



Static and Dynamic Testing of 0.5-in Monostrand Post-Tensioning Anchorages

AC303 Testing of Splice Coupler – 0.5-in with 1.2-in Three-Piece Wedges



December 16, 2022

WJE No. 2021.3293

PREPARED FOR:

Post-tensioned Products, Inc.

P.O. Box 1969

Callahan, Florida 32011

PREPARED BY:

Wiss, Janney, Elstner Associates, Inc.

330 Pfingsten Road

Northbrook, Illinois 60062

847.272.7400 tel



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Post-tensioned Products, Inc.

A handwritten signature in black ink, reading "John Pearson".

John Pearson
Project Manager

A handwritten signature in black ink, reading "Brian Easton".

Brian Easton
Project Engineer

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INTRODUCTION

At the request of Post-Tensioned Products, Inc. (PTP), the firm of Wiss, Janney, Elstner Associates, Inc. (WJE) conducted testing services following the procedures outlined in the International Code Council-Evaluation Services (ICC-ES) Acceptance Criteria AC303, *Acceptance Criteria for Post-Tensioning Anchorages and Couplers of Prestressed Concrete*. Testing summarized in this report was performed using a coupler configuration of a Splice Coupler – 0.5-in with a 1.2-in three-piece wedge.

Scope of Work

The scope of work consisted of performing tests by WJE in accordance with AC303 for the Splice Coupler – 0.5-in with a 1.2-in three-piece wedge. All testing utilized Grade 270 low relaxation 7-wire strand. The following tasks were performed as part of the scope of work:

- Random sampling of the strand anchorages to be tested from the manufacturer's supply (AC303 Section 2.4)
- Performing static tensile tests to determine the breaking strength of the strand (AC303 Section 3.1)
- Performing static load tests of strand with the use of anchorages (AC303 Sections 3.2 and 4.1)
- Performing fatigue load tests of strand with the use of anchorages (AC303 Sections 3.3 and 4.2)

Test results were compared to the requirements stated in AC303 as well as the requirements of American Concrete Institute (ACI) ACI 318-19, Section 25.8.1, ACI 423.7-14, Section 9.4 and Section 9.5, and Post-Tensioning Institute (PTI) PTI M10.2-17, Section 2.5.

BASIC PRODUCT INFORMATION

Product Description

The Splice Coupler – 0.5-in with a 1.2-in three-piece wedge and 0.5-in. diameter strand consist of a steel coupler and three-piece wedge that gripped the strand (Figure 1). The Splice Coupler – 0.5-in with a 1.2-in three-piece wedge can be used for connecting 0.5-in, 7-wire strand ends. Appendix A contains drawings for the coupler and wedges used for testing the Splice Coupler – 0.5-in with a 1.2-in three-piece wedge.

Product Sampling

All of the products for the testing program were sampled by WJE from samples sent to WJE by PTP. The test sample dimensions were measured and compared to available drawings. The measured dimensions generally agreed with the provided drawings (Appendix A).

TEST METHODS AND REQUIREMENTS

All static and fatigue testing of the strand and coupler were conducted by WJE personnel at our structural laboratory in Northbrook, Illinois. Test machine calibration records are included in Appendix B. All testing protocols followed WJE's Quality Manual. All couplers tested were assembled from components shipped to WJE. WJE personnel assembled each anchorage from production components prior to testing.

Strand Control Test

Representative strands were chosen from the samples provided to determine the actual breaking strength of the strand used for the tests. Tests were conducted in accordance with ASTM A1061, *Standard Test Methods for Testing Multi-Wire Steel Strand* and results were compared to ASTM A416 *Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete* requirements. Data were recorded and are included in Appendix C for the strand used for testing. A total of three strand were tested and averaged, and the results were used to determine the actual breaking strength to be used for comparison of the anchorage static tests. A short length of strand approximately 12-in long was cut from a sample and weighed. The density of steel and the length of strand were used to calculate the cross-sectional area of the strand which is used in determining the strand modulus of elasticity.

Static Load Tests

Three static load tests were performed using a 500,000 lbf capacity Riehle universal test machine (s/n 47247) set on the 100,000 lbf force range. A test sample consisted of the Splice Coupler – 0.5-in with 1.2-in three-piece wedges connecting either end of two 0.5-in, 7-wire strands. Each test resulted in testing one coupler for a total of three tests. The static load tests were performed in accordance with AC303 Section 4.1.

The strands used for the tests had a length of at least 42 in. on either end of the coupler. The actual distance was measured prior to loading the samples. A baseline gage length, a minimum of 3 in. from the ends of the coupler, was measured and recorded prior to loading. At the conclusion of each test, the gage length was re-measured and recorded to determine the actual elongation. Load and elongation data were recorded for each test.

The strand was inserted into either end of the coupler and the opposite ends were gripped by the top and bottom test machine grips designed to prevent strand wire stress risers.

In accordance with AC303, Section 3.2.2, each test assembly was considered to pass when the failure load of the strand exceeded 95 percent of the actual breaking strength of the strand as determined from the strand control test and the strand elongation at failure was at least 2 percent.

Fatigue Load Tests

Fatigue load tests were performed using a Splice Coupler – 0.5-in with 1.2-in three-piece wedges connecting two 0.5-in, 7-wire strand ends. Tests were performed in general accordance with AC303 Section 4.2. An anchorage was used on one end of the test sample that was connected to a fixture consisting of steel plates separated by threaded rods bolted to a hydraulic actuator (Figure 2). A separate strand passed through the structural floor opening with an anchorage bearing on the underside of the floor (Figure 3). A test sample consisted of the Splice Coupler – 0.5-in with 1.2-in three-piece wedges connecting either end of two 0.5-in, 7-wire strands.

The test sample was first subjected to 500,000 cycles between 60 and 66 percent of the strand's minimum specified breaking strength using an MTS Model 661.23A-01 (s/n 1261214) 55,000 lbf actuator. At the conclusion of the 500,000 cycles, the sample was subjected to 50 cycles between 40 and 85 percent of the specified minimum breaking strength.

The first fatigue load test consisted of 500,000 cycles with a cycle frequency of 6 Hz. The load range of cycling was at least between 60 and 66 percent of the strand's minimum specified breaking strength of 41,300 lbf (24,780 lbf to 27,260 lbf). The hydraulic actuator limits were set between 24,700 lbf and 27,400 lbf to ensure the specified load range was achieved. Data for the 500,000-cycle fatigue test were recorded on a per cycle basis. Recorded data included maximum force and minimum force per cycle.

At the completion of the 500,000 cycles, 50 cycles with a cycle frequency of 1 Hz were performed using the same MTS actuator with a load range of cycling between 40 and 85 percent of the strand's minimum specified breaking strength of 41,300 lbf (16,520 lbf to 35,105 lbf). The hydraulic actuator limits were set between 16,400 lbf and 35,200 lbf to ensure the specified load range was achieved. Recorded data included applied maximum and minimum force for each cycle.

At the conclusion of the testing, the coupler configuration was deemed to pass if neither the strand nor coupler failed during any part of the fatigue tests.

TEST DATA AND RESULTS

The strand used for testing the anchorages meets the minimum ultimate tensile capacity requirements listed in ASTM A416. Table 1 summarizes the strand control test results.

The results from the static load tests and fatigue load tests are tabulated in Tables 2 and 3, respectively. Included in each table is the testing summary for each test. The load-elongation plots for the static testing and the load-cycle plots for the fatigue testing are included in Appendix D and Appendix E, respectively.

The anchorage assemblies' static test results exceeded 95 percent of the actual strand tensile strength and the 2 percent minimum elongation requirement. The anchorage assemblies successfully passed the fatigue test requirements by completing the required number of cycles without failure and the strand remaining intact. The anchorage configuration listed in Table 2 and Table 3 passed the requirements outlined in AC303 Sections 3.2.2 and 3.3.2.

Table 1. Summary of 7-Wire Strand Control Tests

Test Number	Weight (g) ¹	Length (in.) ¹	Area (in ²)	Load at 1% Elongation (lbf)	Ultimate Load (lbf)	Elongation at Maximum Load (%)
05-1	228.8	11.884	0.149	38,800	43,190	6.50
05-2				38,720	43,220	6.58
05-3				38,810	43,390	6.66
Average				38,780	43,265	6.58

Note 1: information used to calculate strand area

Table 2. Summary of Splice Coupler – 0.5-in Static Load Tests

Test Number	Anchorage Material	Total Elongation (%) ¹	Ultimate Load (lbf)	95% of Control Strand Ultimate Load (lbf)	Pass/Fail
Splice Coupler 05 - 1	Splice Coupler – 0.5-in with a 1.2- in three-piece wedge	4.05 (top) 3.97 (bottom)	42,480	41,100	Pass
Splice Coupler 05 - 2	Splice Coupler – 0.5-in with a 1.2- in three-piece wedge	2.76 (top) 2.58 (bottom)	41,160	41,100	Pass
Splice Coupler 05 - 3	Splice Coupler – 0.5-in with a 1.2- in three-piece wedge	4.42 (top) 4.18 (bottom)	42,310	41,100	Pass

Note 1: Elongation exceeds 2 percent minimum requirement

Table 3. Summary of Splice Coupler – 0.5-in Fatigue Load Tests

Test Number	Anchorage Material	Load Test Cycles	Start Length (in.)	Final Length (in.)	Load Range		Pass/Fail ¹
					Min Load (lbf)	Max Load (lbf)	
042022	Splice Coupler – 0.5-in with a 1.2-in three-piece wedge	500,000	60	60	24,700	27,400	Pass
042122	Splice Coupler – 0.5-in with a 1.2-in three-piece wedge	50	60	60	16,400	35,200	Pass
042222	Splice Coupler – 0.5-in with a 1.2-in three-piece wedge	500,000	60	60	24,700	27,400	Pass
042322	Splice Coupler – 0.5-in with a 1.2-in three-piece wedge	50	60	60	16,400	35,200	Pass

Note 1: All components remained intact

FIGURES



Figure 1. 0.5-in Splice Coupler with 1.2-in three-piece wedge (wedge tips indicated by arrows)



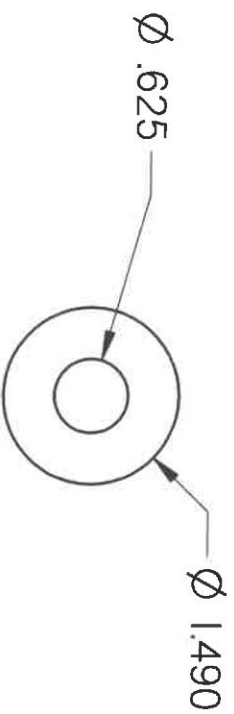
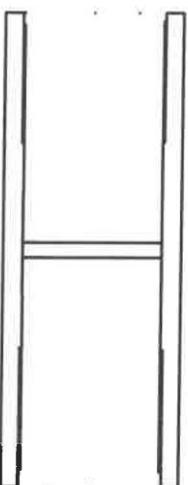
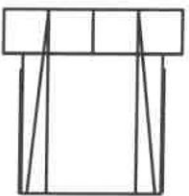
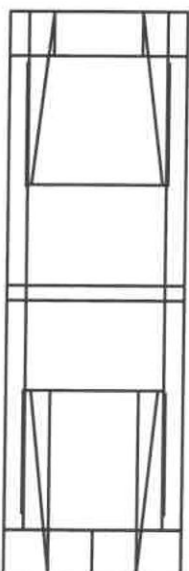
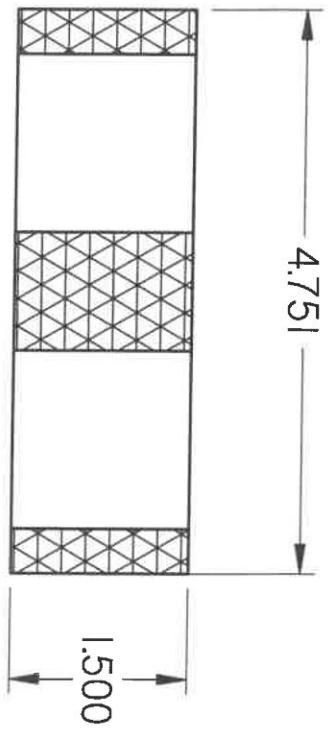
Figure 2. Splice Coupler – 0.5-in fatigue sample



Static and Dynamic Testing of 0.5-in Monostrand Post-Tensioning Anchorages

AC303 Testing of Splice Coupler – 0.5-in with 1.2-in Three-Piece Wedges

APPENDIX A. PRODUCTION DRAWINGS

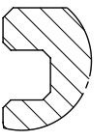
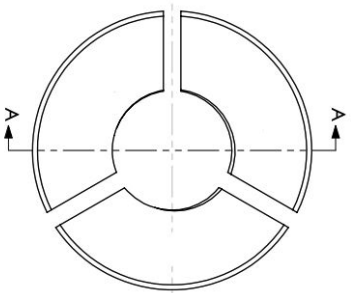


Post-Tensioned Products, Inc.

