Steel Sleeve Fit-Up Test Program

Final Report

Prepared for Allan Edwards, Inc.

Report No. 100160-RP01-Rev2-022521

February 2021

Testing performed by ADV Integrity, Inc.

Thursday, February 25, 2021 100160-RP01-Rev2-022521

Mr. Chip Edwards, President
Allan Edwards
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Phone: (918) 583-7184 | E-mail: cedwards@allanedwards.com

Chip,

The following report documents the test program completed at ADV Integrity, Inc. for Allan Edwards to evaluate the performance of your Type-B reinforced "tight" repair sleeves relative to other designs lacking a tight fit-up. This validation involved a full-scale pressure cycling test of two (2) pressure-containing Type B steel sleeves installed on 24-inch OD x 0.25-inch WT, Grade X52 carrier pipes. One sleeve was installed with a "tight-fit" while the second was a "loose-fit." Both sleeves were manufactured and supplied by Allan Edwards. The repair sleeves were pressure containing due to a ½-inch thru-hole installed in both carrier pipes beneath the repair sleeve.

The "tight" repair sleeve survived 4,934 pressure cycles before a leak developed in the sleeve seam weld. The "loose" sleeve failed after only 1,382 pressure cycles with a similar leakage developing in the seam weld. The pressure cycling test successfully demonstrated that the "tight" Type-B repair sleeve outperformed "loose" sleeves. The conclusion is that for sleeves to perform as intended, they must be tight to minimize stresses in the reinforced pipe and minimize stresses in the sleeve welds.

Thank you for the opportunity to complete this work and please contact me if you have any questions or additional information is required.

Regards,

Chris Alexander

Dr. Chris Alexander, PE, President

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1.0 INTRODUCTION AND BACKGROUND

The following report documents a test program conducted by ADV Integrity, Inc. (ADV) to evaluate via full-scale testing the performance of the Allan Edwards, Inc. Type-B manufactured repair steel sleeves. The purpose of this test program was to compare performance of the Allan Edwards tight steel sleeve relative to a condition lacking a tight fit-up (termed "loose fit" for the remainder of the report). This test program involved installation of Type-B repair sleeves supplied by Allan Edwards on two (2) 24-inch OD x 0.25-inch WT, Grade X52 pipe samples as described in Table 1.

The main difference between the two samples was the fit-up of the sleeves installed on pipe samples. Sample 100160-24RT (24RT) included a tight fit sleeve, while Sample 100160-24RLT (24RLT) had a loose fitting sleeve. These samples had a ½-inch thru-hole drilled into the base pipe to simulate a live leak, which forced pressure in the annulus between the pipe and inside surface of the steel sleeve. The presence of these holes ensured that the entire repair sleeve was pressurized during the pressure cycle fatigue test. A previous Joint Industry study[1] that was co-funded by Allan Edwards and four (4) gas pipeline companies demonstrated long fatigue lives are achieved when using steel sleeves to reinforce dents and corrosion features subjected to cyclic pressures.

Table 1: Sample Description

Sample ID	Pipe Size	Hole Size (in)	Sample Length	Sample Description
100160-24RT	24-inch x 0.25-inch, Grade X52	1/2	10-feet	Tight Fit
100160-24RLT	24-inch x 0.25-inch, Grade X52	1/2	10-feet	Loose Fit

RT: Reinforced Tight
RLT: Reinforced Loose

The following sections of this report document the test setup, procedure, pressure cycle test results including strain gage measurements, and a short discussion on the results. An appendix is attached to this report including the mill test reports (MTRs) for the repair sleeve and pipe materials, a calibration certificate for the pressure transducer used in testing, and the weld procedure used to install the repair sleeves.

[1] Alexander, C., Precht, T., and Edwards, C., "Steel Sleeves: A New Look at a Widely-Used Repair Method", Pipeline Pigging & Integrity Management Conference, Houston, Texas, February 18-22, 2019.

2.0 TEST SETUP AND PROCEDURE

Allan Edwards supplied two (2) 24-inch OD x 0.375-inch WT, ASTM A572 Grade 65 repair steel sleeves and ADV fabricated two samples using (2) 24-inch OD x 0.25-inch WT, API 5L Grade X52 pipe material. Table 2 lists the mechanical properties (yield and tensile strength) of the carrier pipes and repair sleeve plates. Material Test Reports (MTRs) for both the sleeve and carrier pipe are included in the appendix of this report.

Table 2: Mechanical properties of carrier pipe and repair sleeve

Component	Material Grade	Yield (ksi)	Tensile (ksi)
Carrier Pipe	API 5L Grade 52	60.8	77.0
Repair Sleeve	ASTM A572 Grade 65	76.3	84.5

Each repair sleeve also included a 1-inch bosset 90° from the sleeve seam welds as illustrated in Figure 1. ADV drilled a ½-inch hole into the base pipe through the bosset on the steel sleeve and then plugged the bosset. The resulting thru-hole for Sample 24RT can be seen in Figure 2. Similar images for Sample 24RLT and close-up pictures of the bosset for each sample can be found in the Appendix, Figures 10 through 12. ADV installed two (2) biaxial strain gages on the assembly as shown in Figure 1 below, which included:

- One (1) biaxial gage on the repair sleeve located 1-inch from seam weld (90°) in middle of the sleeve.
- One (1) biaxial gage on the base pipe halfway between the end cap and the steel sleeve located 90° from the seam weld.

The same instrumentation installation procedure was used for both samples.

