ALLAN EDWARDS

BURST TEST OF A 24” LEAKING PIPE REPAIRED WITH A TYPE B SLEEVE







100101-RP01-Rev0-042219

APRIL 2019

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 an Allan Edward's (AE's) Type-B manufactured repair steel sleeves. The purpose of this test was to validate and generate a record of the AE repair sleeve performance. This test program involved installation of a Type-B repair sleeve supplied by Allan Edwards used to repair a 24-inch OD x 0.375-inch WT, Grade X65 pipe sample following by a burst test. The 24-inch OD test sample was 10-feet long and had nine (9) ½-inch thru-holes drilled around the pipe circumference beneath the Type-B repair. The presence of these holes ensured that the entire repair sleeve was pressurized during the burst test.

The following sections of this report document the test setup and procedure (including installation of the repair sleeve), burst test results including strain gage measurements, and a short discussion of the results. An appendix is attached to this report including the weld procedure used to install the repair sleeve, mill test reports (MTRs) for the repair sleeve material, and mechanical test results for the test pipe.

2.0 TEST SETUP AND PROCEDURE

ADV obtained the 24-inch OD x 0.375-inch WT, Grade X65 pipe used for the test sample. AE supplied the Type-B repair sleeve, which was 24-inch long x 0.375-inch thick ASTM A572 Grade 65 plate. AE fabricated the repair sleeve using A572 plate. Table 1 lists the mechanical properties (yield and tensile strength) of the carrier pipe and repair sleeve plate. Material property information for both the sleeve and carrier pipe are also contained in the appendix of this report.

Table 1: Mechanical properties of carrier pipe and repair sleeve

Component	Material Grade	Yield (ksi)	Tensile (ksi)
Carrier Pipe	API 5L Grade X65	84.2	98.0
Repair Sleeve	ASTM A572 Grade 65	72.9	84.3

PT Welding of Tomball, TX fabricated the pipe sample and installed the Type B repair sleeve. Prior to the sleeve installation, nine (9) ½-inch thru-holes were installed into the carrier pipe. Figure 1 illustrates the hole installation. The nine (9) holes were spaced circumferentially around the pipe as shown in Figure 2 to ensure the entire repair sleeve was pressurized during the burst test. Three (3) holes were installed at 0° (12 o-clock position), two (2) holes at 180°, (2) holes 4 inches above 90°, and (2) holes 4 inches below 270°. The seam welds for the Type-B sleeve were installed at 90° and 270°. The weld procedure for installation of the repair sleeve is included in the appendix attached to this report.



