LT-13-3691

TEST REPORT:

HIGH CURRENT ARC ENTRY TESTING ON CSST GAS TUBING SAMPLES USING LC1027 & LC1024 METHODS

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Test dates:

1-2 April 2013

References:

PR020924
DB 389, pp 70-71
DB 396, pp 36

22 April 2013

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1.0 INTRODUCTION

This document contains high current, arc entry test results of gas, Corrugated Stainless Steel Tubing (CSST) samples manufactured by Titeflex Inc. (‘*Gastite’* product) and tests on standard black iron pipe. Tests were performed in accordance with the lightning test procedures contained in LC1027 “*PMG Listing Criteria for Conductive Jacketed Corrugated Stainless Steel Tubing*” (Reference 1) and LC1024 “*PMG Listing Criteria for Conductive Jacketed Corrugated Stainless Steel Tubing*” (Reference 2). Two of the tests (Test Nos. 9 and 18) performed on the CSST gas piping samples included the piping filled with propane gas, one of which (Test No. 18) included a strike to a pressurized liquid propane gas pipe.

The tests were performed by D. A. DeBlois, S. M. Baker, and T. P. Zeik of Lightning Technologies in Pittsfield, MA on 1 and 2 April 2013. The tests were witnessed by M. Goodson from Goodson Engineering, M. Wolf from Lyon & Associates, P.C*,* S. Carpenter from Carpenter & Schumacher, P.C and Dr. T. Eager of Materials and Engineering Group, LLC/Massachusetts Institute of Technology. The actual current discharges to the CSST and black iron pipe were photographed by Inertia Unlimited, Inc. of Jacksonville, VT using a digital camera setup capable of up to 100,000 frames per second, separately contracted by Lyon & Associates, P.C. for the purpose of documenting the tests. The test results contained in this report relate only to the test items/part numbers tested.

2.0 TEST SUMMARY

The arc entry, high current tests were performed in accordance with Section 4.3.2.2 “Arcing Resistance, Direct Effects” of LC1027 and Section 4.3.2.1 “Arcing Resistance” of LC1024. The applied current components were as defined in Section 4.2.1 of LC1027 for the ‘Direct Effect’ tests and per Section 4.2 of LC1024, both with varying amplitudes to adjust the amount of total electrical charge delivered to the test article.

Two ‘direct effects’ tests were performed on a 0.76 meter section of black iron pipe without propane, using the Current Components 1, 2 and 3 of Section 4.2.2 of LC1027, with two different amounts of charge deposited, 38.5 and 267.1 Coulombs. Both tests resulted in localized surface melting of the iron at the arc entry area but with no punctures or burn-through of the pipe sidewall observed.

Two ‘direct effects’ tests were performed on 1 meter long, 1.0” sized CSST samples with the non-conductive jacketing but with differences in the ‘pre-puncturing’ method used for the insulating jacket. The CSST sample tested with a small puncture of the insulating, non-conductive jacket had approximately 2.3x the damage area to the gas pipe sidewall verses the CSST sample similarly tested but with a large section of the jacket removed at the arc entry location.

A single 'direct effects' test applying only Current Component 1 at 32.4 kA peak with 2.86 Coulombs of charge to a non-conductive jacketed, 0.5" sized CSST sample resulted in no visible burn through of the pipe sidewall. This test was performed with propane gas filling the pipe section volume. No flame from ignition of propane was observed.

A single 'direct effects' test applying at total of 42.9 Coulombs of charge to a conductive 'Flashguard' jacketed, 0.5" sized CSST sample resulted in localized damage to the jacket. The jacket was not cut back to observe the condition of the pipe sidewall. This test was performed without propane gas.

The remaining tests utilized the 'Arcing Resistance' test setup of Section 4.3.2.2 of LC1024, with all but one test performed without a propane gas supply connected to a plugged CSST pipe section. Four tests were performed on 1 meter long, 0.5" sized CSST, non-conductive jacketed sections with progressively lower levels of total deposited charge, from 3.62 Coulombs to 0.76 Coulombs. All four CSST samples had pipe sidewall burn-through holes at the arc entry locations, ranging in size from approximately 0.0625 inches to 0.03125 inches in diameter, with the larger holes due to the higher charge transfers. A single, 1 meter long, 1.0" sized CSST, non-conductive jacketed sample was also tested with a total of 4.69 Coulombs of charge deposited, resulting in a <0.5 inch diameter hole in the pipe sidewall.

The final test performed was an arc entry discharge per Section 4.3.2.2 of LC1024 to a 1 meter long, 0.75" sized CSST with non-conductive jacketing with the gas pipe pressurized by a liquid propane (LP) tank, one end of the gas pipe plugged with a short brass fitting attached to a shut-off ball valve. An acrylic three sided enclosure of approximately 12" x 4" x 4" dimensions was placed overtop of the arc entry test location. A current transient of 25µs x 2800µs waveshape at 1.22 kA and 4.72 Coulombs was discharged to the CSST at a pre-punctured location in insulating jacket. The test result was a puncture of the gas pipe sidewall along with ignition and continued burning of the propane gas until the LP tank supply was turned off. Specific high current test results can be found in Section 6.2 of this Report

3.0 TEST ARTICLES

The test articles consisted of 1 meter long Corrugated Stainless Steel Tubing (CSST) made of ASTM A240 type 304 Stainless Steel with a nominal wall thickness of 0.010" and covered with either a non-conductive Polyethylene jacketing or a conductive, proprietary 'Flashguard' jacketing. The CSST types tested were either of the 1.0", 0.75", or 0.5" fitting sizes. Each CSST test sample had the appropriate manufacturer's C360 brass fitting installed on both ends. The CSST gas tubing test articles were approximately one meter in length. Additionally, a 0.76 meter long section of 0.75" black iron pipe (BIP) was tested.

All CSST test samples were manufactured by Titeflex Inc. ('*Gastite*' product). M. Goodson prepared the CSST test samples by connecting the various end fittings.

4.0 APPLICABLE DOCUMENTS

Reference 1 ICC Evaluation Service, Inc. LC1027, "*PMG Listing Criteria for Conductive Jacketed Corrugated Stainless Steel Tubing"*, September 2010

Reference 2 ICC Evaluation Service, Inc. LC1024, "*PMG Listing Criteria for Conductive Jacketed Corrugated Stainless Steel Tubing"*, revised April 2010

Reference 3 ISO/IEC 17025:2005, "General Requirements for the Competence of Testing and Calibration Laboratories", 2005

Reference 4 ANSI/NCSL Z540-1-1994, "Calibration Laboratories and Measuring and Test Equipment-General Requirements", 1994

5.0 HIGH CURRENT CALIBRATIONS

5.1 Test Measurement Equipment

All measurement equipment furnished by Lightning Technologies is calibrated by a commercial calibration agency in accordance with the requirements of the second edition of ISO/IEC 17025:2005 (Reference 3) and/or ANSI/NCSL Z540-1-1994 (Reference 4) using standards traceable to the National Institute of Standards and Technology. Table 1 lists the test measurement equipment used for the high current, arc entry tests.

Table 1 – High Current Test Measurement Equipment

Manufacturer	Equipment	Model No.	Serial No.	Calibration Date	Calibration Due Date
T & M Research	Current Viewing Shunt Resistor	W-2-01-4S	8303-10	25 Oct 12	25 Oct 13
		F-1000-4	0410-28	25 Oct 12	25 Oct 13
Pearson	Current Probe	1423	118521	5 Feb 13	5 Feb 13
			099639	11 Dec 12	11 Dec 13
		4160	080860	16 Jul 12	16 Jul 13
		3525	080334	16 Oct 12	16 Oct 13
	Attenuator	A5	106787	18 Jun 12	18 Jun 13
Tektronix	Digital Storage Oscilloscope	TDS3034B	C010791	11 Jan 13	11 Jan 14
		TDS3032B	B015906	28 Jun 12	28 Jun 13
		TDS3032B	B010832	30 May 12	30 May 13

5.2 Ambient Test Conditions

The high current tests were performed with the following ambient conditions, as shown in Table 2.

Table 2 – Ambient Test Conditions

Test Sample	Temperature (°C/°F)	Relative Humidity (%)	Barometric Pressure (kPa/in. Hg)
1 April 2013	16/60.8	36	98.88/29.20
2 April 2013	18.89/66	16	98.04/28.95

6.0 HIGH CURRENT, ARC ENTRY TESTING

The high current, arc entry testing was performed in accordance with either Section 4.3.2.2 of LC1027, “Arcing Resistance, Direct Effects” or with Section 4.3.2.1 of LC1024, “Arcing Resistance”. Discharges of the current transients were photographed by Inertia Unlimited, Inc. of Jacksonville, VT. These images are not included in this Report. Two tests were performed with the CSST section of gas piping filled with propane (LTI Test Nos. 9 and 18). Test No. 18 was conducted with the CSST section of gas piping pressurized as well.

6.1 High Current, Arc Entry Test Setups

The high current, arc entry tests were performed using two different test setup arrangements, one set of tests using the “Arcing Resistance, Direct Effects” test described in Section 4.3.2.2 of LC1027 and the other set of tests per the “Arcing Resistance” tests from Section 4.3.2.1 of LC1024.

The first tests performed on the Titeflex, Gastite CSST test samples as well as on a section of 0.75” sized black iron pipe were the arc entry tests described in LC1027. This setup involves orienting the test pipe sample vertically, with one end of the pipe connected to the output of the current transient generator. The pipe is then positioned such that one side is within 0.125 inches from the edge of a 0.25 inch thick grounded plate electrode, which serves as the transient generator’s current return. The arc is then established between the pipe and the edge of the grounded plate, with the other three sides of the pipe ‘boxed’ in with non-conductive supports, spaced one inch from the pipe surface. This test procedure only requires that one end of the CSST test sample be terminated with the manufacturer’s end fitting. Figure 1 shows a basic cartoon of this test arrangement, with Figure 2 showing a photograph of the calibration setup. Figure 3 shows a photograph of the test setup using the black iron pipe sample and typical setups for the conductive and non-conductive jacketed CSST gas pipe samples are shown in Figures 4 and 5, respectively. Figure 6 shows the single CSST test performed with the gas pipe volume filled with propane gas. Figure 7 shows the single CSST test conducted with the gas pipe volume filled with propane gas, and pressurized.

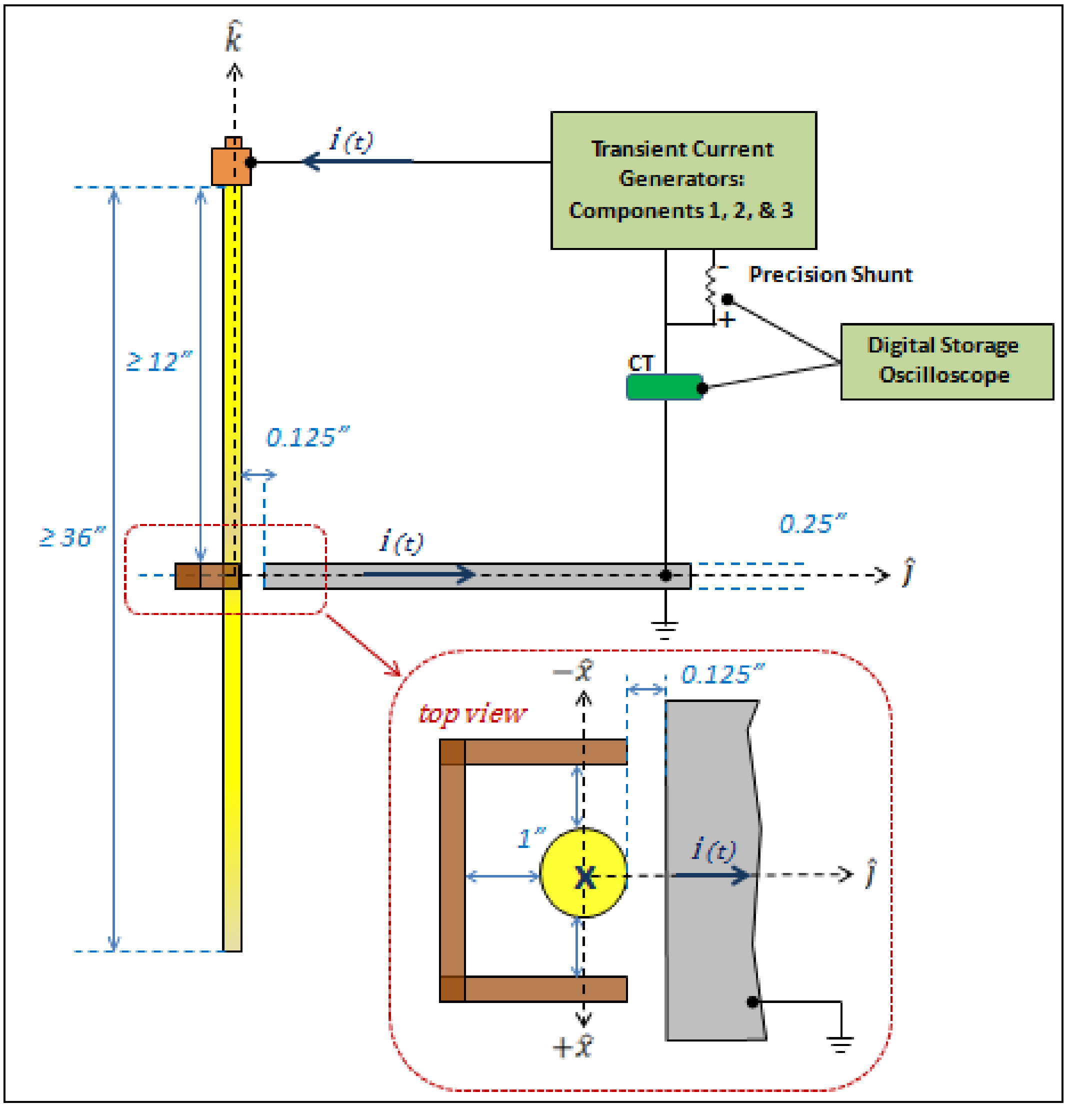

Figure 1 – General Setup Diagram for LC1027 "Arcing Resistance, Direct Effects" Tests

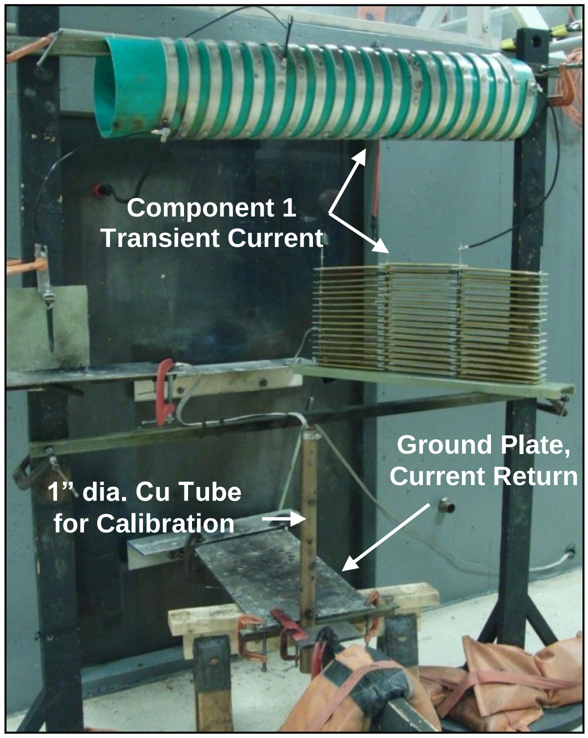

Figure 2 – Photograph of Setup for LC1027 “Arcing Resistance, Direct Effects” Tests

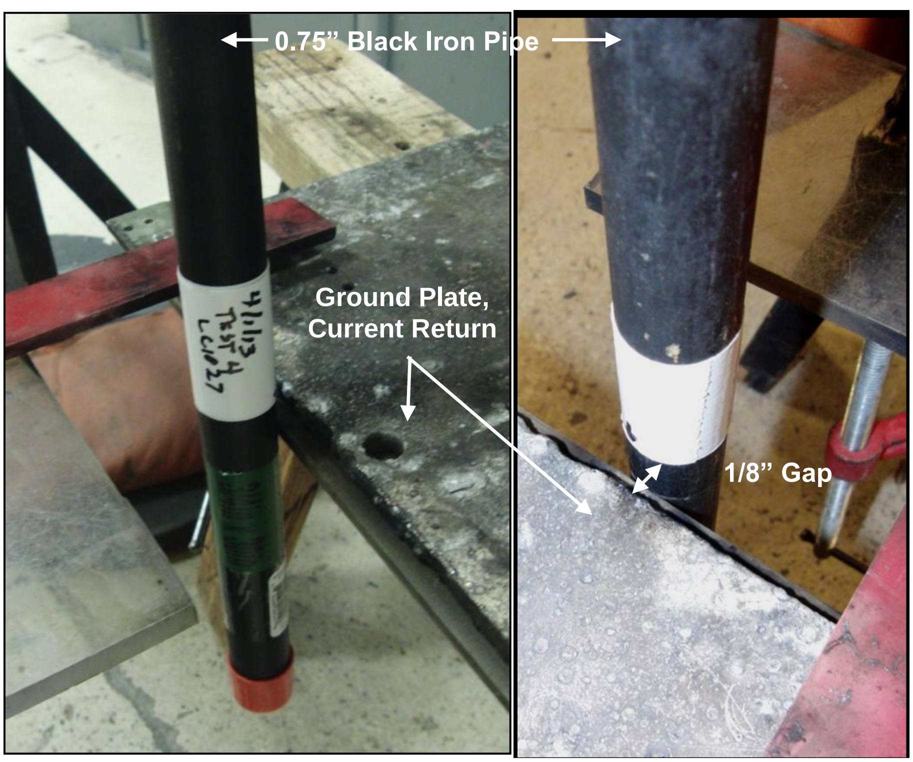

Figure 3 – Photograph of Typical Setup for LC1027 “Arcing Resistance, Direct Effects” Tests, Black Iron Pipe Test Sample

