Innershield Wire

FCAW-S Welding Guide

LINCOLN ELECTRIC

INTRODUCTION

Innershield Product Line

Lincoln Electric manufactures a complete portfolio of Innershield electrodes used for a variety of welding applications (see table).

Electrode Name	Electrode Type and Welding Position	Key Attributes/Common Applications
High Speed, Single Pass Only (no specified CVN toughness)		
Innershield NR®-5	Carbon Steel Flat and Horizontal	Single pass, up to 3/16 in. (4.8 mm) sheet metal, robotics/hard automation, automotive, propane cylinders, very fast travel speeds, 3 o'clock weld position, open root joints with copper back-up bar.
Innershield NR-131	Carbon Steel Flat and Horizontal	Single pass on 12 gauge (0.11 in. or 2.8 mm) or thicker steel, automotive, transportation, very fast travel speeds, automatic or semiautomatic welding, joining dissimilar thickness plates.
Innershield NR-152	Carbon Steel All Position (except vertical up)	Single pass, up to 3/16 in. (4.8 mm) sheet metal, designed for high speed welding on galvanized or zinc coated carbon steel, automotive, transportation, robotic and hard automation welding.
Sheet Metal to Thinner Plate/General Purpose (no specified CVNs)		
Innershield NR-211-MP	Carbon Steel All Position [except 3/32 in. (2.4 mm) diameter]	General fabrication with sheet metal, excellent operator appeal, galvanized or zinc coated sheet metal. Maximum plate thickness restrictions: - 5/16 in. (7.9 mm) for 0.030 - 0.045 dia. - 1/2 in. (12.7 mm) for 0.068 - 3/32 dia.
Innershield NR-212	Low Alloy Steel All Position	General fabrication with sheet metal to thinner plate, very good operator appeal, galvanized or zinc coated thinner plate, truck bodies, tanks, hoppers, racks and scaffolding. Maximum plate thickness restrictions: - 3/4 in. (19 mm) for all diameters
High Deposition/General Purpose (no specified CVN toughness)		
Innershield NS-3M	Carbon Steel Flat and Horizontal	Very high deposition rates, large groove and fillet welds, machinery bases, heavy equipment repair, installing wear plates, increased resistance to hydrogen cracking and porosity, good on high sulfur and off-analysis steels, low penetration/minimal admixture welds.
Innershield NR-311	Carbon Steel Flat and Horizontal	Very high deposition rates, fillet and groove welds on 1/8 in. (3.2 mm) and thicker steel, general fabrication, structural, assembly welding, deep penetration, fast travel speeds, good slag removal in deep grooves.

Electrode Name	Electrode Type and Welding Position	Key Attributes/Common Applications
All Position/Structural (with CVN toughness properties)		
Innershield NR-203MP	Carbon Steel All Position	Open root welding, handles poor fit-up and gaps up to 3/8 in. (6.4 mm) wide, general plate fabrication, galvanized plate, bridge fabrication, structural, hull plate and stiffener welding on ships and barges, etc.
Innershield NR-203 Nickel (1%)	Low Alloy All Position	Open root welding, handles poor fit-up. Produces a nickel alloyed weld deposit (just under 1%) for NACE applications or color match with weathering steels for bridges and other structural fabrication. Also for offshore and groove welds on heavy wall tubular construction.
Innershield NR-203 Ni C Plus-H	Low Alloy All Position	Open root welding, handles poor fit-up. Produces a nickel alloyed weld deposit (1.0 – 2.0%) and meets an "H8" maximum diffusible hydrogen rating. Used for offshore, weathering steel, structural, bridges, hull plate and stiffener welding on ships and barges and general fabrication.
Innershield NR-232	Carbon Steel All Position (except vertical down)	For 3/16 in. (4.8 mm) and thicker steel. Maximum deposition rates when welding out-of-position. Has a heavy, fast freezing, self peeling slag system and penetrating arc. Produces smooth, flat weld beads. Used for structural fabrication, including those subject to seismic requirements (meets AWS D1.8 seismic lot waiver requirements). Also for hull plate and stiffener welding on ships and barges, machinery parts, tanks, hoppers, racks, scaffolding and general plate fabrication.
Innershield NR-233	Carbon Steel All Position (except vertical down)	Same attributes and applications as Innershield NR-232, but with a softer arc characteristic and a slightly easier to manage slag system. NR-233 is generally preferred to NR-232 for welders new to this type of heavy slag system.
Innershield NR-440Ni2	Low Alloy All Position	Designed for offshore industry. Provides improved weldability in narrow TKY connections and poor fit up conditions. Has excellent CVN toughness (meets ABS "4YSA" and AWS "J" classifications) and meets "H8" diffusible hydrogen rating.
Innershield NR-555	Low Alloy All Position	80 ksi min. tensile strength wire for general fabrication and structural steel applications, including those subject to seismic requirements (meets AWS D1.8 seismic lot waiver requirements).

