3M Electrical Markets Division

Certified Test Report On

3M™ Cold Shrink Cold Shrink Splice QS-III, Series 5488A for 69kV

This report details the evaluation of 3M™ Cold Shrink Splice QS-III, 5488A for 69 kV specimens to IEEE Standard 404-2006. These specimens met or exceeded the design test requirements as specified in IEEE Standard 404-2006.

I hereby certify that this Test Report is a true and correct record of tests conducted under my direction

Jaylon Loyd
3M EMD High Voltage Laboratory

Notary Public:
Sworn and subscribed before me this: 1st, day of Aug, 2008

Olga Hernandez, Travis County, Austin TX

OLGA C. HERNANDEZ
MY COMMISSION EXPIRES
November 1, 2011

Approved By:

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Technical Director

Test Report: **CRQSIII-5488A**

Testing Period For This Report: August 31, 2007 thru December 4, 2007

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3M Electrical Markets Division

Test Report CRQSIII-5488A

Purpose

The purpose of the testing covered by this report was to evaluate the performance of the 3M™ Cold Shrink Splice QS-III, Series 5488A for 69 kV to IEEE Standard 404-2006.

IEEE Std. 404-2006: *"IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 to 500,000 V"*

Test Specimens

Each test specimen consisted of approximately 24 feet of polymeric cable containing two splice joints and standard terminations on each end. The splice joints each consisted of a 3M™ Cold Shrink Splice QS-III, Series 5488A for 69 kV. The polymeric cable has a nominal voltage class of 69kV, a 500 MCM aluminum conductor, 0.650 inches of XLPE insulation, a welded corrugated sheath shield configuration, and a PVC jacket. 3M EMD High Voltage Laboratory test number 92615 was assigned to the specimen that was tested in air. 3M EMD High Voltage Laboratory test number 92652 was assigned to the specimen that was tested in water.

Tests

Electrical tests on all specimens were executed in accordance with **IEEE Std. 404-2006**: "*IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 to 500,000 V*" Tests were run as outlined in paragraphs 7.6.1, 7.7.1, 7.7.2, 7.7.3, 7.9.2, and 7.10.

Test Deviations

Section 7.6.1	3M chooses to report actual Partial Discharge Inception Level, Discharge Magnitude at Inception and Discharge Extinction Level at < 3 pC obtained instead of pass or fail at a specified level as required by IEEE Std 404-2006. 3M also uses a more stringent 3 pC sensitivity level rather than the less sensitive 5 pC level called out in IEEE Std 404-2006.
Additional test	3M also reports Partial Discharge Results after completing the 30 day current cycle.

Test Conclusion

The 3M™ Cold Shrink Splice QS-III, Series 5488A for 69 kV specimens tested met or exceeded the design test requirements as specified in IEEE Standard 404-2006.

Design Test Results for Specimen 92615

Tests In Chronological Order:	**Value:**	**Result:**
Partial Discharge Measurement		
***According to IEEE Std. 404-2006, 7.6.1*:**		
Calibration [Hipotronics] (pC)	2.0	
Partial Discharge at 72.0 kV-RMS (pC)	< 3	
Partial Discharge at 60.0 kV-RMS (pC)	< 3	
Partial Discharge Inception Voltage (kV-RMS)	85.9	
Discharge Magnitude at Inception (pC)	6.36	
Partial Discharge Extinction Voltage < 3pC (kV-RMS)	80.2	Pass
AC Withstand Voltage		
***According to IEEE Std. 404-2006, 7.7.1*:**		
Fifteen Minute Withstand (kV-RMS)	120	Pass
DC Withstand Voltage		
***According to IEEE Std. 404-2006, 7.7.2*:**		
Fifteen Minute Withstand (kV)	240	Pass
Impulse Withstand Voltage at 25℃		
***According to IEEE Std. 404-2006, 7.7.3*:**		
25°C BIL – 10 surges at each polarity (kV-Crest)	349.6	Pass
Wave Shape - µsec (Front / Tail)	1.22 / 47.01	
Impulse Withstand Voltage (130℃ conductor)		
***According to IEEE Std. 404-2006, 7.7.3*:**		
130°C BIL – 10 surges at each polarity (kV-Crest)	350.4	Pass
Wave Shape - µsec (Front / Tail)	1.19 / 47.04	
Partial Discharge Measurement		
***According to IEEE Std. 404-2006, 7.6.1*:**		
Calibration [Hipotronics] (pC)	2.0	
Partial Discharge at 72.0 kV-RMS (pC)	< 3	
Partial Discharge at 60.0 kV-RMS (pC)	< 3	
Partial Discharge Inception Voltage (kV-RMS)	Discharge	
Discharge Magnitude at Inception (pC)	Free	
Partial Discharge Extinction Voltage < 3pC (kV-RMS)	at 100kV	Pass
Thirty Day Current Cyclic aging in Air		
According to IEEE 404-2006, 7.9.2:		
Ambient Temperature (°C)	23.8	
Current Applied (Amps)	764	
Current Cycle, (hours on/hours off)	12 / 12	
Continuous Voltage Applied (kV-RMS)	80	
Total Number of Hours @ Voltage	723	
Total Number of Current Cycles	30	Pass

