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# CSST Test Report

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## 1.0 INTRODUCTION

On January 24 to 26, 2013, RTI Group LLC (RTI) conducted testing on three different natural gas fuel distribution systems: a black iron pipe (BIP), and two corrugated stainless steel tubing (CSST) products. The CSST products were both manufactured by Omega Flex, Inc, and consisted of TracPipe® and CounterStrike® products. The BIP system was assembled to closely replicate the configuration found connecting a gas clothes dryer to the apartment natural fuel gas distribution system in the Village Green apartments<sup>1</sup> Section “A” basement. The two CSST products were likewise configured as if they were the product intended for the same use. All three systems were then subjected to identical loading that approximated the load imposed by the movement of the clothes dryer when the basement filled with flood waters. In a subsequent test, the Gas Appliance Connectors (GAC) attached to the CSST systems were removed, and the CSST was tested under those conditions. The loads were induced by a winch pulling a wire rope that was connected to the end of the gas pipe system. The force in the line was measured over time with a digital data acquisition system through a load cell connecting the winch to the end of the tested system. The maximum pull loads and their effects are presented herein.

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<sup>1</sup> Village Green explosion of June 16, 2001, Hatboro, PA

## 2.0 TESTING

### 2.1 Materials

To compare the performance of BIP and CSST systems subject to the displacement of the dryer in the Village Green Apartments, the following materials were obtained:

#### Black Iron Pipe System:

1. 2-inch black iron tee
2. 1-inch diameter pipe, 12 inches in length, member 1
3. 1-inch to  $\frac{3}{4}$ -inch reducer
4.  $\frac{3}{4}$ -inch 90 degree elbow
5.  $\frac{3}{4}$ -inch diameter pipe, 36 inches in length, member 2
6.  $\frac{3}{4}$ -inch 90 degree street elbow
7.  $\frac{3}{4}$ -inch diameter pipe, 18 inches in length, member 3
8.  $\frac{3}{4}$ -inch shut off valve
9.  $\frac{3}{4}$ -inch diameter pipe, 25 inches in length, member 4
10.  $\frac{3}{4}$ -inch to 1-inch coupler
11. 1-inch to  $\frac{1}{2}$ -inch reducer
12.  $\frac{1}{2}$ -inch diameter GAC gas line, 36 inches in length
13.  $\frac{3}{4}$ -inch tee
14. Steel Pipe strap loop support

The BIP system was constructed according to **Figure 1**.

