

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



November 24, 2020

MATERIALS LABORATORY FACTUAL REPORT

Report No. 19-054

A. ACCIDENT INFORMATION

Place : Fort Worth, Texas
Date : April 24, 2019
Vehicle : DOT-117R100W tank car UTLX 209301
NTSB No. : RRD19FR007
Investigator : Paul Stancil

B. COMPONENTS EXAMINED

1. UTLX 209301 reference shell plate coupon 40" x 40" x 7/16" from the right-center side of Shell 2 (Ring 2).

C. DETAILS OF THE EXAMINATION

UTLX 209301, a derailed specification DOT-117R100W tank car transporting denatured ethanol became punctured, released product and was exposed to a pool fire. The tank car was originally a specification DOT-111A and was retrofitted in 2016 to DOT-117R by the addition of a jacket, thermal protection, and head shields. The tank car was initially used in crude oil transportation and was repurposed to ethanol transportation. The purpose of this laboratory investigation is to determine the compositional and mechanical properties of a shell plate coupon from the right-center side of Shell 2 (Ring 2).

Tank car UTLX 209301 is fabricated from non-normalized steel AAR TC-128 Gr.B (Appendix M from Association of American Railroads, Safety and Operations, Manual of Standards and Recommended Practices, Section C-111, Specification for Tank Cars, October 2003).

COMPOSITIONAL TESTING

The chemical composition on a sample from the Shell 2 plate coupon was determined in accordance with ASTM A20. All elements greater than 0.01% by weight were identified, including: carbon, manganese, phosphorus, sulfur, silicon, vanadium, copper, nickel, chromium, molybdenum, aluminum, niobium, titanium, boron, nitrogen, and tin. The results are presented in Appendix 1 and summarized in Table 1.

Table 1 Compositional Analysis of UTLX 209301 Shell 2 Plate Coupon

AAR TC-128 Gr.B compositional limits		
Element	Product analysis	UTLX 209301
Carbon (max %)	0.26	0.19
Manganese (%)	1.00 to 1.70	1.17
Phosphorous (max %)	0.025	0.006
Sulfur (max %)	0.015	0.006
Silicon (%)	0.13 to 0.45	0.34
Vanadium (max %)	0.084	0.02
Copper (max %)	0.035	0.01
Nickel (max %)	No limit	0.01
Chromium (max %)	No limit	0.16
Molybdenum (max %)	No limit	0.04
Aluminum (max %)	0.015 to 0.060	0.04
Niobium (max %)	Per ASTM A20	<0.001
Titanium (max %)	0.020	0.003
Boron (max %)	0.0005	0.0017
Nitrogen (max %)	0.012	0.004
Tin (max %)	0.020	<0.01
Carbon Equivalent, CE (max%)	0.55	0.43*
Cu+Ni+Cr+Mo (max %)	0.65	0.22
Nb+V+Ti (max %)	0.11	0.024
Ti/N (max ratio)	4	0.75

*ASTM A6 S31.2

MECHANICAL TESTING

Longitudinal and transverse uniaxial tensile tests were performed on the Shell 2 plate coupon (three replicates each) using two different testing laboratories. The tensile testing was conducted in accordance with ASTM A370 using full thickness standard plate-type specimens with flat faces in the as-received condition. Paint was removed from the surface without altering the underlying material. The longitudinal specimens were cold flattened according to ASTM A370 Annex A2.2.3 with no subsequent heat treatment. The following properties were measured.

1. Yield strength at 0.5% extension under load method
2. Yield strength at 0.2% offset method
3. Ultimate tensile strength
4. Percent elongation in 2 inches
5. Percent elongation in 8 inches

