CEL CONSULTING, INC

Product Evaluations - Metallurgy
Structural Investigations - Forensics

PIPE PROP

TESTING PROGRAM ACCORDING TO: **FM 1950-16**
Approval Stradard for Seismic Sway Braces for Automatic Sprinkler Systems

Prepared for: JMB Industries LLC.
Fort Worth, Texas

Prepared by: CEL Consulting, Inc. Approved by:

Nathan Westin, P.E. Jay Dorst, P.E.

Report Date: January 19, 2018
Report Number: 18J377 CEL Project No. 50-53424-C
Report Revised April 4, 2018*

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this testing program was to provide data to substantiate performance capabilities of the Pipe Prop system ***per ASCE 7-10 Section 1.3.1.3 Performance-Based Procedures.***

1.2 Scope of Testing

The scope of this testing program consisted of cyclic testing of the Pipe Prop system at three different lengths at a 90° angle (θ) pursuant to FM 1950-16.

1.3 Installation and Test Set-up

The Pipe Prop base was installed into a ridged steel mount using adhesive and steel rods supplied by the manufacturer. Additionally, clamps were used to secure the base to the steel mount. PVC pipe was cut to the desired length to meet the overall Pipe Prop specified test length measured from the surface of the steel mount to the center of a pipe affixed in the Pipe Prop sadle. A PVC pipe was inserted into the Pipe Prop base with the steel rod inside the PVC pipe was treated with a primer and glued. Steel ties supplied by the manufacturer were used to fix a pipe inside the Pipe Prop saddle. The system component tested product numbers for this program are: APS-1, MDA-HZ1, MDA-1000, and SSPP-14. More information is available in Appendix C. The fixing of PVC pipe utilized Oatey Purple Primer and Oatey Hot Medium Blue Lava PVC Cement.

2.0 TESTING PROGRAM

Table 2.0: FM 1950-16 Testing Program

Tested Length (in.)	No. of Tests	Initial Loading (lbf.)
$3^1/_2$	3	200
6	3	75
8	3	45

3.0 FACILITIES AND TEST EQUIPMENT

3.1 General

All testing was performed at the CELC Testing Laboratory in Oakland, California. CELC is accredited to ISO/IEC 17025 by the International Accreditation Service, Inc. (IAS) for testing in accordance with FM 1950-16.

3.2 Cyclic Testing

The loading system is supported on an independent rigid frame. A closed loop hydraulic system consisting of a hydraulic ram actuator with integral load cell mounted on a large steel test frame was used to load the test. The 22-kip hydraulic actuator ram was controlled by a MTS 407 controller capable of applying the required load cycles. A PC-based data acquisition system

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consisting of National Instruments DAQ hardware chassis and LabView testing software was used to record the data. Displacement was measured using a linear variable displacement transducer (LVDT).

The load cell and LVDTs were calibrated in accordance with the CELC quality system. LVDTs are calibrated in-house and load cells are calibrated by an independent calibration service with standards traceable to NIST. Calibration documentation is not included in this report since our calibrations are current and in accordance with our quality control procedures and IAS accreditation. Photographs of the test equipment and system configurations are provided in Appendix B.

4.0 TEST PROCEDURES

Testing was performed in accordance with FM 1950-16 section 4.2, Cyclic Testing (Component Testing). The force amplitude was manually adjusted upward for each load increment after the first 15 constant load cycles since the force control hardware was not capable of automatically following the FM 1950-16 force history profile. Frequency of the testing was 0.1 Hz.

Data was imported from the data acquisition system to an Excel computer file. Graphs were plotted for each replicate for displacement versus cycles, load versus cycles and load versus displacement. These graphs are provided in Appendix A for each individual test conducted. Displacement was recorded at the point of loading for all system configurations.

5.0 TEST RESULTS

Loads indicated in the below test result tables were taken from the cyclic peak just prior to failure of the system to be loaded to the FM 1950-16 Force Profile or exceedance of the deformation limit. The deformation limit for 90° installation angle is 1-in. The Nominal Strength (R_n) is the least of the three loads. The horizontal nominal strength (R_{Hn}) is R_n*Sin(θ).

Table 5.0: Summary of Test Results for Pipe Prop at 90° installation angle

Tested Length	Test No.	Load	Displacement	Failure Mode
		(lbf.)	(in)	
$3^1/_2$-in.	1	480	0.41	System Failure
	2	754	0.54	System Failure
	3	329	0.36	System Failure
	Nominal Strength (R_n)	329		
	Horizontal Nominal Strength (R_{Hn})	**329**		

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Table 5.1: Summary of Test Results for Pipe Prop at 90° installation angle

Tested Length	Test No.	Load (lbf.)	Displacement (in)	Failure Mode
6-in.	1	197	0.89	Exceedance of Deformation Limit
	2	197	0.94	Exceedance of Deformation Limit
	3	140	0.97	Exceedance of Deformation Limit
	Nominal Strength (R_n)	140		
	Horizontal Nominal Strength (R_{Hn})	**140**		

Table 5.2: Summary of Test Results for Pipe Prop at 90° installation angle

Tested Length	Test No.	Load (lbf.)	Displacement (in)	Failure Mode
8-in.	1	125	0.98	Exceedance of Deformation Limit
	2	129	0.95	Exceedance of Deformation Limit
	3	139	0.98	Exceedance of Deformation Limit
	Nominal Strength (R_n)	125		
	Horizontal Nominal Strength (R_{Hn})	**125**		

Test data files are provided in Appendix A.

6.0 DESIGN VALUES

Table 6.0 summarizes the design values per FM 1950-16. The strength reduction factor (ϕ) is 0.7 and the factor of safety (Ω) is 2.0.

Table 6.0: Summary of Design Values

Pipe Prop Length (in.)	Brace Orientation Angle (θ)	LRFD Value[1]	ASD Value[2]
$3^1/_2$	$\theta = 90°$	230	165
6	$\theta = 90°$	98	70
8	$\theta = 90°$	88	63

[1]Calculated as $R_{Hn}*\phi$.
[2]Calculated as R_{Hn}/Ω.

7.0 CONCLUSION

The performance values attained for the Pipe Prop system were tested and evaluated in accordance with ANSI/FM 1950-16 per ASCE 7-10 Section 1.3.1.3 Performance-Based Procedures.

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8.0 REFERENCES

ANSI/FM Approvals, Norwood, MA: Class Number 1950 Approval Standard for Seismic Sway Braces for Automatic Sprinkler Systems, Februry 2016.

ASCE. 2010. *Minimum Design loads for Buildings and Other Structures.* ASCE/SEI Standard 7-10.

International Organization for Standardization, Geneva Switzerland: ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories,* May 15, 2005.

International Accreditation Service, Inc., Brea, CA: Testing Laboratory TL-173 (Accreditation to ISO/IEC 17025).

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Report for JMB Industries LLC.
Pipe Prop
FM 1950-16

January 19, 2018
Report Number: 18J377

Appendix A
Test Data Files

Contents:

- Test Data Sheet
- Force History Plots
- Displacement History Plots
- Load vs. Displacement Plots

Client: JMB Industries

Product: Pipe Prop

Project Name: FM 1950-16

Project No: 50-53424-C

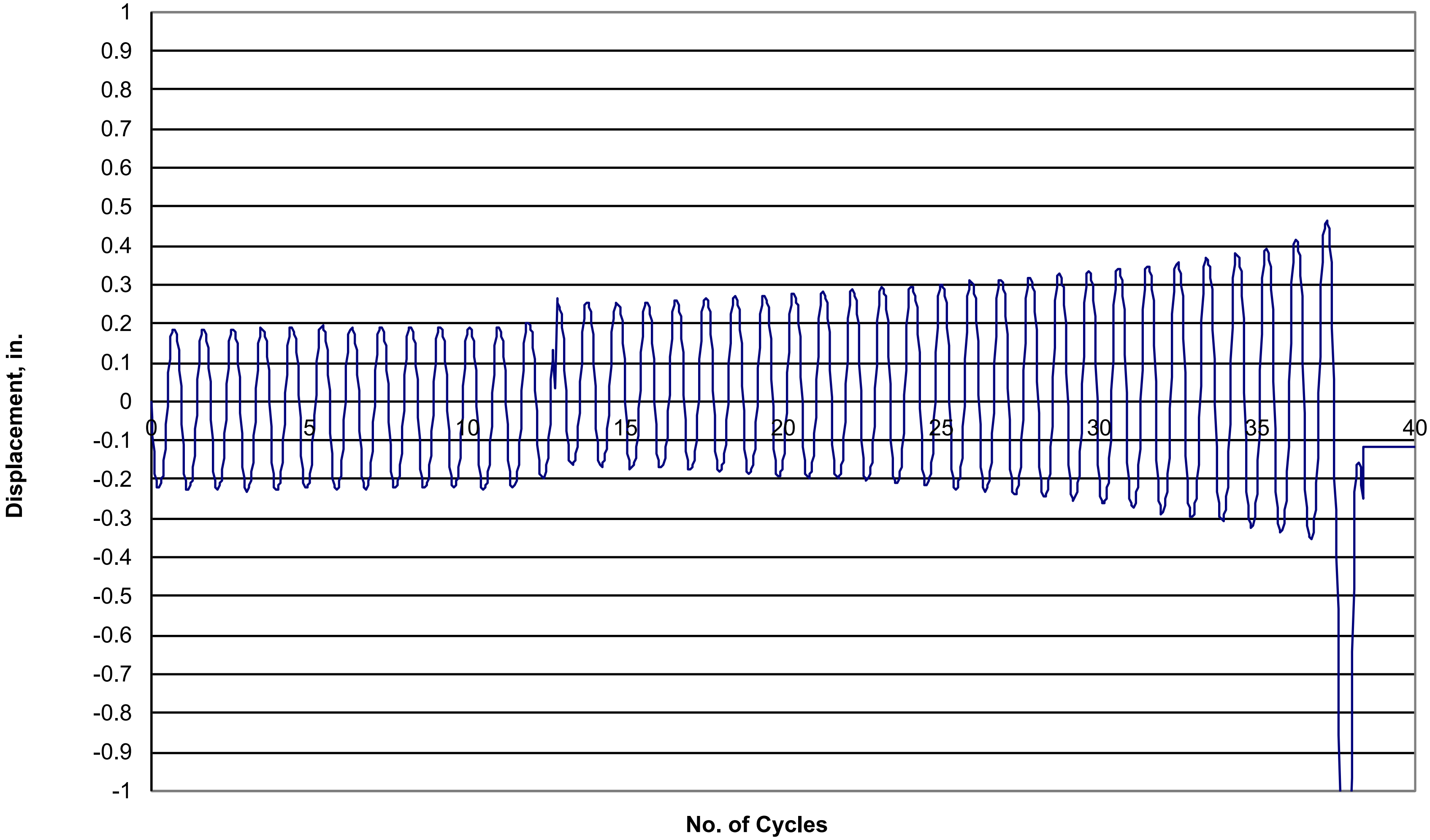
Installation Angle: 90 degrees

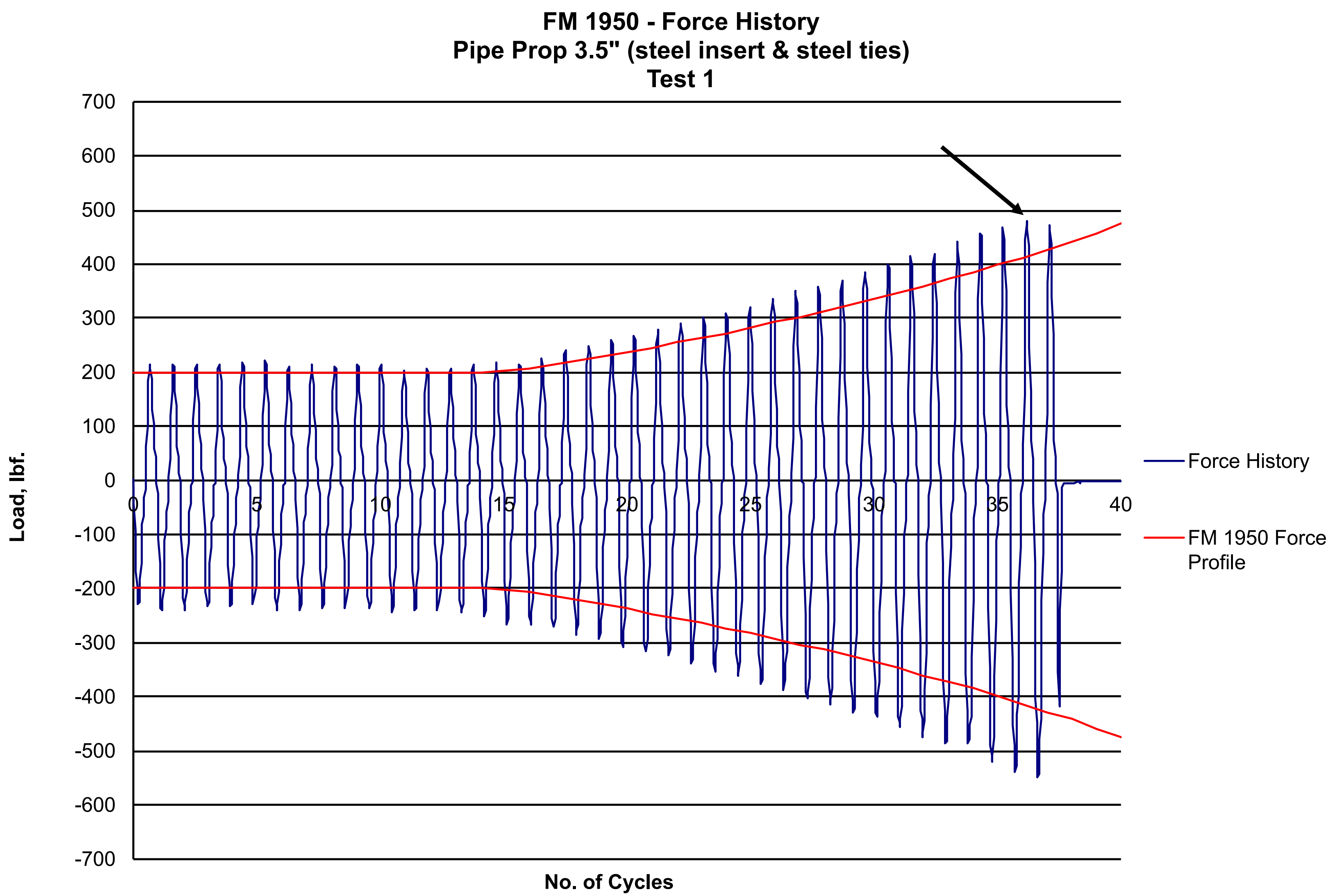
Test #	Test Date:	°F	Initial Load (lbs)	Set-up Length (in)	Ultimate Load (lbs)	Failure Mode/Notes:
1	1/5/18	69	275	3.5	479	PVC pipe broke at the end of the metal insert
2	1/8/18	69	275	3.5	754	PVC pipe broke at the end of the metal insert
3	1/8/18	69	275	3.5	329	Saddle broke

