

PIPELINE WELDING PROCEDURE SPECIFICATION

WPS NUMBER: ENB-MA-WPS-3 REV.0

AUGUST 11, 2014

REVISION LOG

REV. NO. 0:

SCOPE

This welding procedure specification details the procedure to be followed for **SMAW / Mechanized FCAW Up, section & tie-in field butt welding** of pipe as required by CSA Standard Z662, Oil and Gas Pipeline Systems. This procedure uses CRC Evans Welding Equipment and includes a provision for Mechanized Gas Shielded FCAW Up for fill and cap passes.

Normative References: This welding procedure specification was prepared in accordance to CSA Z662-11 and incorporates by undated references, provisions from other publications. Revision to this specification is not required unless subsequent referenced code and or specification additions include changes to essential welding variables.

Service Restrictions: Sweet

Temperature Restrictions: Notch Toughness Tested to -5°C (23°F)

1. WELDING PROCESS & METHOD

- 1.1. Shielded Metal Arc Welding (SMAW) - manual method- Root, Hotpass & Lincoln LHD First Fill.
- 1.2. Flux Core Arc Welding (FCAW) Remaining Fill(s) & Cap- mechanized method.

2. BASE MATERIAL

- 2.1. Composition: This specification applies to pipe and/or component material manufactured in accordance with, or listed as "Acceptable Alternative Materials" in any of the following standards:
 - CSA Z662, Oil and Gas Pipeline Systems
 - CAN/CSA-Z245.1, Steel Line Pipe
 - CAN/CSA-Z245.11, Steel Fittings
 - CAN/CSA-Z245.12, Steel Flanges
 - CAN/CSA-Z245.15, Steel Valves
- 2.2. Pipe Grades: 483 MPa (SMYS) or less
- 2.3. Wall Thickness Qualified: 4.0 to 14.25 mm (0.157 to 0.561 in.) inclusive.
- 2.4. Pipe Diameters Qualified: 457 mm (18 in.) O.D. minimum
- 2.5. Carbon Equivalent: 0.33% maximum

3. FILLER METAL CLASSIFICATION & SIZE

- 3.1. Root Pass: E6010; 3.2 to 4.8 mm (1/8 to 3/16 in.)
- 3.2. Hot Pass: E8010-G; 4.0 to 6.4 mm (5/32 to 1/4 in.)
- 3.3. Fill Pass 1: E8045-P2 H4R (Lincoln LH D80); 3.2 to 4.8mm (1/8 to 3/16 in.)
- 3.4. Remaining Fill Pass(s): E81T1-GM (Lincoln Pipeliner 81M) 1.2mm (0.047in.)
- 3.5. Cap pass: E81T1-GM (Lincoln Pipeliner 81M) 1.2mm (0.047in.)

4. JOINT GEOMETRY

- 4.1. Joint Type: Groove - Single Vee Butt
- 4.2. Bevel Angle: 30°, +6° / -1.5°
- 4.3. Root Face: 1.6mm (0.063 in.), +/- 0.8mm (0.031 in.)
- 4.4. Root Gap: 3.2mm (0.125 in.), +/- 1.6mm (0.063 in.)
- 4.5. The surfaces to be welded shall be smooth, uniform, free of fins, laminations, tears, scale, slag, grease, paint or other foreign matter, which may adversely affect the welding.

5. POSITION & DIRECTION OF WELDING

- 5.1. Position: Pipe horizontal, fixed position (5G)
- 5.2. Direction of Welding: Root, Hotpass & First Fill Pass: Vertical Down
Remaining Fill(s) and Cap Passes: Vertical Up

6. PREHEATING, INTERPASS TEMPERATURE & CONTROLLED COOLING

- 6.1. Butt Welds: A minimum preheat temperature of 120°C (250°F) shall be applied to an area at least 51 mm (2.0 in.) on each side of the weld joint for its entire circumference prior to welding.
- 6.2. During root and second pass welding, under no circumstances shall the minimum temperature fall below the minimum interpass temperature from the start of the root pass until after the completion of the second pass. Reheating is permitted before the start of the fill/cap passes.
- 6.3. If the interpass temperature falls below the minimum preheat temperature after completion of the second pass, the entire weld joint shall be heated to the minimum preheat temperature prior to starting the next weld pass.
- 6.4. The maximum interpass temperature shall not exceed 204°C (400°F).
- 6.5. Preheating may be applied by oxy-fuel torch, propane torch, electrical induction coils or any other method approved by the owner.
- 6.6. Temperature of the joint shall be verified using temperature indicating crayons, thermocouples, pyrometers or other suitable method.
- 6.7. Where applicable, precautions shall be taken through the use of insulating covers or other means to control the cooling rate of the weld after any pass.