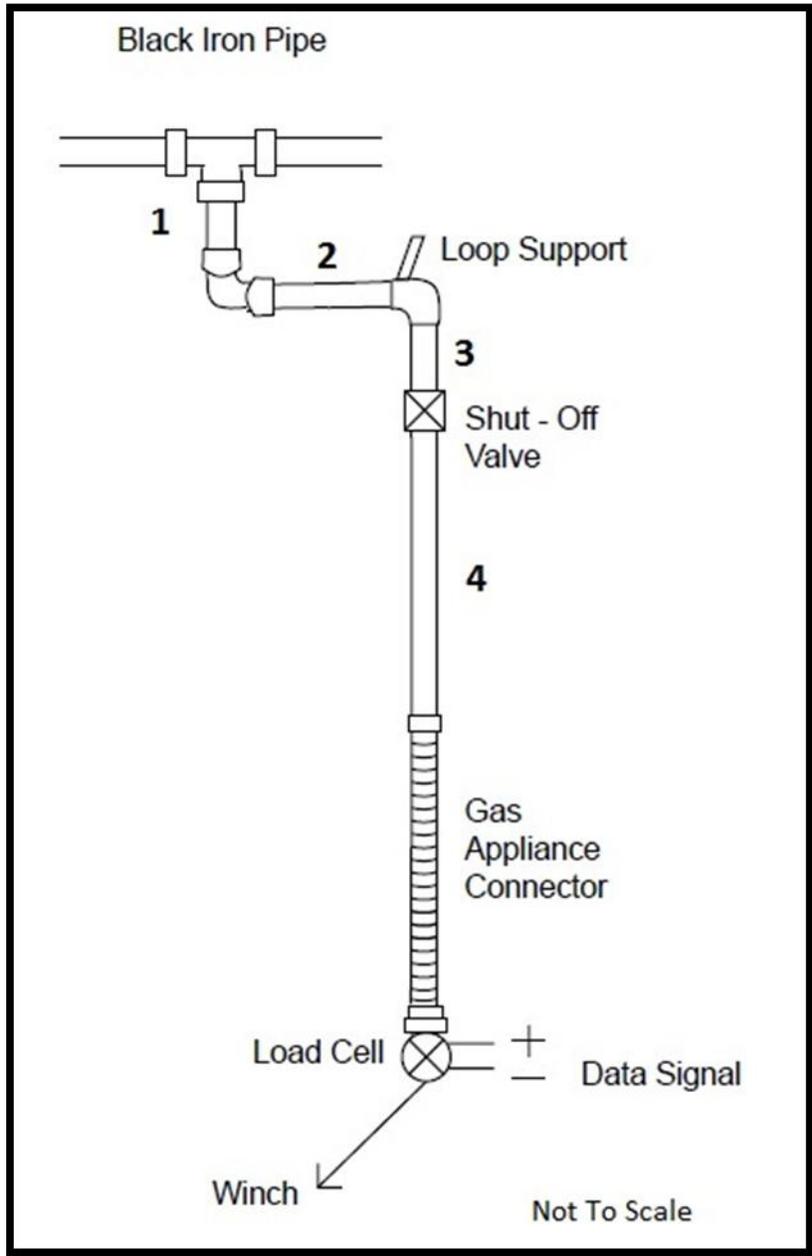


Figure 1. Installation diagram for the Black Iron Pipe System

CSST System, both TracPipe and CounterStrike products:

1. Tee reducer, 2 inch by 2 inch by  $\frac{3}{4}$  inch
2.  $\frac{3}{4}$ -inch diameter, 8 feet in length CSST
3.  $\frac{3}{4}$ -inch to  $\frac{1}{2}$ -inch reducing key valve,
4.  $\frac{1}{2}$ -inch shut off valve
5.  $\frac{1}{2}$ -inch diameter Gas Appliance Connector (GAC), 36 inches in length
6.  $\frac{3}{4}$ -inch tee
7. Steel pipe strap loop support

The CSST Systems were both constructed according to **Figure 2**.