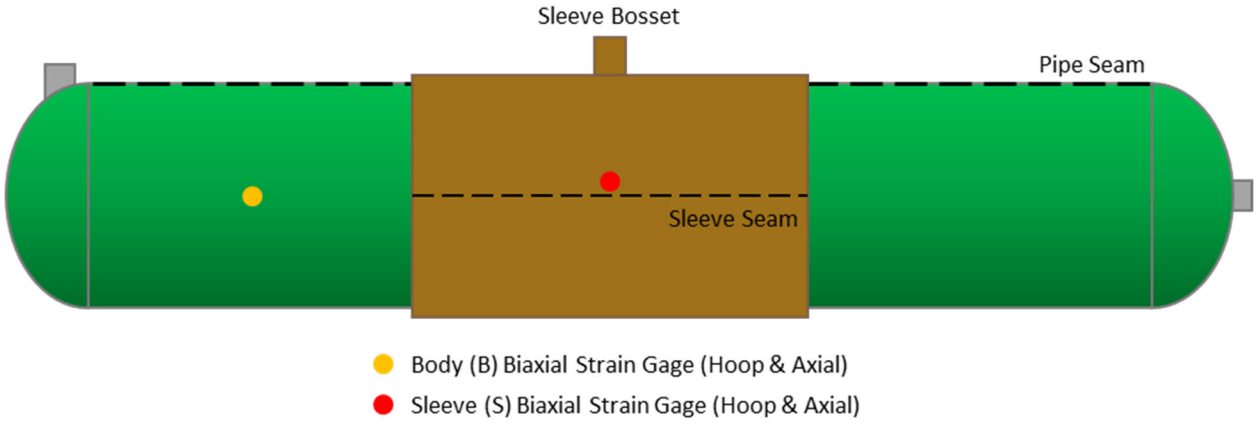


Figure 1: Locations of the two (2) biaxial strain gages and the sleeve bosset with a thru-hole in pipe



Figure 2: Sample 24RT bosset with drilled ½-inch thru-hole

Following the instrumentation installation, both test samples were installed into one of ADV's testing chambers for pressure cycling as shown in Figure 3 and Figure 4. The following procedure was used to complete the pressure cycling:

1. Calibrated instrumentation and data acquisition (DAQ) system.
2. Filled samples with water. NOTE: The steel sleeve carried pressure directly as water filled the gap through the drilled hole.
3. Pressure cycled the samples from 100 to 867 psig (9% to 80% SMYS).
    a. Peak-peak pressure of 780 psig.
    b. Cycle to failure or runout (100,000 cycles).
4. Recorded cycles to failure once sample began leaking.
5. Photographed failure regions.



Figure 3: Samples 24RLT (left) and 24RT (right) installed in the testing chamber for pressure cycling



Figure 4: Reinforced less tight steel sleeve (top) and reinforced tight steel sleeve (bottom) installed on the Sample 24RLT and Sample 24RT, respectively

3.0 TEST RESULTS

The cycles to failure for the tight and loose fit sleeves are listed in Table 1 below. The tight sleeve (Allan Edwards standard installation) outperformed the loose fit sleeve by reaching 3,552 more pressure cycles.

Table 3: Results Summary

Sample ID	Sample Description	Cycles to Failure
100160-24RT	Tight Fit	4,934
100160-24RLT	Loose Fit	1,382

Figure 5 displays the strain range in microstrain and internal pressure vs. cycles for both the tight fit sleeve and loose fit sleeve samples. All values shown in Figures 5, 6 and 8 are peak-to-peak, which is the difference between the measured maximum and minimum strain values. The tight fit sleeve sample pressure cycling is displayed in Figure 6. The sleeve reached a peak-to-peak hoop strain (shown as RT-S-H in Figure 6) of approximately 0.20% and an internal pressure of 795 psig prior to failure. The sleeve leaked at the sleeve seam weld as pictured in Figure 7. The loose fit sleeve sample pressure cycling is displayed in Figure 8. The sleeve reached a peak-to-peak hoop strain (shown as RLT-S-H in Figure 8) of approximately 0.23% and an internal pressure of 765 psig prior to failure. The sleeve leaked at the sleeve seam weld as pictured in Figure 9.

What is especially important to note in Figure 5 is that the hoop strain in the loose sleeve “spikes” much sooner than the increase in strain observed in the tight sleeve configuration. Almost immediately the RLT-S-H strain gage located on the loose sleeve shows an increase in hoop strain, while the RT-S-H strain gage located on the tight sleeve only starts showing a notable increase in strain after 3,000 pressure cycles have been applied. An increase in axial strain was also measured by the gage installed on the loose sleeve (RLT-S-A); however, no appreciable axial strains were measured in the tight sleeve during cycling.

Another noteworthy observation from Figure 5 is that from the beginning of testing the hoop strain in the loose sleeve is significantly less than the hoop strain in the tight sleeve (i.e., less than 50%). This indicates that the loose sleeve is not providing the same level of reinforcement (or restraint) as observed with the tight sleeve. This is extremely important when considering the level of stress reduction provided to the reinforced carrier pipe beneath the steel sleeve. The goal with any reinforcing sleeve is to “pick-up” load as soon as possible after pressurization. The presence of a lag in load transfer results in higher stresses being generated in the carrier pipe.