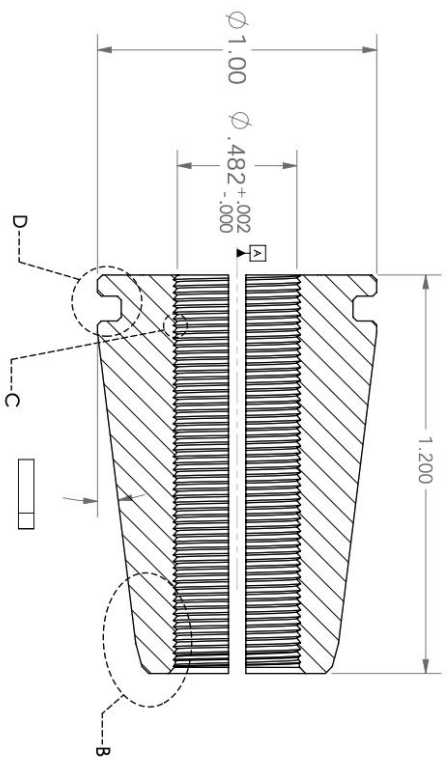
Part# Splice Coupler-.5"

Design: Robert Godino Frank Gast

Date- 2-1-2022



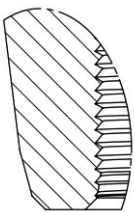
DETAIL D
SCALE 4 : 1



SECTION A-A



DETAIL C
SCALE 10 : 1



DETAIL B
SCALE 4 : 1

- NOTES:
- Remove all burrs and sharp edges.
 - Heat Treat: 79-85 HRA, .015"-.025" Case depth.



Static and Dynamic Testing of 0.5-in Monostrand Post-Tensioning Anchorages

AC303 Testing of Splice Coupler – 0.5-in with 1.2-in Three-Piece Wedges

APPENDIX B. TEST MACHINE CALIBRATION CERTIFICATES

Certificate Of Calibration

Equipment Calibration was performed at the address below for

WISS, JANNEY, ELSTNER ASSOC.

330 PFINGSTEN ROAD

NORTHBROOK, IL 60062

Date of Calibration

Thursday, April 07, 2022

Next Calibration Due

Friday, April 07, 2023

Calibration Performed By

Cal~Rite Corporation, Naperville, IL



Certificate # 866.01
Calibration

Instrument Profile

Customer # : 5147

Manufacturer:	EPSILON	Mach/Rec#:	47247	G.L. Measurement:	DIRECT
Model #:	3543-0200-200T-ST	Scaling #:	-547.959914	G.L. Measure(1/2):	23.9960/23.9950
Serial #:	E84840-24	Temp/Humid:	69.2 F/33.7%	G.L. Error (1/2):	0.02% / 0.02%

Instrument Calibration Results

Range Capacity	Verified Range IN/IN	Uncertainty	Maximum Error	ASTM Class
0.0500	0.0005 - 0.05	0.000106	0.000117	B-1

Range Capacity	Verified Range IN/IN	Uncertainty	Maximum Error	ISO Class
0.0500	0.0005 - 0.05	0.000106	0.000117	1

EXTENSOMETER WAS CALIBRATED BY MOUNTING ONTO A CALIBRATOR FRAME WITH A MICROMETER HEAD. THE ACCURACY OF THE CALIBRATION APPARATUS IS EQUAL TO OR BETTER THAN 1/3 OF THE CLASSIFICATION CRITERIA.

CAL-RITE CORPORATION HAS CALIBRATED THE TESTING EQUIPMENT DESCRIBED ABOVE IN ACCORDANCE WITH THE LATEST SPECIFICATIONS (10-CFR-21, ISO/IEC 17025 AND ISO 10012-1 AND MIL-STD 45662A). ALL VERIFICATION DEVICES ARE TRACEABLE TO

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY(NIST).
THIS CERTIFICATE RELATES ONLY TO THE ITEMS CALIBRATED.

THE UNCERTAINTY OF THE CALIBRATION PROCESS WAS ESTIMATED AT THE 95% CONFIDENCE LEVEL (K=2).

Specification: ASTM E 83-16 / EN ISO 9513-12

QMS Revision: 01-22

Service Comments: Verified proper operation of extensometer. Calibrated instrument in accordance with ASTM and ISO requirements. All readings within required tolerances and repeatable. System is functioning properly at this time.

As Found Condition: In Tolerance

Service Order 18849 - 6

SERVICE ENGINEER

Note: The recording or false, fictitious or fraudulent statements or entries on this document may be punishable as a felony under Federal Statute.



Certificate # 866.01
 Calibration

REPORT OF CALIBRATION

WISS, JANNEY, ELSTNER ASSOC.
 330 PFINGSTEN ROAD
 NORTHBROOK, IL 60062

Calibration Date: 07-Apr-2022
 Next Calibration: 07-Apr-2023
 Temp Variance: 1.2
 Temp/Humidity: 69.2 F/33.7%

Instrument Profile

Manufacture: EPSILON	Serial #: E84840-24	G.L. Measurement: DIRECT
Model: 3543-0200-200T-ST	Customer #: 5147	G.L. Measured(1/2): 23.996/23.995
Mach/Rec #: 47247	Mounting: CLAMP ON	G.L. Error(1/2): 0.02% / 0.02%

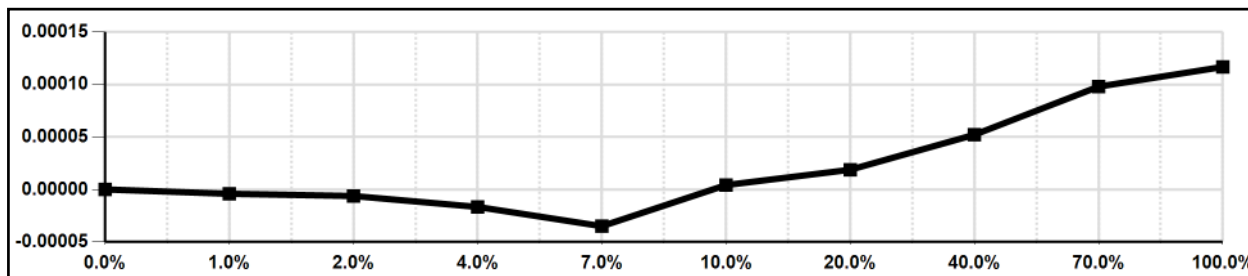
Range: 0.05 IN/IN

Resolution: 0.00001

Uncertainty: 0.000106

Range %	Readout UUT	As Found	As Adjusted	As Left	Repeat %	Fixed Error	Relative Err %	Class/ASTM	Class/ISO
0.00	0.000000	0.000000	0.000000	0.000000	0.000	0.000000	0.0000		
1.00	0.000500	0.000502	0.000000	0.000504	0.414	-0.000004	-0.8264	B-1	1
2.00	0.001000	0.001004	0.000000	0.001006	0.207	-0.000006	-0.6211	B-1	1
4.00	0.002000	0.002006	0.000000	0.002017	0.518	-0.000017	-0.8264	B-1	1
7.00	0.003500	0.003508	0.000000	0.003535	0.757	-0.000035	-0.9901	B-1	1
10.00	0.005000	0.004996	0.000000	0.005004	0.167	0.000004	0.0834	B-1	1
20.00	0.010000	0.009981	0.000000	0.009988	0.063	0.000019	0.1879	B-1	1
40.00	0.020000	0.019948	0.000000	0.019965	0.084	0.000052	0.2611	B-1	1
70.00	0.035000	0.034902	0.000000	0.034910	0.024	0.000098	0.2805	B-1	1
100.00	0.050000	0.049883	0.000000	0.049915	0.063	0.000117	0.2339	B-1	1

Linearity Profile (Percent Full Scale)



Calibrating Apparatus Used

Manufacturer	Serial Number	Model	Calibration Date	Calibration Due
MITUTOYO	200014	164-164	11/29/2021	11/29/2022
MITUTOYO	14634753	CD-8" ASX	8/2/2021	8/2/2023

☒ SPECIFICATION COMPLIANT

☐ REPAIRED:

☐ ADJUSTED:

CONDITION: Good

Specification's: ASTM E 83-16 / EN ISO 9513-12

Calibration Procedure: CR101 Rev 15

Service Order #: 18849 - 6

NATHAN HATHAWAY

SERVICE ENGINEER

As a mutual protection to the purchaser, the public, and ourselves, all Cal-Rite calibration reports are submitted as the confidential property of the purchaser, and any authorization for publication of statements, conclusions, or extractions from or regarding our reports is reserved pending our prior written approval.



Customer Address:
330 Pfingsten Road
Northbrook, IL 60062U
SA

MTS Field Service

MTS Systems Corporation

14000 Technology Drive
Eden Prairie, MN 55344-2290



Certificate of Calibration

Page: 1 of 2

Customer	Name: Wiss, Janney, Elstner Associates, Inc.	Certificate Number: 2394-13442
	System ID: Seismic Frame	MTS System No: Seismic
	Device ID:	Location: Anchor Testing Lab
		Country: SA

Equipment	Device Type: Length	Model: 204.71	Serial No.: 494
	Conditioner Model: 493.21B AC	Serial No.: 1149814	
	Readout Device Model: 493-21B_AC	Serial No.: 1149814	Channel: Displacement

MTS Field Service is accredited by the American Association for Laboratory Accreditation (A2LA Cert. No. 1145.01).
The basis for this accreditation is the international standard for calibration laboratories, ISO/IEC 17025
"General Requirements for the Competence of Testing and Calibration Laboratories".
Defined and documented measurement assurance techniques or uncertainty analyses are used to verify
the adequacy of the measurement processes.

Calibrations are performed with standards whose values and measurements are traceable to the
International System of Units (SI) through a National Metrology Institute (NMI).

The results of this calibration relate only to the items calibrated.

When parameter(s) are reported to be within specified tolerance(s), the measured value(s) shall fall within the appropriate
specification limit and the uncertainty of the measured value(s) shall be stated.

CALIBRATION INFORMATION

As Found:	In Tolerance	Max. Error As Found:	0.89 %	Calibration Date:	09-Sep-2021
As Left:	In Tolerance	Max. Error As Left:	0.89 %	Calibration Due:	30-Sep-2022
Class:	B				
Calibration Procedure:	FS-CA 2124 Rev. G		ASTM E2309/E2309M-20		
Full Scale Ranges:	5 in				
Note:	* The reported Class may be the result of criteria other than the Maximum % Error listed				
	Return to zero errors are not included in the Classification Criteria.				

STANDARDS USED FOR CALIBRATION

MTS Asset Number	Manufacturer	Model Number	Description	Cal. Date	Cal. Due
26923	Rotronic	HL-20D	Temp and Humidity Meter	24-Jun-21	24-Jun-22
26297	MTS	MTS 1800	Displacement Calibrator	23-Feb-21	23-Feb-22

Performed by: *James Rieder* Issued on: 9-Sep-21

ACS Version: 10.45

ACSRepRevBH

Customer

Name: Wiss, Janney, Elstner Associates, Inc.