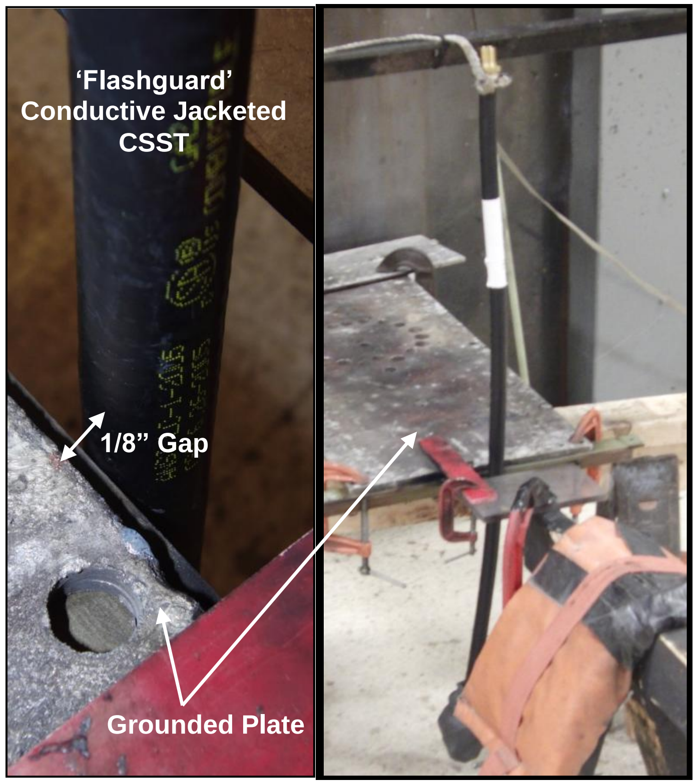

Figure 4 – Photograph of Typical Setup for LC1027 "Arcing Resistance, Direct Effects" Tests, Conductive Jacketed CSST Test Sample

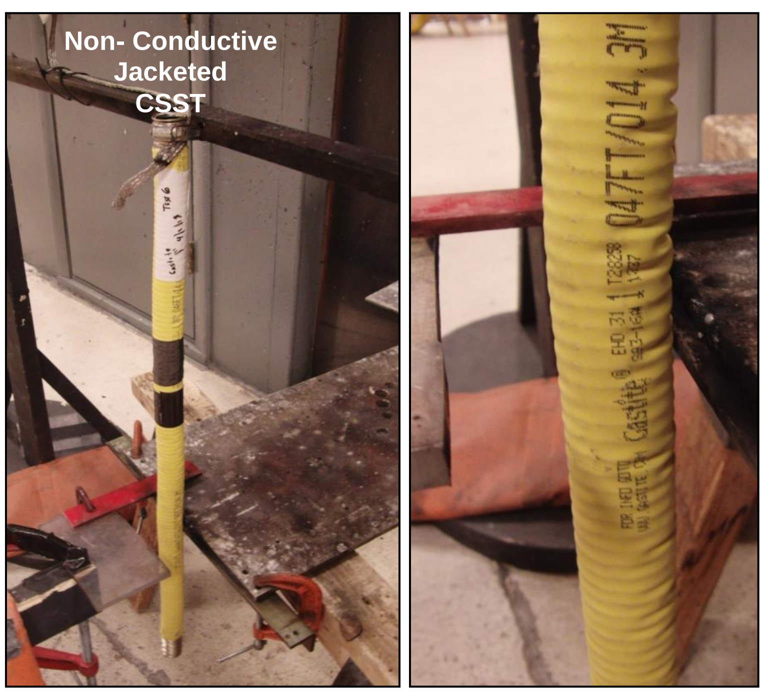

Figure 5 – Photograph of Typical Setup for LC1027 "Arcing Resistance, Direct Effects" Tests, Non-Conductive Jacketed CSST Test Samples

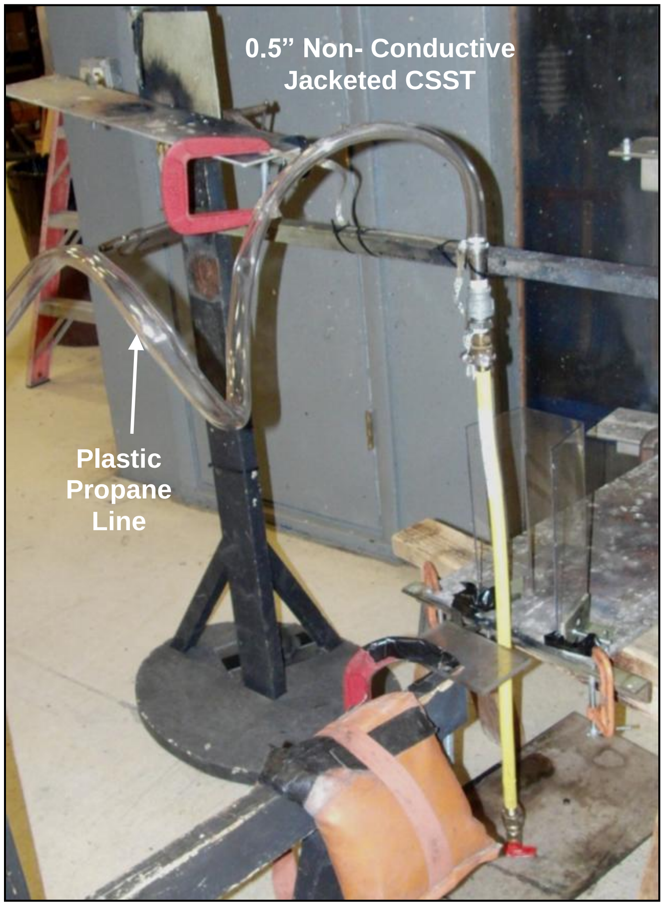

Figure 6 – Photograph of Typical Setup for LC1027 "Arcing Resistance, Direct Effects" Tests, Non-Conductive Jacketed CSST Test Sample using Propane Gas (Not Pressurized)

The second round of tests performed on the Titeflex, Gastite CSST test samples were the 'arc resistance' tests described in LC1024. This setup involves supporting the CSST gas pipe sample with non-conductive supports horizontally above a large flat copper ground plane, which served as the transient generator current return. One end of the gas pipe was connected to this ground plane via a piece of nickel coated copper braid, the other end left open circuit, and the output of the current transient generator connected to a 0.25" diameter, iron rod electrode, positioned to within at least 0.25 inches of the CSST sidewall. The arc is then established between the pipe and the electrode, with ionization of this gap helped by an 'initiating wire', a fine gauge filament (~38 AWG) wrapped around the electrode and positioned to within 0.125" of the arc entry location of the pipe sidewall. The free end of this initiating wire was set just above the 'pre-puncture' location in the non-conductive jacket of the CSST test sample. Figure 7 shows a basic cartoon of this test arrangement, with Figure 8 showing a photograph of a typical setup for the non-conductive jacketed CSST gas pipe tests. Figure 9 shows a close-up of the rod electrode and initiating wire arrangements for the LC1024 'Arc Resistance' tests.

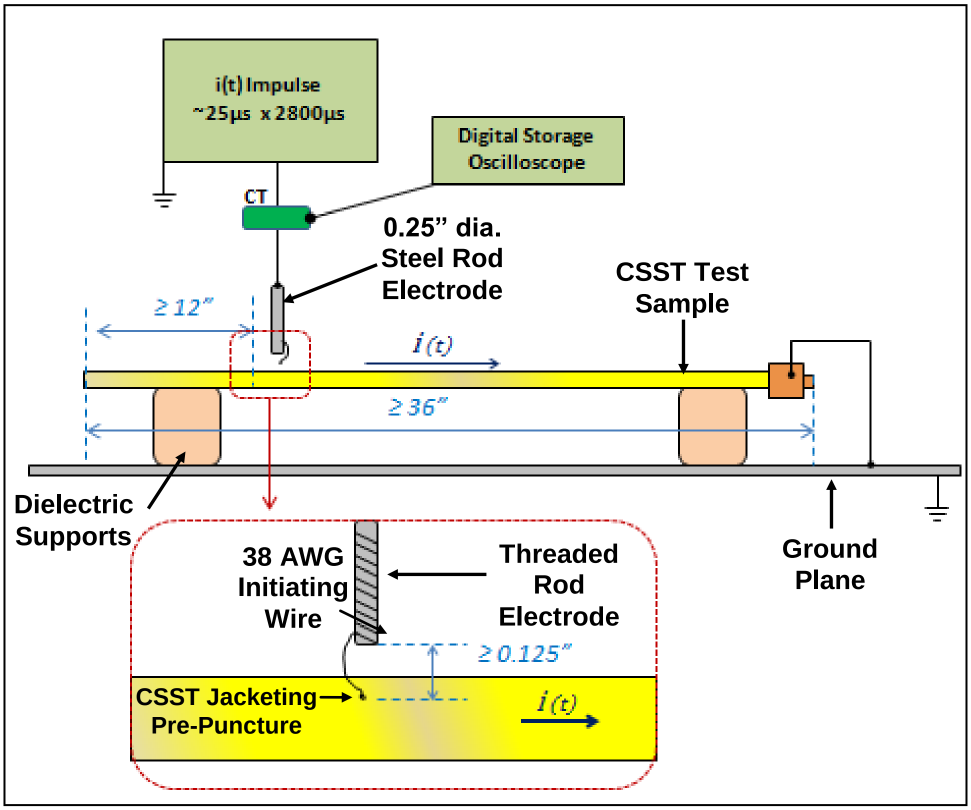

Figure 7 – General Setup Diagram for LC1024 "Arcing Resistance" Tests

Figure 8 – Photograph of Typical Setup for LC1024 "Arcing Resistance" Tests, Non-Conductive Jacketed CSST Test Samples

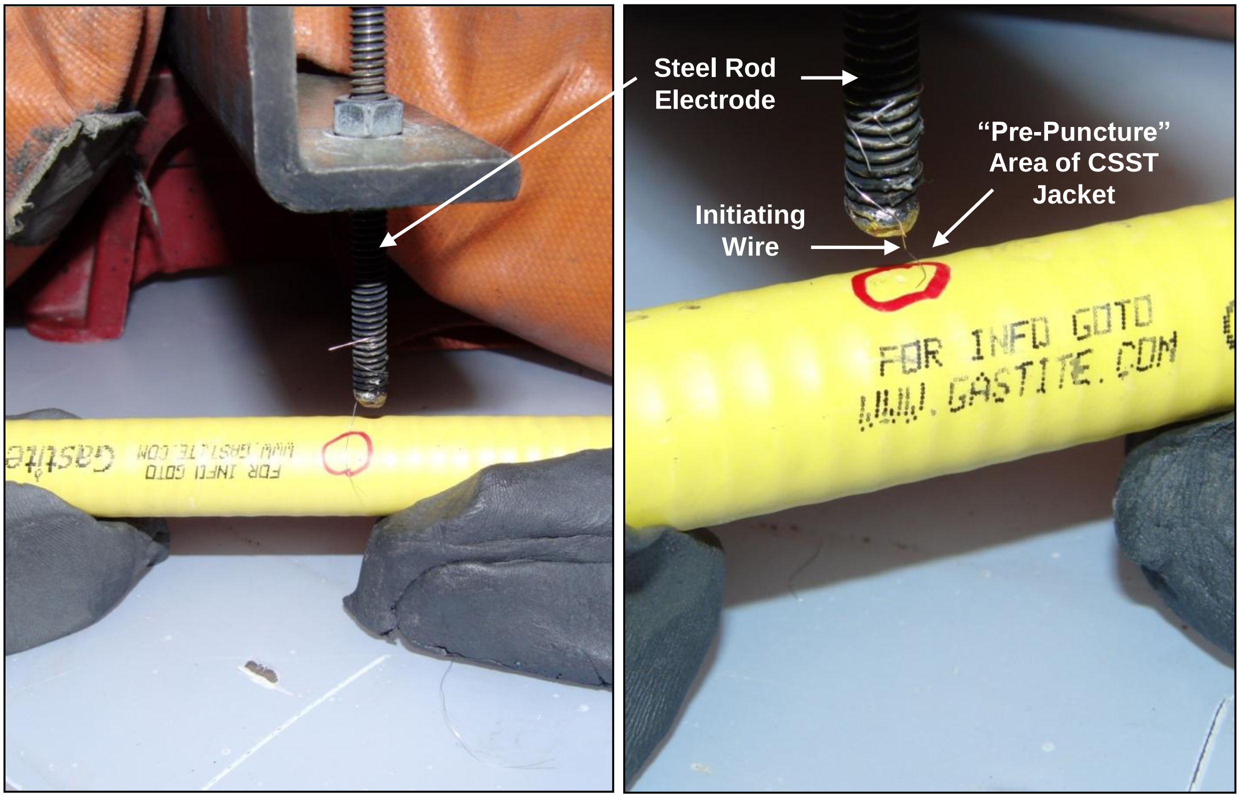

Figure 9 – Photograph of Typical Setup for LC1024 “Arcing Resistance” Tests, Non-Conductive Jacketed CSST Test Samples

A derivative of the’ Arc Resistance’ test of LC1024 was performed on one, 1.0” sized CSST sample using an aluminum frame lattice in lieu of a rod electrode. This setup involves supporting the CSST gas pipe sample with non-conductive supports vertically above a large flat copper ground plane, which served as the transient generator current return. One end of the gas pipe was connected to this ground plane via a piece of nickel coated copper braid, the other end left open circuit. The aluminum frame was connected to the output of the current transient generator and the CSST test article routed through cutouts in the frame, with a CSST to sidewall separation distance of approximately 0.125 inches. Figures 10 and 11 show photographs from this test arrangement, with the non-conductive jacket being similarly ‘pre-punctured’ at a point directly opposite the frame cutout.

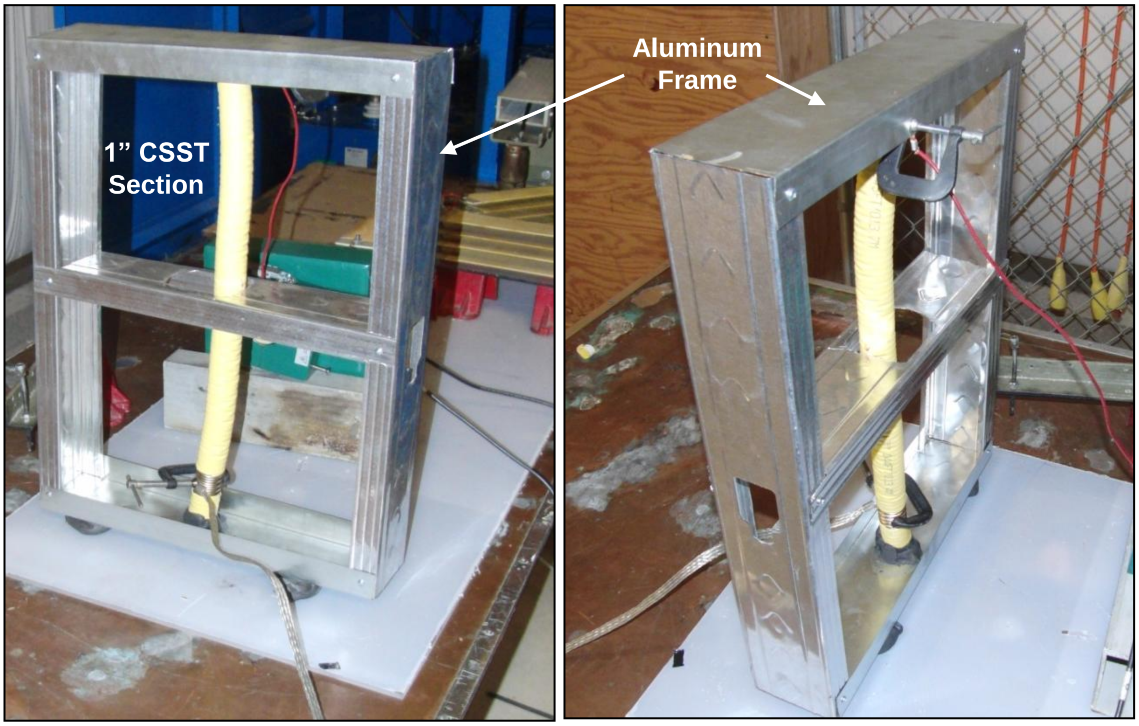

Figure 10 – Photograph of Modified Setup of LC1024 "Arcing Resistance" Test using Aluminum Frame to Non-Conductive Jacketed CSST Gap

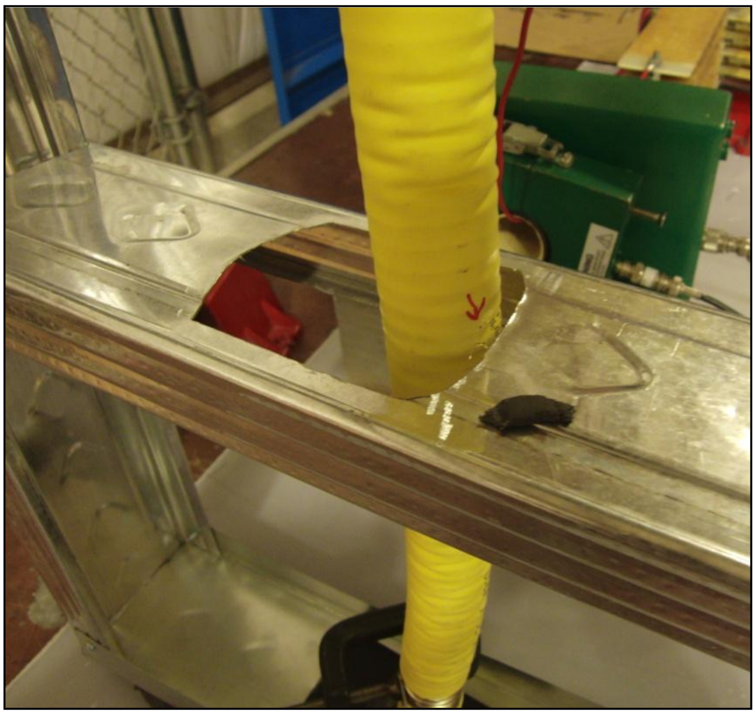

Figure 11 – Photograph of Modified Setup of LC1024 "Arcing Resistance" Test using Aluminum Frame to Non-Conductive Jacketed CSST Gap

The final test performed on the Titeflex CSST test samples per the LC1024 'Arc Resistance' tests was basically the same a described above, with a 0.75" sized CSST gas pipe sample supported horizontally above a large flat copper ground plane, which served as the transient generator current return. One end of the gas pipe was connected to this ground plane via a piece of nickel coated copper braid, this same end being fitted with a shut off stop cock valve to plug this end of the CSST gas pipe. The other electrically open circuit end of the CSST gas pipe was connected to and pressurized by a 15 lb LP tank via a long section of plastic tubing which had an in-line ball shutoff valve (open) and the tank regulator open. The output of the current transient generator was again connected to a 0.25" diameter, iron rod electrode, positioned to within at least 0.25 inches of the CSST sidewall. The arc is then established between the pipe and the electrode, with ionization of this gap helped by an 'initiating wire', a fine gauge filament (~38 AWG) wrapped around the electrode and positioned to within 0.125" of the arc entry location of the pipe sidewall. An Acrylic, three sided enclosure was positioned around the electrode and arc entry area to re-create a loosely confined condition. Figure 12 shows a basic cartoon of this test arrangement, with Figures 13 through 15 showing details of this setup. Figure 16 shows a photograph of the Lyon Associates supplied LP tank and regulator.