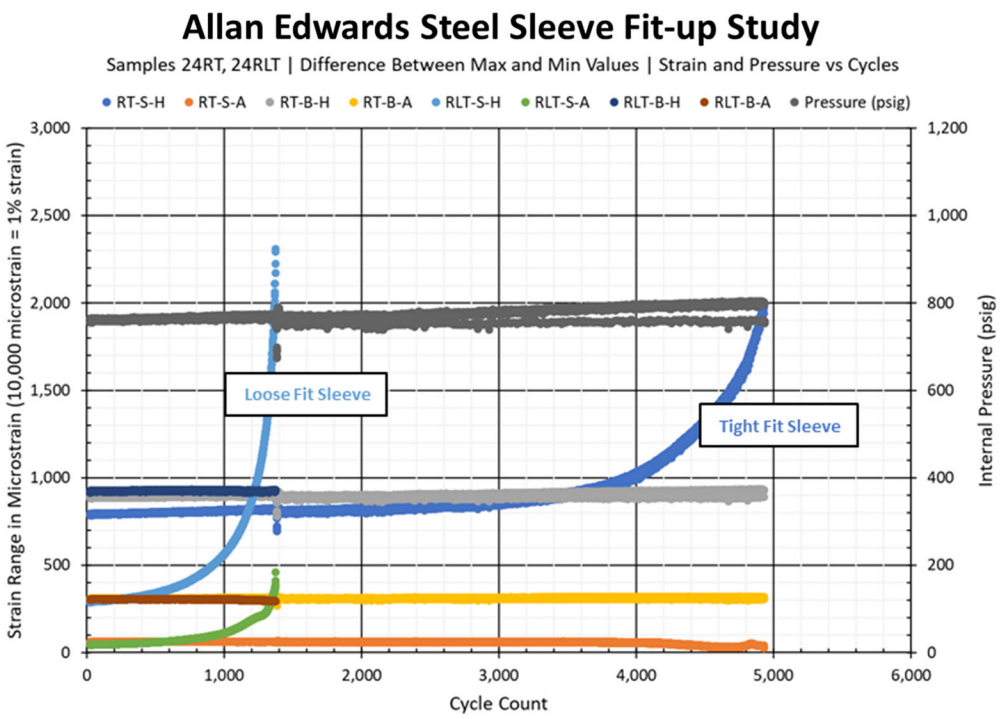


Figure 5: Strain and internal pressure vs. cycles for both Samples 24RT (tight) and 24RLT (loose)

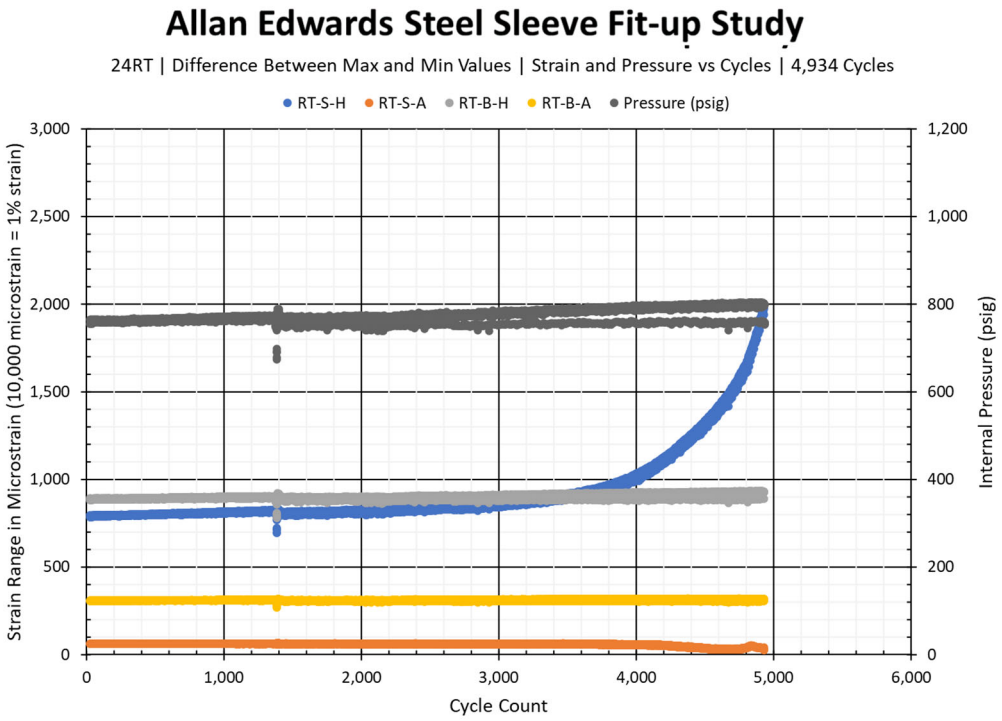


Figure 6: Strain and internal pressure vs. cycles for Sample 24RT (tight fit), reaching 4,934 cycles