7. POSTWELD HEAT TREATMENT

Welds prepared in accordance with this specification shall not be subjected to postweld heat treatment.

8. SHIELDING GAS

- 8.1. Root, Hotpass & Fill 1: N/A
- 8.2. Remaining Fill(s) & Cap Pass(es): 75/25 Argon/CO2 @ 23.6 to 28.3 LPM (50 to 60 CFH)

9. ELECTRICAL CHARACTERISTICS

- 9.1. Current Type: Direct current, reverse polarity (DCRP)
- 9.2. Voltage, amperage & travel speed: See Table #1
- 9.3. Heat Input: See Table #1

10. TECHNIQUE

- 10.1. Minimum number of welders: Two for all passes.
- 10.2. String or Weave:
 - Bead Root, Hotpass & Fill 1-String
 - Fill & Cap-Weave

ENB-MA-WPS-3

- 10.3. Number of Weld Layers: Five layers minimum.
- 10.4. Type of line-up clamp & removal: Internal line-up clamps shall be used wherever practicable and shall not be removed until the root bead is completed.
- 10.5. Movement shall be minimized until the required hot pass on the bottom has been completed as per table below.

Pipe Outside Diameter (OD)	Minimum Length of Second Pass
610 mm and Greater	250 mm
Less than 610 mm to 323.9 mm inclusive	150mm
Less than 323.9 mm	Not Required

- 10.6. When external line-up clamps are used, the root bead shall be uniformly spaced around the circumference of the joint and, where practicable, shall have a cumulative length of at least 50% of the circumference prior to removal.
- 10.7. Cleaning methods: Hand or power tools may be used. Each pass shall be thoroughly cleaned and free of slag and scale prior to depositing the next weld layer. The completed weld shall be brushed and free of spatter.
- 10.8. Finish Profile: The completed weld shall have a substantially uniform cross-section for its entire circumference. The crown of the weld shall not be below the surface of the adjacent base metal.
- 10.9. The time and interval requirements for each welding pass is as follows:

Interval	Time
Root pass to hot pass	10 minutes maximum
Hot pass to fill 1	60 minutes maximum
Fill 1 to completion	24 Hours maximum (Unless otherwise Authorized by Enbridge Assigned Designate)

11. REMOVAL AND REPAIR OF DEFECTS

- 11.1. Repairable areas are restricted to the weld cap and shall be removed by grinding. Welding of such repairable areas shall be performed following the details outlined in this specification.
- 11.2. Subsurface weld repairs shall be made in accordance with WPS# EPI-11-WP9 Rev.1.

12. ATTACHMENTS

- 12.1. Procedure Qualification Test Records: E2H-MA-11.4-1
- 12.2. Laboratory Test Reports: E14-413.1
- 12.3. Radiographic, Automated Ultrasonic & MPI Examination Results:
CRC Evans RT Report: 1071U (E2H-MA-11.4-1)
Applus RTD AUT Report: E2H-MA-11.4/15.9-WPQ
- 12.4. Material Test Reports: Evraz Heat No.514112

**TABLE #1
WELDING PARAMETERS**

Pass	Process	Electrode		Wire Speed mm/min (in./min)	Amperage Range Amperes	Voltage Range volts	Travel Speed mm/min (in./min)	OSC/ BPM	Heat Input kJ/mm (J/in.)
		Size mm (in.)	AWS Class						
Root	SMAW	4.0mm (5/32)	E6010	NA	104-191	17.9-32.5	215-349 (8.5 – 13.7)	NA	0.50-1.14 (12700-28956)
Hot Pass	SMAW	4.8mm (3/16)	E8010-G	NA	151-245	19.6-40	320-508 (12.6 -20)	NA	0.55 – 1.15 (13970-29210)
Fill-1	SMAW	4.0mm (5/32)	*E8045-P2 H4R	NA	166-275	14.9-28.6	197-300 (7.7-11.8)	NA	0.76 – 1.57 (19304-39878)
Fill(s) Mech.	Mech.- FCAW	1.2mm (0.047)	**E81T1-GM	5029-7645 (198-301)	142-264	18.1-28.5	120-280 (4.7-11.0)	As Req.	0.96 – 2.13 (24384-54102)
Cap(s) Mech.	Mech.- FCAW	1.2mm (0.047)	**E81T1-GM	4623-7010 (182-276)	129-240	18.2-28.6	102-210 (4.0-8.3)	As Req.	1.11-2.56 (28194-65024)