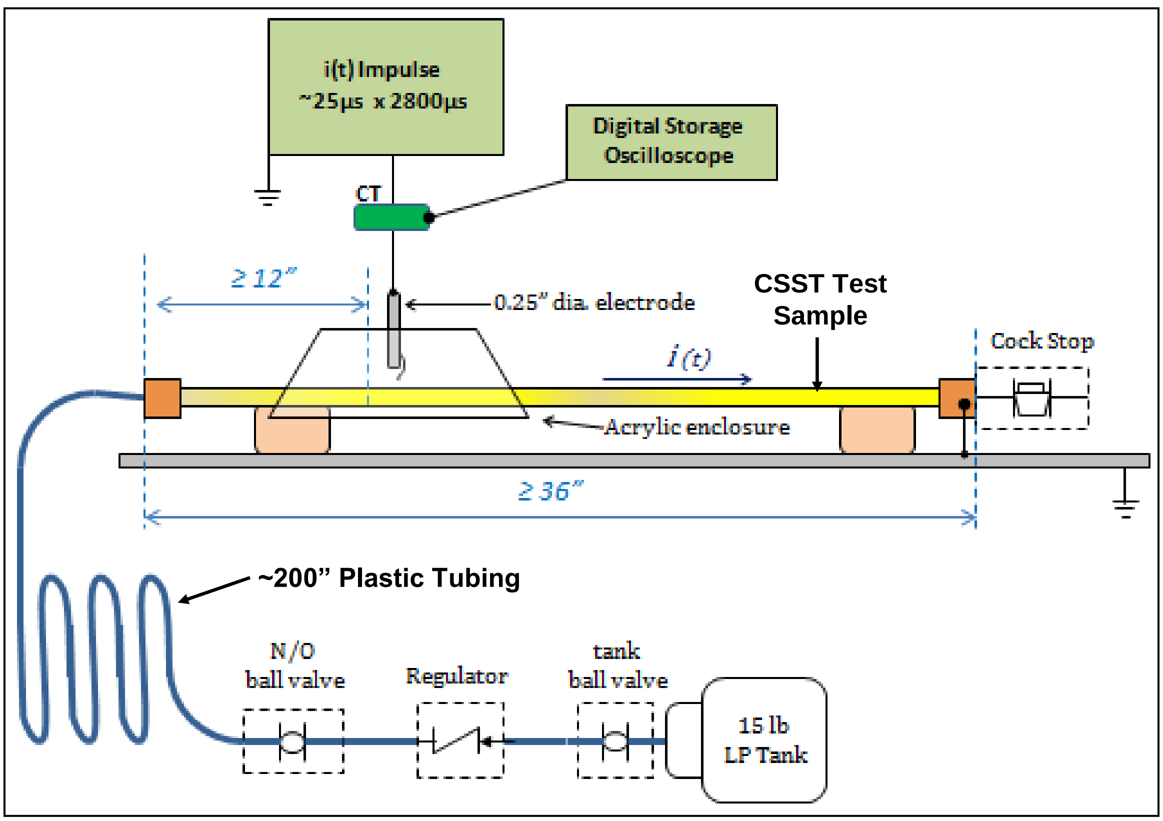

Figure 12 – General Setup Diagram for LC1024 "Arcing Resistance" Tests using Pressurized Propane Gas

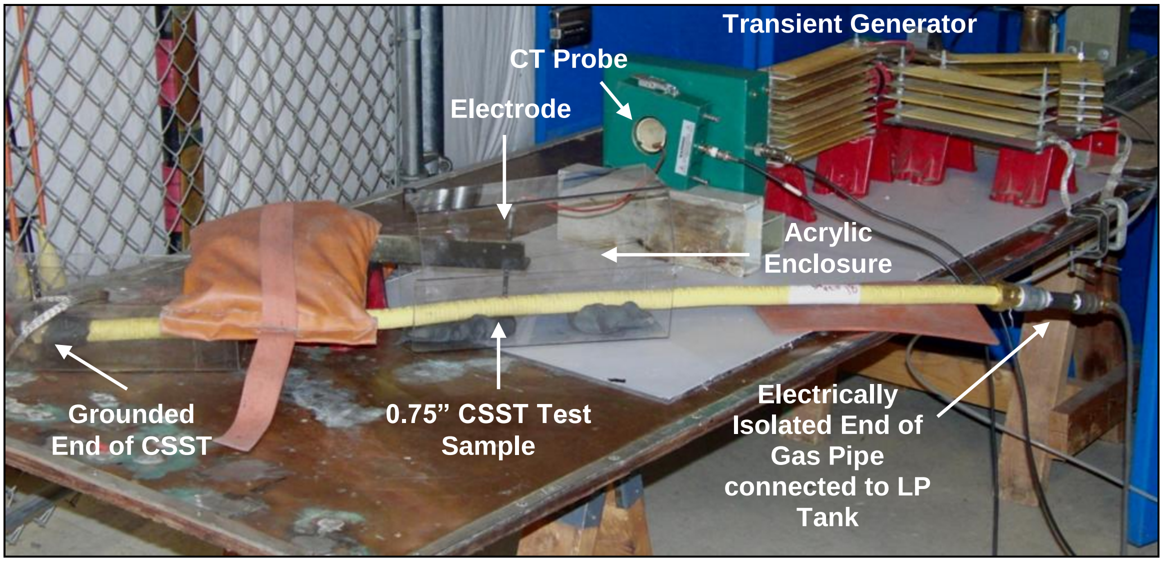

Figure 13 – Photograph of Setup for LC1024 "Arcing Resistance" Test using Pressurized Propane Gas

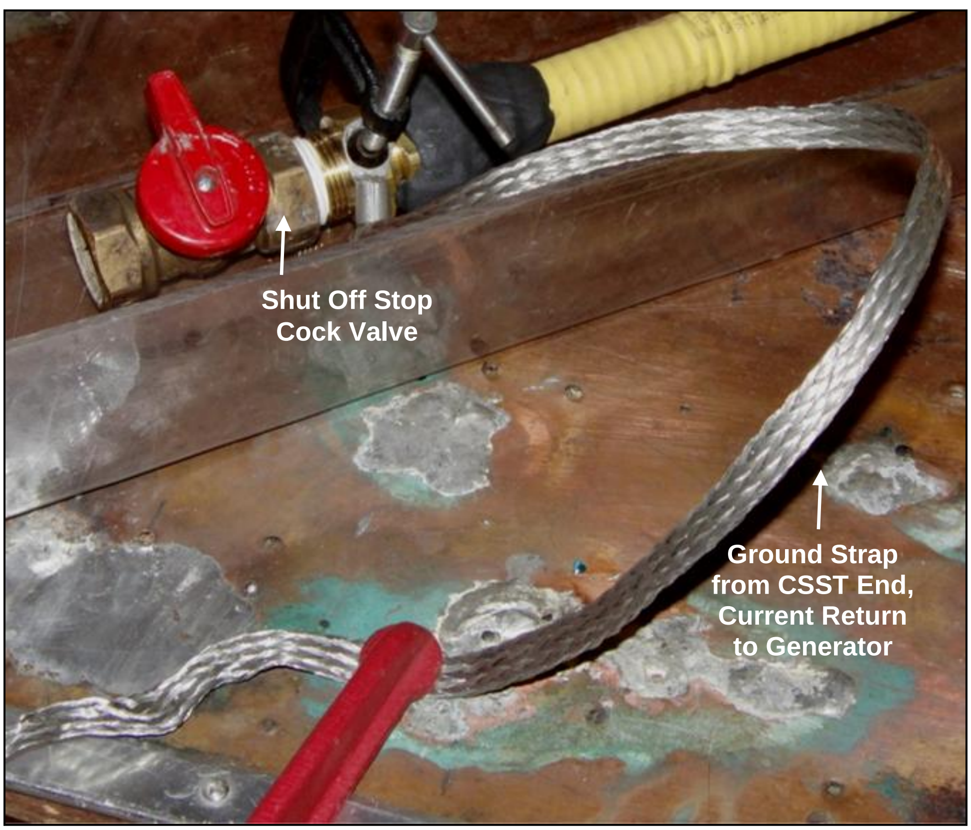

Figure 14 – Photograph of Single CSST Ground Setup for LC1024 "Arcing Resistance" Test using Pressurized Propane Gas

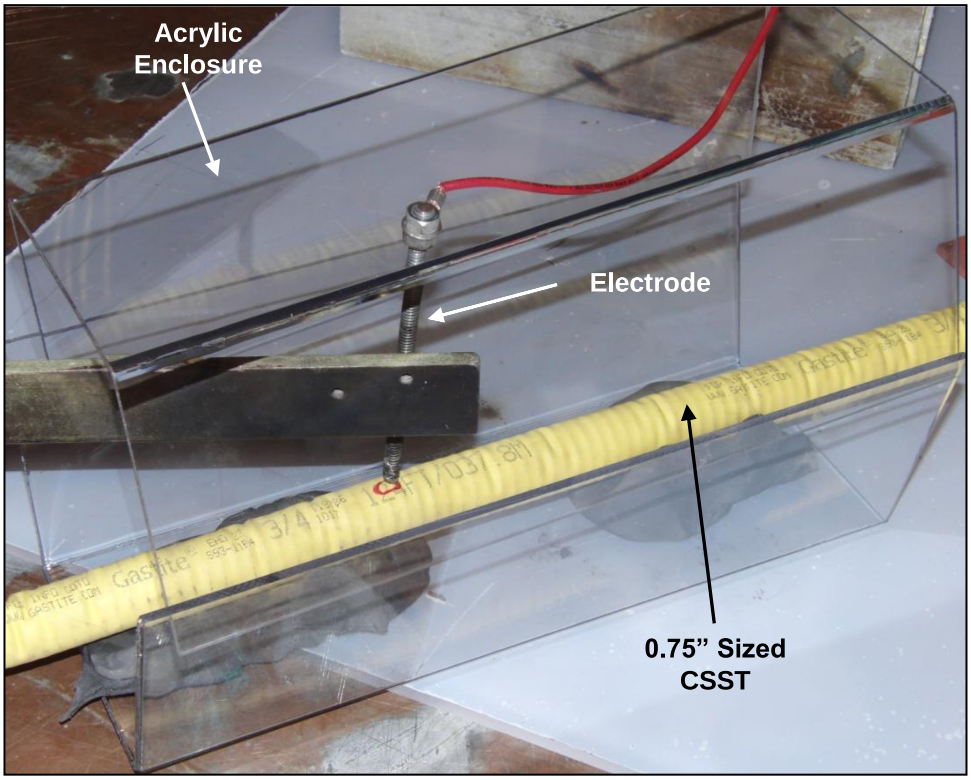

Figure 15 – Photograph of Electrode to CSST Setup for LC1024 "Arcing Resistance" Test using Pressurized Propane Gas

Figure16 – Photograph of LP Tank Source for LC1024 "Arcing Resistance" Test using Pressurized Propane Gas

6.2 High Current, Arc Entry Test Results

In general, both the waveshape and magnitude of the applied current transients deposited to the CSST test samples via an electric arc discharge determined whether sufficient energy was transferred to cause a melting of the pipe sidewall. This was observed in transient currents of longer duration but of lower peak amplitudes causing wall burn through verses shorter duration, higher amplitude transient currents not causing a melt through of the pipe sidewalls. Table 3 summarizes all of the high current, arc entry tests. Appendix A contains all of the recorded oscillographs of the applied current transients.

Two 'direct effects' tests were performed on a single 0.76 meter section of black iron pipe (BIP), using Current Components 1, 2, and 3 of Section 4.2.2 of LC1027, with the second test having a modified Current Component 3 delivering 254 Coulombs of charge in lieu of the 26 Coulombs. Both tests resulted in localized surface melting of the iron at the arc entry area but with no punctures or burn-through of the pipe sidewall noted. The tests performed to the black iron pipe test sample did not use propane. Figure 17 shows the result of Test No. 4, with 38.5 Coulombs of total charge deposited to the arc location on the BIP via all three Current Components 1, 2 and 3, each having peak currents of 33.2 kA, 3.9 kA and 562 Amperes average current, respectively. This resulted in a surface melted area of approximately 0.28 inches in diameter. Figure 18 shows the result of Test No. 5, with 267.1 Coulombs of total charge deposited to the arc location on the BIP via all three Current Components 1, 2 and modified 3, each having peak currents of 33.2 kA, 3.9 kA and 550 Amperes average current, respectively. This resulted in a surface melted area of approximately 0.47 inches in diameter.

Figure 17 – Post-Test Photograph of Arc Discharge Area on Black Iron Pipe Section, 38.5 Coulombs Total (Test No. 4)

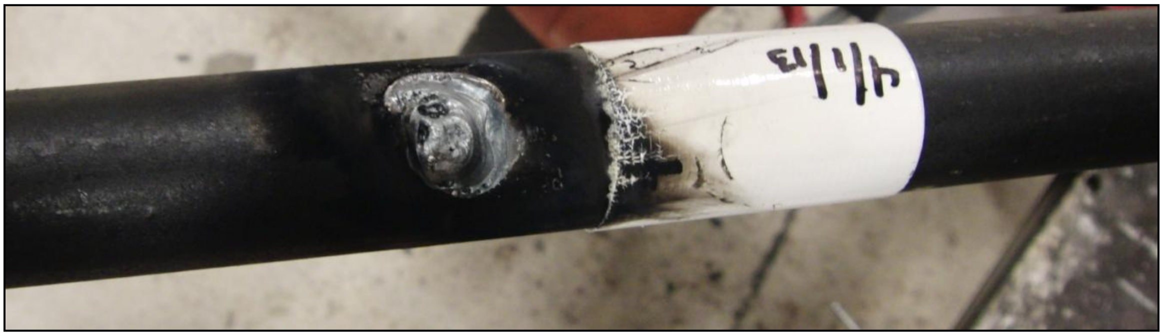

Figure 18 – Post-Test Photograph of Arc Discharge Area on Black Iron Pipe Section, 267.1 Coulombs Total (Test No. 5)

Two 'direct effects' tests were performed on 1 meter long, 1.0" sized CSST samples with non-conductive jacketing but with differences in the 'pre-puncturing' method used for the insulating jacket. One sample had a 1" x 1.5" rectangular 'window' cut out of the jacket to expose the CSST metal sidewall, with the other sample having only a pin head sized hole puncture in the jacket opposite the grounded plate electrode. The results observed were a larger burn-through hole in the CSST sample which had the pin hole sized pre-puncture (Test No. 8), with approximately a 0.375" diameter hole in the gas pipe sidewall as compared to a 0.25" diameter hole in the large jacket cutout setup (Test No. 6), both tests having comparable total amounts of charge delivered (41.2 Coulombs and 38.8 Coulombs, respectively). The CSST test sample discharged to the small puncture in the jacket also had visible damage to the pipe sidewall on the side opposite of the arc entry location. Figure 19 shows the post-test results of Test No. 6 (large jacket 'window') and Figure 20 shows the post-test photograph of the CSST from Test No. 8 (small, pin head sized jacket puncture).