System ID: Seismic Frame

MTS System No: Seismic

Device ID:

Location: Anchor Testing Lab

Page:

Report Number: 2394-13442

Site: 508308

Country: SA

Equipment

Device Type: Length

Model: 204.71

Serial No.: 494

Conditioner Model: 493.21B AC

Serial No.: 1149814

Readout Device Model: 493-21B_AC

Serial No.: 1149814

Channel: Displacement

Range:

1

Full Scale:

5

Units:

in

Linearization Table

As Found:

X

As Adjusted:

100

Standard

Conditioner



Customer Address:
330 Pfingsten Road
Northbrook, IL 60062U
SA

MTS Field Service

MTS Systems Corporation

14000 Technology Drive
Eden Prairie, MN 55344-2290



Certificate of Calibration

Customer Name: Wiss, Janney, Elstner Associates, Inc. Page: 1 of 3
System ID: Seismic Frame MTS System No: Seismic Certificate Number: 2394-13443
Device ID: Location: Anchor Testing Lab Site: 508308
Country: SA

Equipment
Device Type: Force Model: 661.23A-01 Serial No.: 1194
Conditioner Model: 493.21DC Serial No.: 1261214
Readout Device Model: COMPUTER Serial No.: Serial Channel: Port

MTS Field Service is accredited by the American Association of Laboratory Accreditation (A2LA Cert. No. 1145.01).

The basis for this accreditation is the international standard for calibration laboratories, ISO/IEC 17025

"General Requirements for the Competence of Testing and Calibration Laboratories".

Defined and documented measurement assurance techniques or uncertainty analyses are used to verify the adequacy of the measurement processes.

Calibrations are performed with standards whose values and measurements are traceable to the International System of Units (SI) through a National Metrology Institute (NMI).

MTS Reference Force Transducers are calibrated in compliance with ASTM E74.

The results of this calibration relate only to the items calibrated.

When parameter(s) are reported to be within specified tolerance(s), the measured value(s) shall fall within the appropriate specification limit and the uncertainty of the measured value(s) shall be stated.

CALIBRATION INFORMATION

As Found: In Tolerance Max. Error As Found: -0.65 % Calibration Date: 09-Sep-2021
As Left: In Tolerance Max. Error As Left: -0.65 % Calibration Due: 30-Sep-2022
Tolerance: +/-1.0% of Applied Force
Calibration Procedure: FS-CA 2122 Rev. F ASTM E4-20
Full Scale Ranges: 55000 lbf, 27500 lbf
Note:

STANDARDS USED FOR CALIBRATION

MTS Asset Number	Manufacturer	Model Number	Description	Cal. Date	Cal. Due
19695	Interface Inc.	Interface	mV/V Indicator	24-Mar-21	24-Mar-22
26923	Rotronic	HL-20D	Temp and Humidity Meter	24-Jun-21	24-Jun-22
16803	Interface Inc.	CX-0330-1	Bridge Simulator	11-Aug-21	9-Dec-22
20980	Interface	50kip	Load Cell	11-Aug-20	11-Aug-22

Performed by:

James Rieder

Issued on:

9-Sep-21

ACS Version: 10.45

ACSRepRevBH



MTS Systems Corporation
14000 Technology Drive
Eden Prairie, MN 55344-2290

Calibration Report



Page: 2 of 3

Customer

Name: Wiss, Janney, Elstner Associates, Inc.
System ID: Seismic Frame MTS System No: Seismic
Device ID: Location: Anchor Testing Lab

Report Number: 2394-13443
Site: 508308
Country: SA

Equipment

Device Type: Force Model: 661.23A-01 Serial No.: 1194
Conditioner Model: 493.21DC Serial No.: 1261214
Readout Device Model: COMPUTER Serial No.: Serial Channel: Port

Procedure

MTS Procedure: FS-CA 2122 Rev. F
Calibration has been performed in accordance with: ASTM E4-20
Method of Verification: Follow-the-Force Method using Elastic Calibration Devices

ACS Version: 10.45

Calibration Equipment Asset No.

Dead Weight Set: HighLevel Board: LowLevel Board: Standard Asset No.: 20980
DW Compensation: DMM: Digital Indicator: 19695 Lower Limit: 1000 lbf
Temperature Readout: 26923 Additional Equipment: Standardizer: 16803

Conditions

Ambient Temperature: 71.3 °F Polarity(+): Tension Bidirectional: Cable Length: 50 Feet

In Tolerance
Out of Tolerance

☒

As Found: ☒
As Adjusted: ☐

Tolerance: +/-1.0% of Applied Force
As Found System Condition: Good

Conditioner Parameters

Polarity: Normal Total Gain: 475.80599 Fine zero: 0.01007 Shunt Cal (+): 31380.77153 lbf.
Excitation: 8.0 Volts Pre-amp gain: 260.0 Delta K: 0.9968
Post-amp gain: 1.83002

Calibration Data

Range: 1
Compression Resolution: 2.3 Full Scale: 55000
Report Units: lbf

Applied Percent of Full Scale Force	Series 1		Series 1 Errors				Series 2		Series 2 Errors				Repeatability	
	Indicated Reading Ascending	Indicated Reading Descending	Units Error Asc	Percent Error Asc	Units Error Desc	Percent Error Desc	Indicated Reading Ascending	Indicated Reading Descending	Units Error Asc	Percent Error Asc	Units Error Desc	Percent Error Desc	Percent Error	
													Asc	Desc
0	-10.0	43.9	-10.0	-0.02	43.9	0.08	-5.8	6.6	-5.8	-0.01	6.6	0.01	0.01	0.07
-10	-5491.5		-8.5	-0.15			-5478.4		-21.6	-0.39			0.24	
-20	-10953.0		-47.0	-0.43			-10954.0		-46.0	-0.42			0.01	
-40	-21899.0		-101.0	-0.46			-21889.0		-111.0	-0.50			0.05	
-60	-32845.0		-155.0	-0.47			-32841.0		-159.0	-0.48			0.01	
-80	-43787.0		-213.0	-0.48			-43778.0		-222.0	-0.50			0.02	
-100	-54710.0		-290.0	-0.53			-54703.0		-297.0	-0.54			0.01	

Tension Range: 1
Report Units: lbf

Applied Percent of Full Scale Force	Series 1		Series 1 Errors				Series 2		Series 2 Errors				Repeatability	
	Indicated Reading Ascending	Indicated Reading Descending	Units Error Asc	Percent Error Asc	Units Error Desc	Percent Error Desc	Indicated Reading Ascending	Indicated Reading Descending	Units Error Asc	Percent Error Asc	Units Error Desc	Percent Error Desc	Percent Error	
													Asc	Desc
0	-1.2	1.7	-1.2	0.00	1.7	0.00	2.4	1.7	2.4	0.00	1.7	0.00	0.01	0.00
10	5466.1		-33.9	-0.62			5471.1		-28.9	-0.53			0.09	
20	10946.0		-54.0	-0.49			10949.0		-51.0	-0.46			0.03	
40	21913.0		-87.0	-0.40			21912.0		-88.0	-0.40			0.00	
60	32871.0		-129.0	-0.39			32852.0		-148.0	-0.45			0.06	
80	43815.0		-185.0	-0.42			43819.0		-181.0	-0.41			0.01	
100	54773.0		-227.0	-0.41			54771.0		-229.0	-0.42			0.00	

Errors at Zero are computed in % of Range.
Uncertainty of the data supplied is equal to or less than $\pm 0.25\%$ of reading for a coverage factor of $k=2$ and an approximate confidence level of 95%.
This report shall not be reproduced except in full, without the written approval of the laboratory.

☐ Out of Tolerance in % column

American Association of Laboratory Accreditation Certificate Number: 1145.01

Notes:

Performed By: Jim Rieder Field Service Engineer: Date: 9-Sep-21

Signature:

Next Customer Agreed Upon Calibration Date: 30-Sep-22

ACSRepRevBH



MTS Systems Corporation
14000 Technology Drive
Eden Prairie, MN 55344-2290

Calibration Report



Page: 3 of 3
Report Number: 2394-13443
Site: 508308
Country: SA

Customer Name: Wiss, Janney, Elstner Associates, Inc.
System ID: Seismic Frame MTS System No: Seismic
Device ID: Location: Anchor Testing Lab

Equipment
Device Type: Force Model: 661.23A-01 Serial No.: 1194
Conditioner Model: 493.21DC Serial No.: 1261214
Readout Device Model: COMPUTER Serial No.: Serial Channel: Port

Procedure
MTS Procedure: FS-CA 2122 Rev. F ACS Version: 10.45
Calibration has been performed in accordance with: ASTM E4-20
Method of Verification: Follow-the-Force Method using Elastic Calibration Devices

Calibration Equipment Asset No.
Dead Weight Set: HighLevel Board: LowLevel Board: Standard Asset No.: 20980
DW Compensation: DMM: Digital Indicator: 19695 Lower Limit: 1000 lbf
Temperature Readout: 26923 Additional Equipment: Standardizer: 16803

Conditions
Ambient Temperature: 71.6 °F Polarity(+): Tension Bidirectional: Cable Length: 50 Feet

In Tolerance ☒ **As Found:** ☒ **Tolerance: +/-1.0% of Applied Force**
Out of Tolerance ☐ **As Adjusted:** ☐ **As Found System Condition: Good**

Conditioner Parameters
Polarity: Normal Total Gain: 951.61199 Fine zero: 0.00916 Shunt Cal (+): 0.0 lbf.
Excitation: 8.0 Volts Pre-amp gain: 260.0 Delta K: 0.9977
Post-amp gain: 3.66005

Calibration Data
Range: 2
Compression Resolution: 1.7 Full Scale: 27500
Report Units: lbf

Applied Percent of Full Scale Force	Series 1		Series 1 Errors				Series 2		Series 2 Errors				Repeatability	
	Indicated Reading	Indicated Reading	Units Error	Percent Error	Units Error	Percent Error	Indicated Reading	Indicated Reading	Units Error	Percent Error	Units Error	Percent Error	Percent Error	
	Ascending	Descending	Asc	Asc	Desc	Desc	Ascending	Descending	Asc	Asc	Desc	Desc	Asc	Desc
0	5.5	-2.4	5.5	0.02	-2.4	-0.01	7.5	0.1	7.5	0.03	0.1	0.00	0.01	0.01
-10	-2732.0		-18.0	-0.65			-2734.6		-15.4	-0.56			0.09	
-20	-5479.4		-20.6	-0.37			-5470.7		-29.3	-0.53			0.16	
-40	-10949.0		-51.0	-0.46			-10953.0		-47.0	-0.43			0.04	
-60	-16435.0		-65.0	-0.39			-16424.0		-76.0	-0.46			0.07	
-80	-21902.0		-98.0	-0.45			-21904.0		-96.0	-0.44			0.01	
-100	-27372.0		-128.0	-0.47			-27376.0		-124.0	-0.45			0.01	

Tension Range: 2

Applied Percent of Full Scale Force	Series 1		Series 1 Errors				Series 2		Series 2 Errors				Repeatability	
	Indicated Reading	Indicated Reading	Units Error	Percent Error	Units Error	Percent Error	Indicated Reading	Indicated Reading	Units Error	Percent Error	Units Error	Percent Error	Percent Error	
	Ascending	Descending	Asc	Asc	Desc	Desc	Ascending	Descending	Asc	Asc	Desc	Desc	Asc	Desc
0	-1.3	3.5	-1.3	0.00	3.5	0.01	7.1	2.4	7.1	0.03	2.4	0.01	0.03	0.00
10	2739.5		-10.5	-0.38			2740.8		-9.2	-0.33			0.05	
20	5480.0		-20.0	-0.36			5479.4		-20.6	-0.37			0.01	
40	10961.0		-39.0	-0.35			10967.0		-33.0	-0.30			0.05	
60	16444.0		-56.0	-0.34			16446.0		-54.0	-0.33			0.01	
80	21929.0		-71.0	-0.32			21929.0		-71.0	-0.32			0.00	
100	27404.0		-96.0	-0.35			27408.0		-92.0	-0.33			0.01	

Errors at Zero are computed in % of Range.

Uncertainty of the data supplied is equal to or less than $\pm 0.25\%$ of reading for a coverage factor of $k=2$ and an approximate confidence level of 95%.