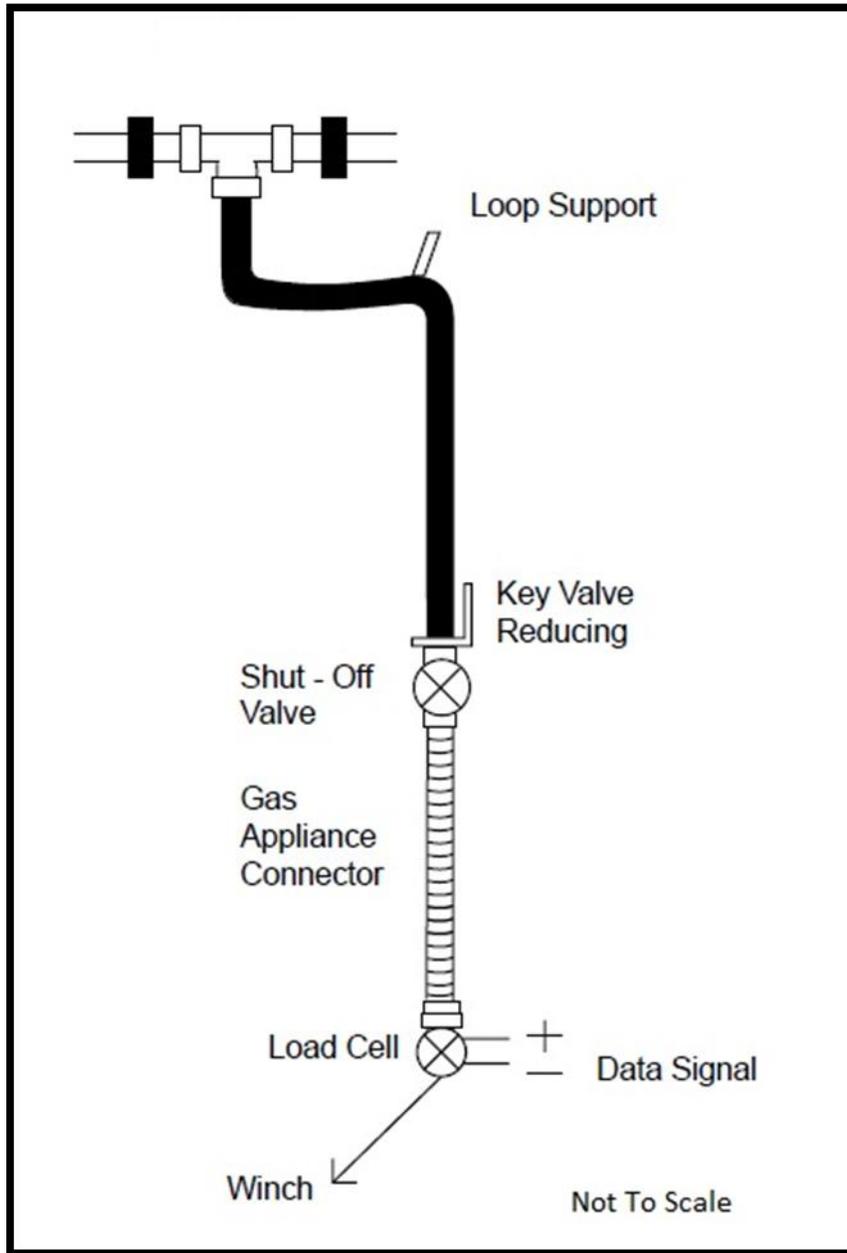


Figure 2. Installation diagram for CSST System.

## 2.2 Testing Frame

A testing platform was constructed to provide the structure to which the gas fuel distribution systems would be attached and to approximately replicate the anchoring used in the Village Green Apartments. The platform consisted of a rectangular wood and steel frame secured by weights, as seen in **Figure 3**. Attached on the opposite end of the base was a 12,000 lbs rated winch with the tension force applied at 45° from the normal of the plane presented by the frame. The angle was selected to best represent the direction of displacement by the dryer in the Village Green Apartments basement at the time of the incident.



Figure 3. Piping system testing platform

### 2.3 Procedure:

The BIP setups were tested using the configuration found in **Figure 1** where the BIP terminated into a GAC that was not anchored to the wall. Each CSST product was tested as seen in **Figure 2** with the GAC attached. Each CSST product was subsequently tested without the GAC attached. Once each piping system was assembled and secured to the test platform, the following procedures were followed for testing:

1. The load cell was attached between the tee connected to the end of the test gas line, and the wire rope attached to the winch hook.
2. Before each test, the data logging equipment was started and verified to be recording.
3. The winch was started and set to pull at the slowest setting.
4. The tests were stopped when either the winch ran out of pull, the piping system failed, or the load registered in the load cell exceeded 250 pounds.
5. After the test, the system was documented and noted for damage and changes.

The data acquisition system was set to sample the load at 1000 hertz. Data acquired from the data acquisition system was then processed and analyzed. The testing was, in some instances, documented by video and still photography. Testing photographs and video are attached as Appendix 4.

Subsequent to the load testing, the gas tight integrity of the tested CSST was checked by placing a plug on one end of the tested line and pressurizing the line to no less than 16 inches water column. With the air pressure set, the line was closed off by use of a shut-off valve and the pressure in the line monitored with a digital manometer. The gas tight integrity was confirmed when the pressure did not drop after 5 minutes.

### 3.0 RESULTS

Four sets of the BIP were tested. All four tests resulted in the BIP pipe section failing at the threads where the pipe entered the elbow fitting between members 2 and 3 (see Figure 1). Twice the tests resulted in the threads on member 2 failing while twice the failures happened in the threads on member 3. The failures occurred when an average of 115 lbs was applied to the end of the GAC. Detailed data can be found in Appendix 1 where the loads are plotted with respect to time.

Two tests were performed on each of the CSST sections: one with the GAC and one without. The CSST was configured approximately as the BIP, as seen in **Figures 4 and 5**. The steel strap at the top bend was wrapped around the CSST and the connection with the GAC was left unanchored. None of the CSST systems failed when subjected to similar loading as the BIP systems.