Design Test Results for Specimen 92615 (Continued)

Tests In Chronological Order:	**Value:**	**Result:**
Six Hour AC Withstand Voltage		
***According to IEEE Std. 404-2006, 7.10*:**		
Six Hour Withstand (kV-RMS)	100	Pass
Impulse Withstand Voltage (130℃ conductor)		
***According to IEEE Std. 404-2006, 7.7.3*:**		
130°C BIL – 10 surges at each polarity (kV-Crest)	349.9	Pass
Wave Shape - μsec (Front / Tail)	1.23 / 46.97	
Partial Discharge Measurement		
***According to IEEE Std. 404-2006, 7.6.1*:**		
Calibration [Hipotronics] (pC)	2.0	
Partial Discharge at 72.0 kV-RMS (pC)	< 3	
Partial Discharge at 60.0 kV-RMS (pC)	< 3	
Partial Discharge Inception Voltage (kV-RMS)	Discharge	
Discharge Magnitude at Inception (pC)	Free	
Partial Discharge Extinction Voltage < 3pC (kV-RMS)	at 100kV	Pass

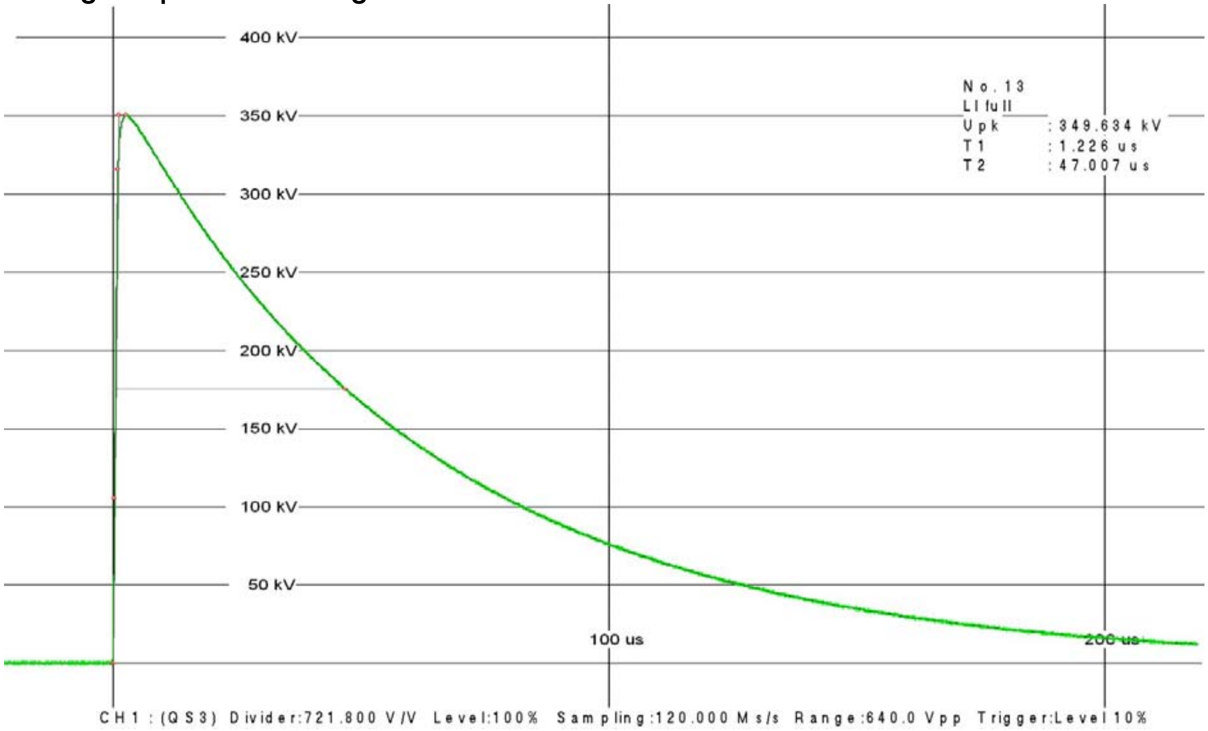
Design Test Results for Specimen 92652

Tests In Chronological Order:	**Value:**	**Result:**
Partial Discharge Measurement		
***According to IEEE Std. 404-2006, 7.6.1*:**		
Calibration [Hipotronics] (pC)	2.0	
Partial Discharge at 72.0 kV-RMS (pC)	< 3	
Partial Discharge at 60.0 kV-RMS (pC)	< 3	
Partial Discharge Inception Voltage (kV-RMS)	88.6	
Discharge Magnitude at Inception (pC)	15.43	
Partial Discharge Extinction Voltage < 3pC (kV-RMS)	76.0	Pass