Table 2 Uniaxial Tensile Properties of UTLX 209301 Shell 2 Plate Coupon

Orientation	Replicate	Width (inch)	Thickness (inch)	Area (inch ²)	Yield strength 0.2% (psi)	Yield strength 0.5% EUL (psi)	Ultimate tensile strength (psi)	Elongation in 2 inch (%)	Elongation in 8 inch (%)	Reduction in area (%)
Lehigh Testing Laboratories—8-inch gage length test bars										
Longitudinal	1	1.510	0.451	0.6810	50300	51600	77400	41	22	52
	2	1.515	0.450	0.6818	51600	51800	77500	39	23	47
	3	1.508	0.450	0.6786	51000	51900	77700	46	25	53
Transverse	1	1.515	0.443	0.6711	54700	54600	76500	48	23	42
	2	1.512	0.443	0.6698	54600	54600	76700	48	24	47
	3	1.521	0.443	0.6738	54400	54400	76200	45	23	48
Engineering Systems, Inc.—2-inch gage length test bars (retest 1)										
Longitudinal	1	1.508	0.448	0.6756	49600	50000	78500	39	-	-
	2	1.508	0.450	0.6786	49400	50000	78500	38	-	-
	3	1.508	0.450	0.6786	50500	50000	78500	38	-	-
Transverse	1	1.508	0.444	0.6696	54500	53500	78500	36	-	-
	2	1.509	0.443	0.6685	55500	53500	78500	37	-	-
	3	1.509	0.440	0.6640	56000	53500	78500	37	-	-
Engineering Systems, Inc.—8-inch gage length test bars (retest 2)										
Longitudinal	1	1.502	0.455	0.6834	48500	48800	76500	44	22	-
	2	1.503	0.455	0.6839	49700	49700	76500	44	22	-
	3	1.503	0.454	0.6824	49000	49300	76500	42	22	-
Transverse	1	1.501	0.438	0.6574	54500	53500	77000	42	23	-
	2	1.502	0.454	0.6819	53500	53500	77500	44	24	-
	3	1.502	0.454	0.6819	53500	52000	78000	42	24	-
Specification requirements										
Tensile requirements for AAR TC120 Gr. B high-strength carbon manganese steel plate					50000 minimum	-	81000 to 101000	22	16	-

Michael Budinski
Chief, Materials Laboratory Division

Appendix 1—Analysis Reports



Lehigh Testing Laboratories

308 WEST BASIN ROAD • P.O. BOX 903 • NEW CASTLE, DELAWARE 19720
(302) 328-0500 • FAX (302) 328-0417

TEST REPORT

NATIONAL TRANSPORTATION SAFETY BOARD
ATTENTION: MICHAEL BUDINSKI
490 L'ENFANT PLAZA EAST SW
WASHINGTON, DC 20594

DATE: September 18, 2019
PO NO: **Scope of Work Dated 9/3/19**
LEHIGH NO: **D-46-36**
PAGE: 1 of 1

MATERIAL: NON-NORMALIZED STEEL AAR TC-128 GR B
SAMPLE DESIGNATION: (1) SAMPLE: 40" X 40" X 7/16" RAIL TANK CAR SHELL WALL
REF: RRD19FR007

CHEMICAL ANALYSIS (%)

Carbon	0.19
Sulfur	0.006
Manganese	1.17
Phosphorus	0.006
Silicon	0.34
Vanadium	0.02
Copper	0.01
Nickel	0.01
Chromium	0.16
Molybdenum	0.04
Aluminum	0.04
Niobium	<0.001
Titanium	0.003
Boron	0.0017
Tin	<0.01
Nitrogen	0.004

Results are for information only.

Procedure: *QA-CH-P-048 Rev 1 (Leco C&S)*
QA-CH-P-018 Rev 5 (OES)
QA-CH-P-122 Rev 1 (Leco N)

Lehigh Testing Laboratories

Peter M. Engelgau

Peter M. Engelgau, Principal Chemist

This certificate of report shall not be reproduced, except in full, without written approval of Acuren Inspection, Inc. dba Lehigh Testing Laboratories. Testing relates only to item(s) tested. The recording of false, fictitious or fraudulent statements or entries in this document may be punishable as a felony under Federal Statutes. Decision Rule: Unless otherwise specified, or inherent in the specification, conformance to requirements is based on reported values or statistically derived value (median or mean) for replicate measurements, even if uncertainty (error band) of the value falls outside of the range.



