Lincoln® Guardian®

Hardbanding Application Manual

2023 Version 1.2

LINCOLN® ELECTRIC

Hardbanding Application Manual

Lincoln® Guardian® Products

TABLE OF CONTENTS

Lincoln® Guardian® Hardbanding Products

Industry Leading Casing Protecting and Tool Joint Wear Resistance

Lincoln Guardian CF - Industry's New Low Cost, Crack Free Hardband
Crack free performance and the ability to be applied over other hardbanding materials.

Key Characteristics
- Crack free performance
- Applicable over other hardband materials
- Industry leader for casing wear protection
- Exceptional tool joint wear resistance

Alternative to chrome carbide, tungsten carbide, steel and titanium alloys.

Versatile Performer
Lincoln Guardian CF is easily welded over other hardbanding materials.

	Lincoln Guardian CF	Armacor MStar	Arnco 100XT	Arnco 150XT	Duraband NC	Tuffband	TCS Titanium
Lincoln Guardian CF	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Product Specifications
Application Processes: Metal-Cored Arc Welding
Recommended Gas 98/2 Argon/Oxygen (75AR/25%CO2 or 100%CO2 can also be used)

PRODUCT NUMBER	Cored Wire Diameter	Wire Spool Packaging	Rockwell C Hardness
ED037920	1/16 in. (1.6 mm)	33 lb. (15 kg) plastic spool	57 HRc
ED037921		45 lb (20.4 kg) fiber spool	

Lincoln Guardian HB - The First Engineered Tool Joint Hardband
Proven on more than 1,000 miles of drill pipe, Lincoln Guardian HB remains a favorite high performance workhorse among oil companies, drilling contractors and hardbanding applicators.

Key Characteristics
- Very low casing wear
- Exceptional tool joint protection
- Proven performance on 1K-plus miles of drill pipe
- Superior spalling resistance

Alternative to chrome carbide, tungsten carbide, steel and titanium alloys.

Product Specifications
Application Processes: Metal-Cored Arc Welding
Recommended Gas 100%CO2

PRODUCT NUMBER	Cored Wire Diameter	Wire Spool Packaging Vacuum Foil Bag	Rockwell C Hardness
ED035667	1/16 in. (1.6 mm)	33 lb. (15 kg) plastic spool	57 - HRc

General Preparation Guidelines

Specifications and Information

Preheat

Proper preheating of the tool joint or drill collar must be performed regardless of the O.D. or ambient temperature of the steel. Inadequate preheating of the parent steel may cause undesirable cracking in the parent metal and/or weld metal.

Applicators shall refer to Section 3 of this manual for the specific preheat temperature ranges for the type of steel and outer diameter size of the parent metal and ensure that the pre- heat is a "soak" heat and not a surface heat.

Customers and applicators are advised that utilizing any method to cool internal plastic coating during hardbanding can cause embrittlement of the Heat Affected Zone (HAZ) below the weld and negatively affect the fusion bond of the hardband to the parent metal. Cooling the ID of pipe will not allow for proper preheat of the parent metal prior to hardbanding.

Slow Cooling

The Applicator must "slow-cool" the hardbanded tool joints. To ensure the required slow cooling, the tool joints need to be wrapped immediately in thermally insulated blankets or canisters. If shop ventilation fans are in use, airflow shall be directed away from the hardbanded tool joints during handling, wrapping and slow cool storage. The wrapping and subsequent slow cooling must take place in "still air". The blankets or canisters shall remain on the tool joint ends until the tool joint has cooled down to less than 150° F (66° C).

Any method utilized to cool tool joint ends to facilitate handling and inspection, after the Q&T process following friction weld, can negatively affect the hardband. Manufacturers that apply hardbanding should not use any method of cooling solely to handle or speed-up production. Adequate time must be allowed for the tool joint ends to slow cool naturally after the Q&T process.

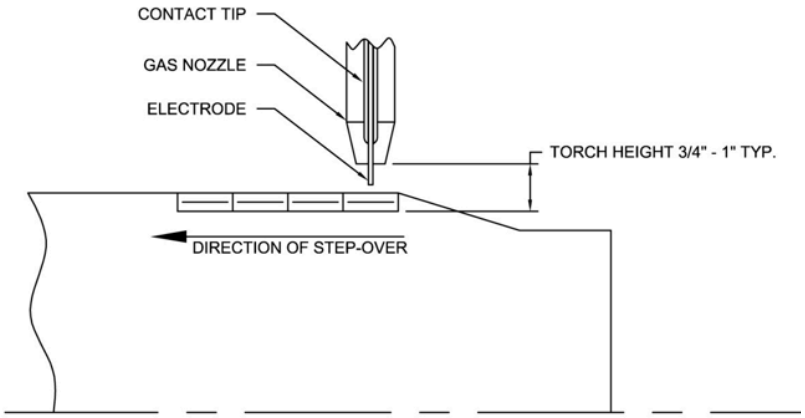
Grinding

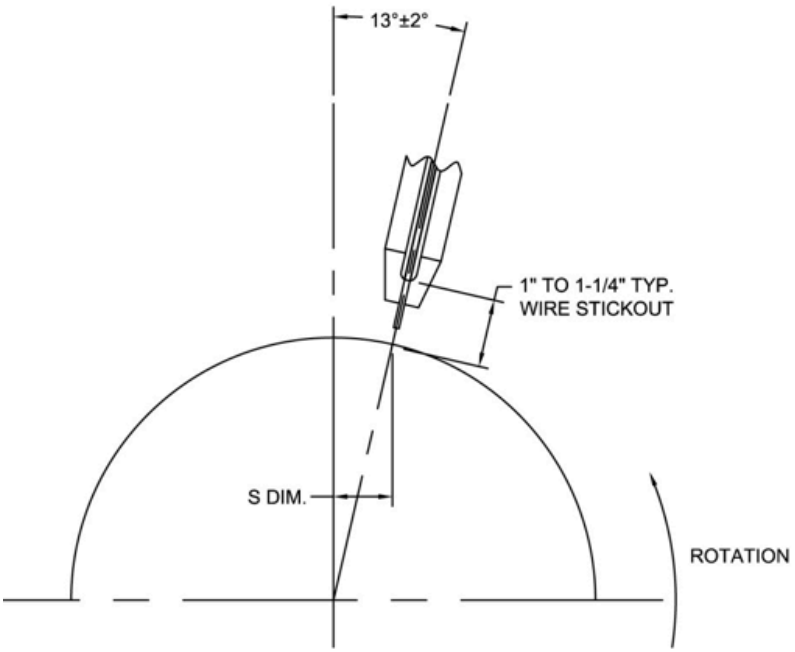
Repair grinding to contour overlap areas of the weld bead or to remove spatter or minor protrusions shall be performed as necessary after the tool joint has been cooled down to less than 150°F (66°C). Heavy, continuous grinding with stationary grinding wheels is not necessary and should not be performed.