AC Withstand Voltage		
***According to IEEE Std. 404-2006, 7.7.1*:**		
Fifteen Minute Withstand (kV-RMS)	120	Pass
DC Withstand Voltage		
***According to IEEE Std. 404-2006, 7.7.2*:**		
Fifteen Minute Withstand (kV)	240	Pass
Impulse Withstand Voltage at 25°C		
***According to IEEE Std. 404-2006, 7.7.3*:**		
25°C BIL – 10 surges at each polarity (kV-Crest)	351.1	Pass
Wave Shape - µsec (Front / Tail)	1.28 / 47.09	
Impulse Withstand Voltage (130°C conductor)		
***According to IEEE Std. 404-2006, 7.7.3*:**		
130°C BIL – 10 surges at each polarity (kV-Crest)	350.8	Pass
Wave Shape - µsec (Front / Tail)	1.20 / 46.95	
Partial Discharge Measurement		
***According to IEEE Std. 404-2006, 7.6.1*:**		
Calibration [Hipotronics] (pC)	2.0	
Partial Discharge at 72.0 kV-RMS (pC)	< 3	
Partial Discharge at 60.0 kV-RMS (pC)	< 3	
Partial Discharge Inception Voltage (kV-RMS)	85.2	
Discharge Magnitude at Inception (pC)	31.0	
Partial Discharge Extinction Voltage < 3pC (kV-RMS)	81.5	Pass
Thirty Day Current Cyclic aging in Water		
According to IEEE 404-2006, 7.9.2:		
Ambient Temperature (°C)	23.8	
Current Applied (Amps)	764	
Current Cycle, (hours on/hours off)	12 / 12	
Continuous Voltage Applied (kV-RMS)	80	
Total Number of Hours @ Voltage	723	
Total Number of Current Cycles	30	Pass