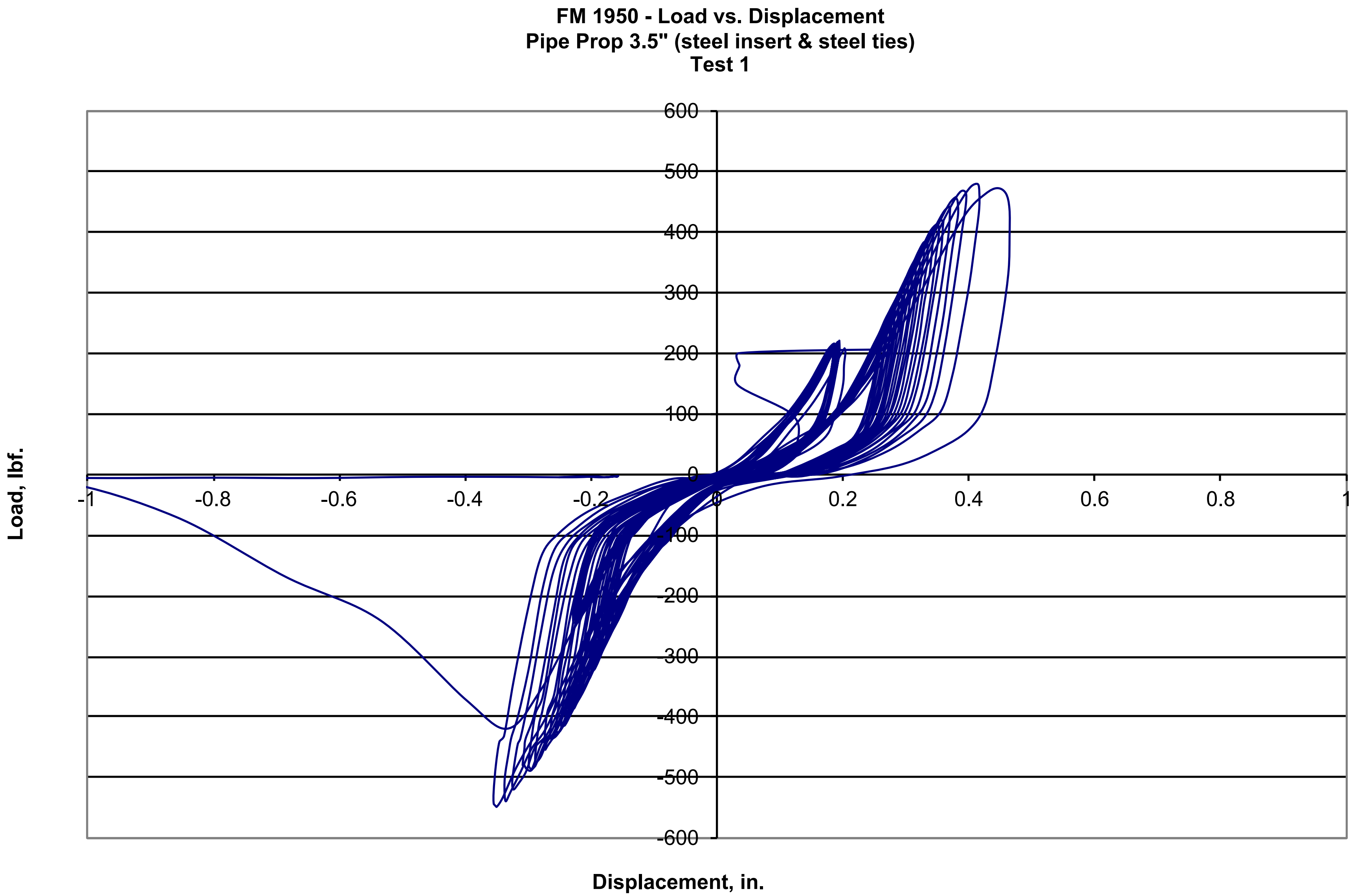
Seismic Tested By: EG

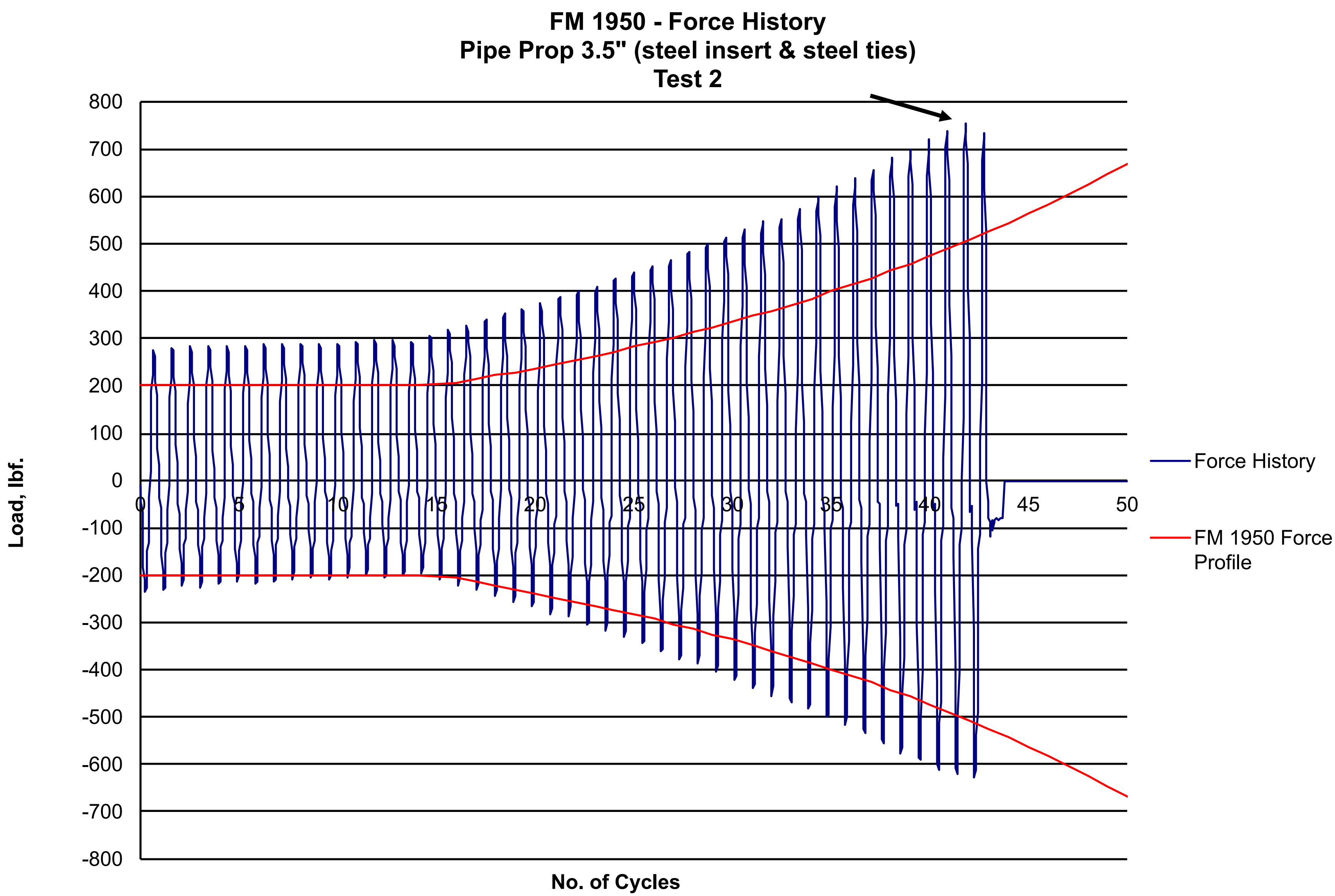
LVDT: DT13
Load Cell: LM22
DAS: DA11

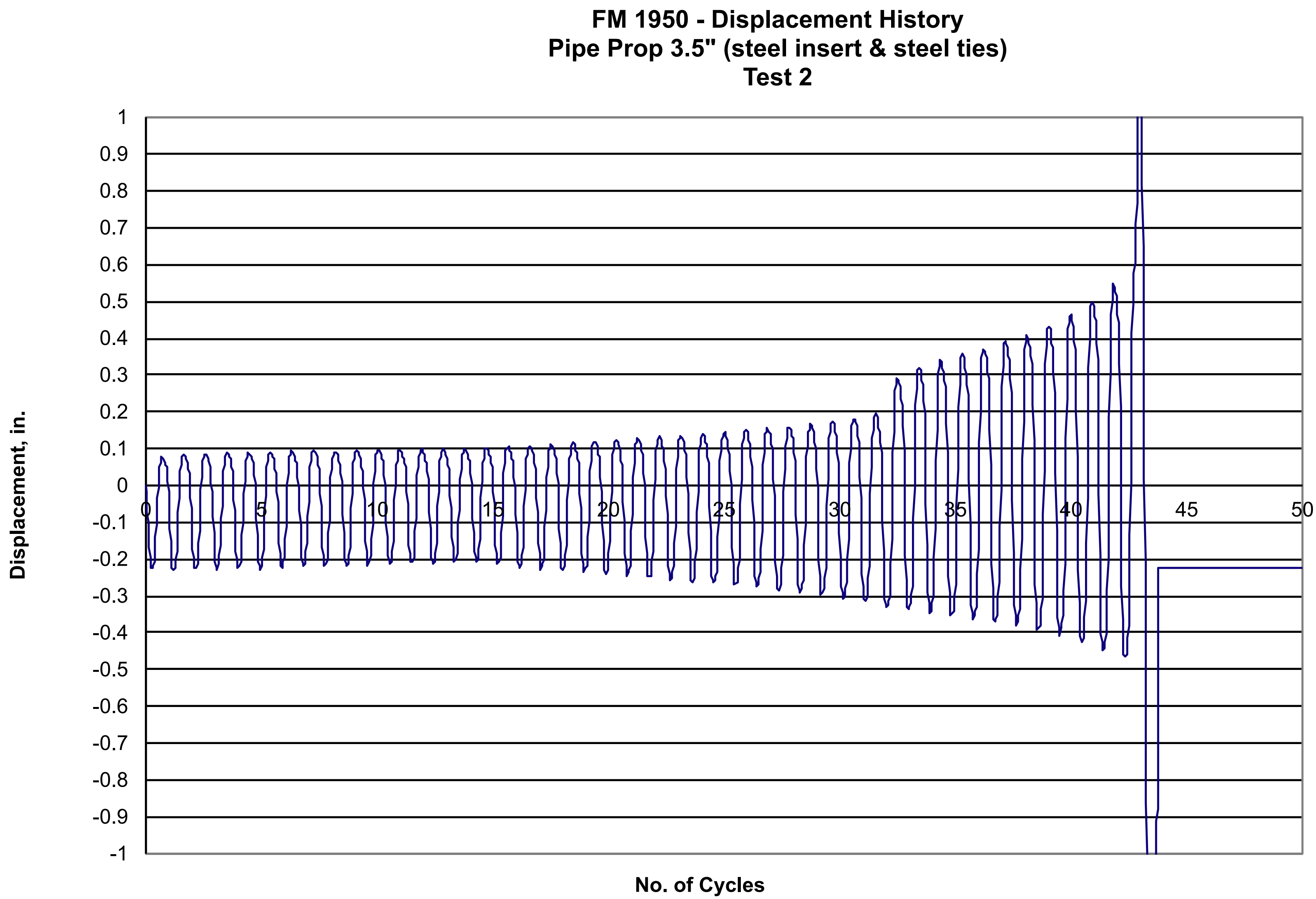
FM 1950 - Displacement History
Pipe Prop 3.5" (steel insert & steel ties)
Test 1