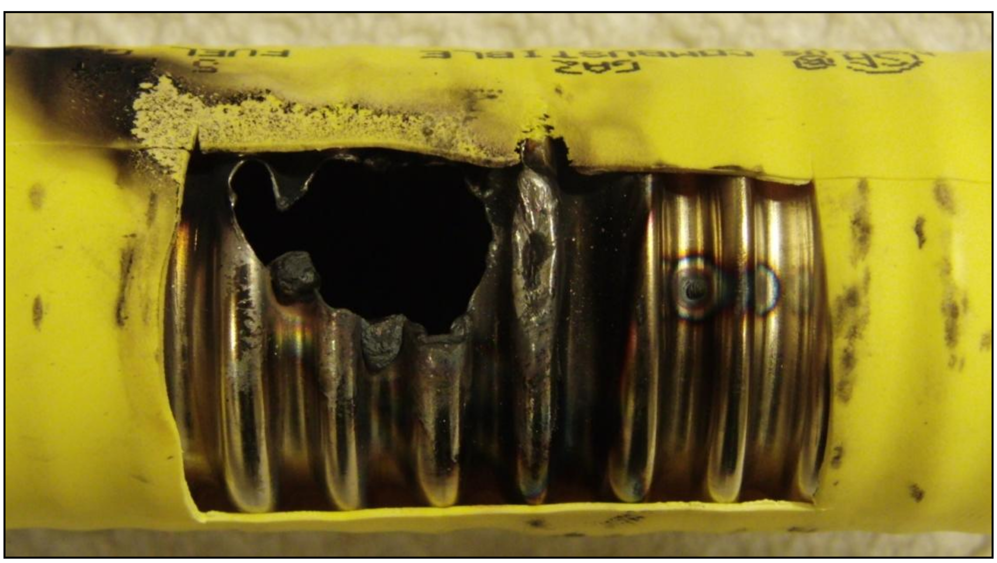

Figure 19 – Post-Test Photograph of Arc Discharge Area on 1.0" sized CSST, 38.8 Coulombs Total (Test No. 6)

Figure 20 – Post-Test Photograph of Arc Discharge Area on 1.0” sized CSST, 41.2 Coulombs Total (Test No. 8)

A single ‘direct effects’ test applying only Current Component 1 at 32.4 kA peak with 2.86 Coulombs of charge to a non-conductive jacketed, 0.5” sized CSST sample resulted in no visible burn through of the pipe sidewall. This test was performed with propane gas filling the pipe section volume. No flame from the arc discharge was observed. Figure 21 shows the post-test results from Test No. 9, with only the Current Component 1 of LC1027 ‘direct effects’ being discharged to a pre-punctured location in the CSST insulating jacket.

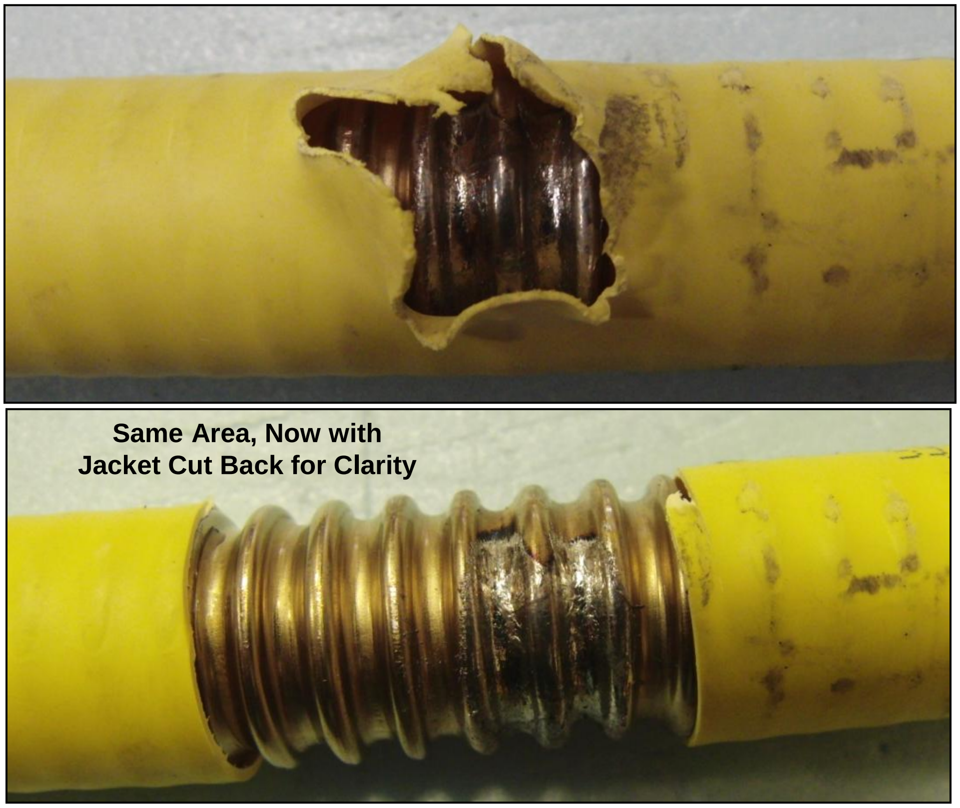

Figure 21 – Post-Test Photograph of Arc Discharge Area on 0.5” sized CSST, 2.86 Coulombs Total (Test No. 9)

A single ‘direct effects’ test applying a total of 42.9 Coulombs of charge to a conductive ‘Flashguard’ jacketed, 0.5” sized CSST sample resulted in localized damage to the jacket at the arc entry area. The jacket was not cut back to observe the condition of the pipe sidewall. This test was performed without using propane gas in the CSST section. Figure 22 shows the post-test results from Test No. 7, with all three current components of LC1027 ‘direct effects’ being discharged to a nominal (non-punctured) location of the CSST conductive jacket.

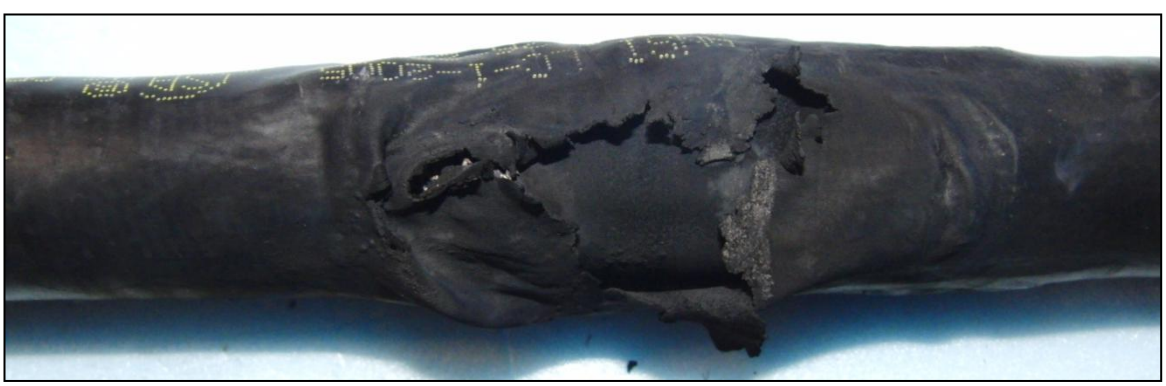

Figure 22 – Post-Test Photograph of Arc Discharge Area on 0.5” sized CSST, Conductive Jacket, 42.9 Coulombs Total (Test No. 7)

The remaining tests utilized the ‘Arcing Resistance’ test setup of Section 4.3.2.2 of LC1024, using a current transient approximately 25 µs x 2,800 µs in waveshape. This waveform, at a peak current level of 1.2 kA would deliver 4.5 Coulombs of charge within 2 milliseconds, per Figure 1 of LC1024. The first four tests were performed on 1 meter long, non-conductive jacketed, 0.5” sized CSST sections with progressively lower levels of total charge being deposited. The charge delivered varied from 3.91 Coulombs to 0.76 Coulombs, with all four tests resulting in burn-through of the pipe sidewalls. The resulting holes sizes melted in the sidewalls at the arc entry locations ranged in size from approximately 0.0625 inches to 0.03125 inches in diameter, with the larger hole due to the higher charge transfer. All four of these tests (Test Nos. 12 ~ 15) were performed without any propane gas, using a ‘pre-puncture’ pin head sized hole in the insulating jacket of the CSST gas pipe at the arc entry locations. A single CSST test article was used for all four tests. Figures 23 through 26 show the post-test photographs from Test Nos. 12 ~ 15, respectively.

Figure 23 – Post-Test Photograph of Arc Discharge Area on 0.5” sized CSST, Non-Conductive Jacket, 3.62 Coulombs Total (Test No. 12)

Figure 24 – Post-Test Photograph of Arc Discharge Area on 0.5” sized CSST, Non-Conductive Jacket, 1.96 Coulombs Total (Test No. 13)

Figure 25 – Post-Test Photograph of Arc Discharge Area on 0.5” sized CSST, Non-Conductive Jacket, 0.77 Coulombs Total (Test No. 14)

Figure 26 – Post-Test Photograph of Arc Discharge Area on 0.5” sized CSST, Non-Conductive Jacket, 0.76 Coulombs Total (Test No. 15)

A single, 1 meter long, non-conductive jacketed, 1.0” sized CSST, sample was also tested using a steel frame, with the CSST test sample being routed through the frame lattice. The CSST test article had a 1/8” air gap between the jacket and a portion of the steel frame, the frame being connected to the transient generator output and one end of the CSST test sample grounded to the current return of the generator. A total of 4.69 Coulombs of charge was deposited from a 25 µs x 2,800 µs current transient at 1.22 kA peak, resulting in a 0.25 inch diameter hole in the pipe sidewall. This test (Test No. 17) was also performed without using any propane gas, using a ‘pre-puncture’ pin head sized hole in the insulating jacket of the CSST gas pipe at the arc entry location. Figure 27 shows the post-test photograph from Test No. 17.

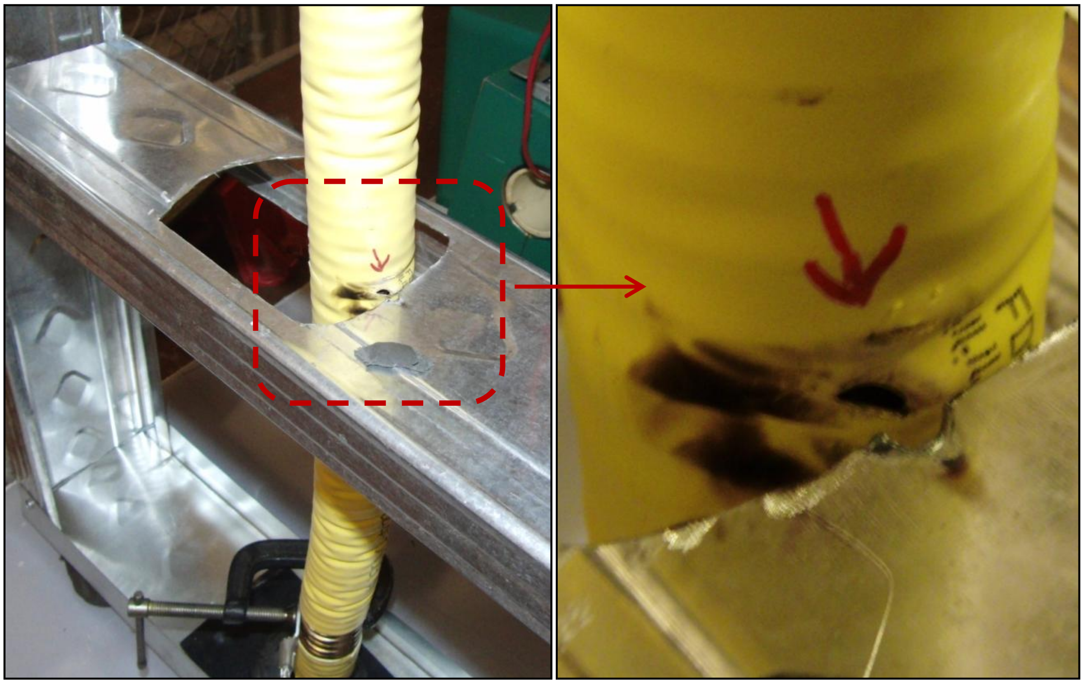

Figure 27 – Post-Test Photograph of Arc Discharge Area on 1.0" sized CSST, Non-Conductive Jacket, 4.69 Coulombs Total (Test No. 17)

The final test performed was an arc entry discharge per Section 4.3.2.2 of LC1024 to a 1 meter long, non-conductive jacketed, 0.75" sized CSST with the gas pipe pressurized by a remote liquid propane (LP) tank, one end of the gas pipe plugged with a short brass fitting attached to a shut-off ball valve. An acrylic, three sided enclosure approximately 8" x 4" x 4" was placed overtop of the arc entry test location. The test result was a puncture of the gas pipe sidewall along with an ignition of the exhausting propane gas and continued burning of the gas until the LP tank supply was turned off. Total charge deposited by the 25 µs x 2,800 µs current transient at 1.22 kA peak was 4.72 Coulombs. Figure 28 shows the post-test photograph from Test No. 18. Figure 29 shows the applied transient current waveform with Figure 30 showing the integral of the applied current transient, or the total charge delivered.

Figure 28 – Post-Test Photograph of Arc Discharge Area on 0.75" sized CSST, Non-Conductive Jacket w/ LP gas, 4.72 Coulombs Total (Test No. 18)

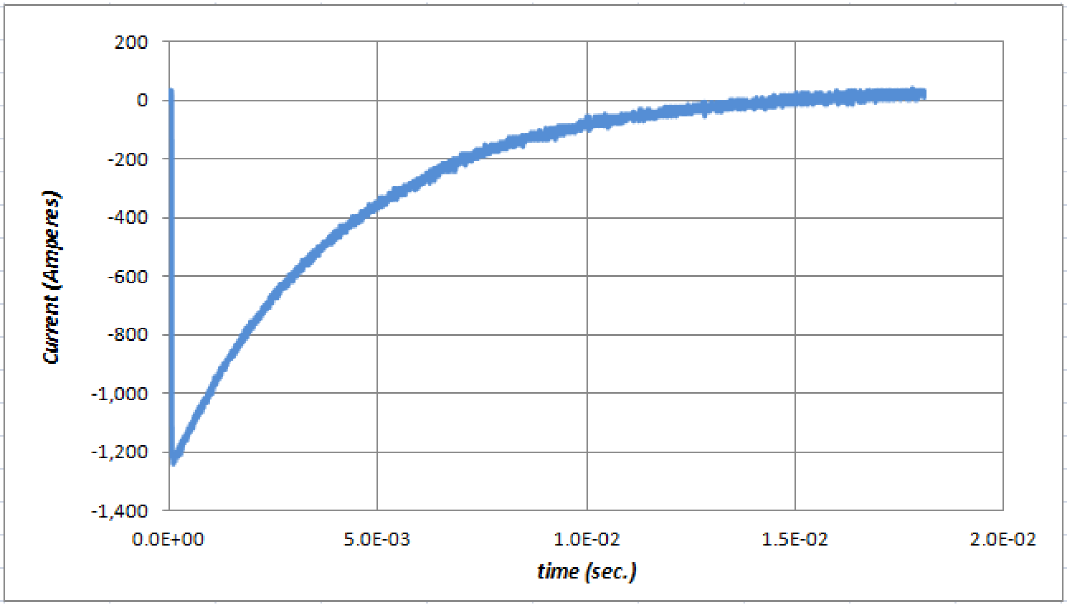

Figure 29 – Applied Current Transient to 0.75" sized CSST, Non-Conductive Jacket with LP Gas, 1.22 kA Peak (Test No. 18)

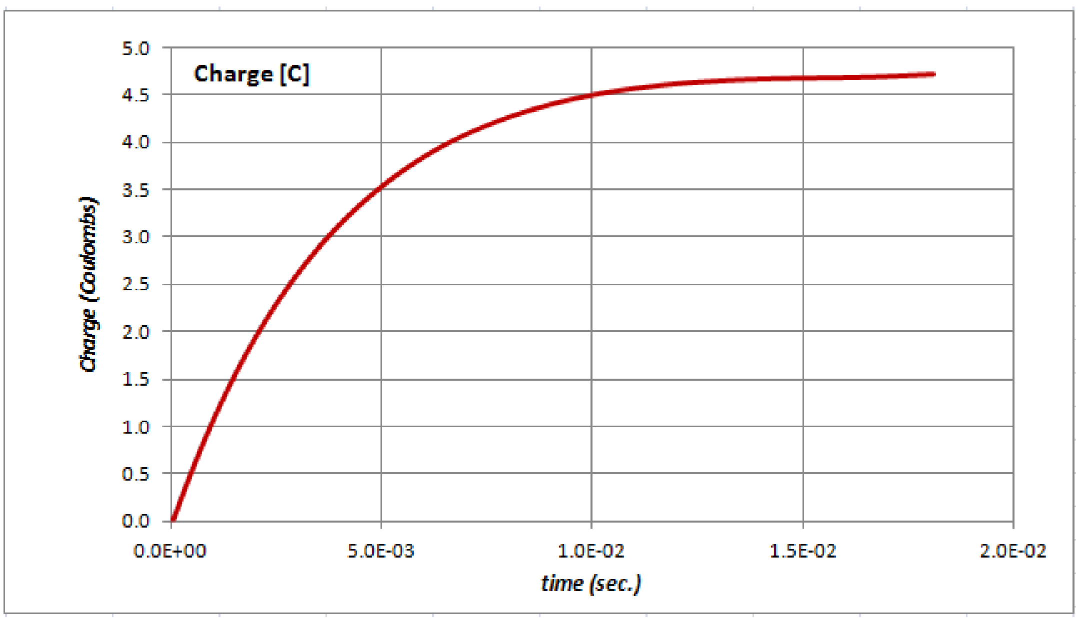

Figure 30 – Total Charge Deposited to 0.75" sized CSST, Non-Conductive Jacket with LP Gas, 4.72 Coulombs (Test No. 18)