General Preparation Guidelines

Lincoln® Guardian® CF Weld Parameters

Set-up for drill pipe





General Preparation Guidelines

Lincoln® Guardian® CF Weld Parameters

Tool Joint Tolerances

Outside diameter of joint	Seconds per rev. of joint	S dim.	Preheat (ºF)
2-7/8 - 4-1/8 in. **	55 - 90	1/2 - 3/4 in.	300 - 400
4-1/4 - 5-7/8 in.	85 - 125	1/2 - 7/8 in.	450 - 550
6 - 7 in.	100 - 150	5/8 - 1 in.	450 - 550
7-1/8 - 9 in.	125 - 165	3/4 - 1 in.	500 - 600

** To keep the interpass within tolerance on box tool joints with O.D. less than 4-1/4 in.:
1) Preheat towards the minimum temperature for the O.D
2) Increase voltage when welding the first band (amps will change as a result)
3) Return volts to normal for the remaining bands

Weld Parameters

Electrode	Lincoln Guardian CF
Gas-Shielded Application	98Ar/2O_2, or Ar/CO_2 blends. Can also be welded open arc (OAW).
Gas Flow	40 - 60 CFH
Open Arc Application (OAW)	No shielding gas, maintain 1 in. minimum contact tip to work distance (CTWD)
Machine Polarity	Reverse DC+
Weld Current	200 - 350 Amps
Weld Voltage	23 – 28 V for globular transfer 27 – 33 V for spray transfer, 98Ar/2O_2 shielding gas recommended
Torch Oscillation Rate	40 - 70 OSC / Min.
Torch Oscillation Width	5/8 - 1 in. (16-25 mm)
Beam Tilt for Elevation Band (for 18º groove)	17º (+/- 1º)
Bead Overlap	1/8 - 1/4 in. (3-6 mm)
Maximum Interpass Temperature	850º F (454º C)
Soak Heat	50º F (10º C) maximum temperature change in 4 min.
Wire Storage	On pallet in dry area

Post Weld
Wrap hardbanding area after removal from welding machine.
Let slow cool to 150º F or less. Verify temperature and then unwrap.

All settings are approximate start-up settings. Optimum settings may vary. Hardbanding tolerance is specified on product print.

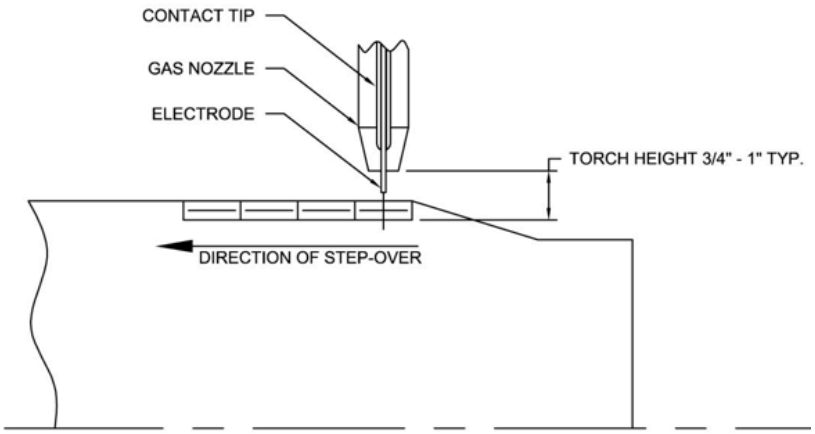
Weld Tolerances (unless otherwise specified)

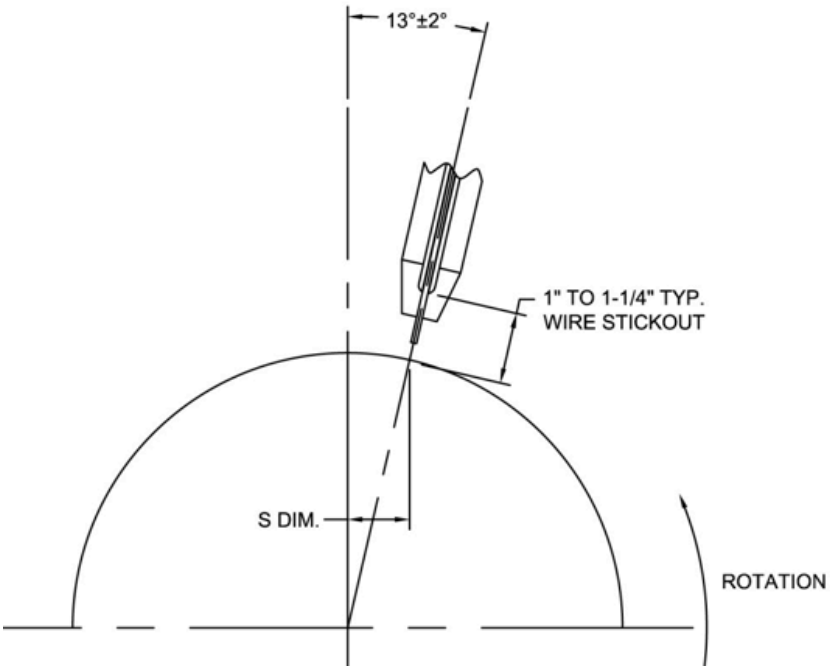
0.X	+/- 0.1
0.XX	+/- 0.03
0.XXX	+/- 0.010
	+/- 1/2 in.
Fractional	+/- 1/64 in.
Machined Surface Finish	500 maximum
Break all sharp edges	

General Preparation Guidelines

Lincoln® Guardian® HB Weld Parameters

Set-up for drill pipe





General Preparation Guidelines

Lincoln® Guardian® HB Weld Parameters

Tool Joint Tolerances

Outside diameter of joint	Seconds per rev. of joint	S dim.	Preheat (ºF)
2-7/8 - 4-1/8 in. **	55 - 90	1/2 - 3/4 in.	300 - 400
4-1/4 - 5-7/8 in.	85 - 125	1/2 - 7/8 in.	450 - 550
6 - 7 in.	100 - 150	5/8 - 1 in.	450 - 550
7-1/8 - 9 in.	125 - 165	3/4 - 1 in.	500 - 600

** To keep the interpass within tolerance on box tool joints with O.D. less than 4-1/4 in.:
1) Preheat towards the minimum temperature for the O.D
2) Increase voltage when welding the first band (amps will change as a result)
3) Return volts to normal for the remaining bands

Weld Parameters

Electrode	Lincoln Guardian HB
Gas Type	CO_2
Gas Flow	40 - 60 CFH
Machine Polarity	Reverse DC+
Weld Current	200 - 280 Amps
Weld Voltage	24 -30 Volts
Torch Oscillation Rate	40 - 70 OSC / Min.
Torch Oscillation Width	5/8 - 1 in.
Beam Tilt for Elevation Band (for 18º grove)	17º (+/- 1º)
Bead Overlap	1/8 - 1/4 in.
Maximum Interpass Temperature	850º F
Soak Heat	50º F maximum temperature change in 4 min.
Wire Storage	On pallet in dry area

Post Weld
Wrap hardbanding area after removal from welding machine.
Let slow cool to 150º F or less. Verify temperature and then unwrap.

All settings are approximate start-up settings. Optimum settings may vary. Hardbanding tolerance is specified on product print.

Weld Tolerances (unless otherwise specified)

0.X	+/- 0.1
0.XX	+/- 0.03
0.XXX	+/- 0.010
	+/- 1/2 in.
Fractional	+/- 1/64 in.
Machined Surface Finish	500 maximum
Break all sharp edges	

General Preparation Guidelines

Material Preparation Requirements

General Material Preparation Information

Preparation of the hardband area must be performed to minimize, if not eliminate, foreign matter becoming an impurity in the molten weld puddle and to ensure a good fusion bond with the parent metal. Preparation must be performed when applying hardbanding onto either new or used material.

Visually inspect the weld surface of all tool joints or hardband areas to ensure they are clean and free of all foreign matter such as rust, dirt, grease, oil, paint or pipe coating.