Figure 7: Sample 24RT (tight fit) failure location after 4,934 cycles

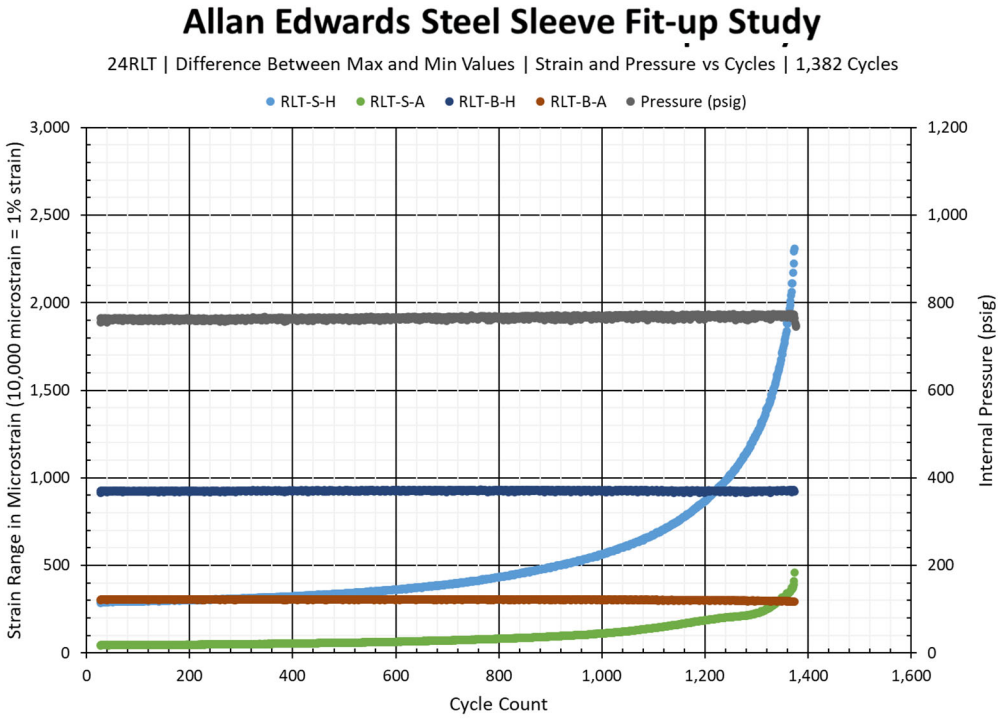


Figure 8: Strain and internal pressure vs. cycles for Sample 24RLT (loose fit), reaching 1,382 cycles



Figure 9: Sample 24RLT (loose fit) failure location after 1,382 cycles

4.0 DISCUSSION AND CLOSING COMMENTS

This report has provided results for the performance of the Allan Edwards Type-B sleeves considering a tight fit and a loose fit. The loose fit repair sleeve did not perform as well when it was pressurized as it experienced more bending at the weld leading up to failure. As shown in Figure 8, both the hoop and axial strain values at the sleeve seam (labels RLT-S-H and RLT-S-A, respectively) steadily increased and the sleeve was able to bend axially which accelerated the increase in strain. The observed change in strain early in the cycling process is an indication that the loose sleeve was experiencing bending loads that contributed to the premature failure of the sleeve's long seam weld.

The tight fit repair sleeve performed significantly better due to the compressive residual stress applied to the pipe body when the sleeve was installed. The presence of the compression counteracts the tendency of the sleeve to expand during pressure cycling. In Figure 6, the tight fit sleeve begins with a higher hoop strain (labeled as RT-S-H) than the loose fit sleeve, but slowly increases over cycles while the axial strain (labeled as RT-S-A) remains constant until approximately 4,000 cycles. Something to note is that the peak-to-peak axial strain does not increase as the sleeve approaches failure, therefore it is more resistant to bending axially and improves performance.

In the context of pipeline operation, how do the experimental cycles to failure correspond to actual pipeline operation? Consider the results presented in Table 4 and the conversion of "Experimental Cycles to Failure" to "Service Life". In making this conversion a fatigue safety factor of 5.0 is used and a "Light" pressure cycle condition using the Kiefner Pressure Industry Study[2] (10 cycles per year at ΔP = 72% SMYS) is assumed that is typical for a gas transmission pipeline.

Table 4: Results Summary in the Context of Actual Pipeline Operation

Sample ID	Sample Description	Experimental Cycles to Failure (ECTF)	ECTF / 5.0 (Fatigue Safety Factor)	Service Life in Years ("Light" 10 cycles per year)
100160-24RT	Tight Fit	4,934 cycles	987 cycles	99 years
100160-24RLT	Loose Fit	1,382 cycles	276 cycles	28 years

This pressure cycling test successfully demonstrated that the Type-B tight fit repair steel sleeve manufactured and supplied by Allan Edwards performs considerably better than an alternative steel sleeve design that might lack a tight fit-up. This is an important consideration for pipe operators who use steel sleeves to repair pipelines, especially when using Type-B steel sleeves where the sleeve is required to contain internal pressure. It is possible that a tight fitting sleeve might prevent the formation of thru-wall defects that will in turn will prevent pressure in the annulus between the pipe and sleeve and prevent the fatigue failures that occurred in this test program.

[2] Kiefner, J.F. et al., "Estimating Fatigue Life for Pipeline Integrity Management", Paper No. IPC2004-0167, Presented at the International Pipeline Conference, Calgary, Canada, October 4–8, 2004.