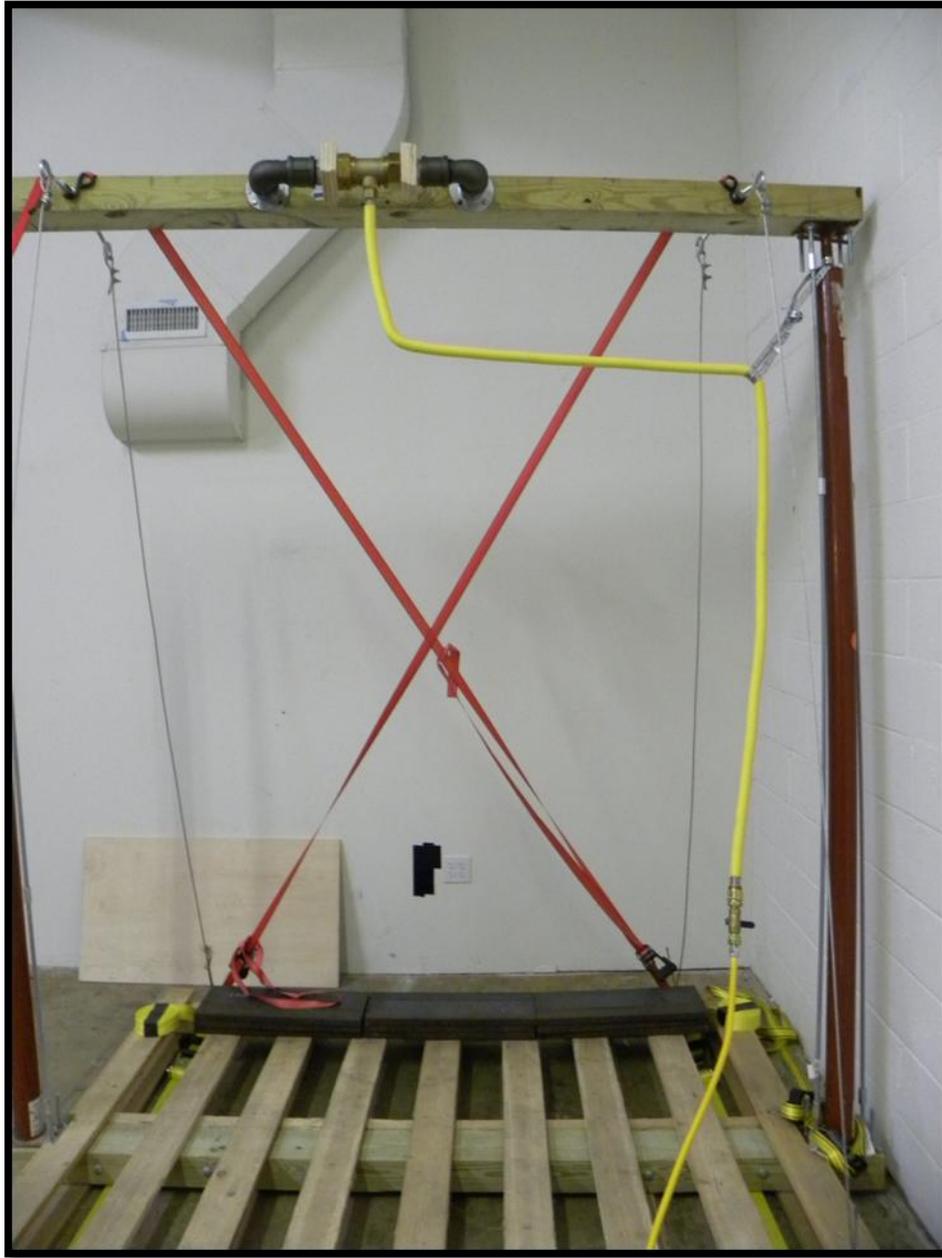


Figure 4. TracPipe installation as tested with the GAC.



Figure 5. CounterStrike installation as tested with the GAC.

The testing demonstrated that both CSST systems would withstand greater loads than the BIP system when stressed in a like manner. With the GAC attached, the maximum load achieved by TracPipe test was 218 lbs. and CounterStrike test achieved 211 lbs., both without failure or loss of gastight integrity. The testing was stopped because there was no more space available between the rack and the winch to continue displacing the CSST section, and the measured loads well exceeded the failure loads of the BIP sections. The metal strap deformed the exterior

sheathing of both CSST products, but failed to perforate it. Detailed load data can be found in Appendix 2.

In a subsequent test with the GAC removed, the TracPipe test was tensioned to a maximum measured load of 250 lbs while the CounterStrike test achieved a measured load of 282 lbs without failure or loss of gas tight integrity. The tests were stopped because the measured loads had exceeded the protocol limit of 250 lbs.

It was noted that during the tests without the GAC, the metal pipe straps cut into the insulation of the TracPipe and deformed the insulation of the CounterStrike (**Figures 6 and 7**). However, the integrity of the internal tubing was maintained; the interaction of the metal strap with the CSST never resulted in a gas leak. Detailed load data can be found in Appendix 3.



Figure 6. A perforation in the insulation resulting from the use of metal pipe straps



Figure 7. The deformation of the insulation resulting from the use of metal pipe straps

#### 4.0 TEST SUMMARY

The maximum loads and the results are summarized below in Table 1.