* - Lincoln LH-D80

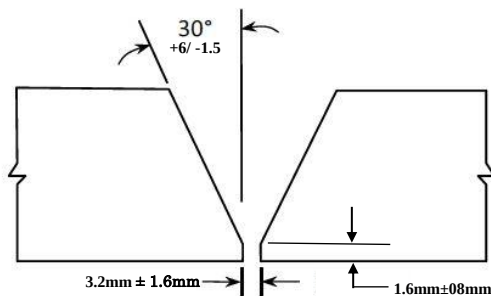
** - Lincoln Pipeliner 81M

Note #1 - The use of stripper passes is optional, however welding parameters must remain within the parameters of the above table.

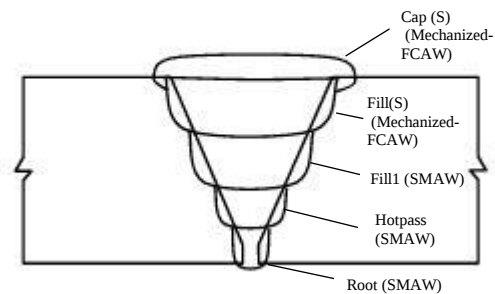
Note#2 - Maximum cap height above adjacent parent material: 2.5mm for W.T. ≤ 10.0mm.
3.5mm for W.T. >10.0 mm. (+1mm permitted in localized areas).

13. JOINT GEOMETRY

Schematic of Joint Design



Pass Sequence





TENSILE / BEND / NICK BREAK

Customer: Enbridge Pipelines Inc.
PO Box 398, 10201 Jasper Avenue
Edmonton, Alberta
T5J 2J9

Laboratory Test No.: E14-413.1
Date: July 16, 2014
P.O. No.: WP-41001-10135

Attention: Luke Ludwig

Weld I.D.: E2H-MA-11.4-1 (NI)
Project: Edmonton to Hardisty
Material: CSA Z245.1 Gr. 483
Size: 914.4 mm (36.0 in.) O.D. x 11.4 mm (0.449 in.) w.t.
Thermal Condition: As Welded

Governing Spec.: CSA Z662-2011

SAMPLE NO.	T1	T2
WIDTH mm (in.)	25.3 (0.996)	25.4 (1.00)
THICKNESS mm (in.)	11.5 (0.453)	11.5 (0.453)
AREA sq. mm (sq. in.)	291 (0.451)	292 (0.453)
ULTIMATE LOAD N (lbf)	183 504 (41,300)	185 260 (41,600)
ULTIMATE STRESS MPa (psi)	631 (91,500)	634 (92,000)
FRACTURE TYPE	Partial Cup & Cone	Partial Cup & Cone
FRACTURE LOCATION	Parent Metal	Parent Metal

Note: Imperial values calculated by direct conversion.

SAMPLE TYPE	Face Bend	Face Bend	Root Bend	Root Bend
SAMPLE NO.	F1	F2	R1	R2
RESULTS	Pass	Pass	Pass	Pass

NICK BREAK NO.	N1	N2
REMARKS	Pass	Pass

Test Conducted By: Tong Zhao, T.T.

Certified By: 

Karen Koens, R.E.T.

This report (or certificate) is issued by the Company under its General Conditions for Inspection and Testing Services (copy available upon request). The issuance of this report (or certificate) does not exonerate buyers or sellers from exercising all their rights and discharging all their liabilities under the Contract of Sale. Stipulations to the contrary are not binding on the Company. The Company's responsibility under this report (or certificate) is limited to proven negligence and will in no case be more than ten times the amount of the fees or commission. Except by special arrangement, samples, if drawn, will not be retained by the Company for more than 30 days. The information stated in this report (or certificate) is derived from the results of inspection or testing procedures carried out in accordance with the instructions of our Client, and/or our assessment of such results on the basis of any technical standards, trade custom or practice, or other circumstances which should in our professional opinion be taken into account.



