D1.8 Seismic Supplement Welding Manual

A General Overview of AWS D1.8 Structural Welding Code - Seismic Supplement

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AWS D1.8
Structural Welding Code
Seismic Supplement

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THE WELDING EXPERTS®

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Introduction

Lincoln Electric, the worldwide leader in welding equipment and consumables, is proud to present this manual to the American Welding Society's D1.8 Seismic Supplement.

Because welding is essential in the construction of the vast majority of buildings, innovative welding techniques are and will continue to be critical to safer, sounder structures in seismic zones.

The leader in seismic welding solutions is Lincoln Electric.

Our leadership comes from our history; for over 100 years Lincoln Electric has been at the forefront of welding technology. It comes from our people; Duane Miller, Lincoln's Manager of Engineering Services, chaired the D1.8 committee. And it comes from our products; we have consumables and welding solutions designed help you meet new and evolving requirements.

To assist structural fabricators, erectors, inspectors and specifying engineers, Lincoln Electric has created this *D1.8 Seismic Supplement Welding Manual* as an aid to understand seismic welding requirements and the Lincoln Electric consumables tested to meet the AWS D1.8 requirements.

This update to Lincoln Electric's *D1.8 Seismic Supplement Welding Manual* is just one more way Lincoln sets the standard for the welding industry. That is why, for the most reliable welds in seismic zones, the structural fabrication industry chooses Lincoln.

Note: Please refer to the Safety References Section on page 18 for more information on certificates, booklets and general safety practices.

Customer Assistance Policy

The Lincoln Electric Company sells welding consumables and related equipment. On occasion, purchasers may ask the Company for advice or information about the use of these products. As a customer accommodation, our employees respond without charge based on information provided and their knowledge of Lincoln Electric products. Lincoln Electric offers no guarantee or warranty, and assumes no liability, with respect to such information or advice; nor does it assume any responsibility for updating or correcting any such information or advice once it is given; nor does its provision of information or advice create, expand or alter any warranty with respect to the sale of the Company's products. Lincoln Electric expressly disclaims any warranty of any kind, including any warranty of fitness for any particular purpose, with respect to such information or advice. The selection and use of products sold by Lincoln Electric is solely within the control of, and remains the sole responsibility of, the customer.

Document Updates

The information contained in this document is believed to be accurate at the time of printing and is subject to change as additional information and data becomes available. Examples of such modifications include, but are not limited to, the incorporation of additional product data and alterations due to AWS D1.8 updates. The reader is encouraged to check the Lincoln Electric website for updates (www.lincolnelectric.com). This manual references other documents not published by Lincoln Electric. Those documents are also subject to change, and the reader is encouraged to check the latest edition of referenced documents for any changes that might affect the content of this manual.

This document is an update to Lincoln Electric's 2008 *D1.8 Seismic Supplement Welding Manual* and reflects changes made to the AWS D1.8 *Structural Welding Code - Seismic Supplement* in 2009.

Background

In January 1994, the Northridge, California earthquake caused unexpected damage to a number of welded steel-framed buildings in the greater Los Angeles area. The Federal Emergency Management Agency (FEMA) funded a variety of investigations that sought to address both the immediate and long-term needs related to solving the performance problems associated with welded steel moment-frame connections. Several documents were published as a result of these investigations, including *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications* (FEMA 353)[1].

FEMA 353 discusses what has come to be known as the "Pre-Northridge Connection" and concluded that "…the typical moment-resisting connection detail employed in steel moment-frame construction prior to the 1994 Northridge earthquake… had a number of features that rendered it inherently susceptible to brittle fracture. These included the following:

- The most severe stresses occurred in the connection
- "Wildcat" welding position
- Connection detail makes it hard to inspect
- Significant flexural stresses on the beam flange at the column face
- Weld access hole geometry
- High restraint
- Weak panel zones

The report continued on to say "…additional conditions contributed significantly to the vulnerability of connections..." including:

- Low toughness FCAW-S welding the consumables
- Low redundancy
- Matching beam and column strength

FEMA 353 then proposed a variety of recommendations and quality assurance guidelines that addressed various topics, including:

- Overall structural design
- Connection design
- Connection details
- Materials, including both base metal and weld metal
- Workmanship
- Inspection

The provisions within FEMA 353 were not binding but did become mandatory when incorporated into Contract Documents.

While the FEMA recommendations were being drafted, the American Institute of Steel Construction (AISC) and the American Welding Society (AWS) began to evaluate their specifications and codes and revise them to incorporate the post-Northridge research on steel connections. AISC issued a variety of interim updates to the Seismic Provisions, as well as complete new editions of the standard. Contained in these AISC documents are a variety of welding-related provisions. The primary focus of the AISC Seismic Provisions, however, is on the design of structures intended to resist seismically induced loads, including the design of the connections and thus, some welding-related provisions.

During this same time period, the AWS D1 Structural Welding Committee formed a new subcommittee D1L, charged with the responsibility of developing a new standard to address welding-related requirements for buildings designed to resist seismically induced loads. Ultimately, this subcommittee produced and the D1 committee approved, AWS D1.8 *Structural Welding Code-Seismic Supplement*[2].

Many of the changes made to the AISC and AWS standards were the direct result of the work sponsored by FEMA. Some of the provisions directly reflect the recommendations of FEMA 353. In other cases, the initial recommendations were modified by the AISC and AWS consensus committees. Finally, some FEMA 353 recommendations deemed to be unnecessary by the AISC or AWS committees were eliminated.

The FEMA-sponsored effort focused on moment-resisting connections, whereas the AISC and AWS documents addressed other Seismic Force Resisting Systems (SFRS), thus justifying some additional provisions that were not contained within FEMA 353. Therefore, these latest documents do more than simply incorporate FEMA 353 provisions directly into AISC or AWS specifications.

AWS D1.8 was approved in 2005 and first printed and distributed in 2006. In 2009 the AWS published the second edition of the AWS D1.8/D1.8M, *Structural Welding Code - Seismic Supplement*. Subsequent revisions have also been made to this document.

The Purpose and Use of This Manual

This manual has been prepared by The Lincoln Electric Company to assist our customers in complying with the requirements of AWS D1.8. Additionally, a summary of important provisions is included to assist engineers, steel detailers and inspectors. This manual does not address every provision of D1.8, and tends to discuss only the general condition that will typically be encountered, versus unique situations that may arise. Readers of this manual are encouraged to obtain and review a copy of AWS D1.8, which can be purchased through the AWS (www.awspubs.com).

Reference to AISC specifications is also made throughout this manual. Copies of pertinent AISC documents can be downloaded from the AISC website (www.AISC.org) for free, or can be purchased in printed form.

This manual does not in any respect act as a substitute for or in compliance with AWS D1.8 or AISC specifications. Should any conflict exist between the content of this manual and these referenced specifications, the documents as published by AISC or AWS should be taken as the authoritative reference.

To assist the user, applicable provisions as contained in D1.8:2009 are referenced at the end of paragraphs describing the requirements.

Specifications

AWS D1.8 and Other Specifications

AWS D1.8 alone cannot be used to design, fabricate, erect and inspect a structure intended to resist seismic loadings. Of necessity, D1.8 is used in conjunction with other construction documents, specifications and codes. Importantly, D1.8 does not contain all the welding-related requirements. The general interaction of D1.8 and welding-related provisions is outlined below.

AWS D1.8 and AISC Specifications

Three AISC specifications may apply to a project where seismic resistance is required: AISC 360 *Specifications for Structural Steel Buildings*[3], AISC 341 *Seismic Provisions for Structural Steel Buildings*[4], and AISC 358 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*[5]. These three documents will be referred to as AISC Specifications, AISC Seismic Provisions and AISC Prequalified Connections, respectively, throughout the remainder of this manual.

The relationship between AWS D1.8 and the AISC Specifications is no different than that between the AISC Specifications and AWS D1.1.

There is significant interaction between the AISC Seismic Provisions and D1.8. Typically, AISC Seismic Provisions specify where and when certain welding related provisions apply, while AWS D1.8 will specify how such provisions are implemented. For example, AWS D1.8 does not specify when steel backing must be removed from a connection. However, when backing removal is required by AISC specifications, AWS D1.8 specifies how the backing is to be removed.

The AISC's Prequalified Connections document prescribes prequalified structural connections (beam-to-column connections, for example, not to be confused with AWS prequalified welding procedure specifications, or with prequalified joint details). As part of connection prequalification, welding-related issues such as backing removal, weld tab removal, weld metal properties and inspection requirements are prescribed.

AWS D1.8 and Other AWS Standards

AWS D1.8 supplements AWS D1.1 *Structural Welding Code—Steel*[6]. D1.8 does not replace D1.1, and except as modified by D1.8, all of D1.1 still applies when D1.8 is specified. See D1.8, clause 1.1.

AWS D1.8 is intended to be used on steel structures, where D1.1 applies. D1.8 should not, for example, be used to supplement AWS D1.6 *Structural Welding Code—Stainless Steel*[7]. See D1.8, clause 1.3.

AWS D1.8 references the AWS A5 Filler Metal Specifications. Of particular interest is the reference to AWS A5.20: 2005[8] since this specification has incorporated a new supplemental electrode designator, the "-D" suffix. This suffix reflects a concept contained in both FEMA 353 and D1.8, that of high-low heat input testing, discussed later in this manual. It is expected that future editions of AWS A5.29 will include a similar supplemental designator.

AWS D1.8 and Contract Documents

Contract Documents are used to specify requirements that may modify provisions contained within codes. In the case of D1.8, Contract Documents play an especially important role, since many provisions typically required for buildings designed to resist seismic loading are not specified in D1.8. Rather, D1.8 requires that when such provisions are to apply, the Engineer must specify them in the Contract Documents. Thus, Contract Documents may be used to "customize" requirements around a specific project. The implication is that one project governed by D1.8 may have significantly different requirements from another, because the Contract Documents for the two projects are different.