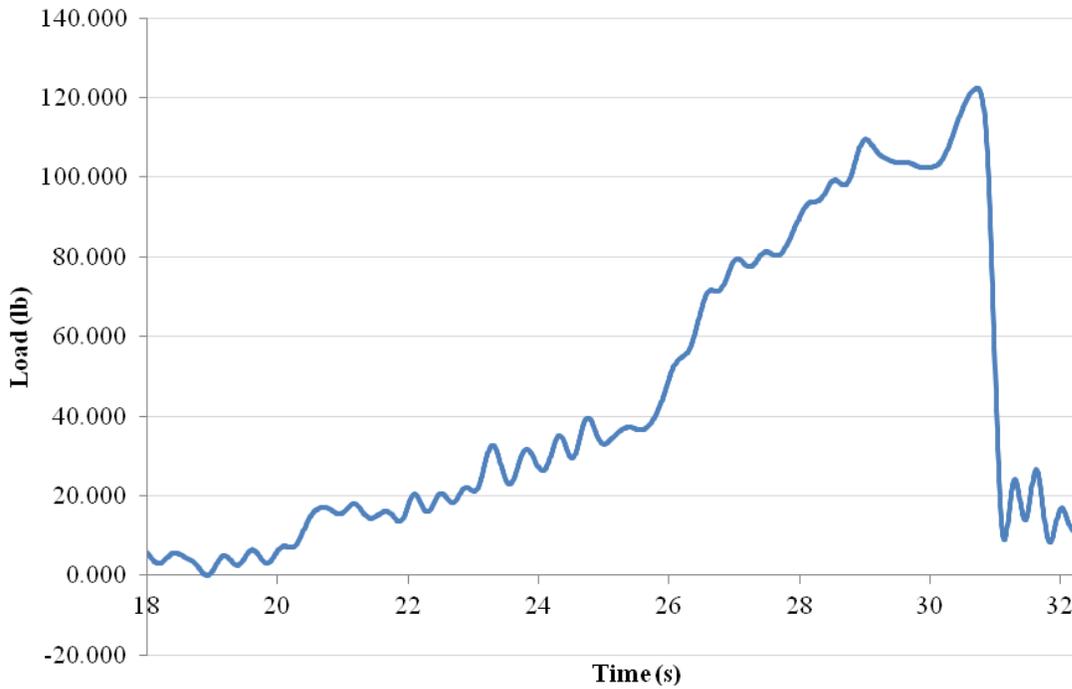
Table 1. Summary of test results

Test	Maximum Load, lbs	Result
<b>BIP 1</b>	121	Failed at threads of component 2
<b>BIP 2</b>	141	Failed at threads of component 2
<b>BIP 3</b>	96	Failed at threads of component 3
<b>BIP 4</b>	102	Failed at threads of component 3
<b>CounterStike w/ GAC</b>	211	No failure, insulation deformed
<b>ConterStrike w/o GAC</b>	282	No failure, insulation deformed
<b>TracPipe w/ GAC</b>	218	No failure, insulation deformed
<b>TracPipe w/o GAC</b>	250	No failure, insulation deformed and perforated