Table 3 – High Current, Arc Entry Test Summary

Test No.	Generator Charge Voltage (kV)	Component 1			Component 2		Component 3			Notes/Results
		Ipk (kA)	Action Integral (x10⁶ J/Ω)	Total Charge (C)	Ipk/ Iavg (kA)	Charge Q in 5msec (C)	Duration (msec)	Total Charge (C)	Average Current (A)	
1 April 2013										
1	76	33.8	0.0632	3.03	3.72/ 1.90	9.5	14.7	6.5	442.2	Calibrations to Cu Pipe using Setup of Figure 7 of LC1027
2	76	33.8	0.0632	3.03	*not applied*		41.0	24.2	590.2	Calibrations to Cu Pipe using Setup of Figure 7 of LC1027
3	74	33.2	0.0604	3.04	3.90/ 2.01	10.1	45.0	25.2	560	Calibrations to Cu Pipe using Setup of Figure 7 of LC1027
4	75	33.2	0.0612	3.01	3.90/ 2.01	10.1	45.2	25.4	562	BIP, at Test Location No. 1
5	75	33.2	0.0612	3.01	*Applied, but not captured on DSO*		462	254	550	BIP, at Test Location No. 1
6	75	32.8	0.0608	2.98	3.88/ 2.00	10.0	47.0	25.8	549	1" sized CSST Gastite (Non-Conductive jacket) Line Not Filled w/ LP; Result: Hole in Pipe Sidewall ~0.185 in² Area
7	75	32.8	0.0604	3.12	3.90/ 2.00	10.0	68.4	29.8	436	0.5" sized CSST Gastite (Conductive Jacket) Line Not Filled w/ LP; Result: Damage to Jacketing Not Inspected for Hole
8	75	32.8	0.060	2.91	3.88/ 2.02	10.1	58.8	28.2	479.6	1" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Hole in Pipe Sidewall ~0.419 in² Area
9	75	32.4	0.0596	2.86	*Not Applied*					0.5" sized CSST Gastite (Non-Conductive Jacket) Line Filled w/ LP; Result: No Hole in Pipe
Now Applying Longer Duration Current Transients per LC1024 (~25 µs x 2,800 µs Waveshape)										
2 April 2013										
9-B	13	1.25	*Not recorded*	4.8	*Not Applied*					Calibrations to Cu Pipe using Setup of Figure 2 of LC1024
10	10	1.6	*Not recorded*	3.3	*Not Applied*					Calibrations to Cu Pipe using Setup of Figure 2 of LC1024
10-B	10	0.94	*Not recorded*	3.6	*Not Applied*					Calibrations to Cu Pipe using Setup of Figure 2 of LC1024
11	9	0.86	0.0015	3.2 (3.27)*	*Not Applied*					Calibrations to Cu Pipe using Setup of Figure 2 of LC1024

Table 3 – High Current, Arc Entry Test Summary (*Continued*)

Test No.	**Generator Charge Voltage (kV)**	**Component 1**			**Component 2**		**Component 3**			**Notes/Results**
		Ipk (kA)	**Action Integral ($x10^6$ J/Ω)**	**Total Charge (C)**	**Ipk/ Iavg (kA)**	**Charge Q in 5msec (C)**	**Duration (msec)**	**Total Charge (C)**	**Average Current (A)**	
2 April 2013										
12	10	0.94	0.0018	3.50 (3.62)*	*Not Applied*					0.5" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Hole in Pipe Sidewall ~0.0625" dia.
13	5.5	0.50	0.00053	1.84 (1.96)*	*Not Applied*					0.5" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Hole in Pipe Sidewall ~0.03125" dia.
14	2.2	0.20	*Not recorded*	0.77	*Not Applied*					0.5" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Hole in Pipe Sidewall ~0.03125" dia.
15	2.2	0.20	*Not recorded*	0.76	*Not Applied*					0.5" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Hole in Pipe Sidewall ~0.03125" dia.
Now Testing CSST Gas Pipe Section Routed through Grounded Aluminum Frame										
16	13	1.26	*Not recorded*	4.6	*Not Applied*					1" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Arc at Pipe Bottom Edge
Added more Insulation at Bottom of CSST Gas Pipe Support, Repeating Test No. 16										
17	13	1.22	0.00304	4.6 (4.69)*	*Not Applied*					1" sized CSST Gastite (Non-Conductive Jacket) Line Not Filled w/ LP; Result: Arc from CSST to Steel Frame, Hole in Pipe Sidewall ~0.25" dia.
Testing 0.75" sized CSST (Gastite) w/ LP Filled Line & Pressurized by LP Tank; Acrylic, 3-Sided Enclosure Placed Around Arc Entry Area										
18	13	1.22	0.00304	4.6 (4.72)*	*Not Applied*					0.75" sized CSST Gastite (Non-Conductive Jacket) Line Filled w/ LP; Result: Arc from CSST to Al Frame, Hole in Pipe Sidewall ~0.25" dia. Ignition of LP Gas, Extinguished by Shutting Off LP Tank

** indicates the full integration of current for total charge delivered*

APPENDIX A

Raw Data Oscillograms

TDS3032B B010832 192.168.1.41 1 Apr 2013 10:48:16

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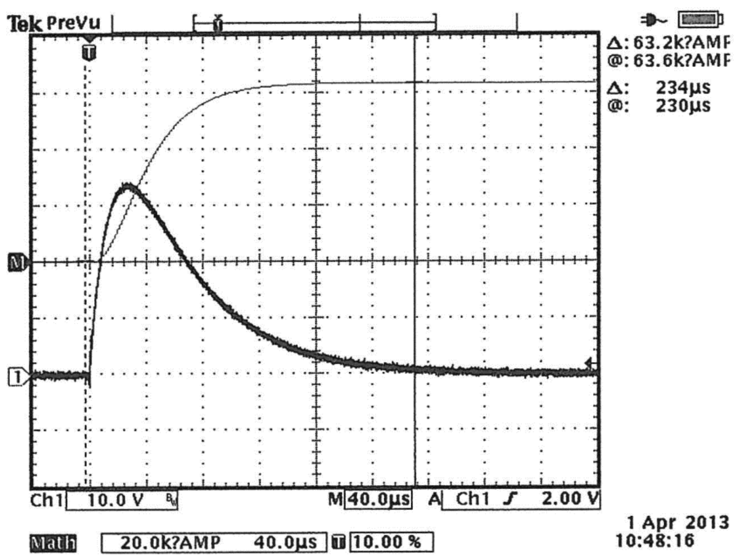

Test No. 1

☑ Comp A, Ah, A/5	☐ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: 33.8 kA	Ipk: ____ kA	Iavg: ____ A	Ipk: ____ kA	____
AI: 0.0632 x 10^6 A^2 s	Chg: ____ C	Chg: ____ C	AI: ____ x 10^6 A^2 s	____
Scale 10 kA/Div	Iavg: ____ kA	Time: ____ ms	Scale ____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS, LC1027
DIRECT EFFECTS

TDS3032B SNB015906 192.168.1.53 28 Mar 2013 12:03:18

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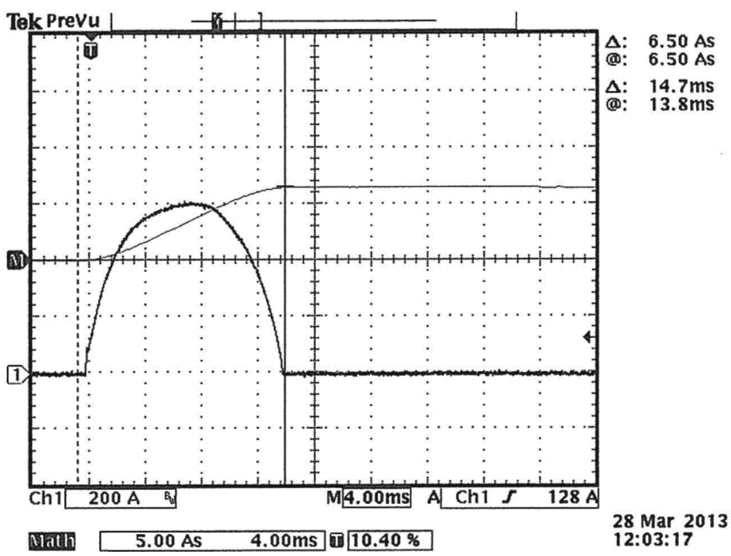

Test No. 1

☐ Comp A, Ah, A/5	☐ Comp B	☑ Comp C/C*	☐ Comp D	☐ Other
Ipk:____ kA	Ipk:____ kA	Iavg: 442.2 A	Ipk:____ kA	____
AI:____ x 10^6 A^2 s	Chg:____ C	Chg: 6.5 C	AI:____ x 10^6 A^2 s	____
Scale____ kA/Div	Iavg:____ kA	Time: 14.7 ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS

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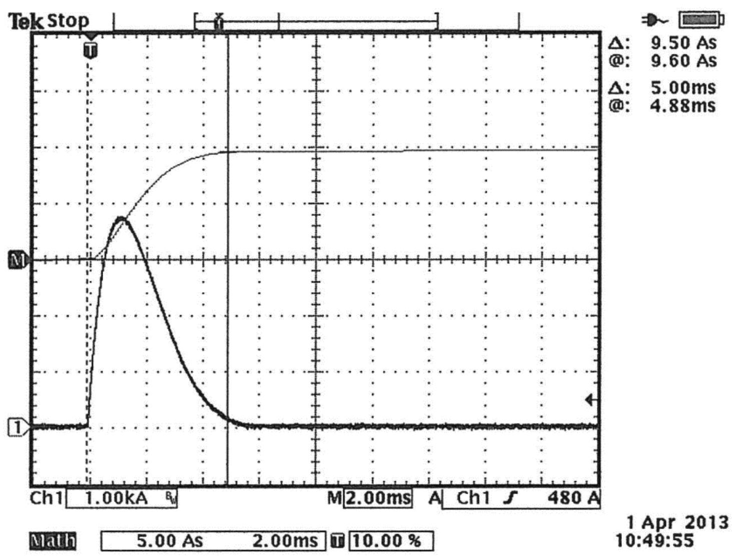

Test No. 1

☐ Comp A, Ah, A/5
Ipk:__________kA
AI:__________ x 10^6 A^2 s
Scale________kA/Div

☑ Comp B
Ipk: 3.72 kA
Chg: 9.5 C
Iavg: 1.9 kA
Scale__1___ kA/Div

☐ Comp C/C*
Iavg:_________A
Chg:_________C
Time:_________ms
Scale__200 A/Div

☐ Comp D
Ipk:________kA
AI:______ x 10^6 A^2 s
Scale____ kA/Div

☐ Other

REMARKS: CALIBRATIONS

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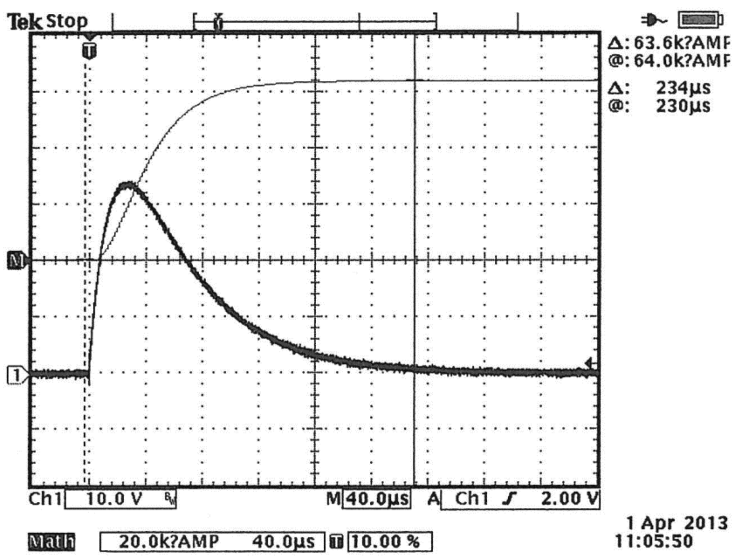

Test No. 2

☑ Comp A, Ah, A/5	☐ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: 33.8 kA	Ipk:_____kA	Iavg:_____A	Ipk:_____kA	_____
AI: 0.0632 x 10^6 A^2 s	Chg:_____C	Chg:_____C	AI:_____ x 10^6 A^2 s	_____
Scale 10 kA/Div	Iavg:_____kA	Time:_____ms	Scale_____ kA/Div	_____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS, #2

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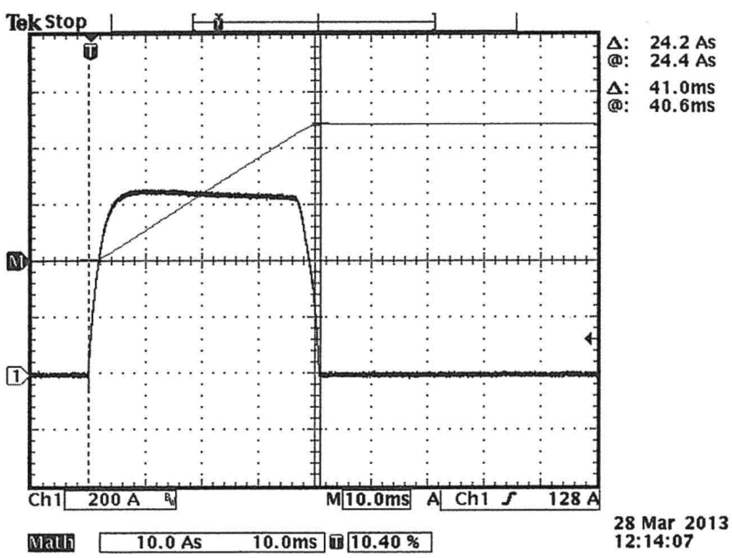

Test No. 2

☐ Comp A, Ah, A/5	☐ Comp B	☑ Comp C/C*	☐ Comp D	☐ Other
Ipk:____kA	Ipk:____kA	Iavg: 590.2 A	Ipk:____kA	____
AI:____x $10^6 A^2 s$	Chg:____C	Chg: 24.2 C	AI:____ x $10^6 A^2 s$	____
Scale____kA/Div	Iavg:____kA	Time: 41.0 ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS, #2

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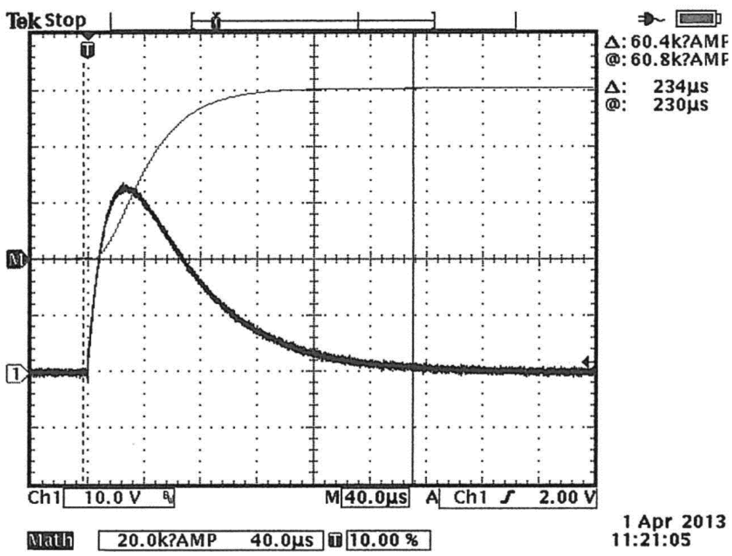

Test No. 3

☑ Comp A, Ah, A/5 | ☐ Comp B | ☐ Comp C/C* | ☐ Comp D | ☐ Other

Ipk: 33.2 kA	Ipk: ___ kA	Iavg: ___ A	Ipk: ___ kA	___
AI: 0.0604 x 10^6 A^2 s	Chg: ___ C	Chg: ___ C	AI: ___ x 10^6 A^2 s	___
Scale 10 kA/Div	Iavg: ___ kA	Time: ___ ms	Scale ___ kA/Div	___
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS, #3

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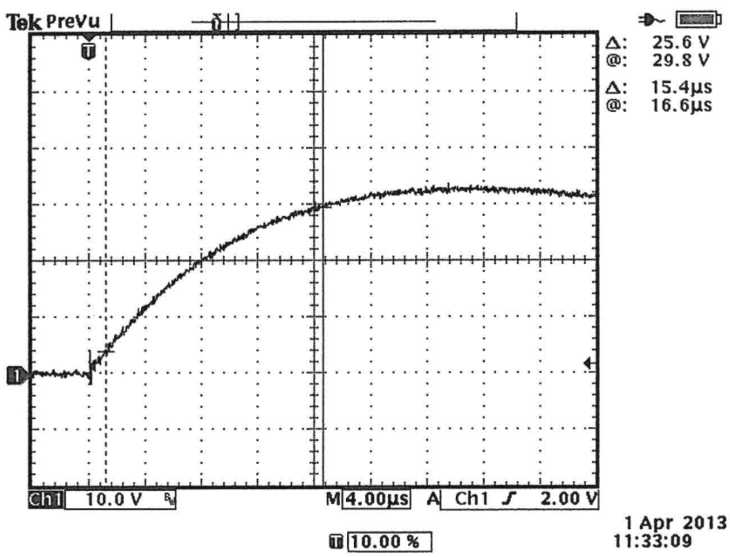

Test No. 3

☑ Comp A, Ah, A/5
Ipk: 33.2 kA
AI: 0.0604 x 10^6 A^2 s
Scale 10 kA/Div

☐ Comp B
Ipk: ______ kA
Chg: ______ C
Iavg: ______ kA
Scale 1 kA/Div

☐ Comp C/C*
Iavg: ______ A
Chg: ______ C
Time: ______ ms
Scale 200 A/Div

☐ Comp D
Ipk: ______ kA
AI: ______ x 10^6 A^2 s
Scale ______ kA/Div

☐ Other

REMARKS: CALIBRATIONS
FRONT TIME, 10% - 90%, 15.4 μs

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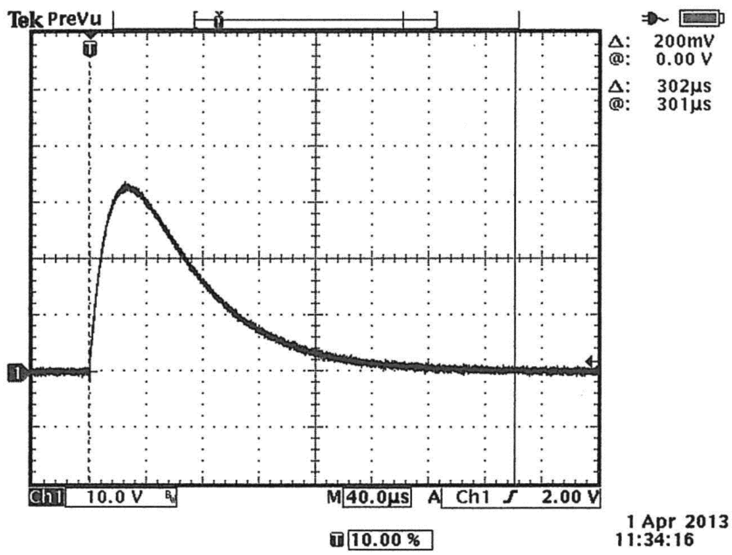