APPENDIX



Figure 10: Close-up shot of Sample 24RT (tight fit) bosset with drilled ½-inch thru-hole



Figure 11: Sample 24RLT (loose fit) bosset with drilled ½-inch thru-hole



Figure 12: Close-up shot of Sample 24RLT (loose fit) bosset with drilled ½-inch thru-hole

Specialloy Texas, Inc.
11702 Brittmoore Park
Houston, Texas 77041
(713) 827-7776

SPECIALLOY INSTRUMENTATION

Certificate of Calibration

Transmitter

Certificate No. 92920-5 **Print Date** 9/29/2020

Unit Under Test(UUT)

UUT ID :	98495-G5	**Calibration Date:**	9/29/2020
Model:	TD1000BBG500003Q002X	**Expiration Date:**	9/29/2021
Range:	(0~5000)psi	**Manufacturer:**	TRANSDUCERS DIRECT
Resolution:	0.001mA	**Customer:**	ADV INTEGRITY
Application Site:	Specialiloy Calibration Laboratory		
Accuracy:	0.25% FS		

Calibration Results

	Result	Max Error	Temperature	Humidity	Atmospheric pressure
As Found	In- tolerance	0.54 %	72°F	53%	1.005 kPa
As Left	In- tolerance	0.54 %	72°F	53%	1.005 kPa

Calibration Data - As Found

Max Error: 0.54 %

SetPoints psi	Reference psi	Nominal mA	Reference mA	Tolerance mA	Deviation mA	Error (%)
0	0	4.0000	4.0598	0.0400	0.0598	0.37
1250	1250	8.0000	8.0658	0.0400	0.0658	0.41
2500	2503	12.0096	12.0963	0.0400	0.0867	0.54
3750	3746	15.9872	16.0348	0.0400	0.0476	0.30
5000	5001	20.0032	20.0477	0.0400	0.0445	0.28
3750	3748	15.9936	16.0503	0.0400	0.0567	0.35
2500	2502	12.0064	12.0710	0.0400	0.0646	0.40
1250	1250	8.0000	8.0601	0.0400	0.0601	0.38
0	0	4.0000	4.0453	0.0400	0.0453	0.28

=== As Found Calibration Data End ===

Calibration Data - As Left

Max Error: 0.54 %

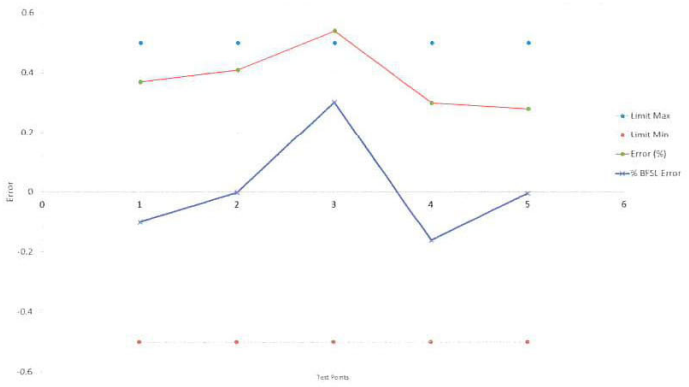
Test Point	Limit Max	Limit Min	SetPoints psi	Reference psi	Nominal mA	Reference mA	Tolerance mA	Deviation mA	Error (%)	BFSL
1	0.5	-0.5	0	0	4.0000	4.0598	0.0400	0.0598	0.37	4.0719
2	0.5	-0.5	1250	1250	8.0000	8.0658	0.0400	0.0658	0.41	8.0660
3	0.5	-0.5	2500	2503	12.0096	12.0963	0.0400	0.0867	0.54	12.0601
4	0.5	-0.5	3750	3746	15.9872	16.0348	0.0400	0.0476	0.30	16.0542
5	0.5	-0.5	5000	5001	20.0032	20.0477	0.0400	0.0445	0.28	20.0483
6	0.5	-0.5	3750	3748	15.9936	16.0503	0.0400	0.0567	0.35	16.0542
7	0.5	-0.5	2500	2502	12.0064	12.0710	0.0400	0.0646	0.40	
8	0.5	-0.5	1250	1250	8.0000	8.0601	0.0400	0.0601	0.38	
9	0.5	-0.5	0	0	4.0000	4.0453	0.0400	0.0453	0.28	

=== As Left Calibration Data End ===

References

Manufacturer	Model	Serial Number	Certificate No.	Due Date	Accuracy
Additel Corporation	ADT672 (0~10000)PSI	27314130094	177864	4/30/2021	0.025% FS
—	—	—	—	—	—
Ambient Weather	WH117H	MO-3345A	4035191	10/29/2020	0.01

BFSL ERROR: 0.302



Inspector

CUSTOMER ACCEPTS TOLERANCE OUT OF MANUFACTURERS SPECS/NEW ACCURACY OF 0.5%FS

All Inspections are traceable to the National Institute of Standards and Technology. The Calibration & Certifications have been performed to Specialloy's Quality & Laboratory Procedures. All Calibration Equipment used per ANSI/NCSL Z540-1-1994

Figure 13: Certificate of Calibration

ArcelorMittal Burns Harbor Plate TAG: 120-660

QUALITY ASSURANCE
REPORT OF TEST AND ANAYLSES

SHIPMENT NO. 803-61765 | DATE SHIPPED 07-01-20 | CAR OR VEHICLE NO. LMIC 007265 | PAGE 2

SOLD TO
LEECO STEEL LLC
1011 WARRENVILLE RD STE 500
LISLE IL 60532-0933

SHIP TO
LEECO STEEL LLC
C/O WATCO TERMINAL & PORT SERVICES
PORT OF CATOOSA
CIF-A00129465-9000
TULSA PORT AUTHORITY OK 74015

NOTE	SERIAL NUMBER	PAT NO.	HEAT NUMBER	NO. PCS.	SIZE AND QUANTITY THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	ELONG.	RED.
					INCHES	INCHES	INCHES	POUNDS	PSI	PSI	IN %	%