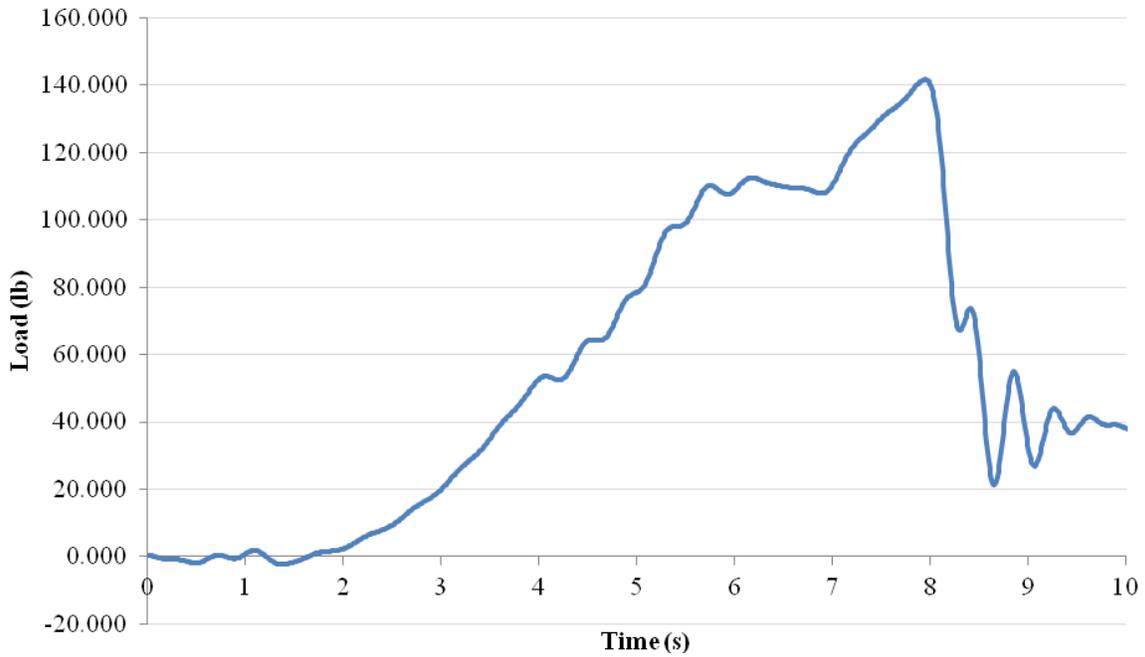


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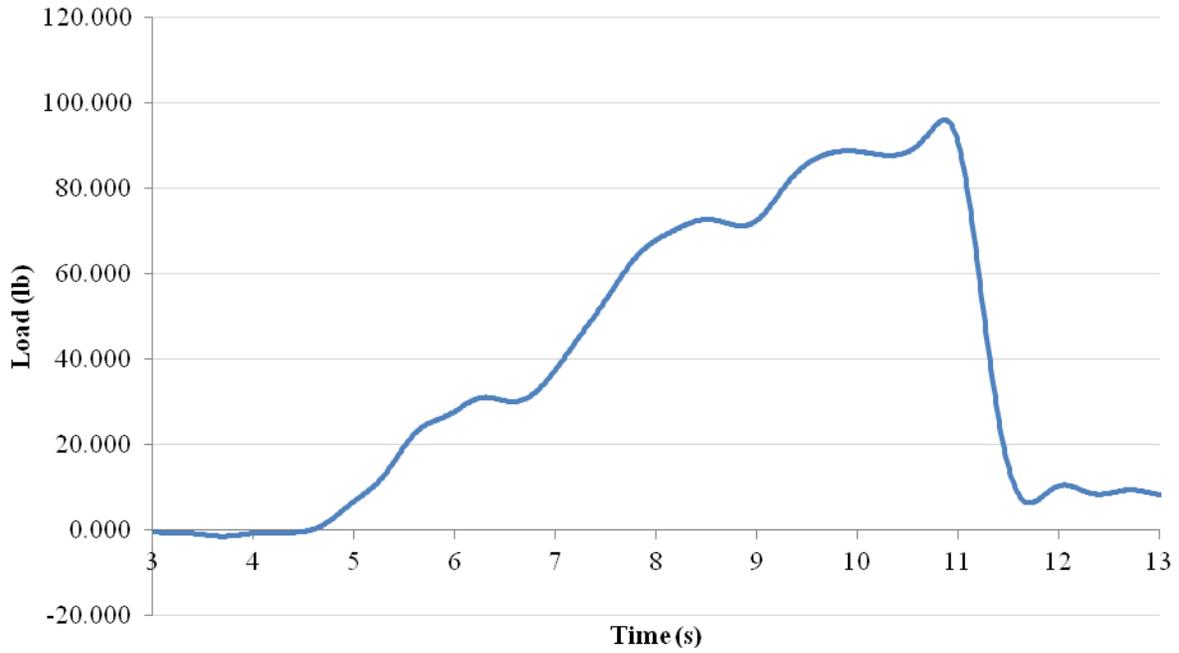
### BIP Test 1