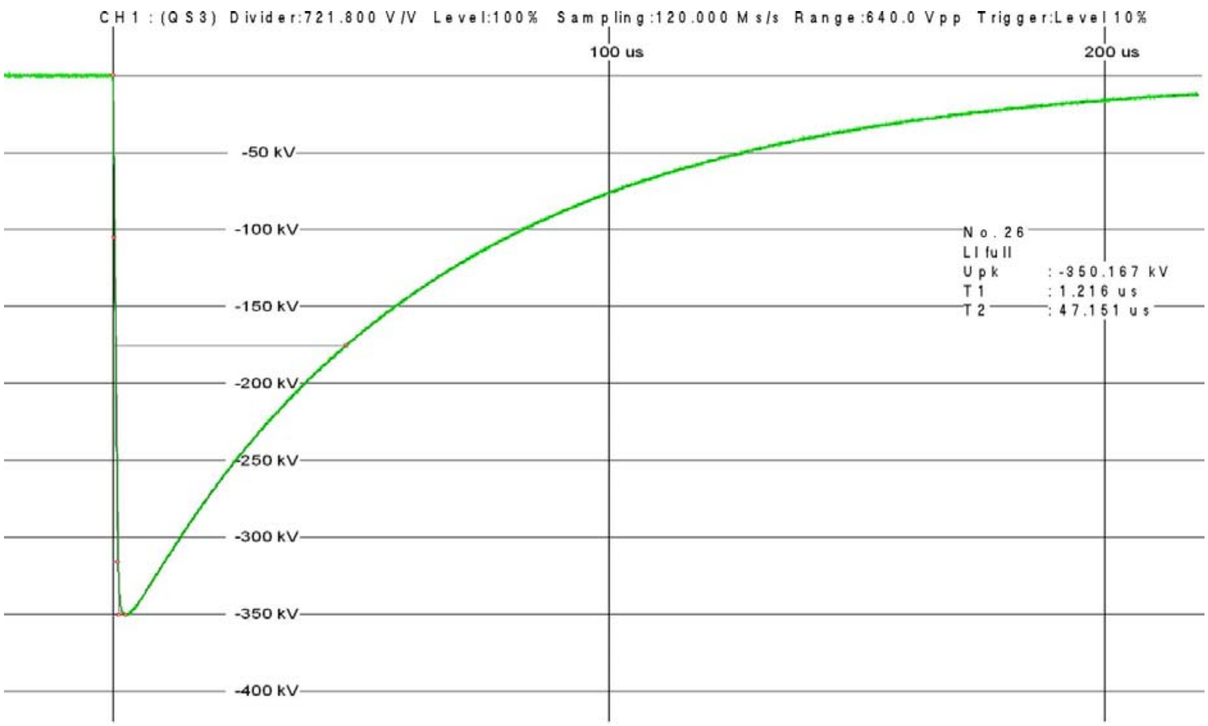
Design Test Results for Specimen 92652 (Continued)

Tests In Chronological Order:	**Value:**	**Result:**
Six Hour AC Withstand Voltage		
***According to IEEE Std. 404-2006, 7.10*:**		
Six Hour Withstand (kV-RMS)	100	Pass
Impulse Withstand Voltage (130°C conductor)		
***According to IEEE Std. 404-2006, 7.7.3*:**		
130°C BIL – 10 surges at each polarity (kV-Crest)	349.3	Pass
Wave Shape - μsec (Front / Tail)	1.23 / 47.00	
Partial Discharge Measurement		
***According to IEEE Std. 404-2006, 7.6.1*:**		
Calibration [Hipotronics] (pC)	2.0	
Partial Discharge at 72.0 kV-RMS (pC)	< 3	
Partial Discharge at 60.0 kV-RMS (pC)	< 3	
Partial Discharge Inception Voltage (kV-RMS)	Discharge	
Discharge Magnitude at Inception (pC)	Free	
Partial Discharge Extinction Voltage < 3pC (kV-RMS)	at 100kV	Pass