Lehigh Testing Laboratories

308 WEST BASIN ROAD • P.O. BOX 903 • NEW CASTLE, DELAWARE 19720
(302) 328-0500 • FAX (302) 328-0417

TEST REPORT

NATIONAL TRANSPORTATION SAFETY BOARD
ATTENTION: MICHAEL BUDINSKI
490 L'ENFANT PLAZA EAST SW
WASHINGTON, DC 20594

DATE: September 18, 2019
PO NO: **Scope of Work Dated 9/3/19**
LEHIGH NO: **D-46-36**
PAGE: 1 of 1

MATERIAL: NON-NORMALIZED STEEL AAR TC-128 GR B
SAMPLE DESIGNATION: (1) SAMPLE: 40" X 40" X 7/16" RAIL TANK CAR SHELL WALL
REF: RRD19FR007

MECHANICAL PROPERTIES (Per ASTM A370-18)

	<u>LONGITUDINAL TENSILES</u>			<u>TRANSVERSE TENSILES</u>		
	<u>L-1</u>	<u>L-2</u>	<u>L-3</u>	<u>T-1</u>	<u>T-2</u>	<u>T-3</u>
Width (inches):	1.510	1.515	1.508	1.515	1.512	1.521
Thickness (inches):	0.451	0.450	0.450	0.443	0.443	0.443
Area (square inches):	0.6810	0.6818	0.6786	0.6711	0.6698	0.6738
Yield Strength (psi): 0.2% offset:	50,300	51,600	51,000	54,700	54,600	54,400
Yield Strength (psi): 0.5% EUL:	51,600	51,800	51,900	54,600	54,600	54,400
Ultimate Tensile Strength (psi):	*77,400	*77,500	*77,700	*76,500	*76,700	*76,200
Elongation (%) in 2":	41	39	46	48	48	45
Elongation (%) in 8":	22	23	25	23	24	23
Reduction of Area (%):	52	47	53	42	47	48

*Based on the above testing this material **does not meet** the tensile requirements of AAR TC-128 Gr B.

Stress Strain Charts Attached.

