) E70T-6, E70T6-A2-CS3-H16 1-3/4 (44) 1.39 lbs/1000 in.	160 (4.1) 240 (6.1) 300 (7.6) 400 (10.2)	21 - 23 24 - 26 27 - 29 33- 35	330 425 475 525	11.0 (5.0) 16.7 (7.6) 21.0 (9.5) 28.0 (12.7)
5/64 in. (2.0 mm) NR-311 (DC-) E70T-7, E70T7-AZ-CS3 1-1/2 (38) 1.07 lbs/1000 in.	100 (2.5) 160 (4.1) 240 (6.1) 300 (7.6)	20 - 22 24 - 26 25 - 28 27 - 30	190 275 355 410	5.0 (2.3) 8.0 (3.6) 12.4 (5.6) 15.8 (7.2)

(6) Requires extended insulator guides. Key: CTWD = ESO + 1/4 in. (6 mm)

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

OPERATING GUIDE

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
3/32 in. (2.4 mm) NR-311	75 (1/9)	20 - 22	200	5.4 (2.5)
(DC-) E70T-7,	135 (3.4)	23 - 26	300	10.2 (4.6)
E70T7-AZ-CS3	150 (3.8)	24 - 27	325	11.4 (5.2)
1-3/4 (44)	210 (5.3)	26 - 28	400	16.5 (7.5)
1.62 lbs/1000 in.	270 (6.9)	28 - 30	450	22.0 (10.0)
7/64 in. (2.8 mm) NR-311	100 (2.5)	23 - 26	325	10.0 (4.5)
(DC-) E70T-7,	145 (3.7)	25 - 27	400	14.5 (6.6)
E70T7-AZ-CS3	175 (4.4)	26 - 28	450	18.0 (8.2)
1-3/4 (44)	240 (6.1)	30 - 32	550	25.5 (11.6)
2.05 lbs/1000 in.	300 (7.6)	32 - 34	625	33.0 (15.0)
5/64 in. (2.0 mm) NR-311 Ni	100 (2.5)	21 - 23	170	3.9 (1.8)
(DC-) E80TG-K2,	130 (3.3)	24 - 26	205	5.2 (2.4)
E80TG-A2-K2-H16	160 (4.1)	25 - 27	235	6.5 (3.0)
1-1/4 (32)	200 (5.1)	26 - 28	270	8.3 (3.8)
0.93 lbs/1000 in.	240 (6.1)	27 - 29	295	10.0 (4.5)
3/32 in. (2.4 mm) NR-311 Ni	75 (1.9)	20 - 22	200	4.2 (1.9)
(DC-) E80TG-K2,	125 (3.2)	23 - 25	285	7.5 (3.4)
E80TG-A2-K2-H16	150 (3.8)	25 - 27	330	9.1 (4.1)
1-1/2 (38)	175 (4.4)	26 - 28	365	10.8 (4.9)
1.39 lbs/1000 in.	200 (5.1)	27 - 29	390	12.3 (5.6)
7/64 in. (2.8 mm) NR-311 Ni	100 (2.5)	22 - 24	310	8.4 (3.8)
(DC-) E80TG-K2,	140 (3.6)	24 - 26	370	11.8 (5.4)
E80TG-A2-K2-H16	170 (4.3)	26 - 28	430	14.5 (6.6)
1-3/4 (44)	200 (5.1)	28 - 30	470	17.0 (7.7)
1.89 lbs/1000 in.	240 (6.1)	29 - 31	520	20.4 (9.3)
3/32 in. (2.4 mm) NR-FAB-70	100 (2.5)	22 - 24	265	6.1 (2.8)
(DC-) E70T7-G,	125 (3.2)	23 - 25	320	7.9 (3.6)
E70T7-A2-G-H16	150 (3.8)	25 - 27	355	10.1 (4.6)
1-1/2 (38)	180 (4.6)	25 - 27	380	12.2 (5.5)
1.46 lbs/1000 in.	210 (5.3)	27 - 29	425	14.3 (6.5)
1/16 in. (1.6 mm) NR-440Ni2	90 (2.3)	17 - 18	160	2.5 (1.1)
(DC-) E71T8-Ni2-JH8,	100 (2.5)	18 - 19	170	2.8 (1.2)
E71T8-A4-Ni2-H8	110 (2.8)	18 - 19	180	3.1 (1.4)
3/4 (20)	120 (3.0)	19 - 20	195	3.5 (1.6)
0.67 lbs/1000 in.	130 (3.3)	19 - 20	210	3.7 (1.7)
5/64 in. (2.0 mm) NR-440Ni2	70 (1.8)	17 - 18	205	3.2 (1.5)
(DC-) E71T8-Ni2-JH8,	80 (2.0)	18 - 19	225	3.6 (1.6)
E71T8-A4-Ni2-H8	90 (2.3)	18 - 19	240	4.2 (1.9)
1 (25)	100 (2.5)	19 - 20	260	4.7 (2.1)
0.98 lbs/1000 in.	120 (3.0)	20 - 21	295	5.6 (2.5)