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☐ Out of Tolerance in % column

American Association of Laboratory Accreditation Certificate Number: 1145.01

Notes:

Performed By: Jim Rieder Field Service Engineer: Date: 9-Sep-21

Signature:

Next Customer Agreed Upon Calibration Date: 30-Sep-22

ACSRepRevBH

Certificate Of Calibration

Equipment Calibration was performed at the address below for

WISS, JANNEY, ELSTNER ASSOC.

330 PFINGSTEN ROAD

NORTHBROOK, IL 60062



Date of Calibration

Monday, March 21, 2022

Calibration Performed By

Cal~Rite Corporation, Naperville, IL



Certificate # 866.01
Calibration

Customer #: 691

Machine Profile

Manufacturer:	RIEHLE	Capacity:	500000	Next Cal:	21-Mar-2023
Model:	500FH	Serial #:	47247	Temp/Humid:	68.7 F/36.6%

Language: Lbs

Force Calibration Result Accuracy **1.0 %**

Range	Verified Range Force	Maximum Error %
500000.000	50000.000 - 500000.000	0.33
250000.000	25000.000 - 250000.000	0.58
100000.000	20000.000 - 100000.000	-0.42
20000.000	2000.000 - 20000.000	0.54

CAL-RITE CORPORATION HAS CALIBRATED THE TESTING EQUIPMENT DESCRIBED ABOVE IN ACCORDANCE WITH THE LATEST SPECIFICATIONS (10-CFR-21, ISO/IEC 17025 AND ISO 10012-1 AND MIL-STD 45662A). ALL VERIFICATION DEVICES CALIBRATED IN ACCORDANCE WITH ASTM-E74 PRACTICES AND ARE TRACEABLE TO NIST.

THIS CERTIFICATE RELATES ONLY TO THE ITEMS CALIBRATED.

THE UNCERTAINTY OF THE CALIBRATION PROCESS WAS ESTIMATED AT THE 95% CONFIDENCE LEVEL (K=2).

COMPUTED FORCES HAVE BEEN TEMPERATURE CORRECTED AS NECESSARY

THE EQUIPMENT LISTED ABOVE HAS MET ALL APPLICABLE CLAUSES OF THE GOVERNING SPECIFICATION UNLESS NOTED BELOW.

☐ 10.1 Lower Limit below 200X Resolution

☐ 10.5 Does not return to zero in 30 seconds

Specification: ASTM E 4-21

QMS Revision: 01-22

Service Comments: Verified proper operation of machine. Calibrated all load ranges in accordance with ASTM standards. All readings found within tolerance and repeatable. Made adjustments to 100k range only. System is in good condition and functioning properly at this time.

As Found Condition: In Tolerance

Calibration Method: Follow The Force



Service Order #: 18837 - 26

SERVICE ENGINEER

Note: The recording or false, fictitious or fraudulent statements or entries on this document may be punishable as a felony under Federal Statute.



Certificate # 866.01
Calibration

REPORT OF CALIBRATION

WISS, JANNEY, ELSTNER ASSOC.
 330 PFINGSTEN ROAD
 NORTHBROOK, IL 60062

Calibration Date: 21-Mar-2022
 Next Calibration: 21-Mar-2023
 Customer #: 691
 Temp/Humidity: 68.7 F/36.6%

Manufacture: RIEHLE
 Model: 500FH
 Indicator: DIGITAL

Capacity: 500000
 Serial #: 47247
 Shunt #: N/A

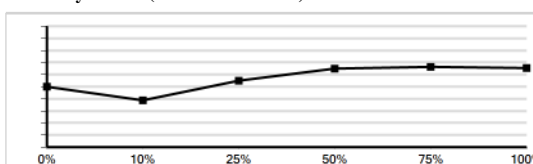
Test Direction: COMPRESSION
 External Cell: N/A
 Temp Variance: 0.7

Range: 500000 Lbs Resolution: 100.00000 Accuracy +/- 1.0%

FS %	Reading	As Found	As Adj.	As Left	Repeat %	Max Error	Error %	Uncert %
0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
10.00	50,000.00	50,072.700	0.000	50,112.900	-0.080	-112.900	-0.225	0.29
25.00	125,000.00	124,874.800	0.000	124,899.700	-0.020	125.200	0.100	0.29
50.00	250,000.00	249,250.800	0.000	249,311.800	-0.024	749.200	0.301	0.29
75.00	375,000.00	373,770.900	0.000	373,898.000	-0.034	1,229.100	0.329	0.29
100.00	500,000.00	498,456.900	0.000	498,873.200	-0.084	1,543.100	0.310	0.29

Zero Return: -0.02 % 0.00 % 0.02 %

Linearity Profile (Percent Full Scale)

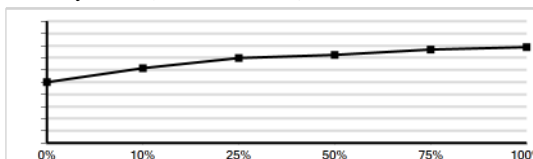


Range: 250000 Lbs Resolution: 100.00000 Accuracy +/- 1.0%

FS %	Reading	As Found	As Adj.	As Left	Repeat %	Max Error	Error %	Uncert %
0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
10.00	25,000.00	24,969.800	0.000	24,942.400	0.110	57.600	0.231	0.29
25.00	62,500.00	62,252.300	0.000	62,317.800	-0.105	247.700	0.398	0.29
50.00	125,000.00	124,441.100	0.000	124,502.100	-0.049	558.900	0.449	0.29
75.00	187,500.00	186,498.000	0.000	186,552.300	-0.029	1,002.000	0.537	0.29
100.00	250,000.00	248,567.000	0.000	248,599.500	-0.013	1,433.000	0.577	0.29

Zero Return: 0.00 % 0.00 % 0.04 %

Linearity Profile (Percent Full Scale)

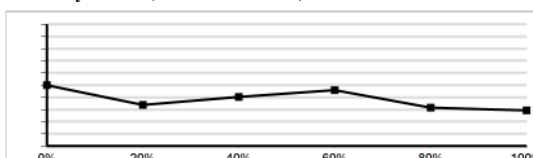


Range: 100000 Lbs Resolution: 100.00000 Accuracy +/- 1.0%

FS %	Reading	As Found	As Adj.	As Left	Repeat %	Max Error	Error %	Uncert %
0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000000
20.00	20,000.00	19,872.400	20,022.300	20,065.100	-0.214	-65.100	-0.324	0.29
40.00	40,000.00	39,791.300	40,051.800	40,077.300	-0.064	-77.300	-0.193	0.29
60.00	60,000.00	59,624.100	60,026.400	60,048.800	-0.037	-48.800	-0.081	0.29
80.00	80,000.00	79,465.800	80,296.800	80,233.700	0.079	-296.800	-0.370	0.29
100.00	100,000.00	99,489.100	100,416.800	100,368.500	0.048	-416.800	-0.415	0.29

Zero Return: 0.00 % 0.00 % 0.00 %

Linearity Profile (Percent Full Scale)

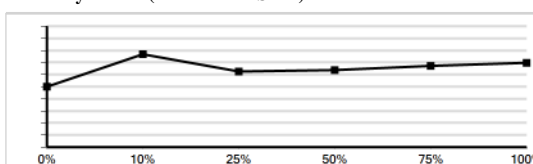


Range: 20000 Lbs Resolution: 10.00000 Accuracy +/- 1.0%

FS %	Reading	As Found	As Adj.	As Left	Repeat %	Max Error	Error %	Uncert %
0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
10.00	2,000.00	1,989.300	0.000	1,991.500	-0.111	10.700	0.538	0.29
25.00	5,000.00	4,998.500	0.000	4,987.400	0.222	12.600	0.253	0.29
50.00	10,000.00	9,987.100	0.000	9,972.500	0.146	27.500	0.276	0.29
75.00	15,000.00	14,957.400	0.000	14,948.400	0.060	51.600	0.345	0.29
100.00	20,000.00	19,930.900	0.000	19,921.100	0.049	78.900	0.396	0.29

Zero Return: 0.00 % 0.00 % 0.00 %

Linearity Profile (Percent Full Scale)



Calibrating Apparatus Used

Manufacture	Serial Number	Capacity	Class A	Dir	Cal Date	Cal Due	Calibrated By
STRAINSSENSE	101208	600000	12089	C	6/21/2021	6/21/2023	TOVEY
STRAINSSENSE	030210	60000	1233	C	9/12/2021	11/12/2023	CAL-RITE

☒ SPECIFICATION COMPLIANT

☐ REPAIRED:

☒ ADJUSTED:

CONDITION: Good

Specification: ASTM E 4-21

☐ A-1 Verified Outside Testing Machine

☐ 7.3 Interchangeability Established

Calibration Procedure: CR100 Rev 16

Service Order #: 18837 - 26

NATHAN HATHAWAY

SERVICE ENGINEER

As a mutual protection to the purchaser, the public, and ourselves, all Cal-Rite calibration reports are submitted as the confidential property of the purchaser, and any authorization for publication of statements, conclusions, or extractions from or regarding our reports is reserved pending our prior written approval.



Static and Dynamic Testing of 0.5-in Monostrand Post-Tensioning Anchorages

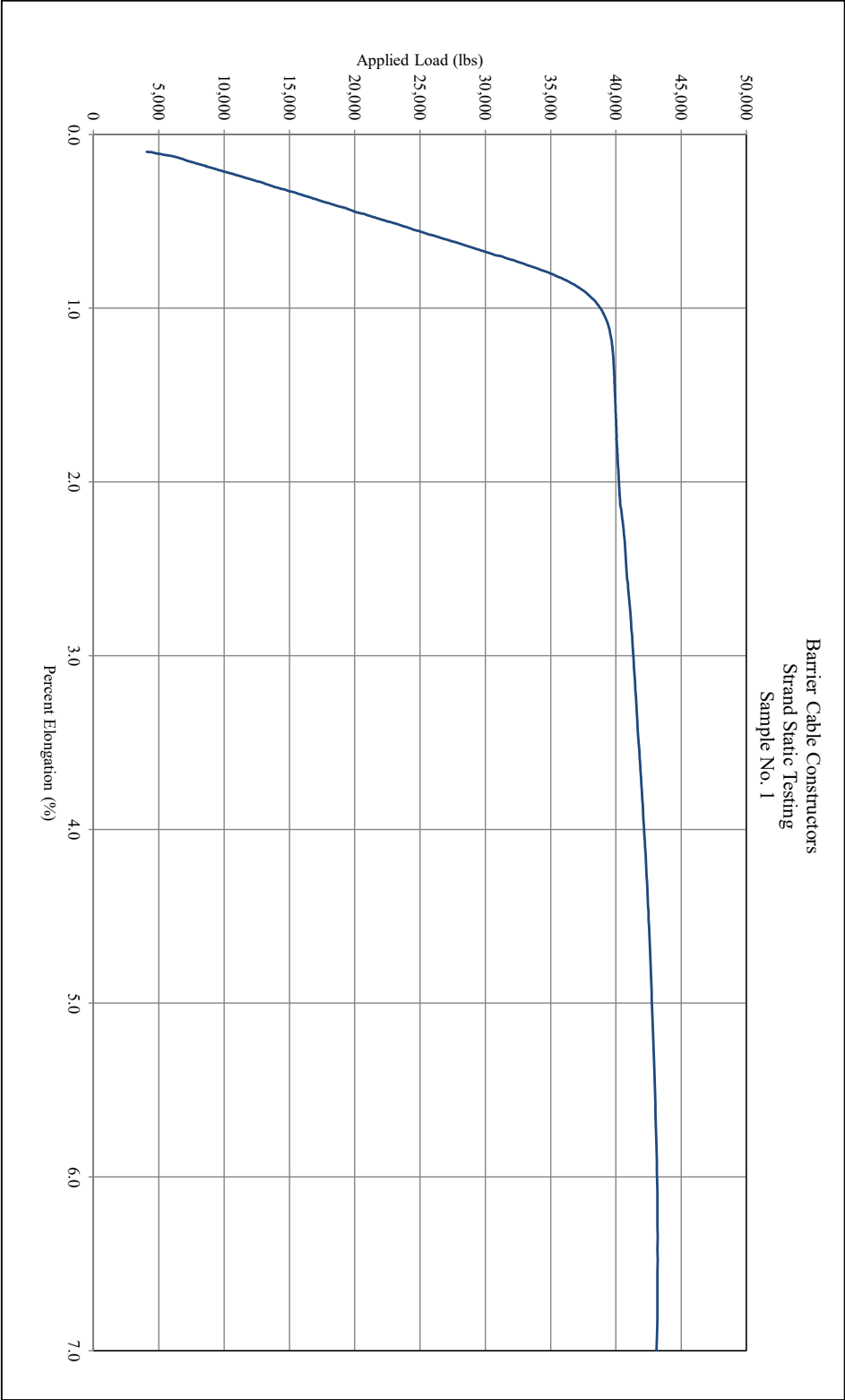
AC303 Testing of Splice Coupler – 0.5-in with 1.2-in Three-Piece Wedges