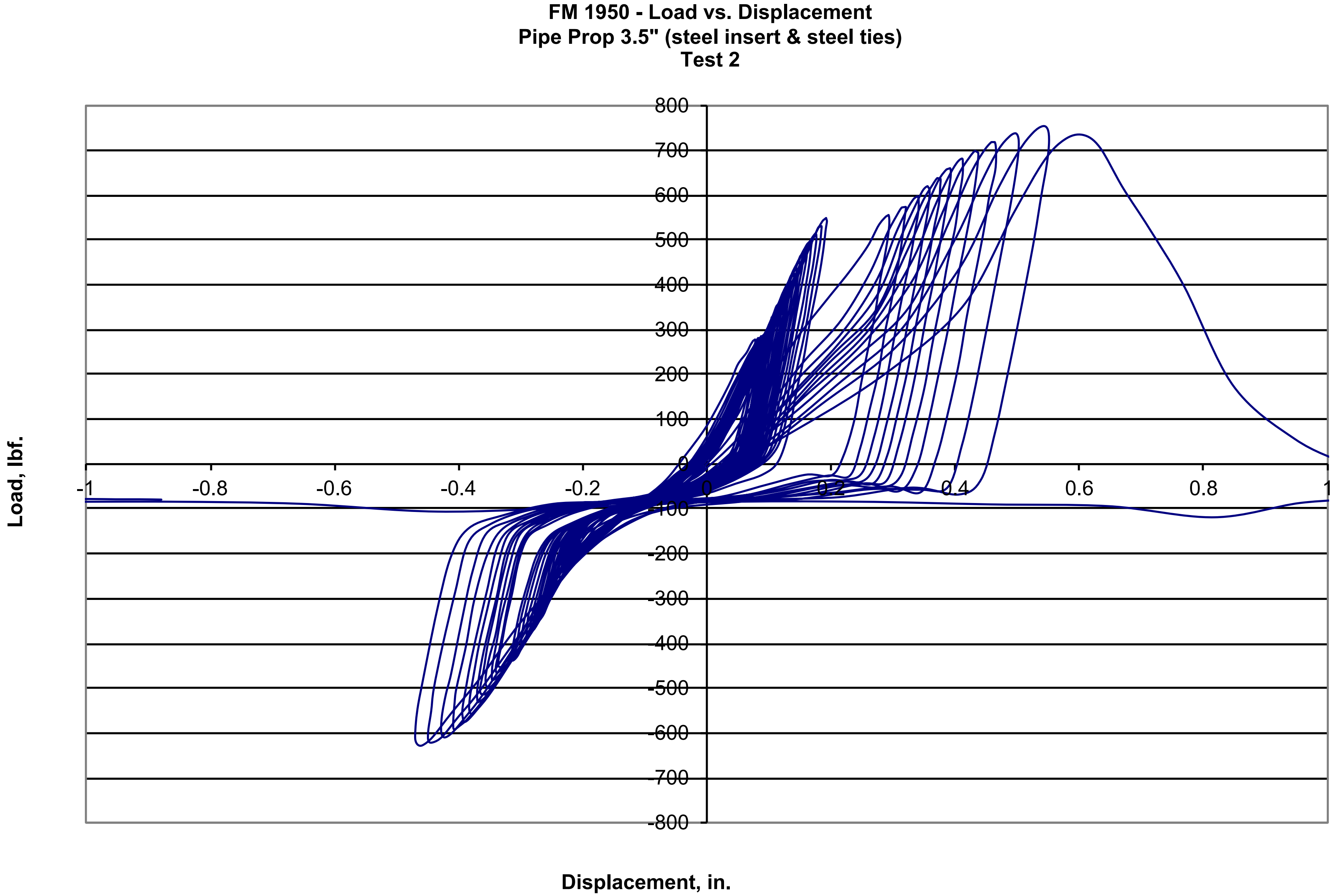


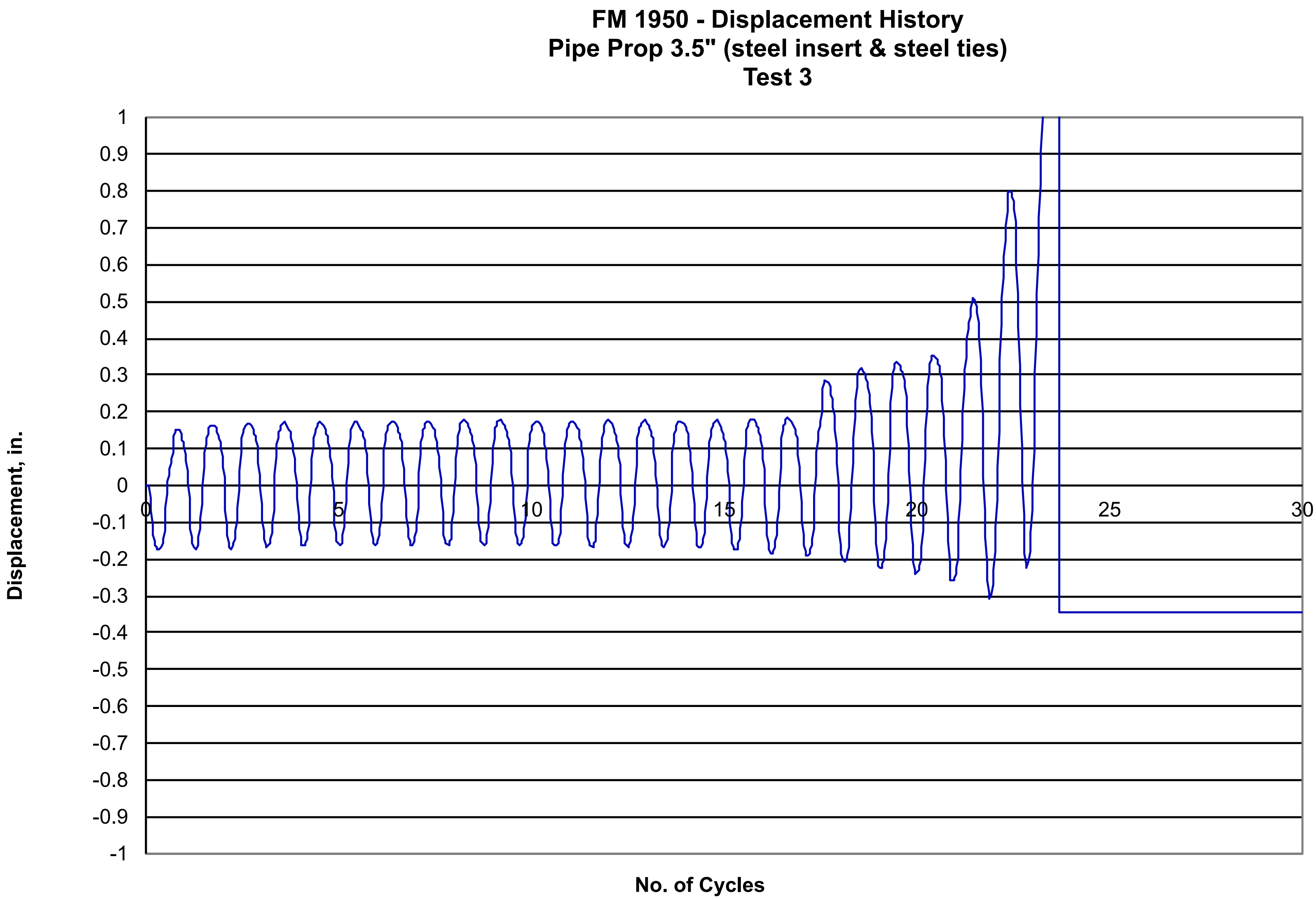

FM 1950 - Force History
Pipe Prop 3.5" (steel insert & steel ties)
Test 1
Load, lbf.
No. of Cycles
Force History
FM 1950 Force Profile
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
0
5
10
15
20
25
30
35
40

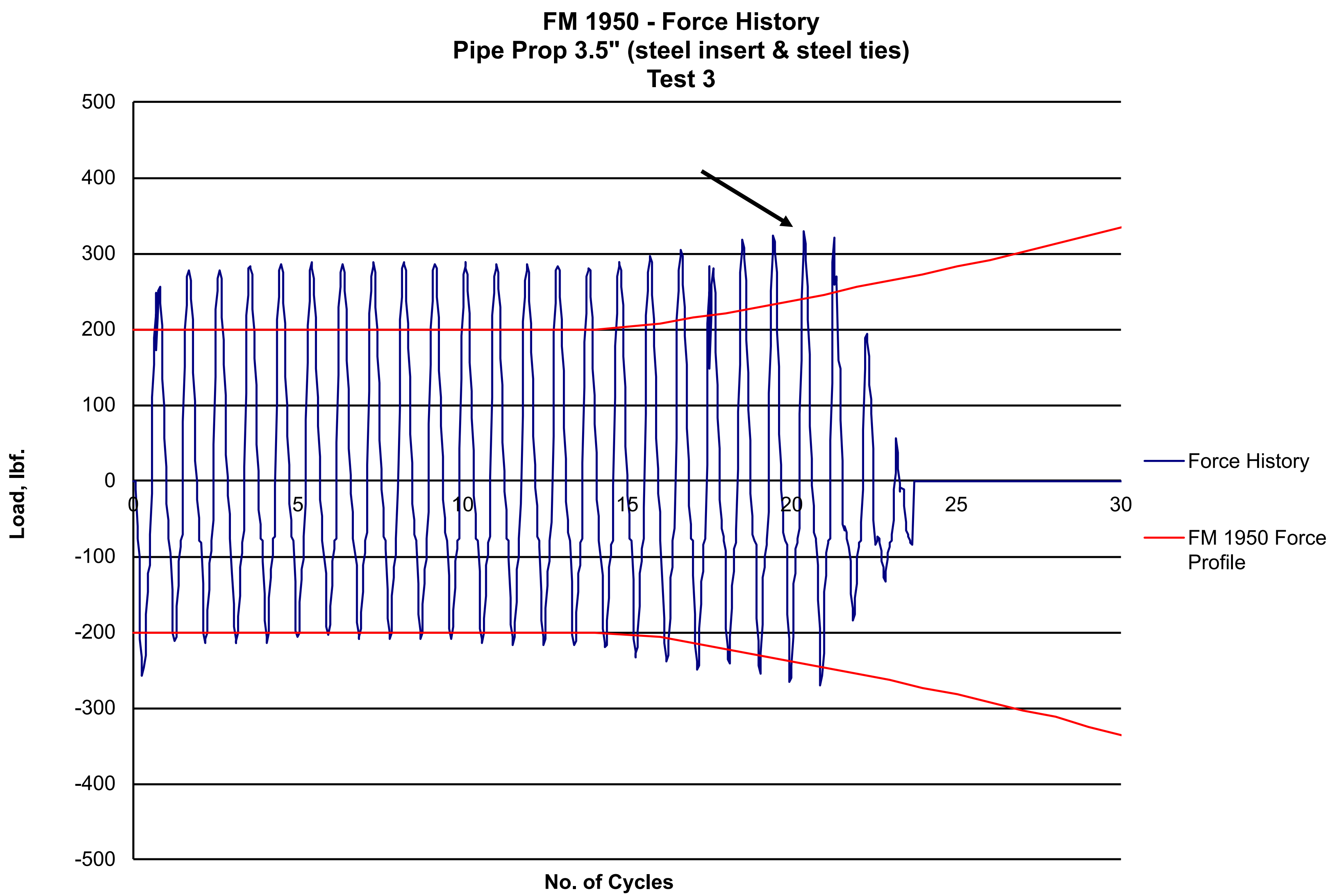

FM 1950 - Load vs. Displacement
Pipe Prop 3.5" (steel insert & steel ties)
Test 1
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Load, lbf.
Displacement, in.

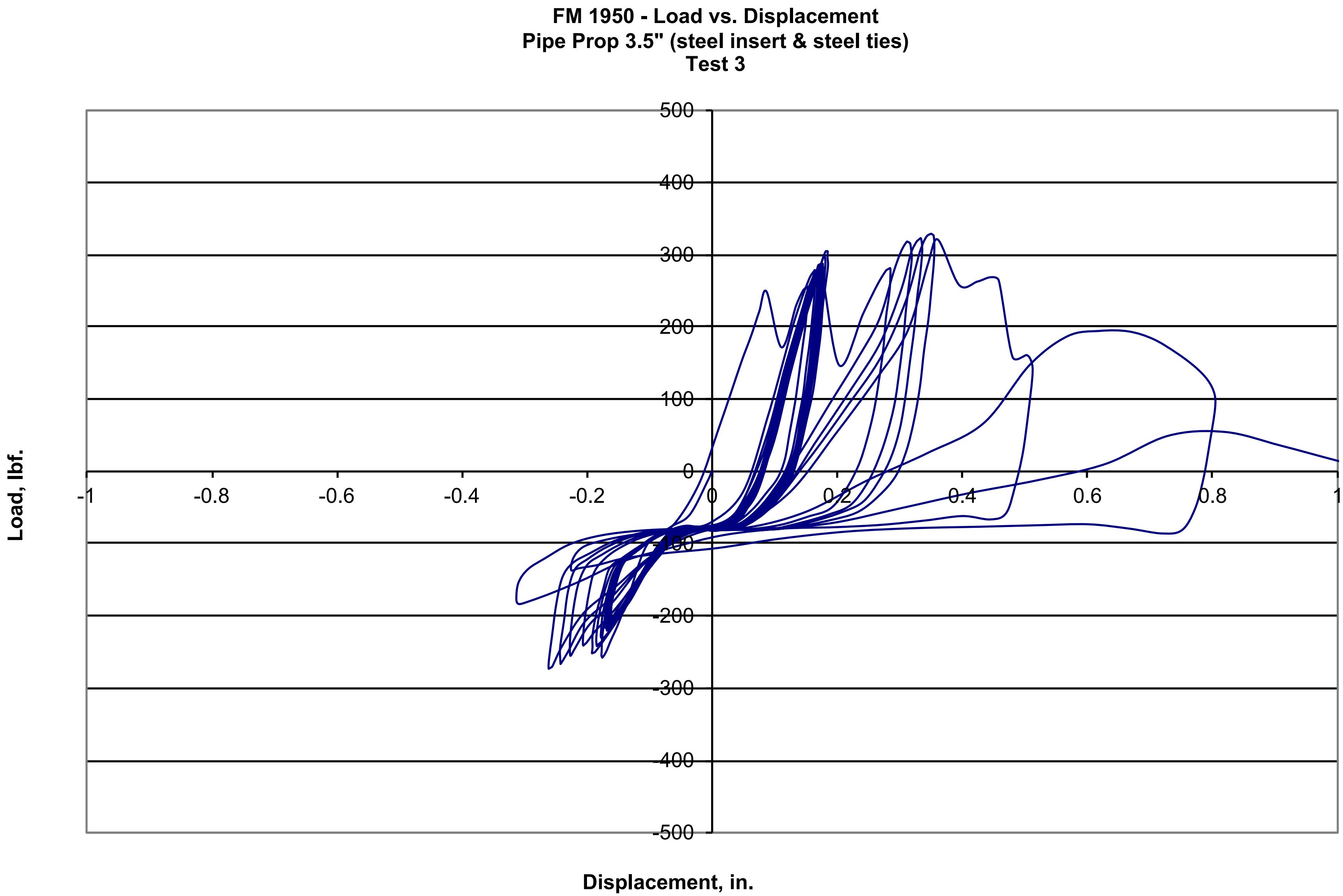

FM 1950 - Force History
Pipe Prop 3.5" (steel insert & steel ties)
Test 2
Load, lbf.
No. of Cycles
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
0
5
10
15
20
25
30
35
40
45
50
Force History
FM 1950 Force Profile


FM 1950 - Displacement History
Pipe Prop 3.5" (steel insert & steel ties)
Test 2
Displacement, in.
No. of Cycles
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
0
5
10
15
20
25
30
35
40
45
50


FM 1950 - Load vs. Displacement
Pipe Prop 3.5" (steel insert & steel ties)
Test 2
Load, lbf.
Displacement, in.
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


FM 1950 - Displacement History
Pipe Prop 3.5" (steel insert & steel ties)
Test 3
Displacement, in.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
0
5
10
15
20
25
30
No. of Cycles


FM 1950 - Force History
Pipe Prop 3.5" (steel insert & steel ties)
Test 3
500
400
300
200
100
0
-100
-200
-300
-400
-500
Load, lbf.
0
5
10
15
20
25
30
No. of Cycles
Force History
FM 1950 Force Profile


FM 1950 - Load vs. Displacement
Pipe Prop 3.5" (steel insert & steel ties)
Test 3
Load, lbf.
Displacement, in.
500
400
300
200
100
0
-100
-200
-300
-400
-500
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