AWS D1.8 and FEMA 353

D1.8 and FEMA 353 are totally separate documents, and it would be impossible to impose both provisions to govern a project without creating significant conflict and contradictions. However, qualifications and various tests done to meet the criteria of FEMA 353 may be used to meet similar or identical requirements in D1.8. Accordingly, such transfer of results is encouraged in D1.8, subject to the Engineer's approval. For example, the welder qualification test as prescribed in FEMA 353, Appendix B is similar to that specified in D1.8 Annex D, and the D1.8 commentary specifically encourages the Engineer to accept previous welder qualification testing done to FEMA 353 requirements.

Overview of D1.8

Content

FEMA 353 identified a variety of factors that made the pre-Northridge connection "…inherently susceptible to brittle fracture..." and then listed variables that can be grouped into the broad categories of overall structural design, connection design, connection details, materials, workmanship and inspection. While most of the design-related issues are covered in AISC standards, D1.8 addresses connection details, materials, workmanship and inspection issues.

These topics are covered in seven clauses as follows:

Clause 1	General Requirements
Clause 2	Reference Documents
Clause 3	Definitions
Clause 4	Welded Connection Details
Clause 5	Welder Qualification
Clause 6	Fabrication
Clause 7	Inspection

Following these clauses are eight mandatory annexes as follows:

Annex A	WPS Heat Input Envelope Testing of Filler Metals for Demand Critical Welds
Annex B	Intermix CVN Testing of Filler Metal Combinations (where one of the filler metals is FCAW-S)
Annex D	Supplemental Welder Qualification for Restricted Access Welding
Annex E	Supplemental Testing for Extended Exposure Limits for FCAW Filler Metals
Annex F	Supplemental Ultrasonic Technician Testing
Annex G	Supplemental Magnetic Particle Testing Procedures
Annex H	Flaw Sizing by Ultrasonic Testing
Annex I	Guidelines for the Preparation of Technical Inquiries for the Structural Welding Committee

Finally, the document concludes with an extensive commentary that provides background material and explains the Structural Welding Committee's intent behind many of the provisions, as well as an index.

New Terminology

In a manner that has been coordinated with the applicable AISC committees, D1.8 utilizes some new terminology. An understanding of these terms, officially defined in Clause 3: Terms and Definitions of D1.8, is necessary to properly apply the code.

The seismic load resisting system (SLRS) has been renamed as seismic force resisting system (SFRS) to be consistent with terminology as revised in AISC seismic provisions and is "the assembly of structural elements in the building that resists seismic loads." These are the specific components in a building, such as columns, beams, girders and braces, and the connections that join those components designed to resist seismic loads. The SFRS does not typically include all the various structural elements in a building. See D1.8, clause 3.1.

Demand Critical welds are defined as "welds designated by the Engineer in Contract Documents, and required to meet specific requirements of this code." The most rigorous requirements of D1.8 are imposed upon welds designated as "Demand Critical" (DC). See D1.8, clause 3.2.

The protected zone (PZ) is "that portion of a member of the SFRS… in which inelastic straining is anticipated to occur…." Special limitations apply to attachments and fabrication practices associated with this zone. See D1.8, clause 3.3.

It is important to note that D1.8 requires the Engineer to specify in contract documents the locations of members that are part of the SFRS, which welds are Demand Critical, and the portion of members that comprise the protected zone. Illustrative examples are contained in the commentary, although such examples are not prescriptive or definitive. Contract documents should contain the specific requirements applicable to a particular project. See D1.8, clause 1.2.1.

Three Kinds of Welds

When a structure is designed in accordance with the AISC Seismic Provisions, the welds on the building will fit into three categories. The applicable code depends on the characteristics of the weld, as illustrated in the following table:

TABLE 1: CODE COVERAGE FOR VARIOUS WELDS

	Not Part of SFRS	Part of SFRS	
		Not Demand Critical	Demand Critical
Code Coverage	AWS D1.1	AWS D1.8	AWS D1.8 DC

Welds that are not on the SFRS as designated by the Engineer in contract documents are governed by D1.1, and no special requirement for seismic considerations apply. Welds on the SFRS, but not designated Demand Critical by the Engineer in contract documents, are governed by D1.8, but the additional provisions for Demand Critical welds do not apply. Demand Critical welds (which, by definition, must be part of the SFRS), are subject to all the applicable requirements of D1.8, as well as those additional provisions that apply to Demand Critical welds. See D1.8, Commentary C-1.1.

Differences between FEMA 353 and AWS D1.8

As was previously mentioned, much of D1.8 was based upon recommendations contained within FEMA 353. However, differences between the two documents exist. In many cases, FEMA 353 recommendations are not contained in D1.8, but rather reside in the applicable AISC specification. In some situations, the AWS consensus committee made deliberate decisions to approach the issue in a different manner.

Contained below is a partial listing of some of the significant differences:

- The complicated and complex "weld categories" as contained in FEMA 353 have been replaced with the three broader and simpler categories as outlined previously in Table 1.
- Details of the WPS Heat Input Envelope Testing have been modified. In D1.8, the root pass can be made in a single pass (versus a split pass, as required in FEMA 353), and the position of welding is no longer an essential variable for this test. See D1.8, Annex A.
- The Supplemental Welder Qualification test was expanded to include a testing procedure to address welder qualification when steel backing is not used, including where copper or ceramic backing is used, as well as when open root joints are used. See D1.8, Annex D.
- Testing of the Supplemental Welder Qualification for Restricted Access Welding may be accomplished by either radiographic testing (RT), ultrasonic testing (UT) or by mechanical testing (FEMA 353 permitted only mechanical testing or RT). Additionally, the typographical error as contained in FEMA 353 that called for 3/4 in. bend tests has been corrected in D1.8 to call for the intended 3/8 in. thick bend specimens. See D1.8, Annex D.
- D1.8 contains more definitive alternatives to lot tested filler metals. See D1.8, clause 6.3.8.
- D1.8 specifically exempts the high/low heat envelope testing for the welding consumables when SMAW is used with specific filler metals, and when GMAW is performed with solid electrodes. See D1.8, clause 6.3.5.
- D1.8 has extended the standard exposure period for FCAW electrodes from 24 to 72 hours. See D1.8, clause 6.4.3.

A variety of other changes have been made, and a careful review of the two documents must be made if the user is interested in a comprehensive comparison.

Differences between AWS D1.8/D1.8M:2005 and AWS D1.8/D1.8M: 2009

The second edition of the AWS D1.8/D1.8M, *Structural Welding Code – Seismic Supplement* features editorial and technical revisions from the previous edition. These revisions are primarily refinements or clarifications of information presented in the 2005 edition.

Significant revisions in the second edition are listed below. For more revisions please see pages vii-viii in the AWS D1.8/D1.8M:2009.

- Figures 4.1 and 4.2 – New figures added to illustrate detail of the transition of butt joints for unequal thicknesses.
- Subclause 6.3.2 – Clarified and corrected diffusible hydrogen requirements for filler metals.
- Subclause 6.3.6 – Modified to disallow exemptions from heat input envelope and classification lot testing when lowest anticipated service temperature (LAST) is less than +50°F.
- Subclause CA5.2 – Removed the provision that required two passes per layer to fill the test plate. It is now deemed acceptable to use single passes per layer since achieving acceptable results under such conditions is typically more difficult than when split layers are used.
- Subclause C6.13 – Revised welder identifications requirements to permit methods other than the use of stamps or marks on the piece.

A User's Guide to AWS D1.8

Certain portions of D1.8 are more important to some parties than others, depending on their specific role in the construction process. The following is a general summary of sections of particular interest to the various participants in a construction project.

Engineers

The primary tasks of the Engineer as they relate to D1.8 are contained in Clause 1.2.1, entitled "Engineer's Responsibilities." The Engineer must identify, among other items, the following:

- Members that comprise the SFRS
- Locations of the Protected Zones in members of the SFRS
- Welds that are Demand Critical
- Locations where steel backing is required to be removed
- Locations where fillet welds are required when backing is permitted to remain
- Locations where weld tabs are to be removed
- Locations where fillet welds are required to reinforce groove weld, or to improve connection geometry
- Locations of weld access holes, and their required shape

The Engineer is also required to develop a Quality Assurance Plan (QAP) for the project. AISC Seismic Provisions Annex Q contains a recommended example of a QAP that the D1.8 commentary encourages the Engineer to adopt without modification. See D1.8, clause 1.2.1.

Structural Detailers

Table 2 provides a list of references to specific D1.8 code provisions of particular interest to the structural detailer:

TABLE 2: SPECIFIC D1.8 CODE PROVISIONS

Structural Detail	D1.8 Coverage
Access Holes	1.2.1(9), 6.9
Backing—Removal	1.2.1(5), 6.7, 6.8
Backing—Remaining in Place	1.2.1(6), 6.12
Contouring Fillet Welds	1.2.1(8), 6.8
Corner Clips	4.1
Demand Critical Welds	1.2.1(4), 3.2
End Dams	6.11
k-Area Detailing	3.6, 4.1
Protected Zone	1.2.1(3), 3.3, 6.6, 6.15
Reinforcing Fillet Welds	See Contouring Fillet Welds
Seismic Force Resisting System (SFRS)	1.2.1(2), 3.1
Tabs	1.2.1(7), 6.10
Tack Welds	6.6, 6.16
Tension Transition Butt Joints	1.2.1(11)

Fabricators and Erectors

Much of D1.8 is directed to the Contractor performing the welding. The various provisions directed toward the Contractor can be grouped into these major categories:

- Welder Qualification
- Welding Procedure Specifications (WPSs)
- Filler Metals
- Techniques

Welder Qualification

Clause 5 and Annex D of D1.8 are devoted to welder qualification. In addition to meeting the welder qualification requirements of D1.1, welders performing work under D1.8 are required to take the Supplemental Welder Qualification for Restricted Access Welding Test, as prescribed in Annex D, when the production weld involves all of the following:

a) the weld is Demand Critical; and

b) the weld joins the beam bottom flange to a column flange; and

c) the weld must be made through a weld access hole in the beam web.