APPENDIX C. STRAND CONTROL TEST



Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,800 lbs
Breaking Load	43,190 lbs
Total Elongation	6.50 percent
Modulus of Elasticity	29,134 ksi



WJE Project Number	2021.3293
Client	Barrier Cable Constructors
Sample Tested	0.5-in, 270 ksi, 7-wire strand
Notes	

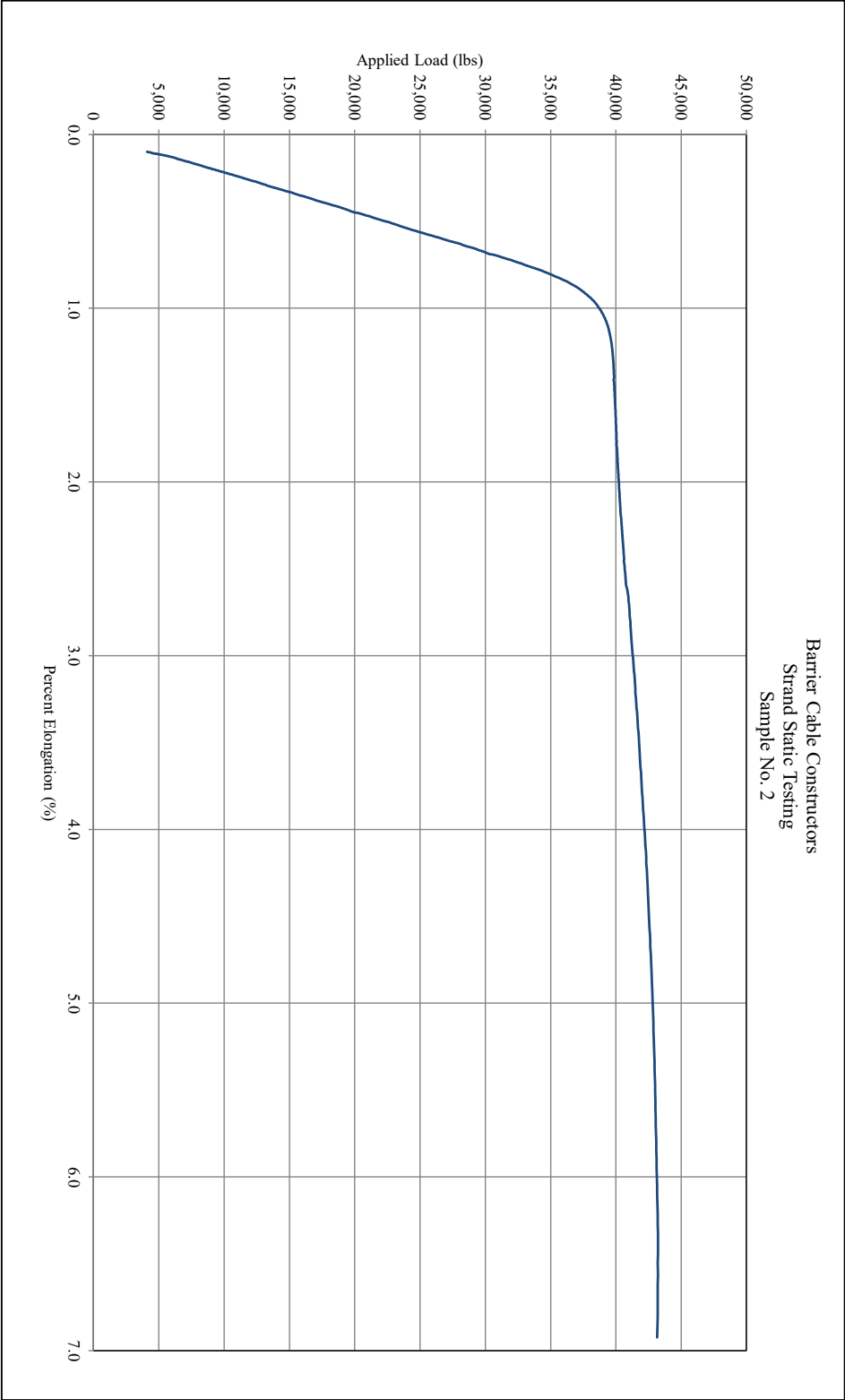
Test Location	Northbrook, IL
Test Operator	B Easton
Test Date	4/15/2022
Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,720 lbs
Breaking Load	43,220 lbs
Total Elongation	6.58 percent
Modulus of Elasticity	29,250 ksi



WJE Project Number	2021.3293
Client	Barrier Cable Constructors
Sample Tested	0.5-in, 270 ksi, 7-wire strand
Notes	

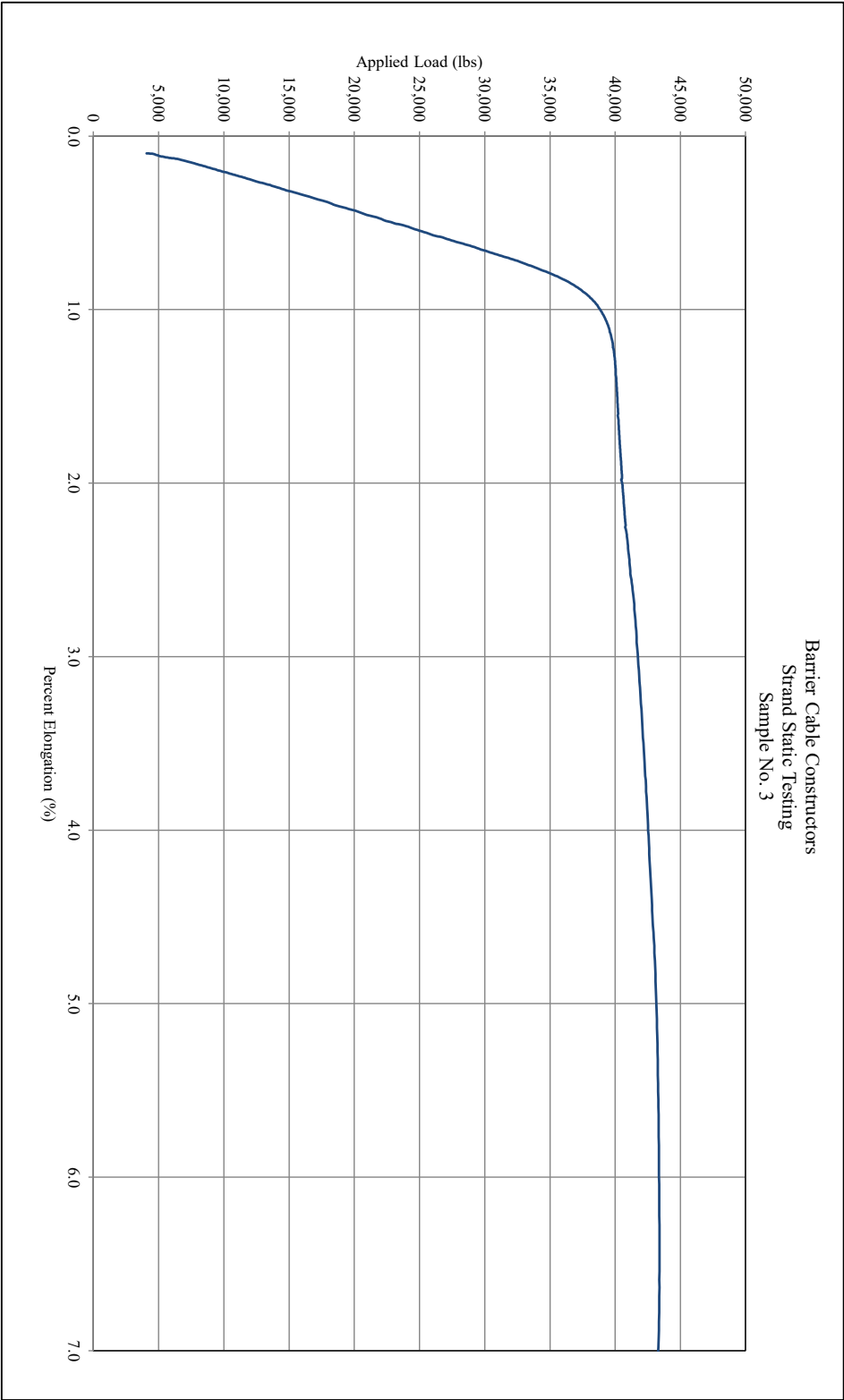
Test Location	Northbrook, IL
Test Operator	B Easton
Test Date	4/15/2022
Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,810 lbs
Breaking Load	43,390 lbs
Elong @ Max Load	6.66 percent
Modulus of Elasticity	29,708 ksi



WJE Project Number	2021.3293
Client	Barrier Cable Constructors
Sample Tested	0.5-in, 270 ksi, 7-wire strand
Notes	

Test Location	Northbrook, IL
Test Operator	B Easton
Test Date	4/15/2022
Test Methods	ASTM A1061, A416

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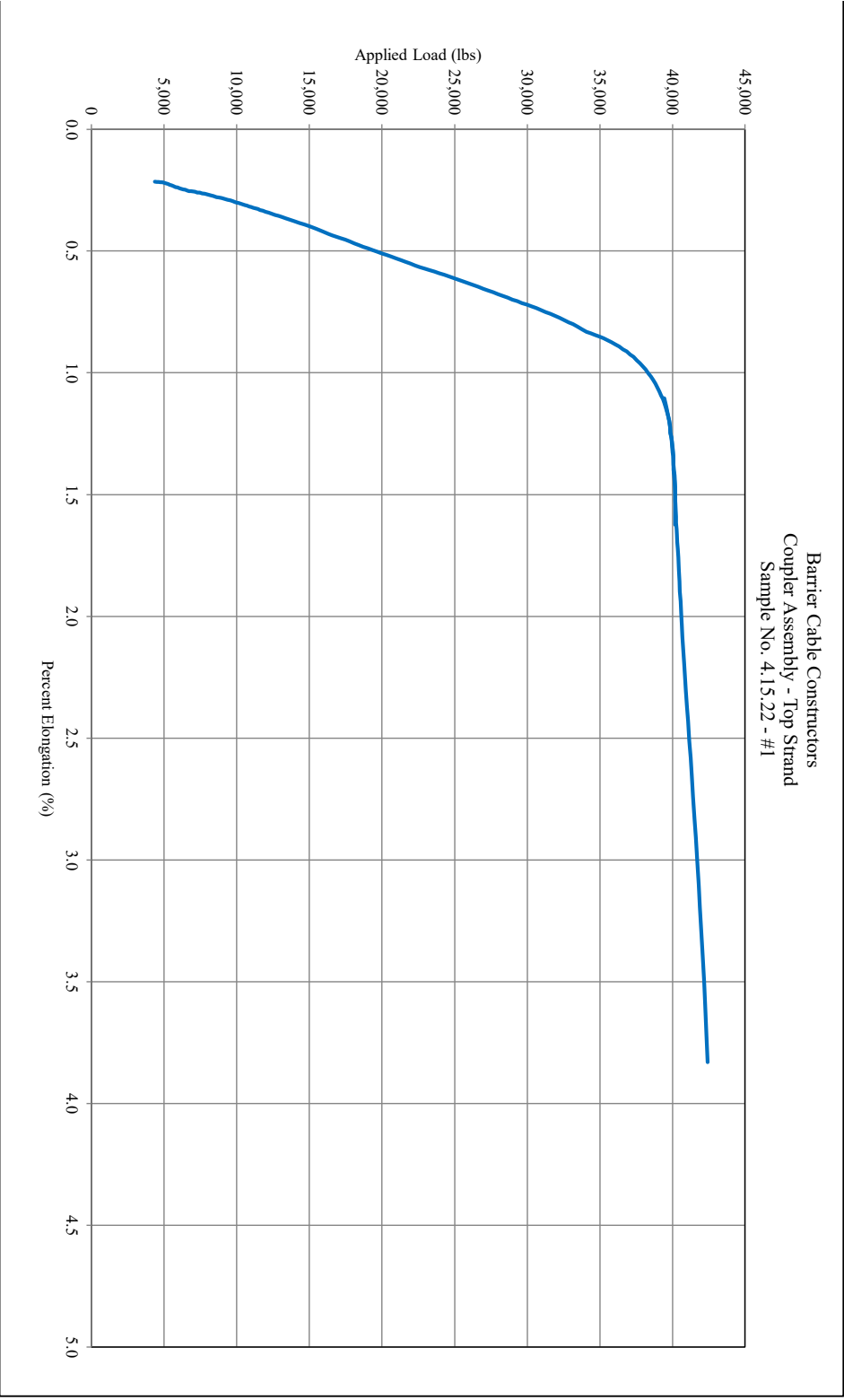
Static and Dynamic Testing of 0.5-in Monostrand Post-Tensioning Anchorages