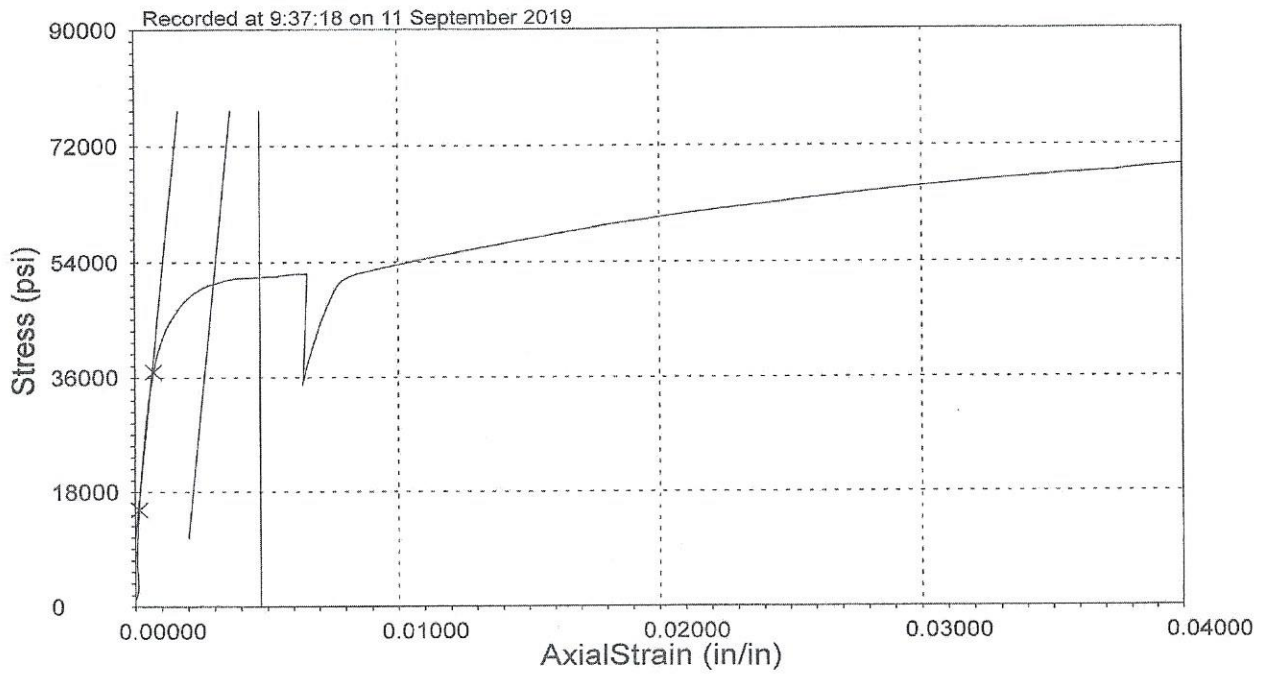
Lehigh Testing Laboratories

Kenneth M. Petito

Kenneth M. Petito Supvr., Mechanical Testing

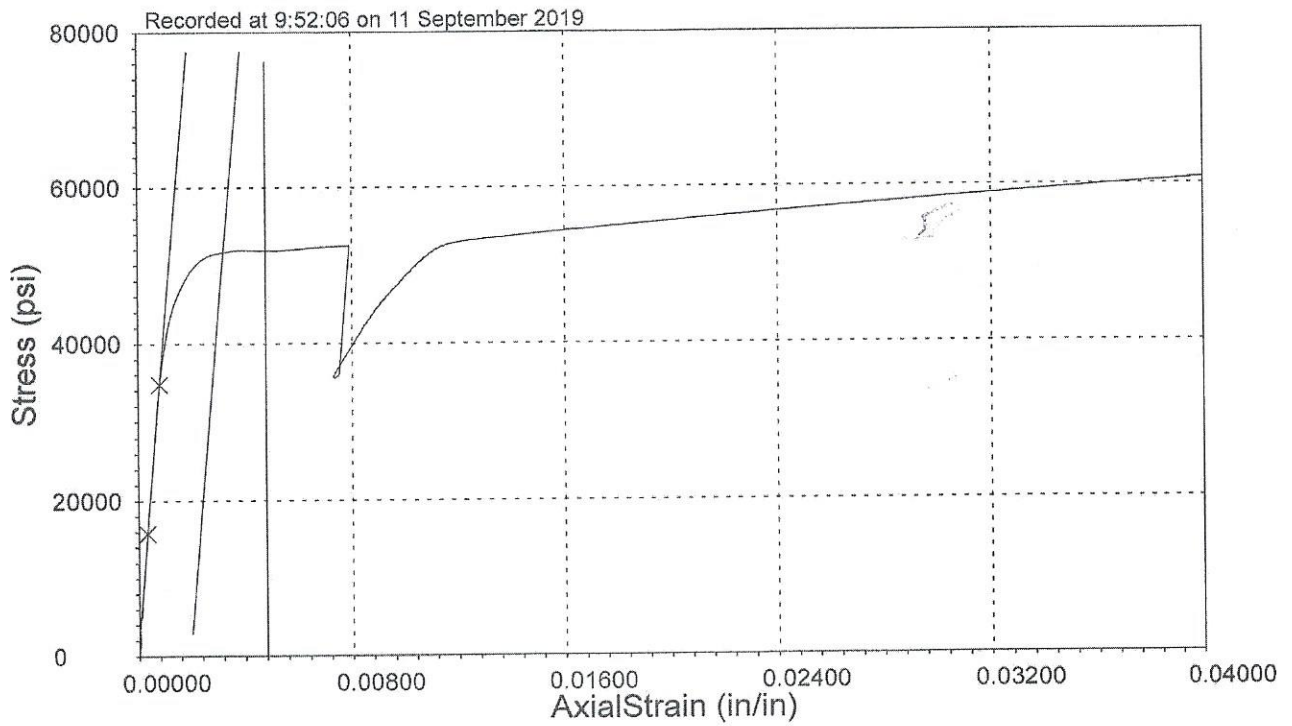
This certificate of report shall not be reproduced, except in full, without written approval of Acuren Inspection, Inc. dba Lehigh Testing Laboratories. Testing relates only to item(s) tested. The recording of false, fictitious or fraudulent statements or entries in this document may be punishable as a felony under Federal Statutes. Decision Rule: Unless otherwise specified, or inherent in the specification, conformance to requirements is based on reported values or statistically derived value (median or mean) for replicate measurements, even if uncertainty (error band) of the value falls outside of the range.