As mentioned above, the qualification of welders in accordance with Annex D is only required when all three of these preceding conditions are part of the production weld. If any one is not present (i.e. a production weld that is not made through a weld access hole) this qualification is not required, even though such a weld may be Demand Critical. See D1.8, clause 5.1.1

The Annex D test was designed to simulate the restricted access conditions that are typically associated with welding a beam bottom flange to a column in a moment connection. However, unlike the production connection, the qualification test plate is a butt joint, permitting easier inspection and testing of the completed weld. See D1.8, Annex D Figure D.1, D.2 and D.3.

Two test configurations are described in Annex D, known as Option A and Option B. Option A is to be used when steel backing is specified on the WPS, while Option B is used for open root joints, or joints backed with ceramic, copper or other non-steel materials. The type of test to be taken is dependent on the type of backing (if any) that will be used in production, and as shown on the WPS. See D1.8, clause 5.1.3 and Annex D clause D3.2, D3.3.

While the test plate can be tacked together by anyone, the welder must affix the weld tabs to the test plate. Also, the welder is required to measure the preheat and interpass temperature of the test plate assembly. See D1.8, Annex D clause D3.1.1, D3.1.3.

As is the case for D1.1, welders taking the Annex D test must qualify by welding process. In addition, the test plate must be welded with a deposition rate equal to or higher than that which will be used in production. It is wise, therefore, to use a slightly higher deposition rate in the welder qualification test so that the welder will be qualified to use all production WPSs. See D1.8, Annex D clause D3.1.2

After the test plate is complete, the various restriction plates are removed and the test plate is visually inspected. Then, at the Contractor's option, the test plate is non-destructively (NDT) or mechanically tested. NDT options include ultrasonic inspection (UT) and radiographic inspection (RT). Four bend tests are used for mechanical testing. See D1.8, Annex D clause D4.

The Annex D test is similar in design, and identical in purpose, to a similar test prescribed in FEMA 353. Welders who have been qualified previously using "similar restricted access plate tests" before D1.8 was issued are not required to take the Annex D test, providing all the time continuity requirements are still met. See D1.8, Annex D clause D1.

The qualification of a welder who has taken the Annex D Supplemental Welder Qualification test is valid for 36 months, providing the D1.1 continuity requirements are also met (i.e., the process is used at least every six months). See D1.8, clause 5.2.

Welding Procedure Specifications (WPSs)

A welding procedure specification is "a document providing the required welding variables for a specific application to assure repeatability by properly trained welders and welding operators" according to AWS A3.0 *Standard Terms and Definitions*. AWS D1.1 requires WPSs to be documented (see D1.1 subclause 3.1, 4.6). Under D1.1, WPSs may be either prequalified or qualified by test, and both types of WPSs may be used under D1.8 as well.

In addition to meeting the requirements of D1.1, D1.8 mandates additional WPS requirements. Under D1.8, WPSs must list the filler metal manufacturer as well as the filler metal trade name (such as Lincoln Electric's Innershield® NR®-233) as opposed to showing only the AWS classification (in this case, E71T-8). D1.8 mandates a variety of other filler metal requirements that are addressed in the next section of this manual. See D1.8, clause 6.1(1).

WPSs must also list one or more combinations of welding variables that produce heat inputs within the limits of the tests performed on the specific filler metal (this will be discussed in greater detail under "Filler Metals"). Heat input is determined from the following equation:

$$\text{Heat Input (H)} = \frac{(60 \times E \times I)}{1000\ S}$$

Where: H = Heat input in KJ/in (KJ/mm)
E = Arc voltage in volts
I = Current in amps
S = Travel speed in inches per minute (mm per minute)

The values for E, I and S as shown on the WPS must result in a heat input within the high and low heat input limits for the specific electrode being used. See D1.8, clause 6.1(2).

The welding process shown on the WPS may be SMAW, GMAW (except for short circuit transfer), FCAW (either self-shielded or gas-shielded) or SAW. Other processes are permitted under specific conditions. See D1.8, clause 6.2.1.

The maximum interpass temperature to be shown on the WPS shall not exceed 300°C (550°F), unless an alternative temperature (either higher or lower) has been established by test. See D1.8, clause 6.5.

Filler Metals – General

Filler metals acceptable for use on D1.8 projects are subject to a variety of requirements beyond those imposed by D1.1. Some requirements apply to all welds governed by D1.8 while other provisions are mandated only for the Demand Critical (DC) welds. If the weld is not on or part of the seismic force resisting system, only D1.1 requirements apply. See D1.8, clause 6.3.

From a practical perspective, it is expected that most contractors doing D1.8 work will use the same filler metals for both Demand Critical welds and other welds that are part of the seismic force resisting system. The effort required to segregate the different filler metals for different joints, and the potential consequences of inadvertently using the wrong filler metal to make a Demand Critical weld, suggest that it is prudent to use the same materials (i.e., those qualified for Demand Critical welds) throughout a project.

Filler Metals – All D1.8 Welds

Certificates of conformance for Lincoln Electric's D1.8 products can be obtained at http://www.mylincolnelectric.com/LEExtranet/MyLincolnCerts/site/awsd.aspx. Charpy V-Notch (CVN) properties and diffusible hydrogen levels for each product are contained in these certificates.

For all work done under D1.8, filler metals are required to meet a minimum Charpy V-Notch requirement of 20 ft•lbf at 0°F, as measured in a standard AWS A5 filler metal classification test. Higher values for the CVN energy (i.e., >20 ft•lbf) are acceptable, as are test results involving lower testing temperatures (i.e., lower than 0°F). See D1.8, clause 6.3.1 and Table 6.1.

Most filler metals are required to be capable of depositing weld metal with a maximum diffusible hydrogen content of 16 mL per 100 grams of deposited weld metal, meeting the requirement for H16. Lower diffusible hydrogen levels are acceptable (for example, H8, H4, or H2). Exemptions from the requirement include SMAW electrodes with low hydrogen coatings which may be accepted based on meeting AWS A5.1 or A5.5 electrode specification for coating moisture content. Solid electrodes for GMAW and EGW are exempted from any hydrogen measurement. See D1.8, clause 6.3.2.

When FCAW-S filler metals are combined with filler metals deposited by other processes, the combination of the two must be checked to ensure that the minimum required Charpy V-Notch toughness can be obtained. Annex B of D1.8 prescribes the required tests. Such testing is not required when FCAW-S is intermixed with other FCAW-S. Alternatives to Annex B testing are also permitted by D1.8. See D1.8, clause 6.3.4 and Annex B. Annex B of this manual contains intermix data on Lincoln Electric products.

Filler Metals – Demand Critical Welds

In addition to meeting the requirements above, filler metals used for making Demand Critical welds are required to meet even more stringent requirements. Included are tests to evaluate the weld metal mechanical properties at high and low heat input levels, as well as a variety of means by which lot-to-lot consistency of filler metals is ensured.

The actual mechanical properties (tensile, elongation and CVN toughness) of deposited weld metal are dependent on a variety of factors, including the cooling rate experienced during the welding cycle. As cooling rates are increased, the yield and tensile strength of the weld deposit typically increases, but the elongation usually decreases. Conversely, slower cooling rates result in lower strength deposits with greater elongation. Charpy V-notch toughness values are typically optimal at an intermediate cooling rate, and significant changes in cooling rate (both increases and decreases) will often result in lower CVN values.

Cooling rates are a function of several variables, including heat input. High heat input levels result in slower cooling rates, whereas low heat input levels increase cooling rates.

D1.8 requires that the filler metals to be used in production first be evaluated in tests run at high and low levels of heat input, that is, under slow and fast cooling rates. Production welding WPSs are then permitted to use a wide range of variables, providing the calculated heat input levels are within the range of tested values. See D1.8, clause 6.3.5 and Annex A.

Testing at high and low heat inputs may be casually called “hi/lo” testing, or “envelope” testing.

The Seismic Welding Supplement provides two means by which the high and low heat input tests can be conducted. The first approach is detailed in Annex A of D1.8. Suggested heat input levels are provided, but alternative values may be used as well. The second approach applies to FCAW electrodes, and uses the new supplemental designator “-D” as defined in AWS A5.20:2005. Filler metals with this supplemental designator are required to be tested at a prescribed high and low heat input level, as well as tested according to the standard A5 classification test.

Filler metals for Demand Critical welds must meet the requirement of 20 ft•lbf at 0°F when tested in accordance with the applicable AWS A5 filler metal specification, as previously discussed. Filler metals for Demand Critical welds are additionally required to be tested at high and low heat input levels in accordance with D1.8 Annex A, and the welds are required to deliver a minimum CVN toughness value of 40 ft•lbf at 70°F, assuming the structure is subject to service temperatures of at least 50°F. If not, other requirements may apply. The strength and ductility requirements for the electrode classification per the standard A5 classification test must also be achieved on these high and low heat input tests. See D1.8, Table 6.2 and clause 6.3.6.

This testing can be performed by the filler metal manufacturer, the Contractor, or a third party acceptable to the Engineer. See D1.8, clause 6.3.7. Results on Lincoln Electric products are included in Appendix A of this manual.

E7018, E7018-X, E7018-C3L, and E8018-C3 are exempted from the hi/lo heat input testing, as are solid GMAW electrodes. See D1.8, clause 6.3.5.1 and 6.3.5.2.

Filler metals to be used in making Demand Critical welds must also comply with one or more of the methods offered by D1.8 to ensure lot-to-lot consistency. Three methods are provided. First, each lot of material can be tested. Secondly, manufacturers who are audited and approved by various third party agencies can supply untested product, providing at least three lots of material for each filler metal trade name and diameter have been tested, and such a test is repeated within every three years. Finally, SMAW electrodes of the classification E7018, E7018-X, E7018-C3L and E8018-C3, as well as solid GMAW electrodes, are exempt from lot testing, providing the certificate of conformance shows a minimum of 20 ft•lbf at 0°F.
See D1.8, clause 6.3.8.