Figure 1: Installation of ½-inch holes into carrier pipe

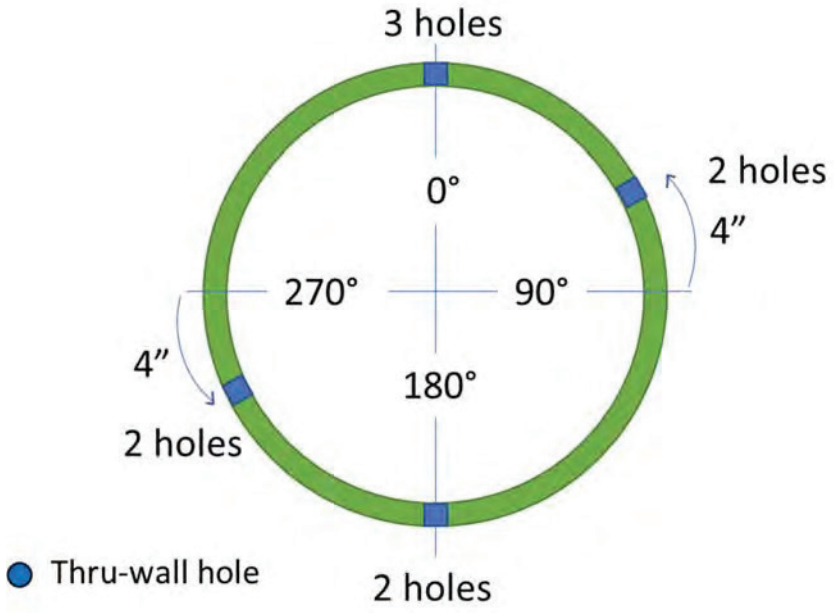


Figure 2: Locations of the nine (9) ½-inch thru-holes in carrier pipe

ADV installed two (2) biaxial strain gages on the carrier pipe and three (3) biaxial strain gages the repair sleeve to monitor strains during testing. Figure 3 illustrates the locations of the strain gages which included:

- One (1) biaxial gage on the carrier pipe 24 inches from sample center (center of sleeve)
- One (1) biaxial gage on the carrier pipe 48 inches from sample center (center of sleeve)
- Three (3) biaxial gages on repair sleeve at 0°, 180°, and 4 inches above the sleeve seam weld at 90° (positioned over the holes installed in the carrier pipe).

Following instrumentation, the test sample was installed into ADV's test chambers for burst testing. This chamber provides safety for those completing and witnessing the test. The completed sample fabrication and test setup are shown in Figure 4. The following procedure was used to complete the burst test:

1. Pressurize sample at approx. 10-15 psig/sec and perform the following 5-minute holds:
    a. 1,469 psig (72% SMYS) +/- 50 psig.
    b. 2,041 psig (100% SMYS) +/- 50 psig.
2. Pressurize sample to failure following the last hold.
3. Photograph failure surface and record failure mode.