Client: JMB Industries

Product: Pipe Prop

Project Name: FM 1950-16

Project No: 50-53424-C

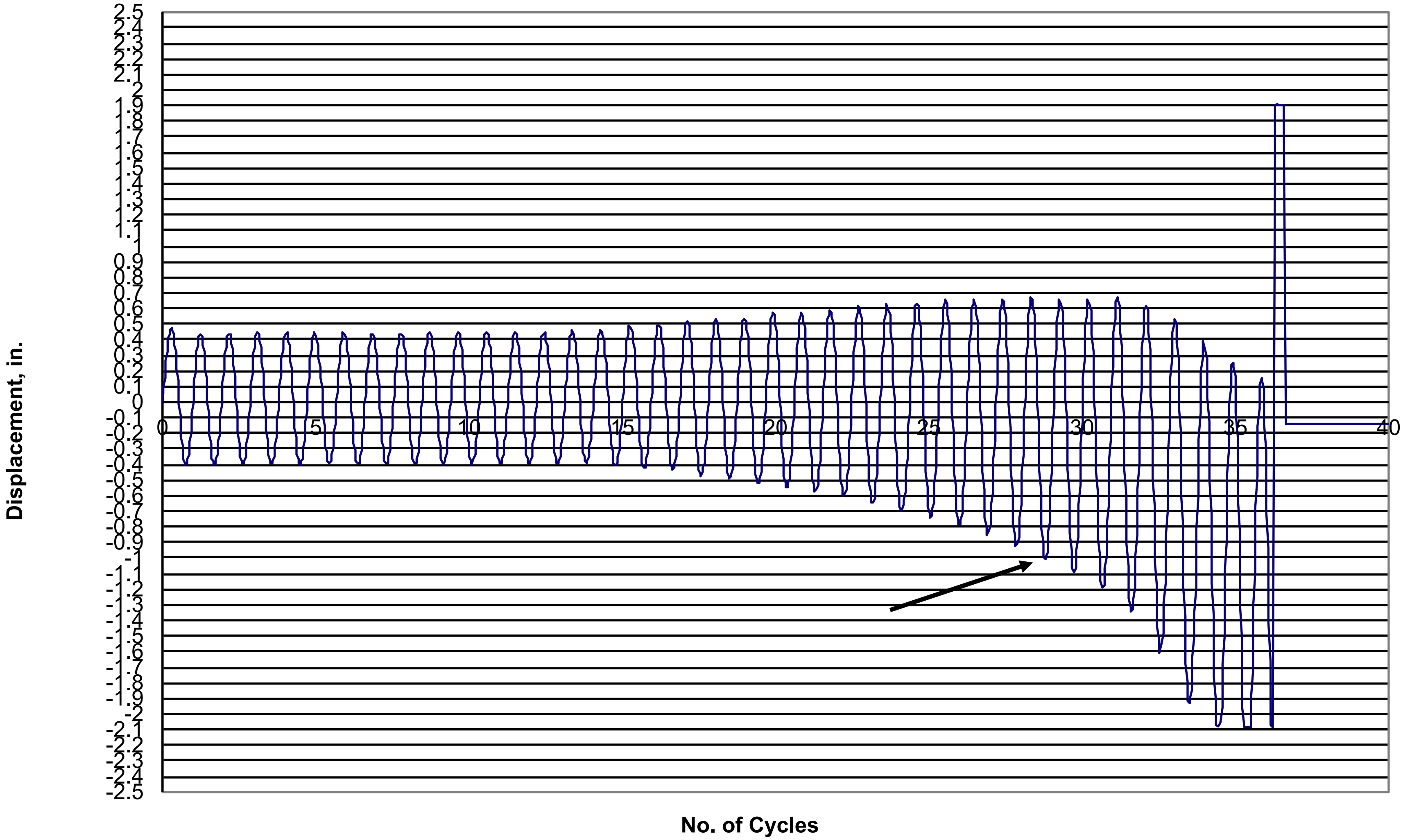
Installation Angle: 90 degrees

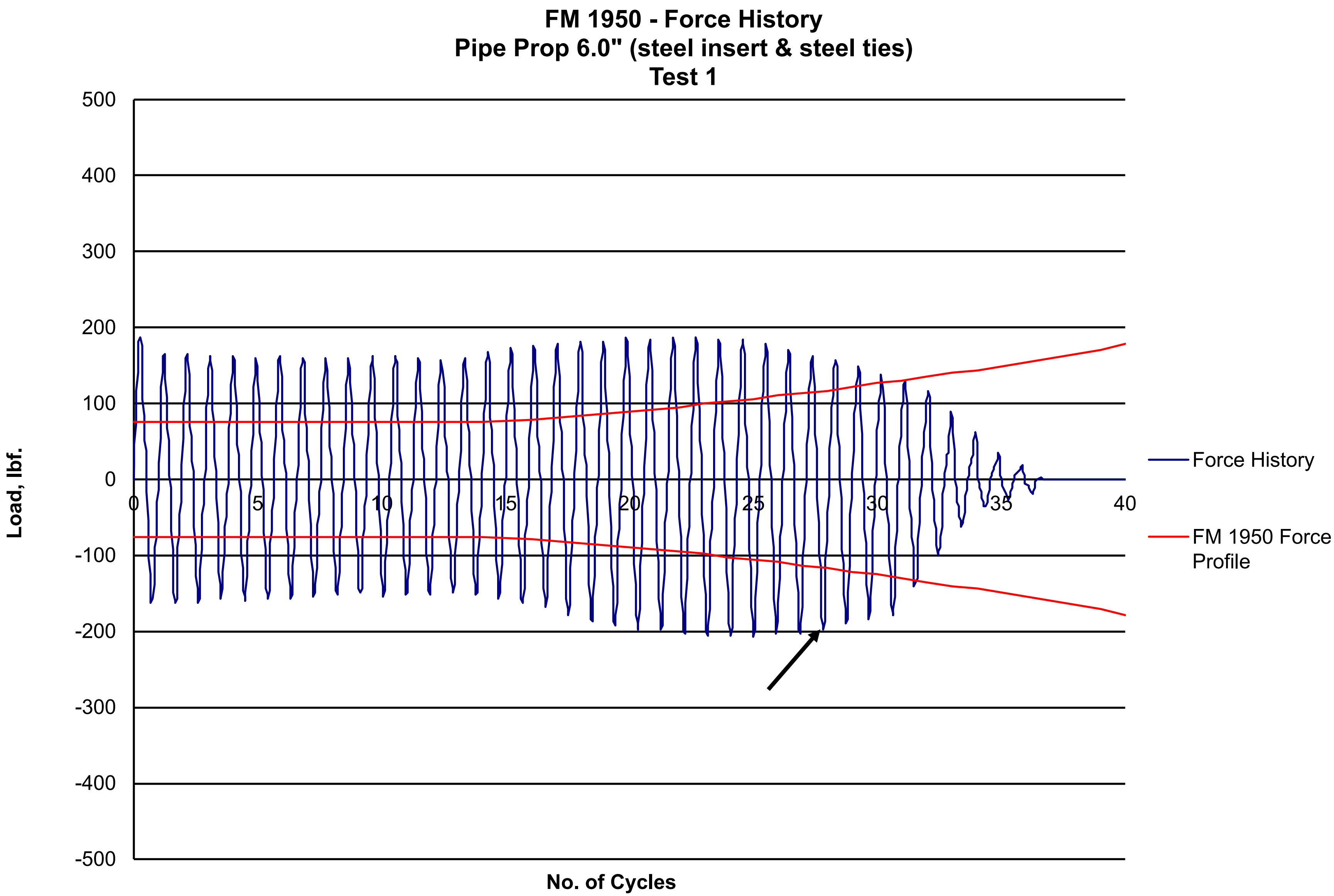
Test #	Test Date:	°F	Initial Load (lbs)	Set-up Length (in)	Ultimate Load (lbs)	Failure Mode/Notes:
1	12/8/17	69	315	6.0	187	PVC pipe broke at the end of the metal insert
2	1/4/18	69	315	6.0	179	PVC pipe broke at the end of the metal insert
3	1/4/18	69	315	6.0	160	Saddle came off the end of the PVC pipe

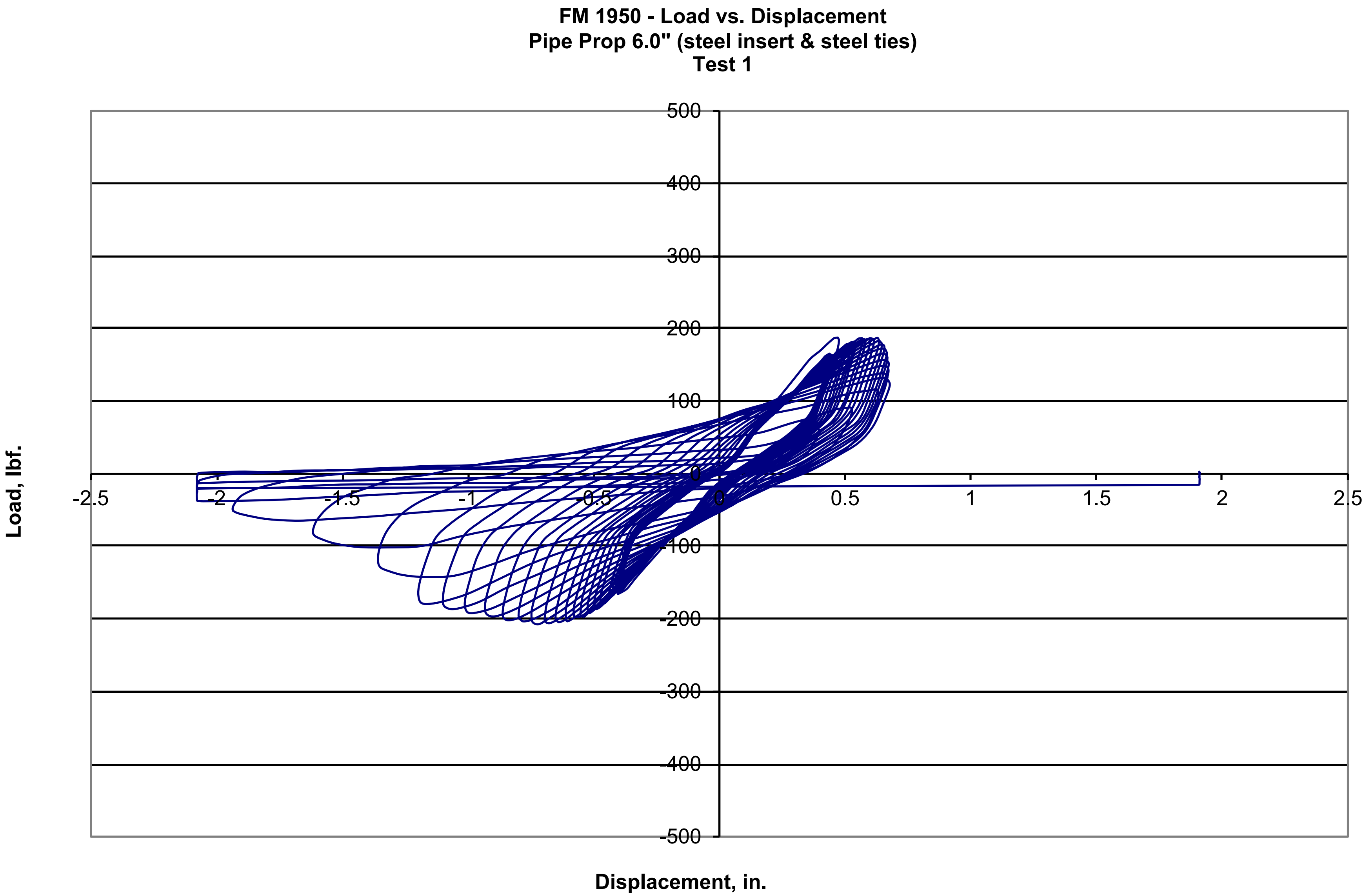
Seismic Tested By: EG

LVDT: DT13
Load Cell: LM22
DAS: DA11

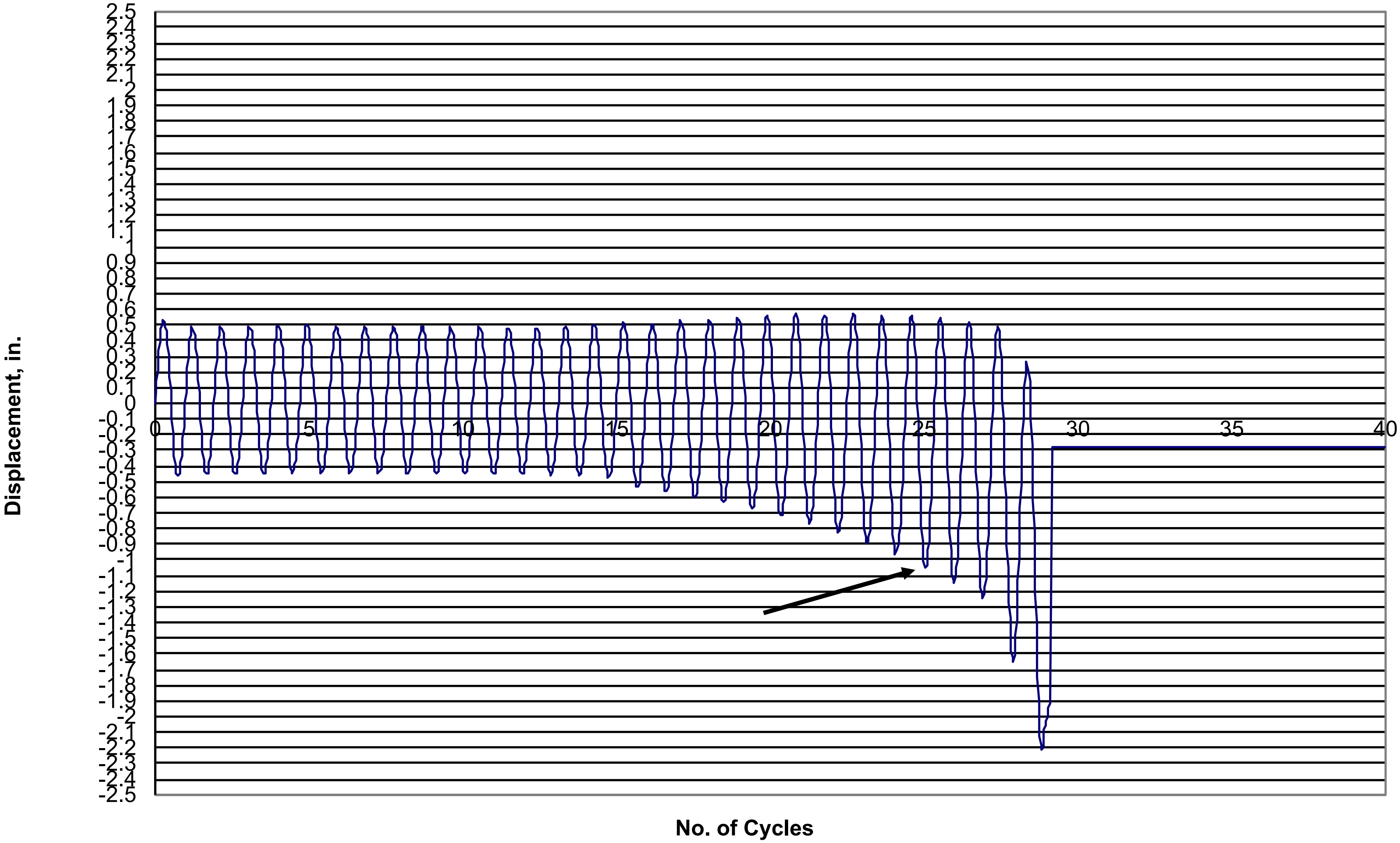
FM 1950 - Displacement History
Pipe Prop 6.0" (steel insert & steel ties)
Test 1