Key: CTWD = ESO + 1/4 in. (6 mm)

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

OPERATING GUIDE

Suggested Welding Procedures

Wire, Polarity, AWS Class, CTWD in. (mm), Wire Weight	Wire Feed Speed in/min (m/min)	Arc Voltage (volts)	Approx. Current (amps)	Deposit Rate lbs/hr (kg/hr)
1/16 in. (1.6 mm) NR-555	75 (1.9)	16 - 17	145	2.2 (1.0)
(DC-) E81T8-G,	90 (2.3)	17 - 18	160	2.7 (1.2)
E81T8-A5-K8-H8	100 (2.5)	17 - 18	175	3.1 (1.4)
7/8 (22)	110 (2.8)[7]	18 - 19	185	3.4 (1.5)
0.68 lbs/1000 in.	120 (3.0)	19 - 20	200	3.6 (1.6)
5/64 in. (2.0 mm) NR-555	75 (1.9)	16 - 17	185	3.0 (1.4)
(DC-) E81T8-G,	90 (2.3)	17 - 18	215	4.0 (1.8)
E81T8-A5-K8-H8	100 (2.5)	17 - 18	230	4.8 (2.0)
7/8 (22)	110 (2.8)[7]	18 - 19	245	5.5 (2.5)
0.98 lbs/1000 in.	120 (3.0)	19 - 20	260	5.8 (2.6)

(7) Optimal settings. Key: CTWD = ESO + 1/4 in. (6 mm)

NOTE: These are typical operating procedures only and are not intended to serve as specific procedures for any applications.

EFFECT OF WELDING PARAMETERS

The four major welding parameters with Innershield welding are arc voltage, wire feed speed (WFS), travel speed and contact tip to work distance (CTWD). These variables were explained in detail earlier in this booklet in the "WELDING PARAMETERS" section. Each of these parameters is interdependent. If one is changed, usually the other three must also be adjusted in order to maintain a stable arc and good weld quality.

Arc Voltage

If WFS, travel speed and CTWD are held constant, changing the arc voltage will have the following effects:

1. Higher arc voltage increases arc length and broadens the arc cone, which results in a wider and flatter bead.
2. Excessive arc voltage causes porosity.
3. Lower arc voltage decreases arc length and narrows the arc cone, which results in a narrower and more convex bead.
3. Too low of arc voltage causes a convex, ropey bead.
4. Extremely low voltage will cause the wire to stub on the plate. That is, the wire will dive through the molten metal and strike the joint bottom, tending to push the gun up.

Wire Feed Speed (WFS) (which controls welding current)

If arc voltage, travel speed and CTWD are held constant, WFS variations have the following major effects:

1. Increasing the WFS increases melt-off and deposition rates.
2. Excessive WFS produces convex beads. This wastes weld metal and results in poor appearance. As WFS is increased, the arc voltage must also be increased to maintain proper bead shape.
3. Increasing WFS also increases the maximum voltage which can be used without porosity. Lowering the WFS requires lowering the voltage to avoid porosity.
4. If WFS is too low, the arc will burn towards (and possibly into) the contact tip.

Travel Speed

If arc voltage, WFS and CTWD are held constant, travel speed variations have the following major effects:

1. Too fast of a travel speed increases the convexity of the bead and causes uneven edges.
2. Too slow of a travel speed results in slag interference, slag inclusions and a rough, uneven bead.

Contact Tip to Work Distance (CTWD)

If the voltage and wire feed speed setting and the travel speed are held constant, variations in CTWD have the following major effects:

1. Increasing CTWD reduces the welding current.
2. Decreasing CTWD increases current.
3. Increasing CTWD reduces actual arc voltage and results in more convex beads and reduces the tendency of porosity.
4. Momentarily increasing CTWD can be used to reduce burnthrough tendency when poor joint fit-up conditions are encountered.

TROUBLESHOOTING INNERSHIELD WELD PROBLEMS

Innershield welds that are properly made have excellent appearance. However, follow the tips in this weld troubleshooting guide when the bead appearance is not as desired.

To Eliminate Porosity (In order of importance)

1. Clean the joint of moisture, rust, oil, paint and other contaminants
2. Decrease voltage
3. Increase CTWD
4. Increase WFS
5. Decrease drag angle
6. Decrease travel speed

To Eliminate a Ropey Convex Bead (In order of importance)

1. Increase voltage (within wire specifications)
2. Decrease CTWD
3. Decrease WFS
4. Decrease travel speed
5. Decrease drag angle

To Reduce Spatter (In order of importance)

1. Adjust voltage
2. Decrease drag angle
3. Decrease CTWD
4. Increase WFS
5. Decrease travel speed

To Correct Poor Penetration (In order of importance)

1. Decrease CTWD
2. Increase WFS
3. Decrease voltage
4. Decrease travel speed
5. Decrease drag angle

To Minimize Arc Blow (In order of importance)

Arc blow occurs when the arc stream does not follow the shortest path between the electrode and the work piece.