Utilizing a side-grinder and cup-brush will usually produce a sufficiently clean weld surface for hardbanding new tool joints. Perform a visual inspection of the tool joint O.D. surface after buffing. "Buffing" of the tool joint surface does not always produce a clean weld surface, consequently, further cleaning may be necessary. Applicators are to determine the best method available to prepare the weld surface.

The threaded connections should be cleaned of all thread lubricants or storage compounds. This will ensure a much cleaner welding process and eliminate the probability of the lubricant or compound igniting during Preheat.

Prior to application on used drill pipe which have not been hardbanded, the tool joints should be examined for eccentric wear caused by downhole drilling conditions. The concentricity of the tool joint should be within 0.030 in. (0.76 mm) of the center axis in order to apply an even layer of hardbanding. If the eccentricity of the tool joint is greater than 0.030 in. (0.76 mm) it may cause the welding arc to be erratic and/or produce an unacceptable weld bead of insufficient height over ~180° of the circumference of the hardband area.

Wire Usage Chart

Estimated material usage for Lincoln Guardian hardband wires.
NOTE: All estimates based on overlay thickness of 1/8 in.

	Pounds (lbs.) per Tool Joint Based on Width of Hardband (in.)				
Tool Joint Diameter (in.)	2.0	2.5	3.0	3.5	4.0
4-1/2	1.08	1.34	1.61	1.88	2.15
4-3/4	1.14	1.42	1.70	1.99	2.27
5	1.20	1.49	1.79	2.09	2.39
5-1/4	1.25	1.57	1.88	2.20	2.51
5-1/2	1.31	1.64	1.97	2.30	2.63
5-3/4	1.37	1.72	2.06	2.41	2.75
6	1.43	1.79	2.15	2.51	2.87
6-1/8	1.46	1.83	2.20	2.56	2.93
6-1/4	1.49	1.87	2.24	2.61	2.99
6-1/2	1.55	1.94	2.33	2.72	3.11
6-5/8	1.58	1.98	2.38	2.77	3.17
6-3/4	1.61	2.20	2.42	2.82	3.23
7	1.67	2.09	2.51	2.93	3.35
7-1/4	1.73	2.17	2.60	3.03	3.47
7-1/2	1.79	2.24	2.69	3.14	3.59
8	1.91	2.39	2.87	3.35	3.82
8-1/4	1.97	2.47	2.96	3.45	3.94
8-1/2	2.03	2.54	3.05	3.56	4.06

General Preparation Guidelines

Material Preparation Requirements

TEMPERATURE CONVERSION CHART

Fahrenheit (ºF)	Celsius (ºC)
900	482
875	468
850	454
825	441
800	427
775	413
750	399
725	385
700	371
675	357
650	343
625	329
600	316
575	302
550	288
525	274
500	260
475	246
450	232
425	218
400	204
375	191
350	177
325	163
300	149
275	135
250	121
225	107
200	93

Application Procedures

Acceptance Standard

Scope

This specification addresses the standards of acceptance for The Lincoln Electric's Company Lincoln Guardian CF and Lincoln Guardian HB hardbanding materials.

Procedure

The operator shall perform a visual and dimensional inspection on the applied hardband end product. Dimensional acceptance criteria shall be obtained from customer requirements.

The following areas of the hardband shall be examined to determine acceptance of the product.

- Inches of the hardband coverage
- Finished height
- Surface irregularities. Surface irregularities may be ground to remove high spots (such as spatter).
- Overlap between bands. Overlap may be ground to meet Figure 1 requirements. Small "depressions" between the welded bands are acceptable if they are not greater than 1/8 inch wide or 1/16 inch deep.
- Finished hardband product shall be uniform and display good workmanship.
- Bead geometry or appearance is controlled through proper overlap and oscillation width. The weld bead shall be adjusted to obtain an ideal flat hardband area. Other geometries, although not ideal, are acceptable but should be viewed as suspect thus closely scrutinized to ensure they meet customer requirements.

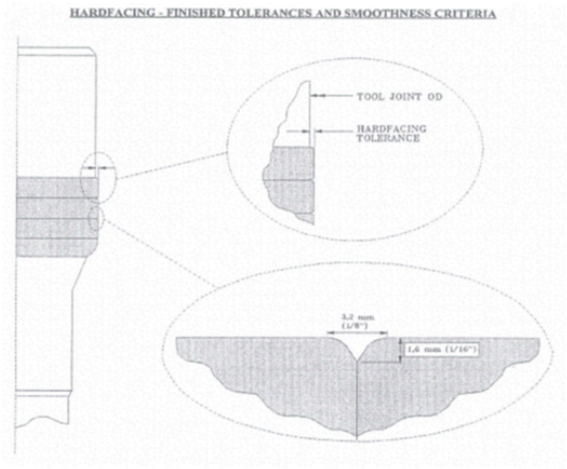
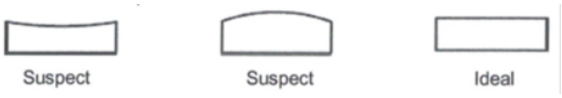
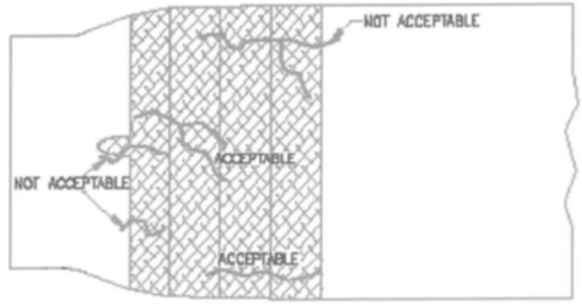


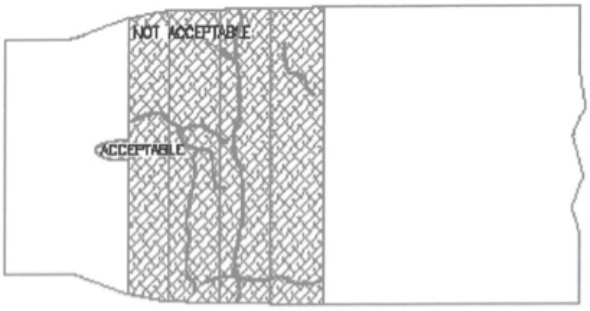
Figure 1

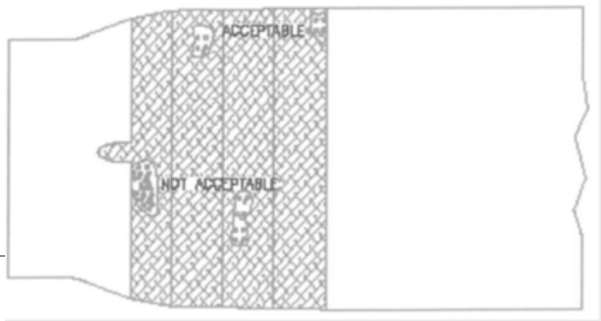


Acceptance/Rejection Criteria

- Visible cracks should be less than 0.050 inch wide, as determined using a feeler gauge. If any crack is greater than 0.050 inch wide, the part shall be rejected.
- If a crack extends from the hardband area into the base material, the part shall be rejected.
- If a circumferential crack extends 180° around the tool joint, even with interruption, the part shall be rejected.
- If there is porosity consisting of more than 5 pinholes in an area of approximately 1 inch diameter, any single pinhole of more than 1/8 inch diameter, or any single pinhole with a depth greater than 1/16 inch, the part shall be rejected. Depth of porosity will be measured from the surface of the hardband using a 1/16 inch diameter rod.