CHARPY V-NOTCH IMPACT TEST

Customer: Enbridge Pipelines Inc.
PO Box 398, 10201 Jasper Avenue
Edmonton, Alberta
T5J 2J9

Laboratory Test No.: E14-413.1

Date: July 21, 2014

P.O. No.: WP-41001-10135

Attention: Luke Ludwig

Weld I.D.: E2H-MA-11.4-1 (NI)
Project: Edmonton to Hardisty
Material: CSA Z245.1 Gr. 483
Size: 914.4 mm (36.0 in.) O.D. x 11.4 mm (0.449 in.) w.t.
Thermal Condition: As Welded

Specimen Size: 10 x 10 mm (0.394 x 0.394 in.)
Orientation: Transverse
Test Temperature: -5°C (23°F)
Governing Spec.: ASME Section VIII, Div. I, UG-84 – 2013

Machine: Satec SI-1K3, S/N: 1503
Capacity: 407 J (300 ft-lbf)
Verified Range: 3.4-149 J (2.5-110 ft-lbf)

Specimen Number	Notch Location	Impact Values		Shear %
		Joules	(ft-lbf)	
D2.1	Weld Metal within 1/16" of root	87.6	(64.6)	70
D2.2	Weld Metal within 1/16" of root	77.8	(57.4)	56
D2.3	Weld Metal within 1/16" of root	62.6	(46.2)	59
D3.1	HAZ (fusionline @ midwall)	149	(110)	75
D3.2	HAZ (fusionline @ midwall)	>149	(>110)	85
D3.3	HAZ (fusionline @ midwall)	97.1	(71.6)	66

Note: Metric values calculated by direct conversion.

Test Conducted By: Eric Dacyk, C.E.T.

Certified By: 

Eric Dacyk, C.E.T.

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HARDNESS TEST

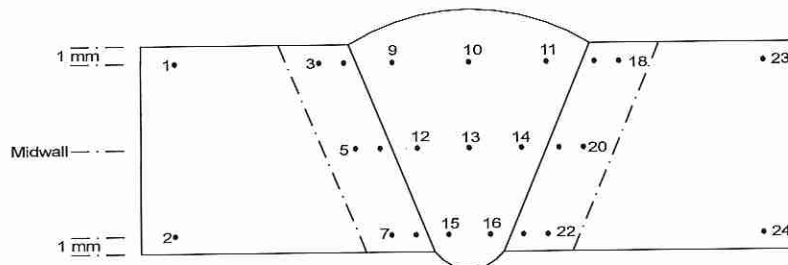
Customer: Enbridge Pipelines Inc.
PO Box 398, 10201 Jasper Avenue
Edmonton, Alberta
T5J 2J9

Laboratory Test No.: E14-413.1
Date: July 18, 2014
P.O. No.: WP-41001-10135

Attention: Luke Ludwig

Weld I.D.: E2H-MA-11.4-1 (NI)
Project: Edmonton to Hardisty
Material: CSA Z245.1 Gr. 483
Size: 914.4 mm (36.0 in.) O.D. x 11.4 mm (0.449 in.) w.t.
Thermal Condition: As Welded

Type of Test: Vickers 10kg (HV10)
Instrument: DuraScan 70
Governing Spec.: ASTM E384-11^{e1}



Parent Metal		HAZ		Weld Metal		HAZ		Parent Metal	
1	216	3	201	9	200	17	215	23	215
2	220	4	206	10	197	18	193	24	218
		5	211	11	203	19	210		
		6	199	12	175	20	183		
		7	195	13	184	21	225		
		8	233	14	182	22	203		
				15	196				
				16	192				

Test Conducted By: Tong Zhao, T.T.

Certified By: 

Karen Koens, R.E.T.

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Date Tested: 24 May 2014

Applus⁺

RTD

Report number

E2H-M-11,4/15.9-WPQ

[illegible]

Contractor Midwest Pipelines

Name:

Signature: _____



7011 High Life Road
Houston Tx, 77066
Phone: 832-249-3100
Fax: 832-249-3292

RADIOGRAPHY REPORT

CUSTOMER: ENBRIDGE

DATE: 05/24/2014

INSPECTION STD: CSA-Z662-11

FILM TYPE: FUJI 50

BASE METAL: CSA 483 X-70

NO FILMS: 1

DIA/WT: 36"x 11.4mm

SENSITIVITY: 2.0%

WELD NO: 1071-U (E2H-MA-11.4-1)