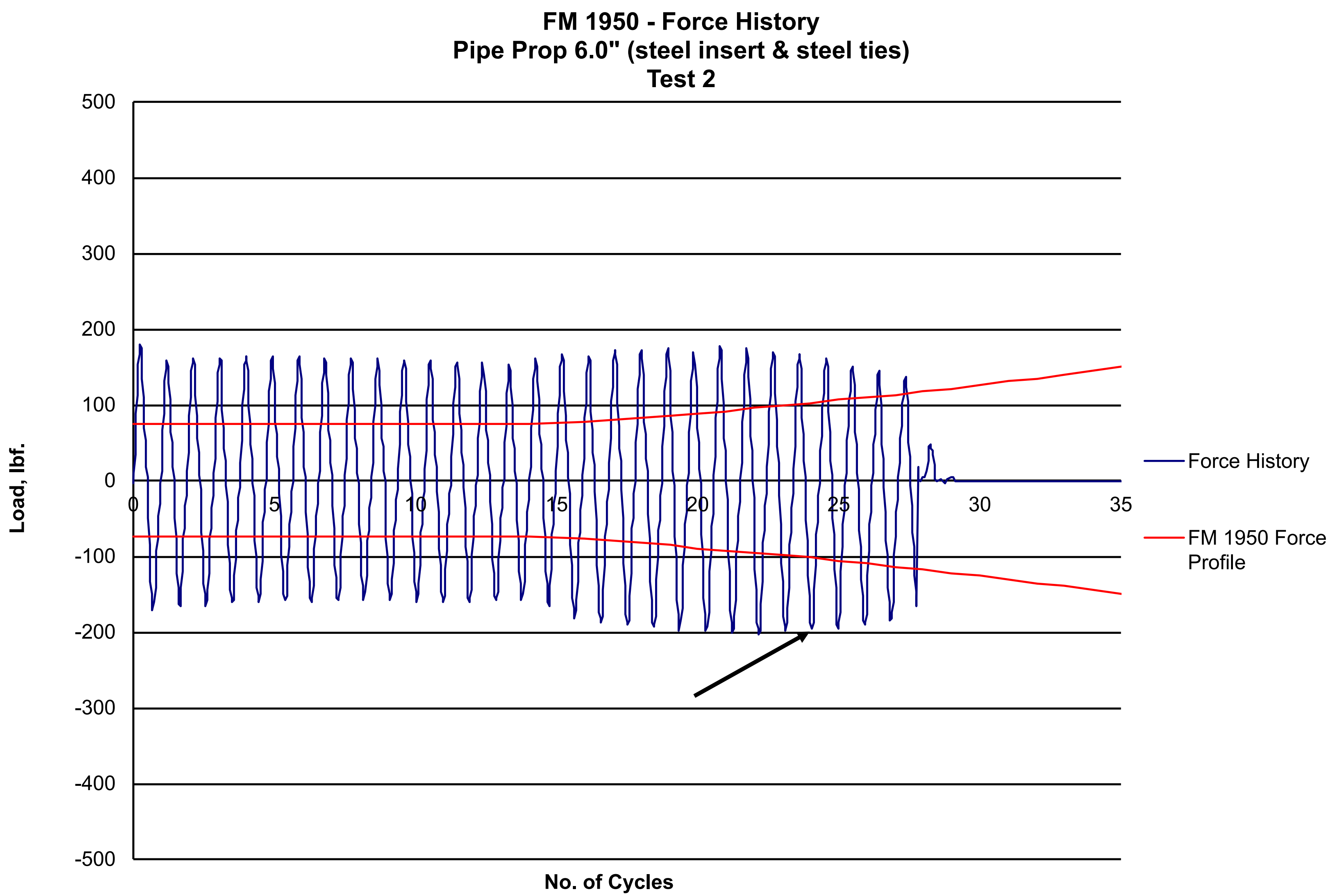



FM 1950 - Force History
Pipe Prop 6.0" (steel insert & steel ties)
Test 1
Load, lbf.
500
400
300
200
100
0
-100
-200
-300
-400
-500
0
5
10
15
20
25
30
35
40
No. of Cycles
Force History
FM 1950 Force Profile

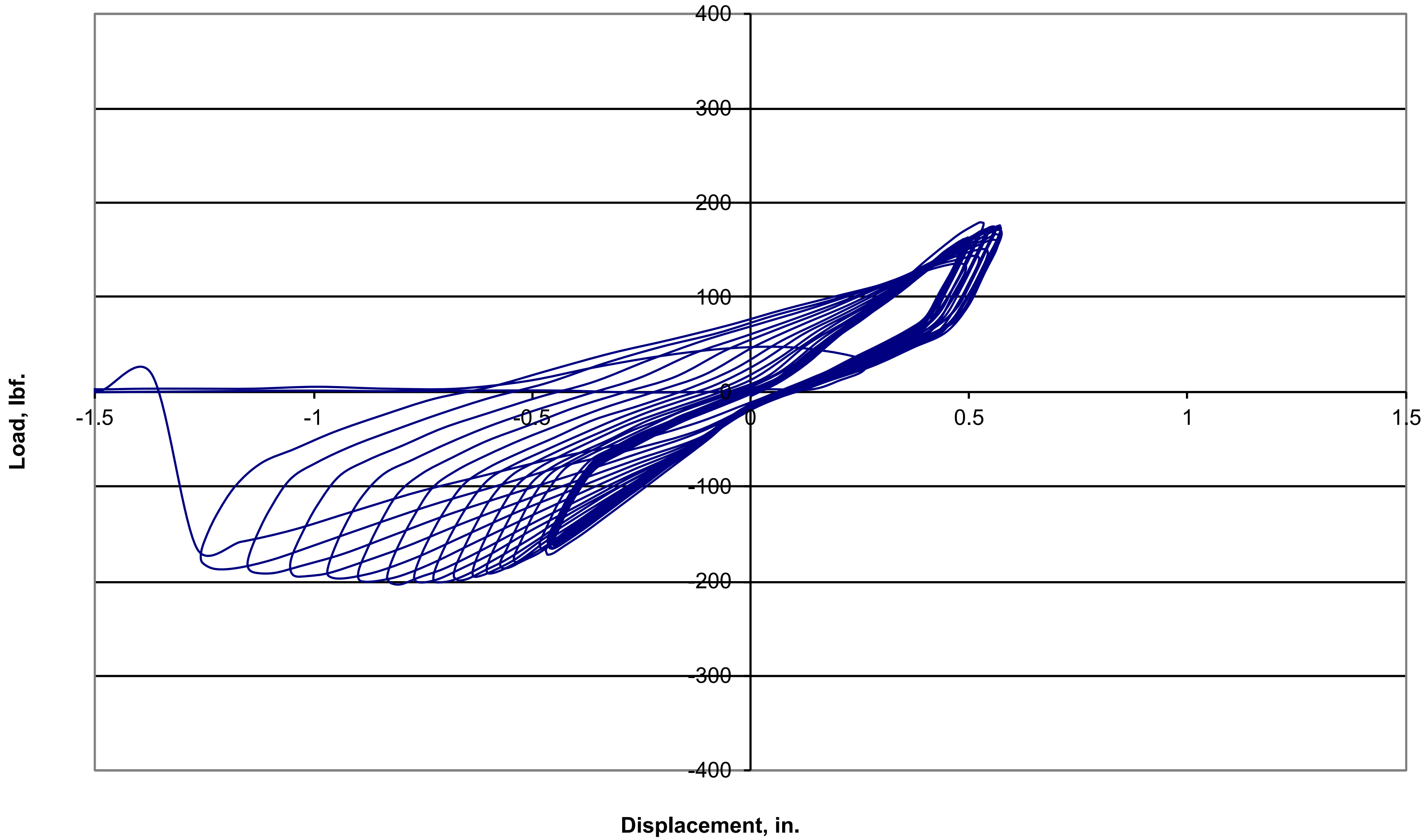

FM 1950 - Load vs. Displacement
Pipe Prop 6.0" (steel insert & steel ties)
Test 1
500
400
300
200
100
0
-100
-200
-300
-400
-500
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Load, lbf.
Displacement, in.

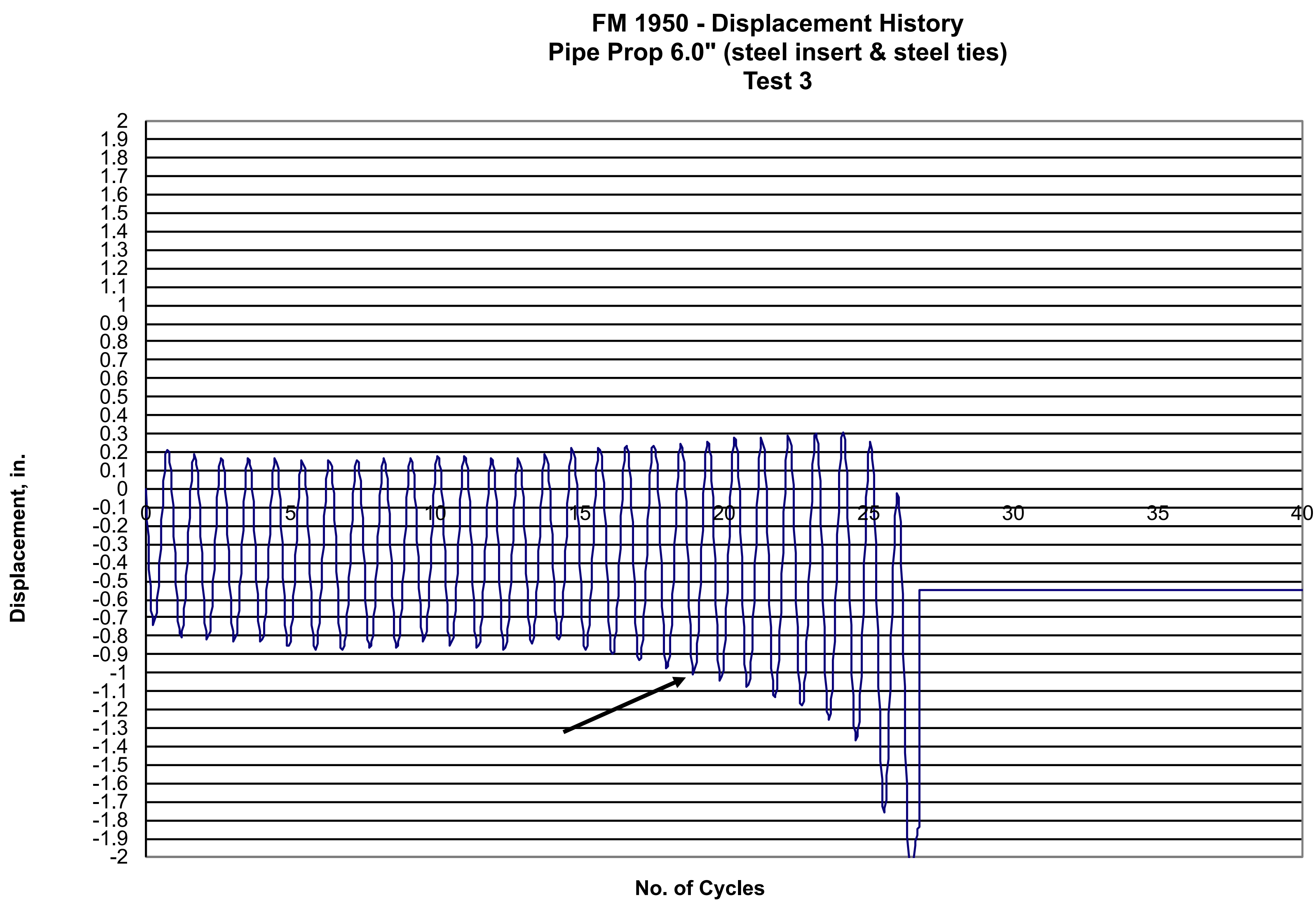
FM 1950 - Displacement History
Pipe Prop 6.0" (steel insert & steel ties)
Test 2



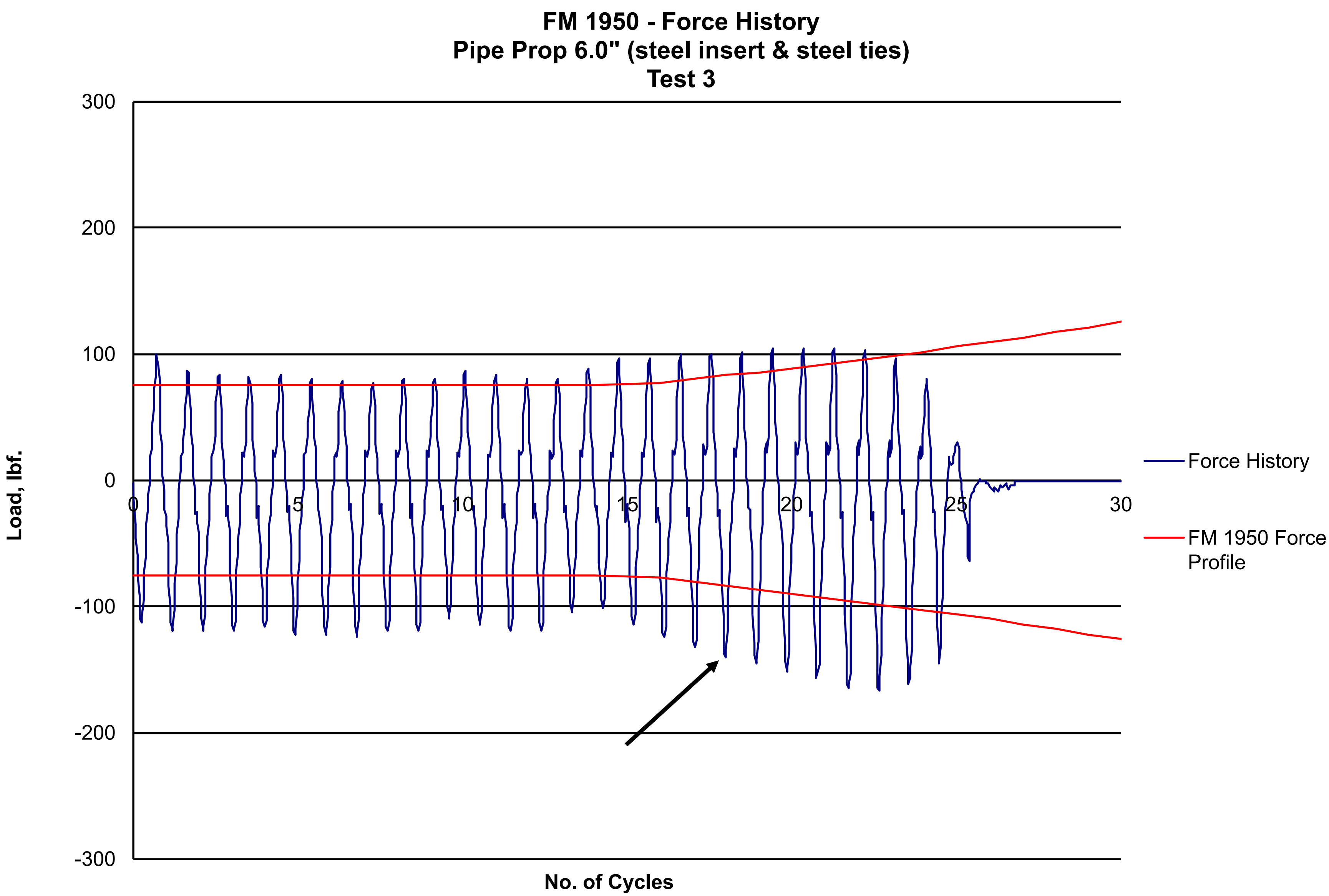

FM 1950 - Force History
Pipe Prop 6.0" (steel insert & steel ties)
Test 2
500
400
300
200
100
0
-100
-200
-300
-400
-500
Load, lbf.
0
5
10
15
20
25
30
35
No. of Cycles
Force History
FM 1950 Force Profile