Electrode Name	Electrode Type and Welding Position	Key Attributes/Common Applications
High Deposition/Structural (with CVN toughness properties)		
Innershield NR-305	Carbon Steel Flat and Horizontal	High deposition rates and fast travel speeds in the flat and horizontal positions. Smooth arc with lower spatter level. Used for structural fabrication, including those subject to seismic requirements (meets AWS D1.8 seismic lot waiver requirements). Also for general plate fabrication, shipyards, stiffener welding on barges, bridges and offshore applications.
Innershield NR-311 Ni	Low Alloy Flat and Horizontal	High deposition rates and fast travel speeds in the flat and horizontal positions. Used for structural fabrication, including those subject to seismic requirements (3/32 in. (2.4 mm) size meets AWS D1.8 seismic lot waiver requirements). Very good bead stacking capability with horizontal groove welds, such as column-to-column structural connections. Produces a nickel alloyed weld deposit (nominal 1.5%). Provides color match on weathering steel.
Innershield NR-FAB-70	Carbon Steel Flat and Horizontal	Best in class toughness properties and without nickel. Used for structural fabrication, including those subject to seismic requirements (meets AWS D1.8 seismic lot waiver requirements).
Cross-Country Pipelines/Vertical Down (with CVN toughness properties)		
Innershield NR-207	Low Alloy Vertical Down	Hot, fill and cap passes on API standard and artic grades X42 up to under matched X70 pipe.
Innershield NR-208-H	Low Alloy Vertical Down	Hot, fill and cap passes on up to API grade X80 pipe. Also artic grades up to under matched X70 pipe.
Pipeliner® NR-207+	Low Alloy Vertical Down	Hot, fill and cap passes on API grades X42 through X70 pipe. All "Pipeliner" products include ProTech® hermetically sealed packaging and Q2 Lot® control (certificate showing actual deposit chemistry available online).
Pipeliner NR-208-P(1)	Low Alloy Vertical Down	Hot, fill and cap passes on up to API grade X80 pipe. Best operator appeal. First choice for higher service temperatures.
Pipeliner NR-208-XP	Low Alloy Vertical Down	Hot, fill and cap passes on up to grade API X80 pipe. Excellent CVN toughness properties. First choice for lower service temperatures.

(1) Special order product.

AWS ELECTRODE CLASSIFICATIONS

Flux-cored electrodes have been classified per The American Welding Society (AWS) filler metal specifications AWS A5.20/A5.20M *Specification for Carbon Steel Electrodes for Flux-Cored Arc Welding* and AWS A5.29/A5.29M *Specification for Low Alloy Steel Electrodes for Flux-Cored Arc Welding*. These are traditional "fixed classification" systems. AWS has since introduced a new type of "open classification" system, which makes it easier to address the changing requirements of the marketplace. The first one covers all flux-cored and metal-cored electrodes. The specification is **AWS A5.36/A5.36M:2012 Specifications for Carbon and Low-Alloy Steel Flux-Cored Electrodes for Flux-Cored Arc Welding and Metal-Cored Electrodes for Gas Metal Arc Welding.** The old (A5.20/A5:20M and A5:29/A5:29M) and new (A5.36:A5.36M) specifications run concurrently with dual classification authority.