Stress (psi) versus AxialStrain (in/in)



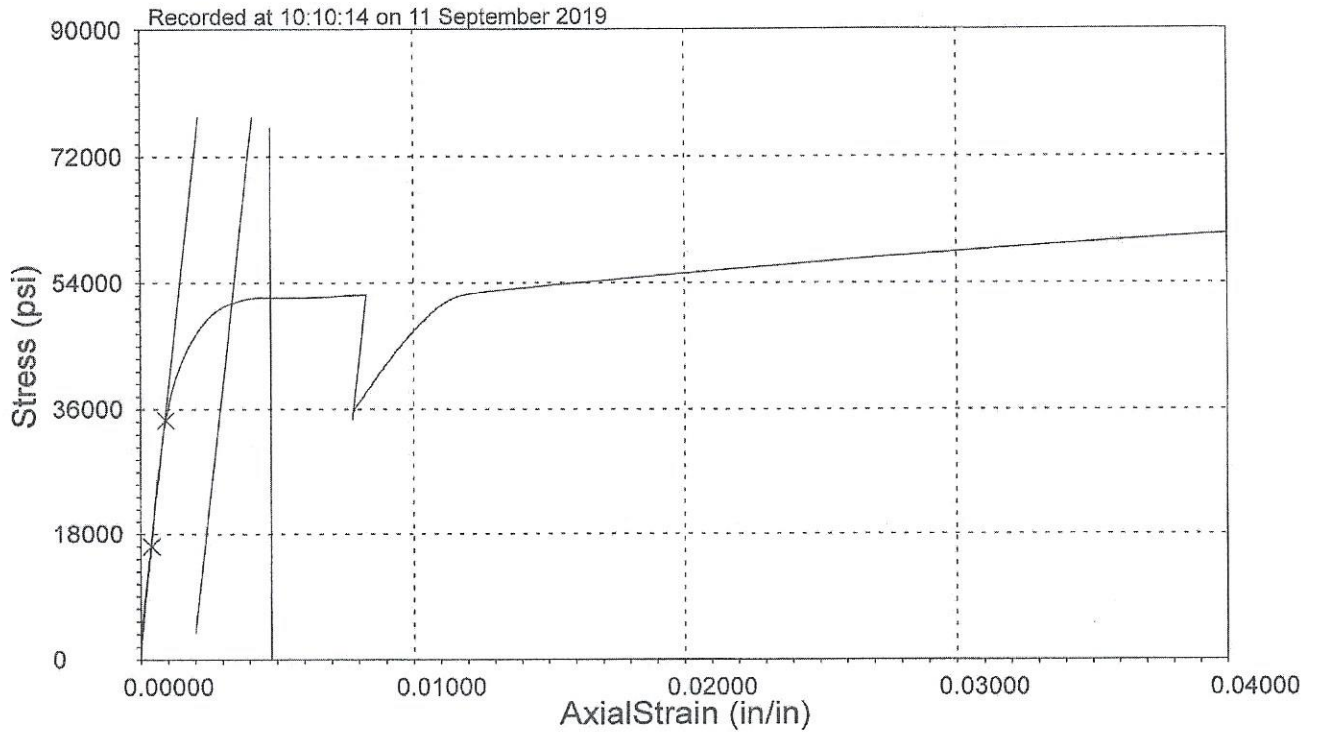
LONGITUDINAL TENSILE
"L-1"

Stress (psi) versus AxialStrain (in/in)