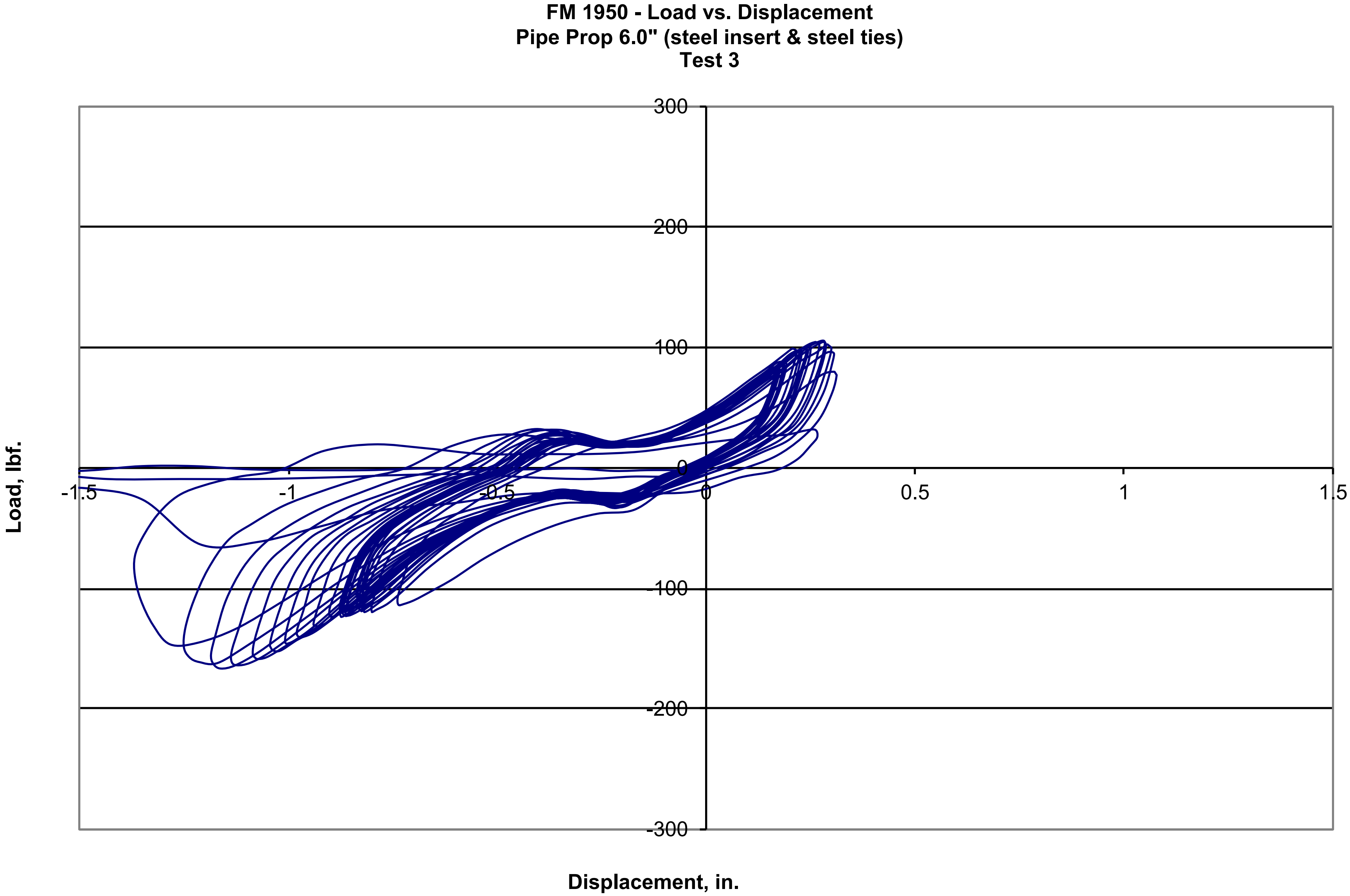
FM 1950 - Load vs. Displacement
Pipe Prop 6.0" (steel insert & steel ties)
Test 2





FM 1950 - Displacement History
Pipe Prop 6.0" (steel insert & steel ties)
Test 3
Displacement, in.
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
-1.8
-1.9
-2
0
5
10
15
20
25
30
35
40
No. of Cycles


FM 1950 - Force History
Pipe Prop 6.0" (steel insert & steel ties)
Test 3
300
200
100
0
-100
-200
-300
0
5
10
15
20
25
30
Load, lbf.
No. of Cycles
Force History
FM 1950 Force Profile



FM 1950 - Load vs. Displacement
Pipe Prop 6.0" (steel insert & steel ties)
Test 3
300
200
100
0
-100
-200
-300
-1.5
-1
-0.5
0
0.5
1
1.5
Load, lbf.
Displacement, in.

Client: JMB Industries

Product: Pipe Prop

Project Name: FM 1950-16

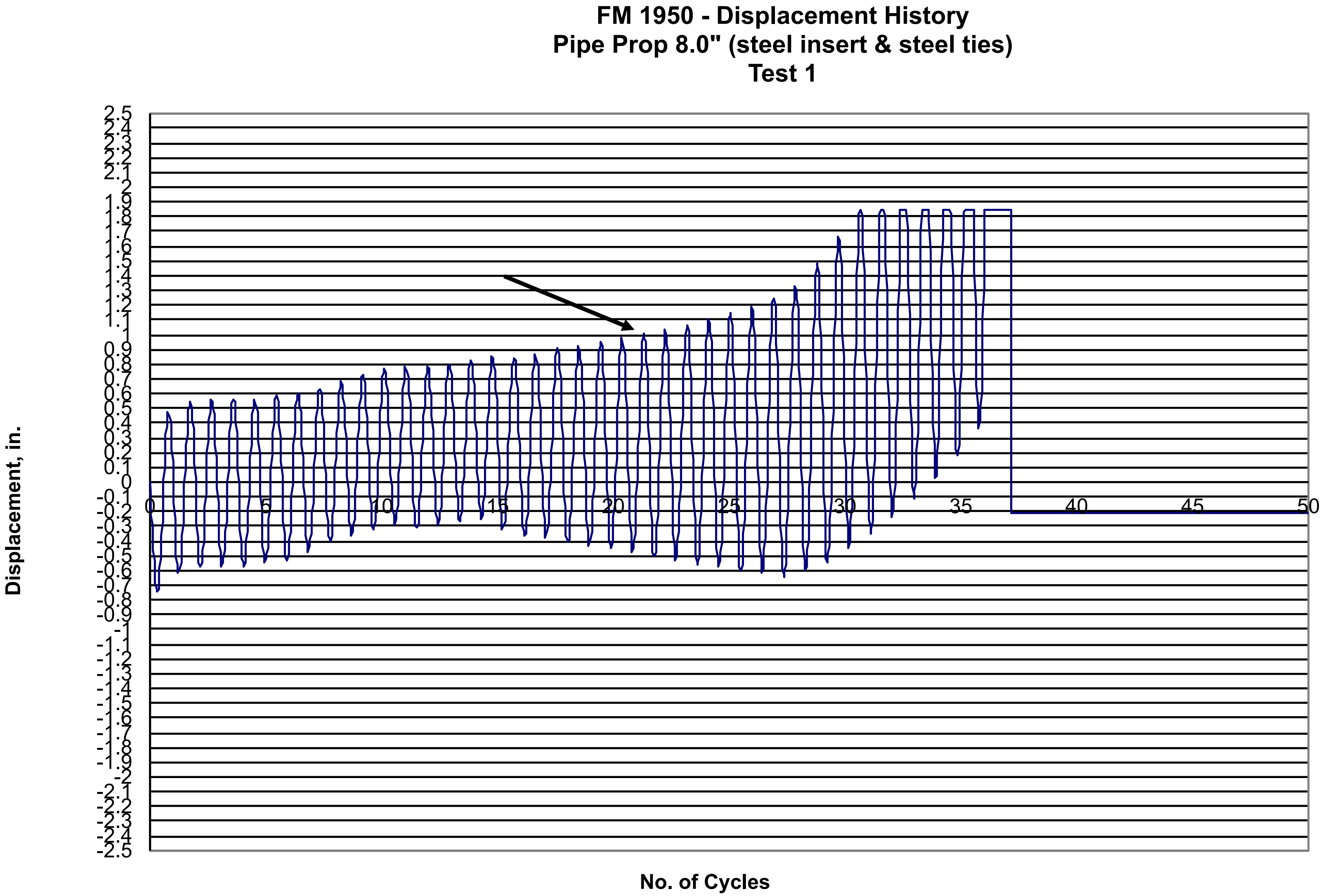
Project No: 50-53424-C

Installation Angle: 90 degrees

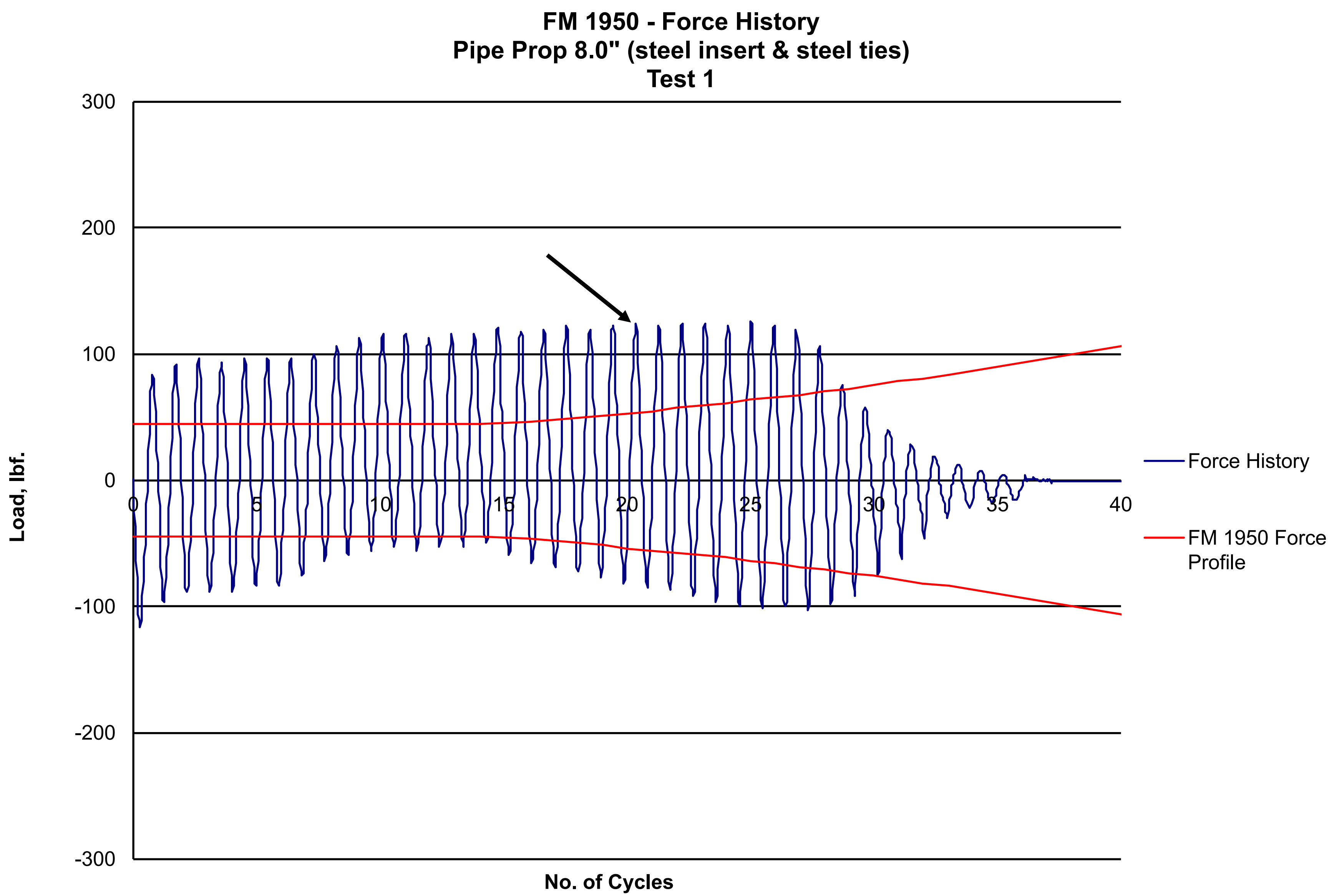
Test #	Test Date:	°F	Initial Load (lbs)	Set-up Length (in)	Ultimate Load (lbs)	Failure Mode/Notes:
1	12/20/17	69	315	8.0	126	PVC pipe broke at the end of the metal insert
2	1/2/18	69	315	8.0	99	PVC pipe broke at the end of the metal insert
3	1/2/18	69	315	8.0	117	PVC pipe broke at the end of the metal insert