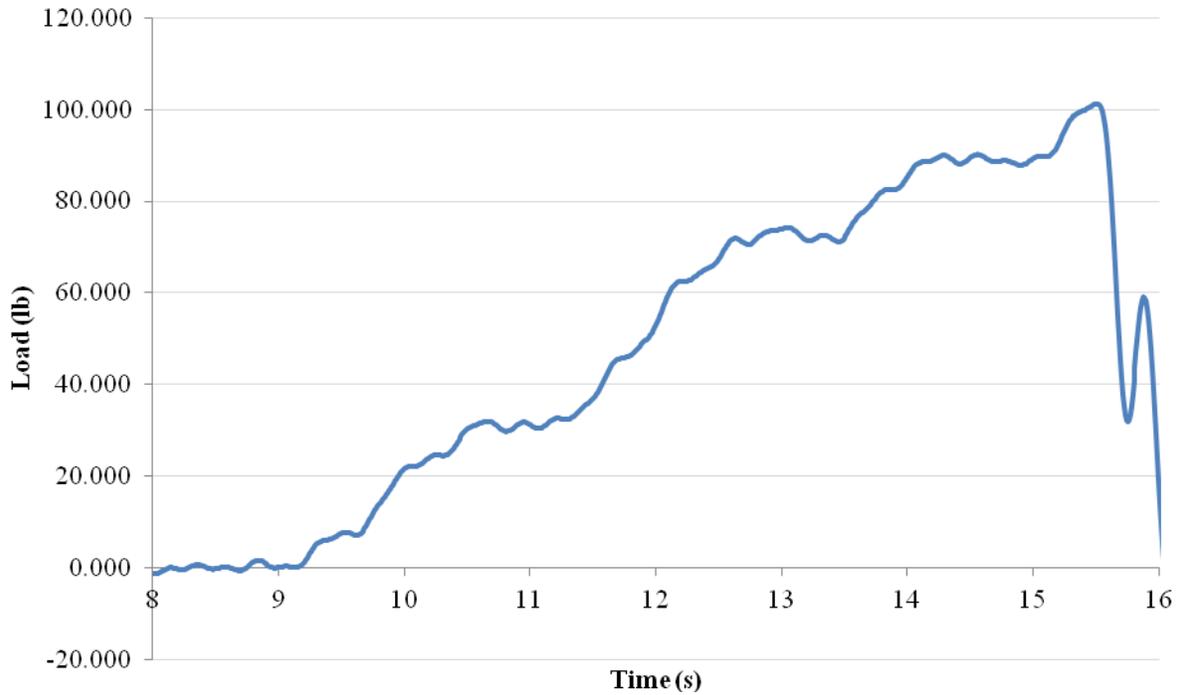
### BIP Test 2



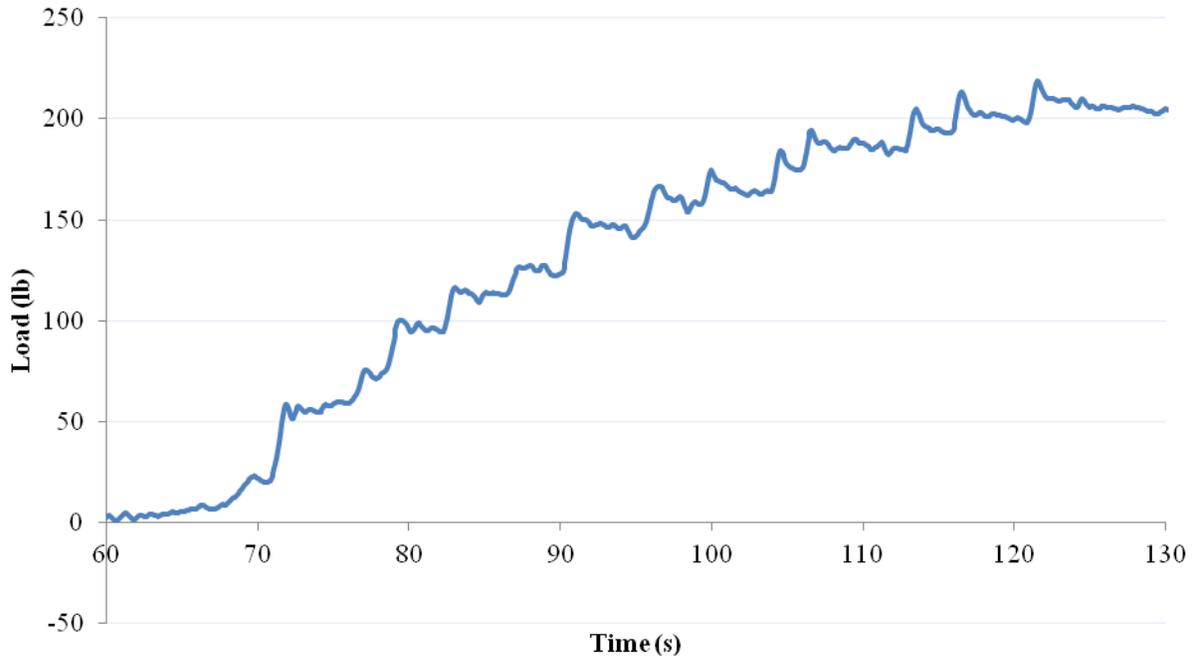
### BIP Test 3



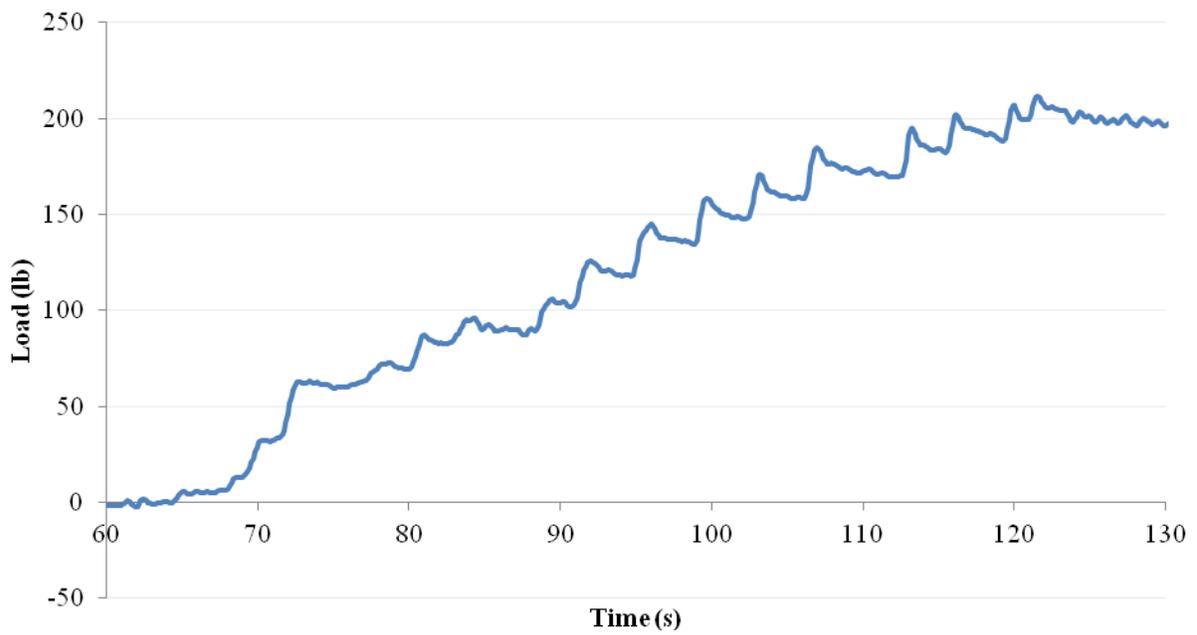