Test No. 3

☑ Comp A, Ah, A/5	☐ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: 33.2 kA	Ipk:______kA	Iavg:______A	Ipk:______kA	______
AI: 0.0604 x 10^6 A^2 s	Chg:______C	Chg:______C	AI:______ x 10^6 A^2 s	______
Scale 10 kA/Div	Iavg:______kA	Time:______ms	Scale____ kA/Div	______
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS #3
TIME TO 1% ≈ 302 μs

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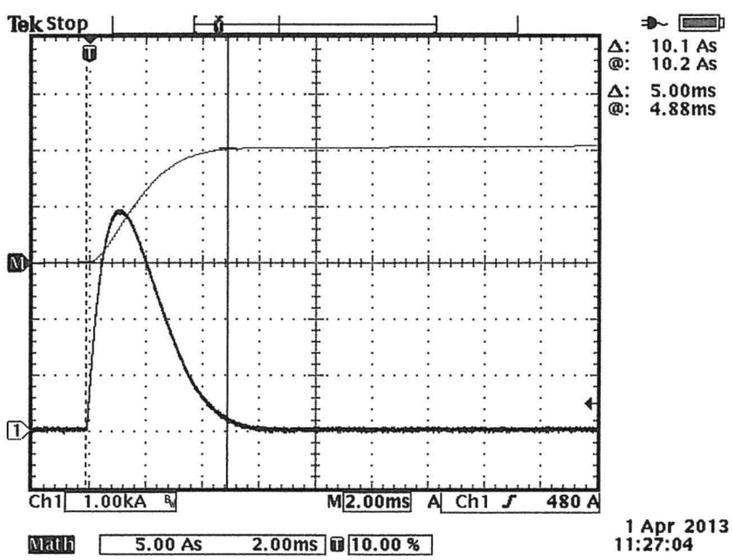

Test No. 3

☐ Comp A, Ah, A/5	☑ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:______ kA	Ipk: 3.90 kA	Iavg:______ A	Ipk:______ kA	______
AI:______ x 10^6 A^2 s	Chg: 10.1 C	Chg:______ C	AI:______ x 10^6 A^2 s	______
Scale______ kA/Div	Iavg: 2.01 kA	Time:______ ms	Scale____ kA/Div	______
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATIONS #3

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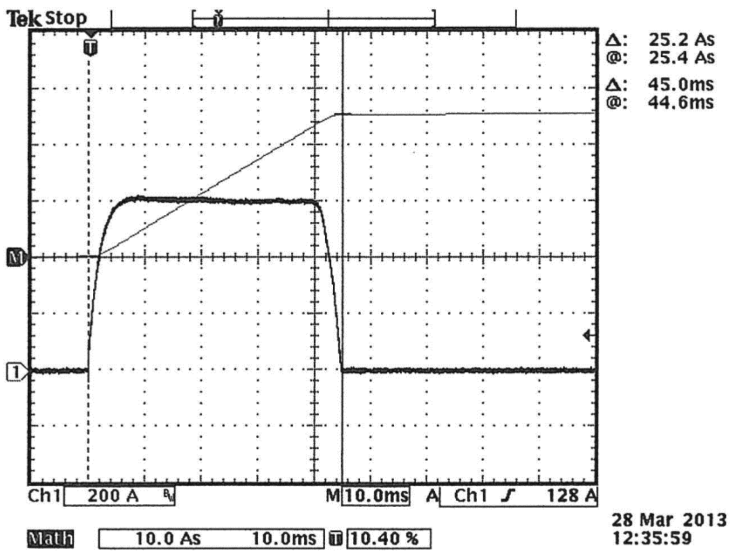

Test No. 3

☐ Comp A, Ah, A/5	☐ Comp B	☑ Comp C/C*	☐ Comp D	☐ Other
Ipk:_____kA	Ipk:_____kA	Iavg: 560 A	Ipk:_____kA	_____
AI:_____x $10^6 A^2 s$	Chg:_____C	Chg: 25.2 C	AI:_____ x $10^6 A^2 s$	_____
Scale_____kA/Div	Iavg:_____kA	Time: 45.0 ms	Scale_____ kA/Div	_____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: CALIBRATION S1 #3

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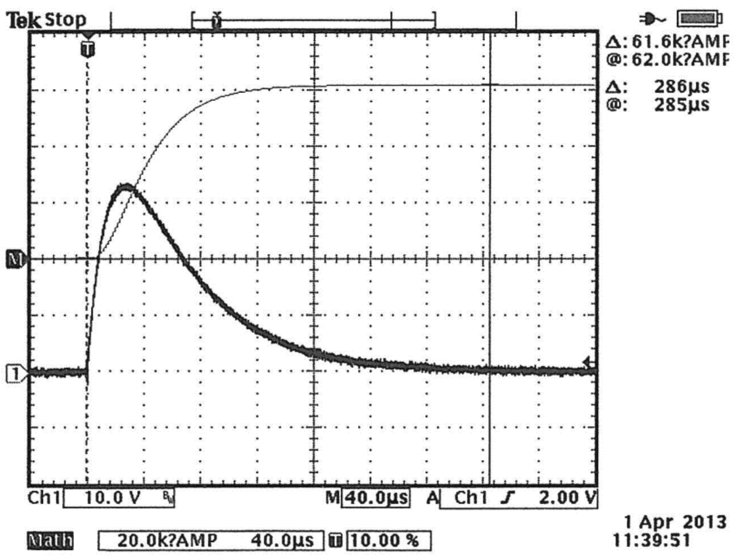

Test No. 4

☑ Comp A, Ah, A/5 | ☐ Comp B | ☐ Comp C/C* | ☐ Comp D | ☐ Other

Ipk: 33.2 kA	Ipk: ______ kA	Iavg: ______ A	Ipk: ______ kA	______
AI: 0.0612 x 10^6 A^2 s	Chg: ______ C	Chg: ______ C	AI: ______ x 10^6 A^2 s	______
Scale 10 kA/Div	Iavg: ______ kA	Time: ______ ms	Scale ____ kA/Div	______
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 3/4" BIP, TEST LOCATION #1

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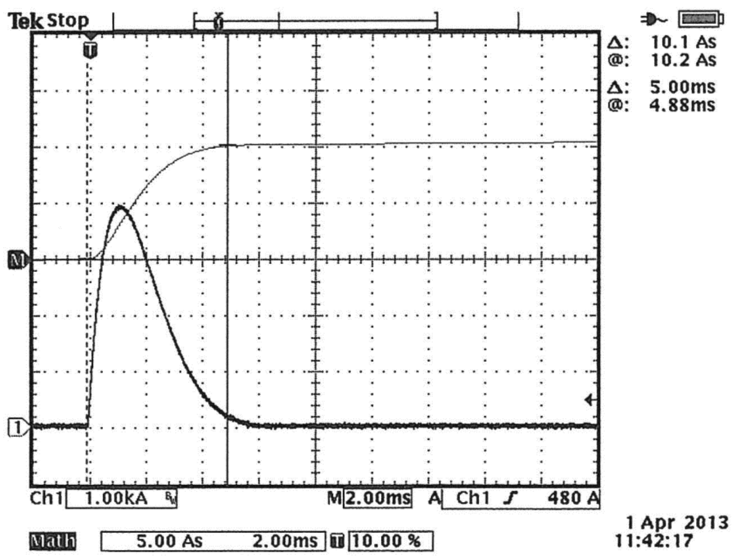

Test No. 4

☐ Comp A, Ah, A/5
Ipk:________kA
AI:________ x 10^6 A^2 s
Scale______kA/Div

☑ Comp B
Ipk: 3.90 kA
Chg: 10.1 C
Iavg: 2.01 kA
Scale 1 kA/Div

☐ Comp C/C*
Iavg:________A
Chg:________C
Time:________ms
Scale 200 A/Div

☐ Comp D
Ipk:________kA
AI:______ x 10^6 A^2 s
Scale____ kA/Div

☐ Other

REMARKS: 3/4" BiP, TEST LOCATION #1

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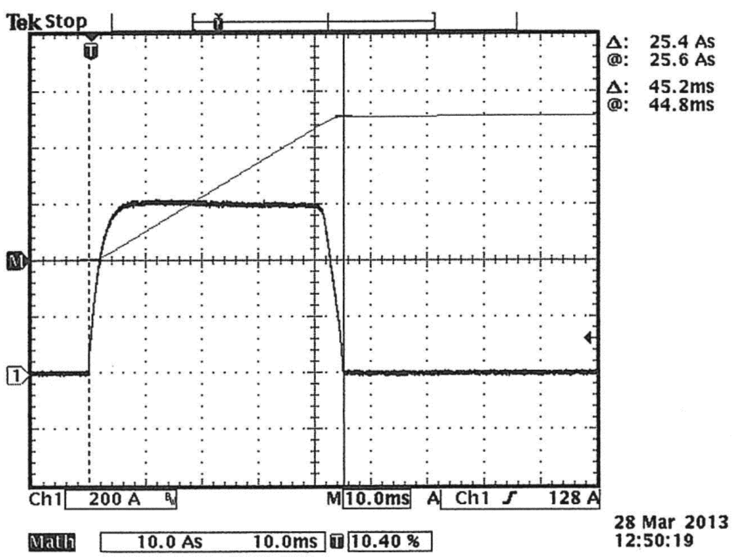

Test No. 4

☐ Comp A, Ah, A/5	☐ Comp B	☑ Comp C/C*	☐ Comp D	☐ Other
Ipk:____kA	Ipk:____kA	Iavg: 562 A	Ipk:____kA	____
AI:____ x 10^6 A^2 s	Chg:____C	Chg: 25.4 C	AI:____ x 10^6 A^2 s	____
Scale____kA/Div	Iavg:____kA	Time: 45.2 ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 3/4" BiP, TEST LOCATION #1

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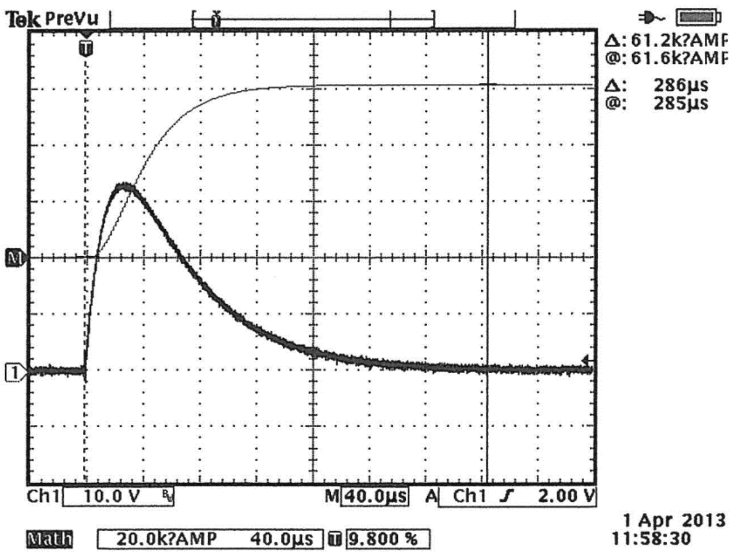

Test No. 5

☑ Comp A, Ah, A/5	☐ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: 33.2 kA	Ipk: ______ kA	Iavg: ______ A	Ipk: ______ kA	______
AI: 0.0612 x 10^6 A^2 s	Chg: ______ C	Chg: ______ C	AI: ______ x 10^6 A^2 s	______
Scale 10 kA/Div	Iavg: ______ kA	Time: ______ ms	Scale ____ kA/Div	______
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 3/4" BIP, TEST LOCATION #2

TDS3032B SNB015906 192.168.1.53 28 Mar 2013 13:05:49

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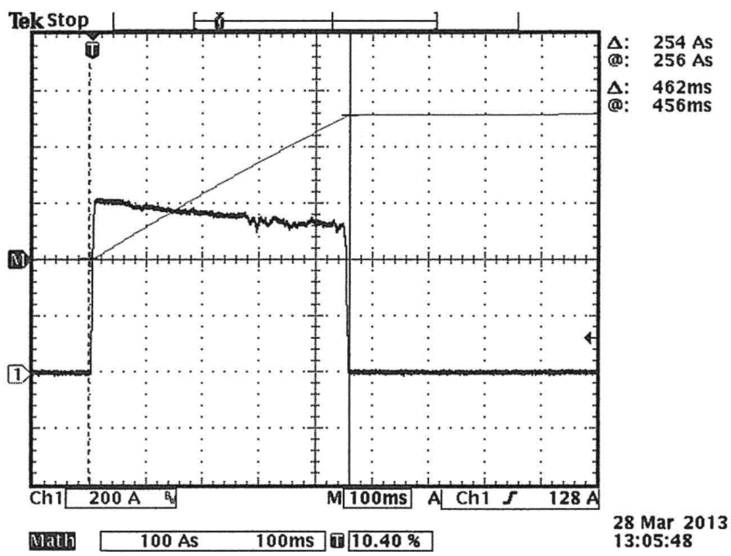

Test No. 5

☐ Comp A, Ah, A/5	☐ Comp B	☑ Comp C/C*	☐ Comp D	☐ Other
Ipk:______ kA	Ipk:______ kA	Iavg: 550 A	Ipk:______ kA	______
AI:______ x $10^6 A^2 s$	Chg:______ C	Chg: 254 C	AI:______ x $10^6 A^2 s$	______
Scale______ kA/Div	Iavg:______ kA	Time: 462 ms	Scale____ kA/Div	______
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 3/4" BIP TEST LOCATION #2

TDS3032B B010832 192.168.1.41 1 Apr 2013 13:33:14

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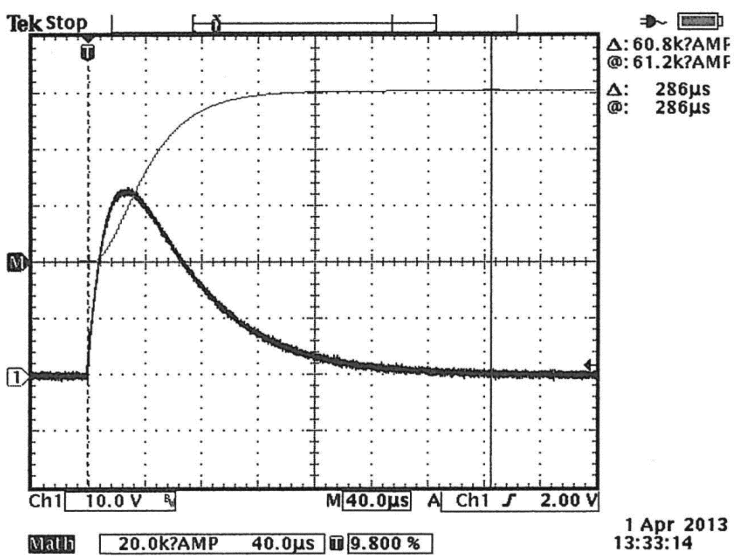

Test No. 6

☑ Comp A, Ah, A/5 | ☐ Comp B | ☐ Comp C/C* | ☐ Comp D | ☐ Other

Ipk: 32.8 kA | Ipk:____ kA | Iavg:____ A | Ipk:____ kA | ____

AI: 0.0608 x 10^6 A^2 s | Chg:____ C | Chg:____ C | AI:____ x 10^6 A^2 s | ____

Scale 10 kA/Div | Iavg:____ kA | Time:____ ms | Scale____ kA/Div | ____

Scale 1 kA/Div | Scale 200 A/Div

REMARKS: 1" CSST, GASTITE, NON-CONDUCTIVE JACKET

TDS3034B SNC010791 192.168.1.42 1 Apr 2013 13:34:27

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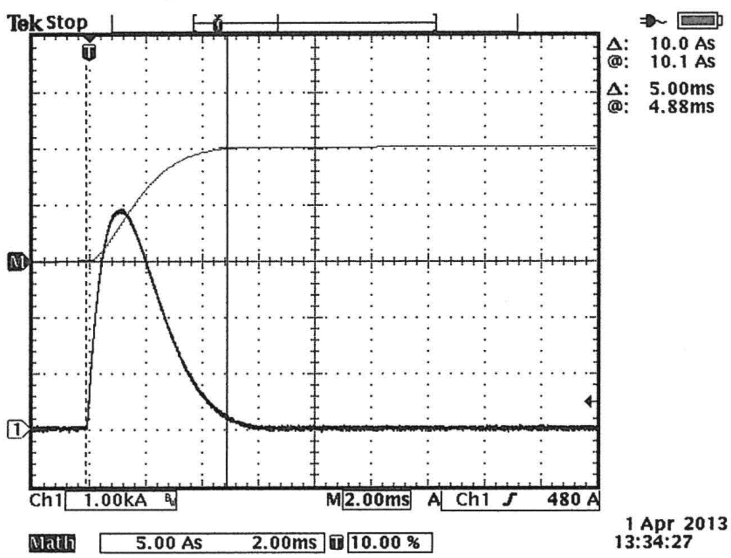

Test No. 6

☐ Comp A, Ah, A/5	☑ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:_____kA	Ipk: 3.88 kA	Iavg:_____A	Ipk:_____kA	_____
AI:_____ x 10^6 A^2 s	Chg: 10.0 C	Chg:_____C	AI:_____ x 10^6 A^2 s	_____
Scale_____kA/Div	Iavg: 2.00 kA	Time:_____ms	Scale_____ kA/Div	_____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1" CSST, GASTITE, NON-CONDUCTIVE JACKET