For FCAW-G and FCAW-S electrodes used to make Demand Critical welds, exposure of the filler metal after it has been removed from protective packaging is required to be controlled. In the absence of test data indicating otherwise, exposure is limited to 72 hours. Tests can be performed in accordance with Annex E of D1.8, permitting this exposure time to be extended. Overexposed electrodes may be dried in accordance with the electrode manufacturer's recommendations. See D1.8, clause 6.4. Extended exposure information for Lincoln Electric products is shown on the documents contained in Appendix A of this manual.

Techniques

All tack welds made under D1.8 are required to be made with the preheat as listed in the WPS. Tack welding on members in the protected zone is restricted, generally being prohibited except when made in certain locations, such as within the joint. Specific provisions apply to the removal of improperly placed tack welds. See D1.8, clause 6.6 and 6.16.

Minimum lengths for weld tabs have been imposed by D1.8. Where practicable, weld tabs are to be at least the thickness of the part, but no less than 1 inch. However, they need not exceed 2 inches in length. Tack welds that attach weld tabs in the protected zone must be made within the joint. See D1.8, clause 6.10.

The sequence of depositing the half length weld beads associated with making Demand Critical welds in beam bottom flange-to-column flange welds, where the welds are made through a weld access hole, is detailed. Welds should not be started or stopped directly under the web, and each layer must be completed on both sides of the beam web before a new layer can be started. Finally, weld starts and stops are to be staggered, layer to layer, on opposite sides of the beam web. See D1.8, clause 6.14.

Contractors must establish and implement an identification system by which the welder welding on each joint can be identified. See D1.8, clause 6.13.

The protected zone is the region within the structural member in which plastic hinging is expected to occur during seismic events. In order to facilitate this inelastic deformation (instead of initiating fracture), the protected zone must be kept free of notches and gouges, as well as miscellaneous attachments that may impede the desired behavior of the member. With the exception of arc spot welds used to hold steel decking in place, unauthorized welds and attachments should not be made in the protected zone. This would include, but not be limited to, welded studs, erection aids, and attachments for non-structural members (such as sprinkler system supports). See D1.8, clause 6.15.

If unauthorized welds are inadvertently added to the protected zone, D1.8 provides techniques to be used when corrective measures are mandated. Magnetic particle inspection (MT) of these repaired regions is typically required. See D1.8, clause 6.15.

Inspectors

The Inspector's role with respect to D1.8 is no different than the role as defined by AWS D1.1, namely to ensure that materials and workmanship meet the requirements of the code and contract documents. This is done by performing inspection as necessary prior to assembly, during assembly, during welding, and after welding. All welds are subject to visual inspection, and depending on contract documents, nondestructive testing may also be required. For work done under the control of D1.8, details of required inspections will typically be specified in the Quality Assurance Plan (QAP).

The Inspector has neither the responsibility nor the authority to determine when and where D1.8 is to be applied. This task is assigned to the Engineer who is to identify such requirements in the contract documents.

Compliance with all applicable provisions of D1.1 and D1.8 is required when D1.8 is specified, and the Inspector should perform all the necessary inspections to ensure such compliance. D1.8 has brought about some new requirements, however, that justify specific attention on the part of the Inspector, as follows:

Regarding Welder Qualification

- Ensure that the welder has been qualified in accordance with the Annex D Supplemental Welder Qualification for Restricted Access Welding when such qualification is required. See D1.8, clause 5.1.1.
- Ensure that the weld backing type (steel, ceramic, copper, or none) is consistent with the type of backing for which the welder has been qualified. See D1.8, clause 5.1.3.
- Ensure that the production WPSs used by the welder are at a deposit rate at or below the value used for qualification of the welder when applicable. See D1.8, clause 5.1.2.

Regarding Filler Metals

- Ensure that the filler metals used for Demand Critical welds have been tested in accordance with the Annex A WPS Heat Input Envelope Testing, or carry the "-D" designator, or are exempt from such testing. See D1.8, clause 6.3.5.
- Ensure that the WPSs show combinations of welding variables that are within the range of permissible heat input values, when applicable. See D1.8, clause 6.1(2).

Regarding Production Welding

- Ensure that the values prescribed on the WPS are employed in production.
- Ensure that the required layering sequence for welding beam bottom flange to column flange connections is followed. See D1.8, clause 6.14.

Regarding Structural Details

- Ensure that weld access holes are properly prepared. See D1.8, clause 6.9.
- Ensure that weld tabs and backing have been removed, when required. See D1.8, clause 6.7, 6.10.

Regarding the Protected Zone

- Ensure that no unauthorized welds or attachments have been added. See D1.8, clause 6.15.
- Ensure that no unacceptable notches or gouges are in the protected zone. See D1.8, clause 6.15.
- Ensure that repairs in the protected zone are properly made and inspected, as necessary. See D1.8, clause 6.15.

References

1. Federal Emergency Management Agency, July 2000, *Recommended Specifications and Quality Assurance Guidelines for Steel Moment - Frame Construction for Seismic Applications (FEMA 353),* FEMA, Washington, D.C.
2. American Welding Society, 2005, *Structural Welding Code-Seismic Supplement (AWS D1.8/D1.8M:2009),* AWS, Miami, FL.
3. American Institute of Steel Construction, 2005, *Specifications for Structural Steel Buildings (AISC 360-05),* AISC, Chicago, IL.
4. American Institute of Steel Construction, 2005, *Seismic Provisions for Structural Steel Buildings (AISC 341-05),* AISC, Chicago, IL.
5. American Institute of Steel Construction, 2005, *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications (AISC 358-05),* AISC, Chicago, IL.
6. American Welding Society, 2010, *Structural Welding Code-Steel (AWS D1.1/D1.1M:2010),* AWS, Miami, FL.
7. American Welding Society, 1999, Structural Welding Code-Stainless Steel (AWS D1.6/D1.6M:1999), AWS, Miami, FL.
8. American Welding Society, 2005, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding (AWS A5.20/A5.20M:2005),* AWS, Miami, FL.

References

Consumable AWS Certificates:
http://www.lincolnelectric.com/products/certificates/

Safety References

Material Safety Data Sheets (MSDS):
http://www.lincolnelectric.com/product/msds/

ANSI Z49.1:
http://www.lincolnelectric.com/community/safety/

E205 Safety Booklet, and other Arc Welding Safety Materials:
http://www.lincolnelectric.com/community/safety/

Safe Practices Article:
http://www.lincolnelectric.com/knowledge/articles/content/lenstaybl.asp

Note

A FEMA 353 Welding Manual was prepared and is still available for download at http://content.lincolnelectric.com/pdfs/products/literature/c160.pdf. Also, FEMA 353 is available for download at http://www.fema.gov/plan/prevent/earthquake/pdf/fema-353.pdf.

Lincoln Electric Products

The Lincoln Electric Company offers a broad range of filler metals capable of meeting the requirements of AWS D1.8 Seismic Welding Supplement. Whether your choice of welding process is SMAW, FCAW-S, FCAW-G, GMAW, GMAW-C or SAW, Lincoln manufactures and offers consumables that will satisfy D1.8 requirements for nearly every application.

To save our customers time and money, Lincoln has already performed various tests required by AWS D1.8 on select on select Innershield®, Outershield®, UltraCore®, Metalshield®, and Lincolnweld® products. Additionally, select Excalibur® and SuperArc® products that meet all D1.8 requirements for Demand Critical welds are available.

As a benefit to customers, Lincoln Electric has added the following symbol to labels, literature and packaging of all D1.8 qualified electrodes:

For the most up-to-date information, please refer to electrode information listed at www.lincolnelectric.com.

Many factors must be considered when selecting the best electrode for a specific project. One of the most important factors is for the filler metal to meet the applicable specification requirements. Additionally, the filler metal and the procedures used with that filler metal must produce a weld which is suitable for the application. While AWS D1.8 does not require welding procedure qualification, it is nevertheless essential that the procedure used follow good welding practice in order to ensure sound welds with the requisite mechanical properties. Weld metal soundness and mechanical properties are dependent on many variables, including the base metal, preheat and interpass temperature, heat input, bead sizes and other factors. If there are uncertainties as to whether or not the combination of welding parameters to be employed on the project are appropriate, the customer is encouraged to perform suitable tests to ensure that quality weld will be achieved.

The three possible types of welds in D1.8 are:

- Welds that are not part of the SFRS
- Welds that are part of the SFRS but not Demand Critical
- Welds that are part of the SFRS and are Demand Critical

For welds in the first category, no special provisions beyond normal D1.1 requirements apply.

The requirements for Demand Critical welds are the most rigorous. Filler metals that meet D1.8 requirements for Demand Critical welds will automatically meet all the requirements for welds that are on the SFRS but not Demand Critical. For consistency and simplicity, Lincoln Electric suggests that filler metals that meet the requirements for Demand Critical be used on all welds made on the SFRS. This simple practice will eliminate the possibility of using an unacceptable product on a Demand Critical weld.

Lincoln Electric filler metals for D1.8 Demand Critical welds all meet the following requirements:

- AWS A5 yield, tensile, elongation and CVN requirements for classification
- AISC Seismic Provision requirements of 20 ft•lbf @ -20°F.
- D1.8 Annex A high/low heat input testing requirements (40 ft•lbf @ 70°F), or A5.20 optional "-D" designator requirements, or are exempted from high/low heat input testing.
- D1.8 diffusible hydrogen limits (applicable to FCAW-G, FCAW-S, GMAW, GMAW-C and SAW)
- For FCAW-G and FCAW-S, D1.8 extended exposure time of at least one week when tested in accordance with Annex E. Some products have been tested to time periods exceeding one week. See applicable exposure test results.
- For FCAW-G and FCAW-S, ProTech® foil bag protective packaging (D1.8 clause 6.4.1).
- For suggested FCAW-S, common intermix combinations (D1.8 Annex B).