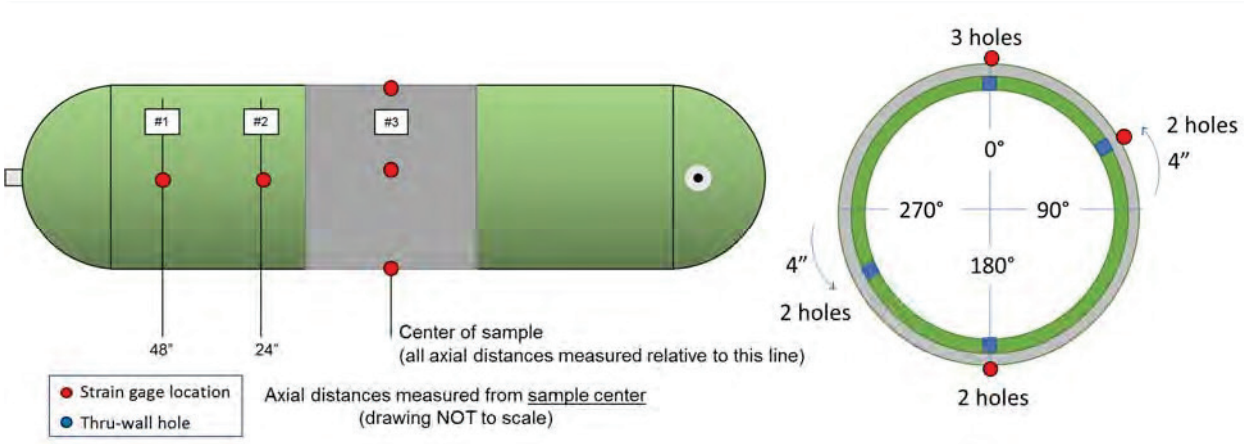


Figure 3: Test sample instrumentation locations



Figure 4: Test sample installed in ADV test chamber prior to burst testing

3.0 TEST RESULTS AND DISCUSSION

The test sample failed at a pressure of 2,578 psig (126% SMYS). Figure 5 displays the internal pressure vs. elapsed time for the burst test. The hoop strains vs. internal pressure in Figure 6 indicate yielding in the repair sleeve prior to the carrier pipe, which was expected based on the material properties in Table 1. Although the carrier pipe is Grade X65, it has a higher yield strength of 84.2 ksi that corresponds to a predicted yield pressure of 2,631 psig. The linear hoop strain results measured by the base pipe gages in Figure 6 confirm this higher yield strength. The repair sleeve reached its proportional limit at approximately 2,300 psig which is in-line with the predicted yield pressure of 2,280 psig based on the 72.9 ksi yield strength for the A572 Gr. 65 plate. The repair sleeve reached a hoop strain of approximately 1.8% to 2.0% prior to failure. The failure occurred in the seam weld of the Type-B repair sleeve as shown in Figure 7 and Figure 8. The backing strip of the repair sleeve seam weld pushed between the two sleeves halves and is visible in both figures.

This burst test has successfully demonstrated that the Type-B repair sleeve manufactured and supplied by Allan Edwards can reinforce a leaking defect past the maximum allowable design pressure of the carrier pipe with a considerable safety margin. The failure occurred at 2,578 psig (126% SMYS), which exceed the maximum allowable operating pressure of 1,470 psig (72% SMYS) for this 24-inch OD x 0.375-inch WT, Grade X65 pipe by a factor of 1.75. The failure occurred in the seam weld of the repair sleeve.

In this instance, the carrier pipe had a significantly higher yield and tensile strength than the minimum limits for an API 5L Grade X65 pipe (84.2 ksi and 98 ksi, respectively). The repair sleeve for this carrier pipe would have to be oversized on both wall thickness and material grade to force failure outside of the repair sleeve, as well as selection of a higher strength weld material. However, this oversizing is unnecessary as the repair sleeve was designed to contain a leaking defect in a Grade X65 carrier pipe, which was successfully demonstrated in this test. In some regards, having a higher strength carrier pipe was advantageous from a testing standpoint as it allowed Allan Edwards' sleeves to be pushed well beyond any pressure condition that would actually occur in service.