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.
PLATES - ASTM A572-18 GR 65 MOD C.12 MAX YS
65/85000, YTR.95 MAX KLD FINE GRAIN
PRAC TYPE 3 CE=.25X PER PCM
FORMULA, CH-V A370 FREQ (H) T 30/20
FTLBS & 85/60 % SHR AT +32F, UT
A578 LEVEL C 100% S1 --- PLT
CONTROL ROLL --- IN ACCORDANCE WITH
EN 10204:2004 TYPE 3.1 10204:2004
TYPE 3.1
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)
CO# V20465 GH 875-7765
PLATES ULTRASONICALLY TESTED PER ATTACHMENT

822M35960	41	3/8	72	122	38294	76300	84500	2 30
						76800	84600	2 40

(M55)MFST REF#:037072122A572-65

822M35980	25	3/8	72	122	23350	82200	89500	2 40
						79000	87000	2 30

(M55)MFST REF#:037072122A572-65

Q-QUENCH TEMPERATURE T-TEMPER TEMPERATURE N-NORMALIZE TEMPERATURE

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD BHN	BEND	THICKNESS INCHES	TYPE	SIZE	DIR	TEST TEMP F	CHARPY IMPACT ENERGY FT LBS 1	2	3	SHEAR(%) 1	2	3	LAT EXP MILS 1	2	3
		822M35960			.375	V	3/4	T	+32	224	204	221	99	99	99			
		822M35980			.375	V	3/4	T	+32	112	135		99	99	99	99		

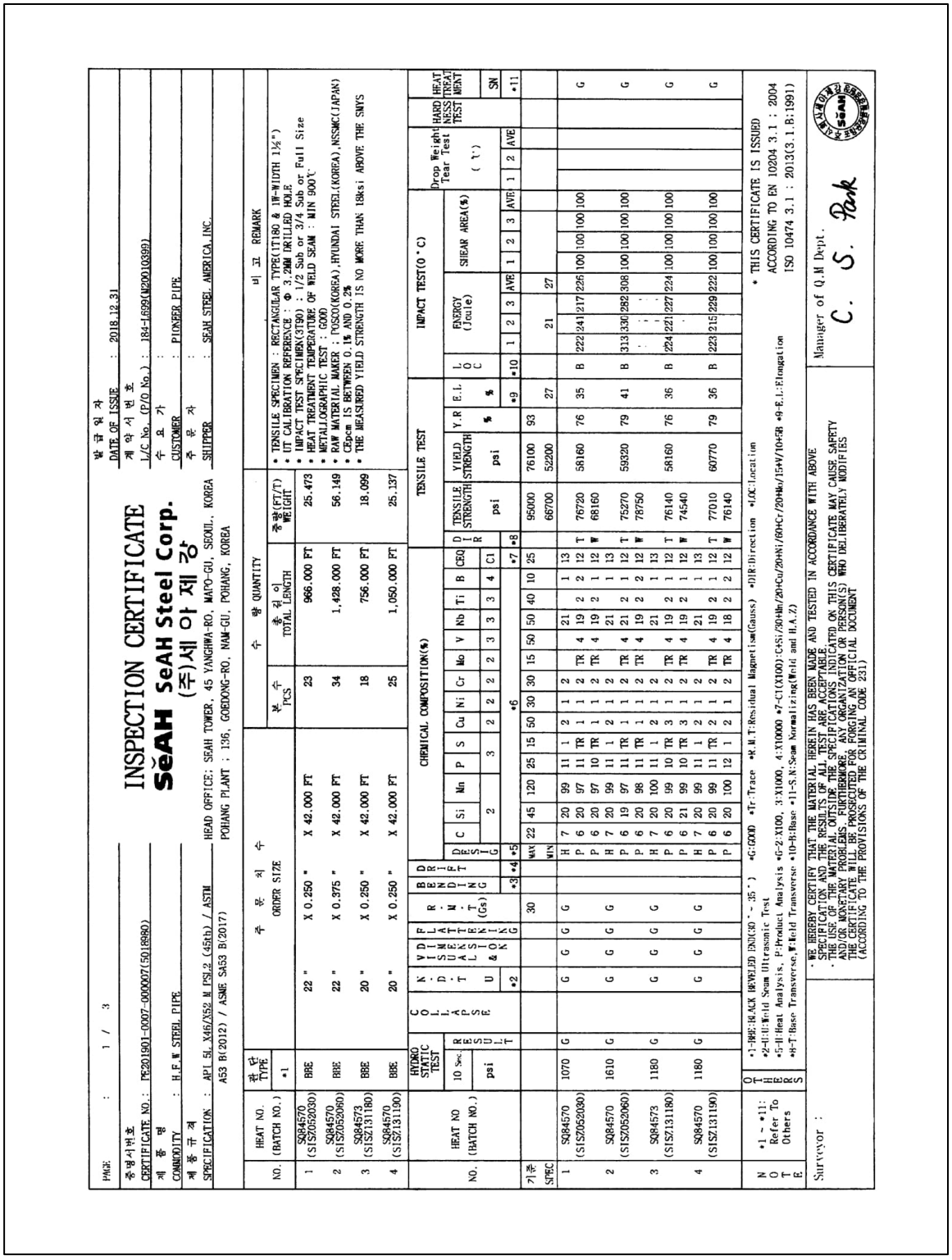
HEAT NUMBER	CHEMICAL ANALYSIS C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Cb	N	Sn	MQUAID GRAIN SIZE
822M35960	.07	1.46	.010	.003	.284	.015	.01	.02	.004	.068	.014	.029	.0002	.026	.005	.002	
	PCM .16																
822M35980	.08	1.49	.012	.004	.292	.013	.01	.03	.006	.070	.016	.028	.0002	.031	.004	.002	
	PCM .17																

I certify that the above results are a true and correct copy of actual results contained in records maintained by ArcelorMittal Burns Harbor and are in full compliance with the requirements of the specification cited above. This test report connot be altered and must be transmitted intact with any subsquent third party test reports, If required.