TDS3032B SNB015906 192.168.1.53 28 Mar 2013 14:42:22

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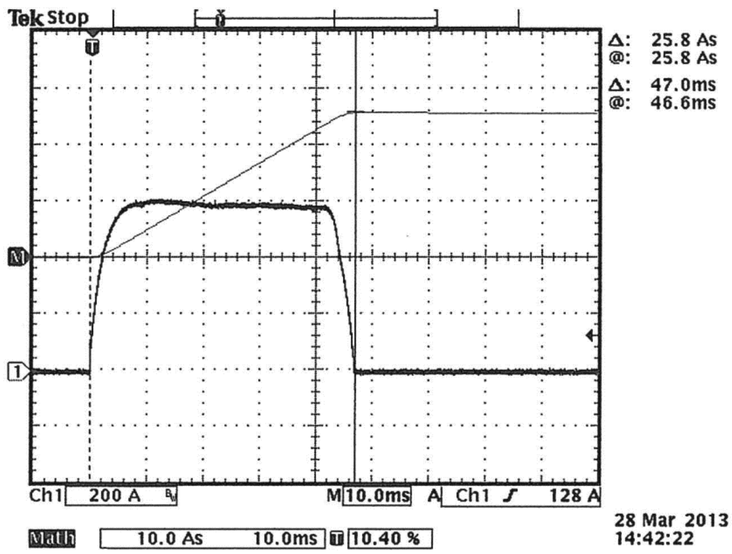

Test No. 6

☐ Comp A, Ah, A/5	☐ Comp B	☑ Comp C/C*	☐ Comp D	☐ Other
Ipk:____kA	Ipk:____kA	Iavg: 549 A	Ipk:____kA	____
AI:____x 10^6 A^2 s	Chg:____C	Chg: 25.8 C	AI:____ x 10^6 A^2 s	____
Scale____kA/Div	Iavg:____kA	Time: 47.0 ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1" CSST, GAS-TITE, NON-CONDUCTIVE JACKET

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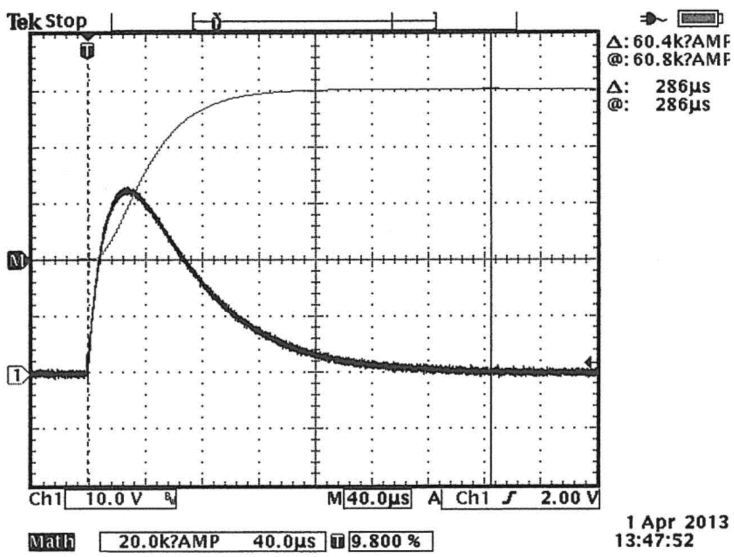

Test No. 7

☑ Comp A, Ah, A/5 | ☐ Comp B | ☐ Comp C/C* | ☐ Comp D | ☐ Other

Comp A, Ah, A/5	Comp B	Comp C/C*	Comp D	Other
Ipk: 32.8 kA	Ipk:____ kA	Iavg:____ A	Ipk:____ kA	____
AI: 0.0604 x 10^6 A^2 s	Chg:____ C	Chg:____ C	AI:____ x 10^6 A^2 s	____
Scale 10 kA/Div	Iavg:____ kA	Time:____ ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1/2" CSST GASTITE
CONDUCTIVE JACKET

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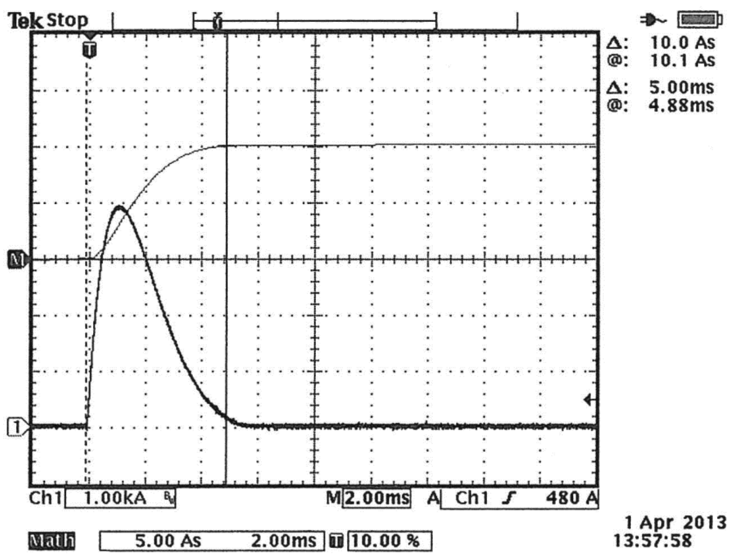

Test No. 7

☐ Comp A, Ah, A/5
Ipk:__________kA
AI:__________x 10^6 A^2 s
Scale________kA/Div

☑ Comp B
Ipk: 3.90 kA
Chg: 10.0 C
Iavg: 2.00 kA
Scale 1 kA/Div

☐ Comp C/C*
Iavg:________A
Chg:________C
Time:________ms
Scale 200 A/Div

☐ Comp D
Ipk:________kA
AI:______ x 10^6 A^2 s
Scale____ kA/Div

☐ Other

REMARKS: 1/2" CSST GASTITE, COND. JACKET

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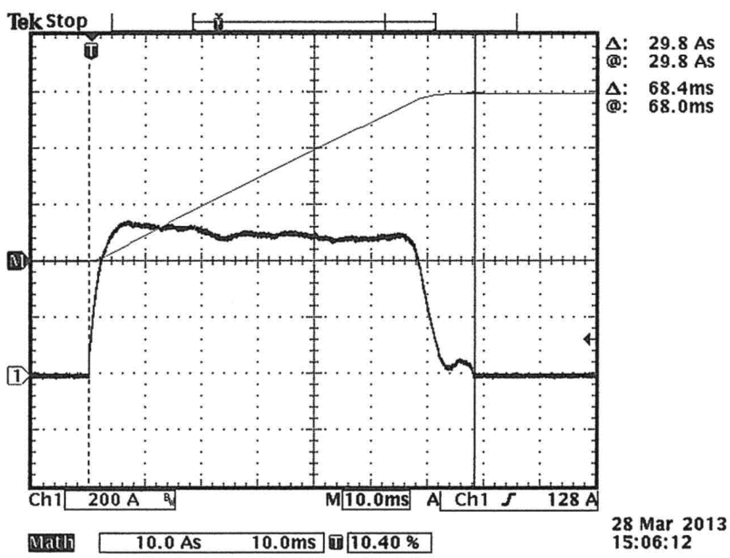

Test No. 7

☐ Comp A, Ah, A/5
Ipk:________kA
AI:________x 10^6 A^2 s
Scale________kA/Div

☐ Comp B
Ipk:________kA
Chg:________C
Iavg:________kA
Scale 1 kA/Div

☑ Comp C/C*
Iavg: 436 A
Chg: 29.8 C
Time: 68.4 ms
Scale 200 A/Div

☐ Comp D
Ipk:________kA
AI:________x 10^6 A^2 s
Scale____ kA/Div

☐ Other

REMARKS: 1/2" CSST, GASTITE CONDUCTIVE JACKET

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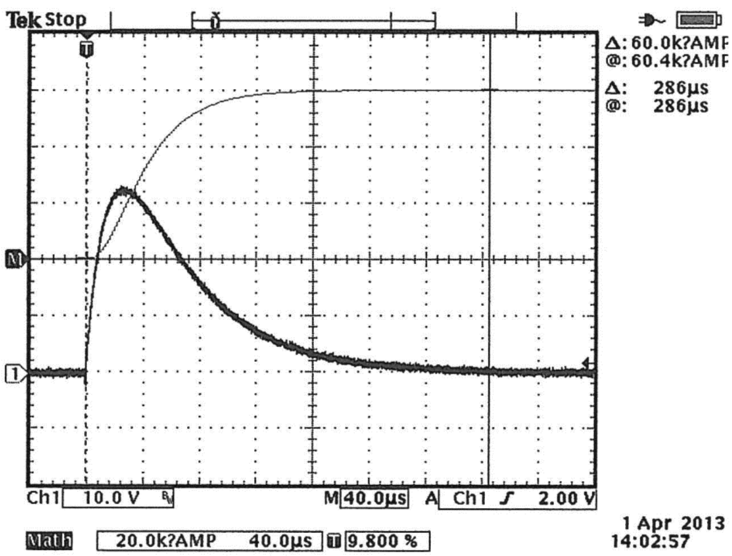

Test No. 8

☑ Comp A, Ah, A/5 ☐ Comp B ☐ Comp C/C* ☐ Comp D ☐ Other

Ipk: 32.8 kA	Ipk:____ kA	Iavg:____ A	Ipk:____ kA	____
AI: 0.060 x 10^6 A^2 s	Chg:____ C	Chg:____ C	AI:____ x 10^6 A^2 s	____
Scale 10 kA/Div	Iavg:____ kA	Time:____ ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1" CSST, GASTITE NON-CONDUCTIVE JACKET, PRE-PUNCTURED

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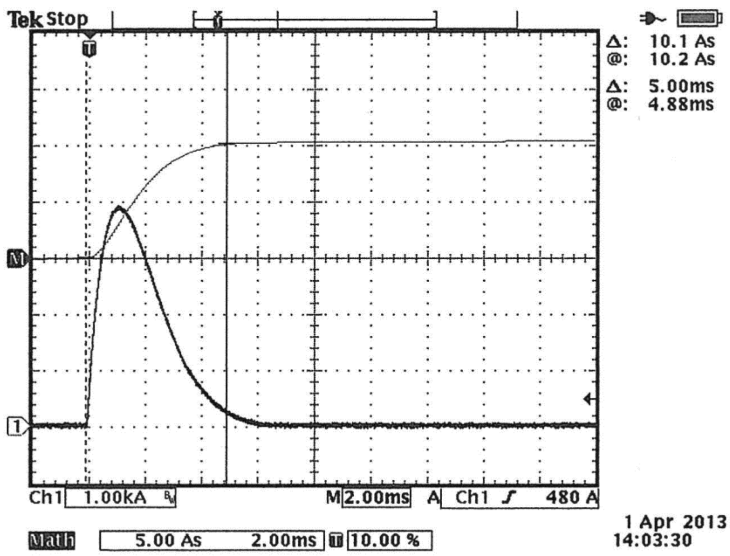

Test No. 8

☐ Comp A, Ah, A/5	☑ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: ______ kA	Ipk: 3.88 kA	Iavg: ______ A	Ipk: ______ kA	______
AI: ______ x 10^6 A^2 s	Chg: 10.1 C	Chg: ______ C	AI: ______ x 10^6 A^2 s	______
Scale ______ kA/Div	Iavg: 2.02 kA	Time: ______ ms	Scale ______ kA/Div	______
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1" CSST, GASTITE, NON-CONDUCTIVE JACKET, PRE-PUNCTURED

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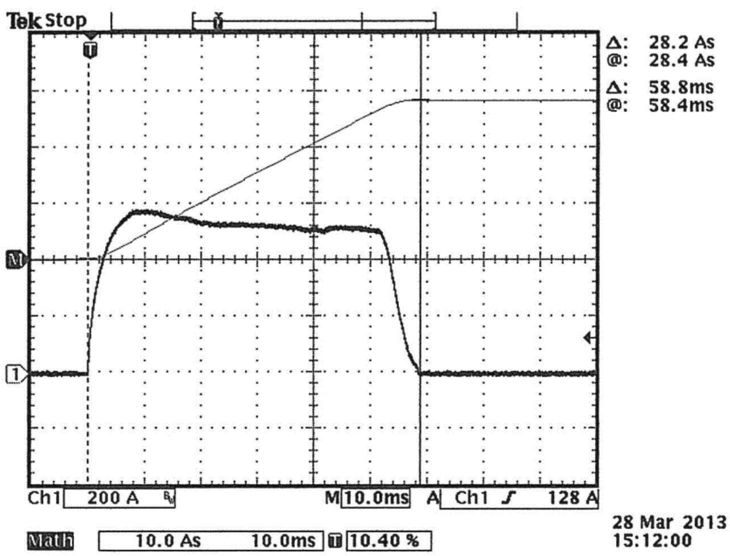

Test No. 8

☐ Comp A, Ah, A/5 — Ipk:______kA — AI:______x 10^6 A^2 s — Scale______kA/Div

☐ Comp B — Ipk:______kA — Chg:______C — Iavg:______kA — Scale 1 kA/Div

☑ Comp C/C* — Iavg: 479.6 A — Chg: 28.2 C — Time: 58.8 ms — Scale 200 A/Div

☐ Comp D — Ipk:______kA — AI:______ x 10^6 A^2 s — Scale____ kA/Div

☐ Other

REMARKS: 1" CSST GASTITE NON-CONDUCTIVE JACKET, PRE-PUNCTURED

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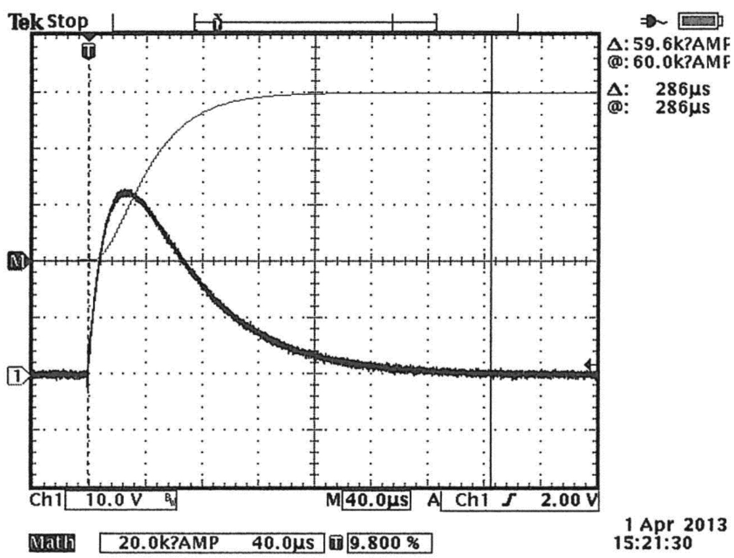

Test No. 9

☑ Comp A, Ah, A/5	☐ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: 32.4 kA	Ipk: ___ kA	Iavg: ___ A	Ipk: ___ kA	___
AI: 0.0596 x 10^6 A^2 s	Chg: ___ C	Chg: ___ C	AI: ___ x 10^6 A^2 s	___
Scale 10 kA/Div	Iavg: ___ kA	Time: ___ ms	Scale ___ kA/Div	___
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1/2" CSST GASTITE, W/ LP
PRESSURIZED

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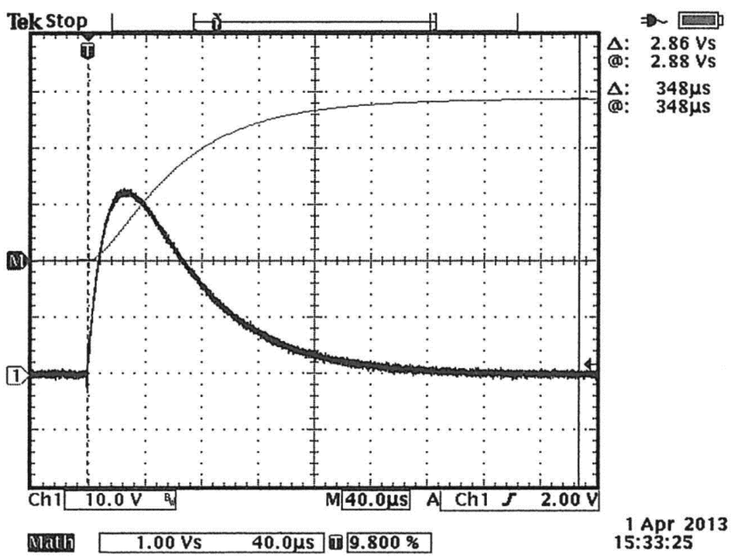

Test No. 9

☑ Comp A, Ah, A/5	☐ Comp B	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk: 32.4 kA	Ipk: ____ kA	Iavg: ____ A	Ipk: ____ kA	____
AI: 0.0596 x 10^6 A^2 s	Chg: ____ C	Chg: ____ C	AI: ____ x 10^6 A^2 s	____
Scale 10 kA/Div	Iavg: ____ kA	Time: ____ ms	Scale ____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS: 1/2" CSST GASTITE, NON-CONDUCTIVE JACKET, w/ LP, PRESSURIZED