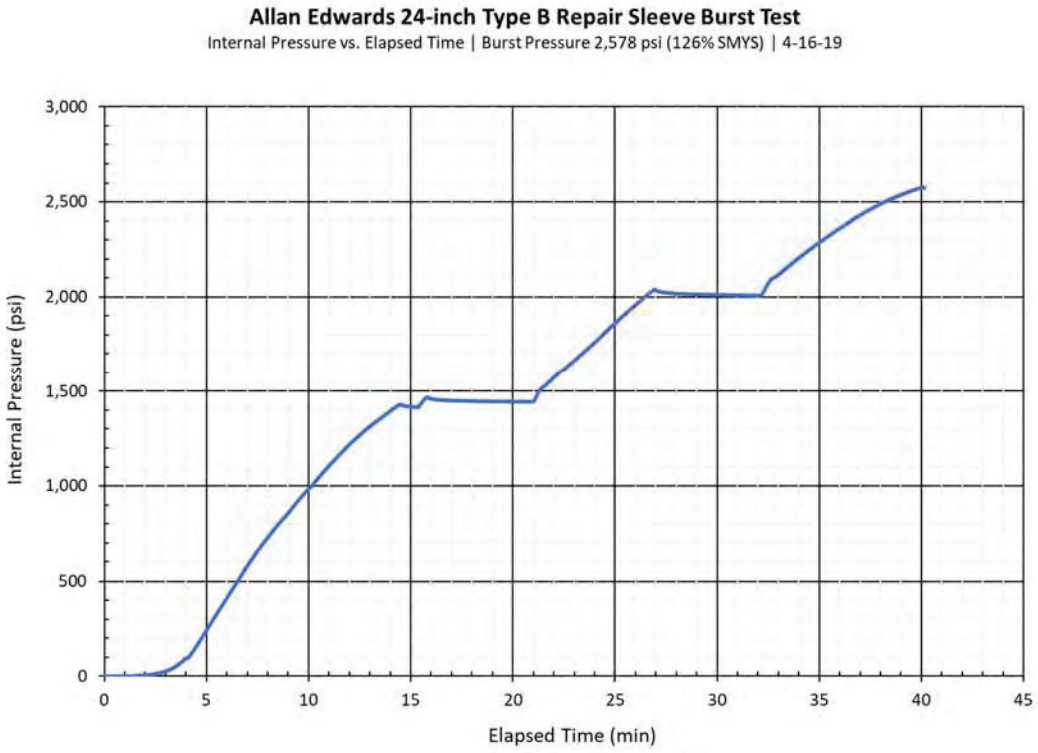


Figure 5: Internal pressure vs. elapsed time for 24-inch Type-B repair sleeve burst test

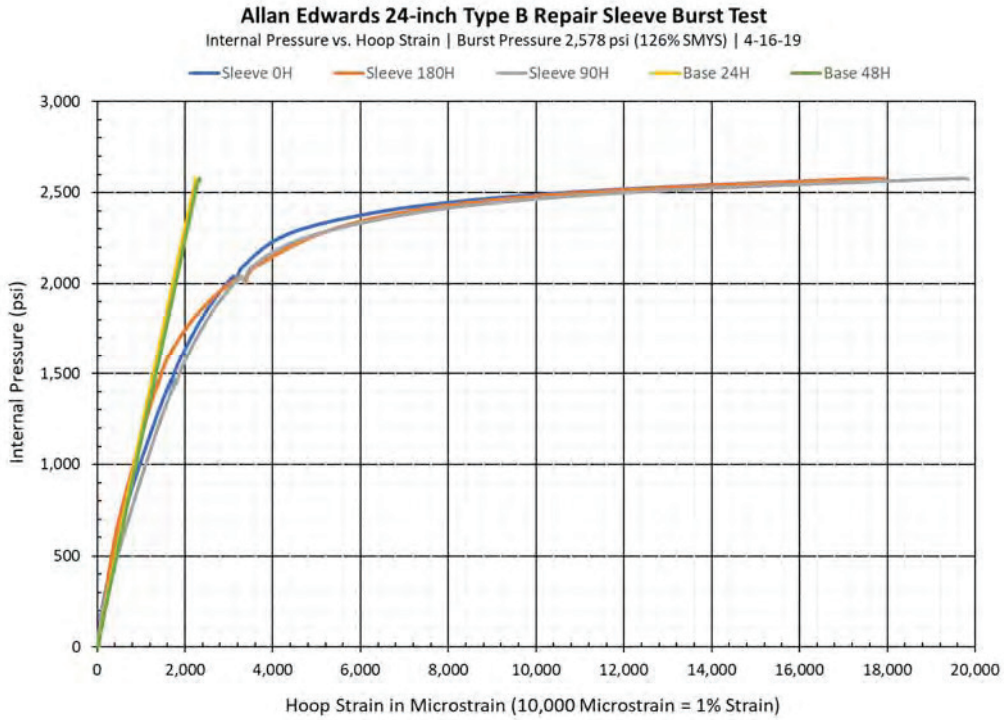


Figure 6: Internal pressure vs. hoop strain for24-inch Type-B burst test
(strain in microstrain, 10,000 microstrain = 1% strain)