Application Procedures

Acceptance Standard

- Very fine crosscheck crack pattern – This may indicate thermal fatigue cracking or heat checking. This condition would result in the part being rejected. Spalling may start with a few small squares at a time. This very fine crosscheck crank pattern could be the result of localized heating induced by grinding.
- Transverse cracks that are parallel to each other – Multiple parallel cracks that are transverse to the weld bead and less than ¾ in. apart are rejectable. This geometry of cracking could result in flaking or spalling of the hardband. A single transverse crack that is less than 0.05 in. wide is acceptable.
- Handling Damage – Hardband that has taken a severe blow from handling damage shall be rejected. This is not necessarily implying a processing issue.
- Lack of Overlap – Parts that exhibit lack of tie-in at edge of the bead shall be rejected.

Product that is deemed rejectable shall be scrapped or reworked. Cracks that do not extend into the base metal which are rejectable shall require complete removal of hardband and reapplication.

Repair or patch of Lincoln Guardian hardbanding.

- No spot weld shall be allowed.
- No stringer beads shall be allowed (stringers beads are much narrower, usually applied at quicker rotational speed, which affects the dilution rate, affecting the weld characteristics such as tie-in to the bands already existing, hardness, which could affect the wear characteristics, as well, etc.).
- Repair weld is acceptable. The area to be repaired shall be ground to a minimum 1 in. square area to a sufficient depth to remove the non-conformance area. This allows the weld to be applied in the standard weave or oscillation pattern to provide proper tie-in and provide the more typical hardband properties for Lincoln Guardian hardband. The welding is performed as standard hardband per Preheat temperatures, volts, amps and shielding flow specified for the tool joint size to be welded. Repair welding is only applicable during the initial hardband welding application or re-application process.
- Immediately after welding, wrap the welded area plus 3 in. or more on both sides and allow to slow cool.

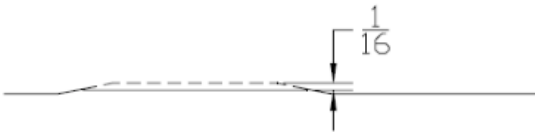
Application Procedures

Field Inspection Procedure and Machining Information for Used Lincoln Guardian Hardbanding

Scope

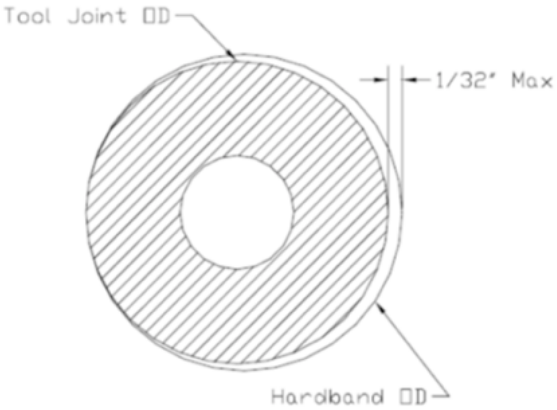
This procedure defines the equipment, inspection methods and acceptance criteria for field inspection of used Lincoln Guardian Hardbanding.

- This procedure shall encompass both dimensional and visual attributes.
- This procedure shall include procedures for removing Lincoln Guardian Hardbanding.



Tools

- Cleansing agent (detergent or solvent)
- Grinder with wire wheel
- Steel brush
- Two steel rulers. Each 12 inches long with 1/64 inch increments



Preparation

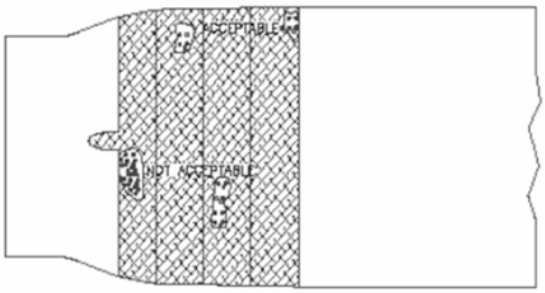
- Prior to inspection, the Lincoln Guardian hardbanding area shall be cleaned with detergent or solvent.
- Cleaning shall be sufficient to allow for visual examination.
- All foreign material shall be removed by cleaning and/or buffing with a wire wheel on a grinder and/or a wire brush.

Inspection

- Lincoln Guardian with less than 1/16 in. wear shall be dispositioned “Return to field as is”.
- Mnimum OD wear of Lincoln Guardian prior to reapplication is 1/16 in. See figure at right.
- Eccentric Lincoln Guardian wear relative to the OD shall not exceed 1/32 inch. This anomaly shall be dispositioned “Machine Lincoln to reduce eccentricity to less than 1/32 inch relative to the OD”. See drawing at right.

The following anomalies shall be cause for removal of Lincoln Guardian by machining or other approved methods.

- Visible cracks should be less than 0.050 inch wide, as determined using a feeler gauge. If any crack is greater than 0.050 inch wide, the part shall be rejected.
- If a crack extends from the hardband area into the base material, the part shall be rejected.
- If a circumferential crack extends 180° around the tool joint, even with interruption, the part shal be rejected.
- If there is porosity consisting of more than 5 pinholes in an area of approximately 1 inch diameter any single pinhole of more than 1/8 inch diameter, or any single pinhole with a depth greater than 1/16 inch, the part shall be rejected. Depth of porosity will be measured from the surface of the hardband using a 1/16 inch diameter rod.



Surfaces that have had Lincoln Guardian removed shall be inspected for cracks. Inspected material not displaying anomalies other than wear greater than 1/16 inch shall be dispositioned “re-hardband as is”.

Application Procedures

Field Inspection Procedure and Machining Information for Used Lincoln Guardian Hardbanding

Lincoln Guardian Removal

Remove Lincoln Guardian hardbanding by machining or grinding.

- It is required that a lathe or a lathe with an OD grinding attachment be used.
- It is recommended that a RNMN 42 CBN insert be used at 300 surface feet per minute with a feed rate of 0.006 inch to 0.010 inch.

If the customer requires an increased OD, the OD shall be turned down 3/32 in. per side (3/16 in. on diameter) prior to applying additional Guardian for an increased diameter. See drawing.

Lincoln Guardian with cracks greater than 0.050 inch wide and with blowholes, spalled material, etc.:

- Shall have all of the Lincoln Guardian hardbanding removed
- Shall have a 5% Nital (or similar product) etch inspection performed to ensure all Lincoln Guardian has been removed (Lincoln Guardian will resist discoloration.)
- Shall have a bidirectional magnetic particle inspection performed
- Cracks of any size shall be reason for rejection.
- Shall not exceed a maximum removal depth of 0.250 in. per side (0.500 in. on diameter)
- Tool joints with removal greater than 0.250 in. per side shall require the application of a butter pass before the application of Lincoln Guardian hardbanding.

⚠ WARNING

⚠ CALIFORNIA PROPOSITION 65 WARNINGS ⚠

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

The Above For Diesel Engines

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

The Above For Gasoline Engines

ARC WELDING CAN BE HAZARDOUS. PROTECT YOURSELF AND OTHERS FROM POSSIBLE SERIOUS INJURY OR DEATH. KEEP CHILDREN AWAY. PACEMAKER WEARERS SHOULD CONSULT WITH THEIR DOCTOR BEFORE OPERATING.