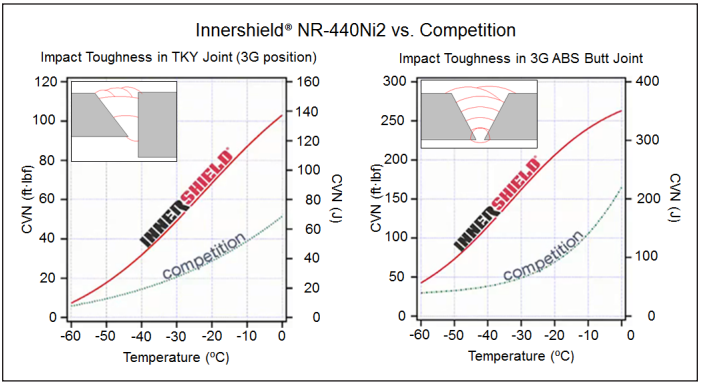
Cross reference table between old and new classification numbers.

Electrode Name	Classification per AWS A5.20 or A5.29	Classification per AWS A5.36/A5.36M:2012
High Speed, Single Pass Only (no specified CVN toughness)		
Innershield NR-5	E70T-3	E70T3S
Innershield NR-131	E70T-10	E70T10S
Innershield NR-152	E71T-14	E71T14S
Sheet Metal to Thinner Plate/General Purpose (no spec. CVNs)		
Innershield NR-211-MP	E71T-11	E71T11-AZ-CS3
Innershield NR-212	E71TG-G	E71TG-AZ-G-H16
HighDeposition/General Purpose (no specified CVN toughness)		
Innershield NS-3M	E70T-4	E70T4-AZ-CS3
Innershield NR-311	E70T-7	E70T7-AZ-CS3
All Position/Structural (with CVN toughness properties)		
Innershield NR-203MP	E71T-8J	E71T8-A4-CS3-H16
Innershield NR-203 Ni 1%	E71T8-Ni1	E71T8-A2-Ni1-H16
Innershield NR-203 Ni C Plus-H	E71T8-K2	E71T8-A2-K2
Innershield NR-232	E71T-8	E71T8-A2-CS3-H16
Innershield NR-233	E71T-8	E71T8-A2-CS3-H16
Innershield NR-440Ni2	E71T8-Ni2-JH8	E71T8-A4-Ni2-H8
Innershield NR-555	E81T8-G	E81T8-A5-K8-H8
High Deposition/Structural (with CVN toughness properties)		
Innershield NR-305	E70T-6	E70T6-A2-CS3-H16
Innershield NR-311 Ni	E70T7-K2/E80T-G-K2	E70T7-A2-K2-H16 / E80TG-A2-K2-H16
Innershield NR-FAB-70	E70T7-G	E70T7-A2-G-H16
Cross-Country Pipelines/Vertical Down (with CVN toughness properties)		
Innershield NR-207	E71T8-K6	E71T8-A2-K6-H16
Innershield NR-208-H	E91T8-G-H8	E91T8-AG-G-H8
Pipeliner NR-207+	E71T8-K6	E71T8-A2-K6
Pipeliner NR-208-XP	E81T8-G	E81T8-A4-G

ADDITIONAL INSTRUCTIONS
Innershield NR-440Ni2

Electrode Highlights (Cont'd):

» **Electrode classification:** A "T-8" low alloy electrode. It most closely resembles the NR-203 family of electrodes in regards to slag system and operability.