AC303 Testing of Splice Coupler – 0.5-in with 1.2-in Three-Piece Wedges

APPENDIX D. ANCHORAGE STATIC TESTS

Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,150 lbs
Breaking Load	42,480 lbs
Elong @ Max Load	4.05 percent
Modulus of Elasticity	32,052 ksi



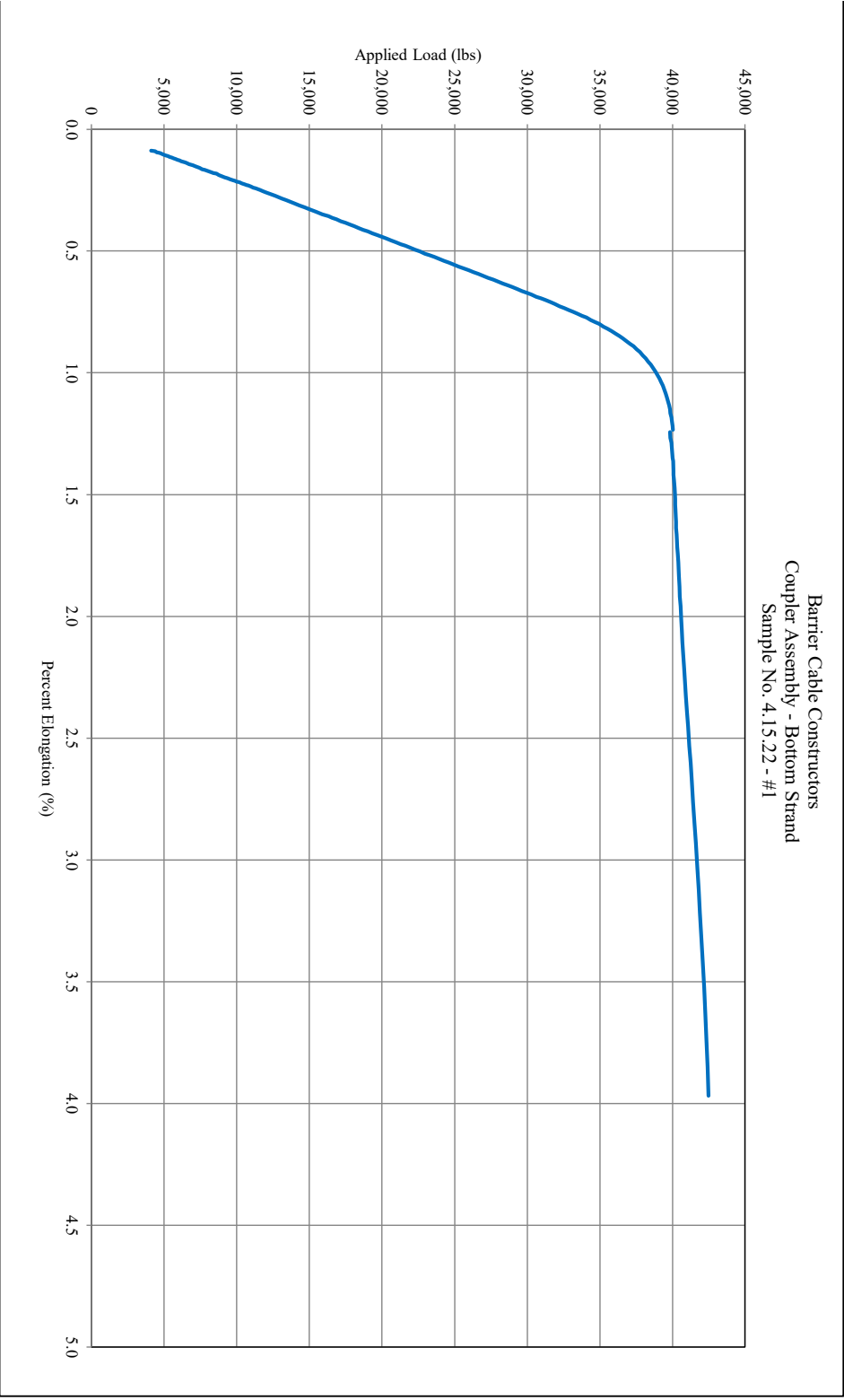
WJE Project Number	2020.2430	Test Location	Northbrook, IL
Client	GTT	Test Operator	B Easton
Sample Tested	0.5-in RU Splice Chuck Assembly	Test Date	4/15/2022
		Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,820 lbs
Breaking Load	42,480 lbs
Elong @ Max Load	3.97 percent
Modulus of Elasticity	29,415 ksi



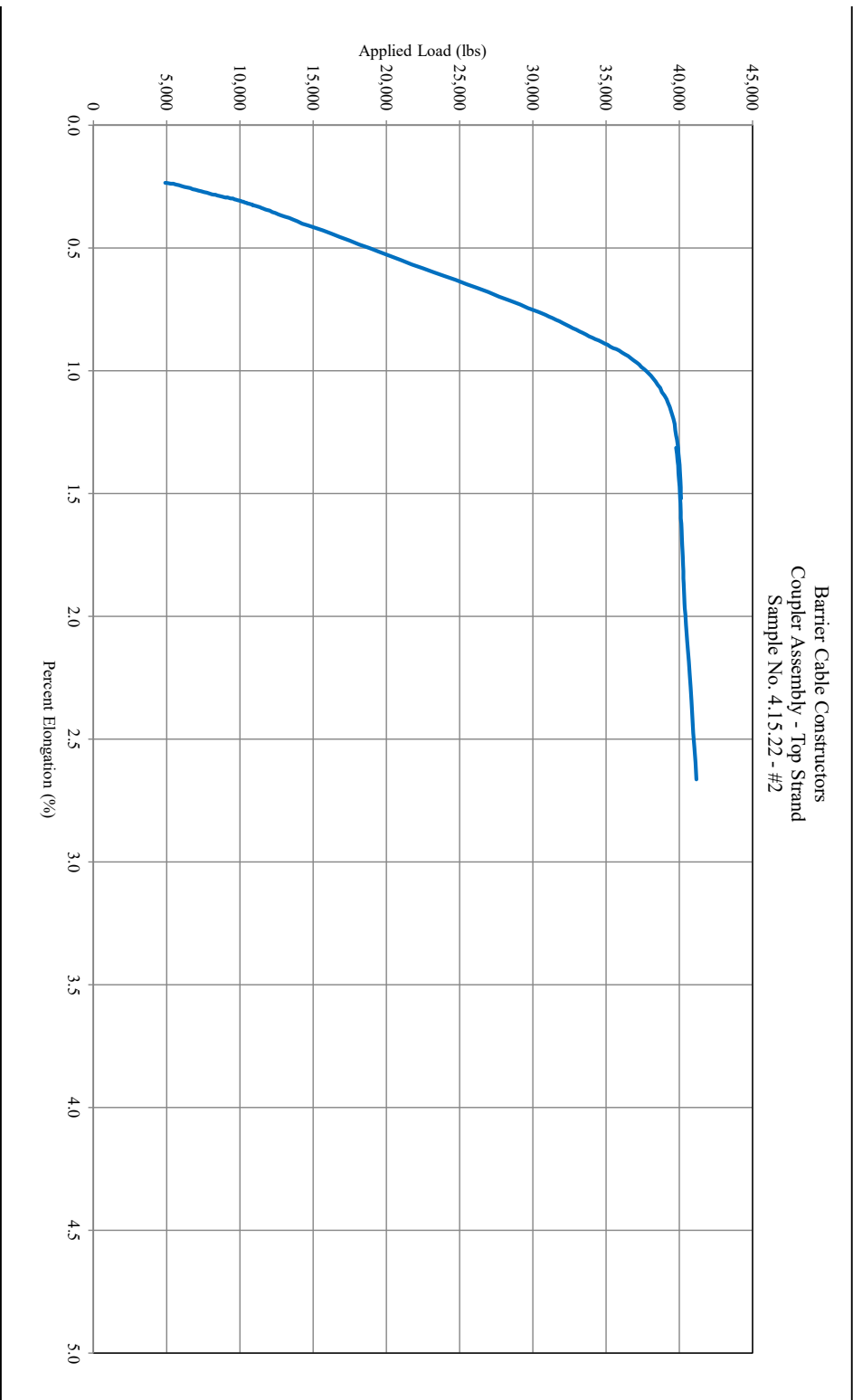
WJE Project Number	2021.3293
Client	Barrier Cable Constructors
Sample Tested	0.5-in Splice Chuck Assembly

Test Location	Northbrook, IL
Test Operator	B Easton
Test Date	4/15/2022
Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	37,580 lbs
Breaking Load	41,160 lbs
Elong @ Max Load	2.76 percent
Modulus of Elasticity	30,301 ksi