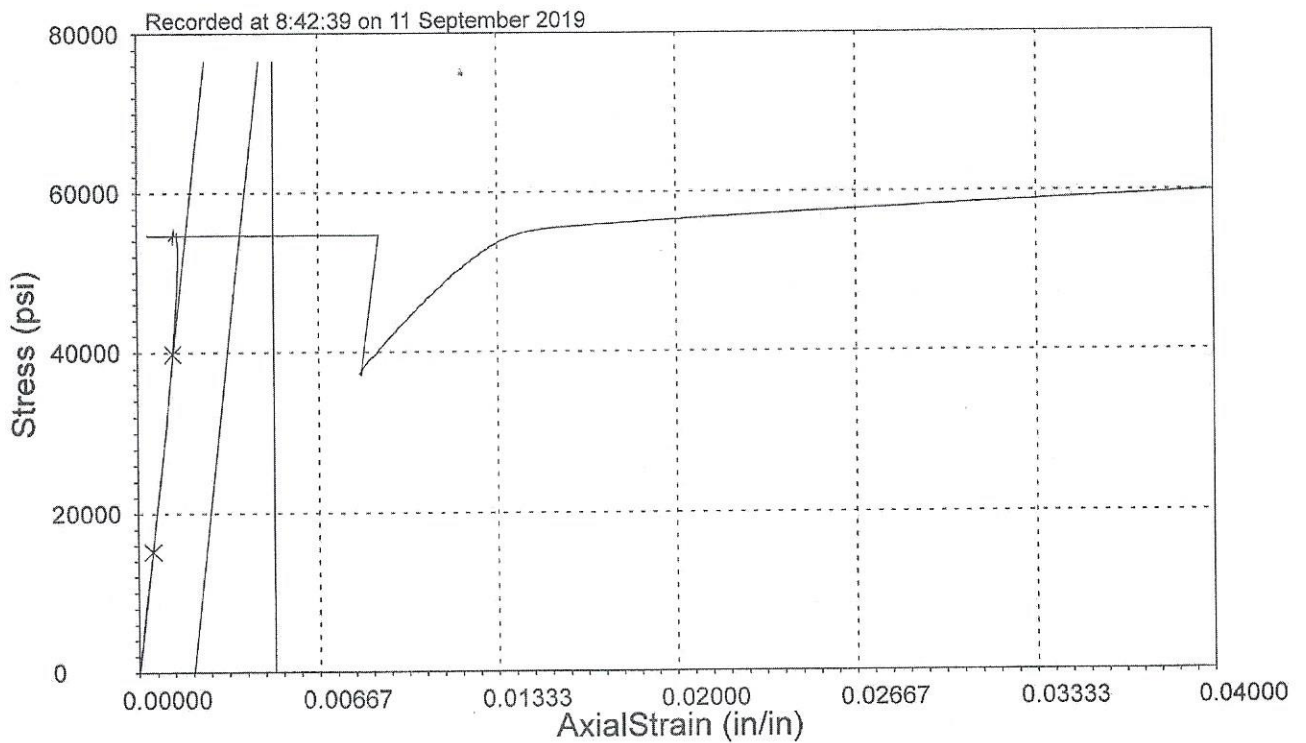
LONGITUDINAL TENSILE
"L-2"

Stress (psi) versus AxialStrain (in/in)



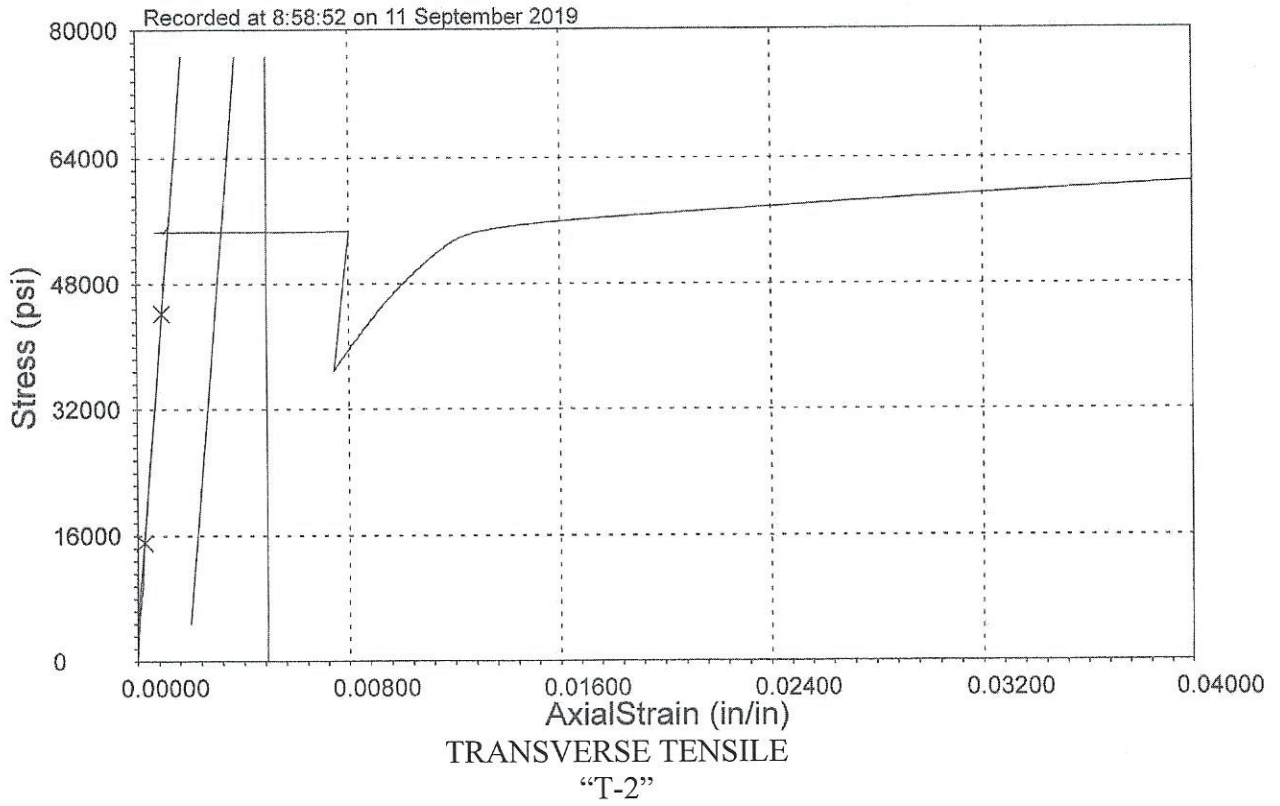
LONGITUNDINAL TENSILE
"L-3"