Lincoln Electric additionally produces a variety of filler metals meeting D1.8 requirements where an 80 ksi tensile strength deposit is required. Contact your Lincoln Electric technical representative for additional information on these products.

Exposure Testing:

Lincoln Electric Approved Filler Metal per AWS D1.8/D1.8M:2009, Subclause 6.1.3

TABLE 3: HEAT INPUT LIMITS FOR DEMAND CRITICAL WELDS

Product Name	Diameters Available	High Heat Input inches avg.	Low Heat Input inches avg.	Exposure Time @ 80°F / 80% Relative Humidity
Filler Metal with 70 ksi Minimum Tensile Strength Requirement per AWS				
Excalibur® 7018 MR AWS E7018 H4R	3/32 1/8 5/32 3/16 7/32 1/4	No heat input testing required		
Excalibur® 7018-1 MR AWS E7018-1 H4R				
Innershield® NR-232 AWS E71T-8	0.068	74	29	1 Week
	0.072	73	31	
	5/64	76	32	
Innershield® NR-233 AWS E71T-8	1/16	74	33	8 Weeks
	0.072	67	31	
	5/64	86	32	1 Week
Innershield® NR-305 AWS E70T-6	3/32	64	37	1 Week
Innershield® NR-311 Ni AWS E70T7-K2	3/32	80	45	—
Outershield® 71 Elite AWS E71T-1C-H8, E71T-9C-H8	1/16	65	30	8 Weeks
UltraCore® 70C AWS E70T-1C-H8, E70T-9C-H8	1/16	79	32	8 Weeks
	3/32	80	38	
	5/64	80	32	
UltraCore® 71C AWS E71T-1C-H8, E71T-9C-H8	0.045	80	31	8 Weeks
	0.052	81	28	—
	1/16	82	28	8 Weeks
UltraCore® 71A85 AWS E71T-1M-H8, E71T-9M-H8	0.045	82	28	8 Weeks
	0.052	81	31	
	1/16	81	28	
Metalshield® MC-706 AWS E70C-6M-H4	0.045	62	34	72 Hours
	1/16	61	34	
SuperArc® L-50 AWS ER70S-3	0.030 0.035 0.045 0.052 1/16	No heat input testing required No heat input testing required		

TABLE 3: HEAT INPUT LIMITS FOR DEMAND CRITICAL WELDS (cont'd)

Product Name	Diameters Available (in)	High Heat Input mm(in.) avg.	Low Heat Input mm (in.) avg.	Exposure Time @ 80°F / 80% Relative Humidity
Filler Metal with 70 ksi Minimum Tensile Strength Requirement per AWS				
SuperArc® L-56 AWS ER70S-6	0.025 0.030 0.035 0.040 0.045 0.052 1/16	No heat input testing required		
SuperArc® L-59 AWS ER70S-6	0.035 0.040 0.045 0.052 1/16			
Lincolnweld® 960/L-61 AWS F7A2-EM12K	1/8	65	32	—
Filler Metal with 80 ksi Minimum Tensile Strength Requirement per AWS				
Excalibur® 8018-C3 AWS 8018-C3 MR	3/32 1/8 5/32 3/16 7/32 1/4	No heat input testing required		
UltraCore® 81Ni1A75-H AWS E81T1-Ni1M-H4	0.045	80	30	16 Weeks
	0.052	78	30	
	1/16	74	30	
UltraCore® 81Ni1C-H AWS E81T1-Ni1C-H4	0.045	74	31	16 Weeks
	0.052	80	30	
	1/16	78	29	
SuperArc® LA-75 AWS ER80S-Ni1	0.035 0.045	No heat input testing required		
SuperArc® LA-90 AWS ER80S-D2, ER90S-D2	0.035 0.045 0.052 1/16			
Pipeliner® 70S-G AWS ER70S-G	0.045			
Pipeliner® 80S-G AWS ER80S-G	0.045			
Pipeliner® 80Ni1 AWS ER80S-G	0.040 0.047			
Lincolnweld® 960/LA-85 AWS F8A2-ENi5-G	1/8	65	32	—

Appendices

The following appendices reference the required documentation required to support the use of suggested Lincoln Electric products for D1.8 Demand Critical applications. Check with your Lincoln Electric sales representative, authorized distributor or the Lincoln Electric website at www.lincolnelectric.com for more information.

Appendix A:	D1.8 Certifications
Appendix B:	Intermix Testing Results
Appendix C:	Lot Control Alternative Documentation

Appendix A: D1.8 Certifications

Additional Certificates Available Online

AWS D1.8 mandates a series of tests that must be performed before various filler metals can be used to make Demand Critical welds. While AWS D1.8 permits these tests to be performed by fabricators and erectors, it also allows for manufacturers like Lincoln Electric to conduct such tests. When three different lot test certificates comply, these approved filler metals fulfill the AWS D1.8 lot waiver requirements. Three certificates are available for the following Lincoln Electric electrodes and diameters online. A sample certificate for each qualified product is included on the following pages.

SMAW and GMAW Certificates of Conformance

SMAW electrodes of the classification E7018, E7018-X, E7018-C3L and E8018-C3, as well as solid GMAW electrodes, are exempt from lot and hi/low heat input testing, providing the Certificate of Conformance shows a minimum of 20 ft•lbf at 0°F. See D1.8, clause 6.3.8.

To view the Certificates of Conformance for AWS D1.8/D1.8M:2009 approved Lincoln SMAW and GMAW products visit the AWS and Lot Test Certs site at www.lincolnelectric.com.

Lincoln Electric D1.8 Approved Products - Certificates Available

TABLE 4: D.18 APPROVED PRODUCTS WITH CERTIFICATES AVAILABLE

Product Name	AWS Classification	Diameters Available (in.)
Self-Shielded, Flux-Cored Wire		
Innershield® NR-232	AWS E71T-8-H16	0.068, 0.072, 5/64
Innershield® NR-233	AWS E71T-8-H16	0.072, 1/16, 5/64
Innershield® NR-305	AWS E70T-6-H16	3/32
Innershield® NR-311 Ni	AWS E70T7-K2-H16	3/32
Gas-Shielded, Flux-Cored Wire		
UltraCore® 71A85	AWS E71T-1M-H8, E71T-9M-H8	0.045 , 0.052, 1/16
UltraCore® 71C	AWS E71T-1C-H8, E71T-9C-H8	0.045, 0.052, 1/16
Outershield® 71 Elite	AWS E71T-1C-H8, E71T-9C-H8	1/16
UltraCore® 70C	AWS E770T-1C-H8, E70T-9C-H8	1/16, 3/32, 5/64
UltraCore® 81Ni1A75-H	AWS E81T1-Ni1M-JH4	0.045, 0.052, 1/16
UltraCore® 81Ni1C-H	AWS E81T1-Ni1C-H4	0.045, 0.052, 1/16
Metal-Cored Wire		
Metalshield® MC-706	AWS E70C-6M-H4	0.045, 0.052, 1/16
Submerged Arc Flux and Electrode		
Lincolnweld® 960/Lincolnweld® L-56	—	3/32
Lincolnweld® 960/Lincolnweld® L-61	—	1/8
Lincolnweld® 960/Lincolnweld® LA-85	—	1/8

NOTE: Lincoln Electric is continuously adding D1.8 approved products. Please check our website for the most up-to-date information, www.lincolnelectric.com.

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

Product:	Innershield NR-232
Lot No.:	830S
Classification:	E71T-8-H16
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	August 24, 2007

This is to certify that the above listed product was manufactured under Lot control per AWS A5.01, Class T2, Schedule K, which will also meet Class T4 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of November 13, 2008.

Test Conditions	**AWS D1.8 Requirements**	**High Heat Input**	**Low Heat Input**
		Results	Results
Electrode Size (inch)		0.068	0.068
Wire Feed Speed **cm/min** (inch/min.)		**381** (150)	**330** (130)
Electrode Polarity		DC-	DC-
Current (amps)		235	210
Arc Voltage (volts)		20	21
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		7/5 (See Note)	24/7
Preheat Temp. **°C** (°F)		**135** (275)	**25** (75)
Interpass Temp. **°C** (°F)		**230** (450)	**120** (250)
Heat Input **kJ/mm** (kJ/in) avg.		**2.9** (74)	**1.1** (29)
Weld Position		3G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(70 min.)	**580** (85)	**620** (90)
Yield Strength 0.2% offset **MPa** (ksi)	(58 min.)	**440** (64)	**500** (72)
Elongation (%)	22 min.	32	28
Avg. Charpy V-notch Impact Properties		**91** (67)	**105** (78)
Joules @ 21°C (ft-lbf @ 70°F)	(40 min.)	**88,91,94** (65,67,69)	**102,104,110** (75,77,81)

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for one week at 80°F, 80% relative humidity.

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero. Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A Fink 23 Oct 2007

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date

Phillip J. Woodring Oct. 11, 2007

Phillip J. Woodring, Certification Supervisor, Date

Certificate No. 22320-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

Product:	Innershield NR-232
Lot No.:	830S
Classification:	E71T-8-H16
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	August 24, 2007

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed product was manufactured under Lot control per AWS A5.01, Class T2, Schedule K, which will also meet Class T4 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of November 13, 2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		0.068	0.068
Wire Feed Speed **cm/min** (inch/min.)		**381** (150)	**330** (130)
Electrode Polarity		DC-	DC-
Current (amps)		235	210
Arc Voltage (volts)		20	21
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		7/5 (See Note)	24/7
Preheat Temp. **°C** (°F)		**135** (275)	**25** (75)
Interpass Temp. **°C** (°F)		**230** (450)	**120** (250)
Heat Input **kJ/mm** (kJ/in) avg.		**2.9** (74)	**1.1** (29)
Weld Position		3G	1G

Mechanical Properties

Tensile Strength **MPa** (ksi)	(70 min.)	**580** (85)	**620** (90)
Yield Strength 0.2% offset **MPa** (ksi)	(58 min.)	**440** (64)	**500** (72)
Elongation (%)	22 min.	32	28
Avg. Charpy V-notch Impact Properties		**91** (67)	**105** (78)
Joules @ 21°C (ft-lbf @ 70°F)	(40 min.)	**88,91,94** (65,67,69)	**102,104,110** (75,77,81)

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for one week at 80°F, 80% relative humidity.