Read and understand the following safety highlights. For additional safety information, it is strongly recommended that you purchase a copy of "Safety in Welding & Cutting - ANSI Standard Z49.1" from the American Welding Society, P.O. Box 351040, Miami, Florida 33135 or CSA Standard W117.2-1974. A Free copy of "Arc Welding Safety" booklet E205 is available from the Lincoln Electric Company, 22801 St. Clair Avenue, Cleveland, Ohio 44117-1199.

BE SURE THAT ALL INSTALLATION, OPERATION, MAINTENANCE AND REPAIR PROCEDURES ARE PERFORMED ONLY BY QUALIFIED INDIVIDUALS.

FOR ENGINE powered equipment.

1.a. Turn the engine off before troubleshooting and maintenance work unless the maintenance work requires it to be running.

1.b. Operate engines in open, well-ventilated areas or vent the engine exhaust fumes outdoors.

1.c. Do not add the fuel near an open flame welding arc or when the engine is running. Stop the engine and allow it to cool before refueling to prevent spilled fuel from vaporizing on contact with hot engine parts and igniting. Do not spill fuel when filling tank. If fuel is spilled, wipe it up and do not start engine until fumes have been eliminated.

1.d. Keep all equipment safety guards, covers and devices in position and in good repair.Keep hands, hair, clothing and tools away from V-belts, gears, fans and all other moving parts when starting, operating or repairing equipment.

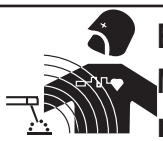
1.e. In some cases it may be necessary to remove safety guards to perform required maintenance. Remove guards only when necessary and replace them when the maintenance requiring their removal is complete. Always use the greatest care when working near moving parts.

1.f. Do not put your hands near the engine fan. Do not attempt to override the governor or idler by pushing on the throttle control rods while the engine is running.

1.g. To prevent accidentally starting gasoline engines while turning the engine or welding generator during maintenance work, disconnect the spark plug wires, distributor cap or magneto wire as appropriate.

1.h. To avoid scalding, do not remove the radiator pressure cap when the engine is hot.

ELECTRIC AND MAGNETIC FIELDS may be dangerous



2.a. Electric current flowing through any conductor causes localized Electric and Magnetic Fields (EMF). Welding current creates EMF fields around welding cables and welding machines

2.b. EMF fields may interfere with some pacemakers, and welders having a pacemaker should consult their physician before welding.

2.c. Exposure to EMF fields in welding may have other health effects which are now not known.

2.d. All welders should use the following procedures in order to minimize exposure to EMF fields from the welding circuit:

2.d.1. Route the electrode and work cables together - Secure them with tape when possible.

2.d.2. Never coil the electrode lead around your body.

2.d.3. Do not place your body between the electrode and work cables. If the electrode cable is on your right side, the work cable should also be on your right side.

2.d.4. Connect the work cable to the workpiece as close as possible to the area being welded.

2.d.5. Do not work next to welding power source.

Mar '95

LINCOLN ELECTRIC

ELECTRIC SHOCK can kill.

3.a. The electrode and work (or ground) circuits are electrically "hot" when the welder is on. Do not touch these "hot" parts with your bare skin or wet clothing. Wear dry, hole-free gloves to insulate hands.

3.b. Insulate yourself from work and ground using dry insulation. Make certain the insulation is large enough to cover your full area of physical contact with work and ground.

In addition to the normal safety precautions, if welding must be performed under electrically hazardous conditions (in damp locations or while wearing wet clothing; on metal structures such as floors, gratings or scaffolds; when in cramped positions such as sitting, kneeling or lying, if there is a high risk of unavoidable or accidental contact with the workpiece or ground) use the following equipment:

· Semiautomatic DC Constant Voltage (Wire) Welder.

· DC Manual (Stick) Welder.

· AC Welder with Reduced Voltage Control.

3.c. In semiautomatic or automatic wire welding, the electrode, electrode reel, welding head, nozzle or semiautomatic welding gun are also electrically "hot".

3.d. Always be sure the work cable makes a good electrical connection with the metal being welded. The connection should be as close as possible to the area being welded.

3.e. Ground the work or metal to be welded to a good electrical (earth) ground.

3.f. Maintain the electrode holder, work clamp, welding cable and welding machine in good, safe operating condition. Replace damaged insulation.

3.g. Never dip the electrode in water for cooling.

3.h. Never simultaneously touch electrically "hot" parts of electrode holders connected to two welders because voltage between the two can be the total of the open circuit voltage of both welders.

3.i. When working above floor level, use a safety belt to protect yourself from a fall should you get a shock.

3.j. Also see Items 6.c. and 8.

ARC RAYS can burn.

4.a. Use a shield with the proper filter and cover plates to protect your eyes from sparks and the rays of the arc when welding or observing open arc welding. Headshield and filter lens should conform to ANSI Z87. I standards.

4.b. Use suitable clothing made from durable flame-resistant material to protect your skin and that of your helpers from the arc rays.

4.c. Protect other nearby personnel with suitable, non-flammable screening and/or warn them not to watch the arc nor expose themselves to the arc rays or to hot spatter or metal.

FUMES AND GASES can be dangerous.

5.a. Welding may produce fumes and gases hazardous to health. Avoid breathing these fumes and gases. When welding, keep your head out of the fume. Use enough ventilation and/or exhaust at the arc to keep fumes and gases away from the breathing zone. **When welding with electrodes which require special ventilation such as stainless or hard facing (see instructions on container or MSDS) or on lead or cadmium plated steel and other metals or coatings which produce highly toxic fumes, keep exposure as low as possible and within applicable OSHA PEL and ACGIH TLV limits using local exhaust or mechanical ventilation. In confined spaces or in some circumstances, outdoors, a respirator may be required. Additional precautions are also required when welding on galvanized steel.**

5. b. The operation of welding fume control equipment is affected by various factors including proper use and positioning of the equipment, maintenance of the equipment and the specific welding procedure and application involved. Worker exposure level should be checked upon installation and periodically thereafter to be certain it is within applicable OSHA PEL and ACGIH TLV limits.

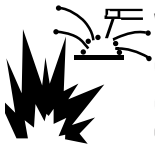
5.c. Do not weld in locations near chlorinated hydrocarbon vapors coming from degreasing, cleaning or spraying operations. The heat and rays of the arc can react with solvent vapors to form phosgene, a highly toxic gas, and other irritating products.

5.d. Shielding gases used for arc welding can displace air and cause injury or death. Always use enough ventilation, especially in confined areas, to insure breathing air is safe.

5.e. Read and understand the manufacturer's instructions for this equipment and the consumables to be used, including the material safety data sheet (MSDS) and follow your employer's safety practices. MSDS forms are available from your welding distributor or from the manufacturer.

5.f. Also see item 1.b.

Jan '09



WELDING and CUTTING SPARKS can cause fire or explosion.

6.a. Remove fire hazards from the welding area. If this is not possible, cover them to prevent the welding sparks from starting a fire. Remember that welding sparks and hot materials from welding can easily go through small cracks and openings to adjacent areas. Avoid welding near hydraulic lines. Have a fire extinguisher readily available.

6.b. Where compressed gases are to be used at the job site, special precautions should be used to prevent hazardous situations. Refer to "Safety in Welding and Cutting" (ANSI Standard Z49.1) and the operating information for the equipment being used.

6.c. When not welding, make certain no part of the electrode circuit is touching the work or ground. Accidental contact can cause overheating and create a fire hazard.