### BIP Test 4



## TracPipe Test 2

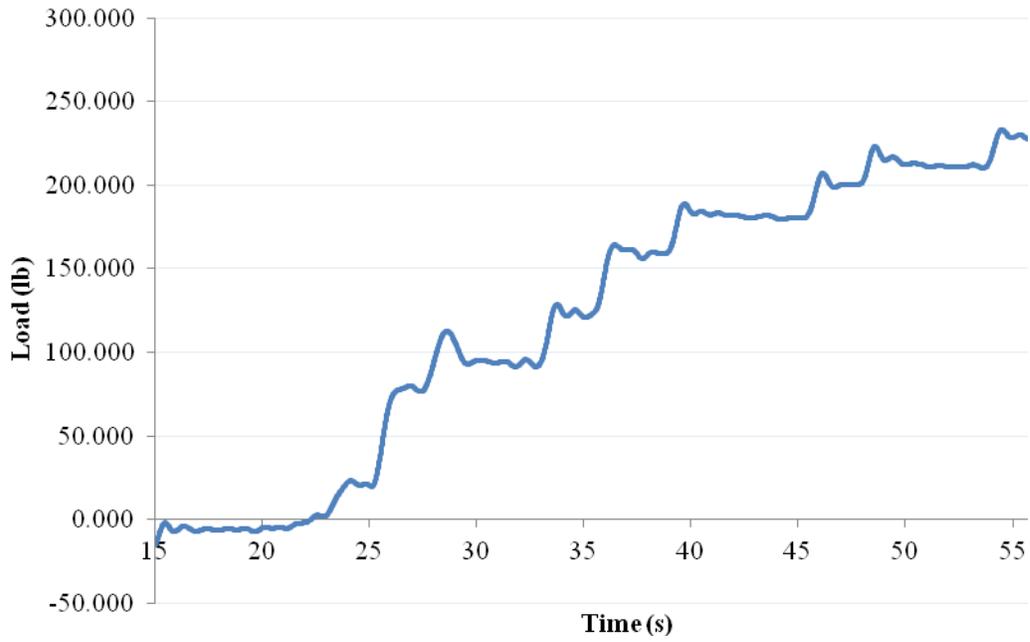


## CounterStrike Test 2



APPENDIX 3

**Tracpipe Test 1, no GAC**



**CounterStrike Test 1, no GAC**