Stress (psi) versus AxialStrain (in/in)

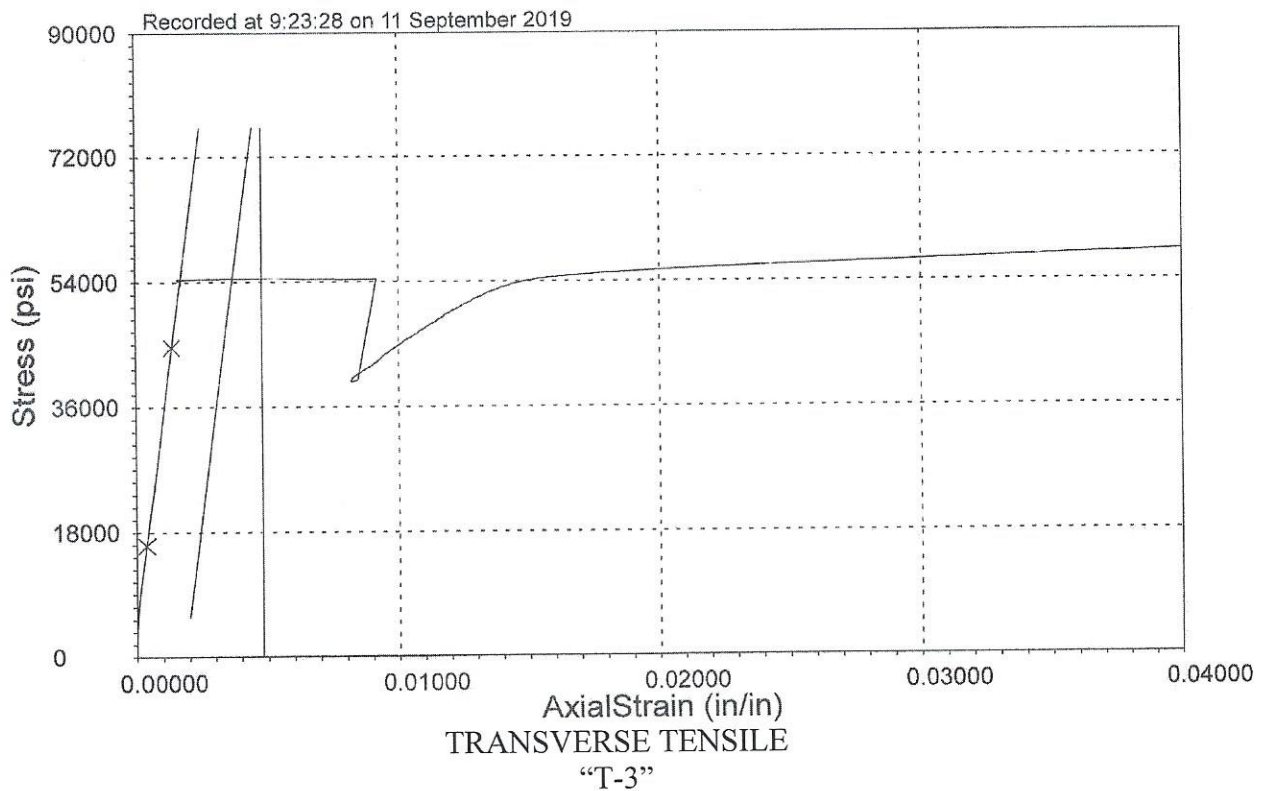


TRANSVERSE TENSILE
"T-1"

Stress (psi) versus AxialStrain (in/in)



Stress (psi) versus AxialStrain (in/in)





Certified Test Report

CLIENT:	Engineering Systems Inc.	CLIENT #:	1140
ADDRESS:	2355 Polaris Ln N, Suite 120	PROJECT #:	12136
CITY, STATE:	Plymouth, MN 55447	PURCHASE ORDER #:	79153H
REPORT DATE:	September 17, 2020	CONTACT:	Ron Parrington

Material Description: 16" x 28" x 7/16" Section of AAR TC-128 Gr. B Rail Tank Car Shell
 Specification: AAR CIII, Appendix M, TC-128 Gr. B

TENSILE TEST – ASTM A370

Specimen ID	Dimensions (inches)	Area (in. ²)	Yield Strength (psi) 0.2% Offset 50,000 Min.	Yield Strength (psi), 0.5% EUL	Ultimate Tensile Strength (psi) 81,000 – 101,000	Elongation after Fracture, % (2 in. Gage) 22 Min.
Longitudinal-1	1.508 x 0.448	0.6756	49,600	50,000	78,500	39
Longitudinal-2	1.508 x 0.450	0.6786	49,400	50,000	78,500	38
Longitudinal-3	1.508 x 0.450	0.6786	50,500	50,500	78,500	38
Transverse - 1	1.508 x 0.444	0.6696	54,500	53,500	78,500	36
Transverse - 2	1.509 x 0.443	0.6685	55,500	53,500	78,500	37
Transverse - 3	1.509 x 0.440	0.6640	56,000	53,500	78,500	37

*Summary of Testing: Reported results pertain only to samples submitted for testing.
 The samples meet / do not meet the specified requirement.*