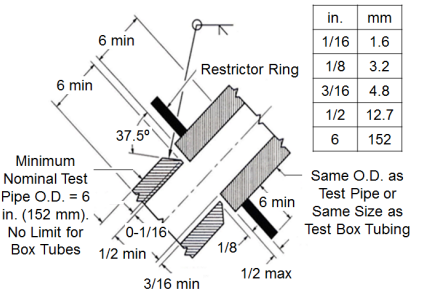
Offshore Welding and T-Y-K Connections:

Innershield NR-440Ni2 is primarily intended for use in offshore welding applications (i.e. offshore oil platforms). In particular, the electrode is used to weld on carbon and some low alloy steels, used in the fabrication of the mostly submerged support towers, called the "jacket", which supports the oil platform above the water. It is generally constructed from heavy wall pipe of various diameters, which come together in a series of T-Y-K tubular connections (aka "TKY" connections).

ADDITIONAL INSTRUCTIONS
Innershield NR-440Ni2

Welding Techniques:
6GR Joint Configuration
Welders typically practice and take a welder qualification test on a "6GR" pipe coupon, which best simulates the TKY connection welding conditions on an offshore jacket. A restrictor ring is tacked on one side of the joint to simulate the wall of the main tubular member. Note that the outside of the two pipes are flush with each other and that the pipe with the square edge has at least 1/4 in. (6 mm) larger wall thickness than the beveled pipe.

Innershield NR-440Ni2 tends to produce a convex, ropy weld when using a stringer bead (i.e. straight progression) technique. Therefore, some manipulation or weaving of the puddle is needed to help flatten out the weld face. Operationally, it is very similar to the Innershield NR-203 family of electrodes.



in.	mm
1/16	1.6
1/8	3.2
3/16	4.8
1/2	12.7
6	152

Root Pass:
- Use a vertical up progression.
- The root pass uses almost a straight progression with only a slight weave (i.e. a "U" motion, or forward or backward "J" motion). Focus the arc on the heavier wall, but frequently and quickly wash the puddle back over to the beveled side of the joint to bridge the root opening.
- Use a drag angle of 10°- 20°.
- CTWD can vary from 5/8 to 1-1/4 in. (16 to 32 mm). You have to constantly adjust CTWD on the root pass. Note that you can "heat up" or "cool down" the puddle by using a shorter or longer CTWD, which has the effect of increasing or decreasing the current level. This in turn has the effect of increasing or decreasing the degree of penetration.
- The electrode should be positioned on the leading half of the puddle, but not on the leading edge of puddle. If too high, it will blow through the gap, leading to puddle loss. If too low, lack of penetration and incomplete back bead occurs.
- Even with proper technique, there may be trapped slag in the toes of the root pass. With a power grinder, grind out the slag in the toes, as well as grind the face of the weld so that it is relatively flat. The first fill pass (aka the "hot" pass) will burn out some of the slag remaining in the joint. However, the majority of it must be first removed with a grinder.

ADDITIONAL INSTRUCTIONS
Innershield NR-440Ni2

Fill Passes:

» Use a vertical up progression.
» The fill passes are made with a straight side to side weave technique, staying on the upper half of the exposed puddle.
» There should be very little hesitation at the edges of the puddle for good wash-in and flat bead face. The weld metal tends to flow to the edges of joint and too much hesitation at edges will push metal to center, causing convex beads. However, too little of hesitation at the edges results in poor wash-in.
» Pass thicknesses should not exceed about 3/16 in. (5 mm).
» Maximum weave width is 3/4 in. (19 mm), after which layers should be split weaves with each bead 1/2 to 3/4 in. (13 – 19 mm) wide.
» To achieve the best CVN toughness values, weld beads should be as small as possible. Again, there will be a natural tendency by welders to do the opposite, because the wider and larger the weld beads, the better they look and the easier the slag is to remove. Be diligent in making sure that after just a few layers the fill passes are split and made as small as possible.
» In 6G position, weave parallel to the ground to produce uniform beads with good wash-in at edges.
» The last cap passes should bring the weld metal flush with the top of the joint. The joint should be completely filled in with weld metal, but avoid over welding the last cap passes.
» Even with proper technique, there will be trapped slag in the toes of the fill passes, particularly the initial ones deep in the groove. With a power grinder, grind out the slag in the toes, as well as grind the face of the weld so that it is relatively flat.
» As you come out of the joint with the fill passes and they become wider, the slag will be less likely to be trapped in the toes and will be easier to remove. Eventually, each fill pass can be thoroughly cleaned with just a power wire wheel.