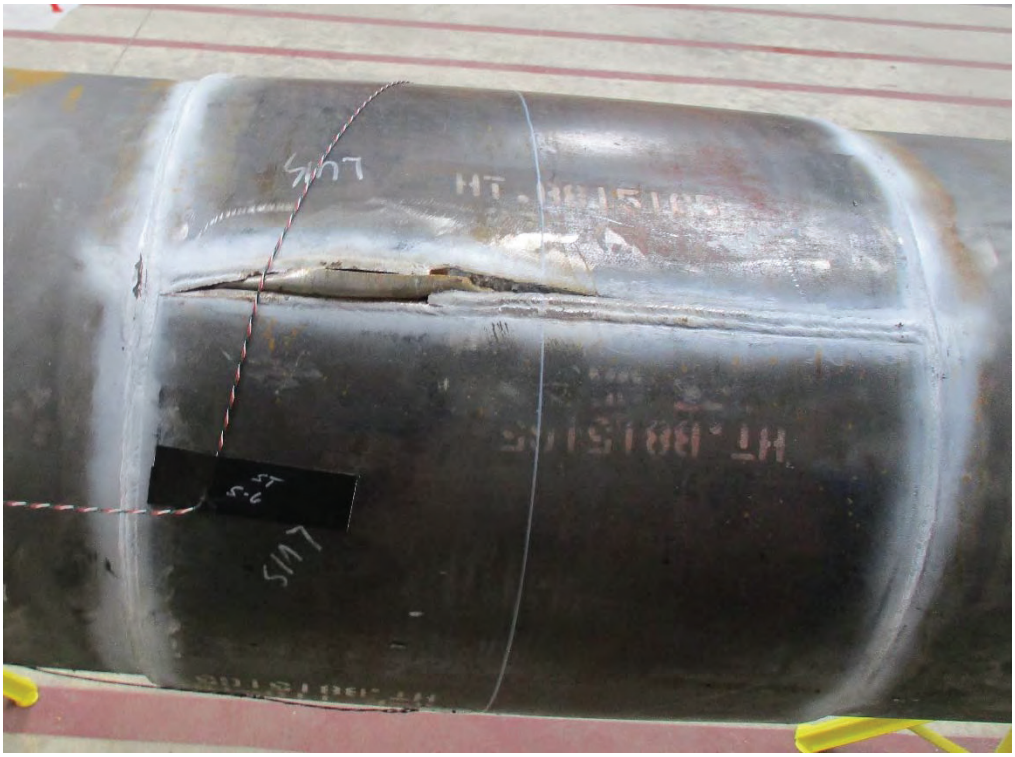


Figure 7: Burst test failure location – failure pressure of 2,578 psig (126% SMYS)



Figure 8: Close-up of burst test failure location – failure pressure of 2,578 psig (126% SMYS)

APPENDIX

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)

Allan Edwards, Inc
6468 N. Yale Ave.
Tulsa, OK 74117

Voice: 918-583-7184
Fax: 918-583-8423

Sales Order Picking List

Sales Order Number: 119-160
Sales Order Date: Apr 2, 2019
Ship By: Apr 4, 2019
Page: 1

Sold To:
Allan Edwards, Inc.
P. O. Box 9457
Tulsa, OK 74157

Ship To:
PT Welding & Fab
c/o Allan Edwards
20500 Calvert Road
Tomball, TX 77377

MTR ENCLOSED

Customer ID	PO Number	Sales Rep Name
ALLAN EDWARDS, INC.	ETC Test Project	Brett, Tom
Customer Contact	**Shipping Method**	**Payment Terms**
	Prepay & Add	Net 30 Days

Quantity	Item	Description	Shipped Prior	This Shipment
10.00		10' (1 pc) reg. half sole to fit 24" OD pipe, 3/8" w/t, A572 GR65 plate, min. yield 65,000 psi, 10' long, bevel long edges 30°. Furnish with 1 pc backing strip 1-1/4" x 16GA, 10' long, precrimped. 1 Bundle = 1 pc of 24" sleeve. 1 Board = 1 pc backing strip. WT: 500 lbs.		10' (1 pc)

CERTIFICATE OF COMPLIANCE

Customer P.O. No.: **ETC Test Project**
Customer P.O. Date: **4/2/19**

A-E Job No.: **119-160**
A-E Job Date: **4/2/19**

SOLD TO: **ALLAN EDWARDS**

SHIP TO: **PT Welding & Fab**
c/o Allan Edwards
28500 Calvert Road
Tomball, TX 77377