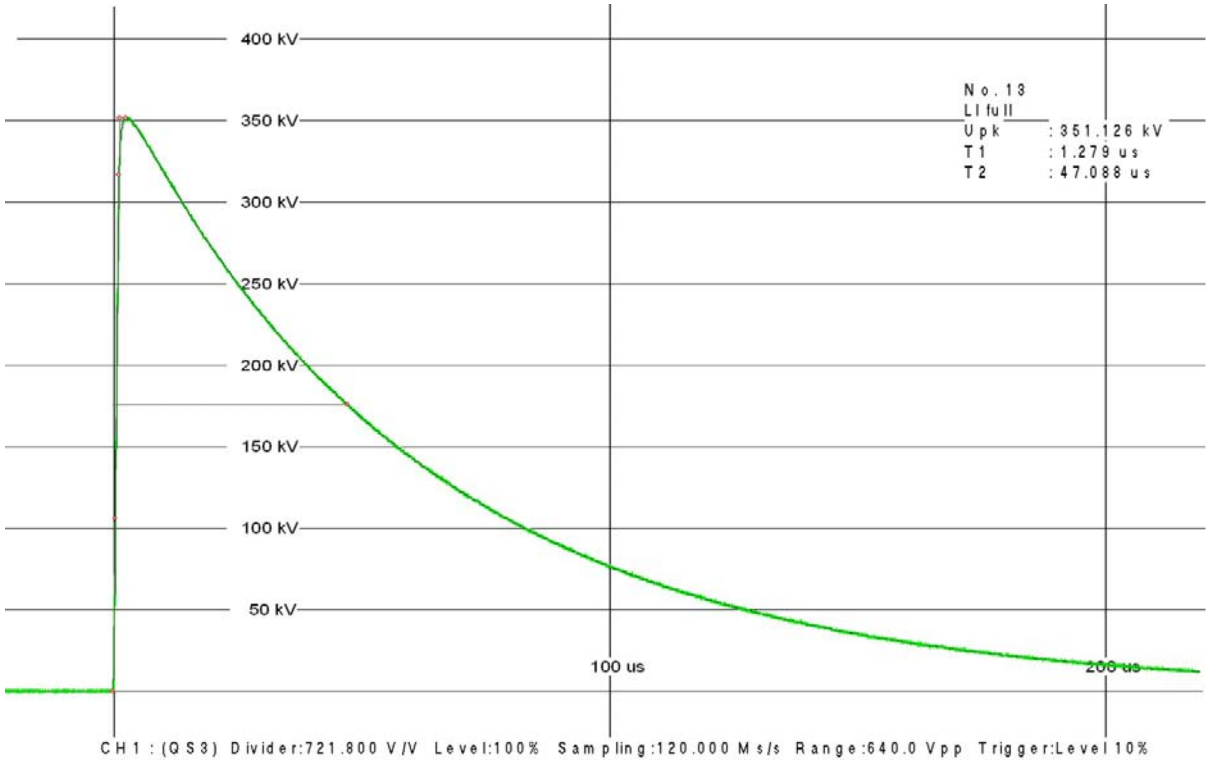
Voltage Impulse Oscillograms 350 kV-Crest:



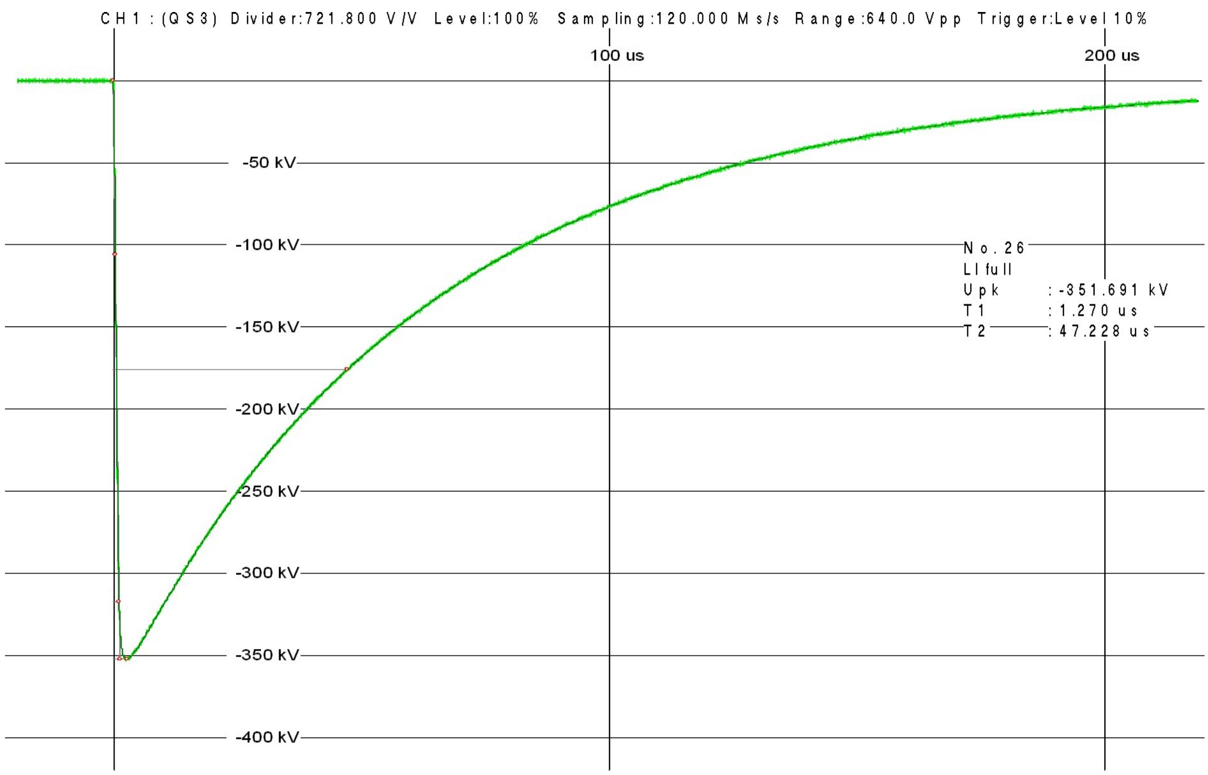
Specimen 92615: Voltage Impulse (Positive BIL) at 25°C