6.d. Do not heat, cut or weld tanks, drums or containers until the proper steps have been taken to insure that such procedures will not cause flammable or toxic vapors from substances inside. They can cause an explosion even though they have been "cleaned". For information, purchase "Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances", AWS F4.1 from the American Welding Society (see address above).

6.e. Vent hollow castings or containers before heating, cutting or welding. They may explode.

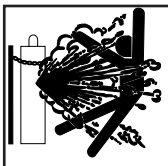
6.f. Sparks and spatter are thrown from the welding arc. Wear oil free protective garments such as leather gloves, heavy shirt, cuffless trousers, high shoes and a cap over your hair. Wear ear plugs when welding out of position or in confined places. Always wear safety glasses with side shields when in a welding area.

6.g. Connect the work cable to the work as close to the welding area as practical. Work cables connected to the building framework or other locations away from the welding area increase the possibility of the welding current passing through lifting chains, crane cables or other alternate circuits. This can create fire hazards or overheat lifting chains or cables until they fail.

6.h. Also see item 1.c.

6.I. Read and follow NFPA 51B " Standard for Fire Prevention During Welding, Cutting and Other Hot Work", available from NFPA, 1 Batterymarch Park, PO box 9101, Quincy, Ma 022690-9101.

6.j. Do not use a welding power source for pipe thawing.



CYLINDER may explode if damaged.

7.a. Use only compressed gas cylinders containing the correct shielding gas for the process used and properly operating regulators designed for the gas and pressure used. All hoses, fittings, etc. should be suitable for the application and maintained in good condition.

7.b. Always keep cylinders in an upright position securely chained to an undercarriage or fixed support.

7.c. Cylinders should be located:

- Away from areas where they may be struck or subjected to physical damage.
- A safe distance from arc welding or cutting operations and any other source of heat, sparks, or flame.

7.d. Never allow the electrode, electrode holder or any other electrically "hot" parts to touch a cylinder.

7.e. Keep your head and face away from the cylinder valve outlet when opening the cylinder valve.

7.f. Valve protection caps should always be in place and hand tight except when the cylinder is in use or connected for use.

7.g. Read and follow the instructions on compressed gas cylinders, associated equipment, and CGA publication P-I, "Precautions for Safe Handling of Compressed Gases in Cylinders," available from the Compressed Gas Association 1235 Jefferson Davis Highway, Arlington, VA 22202.

FOR ELECTRICALLY powered equipment.

8.a. Turn off input power using the disconnect switch at the fuse box before working on the equipment.

8.b. Install equipment in accordance with the U.S. National Electrical Code, all local codes and the manufacturer's recommendations.

8.c. Ground the equipment in accordance with the U.S. National Electrical Code and the manufacturer's recommendations.

Refer to **http://www.lincolnelectric.com/safety** for additional safety information.

LINCOLN ELECTRIC

PRÉCAUTIONS DE SÛRETÉ

Pour votre propre protection lire et observer toutes les instructions et les précautions de sûreté specifiques qui parraissent dans ce manuel aussi bien que les précautions de sûreté générales suivantes:

Sûreté Pour Soudage A L'Arc

1. Protegez-vous contre la secousse électrique:

   a. Les circuits à l'électrode et à la piéce sont sous tension quand la machine à souder est en marche. Eviter toujours tout contact entre les parties sous tension et la peau nue ou les vétements mouillés. Porter des gants secs et sans trous pour isoler les mains.
   b. Faire trés attention de bien s'isoler de la masse quand on soude dans des endroits humides, ou sur un plancher metallique ou des grilles metalliques, principalement dans les positions assis ou couché pour lesquelles une grande partie du corps peut être en contact avec la masse.
   c. Maintenir le porte-électrode, la pince de masse, le câble de soudage et la machine à souder en bon et sûr état defonctionnement.
   d. Ne jamais plonger le porte-électrode dans l'eau pour le refroidir.
   e. Ne jamais toucher simultanément les parties sous tension des porte-électrodes connectés à deux machines à souder parce que la tension entre les deux pinces peut être le total de la tension à vide des deux machines.
   f. Si on utilise la machine à souder comme une source de courant pour soudage semi-automatique, ces precautions pour le porte-électrode s'applicuent aussi au pistolet de soudage.

2. Dans le cas de travail au dessus du niveau du sol, se protéger contre les chutes dans le cas ou on recoit un choc. Ne jamais enrouler le câble-électrode autour de n'importe quelle partie du corps.

3. Un coup d'arc peut être plus sévère qu'un coup de soliel, donc:

   a. Utiliser un bon masque avec un verre filtrant approprié ainsi qu'un verre blanc afin de se protéger les yeux du rayonnement de l'arc et des projections quand on soude ou quand on regarde l'arc.
   b. Porter des vêtements convenables afin de protéger la peau de soudeur et des aides contre le rayonnement de l'arc.
   c. Protéger l'autre personnel travaillant à proximité au soudage à l'aide d'écrans appropriés et non-inflammables.

4. Des gouttes de laitier en fusion sont émises de l'arc de soudage. Se protéger avec des vêtements de protection libres de l'huile, tels que les gants en cuir, chemise épaisse, pantalons sans revers, et chaussures montantes.

5. Toujours porter des lunettes de sécurité dans la zone de soudage. Utiliser des lunettes avec écrans lateraux dans les zones où l'on pique le laitier.

6. Eloigner les matériaux inflammables ou les recouvrir afin de prévenir tout risque d'incendie dû aux étincelles.

7. Quand on ne soude pas, poser la pince à une endroit isolé de la masse. Un court-circuit accidental peut provoquer un échauffement et un risque d'incendie.

8. S'assurer que la masse est connectée le plus prés possible de la zone de travail qu'il est pratique de le faire. Si on place la masse sur la charpente de la construction ou d'autres endroits éloignés de la zone de travail, on augmente le risque de voir passer le courant de soudage par les chaines de levage, câbles de grue, ou autres circuits. Cela peut provoquer des risques d'incendie ou d'echauffement des chaines et des câbles jusqu'à ce qu'ils se rompent.

9. Assurer une ventilation suffisante dans la zone de soudage. Ceci est particuliérement important pour le soudage de tôles galvanisées plombées, ou cadmiées ou tout autre métal qui produit des fumeés toxiques.

10. Ne pas souder en présence de vapeurs de chlore provenant d'opérations de dégraissage, nettoyage ou pistolage. La chaleur ou les rayons de l'arc peuvent réagir avec les vapeurs du solvant pour produire du phosgéne (gas fortement toxique) ou autres produits irritants.

11. Pour obtenir de plus amples renseignements sur la sûreté, voir le code "Code for safety in welding and cutting" CSA Standard W 117.2-1974.

PRÉCAUTIONS DE SÛRETÉ POUR LES MACHINES À SOUDER À TRANSFORMATEUR ET À REDRESSEUR

1. Relier à la terre le chassis du poste conformement au code de l'électricité et aux recommendations du fabricant. Le dispositif de montage ou la piece à souder doit être branché à une bonne mise à la terre.