Reviewed By: Reed Pruitt, CWI
 ESI, Laboratory and Industrial Services



Certified Test Report

CLIENT:	Engineering Systems Inc.	CLIENT #:	1140
ADDRESS:	2355 Polaris Ln N, Suite 120	PROJECT #:	12136
CITY, STATE	Plymouth, MN 55447	PURCHASE ORDER #:	79153H
REPORT DATE:	November 5, 2020	CONTACT:	Ron Parrington

Material Description: Customer Supplied Sections of AAR TC-128 Gr.B Rail Tank Car Shell
 Specification: AAR TC-128 Gr. B

TENSILE TEST – ASTM A370

Specimen ID	Dimensions (inches)	Area (in. ²)	Yield Strength (psi) 0.2% Offset 50,000 Min.	Yield Strength (psi), 0.5% EUL	Ultimate Tensile Strength (psi) 81,000 – 101,000	Elongation after Fracture, % (2 in. Gage) 22 Min.	Elongation after Fracture, % (8 in. Gage) 16 Min.
Longitudinal-1	1.502 x 0.455	0.6834	48,500	48,800	76,500	44	22
Longitudinal-2	1.503 x 0.455	0.6839	49,700	49,700	76,500	44	22
Longitudinal-3	1.503 x 0.454	0.6824	49,000	49,300	76,500	42	22
Transverse - 1	1.501 x 0.438	0.6574	54,500	53,500	77,000	42	23
Transverse - 2	1.502 x 0.454	0.6819	53,500	53,500	77,500	44	24
Transverse - 3	1.502 x 0.454	0.6819	53,500	52,000	78,000	42	24

*Summary of Testing: Reported results pertain only to samples submitted for testing.
 The samples meet / do not meet the specified requirement.*

Reviewed By: Reed Pruitt, CWI
 ESI, Laboratory and Industrial Services