FARID HASSANI PER MWT

BHPLTRPT.TIF SUPV. QUALITY ASSURANCE

Figure 14: MTR for the Type-B repair steel sleeves



INSPECTION CERTIFICATE

SeAH SeAH Steel Corp.
(주)세아제강

PAGE : 1 / 3
증명서번호
CERTIFICATE NO. : PE201901-0007-0000007(5018980)
제 품 명
COMMODITY : H.F.W STEEL PIPE
제 품 규 격
SPECIFICATION : API 5L X46/X52 M PSL2 (45th) / ASTM A53 B(2012) / ASME SA53 B(2017)

HEAD OFFICE : SEAH TOWER, 45 YANGHWA-RO, MAPO-GU, SEOUL, KOREA
POHANG PLANT : 136, GOEDONG-RO, NAM-GU, POHANG, KOREA

발 급 일 자
DATE OF ISSUE : 2018.12.31
계 약 서 번 호
L/C No. (P/O No.) : 184-16994N200103991
수 요 가
CUSTOMER : PIONEER PIPE
수 운 자
SHIPPER : SEAH STEEL AMERICA,INC.

NO.	HEAT NO. (BATCH NO.)	검단 TYPE	주문치수 ORDER SIZE	수량 QUANTITY 본수 PCS	총길이 TOTAL LENGTH	중량(FT/T) WEIGHT
1	SQ84570 (SISZ052030)	BBE	22 " X 0.250 " X 42.000 FT	23	966.000 FT	25.473
2	SQ84570 (SISZ052060)	BBE	22 " X 0.375 " X 42.000 FT	34	1,428.000 FT	56.149
3	SQ84573 (SISZ131180)	BBE	20 " X 0.250 " X 42.000 FT	18	756.000 FT	18.099
4	SQ84570 (SISZ131190)	BBE	20 " X 0.250 " X 42.000 FT	25	1,050.000 FT	25.137

비 고 REMARK
- TENSILE SPECIMEN : RECTANGULAR TYPE(1T180 & 1W-WIDTH 1½")
- 1T CALIBRATION REFERENCE : Φ 3.2MM DRILLED HOLE
- IMPACT TEST SPECIMEN(3T90) : 1/2 Sub or 3/4 Sub or Full Size
- HEAT TREATMENT TEMPERATURE OF WELD SEAM : MIN 900℃
- METALLOGRAPHIC TEST : G200
- RAW MATERIAL MAKER : POSCO(KOREA),HYUNDAI STEEL(KOREA),NSSMC(JAPAN)
- CEpcm IS BETWEEN 0.1% AND 0.2%
- THE MEASURED YIELD STRENGTH IS NO MORE THAN 18ksi ABOVE THE SMYS

NO.	HEAT NO (BATCH NO.)	HYDRO STATIC TEST	COLLAPSE RESULT	N-DUCTILE & OTHERS	WELD-ING	BEVEL-ING	DIMENSION DESIG	DIMENSION MAX	DIMENSION MIN	CHEMICAL COMPOSITION(%) C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	CEQ	DIR	TENSILE STRENGTH	YIELD STRENGTH	Y.R	E.L	LOC	IMPACT TEST(0°C) ENERGY (Joule) 1	2	3	AVE	SHEAR AREA(%) 1	2	3	AVE	Drop Weight Tear Test 1	2	AVE	HARD NESS TEST	HEAT TREAT MENT
		psi	*2			*3	*4	*5							*6									*7	*8	psi	psi	%	*9	*10													SN	*11
기준 SPEC								MAX	22	45	120	25	15	50	30	30	15	50	40	10	25																								
1	SQ84570 (SISZ052030)	1070	G	G	G	G	H	7	20	99	11	1	2	1	2				21		1	13			95000	76100	93																	
							P	6	20	97	11	TR	1	1	2	TR	4	19	2	12	T			66700	52200		27		21			27												
2	SQ84570 (SISZ052060)	1610	G	G	G	G	H	7	20	97	10	TR	1	1	2	TR	4	19	2	12	T	76720	58160	76	35	B	222	241	217	226	100	100	100	100							G
							P	6	20	97	10	TR	1	1	2	TR	4	19	2	12	W	68160																				
							H	7	20	99	11	1	2	1	2				21		1	13			75270	59320	79	41	B	313	330	282	308	100	100	100	100							G
							P	6	19	97	11	TR	1	1	2	TR	4	21	2	12	T			78750																			
3	SQ84573 (SISZ131180)	1180	G	G	G	G	H	7	20	100	11	1	2	1	2				21		1	13			76140	58160	76	36	B	224	221	227	224	100	100	100	100							G
							P	6	21	99	10	TR	3	1	2	TR	4	19	2	12	W	74540																				
4	SQ84570 (SISZ131190)	1180	G	G	G	G	H	7	20	99	11	1	2	1	2				21		1	13			77010	60770	79	36	B	223	215	229	222	100	100	100	100							G
							P	6	20	99	11	TR	2	1	2	TR	4	19	2	12	T			76140																			
							P	6	20	100	12	1	2	1	2	TR	4	18	2	12	W																				