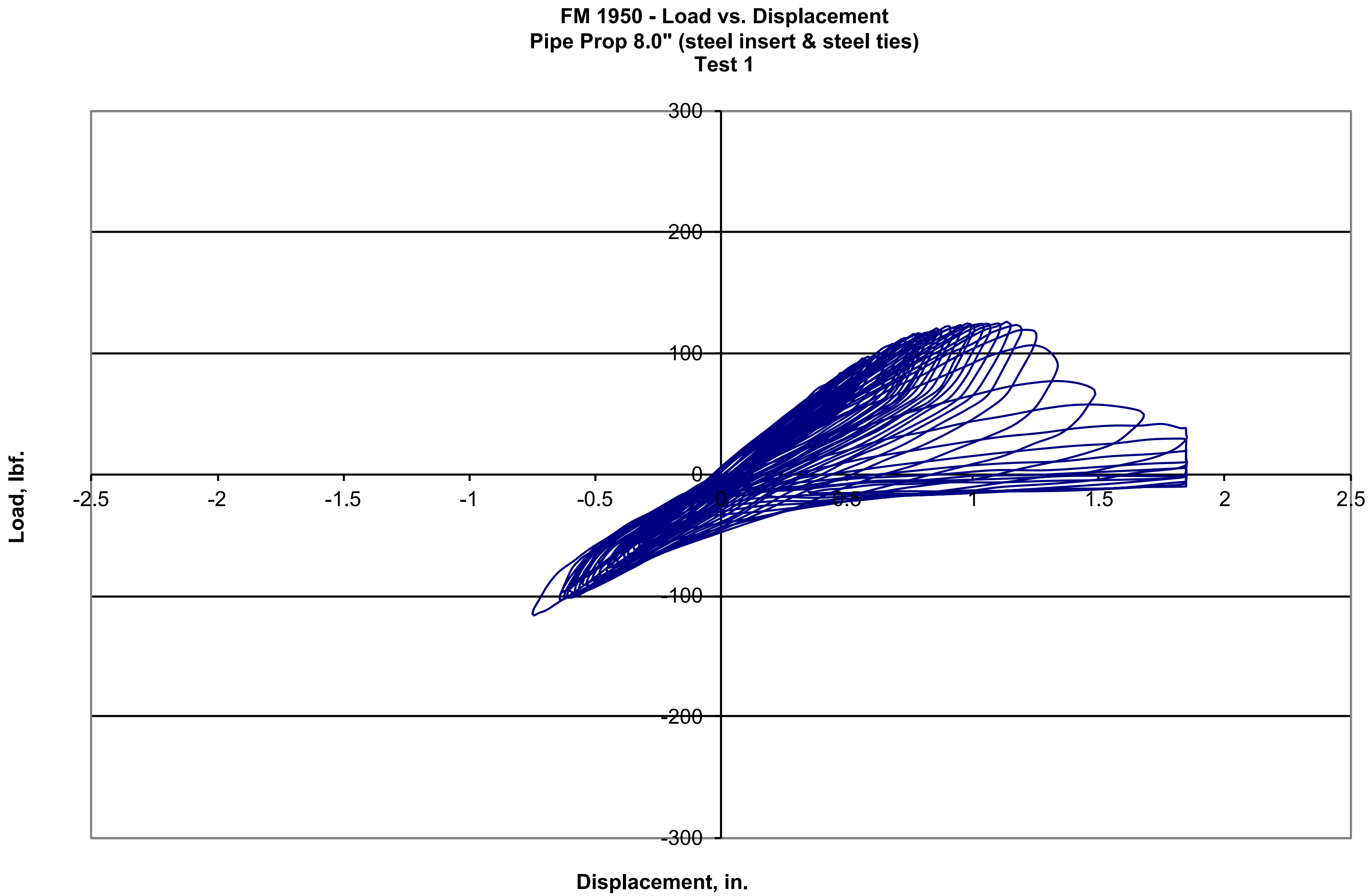
Seismic Tested By: EG

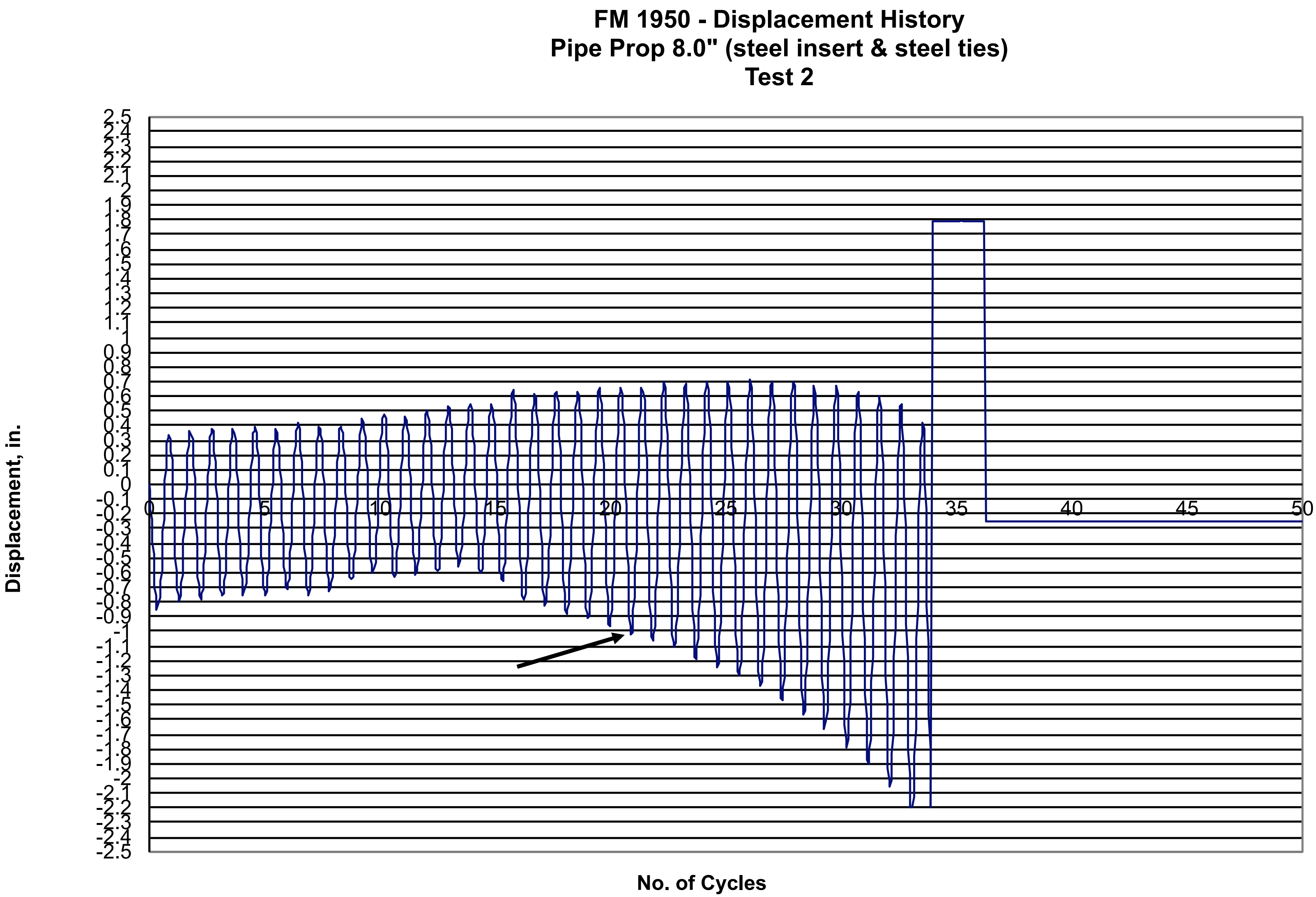
LVDT: DT13
Load Cell: LM22
DAS: DA11

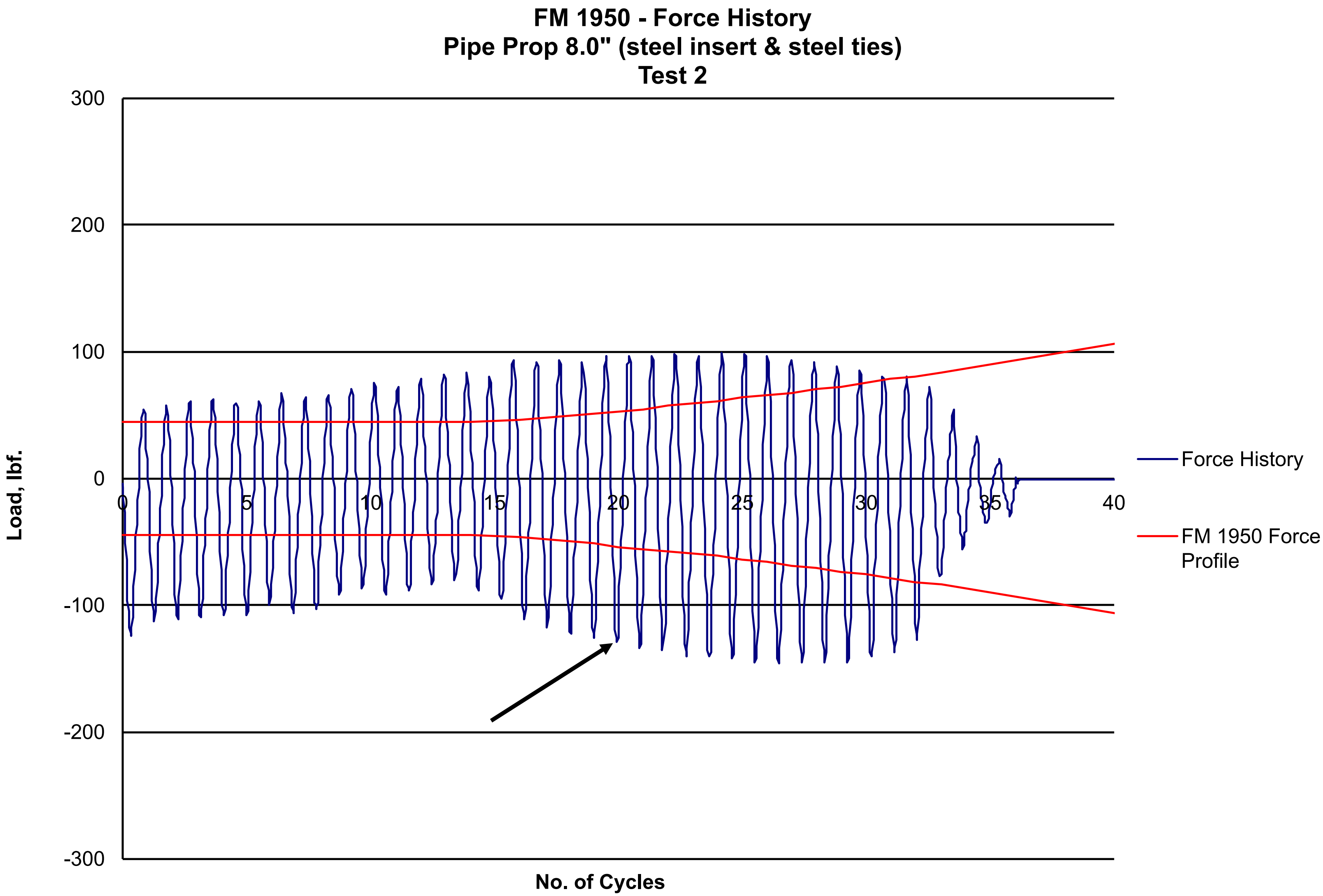


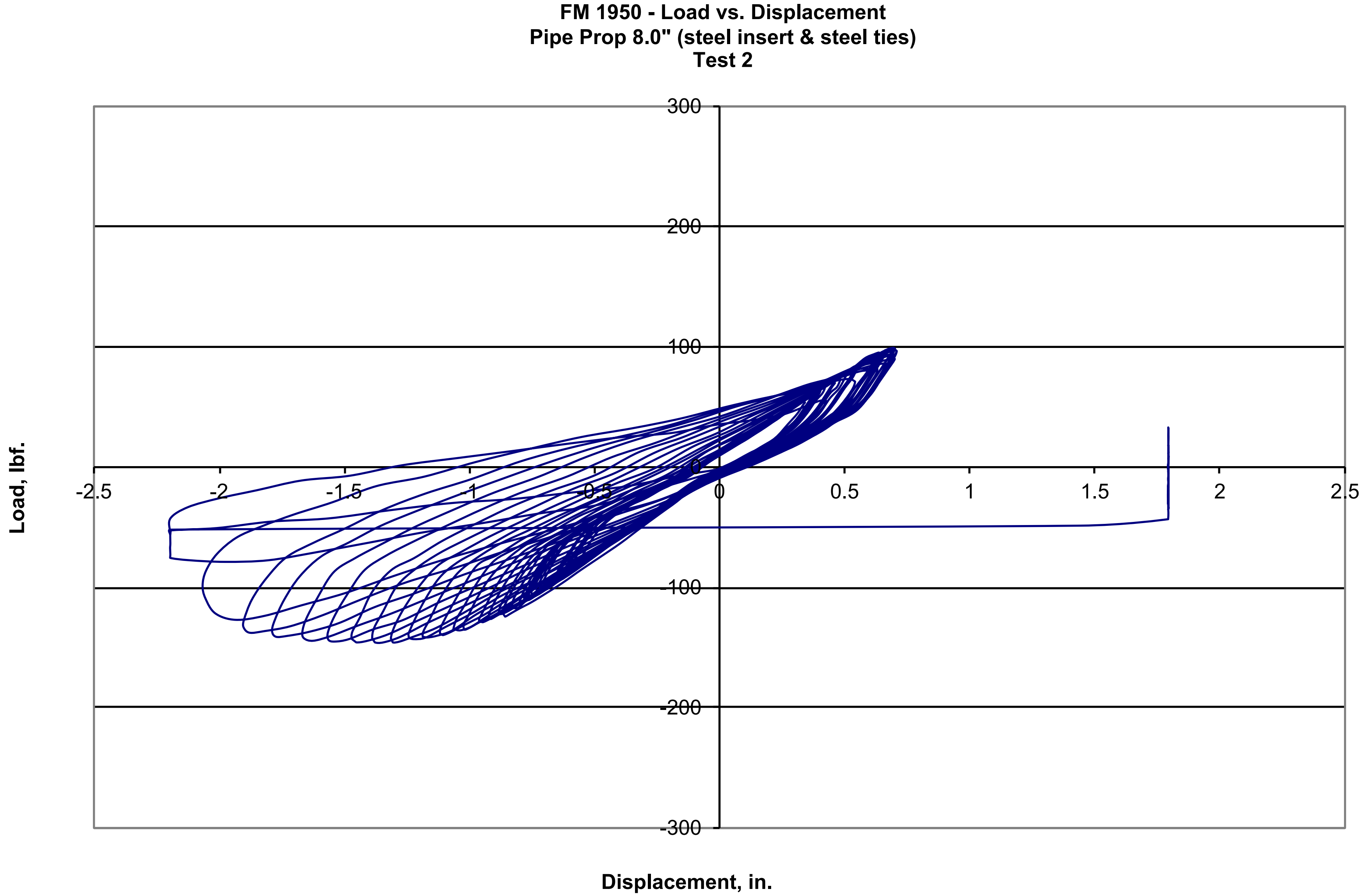
FM 1950 - Displacement History
Pipe Prop 8.0" (steel insert & steel ties)
Test 1
Displacement, in.
No. of Cycles