ITEM NO.	HEAT NO.	MATERIAL DESCRIPTION	MFR or SUPPLIER
1	B815165	ASTM A572 GR65 PLATE; 3/8" x 72" x COIL	Steel Dynamics
2			
3			
4			
5			

CHEMICAL ANALYSIS

ITEM NO.	HEAT NO.	Carbon	Mang	Phos	Sulphur	Silicon	Copper	Nickel	Chrom	Moly	Van	Cb	Alum
1	B815165	0.050	1.170	0.012	0.002	0.040	0.110	0.040	0.050	0.010	0.037	0.000	0.025
2	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

ITEM	HEAT		
1	B815165	CARBON EQUIVALENT (Long Formula) =	0.274
2	0	CARBON EQUIVALENT (Long Formula) =	0.000
3	0	CARBON EQUIVALENT (Long Formula) =	0.000
4	0	CARBON EQUIVALENT (Long Formula) =	0.000
5	0	CARBON EQUIVALENT (Long Formula) =	0.000

BASE METAL TEST RESULTS

ITEM NO.	HEAT NO.	American Yield Strength	American Tensile Strength	European MPA Yield	European MPA Tensile
1	B815165	72,900	84,300	-	-
2	0	-	-	-	-
3	0	-	-	-	-
4	0	-	-	-	-
5	0	-	-	-	-

ORDER / SHIPMENT DESCRIPTION

ALLAN EDWARDS **ETC Test Project** **A-E Job # 119-160**

10' (1 pc) reg. half sole to fit 24" OD pipe, 3/8" w/t A572 GR65 plate, min. yield 65,000 psi, 10' long, bevel long edges 30°.
Furnish with 1 pc backing strip 1-1/4" x 16GA, 10' long, precrimped.

BL

Bryan Laboratory, Inc.

Metallurgical Consultation - Inspection - Testing
Analytical Services - Failure Analysis
6919 Almeda Road (77021)
P. O. Box 300366
Houston, TX 77230-0366
Telephone 713/747-7470 800/922-7470 Fax 713/747-7477

REPORT

Lab. No. B1L8-0217 **March 13, 2018**

ON: Steel Pipe

TO: Mechanical Testing Services, LLC
20530 Stokes Road
Waller, Texas 77484-8804
Attention: Mr. Corey Duncan

IDENTITY: Purchase Order Number MTS-2571; Two samples identified as 24" O.D., 0.250" W.T., marked MTS-2531, X52, HT# SU83946 (our A) and 24" O.D., 0.375" W.T., marked MTS-2531, X65, HT# 746104 (our B)

CHEMICAL ANALYSIS

Sample	-	A	B
Carbon, %	-	0.07	0.05
Manganese, %	-	0.99	1.55
Phosphorus, %	-	0.020	0.008
Sulfur, %	-	0.003	0.003
Silicon, %	-	0.20	0.19
Chromium, %	-	0.03	0.14
Nickel, %	-	0.02	<0.01
Molybdenum, %	-	<0.01	0.11
Copper, %	-	0.02	<0.01
Aluminum, %	-	0.03	0.04
Vanadium, %	-	<0.01	<0.01
Titanium, %	-	<0.01	0.02
Niobium, %	-	0.02	0.05
Boron, %	-	<0.001	<0.001

TENSION TESTS

Specimens	-	Transverse, 1-1/2" wide reduced sections, 90° from the weld	
Sample	-	A	B
Yield Strength*, psi	-	56,500	84,200
Tensile Strength, psi	-	75,600	98,000
Elongation in 2", %	-	37.0	31.5

*At 0.5% total extension

Respectfully submitted,
BRYAN LABORATORY, INC.

Signature on Original Only

Christopher M. Corbin

/cd

NOTICE
The samples and/or specimens remaining from these tests or analyses will be discarded seven days after the date of this report, unless arrangements are made to the contrary.