2. Autant que possible, l'installation et l'entretien du poste seront effectués par un électricien qualifié.

3. Avant de faires des travaux à l'interieur de poste, la debrancher à l'interrupteur à la boite de fusibles.

4. Garder tous les couvercles et dispositifs de sûreté à leur place.

Mar. '93

Appendix

Lincoln Guardian CF Equipment Set-up Worksheet

The Lincoln Electric Company
Certified Applicator Quality Program

Reviewed by: Bill Kiilunen
Approved by:

Operator_____ Welding Unit_____
_____

Date_____ Set-up Drawing Number _____ Revision _____

Type of Steel: AISI 4137 _____ AISI 4145 HT _____ AISI1340HT _____

Current Polarity shall be DCEP (reverse) Amperage _____ Volts _____

Shielding Gas - Flow Rate _____
_____

Torch Settings: Angle _____ Offset from TDC _____ Distance from Part _____

Oscillation: Width _____ Speed _____ Dwell _____

Rotation Speed: _____ Minutes/Seconds per revolution

Preheat Temperature Range _____ Actual
_____

Soak Heat at Four (4) Minutes _____
____

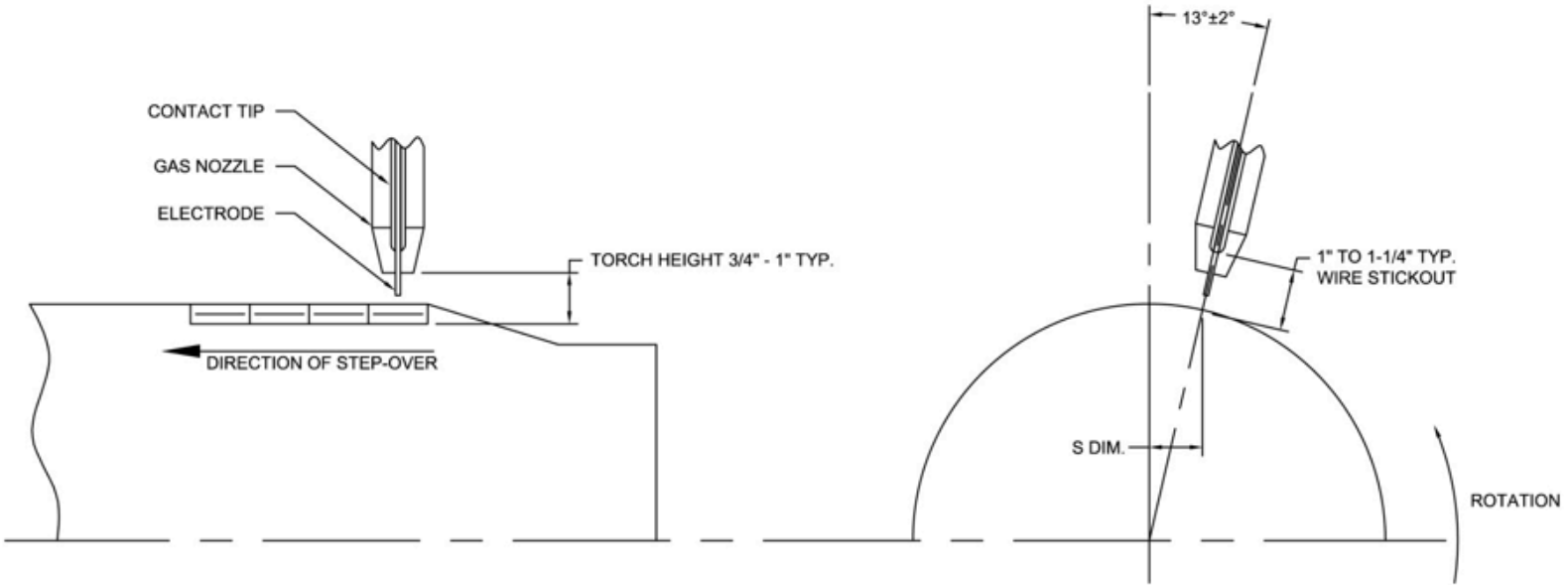
Interpass Temperature: Maximum Allowed 850°F Actual _____

Slow Cool with Wrap

Notes: _____
_____
_____
_____
_____
_____

Set-up Approved by: _____

DRILL PIPE GUARDIAN® CF



NOTES:

ELECTRODE TYPE: Lincoln GUARDIAN CF
GAS-SHIELDED APPLICATION: 98AR/20$_2$, OR AR/CO$_2$ BLENDS
GAS FLOW: 40 - 60 CFH
OPEN ARC APPLICATION (FCAW-S): NO SHIELDING GAS, MAINTAIN 1 IN. MINIMUM CONTACT TIP TO WORK DISTANCE (CTWD)
MACHINE POLARITY: REVERSE
WELD CURRENT: 200 - 350 AMPS
WELD VOLTAGE: 23 – 28 FOR GLOBULAR TRANSFER, 27 – 33 FOR SPRAY TRANSFER, 98AR/20$_2$ SHIELDING GAS RECOMMENDED FOR SPRAY TRANSFER
TORCH OSCILLATION RATE: 40 - 70 OSC / MIN.
TORCH OSCILLATION WIDTH: 5/8 - 1 IN. (16-25 MM)
BEAM TILT FOR ELEVATION BAND (FOR 18º GROVE): 17º (+/- 1º)
BEAD OVERLAP: 1/8 - 1/4 IN. (3-6 MM)
MAXIMUM INNERPASS TEMPERATURE: 850º F (454º C)
SOAK HEAT: 50º F (10º C) MAXIMUM TEMPERATURE CHANGE IN 4 MIN.
WIRE STORAGE: ON PALLET IN DRY AREA

POST WELD:

WRAP HARBAND AREA AFTER REMOVAL FROM WELDING MACHINE, LET SLOW COOL TO 150ºF OR LESS. VERIFY WITH TEMPILSTICK THEN UNWRAP.

NOTE:

ALL SETTINGS ON THIS DRAWING ARE APPROXIMATE START-UP SETTINGS AND OPTIMUM MAY VARY. HARDBAND TOLERANCE TO BE SPECIFIED ON PRODUCT PRINT

OUTSIDE DIA. OF JOINT	SECONDS PER REV. OF JOINT	S DIM.	PREHEAT (°F)
2 7/8 - 4 1/8**	55 - 90	1/2 - 3/4	300 - 400
4 1/4 - 5 7/8	85 - 125	1/2 - 7/8	450 - 550
6 - 7	100 - 150	5/8 - 1	450 - 550
7 1/8 - 9	125 - 165	3/4 - 1	500 - 600

** TO KEEP THE INNERPASS WITHIN TOLERANCE ON BOX TOOL JOINTS WITH O.D. LESS THAN 4 1/4": 1) PREHEAT TOWARDS THE MINIMUM TEMP. FOR THE O.D. 2) INCREASE VOLTAGE (AMPS WILL CHANGE AS A RESULT) WHEN WELDING THE FIRST BAND. 3) RETURN VOLTS TO NORMAL FOR THE REMAINING BANDS.

Assigned to:
By:
Date:

TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .1
.XX ± .03
.XX X ± .010
∠ ± 1/2"
FRACTIONAL ± 1/64"
BREAK ALL SHARP EDGES
MACHINED SURFACE FINNISH = 500 MAX.