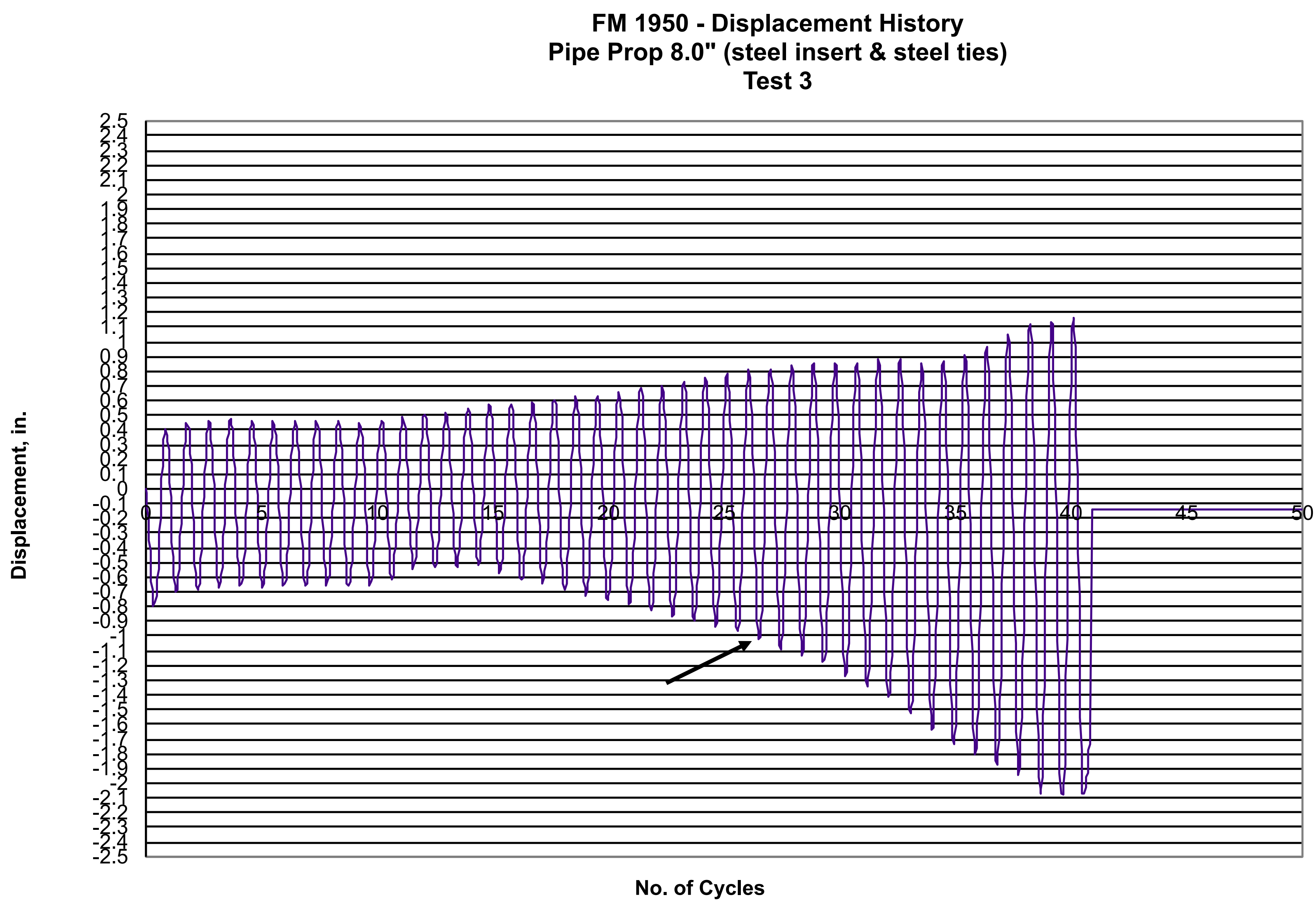

FM 1950 - Force History
Pipe Prop 8.0" (steel insert & steel ties)
Test 1
300
200
100
0
-100
-200
-300
0
5
10
15
20
25
30
35
40
Load, lbf.
No. of Cycles
Force History
FM 1950 Force Profile

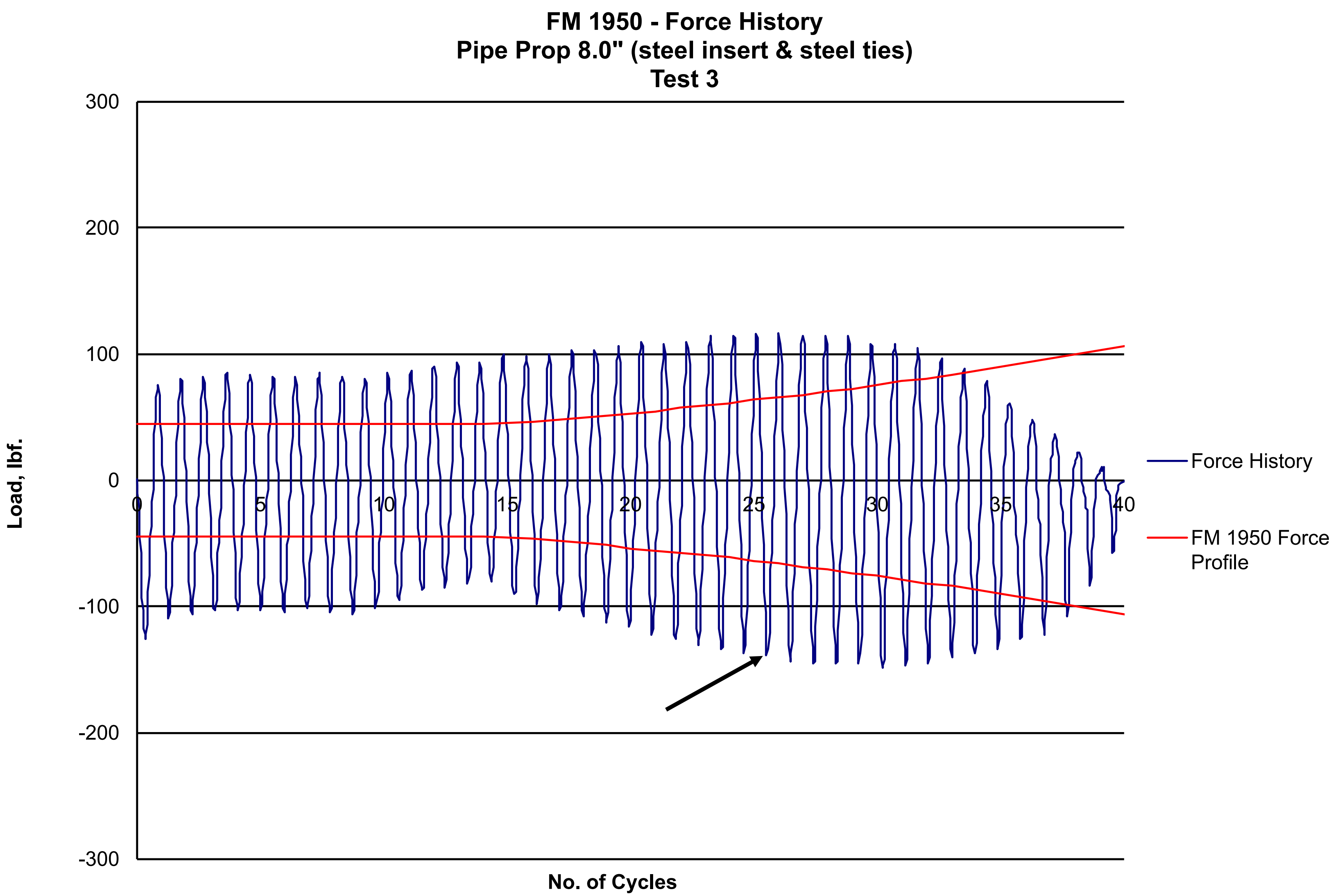

FM 1950 - Load vs. Displacement
Pipe Prop 8.0" (steel insert & steel ties)
Test 1
300
200
100
0
-100
-200
-300
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Load, lbf.
Displacement, in.


FM 1950 - Displacement History
Pipe Prop 8.0" (steel insert & steel ties)
Test 2
Displacement, in.
No. of Cycles
0
5
10
15
20
25
30
35
40
45
50

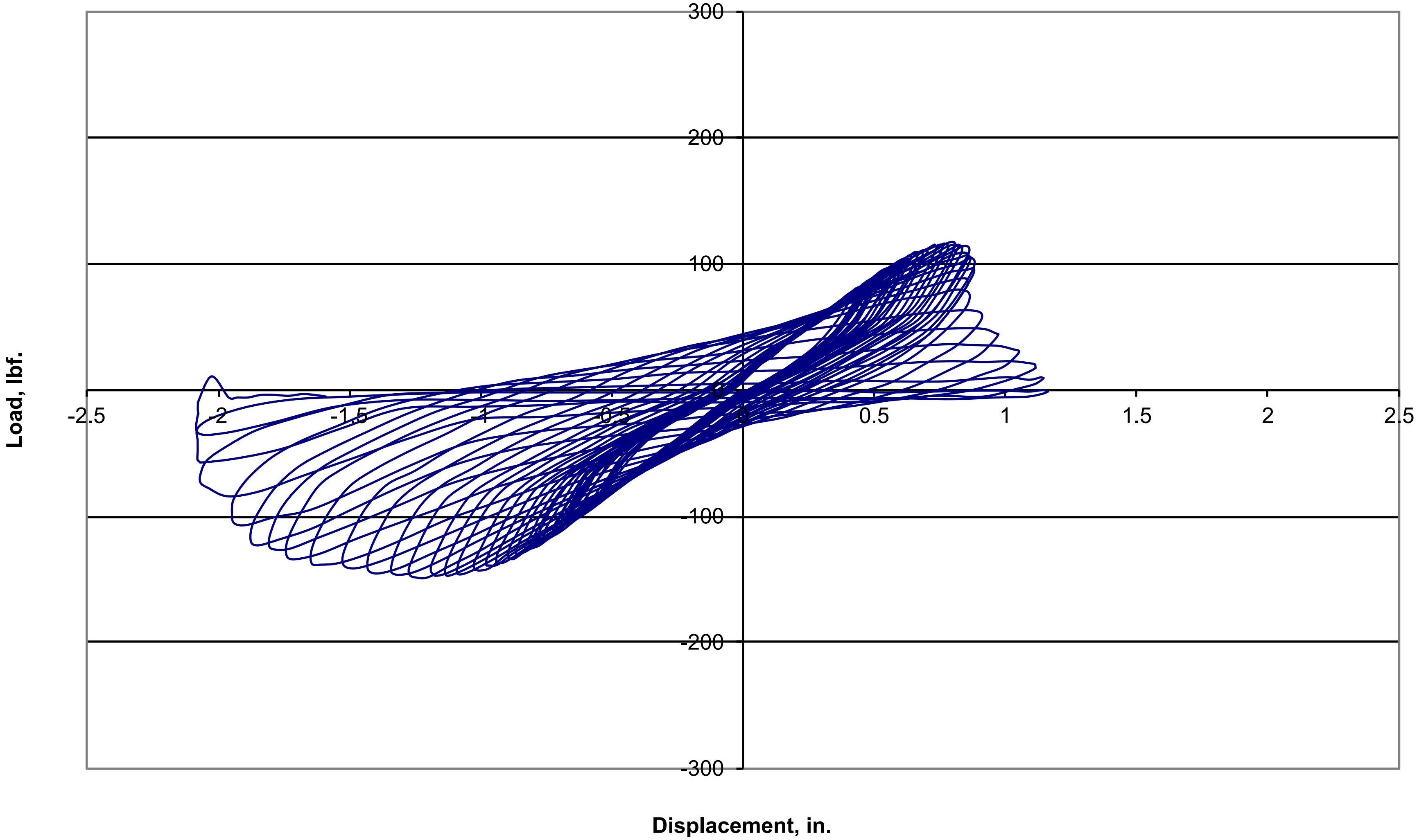

FM 1950 - Force History
Pipe Prop 8.0" (steel insert & steel ties)
Test 2
300
200
100
0
-100
-200
-300
0
5
10
15
20
25
30
35
40
Load, lbf.
No. of Cycles
Force History
FM 1950 Force Profile


FM 1950 - Load vs. Displacement
Pipe Prop 8.0" (steel insert & steel ties)
Test 2
300
200
100
0
-100
-200
-300
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Load, lbf.
Displacement, in.


FM 1950 - Displacement History
Pipe Prop 8.0" (steel insert & steel ties)
Test 3
Displacement, in.
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
-1.8
-1.9
-2
-2.1
-2.2
-2.3
-2.4
-2.5
0
5
10
15
20
25
30
35
40
45
50
No. of Cycles


FM 1950 - Force History
Pipe Prop 8.0" (steel insert & steel ties)
Test 3
300
200
100
0
-100
-200
-300
Load, lbf.
0
5
10
15
20
25
30
35
40
No. of Cycles
Force History
FM 1950 Force Profile

FM 1950 - Load vs. Displacement
Pipe Prop 8.0" (steel insert & steel ties)
Test 3



Report for JMB Industries LLC.
Pipe Prop
FM 1950-16

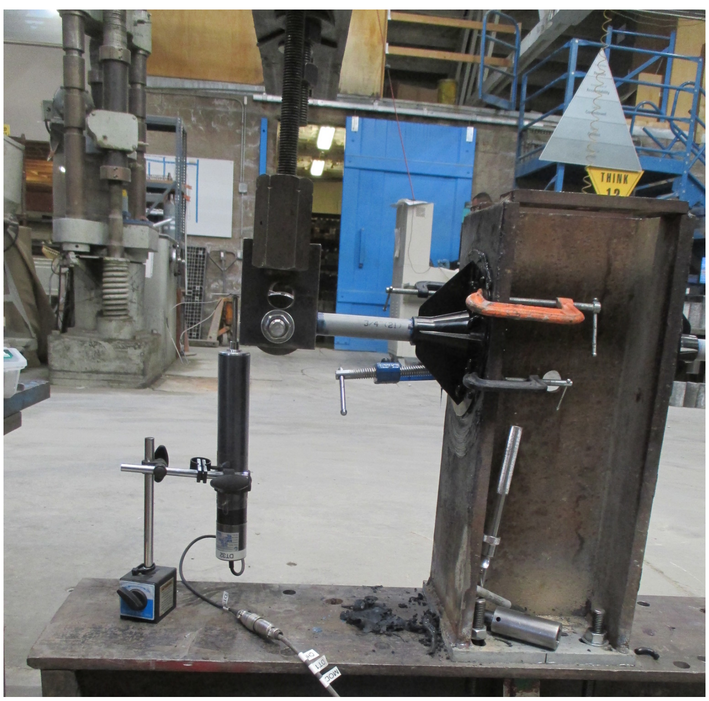
January 19, 2018
Report Number: 18J377

Appendix B
Photographs

Contents:

- Example Test Set-up and Failure Photos

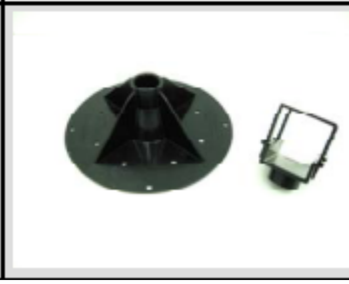
Example Test Set-up $3^1/_2$-in. test length


Example Test Set-up 8-in. test length

Example Failure 8-in. test length

Example Failure 6-in. test length

Appendix C
Cut Sheet

	**APS-1** Includes: 1-Saddle (1 1/2") 1-Base 1-Nylon Strap	
	**APS-2** Includes: 1-Saddle (2 1/2") 1-Base 1-Nylon Strap	
	**USPP** Includes: 1-Saddle 1-Base 2-Self Locking Straps	

	**MDA-HZ1** Steel Insert *If necessary*

	**MDA-1000** 1-Tube Adhesive

	**Electrical Conduit** 3/4" Length PVC Pipe

	**SSPP-14** Stainless Steel Strap *If necessary*

Model APS-1 accommodates up to 1½-inch pipe.

Model APS-2 accommodates from 1½-inch to 2½-inch pipe.

The US-PP serves pipes up to 1.5″ in width or smaller and allows you to determine your own height using 3/4" Schedule 40 PVC Electrical Conduit (cut required).

According to The Plastics Web®, ASA, formally known as Acrylonitrile Styrene Acrylate, has "great toughness and rigidity, good chemical resistance and thermal stability, outstanding resistance to weather, aging, and yellowing, and high gloss." Not only is ASA flame retardant, but it is also weather resistant, heat resistant and UV ray resistant, making it one of the top choices in plastics.