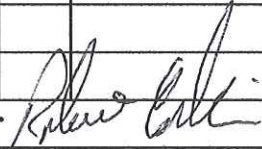
100% X-RAY

PROJECT: E2H

RT Procedure #: 1071-1

☒ **WELD ACCEPTED**

☐ **REJECTED**

Film Number	Acceptable	Unacceptable	No Discontinuities	Porosity	Slag Inclusions	LSF	LCP	Undercut	Incomplete Penetration	Excessive Penetration	REMARKS
0-2	√				√						
3-19	√		√								
20-22	√			√							
23-33	√		√								
34-40	√			√							
41-66	√		√								
67-72	√			√							
73-243	√		√								
244-245	√			√							
246-262	√		√								
263-264	√										Hollow Bead
265-0	√		√								
RADIOGRAPHER /INTERPRETED BY: Robert Collier 											LEVEL: II
ACCEPTED BY:											

This information is the proprietary property of CRC-Evans Automatic Welding which contains trade secrets and/or know how and may only be used in conjunction with equipment rented from CRC-Evans Automatic Welding.

Date: April 24, 2014
Customer: ENBRIDGE PIPELINES INC.
Specification: Enbridge Submerged-Arc-Welded Steel Pipe
Specification Supplementary to CSA Z245.1-07 EES102-
2010 Revision 1 March 4, 2010 and CSA Z245.1-07.
Product: 914.4 mm OD x 11.4 mm WT, Grade 483 CAT I
EVRAZ Changeover L-314E
Mill Order: TU-001156
Customer P.O.: P4000-12652-2W
Mill Certificate: EVRAZ Certification Package ID 5686

All supplied pipe have been manufactured, sampled, tested, and inspected in accordance with the requirements of the Enbridge Submerged-Arc-Welded Pipe Specification Supplementary to CSA Z245.1-07 EES102-2010 Rev.1 and CSA Z245.1-07 and was found to have met such requirements.

EES102-2010 Clause 17 Certification

- 17.2 Reported on Mill Certificate (Chemistry).
- 17.3 Reported on Mill Certificate (Chemistry).
- 17.4 Reported on Mill Certificate (Chemistry).
- 17.8 a) Reported on Mill Certificates (All).
- 17.8 b) Reported on Mill Certificates (Microhardness Test & Tensile).
- 17.8 c) Reported on Mill Certificate (Tensile).
- 17.8 d) Reported on Mill Certificate (Tensile).
- 17.8 e) Non-destructive inspection was performed in accordance with, and met the requirements of Enbridge Submerged-Arc-Welded Pipe Specification Supplementary to CSA Z245.1-07 EES102-2010 Rev. 1 and CSA Z245.1-07.
- 17.8 f) Reported on Heat to Pipe Correlation.
- 17.8 g) Pipe have been manufactured in accordance with the approved EVRAZ Manufacturing Procedure Specification Enbridge E2H Project Revision 2 January 20, 2014, CSA Z245.1-07, and Enbridge Submerged-Arc-Welded Pipe Specification Supplementary to CSA Z245.1-07 EES102-2010 Rev. 1.
- 17.8 h) Not applicable.



David Crone
Quality Assurance Manager – Regina Tubular
CC: File



Spiral Mill

EVRAZ Regina

CERTIFICATE OF TESTING

Microhardness Test Heat Qualifiers

04/24/2014 13:28:17

Certificate ID: **5686**Form No: **L 4443**Customer: **ENBRIDGE PIPELINES INC.**Diameter: **914.400 mm** Wall Thickness: **11.400 mm** Grade: **483 CAT I**Customer PO: **P4000126522W**Specification: **CSA Z245.1-07 / ENBRIDGE SPECIFICATION EES102-2010 REV 1**Mill Order No: **TU001156**

Changeover	Heat	Coil	Pipe	Test Type	Scale	MS		PM	PM	PM	HAZ	HAZ	HAZ	WMZ	WMZ	WMZ	HAZ	HAZ	HAZ	PM	PM	PM
Supplier: EVRAZ REGINA																						
L-314E	495826	A0175	10114	QUAL INITIAL	Vickers	OK	OD	237			224			247			229			212		
							MID	245			227			237			218			229		
							ID	241			245			205			222			231		
L-314E	514112	A0073	40063	QUAL INITIAL	Vickers	OK	OD	208			227			249			243			210		
							MID	229			213			239			213			224		
							ID	224			222			226			202			239		

MS = Micro Structure

Measurement Taken In HV500

We certify that the product described above has been manufactured, sampled, inspected, and tested in accordance to the referenced specification. The product has been found to be in compliance with all requirements.