2.86 C = Qt CHARGE, TOTAL

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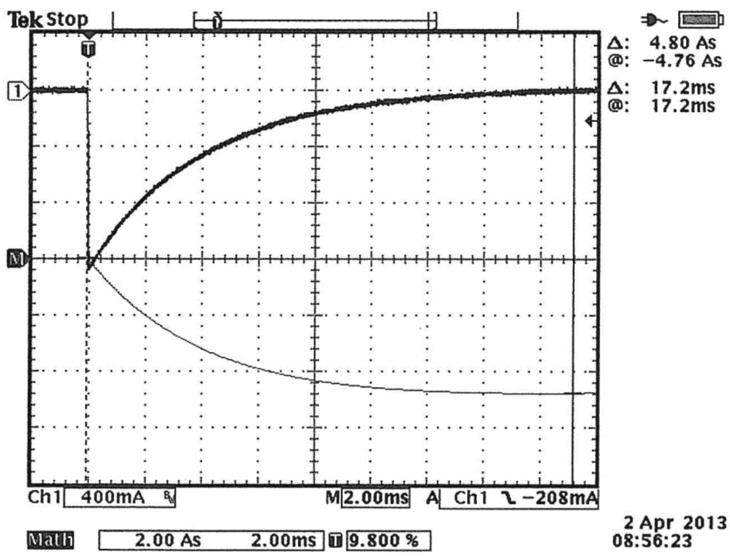

Test No. 9-B

☐ Comp A, Ah, A/5	☒ ~~Comp B~~	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:____ kA	Ipk: 1.25 kA	Iavg:____ A	Ipk:____ kA	____
AI:____ x $10^6 A^2 s$	Chg: 4.8 C	Chg:____ C	AI:____ x $10^6 A^2 s$	____
Scale____ kA/Div	Iavg:____ kA	Time:____ ms	Scale____ kA/Div	____
	Scale 1 kA/Div	Scale 200 A/Div		

REMARKS:
CAL

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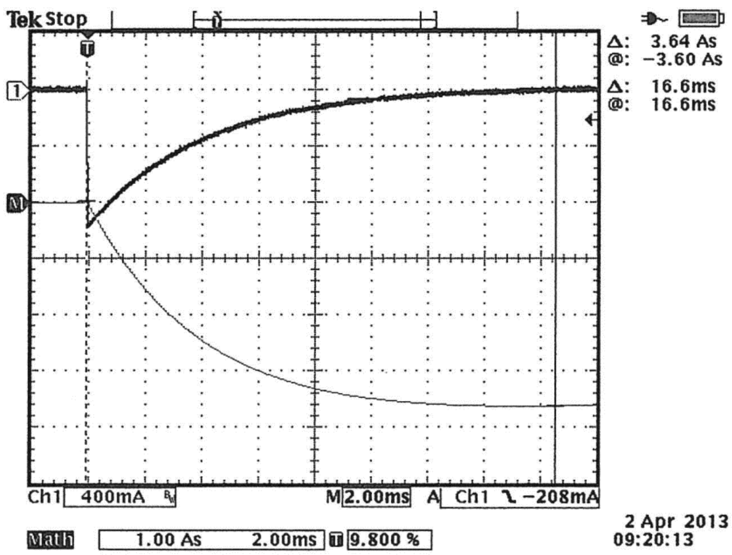

Test No. 10

☐ Comp A, Ah, A/5 ☒ ~~Comp B~~ ☐ Comp C/C* ☐ Comp D ☐ Other

Ipk:_____kA	Ipk: .944 kA	Iavg:_____A	Ipk:_____kA	_____
AI:_____x $10^6 A^2 s$	Chg: 3.6 C	Chg:_____C	AI:_____ x $10^6 A^2 s$	_____
Scale_____kA/Div	Iavg: — kA	Time:_____ms	Scale_____ kA/Div	_____
	Scale ~~1~~ 400 ~~k~~A/Div	Scale 200 A/Div		

REMARKS: Cal

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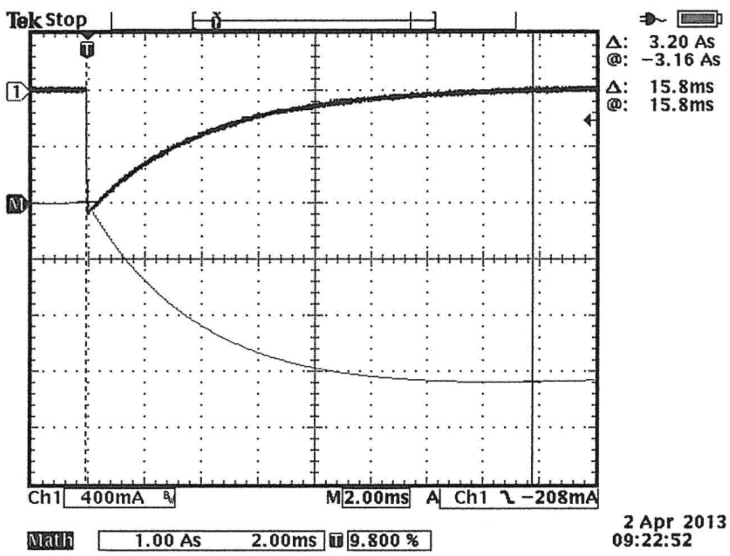

Test No. 11

☐ Comp A, Ah, A/5	☒ ~~Comp B~~	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:____ kA	Ipk: -86 kA	Iavg:____ A	Ipk:____ kA	____
AI:____ x $10^6 A^2 s$	Chg: 3.2 C	Chg:____ C	AI:____ x $10^6 A^2 s$	____
Scale____ kA/Div	Iavg:____ kA	Time:____ ms	Scale____ kA/Div	____
	Scale 400 ~~kA~~ A/Div	Scale 200 A/Div		

REMARKS: ____

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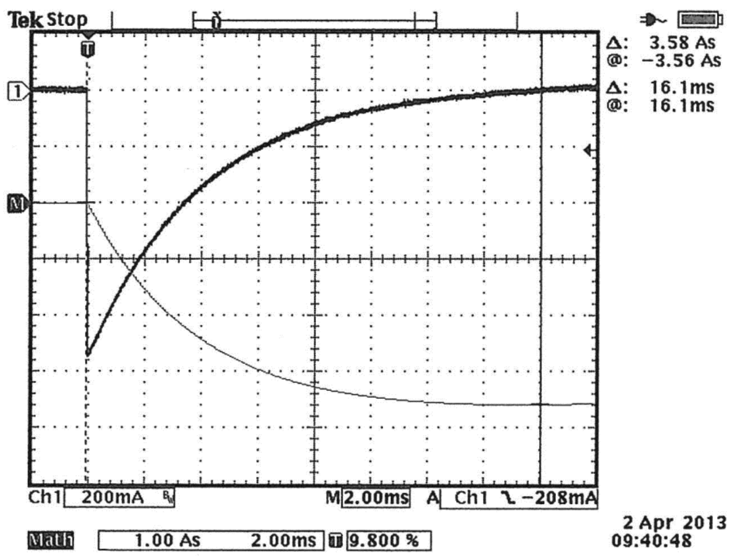

Test No. 12

☐ Comp A, Ah, A/5	☒ ~~Comp B~~	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:_____ kA	Ipk: .94 kA	Iavg:_____ A	Ipk:_____ kA	_____
AI:_____ x 10^6 A^2 s	Chg: 3.5 C	Chg:_____ C	AI:_____ x 10^6 A^2 s	_____
Scale_____ kA/Div	Iavg: — kA	Time:_____ ms	Scale_____ kA/Div	_____
	Scale 200 kA/Div	Scale 200 A/Div		

REMARKS:

Test Sample # 12

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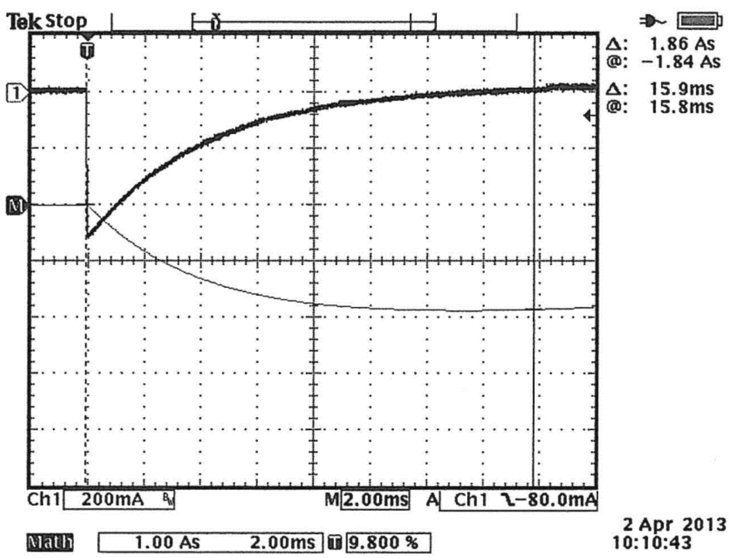

Test No. 13

☐ Comp A, Ah, A/5	☒ ~~Comp B~~	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:____ kA	Ipk: -50 kA	Iavg:____ A	Ipk:____ kA	____
AI:____ x $10^6 A^2 s$	Chg: 1.84 C	Chg:____ C	AI:____ x $10^6 A^2 s$	____
Scale____ kA/Div	Iavg: — kA	Time:____ ms	Scale____ kA/Div	____
	Scale 200 ~~k~~A/Div	Scale 200 A/Div		

REMARKS: ____

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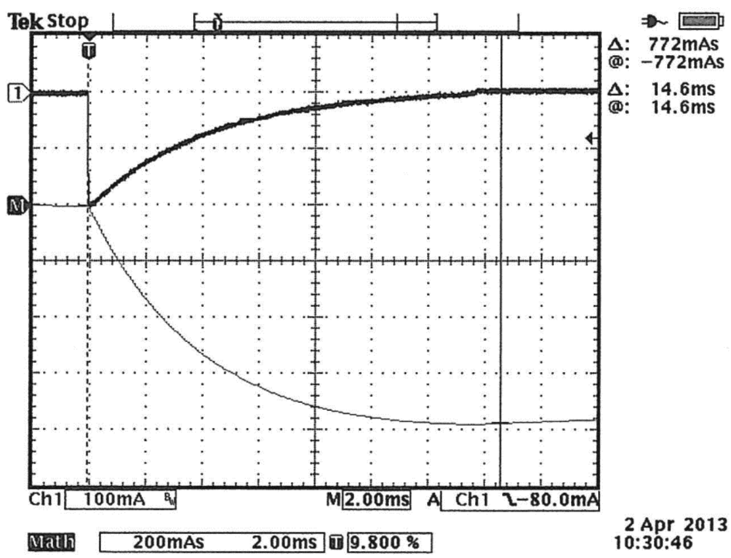

Test No. 14

☐ Comp A, Ah, A/5	☒ ~~Comp B~~	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:_____kA	Ipk: 0.20 kA	Iavg:_____A	Ipk:_____kA	_____
AI:_____x 10^6 A^2 s	Chg: 0.77 C	Chg:_____C	AI:_____ x 10^6 A^2 s	_____
Scale_____kA/Div	Iavg: – kA	Time:_____ms	Scale_____ kA/Div	_____
	Scale 200 kA/Div	Scale 200 A/Div		

REMARKS:

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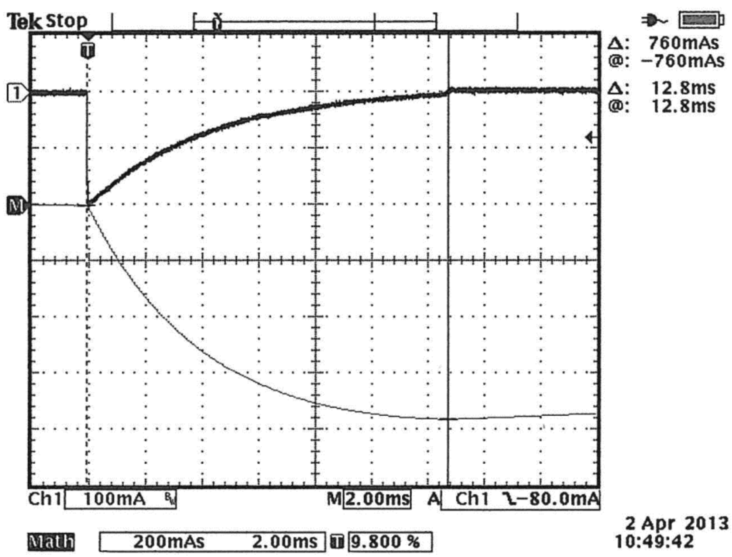

Test No. 15

☐ Comp A, Ah, A/5	☒ ~~Comp B~~	☐ Comp C/C*	☐ Comp D	☐ Other
Ipk:____ kA	Ipk: 0.20 kA	Iavg:____ A	Ipk:____ kA	____
AI:____ x 10^6 A^2 s	Chg: 0.76 C	Chg:____ C	AI:____ x 10^6 A^2 s	____
Scale____ kA/Div	Iavg: — kA	Time:____ ms	Scale____ kA/Div	____
	Scale ~~1~~ 200 ~~k~~A/Div	Scale 200 A/Div		

REMARKS: ____________________

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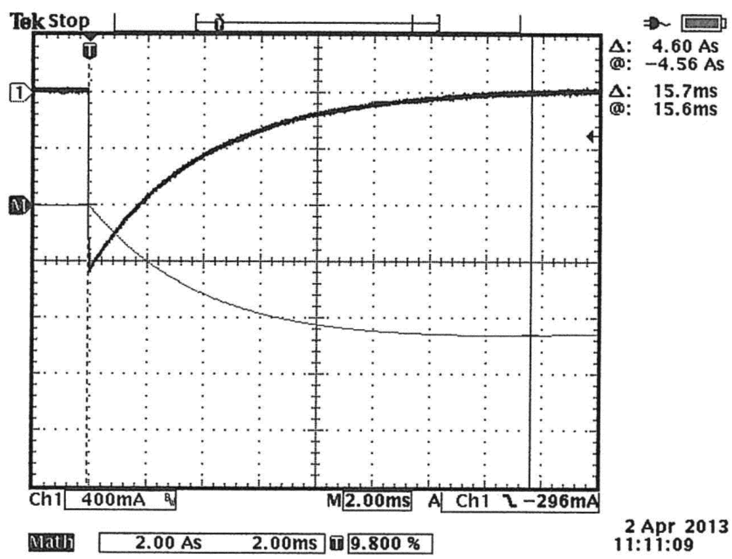

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Test No. 16

☐ Waveform A	☒ ~~Waveform B~~	☐ Waveform C	☐ Waveform D	☐ Other
Vpk:______ kV	Vpk: 1.26 ~~kV~~ kA	Vpk:______ kV	Vpk:______ kV	______
dV/dt:______ kV/µs	4.6 C	Flashover Time:______ µs	Flashover Time:______ µs	______
				______

REMARKS: ____

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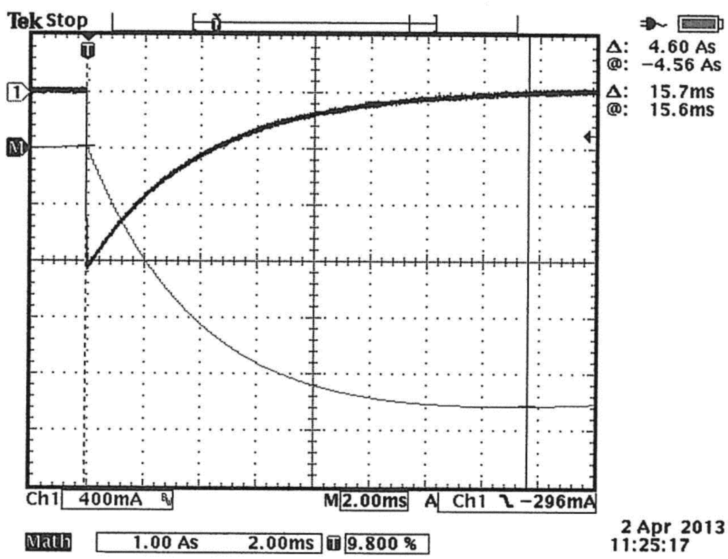

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Test No. 17

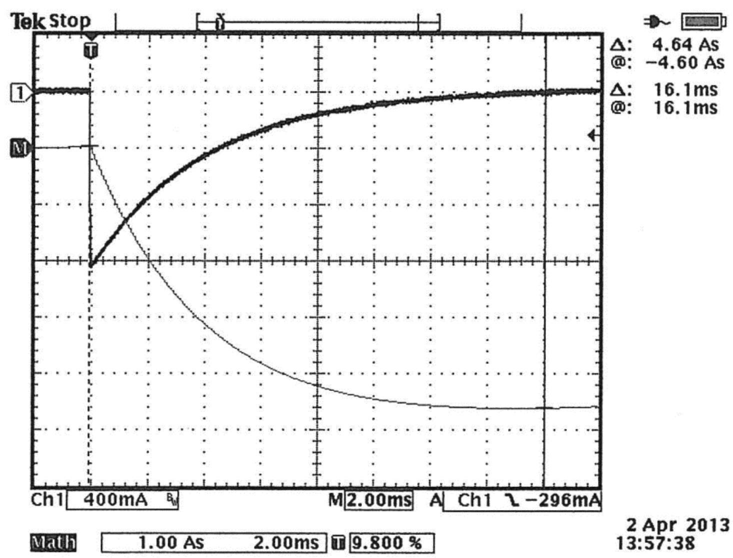
☐ Waveform A ☒ Waveform B ☐ Waveform C ☐ Waveform D ☐ Other

Vpk:_____kV Vpk: 1.22 kA Vpk:_____kV Vpk:_____kV

dV/dt:_____kV/μs C = 4.6 Flashover Time:_____μs Flashover Time:_____μs

REMARKS: Pipe mounted in Aluminum Frame

TDS3032B_B010832 192.168.1.41 2 Apr 2013 13:57:38



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Test No. 18

☐ Waveform A	☒ ~~Waveform B~~	☐ Waveform C	☐ Waveform D	☐ Other
Vpk:______kV	Vpk: 1.22 kA ~~kV~~	Vpk:______kV	Vpk:______kV	______
dV/dt:______kV/µs	C = 4.6	Flashover Time:______µs	Flashover Time:______µs	______

REMARKS: Flowing Propane