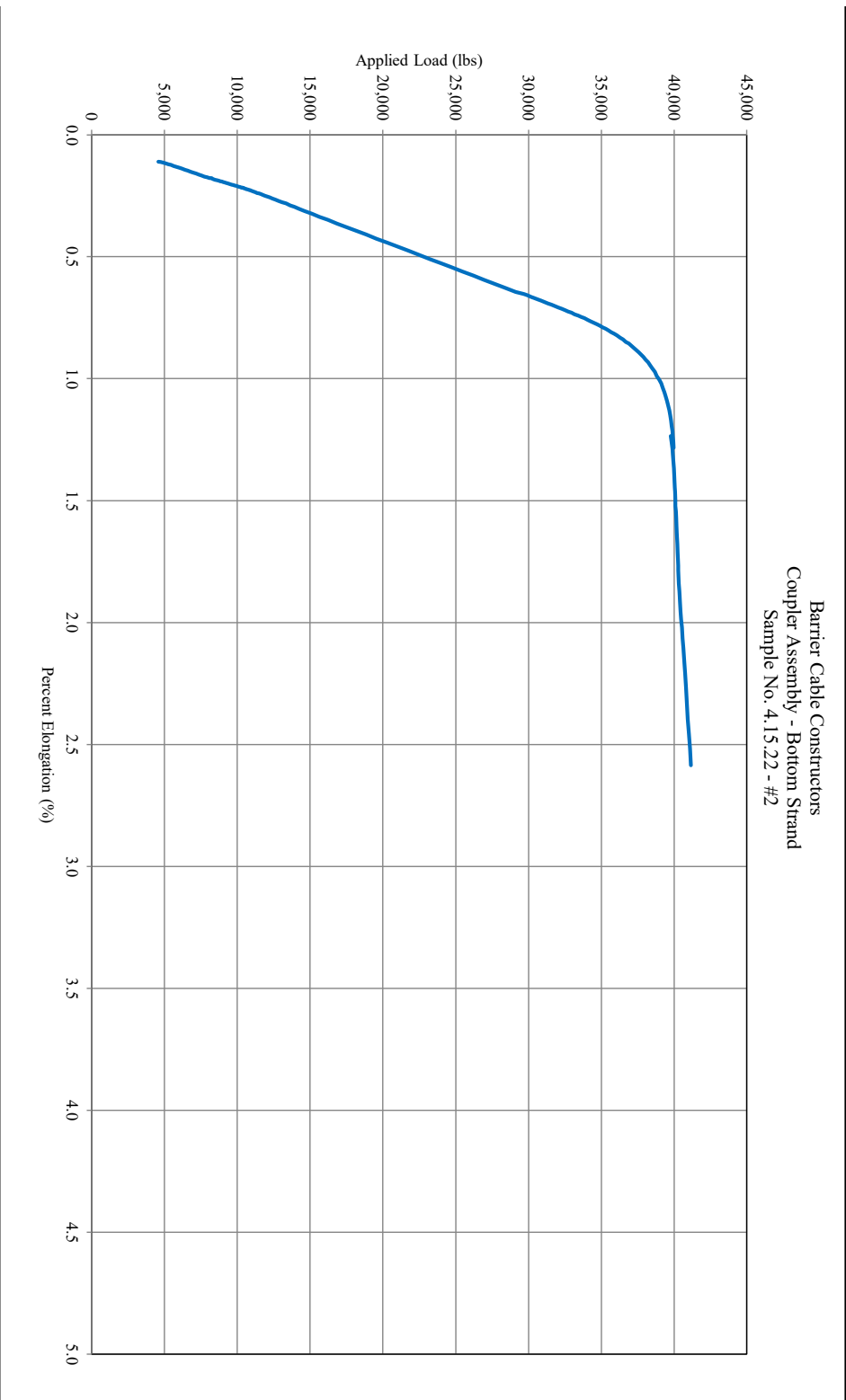
WJE Project Number	2020.2430
Client	GTL
Sample Tested	0.5-in RU Splice Chuck Assembly

Test Location	Northbrook, IL
Test Operator	B Easton
Test Date	5/20/2020
Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,810 lbs
Breaking Load	41,160 lbs
Elong @ Max Load	2.58 percent
Modulus of Elasticity	29,987 ksi



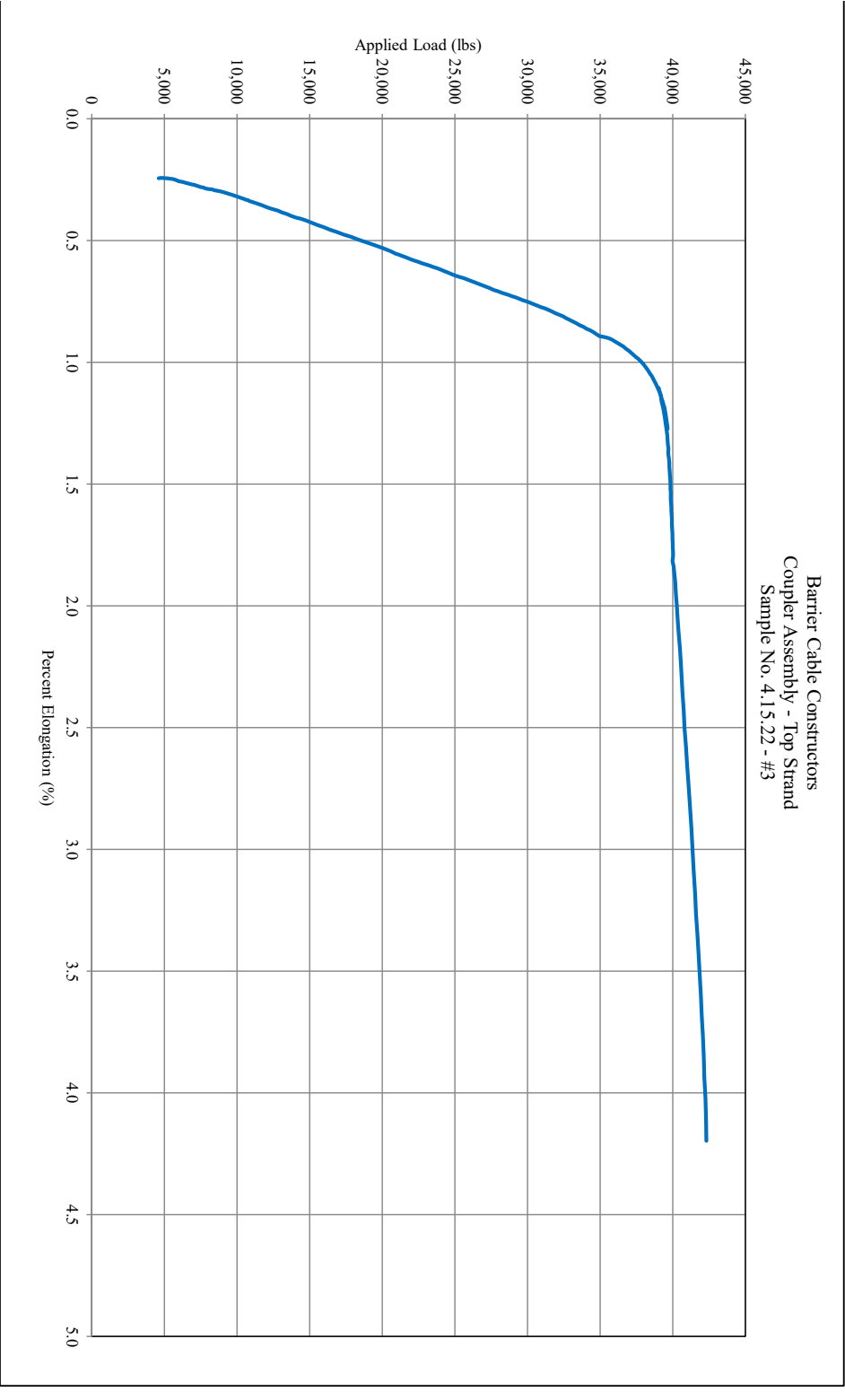
WJE Project Number	2021.3293	Test Location	Northbrook, IL
Client	Barrier Cable Constructors	Test Operator	B Easton
Sample Tested	0.5-in Splice Chuck Assembly	Test Date	10/21/2021
		Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	37,760 lbs
Breaking Load	42,310 lbs
Elong @ Max Load	4.42 percent
Modulus of Elasticity	31,169 ksi



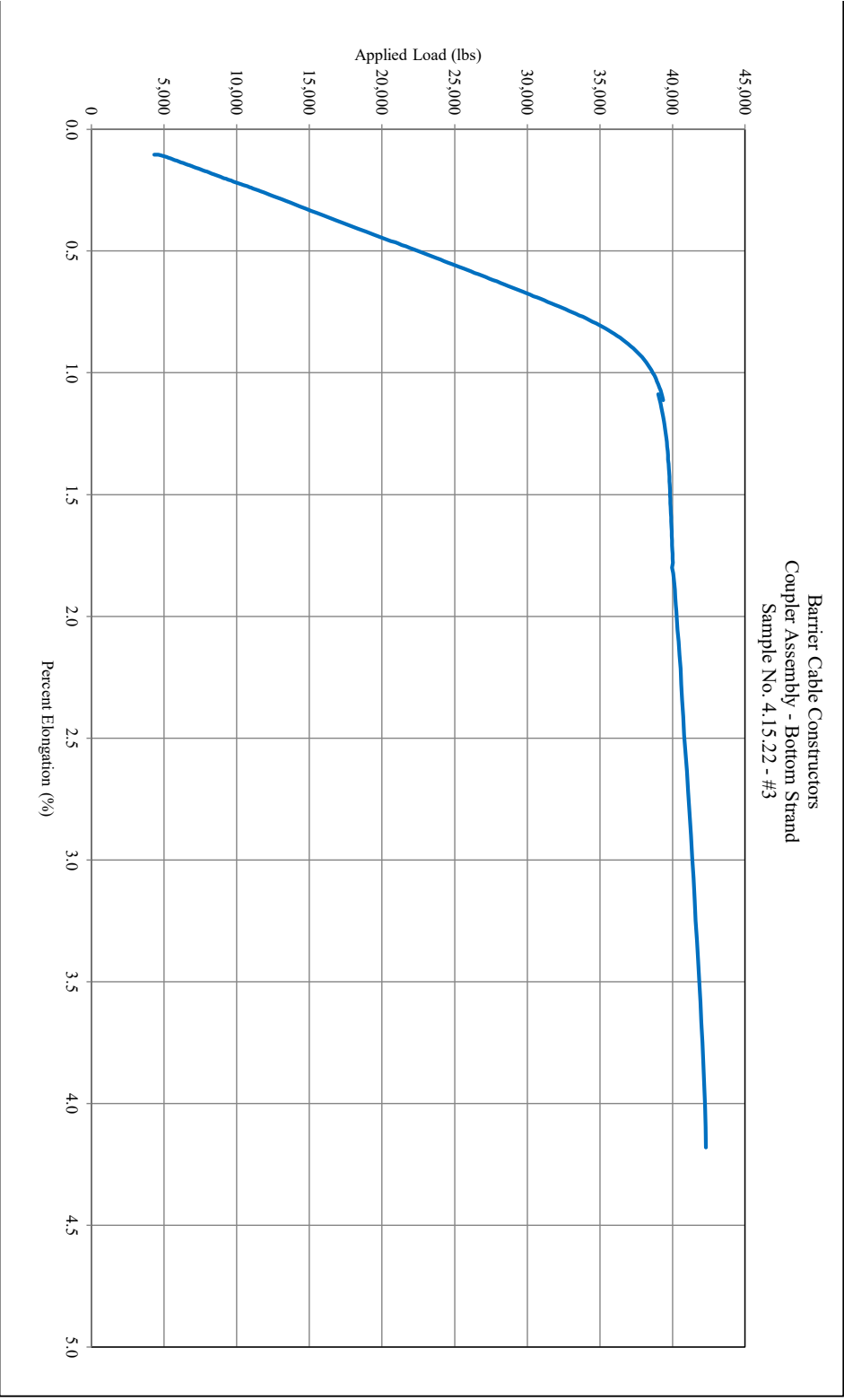
WJE Project Number	2020.2430
Client	GTL
Sample Tested	0.5-in RU Splice Chuck Assembly

Test Location	Northbrook, IL
Test Operator	B Easton
Test Date	5/20/2020
Test Methods	ASTM A1061, A416

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Verified Dimensions	
Strand Diameter	0.500 in
Weight	228.8 grams
Length	11.884 in
Area	0.149 in ²

Measured Values	
Load at 1% Elongation	38,550 lbs
Breaking Load	42,310 lbs
Elong @ Max Load	4.18 percent
Modulus of Elasticity	29,620 ksi



WJE Project Number	2021.3293	Test Location	Northbrook, IL
Client	Barrier Cable Constructors	Test Operator	B Easton
Sample Tested	0.5-in Splice Chuck Assembly	Test Date	10/21/2021
		Test Methods	ASTM A1061, A416