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero. Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A Fink 23 Oct 2007

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date

Phillip J. Woodring Oct. 11, 2007

Phillip J. Woodring, Certification Supervisor, Date

Certificate No. 22320-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

Product:	Innershield NR-305
Lot No.:	780K
Classification:	E70T-6-H16
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	February 17, 2006

This is to certify that the above listed product was manufactured under Lot control per AWS A5.01, Class T2, Schedule K, which will also meet Class T4 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of November 13, 2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		3/32	3/32
Wire Feed Speed **cm/min** (inch/min.)		**762** (300)	**457** (180)
Electrode Polarity		DC+	DC+
Current (amps)		500	370
Arc Voltage (volts)		29	24
Contact Tip to Work Distance **mm** (inch)		**44** (1 ¾)	**44** (1 ¾)
Passes / Layers		8/5(See Note below)	12/5
Preheat Temp. **°C** (°F)		**165** (325)	**20** (67)
Interpass Temp. **°C** (°F)		**260** (500)	**110** (225)
Heat Input **kJ/mm** (kJ/in) avg.		**2.5** (64)	**1.4** (37)
Weld Position		1G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(70 min.)	**560** (82)	**630** (91)
Yield Strength **MPa** (ksi)	(58 min.)	**450** (66)	**550** (79)
Elongation (%)	22% min.	24	24
Avg. Charpy V-notch Impact Properties		**67** (50)	**57** (42)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**66,66,69** (49,49,51)	**54,56,60** (40,41, 44)

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for one week at 80°F, 80% relative humidity

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero. Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink 24 Oct 2006
David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date

Phillip J. Woodring Oct. 24, 2006
Phillip J. Woodring, Certification Supervisor, Date

Certificate No. 23050-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

Product:	Innershield NR-311Ni
Lot No.:	810M
Classification:	E70T7-K2-H16 (also meets requirements of E80TG-K2)
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	December 11, 2006

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of November 13, 2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		3/32	3/32
Wire Feed Speed **cm/min** (inch/min.)		**381** (150)	**254** (100)
Electrode Polarity		DC-	DC-
Current (amps)		375	300
Arc Voltage (volts)		25	21
Contact Tip to Work Distance **mm** (inch)		**35** (1 3/8)	**35** (1 3/8)
Passes / Layers		7/4	15/6
Preheat Temp. **°C** (°F)		**135** (275)	**25** (73)
Interpass Temp. **°C** (°F)		**230** (450)	**120** (250)
Heat Input **kJ/mm** (kJ/in) avg.		**3.1** (80)	**1.8** (45)
Weld Position		1G	1G

Mechanical Properties

Tensile Strength **MPa** (ksi)	(70 min.)	**610** (89)	**620** (90)
Yield Strength 0.2% offset **MPa** (ksi)	(58 min.)	**500** (73)	**530** (77)
Elongation (%)	22 min.	27	27
Avg. Charpy V-notch Impact Properties		**133** (98)	**113** (84)
Joules @ 21°C (ft-lbf @ 70°F)	(40 min.)	**130,133,136** (96,98,100)	**103,115,122** (76,85,90)

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero.
Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 15 May 2007

Phillip J. Woodring, Certification Supervisor, Date — May 11, 2007

Certificate No. 23115-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

Product:	UltraCore 71A85
Lot No.:	11274141
Classification:	E71T-1M-H8, E71T-9M-H8
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	December 1, 2006

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of November 13, 2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		1/16	1/16
Wire Feed Speed **cm/min** (inch/min.)		**444** (175)	**318** (125)
Electrode Polarity		DC+	DC+
Current (amps)		220	185
Arc Voltage (volts)		24	22
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		7/5 (See Note below)	21/8
Preheat Temp. **°C** (°F)		**150** (300)	**20** (72)
Interpass Temp. **°C** (°F)		**260** (500)	**90** (200)
Shielding Gas (per AWS A5.32)		75% Ar/25% CO_2 (SG-AC-25)	75% Ar/25% CO_2 (SG-AC-25)
Heat Input **kJ/mm** (kJ/in) avg.		**3.2** (81)	**1.1** (28)
Weld Position		3G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(70 min.)	**550** (80)	**620** (90)
Yield Strength **MPa** (ksi)	(58 min.)	**480** (69)	**580** (84)
Elongation (%)	22% min.	28	27
Avg. Charpy V-notch Impact Properties		**155** (114)	**185** (136)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**148,154,163** (109,114,120)	**174,179,201** (128,132,148)

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for eight weeks at 80°F, 80% relative humidity.

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero.
Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink 04 Feb 2009
David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date

Phillip J. Woodring January 9, 2008
Phillip J. Woodring, Certification Supervisor, Date

Certificate No. 17350-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

Product:	UltraCore 71C
Lot No.:	11268261
Classification:	E71T-1C-H8, E71T-9C-H8
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	November 22, 2006

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of November 13, 2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		1/16	1/16
Electrode Polarity		DC+	DC+
Wire Feed Speed **cm/min** (inch/min.)		**444** (175)	**318** (125)
Current (amps)		220	175
Arc Voltage (volts)		24	22
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		7/5 (See Note below)	23/8
Preheat Temp. **°C** (°F)		**150** (300)	**20** (70)
Interpass Temp. **°C** (°F)		**260** (500)	**90** (200)
Shielding Gas (per AWS A5.32)		100% CO_2 (SG-C)	100% CO_2 (SG-C)
Heat Input **kJ/mm** (kJ/in) avg.		**3.2** (82)	**1.1** (28)
Weld Position		3G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(70 min.)	**530** (76)	**620** (89)
Yield Strength, 0.2% offset **MPa** (ksi)	(58 min.)	**450** (66)	**570** (82)
Elongation (%)	22% min.	31	24
Avg. Charpy V-notch Impact Properties		**176** (130)	**191** (141)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**172,175,182** (127,129,134)	**183,188,201** (135,139,148)

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for eight weeks at 80°F, 80% relative humidity.

Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering,
Consumable R&D Department, Date

Phillip J. Woodring,
Certification Supervisor, Date

Certificate No. 14131-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

Product:	Outershield 71 Elite
Lot No.:	11932541
Classification:	E71T-1C-H8, E71T-9C-H8
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	February 4, 2010

This is to certify that the above listed product was manufactured under Lot control per AWS A5.01, Class T2, Schedule K, which will also meet Class T4 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2008.

Test Conditions	**AWS D1.8 Requirements**	**High Heat Input**	**Low Heat Input**
		Results	Results
Electrode Size (inch)		1/16 inch	1/16 inch
Electrode Polarity		DC+	DC+
Wire Feed Speed **cm/min** (inch/min.)		**445** (175)	**318** (125)
Current (amps)		215	175
Arc Voltage (volts)		24	22
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		9/6	20/7
Preheat Temp. **°C** (°F)		**165** (325)	**25** (73)
Interpass Temp. **°C** (°F)		**260** (500)	**120** (250)
Shielding Gas (per AWS A5.32)		100% CO2	100% CO2
Heat Input **kJ/mm** (kJ/in) avg.		**2.6** (65)	**1.2** (30)
Weld Position		3G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(70 min.)	**510** (74)	**550** (80)
Yield Strength **MPa** (ksi)	(58 min.)	**440** (64)	**500** (72)
Elongation (%)	22 min.	29	29
Avg. Charpy V-notch Impact Properties		**190** (140)	**182** (134)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**183,186,201** (135,137,148)	**179,180,186** (132,133,137)

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for eight weeks at 80°F, 80% relative humidity.

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero.
Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 17 Feb 2010

James R. Fogle, Certification Supervisor, Date — February 16, 2010

Certificate No. 14130-D1.8-1/16

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

Product:	UltraCore® 70-C
Lot No.:	12014332
Classification:	E70T-1C-H8, E70T-9C-H8
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	January 27, 2010

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2008.

Test Conditions	**AWS D1.8 Requirements**	**High Heat Input**	**Low Heat Input**
		Results	Results
Electrode Size (inch)		1/16 inch	1/16 inch
Electrode Polarity		DC+	DC+
Wire Feed Speed **cm/min** (inch/min.)		**660** (260)	**660** (260)
Current (amps)		285	260
Arc Voltage (volts)		27	28
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers	(See Note Below)	5/8	17/6
Preheat Temp. **°C** (°F)		**150** (300)	**20** (69)
Interpass Temp. **°C** (°F)		**245** (475)	**95** (200)
Shielding Gas (per AWS A5.32)		100% CO2	100% CO2
Heat Input **kJ/mm** (kJ/in) avg.		**3.1** (79)	**1.3** (32)
Weld Position		1G	1G

Mechanical Properties

Tensile Strength **MPa** (ksi)	(70 min.)	**520** (76)	**610** (88)
Yield Strength, 0.2% offset **MPa** (ksi)	(58 min.)	**440** (63)	**570** (82)
Elongation (%)	22 min.	32	25
Avg. Charpy V-notch Impact Properties		**191** (141)	**81** (60)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**183,193,198** (135,142,146)	**77,80,85** (57,59,63)

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for eight weeks at 80°F, 80% relative humidity.

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only the root layer may consist of a single pass layer; both the root pass and second layer were single pass layers for this test.

Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 15 March 2010

James R. Fogle, Certification Supervisor, Date — March 13, 2010

Certificate No. 13160-D1.8-1/16 (12014332)

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

Product:	UltraCore® 81Ni1A75-H
Lot No.:	11787348
Classification:	E81T1-Ni1M-H4
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	May 27, 2009

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of October 25, 2011.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		0.045	0.045
Electrode Polarity		DC+	DC+
Wire Feed Speed **cm/min** (inch/min.)		**100** (256)	**177** (450)
Current (amps)		149	217
Arc Voltage (volts)		24	27
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		7/4	13/7
Preheat Temp. **°C** (°F)		**154** (310)	**11** (52)
Interpass Temp. **°C** (°F)		**254** (489)	**89** (193)
Shielding Gas (per AWS A5.32)		75% Ar/ 25% CO2	75% Ar/ 25% CO2
Heat Input **kJ/mm** (kJ/in) avg.		**3.2** (80.4)	**1.2** (30.1)
Weld Position		3G	1G

Mechanical Properties

Tensile Strength **MPa** (ksi)	(80 min.)	**570** (83)	**650** (94)
Yield Strength, 0.2% offset **MPa** (ksi)	(68 min.)	**480** (69)	**620** (90)
Elongation (%)	19% min.	32	25
Avg. Charpy V-notch Impact Properties		**208** (153)	**183** (135)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**212,199,213** (156,147,157)	**192,184,172** (142,136,127)

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for 16 weeks at 80°F, 80% relative humidity.

Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 25 July 2009

James R. Fogle, Certification Supervisor, Date — July 24 2009

Certificate No. 18220-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

Product:	UltraCore® 81Ni1C-H
Lot No.:	11753907
Classification:	E81T1-Ni1C-H4
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	May 27, 2009

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2000 by Certificate No. 30275 with an expiration date of October 25, 2011.

Test Conditions	**AWS D1.8 Requirements**	**High Heat Input**	**Low Heat Input**
		Results	Results
Electrode Size (inch)		0.045	0.045
Electrode Polarity		DC+	DC+
Wire Feed Speed **cm/min** (inch/min.)		**97** (246)	**174** (441)
Current (amps)		143	216
Arc Voltage (volts)		25	28
Contact Tip to Work Distance **mm** (inch)		**25** (1)	**25** (1)
Passes / Layers		7/4	14/7
Preheat Temp. **°C** (°F)		**155** (312)	**10** (46)
Interpass Temp. **°C** (°F)		**250** (483)	**75** (165)
Shielding Gas (per AWS A5.32)		100% CO2	100% CO2
Heat Input **kJ/mm** (kJ/in) avg.		**3.0** (80.7)	**1.2** (30.7)
Weld Position		3G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(80 min.)	**560** (82)	**650** (94)
Yield Strength, 0.2% offset **MPa** (ksi)	(68 min.)	**480** (70)	**620** (90)
Elongation (%)	19% min.	28	25
Avg. Charpy V-notch Impact Properties		**207** (153)	**174** (128)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**210,198,214** (155,146,158)	**170,174,179** (125,128,132)

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for 16 weeks at 80°F, 80% relative humidity.

Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.20-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.20-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 04 Aug 2009

James R. Fogle, Certification Supervisor, Date — July 25, 2009

Certificate No. 18222-D1.8

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

LINCOLN ELECTRIC

Product:	Metalshield® MC-706
Lot No.:	12019190
Classification:	E70C-6M-H4
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	May 17, 2010

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01 as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co. of Canada LP, Toronto, Ontario. The Quality System Program of The Lincoln Electric Co. of Canada LP has been approved by ABS and is certified to ISO 9001:2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		0.045 inch	0.045 inch
Electrode Polarity		DC+	DC+
Wire Feed Speed cm/min (inch/min.)		1143 (450)	953 (375)
Current (amps)		320	265
Arc Voltage (volts)		28	27
Contact Tip to Work Distance mm (inch)		22 (7/8)	22 (7/8)
Passes / Layers		9/6 (see NOTE)	15/7
Preheat Temp. °C (°F)		120 (250)	20 (70)
Interpass Temp. °C (°F)		230 (450)	120 (250)
Shielding Gas		10% CO2, 90% Ar	10% CO2, 90% Ar
Heat Input kJ/mm (kJ/in) avg		2.4 (62)	1.3 (34)
Weld Position		1G	1G

Mechanical Properties

Tensile Strength MPa (ksi)	(70 min.)	560 (81)	590 (86)
Yield Strength 0.2% offset MPa (ksi)	(58 min.)	470 (68)	530 (77)
Elongation (%)	22 min.	31	29
Avg. Charpy V-notch Impact Properties		111 (82)	128 (94)
Joules @ 21°C (ft-lbf @ 70°F)	(40 min.)	102,115,117 (75,85,86)	125,129,130 (92,95,96)

This product satisfies the requirements of AWS D1.8/D1.8M:2005, Annex D after exposure for 72 hours at 80°F, 80% relative humidity.

NOTE: Due to the heat input required, it was necessary to deviate from the requirement of clause A5.2 of AWS D1.8/D1.8M:2005 that only root layer may consist of a single pass layer; the root, second, and third layers were single pass layers for this test.

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero.
Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

The strength and elongation properties were obtained from **12.5 mm** (0.500 in), A4 tensile specimen artificially aged at **105 °C** (220 °F) for 48 hours, as permitted by AWS A5.18-2005. A naturally aged tensile specimen may take months to achieve the specified properties. See AWS A5.18-2005, paragraph A8.3. The time required for the natural aging of weld deposits is dependent upon ambient conditions, weldment geometry, the metallurgical structure of the weld deposit and other factors.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 01 June 2010

Richard J. Bollas, Certification Supervisor, Date — June 1, 2010

Certificate No. 17116-D1.8-045 (12019190)

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

Product:	Lincolnweld 960 / Lincolnweld L-61
Flux Lot No.:	12005700
Electrode Lot No.:	11997721
Classification:	F7A2-EM12K
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	December 9, 2009

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed flux was manufactured to meet the class F2 requirements of AWS A5.01 and the above listed electrode was manufactured to meet the class S4 requirements of AWS A5.01as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2008.

Test Conditions	AWS D1.8 Requirements	High Heat Input	Low Heat Input
		Results	Results
Electrode Size (inch)		1/8 inch	1/8 inch
Electrode Polarity		DC+	DC+
Arc Voltage (volts)		39	30
Wire Feed Speed **cm/min** (inch/min.)		**155** (61)	**130** (51)
Current (amps)		500	450
Contact Tip to Work Distance **mm** (inch)		**32** (1 1/4)	**25** (1)
Travel Speed **cm/min** (in/min)		**46** (18)	**64** (25)
Passes / Layers		15/7	23/11
Preheat Temp. **°C** (°F)		**120** (250)	**20** (70)
Interpass Temp. **°C** (°F)		**230** (450)	**105** (225)
Heat Input **kJ/mm** (kJ/in) avg.		**2.6** (65)	**1.3** (32)
Weld Position		1G	1G

Mechanical Properties

Tensile Strength **MPa** (ksi)	(70 min.)	**530** (77)	**560** (82)
Yield Strength, 0.2% offset **MPa** (ksi)	(58 min.)	**400** (58)	**470** (68)
Elongation (%)	22 min.	30	29
Avg. Charpy V-notch Impact Properties		**199** (147)	**129** (95)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**198,199,199** (146,147,147)	**126,129,132** (93,95,97)
Avg. Charpy V-notch Impact Properties		**147** (108)	**94** (69)
Joules @ -18°C (ft-lbf @ 0°F)	(40 min.)	**140,148,152** (103,109,112)	**88,88,106** (65,65,78)

Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 25 Jan. 2010

James R. Fogle, Certification Supervisor, Date — January 20, 2010

Certificate No. 56350-D1.8 (12005700-11997721)

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

Product:	Lincolnweld 960 / Lincolnweld LA-85
Flux Lot No.:	11938473
Electrode Lot No.:	735V
Classification:	F8A2-ENi5-G
Specification:	AWS D1.8/D1.8M:2005
Test Completed:	October 28, 2009

MEETS ALL REQUIREMENTS OF AWS D1.8:2009

This is to certify that the above listed flux was manufactured to meet the class F2 requirements of AWS A5.01 and the above listed electrode was manufactured to meet the class S4 requirements of AWS A5.01as required by clause 6.3.8.1 of AWS D1.8/D1.8M:2005.

The product stated herein was manufactured and supplied in accordance with the Quality System Program of The Lincoln Electric Co., Cleveland, Ohio, U.S.A. as outlined in our Quality Assurance Manual. The Quality System Program of The Lincoln Electric Co. has been accepted by ASME, ABS and approved by VdTUV, and is certified to ISO 9001:2008.

Test Conditions	**AWS D1.8 Requirements**	**High Heat Input**	**Low Heat Input**
		Results	Results
Electrode Size (inch)		1/8 inch	1/8 inch
Electrode Polarity		DC+	DC+
Arc Voltage (volts)		39	30
Wire Feed Speed **cm/min** (inch/min.)		**168** (66)	**140** (55)
Current (amps)		500	450
Contact Tip to Work Distance **mm** (inch)		**32** (1 1/4)	**25** (1)
Travel Speed **cm/min** (in/min)		**46** (18)	**64** (25)
Passes / Layers		12/6	21/10
Preheat Temp. **°C** (°F)		**120** (250)	**20** (66)
Interpass Temp. **°C** (°F)		**230** (450)	**105** (225)
Heat Input **kJ/mm** (kJ/in) avg.		**2.6** (65)	**1.3** (32)
Weld Position		1G	1G
Mechanical Properties			
Tensile Strength **MPa** (ksi)	(80 min.)	**610** (89)	**640** (94)
Yield Strength, 0.2% offset **MPa** (ksi)	(68 min.)	**480** (69)	**560** (81)
Elongation (%)	19 min.	26	21
Avg. Charpy V-notch Impact Properties		**118** (87)	**87** (64)
Joules @ 20 °C (ft-lbf @ 70°F)	(40 min.)	**114,119,121** (84,88,89)	**85,88,88** (63,65,65)
Avg. Charpy V-notch Impact Properties		**56** (41)	**74** (55)
Joules @ -18°C (ft-lbf @ 0°F)	(40 min.)	**54,57,57** (40,42,42)	**70,75,77** (52,55,57)

Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 30 Dec 2009

James R. Fogle, Certification Supervisor, Date — Dec 29, 2009

Certificate No. 56428-D1.8 (11938473-735V)

Appendix B: Intermix Testing

When FCAW-S is intermixed with welds made by processes other than FCAW-S, the intermixed zone must be tested in accordance with Annex B of AWS D1.8. This testing can be performed by the filler metal manufacturer, the customer, or by a third party. The results for intermixed weld metal tested by Lincoln Electric are listed as follows:

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

AWS D1.8/D1.8M:2005 Annex B Intermix CVN Testing
TEST RESULTS
(Applies only to U.S. products)

LINCOLN ELECTRIC

This is to state that the electrode combinations manufactured by The Lincoln Electric Co. listed below were welded and tested in accordance with AWS D1.8/D1.8M:2005, Annex B, with the following results:

Root / Substrate Electrode			Fill Electrode			CVN Toughness Test Temperature	
Electrode Diameter (inches) *	Trade Name	AWS Classification	Size (in.)	Trade Name	AWS Classification	Joules @ -18°C (ft-lbf @ 0°F)	Joules @ 20°C (ft-lbf @ 70°F)
1/16	Innershield® NR-233	E71T-8-H16	1/8	Excalibur® 7018-1 MR	E7018-1-H4R	AVG. **70** (52) **64,68,79** (47,50,58)	AVG. **160** (118) **157,159,163** (116,117,120)
0.068	Innershield® NR-232	E71T-8-H16	1/8	Excalibur® 7018-1 MR	E7018-1-H4R	AVG. **75** (55) **68,76,81** (50,56,60)	AVG. **140** (103) **136,142,142** (100,105,105)
3/32	Innershield® NR-311Ni	E70T7-K2-H16	1/8	Excalibur® 7018-1 MR	E7018-1-H4R	AVG. **136** (101) **130,137,142** (96,101,105)	AVG. **221** (163) **210,222,230** (155,164,170)
3/32	Innershield® NR-305	E70T-6-H16	1/8	Excalibur® 7018-1 MR	E7018-1-H4R	AVG. **83** (61) **68,88,94** (50,65,69)	AVG. **167** (123) **157,170,174** (116,125,128)
1/16	SuperArc® L-50 w/ 100%CO_2	ER70S-3	0.072	Innershield® NR-233	E71T-8-H16	AVG. **64** (47) **64,64,64** (47,47,47)	AVG. **94** (69) **92,94,95** (68,69,70)
1/16	SuperArc® L-50 w/ 100%CO_2	ER70S-3	1/16	Innershield® NR-233	E71T-8-H16	AVG. **48** (36) **47,49,49** (35,36,36)	AVG. **79** (58) **77,80,80** (57,59,59)
1/16	SuperArc® L-50 w/ 100%CO_2	ER70S-3	0.072	Innershield® NR-232	E71T-8-H16	AVG. **46** (34) **41,46,50** (30,34,37)	AVG. **100** (74) **94,102,104** (69,75,77)
1/16	SuperArc® L-50 w/ 100%CO_2	ER70S-3	0.068	Innershield® NR-232	E71T-8-H16	AVG. **52** (38) **47,54,54** (35,40,40)	AVG. **96** (71) **91,96,102** (67,71,75)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	1/16	Innershield® NR-233	E71T-8-H16	AVG. **43** (31) **41,41,46** (30,30,34)	AVG. **82** (61) **80,83,84** (59,61,62)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	0.068	Innershield® NR-232	E71T-8-H16	AVG. **57** (42) **54,58,58** (40,43,43)	AVG. **103** (76) **99,102,108** (73,75,80)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	3/32	Innershield® NR-305	E70T-6-H16	AVG. **42** (31) **41,41,43** (30,30,32)	AVG. **78** (58) **74,79,81** (55,58,60)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	3/32	Innershield® NR-311Ni	E70T7-K2-H16	AVG. **58** (43) **42,62,70** (31,46,52)	AVG. **125** (92) **119,122,134** (88,90,99)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	0.072	Innershield® NR-232	E71T-8-H16	AVG. **64** (47) **60,65,66** (44,48,49)	AVG. **110** (82) **104,108,119** (77,80,88)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	0.072	Innershield® NR-233	E71T-8-H16	AVG. **79** (58) **76,80,80** (56,59,59)	AVG. **108** (79) **102,110,111** (75,81,82)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	5/64	Innershield® NR-232	E71T-8-H16	AVG. **90** (66) **83,88,98** (61,65,72)	AVG. **118** (87) **117,118,119** (86,87,88)
1/8	Excalibur® 7018-1 MR	E7018-1-H4R	5/64	Innershield® NR-233	E71T-8-H16	AVG. **64** (47) **56,68,68** (41,50,50)	Not Required**
*Diameter is not an essential variable for the root / substrate electrode.				**Minimum Requirement**		**27 Joules** (20 ft-lbf)	**54 Joules** (40 ft-lbf)

** Per Clause C-B5 of AWS D1.8/D1.8M:2005, a single set of specimens shows conformance to both the 0°F and 70°F requirements if it demonstrates greater than 54J (40 ft.lbf) at -18°C (0°F).

The Lincoln Electric Co.
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

AWS D1.8/D1.8M:2005 Annex B Intermix CVN Testing
TEST RESULTS
(Applies only to U.S. products)

LINCOLN ELECTRIC

Root / Substrate Electrode			Fill Electrode			CVN Toughness Test Temperature	
Electrode Size (inches) *	Trade Name	AWS Classification	Size (in.)	Trade Name	AWS Classification	Joules @ -18°C (ft-lbf @ 0°F)	Joules @ 20°C (ft-lbf @ 70°F)
1/8	Lincolnweld L-61/ Lincolnweld 960	F7A2-EM12K-H8	5/64	Innershield® NR-233	E71T-8-H16	AVG. **71** (52) **68,69,74** (50,51,55)	AVG. **111** (82) **110,111,113** (81,82,83)
1/8	Lincolnweld L-61/ Lincolnweld 960	F7A2-EM12K-H8	5/64	Innershield® NR-232	E71T-8-H16	AVG. **74** (55) **70,76,76** (52,56,56)	AVG. **116** (86) **111,114,123** (82,84,91)
1/8	Lincolnweld L-56/ Lincolnweld 960	F7A2-EH11K-H8	5/64	Innershield® NR-233	E71T-8-H16	AVG. **65** (48) **64,65,66** (47,48,49)	AVG. **104** (77) **99,106,107** (73,78,79)
1/8	Lincolnweld L-56/ Lincolnweld 960	F7A2-EH11K-H8	5/64	Innershield® NR-232	E71T-8-H16	AVG. **77** (57) **72,77,83** (53,57,61)	AVG. **129** (95) **121,129,136** (89,95,100)
1/16	Metalshield MC-706	E70C-6M-H8	5/64	Innershield® NR-233	E71T-8-H16	AVG. **68** (50) **65,68,72** (48,50,53)	AVG. **103** (76) **100,104,104** (74,77,77)
1/16	Metalshield MC-706	E70C-6M-H8	5/64	Innershield® NR-232	E71T-8-H16	AVG. **81** (59) **79,80,83** (58,59,61)	AVG. **131** (96) **123,132,137** (91,97,101)
*Diameter is not an essential variable for the root / substrate electrode.				**Minimum Requirement**		**27 Joules** (20 ft-lbf)	**54 Joules** (40 ft-lbf)

This certificate complies to the requirements of EN 10204, Type 2.2.

David A. Fink, Manager, Compliance Engineering, Consumable R&D Department, Date — 12 May 2010

James R. Fogle, Certification Supervisor, Date — May 8, 2010

Appendix C: Alternative To Production Lot Testing

As an alternative to certification by test of every production lot made, D1.8 allows an alternative means for a manufacturer to demonstrate that products are manufactured consistently and capable of achieving the required weld metal mechanical properties. This includes certification of three lots for each product, as described in Appendix A, in addition to the certification of a manufacturer's production processes to recognized quality management standards.

ABS Quality Evaluations

CERTIFICATE OF CONFORMANCE

This is to certify that the Quality Management System of:

The Lincoln Electric Company
Consumable Division
22801 St. Clair Avenue
Cleveland , OH
U.S.A.

(WITH FACILITIES LISTED ON ATTACHED ANNEX)

has been assessed by ABS Quality Evaluations, Inc. and found to be in conformance with the requirements set forth by:

ISO 9001:2008

The Quality Management System is applicable to:

DESIGN AND MANUFACTURE OF FILLER METALS AND WELDING CONSUMABLES

Certificate No:	30275
Original Certification Date:	22 November 1993
Effective Date:	02 October 2009
Expiration Date:	25 October 2011
Issue Date	02 October 2009

Alex Weisselberg, President

Validity of this certificate is based on periodic audits of the management system defined by the above scope and is contingent upon prompt, written notification to ABS Quality Evaluations, Inc. of significant changes to the management system or components thereof.

ABS Quality Evaluations, Inc. 16855 Northchase Drive, Houston, TX 77060, U.S.A.
Validity of this certificate may be confirmed at www.abs-qe.com/cert_validation.

The American Society of Mechanical Engineers

Quality System Certificate

QUALITY SYSTEM CERTIFICATE

This certificate accredits the named company as having their quality system program verified for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The accreditation granted by this certificate is subject to the provisions of the agreement set forth in the application. Any material produced under this certificate will have been manufactured strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY:

The Lincoln Electric Company
Consumable Division
22801 St. Clair Avenue
Cleveland, Ohio 44117-1199

SCOPE:

Material organization manufacturing and supplying ferrous & nonferrous welding material including shipment of material from qualified material organizations to other parties, qualification of nonaccredited material organizations, utilization of unqualified source material and approval and control of suppliers at various locations accredited by ASME

AUTHORIZED: **April 11, 2008**

EXPIRES: **March 30, 2011**

CERTIFICATE NUMBER: **QSC-489**

Chairman of The Boiler
And Pressure Vessel Committee

Director, Accreditation and Certification

NOTES

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