NOTES
*1 ~ *11: Refer To Others
*1-HYDRO STATIC TEST : 1000 PSI (30 " ~ 35 ") *2-H:Weld Seam Ultrasonic Test *3-H:Heat Analysis, P:Product Analysis *4-G:2.X100, 3:X1000, 4:X10000 *5-T:Base *6-T:Trace *7-C(X100):CaSi/30Mn/20Cu/20Ni/60Cr/20Mo/15V/10Nb *8-M.T:Residual Magnetism(Gauss) *9-T:Transverse,W:Weld Transverse *10-B:Base *11-S.N:Seam Normalizing(Weld and H.A.Z) *DIR:Direction *LOC:Location *E.L:Elongation

- WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH ABOVE SPECIFICATION AND THE RESULTS OF ALL TEST ARE ACCEPTABLE.
- THE USE OF THE MATERIAL OUTSIDE THE SPECIFICATIONS INDICATED ON THIS CERTIFICATE MAY CAUSE SAFETY AND/OR MONETARY PROBLEMS. FURTHERMORE, ANY ORGANIZATION OR PERSON(S) WHO DELIBERATELY MODIFIES THE CERTIFICATE WILL BE PROSECUTED FOR FORGING AN OFFICIAL DOCUMENT (ACCORDING TO THE PROVISIONS OF THE CRIMINAL CODE 231)

* THIS CERTIFICATE IS ISSUED ACCORDING TO EN 10204 3.1 : 2004 ISO 10474 3.1 : 2013(3.1.B:1991)

Surveyor :

Manager of Q.M Dept.
C. S. Park

SEAH

APPROVED

WPS No. 9-SM [1] LH

REV# 0 Date 2/24/1996

PQR No. SMAW-62LH

Welding Process(es) SHIELDED METAL ARC WELDING (SMAW)

Type (manual,automatic,semi-auto) MANUAL

JOINTS (QW-402)

Joint Design SINGLE GROOVE TEE JOINT

Backing No X Yes ____ Backing Material (Type) ____

BASE METALS (QW-403)

P-No. 1 Group No. 1 to P-No. 1 Group No. 1

Specification Type and Grade SA-105 AND SA-106 GRADE B

to Specification Type and Grade SA-105 AND SA-106 GRADE B

Base Metal Thickness Range Groove 0.188" THRU 0.750" Fillet ALL

Pipe Diameter Range Groove ALL Fillet ALL

Other ALL API 5L GRADES ARE ACCEPTABLE FOR ANSI B31.8 SYSTEMS (GATHERING & COMPRESSOR/METER STATIONS)

FILLER METALS (QW-404) Each base metal filler combination should be recorded individually

Spec. No. (SFA)	5.1		
AWS No. (Class)	E7018		
Filler Metal F-No.	4		
Weld Metal Analysis A-No.	1		
Size of Filler Metal	3/32" - 1/8" - 5/32"		
Groove Thickness Range	0.188" THRU 0.750"		
Fillet Thickness Range	UNLIMITED		
Electrode-Flux Class	N/A		

Other ____

POSITIONS (QW-405)

Position(s): Groove ALL Fillet ALL

Welding Progression: Up E7018 Down ____

POSTWELD HEAT TREATMENT (QW-407)

Temperature Range N/A

Time Range N/A

PREHEAT (QW-406)

Preheat Temp. Min. MINIMUM 75 F

Interpass Temp. Max 450 F MAXIMUM

Preheat Maintenance PROPANE TORCH

GAS (QW-408)

	Gas(es)	% Composition	Flow Rate(cfm)
Shielding	N/A		
Trailing			
Backing			

ELECTRICAL CHARACTERISTICS (QW-409)

Weld Layers	Process	Filler Metal Class	Filler Metal Dia.	Current Type Polarity	Current Amp. Range	Volt Range	Travel Speed Range	Other (hot wire addition, technique, torch angle, etc.)
1	SMAW	E7018	3/32-1/8	DCRP	70 - 130	15 - 26	5 - 10 IPM	
2	SMAW	E7018	3/32-1/8	DCRP	70 - 130	15 - 26	5 - 15 IPM	
BALLANCE	SMAW	E7018	3/32-1/8-5/32	DCRP	70 - 150	15 - 26	5 - 15 IPM	

TECHNIQUE (QW-410)

String or Weave Bead STRINGER BEAD FOR ROOT AND HOT PASS - EITHER TECHNIQUE FOR BALANCE AND CAP

Orifice or Gas Cup Size ____ Contact tube to work distance N/A Oscillation N/A

Initial and Interpass Cleaning (Brushing, Grinding, etc.) HAND OR POWER BRUSHING AND GRINDING

Method of Back Gouging GRINDING OR AIR-ARC

Multiple or Single Pass (per side) MULTIPLE Multiple or Single Electrodes SINGLE

Peening N/A

Other ____

Additional Comments THIS WPS IS APPLICABLE FOR WELDING P1 MATERIALS USING THE SMAW PROCESSES ON MATERIALS FROM 0.188" THRU 0.750" THICK - WITH OR WITHOUT BACKING - API MATERIALS ARE NOT APPROVED FOR USE IN ANSI B31.3 SYSTEMS (IN-PLANT)

Figure 16: Shielded Metal Arc Welding Procedure