Cap Passes:

» Grind the last fill passes so that there is a smooth, flat surface in the weld joint on which to weld the cap passes. Think of the cap passes as just a thin blanket laid over the top of the joint. Any bumps, voids, etc. from the last fill passes will show through in the cap passes (unless a clean, flat foundation is made first).
» Using a thin cutting wheel, grind a small line along the edge of one side of joint to provide a guide or path to follow when making the first cover pass. You can also use soap stone to make the guideline. You can then use the previous weld bead as your guide when making the next cover pass, or continue marking or grinding a small guideline next to each succeeding weld pass.
» Use a vertical down progression. Cap passes are typically welded vertical down to ensure a flat bead appearance and good wash in between beads and the pipe.
» Use a straight stringer to slight side to side weave technique, maintaining the weave width at less than 5/16 in. (8 mm) wide and weaving (oscillating) quickly across the weld face.

ADDITIONAL INSTRUCTIONS
Innershield NR-440Ni2

- Adjust travel speed to ensure that the slag line follows at an optimal distance behind the arc.
- Use a shorter CTWD for better arc stability.
- A slight drag angle of about 10° is used to provide enough arc force to maintain puddle control.
- Check the transition between cap passes and between outside cap passes and the pipe with a coin (e.g. U.S. quarter) and paper clip. Hold the coin on end on the ridge between passes. If you can fit the end of the paper clip through the gap, the ridge is too deep. Grind smooth and redo caps.

LINCOLN ELECTRIC WELDING SCHOOL

Need Welding Training?
The Lincoln Electric Company operates one of the oldest and most prestigious arc welding schools in the United States at its corporate headquarters in Cleveland, Ohio. Since 1917, Lincoln Electric's Bill West Memorial Welding School has instructed over 100,000 men and women in the various methods and techniques of safety and arc welding processes. The school is listed by the Ohio State Board of School and College Registration, certificate # 71-02-059T.

Lincoln Electric's Welding School offers a variety of classes, from a six week "Basic" course to an advanced fifteen week "Comprehensive" course, as well as several one week classes on specific welding processes, certification or customized programs. Classes run from 8:00 a.m. – 2:30 p.m. daily, five days per week and fifty weeks per year. Students spend about 20% of their time in the classroom and 80% in the booth learning to weld. Instructor to student ratio is kept small to provide plenty of individual help. A large supply of steel plate is provided so students spend all their time learning to weld, not cutting and preparing practice coupons. For more information, go to **www.lincolnelectric.com/en-us/education-center/welding-school/Pages/welding-school.aspx**

LINCOLN ELECTRIC WELDING SCHOOL

Flux-cored Welding Course
Take a one week class in flux-cored welding (also part of the 15 week Comprehensive program). The course is designed to instruct welders in welding safety and the Flux-Cored Arc Welding process for both the self-shielded (Innershield) and gas-shielded (UltraCore and Outershield) sub-processes. It involves approximately 30 hours of booth instruction, lecture and practice. Course content includes:

» Learn the fundamentals of the FCAW process.
» Weld on 10 gauge (3.5 mm) through 1 in. (25 mm) thick steel in all welding positions.
» Use a variety of electrodes, wire feeders and power sources.
» Practice on typical joint designs used in construction and shipbuildiong, making fillet and groove welds.
» Take a weld test at end of course.

One week courses are also offered to companies and/or individuals who want to practice flux-cored welding techniques for passing an operator qualification test(1) or procedure qualification test(1). This course also gives the proper application skills to an instructor for inplant training with Innershield and/or UltraCore electrodes.

On-site Training
The Lincoln Electric Welding School can also meet your needs for customized Innershield (and other processes) training at your particular location. Contact your local Lincoln Electric Technical Sales Representative or the school manager at 216-383-2259 for details.

(1) Actual testing done by an independent testing facility or at customer's location.

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