1. Move work connection locations
2. Decrease drag angle
3. Increase CTWD
4. Decrease WFS and voltage
5. Decrease travel speed

To Eliminate Stubbing (In order of importance)

Stubbing occurs when the wire drives through the molten puddle and hits the bottom plate tending to push the gun up.

1. Increase voltage
2. Decrease WFS
3. Decrease CTWD
4. Decrease drag angle

NOTE: Equipment troubleshooting instructions are included in the operating manuals for the wire feeder and power source. Be sure to confirm the equipment is operating properly.

TROUBLESHOOTING INNERSHIELD WELD PROBLEMS

To Eliminate Trapped Slag in Weld (In order of importance)

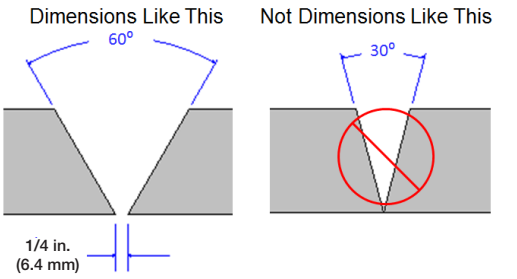
1. Increase weld joint opening
2. Keep arc ahead of the weld puddle by:
   a. Use drag angle of 20° to 30° (never use a push angle)
   b. Increase travel speed
   c. Decrease wire feed speed and voltage
3. Weld with vertical up progression instead of vertical down

Trapped Slag

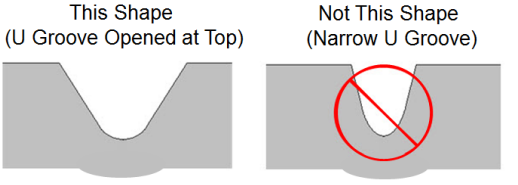
Slag inside the weld is a discontinuity and is often detected using ultrasonic testing (UT) or radiographic testing (RT) (aka x-ray) non-destructive testing (NDT). It can be a fairly common occurrence with flux cored electrodes and is almost always due to improper weld joint dimensions and/or operator technique.

Slag can become trapped inside the weld if there is not enough room in the joint for the slag to fully clear the puddle (i.e. float to the surface) before the weld metal solidifies. This often occurs when welding in a tight narrow joint. With groove welds for example, ensure that the root opening and included angle are wide enough to allow room for the slag to clear. This joint design is also necessary to properly manage the arc and ensure the proper root pass depth to width ratio (~1:1). Proper joint dimensions are critical with both the original joint preparation and when arc gouging the back side of a groove weld to sound weld metal and then welding from that side. Make sure the gouged out joint is not a deep "U" groove, but rather is opened up at the top of joint in more of a "V" pattern. The pictures below illustrate examples only of good and bad joint preparations.

Recommended Joint Prep to Avoid Trapping Slag in Welds



When Arc Gouging to Sound Weld Metal, Recommended Joint Shape to Avoid Trapping Slag in Succeeding Welds



TROUBLESHOOTING INNERSHIELD WELD PROBLEMS

Trapped Slag (Cont'd)
Slag can also get trapped inside the weld if allowed to run ahead of the puddle. The operator needs to keep the arc focused in the joint just ahead of the puddle. Use a drag travel angle to keep the slag behind the arc, with the arc force helping to push it back. Also use a travel speed that is fast enough to stay ahead of the puddle. If too slow, then the arc may ride on top of the puddle, allowing the molten weld metal and molten slag to run around and in front of the arc. Some of the slag then rolls under the puddle and gets trapped inside the bead as it solidifies. In addition, use a controllable wire feed speed. Don't try to "hog in" a large weld bead in the joint by running excessive WFSs and slow travel speeds. This will increase the chances of trapping slag in the weld. If welding in the vertical position, use a vertical up progression, such that gravity helps hold back the slag. With vertical down progression, gravity is always pulling the slag into the arc.

HYDROGEN CONTROL

Hydrogen Control
Minimizing the amount of hydrogen that diffuses into (and over time back out of) weld metal can help make it more resistant to cracking. This is particularly true with higher strength, low alloy steels, hard to weld steels, thicker plates, highly restrained joints, etc. Sources of hydrogen can come from surface contaminants on the steel, the atmosphere and particularly from the welding electrode.

The AWS filler metal specifications for flux-cored electrodes state that "Flux-cored arc welding is generally considered to be a low hydrogen welding process" (section A8.2.4). Further, these specifications have optional supplemental designators for use with the various electrodes' classification numbers which indicate the maximum diffusible hydrogen levels of 4, 8 and 16 milliliters (ml) per every 100 grams (g) of deposited weld metal. In general, Innershield electrodes will produce weld deposits which have a maximum of 16 ml of diffusible hydrogen per 100 g of weld metal.

Innershield products, like other types of electrodes which produce deposits low in diffusible hydrogen, must be protected from exposure to the atmosphere in order to;
(a) Maintain hydrogen levels as low as possible
(b) Prevent porosity during welding
(c) Prevent rusting of the product