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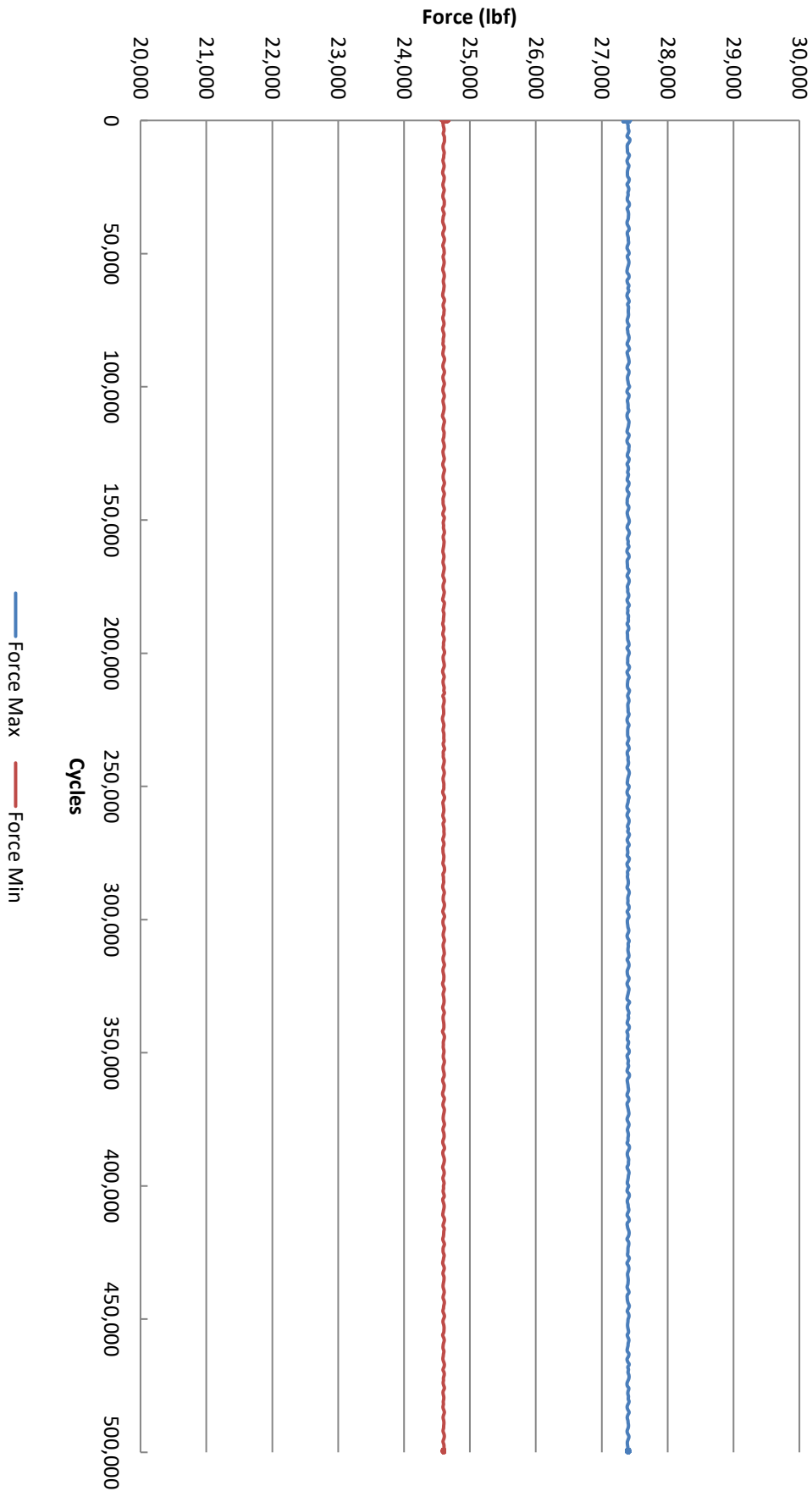
APPENDIX E. ANCHORAGE FATIGUE TESTS



ENGINEERS
ARCHITECTS
MATERIALS SCIENTISTS

Wiss, Janney, Elstner Associates, Inc.
330 Pfingsten Road
Northbrook, Illinois 60062

General Building Services, Inc.
Splice Coupler - 0.5-in with 1.2-in Three-piece Wedge
Sample 042022 - 500,000 Cycles
WJE No. 2021.3293

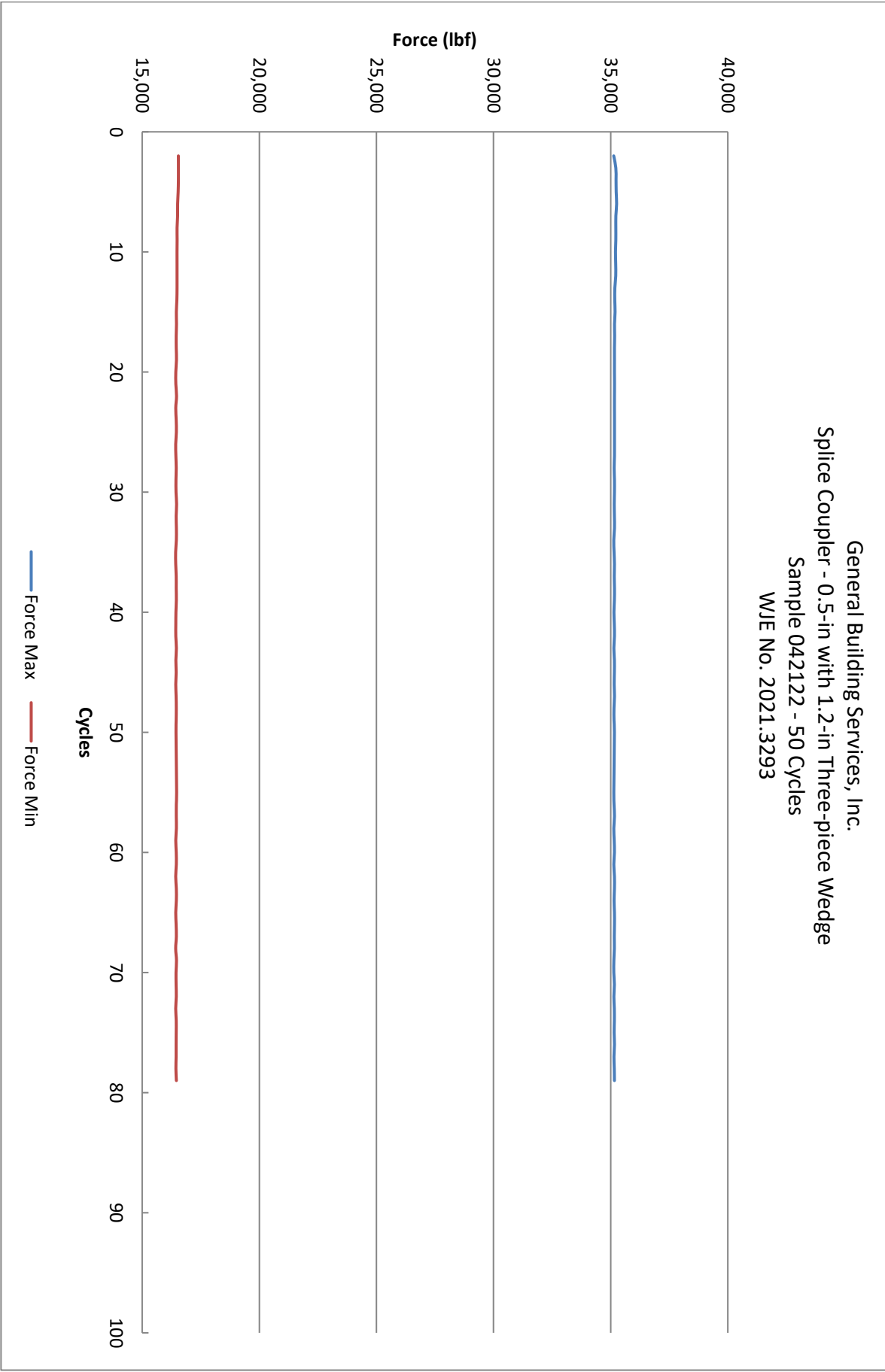




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330 Pfingsten Road
Northbrook, Illinois 60062

General Building Services, Inc.
Splice Coupler - 0.5-in with 1.2-in Three-piece Wedge
Sample 042122 - 50 Cycles
WJE No. 2021.3293

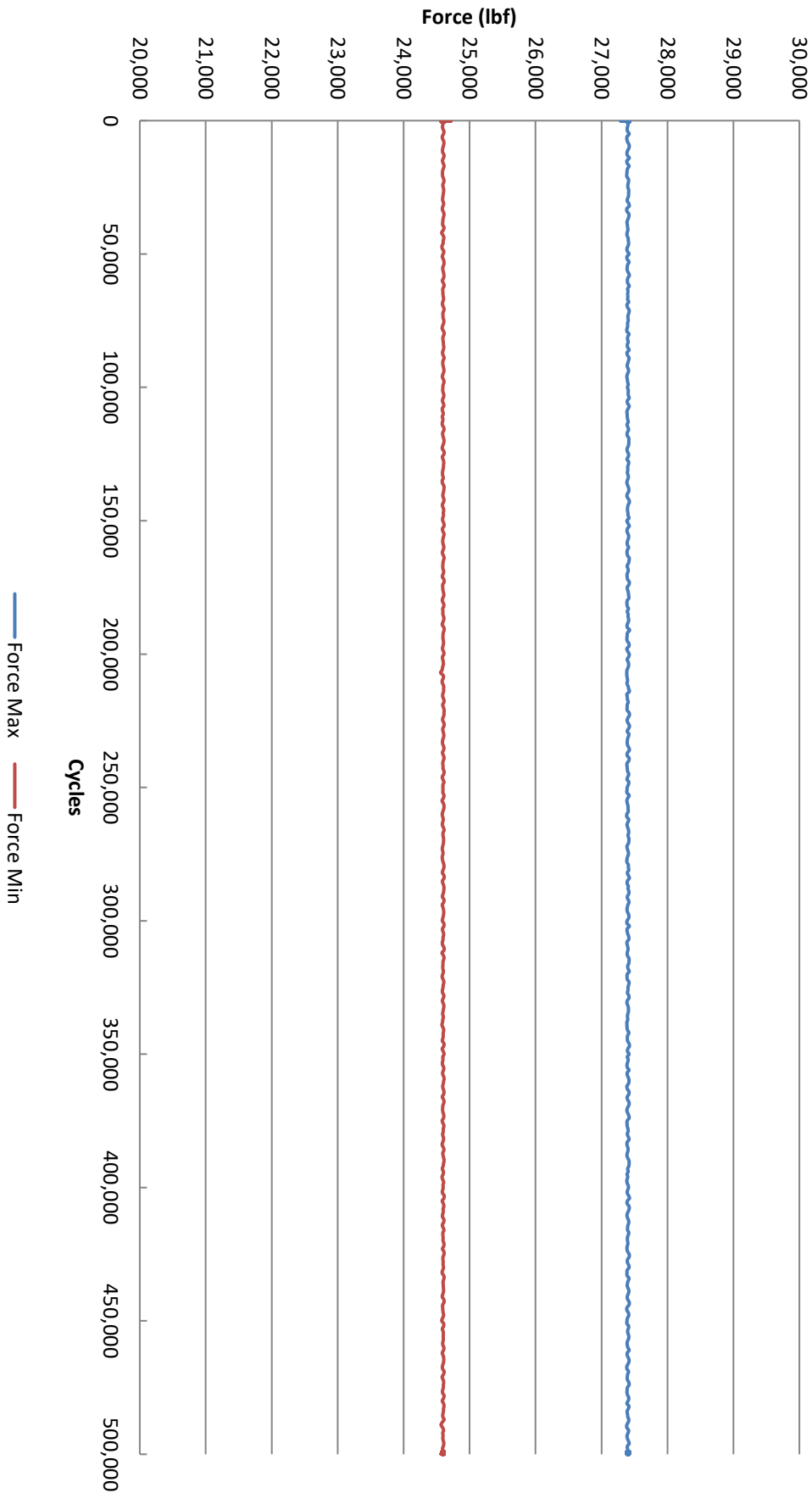




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330 Pfingsten Road
Northbrook, Illinois 60062

General Building Services, Inc.
Splice Coupler - 0.5-in with 1.2-in Three-piece Wedge
Sample 042222 - 500,000 Cycles
WJE No. 2021.3293





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Wiss, Janney, Elstner Associates, Inc.
330 Pfingsten Road
Northbrook, Illinois 60062

General Building Services, Inc.
Splice Coupler - 0.5-in with 1.2-in Three-piece Wedge
Sample 042322 - 50 Cycles
WJE No. 2021.3293