Quality Assurance



Spiral Mill

EVRAZ Regina

CERTIFICATE OF TESTING

Tensile

04/24/2014 13:28:20

Certificate ID: **5686**Form No: **L 4444**Customer: **ENBRIDGE PIPELINES INC.**Diameter: **914.400 mm** Wall Thickness: **11.400 mm** Grade: **483 CAT I**Customer PO: **P4000126522W**Specification: **CSA Z245.1-07 / ENBRIDGE SPECIFICATION EES102-2010 REV 1**Mill Order No: **TU001156**

Changeover	Heat	Coil	Pipe	Test Type	Orientation	Test Width (mm)	Yield Strength (MPa)	Tensile Strength (MPa)	% Elongation		Y/T	Weld Break (mm)
									50 mm	Uniform		
Supplier: EVRAZ REGINA												
L-314E	495826	A0175	10114	QUAL INITIAL	PIPE TPA	38.21	516	659	40.0		.78	
L-314E	495826	A0175	10114	QUAL INITIAL	PIPE TWA	38.19		713	28.0			
L-314E	514112	A0073	40063	QUAL INITIAL	PIPE TPA	38.16	510	646	40.0		.79	
L-314E	514112	A0073	40063	QUAL INITIAL	PIPE TWA	38.11		715	26.0			

TPA - Transverse Pipe Axis
 LPA - Longitudinal Pipe Axis
 TWA - Transverse Weld Axis
 LRD - Longitudinal Rolling Direction
 TRD - Transverse Rolling Direction
 FST - Full Section (Width is the Diameter)

Hydrostatic Parameters: Pressure: 11400 KPA Hydro(%): 95.0 Hold Time: 10 sec.

Guided Bend Tests Were Performed In Accordance With
 And Meet The Requirements Of The Above Specification.

We certify that the product described above has
 been manufactured, sampled, inspected, and
 tested in accordance to the referenced specification.
 The product has been found to be in compliance
 with all requirements.

Quality Assurance



Spiral Mill

EVRAZ Regina CERTIFICATE OF TESTING Chemistry

04/24/2014 13:28:15

Certificate ID: **5686**Form No: **L 4442**Customer PO: **P4000126522W**Mill Order No: **TU001156**Customer: **ENBRIDGE PIPELINES INC.**Diameter: **914.400 mm** Wall Thickness: **11.400 mm** Grade: **483 CAT I**Specification: **CSA Z245.1-07 / ENBRIDGE SPECIFICATION EES102-2010 REV 1**

Heat	Changeover	Coil	Pipe	Type	C	Mn	S	P	Si	Cu	Ni	Cr	V	Cb	Sn	Mo	Al	Ca	B	Ti	N	Ce	CE ceq	SoAl
Supplier: EVRAZ REGINA																								
495826				HEAT	0.05	1.72	0.002	0.009	0.27	0.21	0.07	0.22	0.001	0.079	0.008	0.116	0.041	0.0025	0.0001	0.017	0.007	0.000	0.26	0.035
495826	L-314E	A0175	10114	PRODUCT	0.05	1.72	0.001	0.009	0.28	0.20	0.06	0.23	0.001	0.078	0.008	0.118	0.040	0.0022	0.0001	0.017	0.007	0.000	0.26	0.035
514112				HEAT	0.06	1.74	0.002	0.009	0.24	0.26	0.09	0.22	0.001	0.079	0.009	0.116	0.040	0.0031	0.0002	0.015	0.009	0.000	0.28	0.034
514112	L-314E	A0073	40063	PRODUCT	0.06	1.78	0.002	0.009	0.24	0.26	0.09	0.23	0.001	0.077	0.009	0.117	0.040	0.0026	0.0001	0.015	0.009	0.000	0.28	0.034

Deoxidization Practice: Aluminum Fully Killed
Furnace: ELECTRIC ARC Casting: CONTINUOUS SLAB Rolling Mill: STECKEL

We certify that the product described above has been manufactured, sampled, inspected, and tested in accordance to the referenced specification. The product has been found to be in compliance with all requirements.

Quality Assurance