THE LINCOLN ELECTRIC COMPANY

GUARDIAN® CF SET-UP PARAMETERS FOR WELD PIPE

Date: 03/04/2011 BY: JM

SCALE: NONE SHEET: 1 OF 1

The NanoSteel Company, Proprietary, and Confidential REV. A

Appendix

Lincoln Guardian HB Equipment Set-up Worksheet

The Lincoln Electric Company
Certified Applicator Quality Program

Reviewed by: Bill Kiilunen
Approved by:

Operator_____ Welding Unit_____
_____

Date_____ Set-up Drawing Number _____ Revision _____

Type of Steel: AISI 4137 _____ AISI 4145 HT _____ AISI1340HT _____

Current Polarity shall be DCEP (reverse) Amperage _____ Volts _____

Shielding Gas shall be 100% CO_2 - Flow Rate _____

Torch Settings: Angle _____ Offset from TDC _____ Distance from Part _____

Oscillation: Width _____ Speed _____ Dwell _____

Rotation Speed: _____ Minutes/Seconds per revolution

Preheat Temperature Range _____ Actual
_____

Soak Heat at Four (4) Minutes _____
____

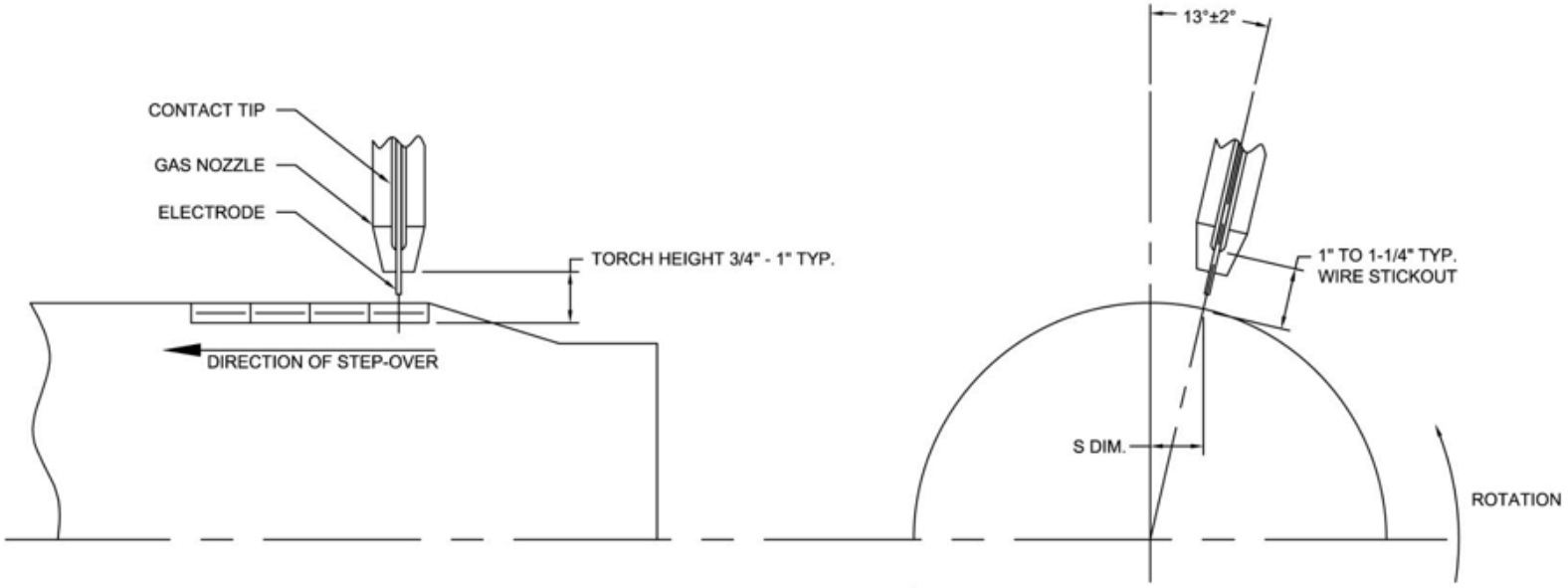
Interpass Temperature: Maximum Allowed 850°F Actual _____

Slow Cool with Wrap

Notes: _____
_____
_____
_____
_____
_____

Set-up Approved by: _____

DRILL PIPE GUARDIAN® HB



NOTES:

ELECTRODE TYPE: GUARDIAN HB
GAS TYPE: CO_2
GAS FLOW: 40 - 60 CFH
MACHINE POLARITY: REVERSE
WELD CURRENT: 200 - 280 AMPS
WELD VOLTAGE: 24 - 30 VOLTS
TORCH OSCILLATION RATE: 40 - 70 OSC / MIN.
TORCH OSCILLATION WIDTH: 5/8 IN. 1 IN. (16 MM 25 MM)
BEAM TILT FOR ELEVATION BAND (FOR 18º GROVE): 17º (+/- 1º)
BEAD OVERLAP: 1/8 - 1/4 IN. (3-6 MM)
MAXIMUM INNERPASS TEMPERATURE: 850º F (454º C)
SOAK HEAT: MAXIMUM TEMPERATURE CHANGE IN 4 MIN. 50°F
WIRE STORAGE: ON PALLET IN DRY AREA

POST WELD:

WRAP HARBAND AREA AFTER REMOVAL FROM WELDING MACHINE, LET SLOW COOL TO 150°F OR LESS. VERIFY WITH TEMPILSTICK THEN UNWRAP.

NOTE:

ALL SETTINGS ON THIS DRAWING ARE APPROXIMATE START-UP SETTINGS AND OPTIMUM MAY VARY. HARDBAND TOLERANCE TO BE SPECIFIED ON PRODUCT PRINT

OUTSIDE DIA. OF JOINT	SECONDS PER REV. OF JOINT	S DIM.	PREHEAT (°F)
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4 1/4 - 5 7/8	85 - 125	1/2 - 7/8	450 - 550
6 - 7	100 - 150	5/8 - 1	450 - 550
7 1/8 - 9	125 - 165	3/4 - 1	500 - 600

** TO KEEP THE INNERPASS WITHIN TOLERANCE ON BOX TOOL JOINTS WITH O.D. LESS THAN 4 1/4": 1) PREHEAT TOWARDS THE MINIMUM TEMP. FOR THE O.D. 2) INCREASE VOLTAGE (AMPS WILL CHANGE AS A RESULT) WHEN WELDING THE FIRST BAND. 3) RETURN VOLTS TO NORMAL FOR THE REMAINING BANDS.

Assigned to:

By:

Date:

TOLERANCES UNLESS OTHERWISE SPECIFIED
.X ± .1
.XX ± .03
.XX X ± .010
∠ ± 1/2"
FRACTIONAL ± 1/64"
BREAK ALL SHARP EDGES
MACHINED SURFACE FINNISH = 500/ MAX.

THE LINCOLN ELECTRIC COMPANY

GUARDIAN® HB SET-UP PARAMETERS FOR WELD PIPE

Date: 03/04/2011 BY: JM

SCALE: NONE | SHEET: 1 OF 1 | The NanoSteel®Company, Proprietary, and Confidential | REV. A

Safety Data Sheets (SDS) and Certificates of Conformance are available on our website at www.lincolnelectric.com

FUMES AND GASES can be hazardous to your health.

- Fumes from the normal use of this product contain significant quantities of potentially hazardous compounds. See consumable product label/insert.
- Keep your head out of the fumes.
- Use enough ventilation and local exhaust to keep fumes and gases from your breathing zone and the general area.
- An approved respirator should be used unless exposure assessments are below applicable exposure limits.

TEST RESULTS

Test results for mechanical properties, deposit or electrode composition and diffusible hydrogen levels were obtained from a weld produced and tested according to prescribed standards, and should not be assumed to be the expected results in a particular application or weldment. Actual results will vary depending on many factors, including, but not limited to, weld procedure, plate chemistry and temperature, weldment design and fabrication methods. Users are cautioned to confirm by qualification testing, or other appropriate means, the suitability of any welding consumable and procedure before use in the intended application.

MC15-60 | Issue Date 06/23

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