Specimen 92615: Voltage Impulse (Negative BIL) at

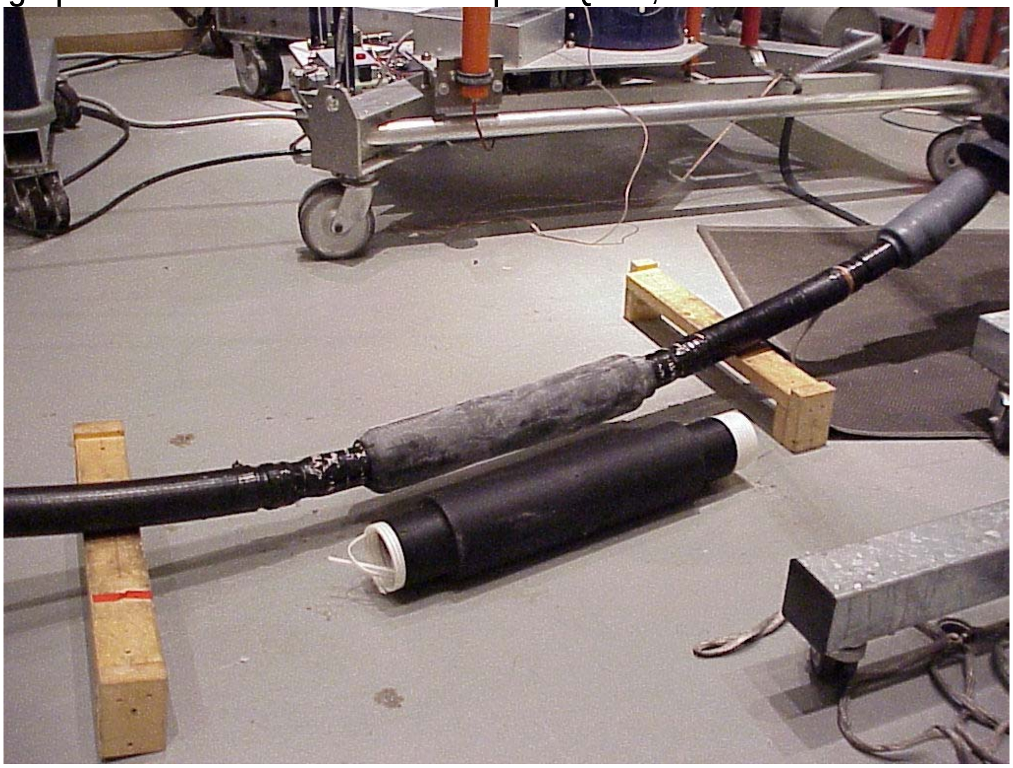


Specimen 92652: Voltage Impulse (Positive BIL) at 25°C

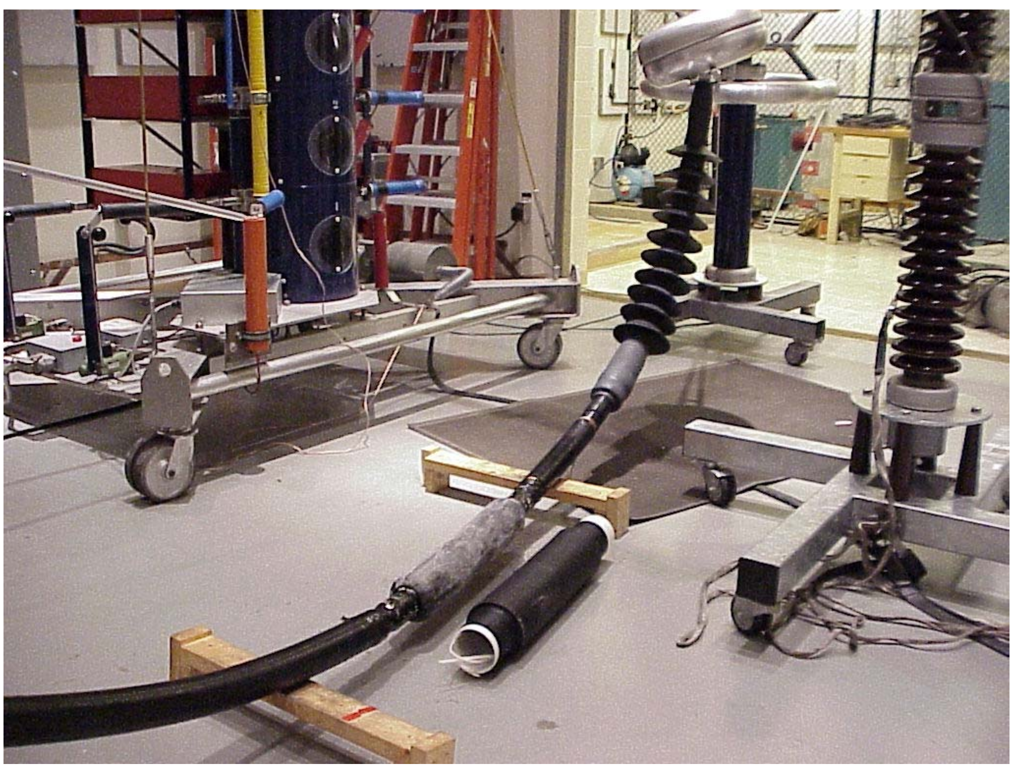


Specimen 92652: Voltage Impulse (Negative BIL) at 25°C

Photographs of the 3M™ Cold Shrink Splice QS-III, Series 5488A



One 3M™ Cold Shrink Splice QS-III, Series 5488A installed on a 500 MCM cable, and one before installation.



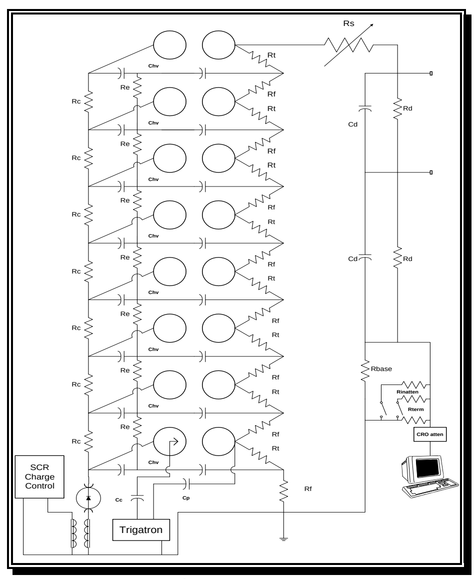
Wide angle view showing cable termination as well.

3M Austin High Voltage Laboratory

Equipment Documentation
Impulse Generator

Manufacturer	Emile Haefely & Co. LTD, Basel-Switzerland
Model	Series "E" Generator
Number Of Stages	8
Maximum Voltage Per Stage	100kV
Maximum Output Voltage	800 kV
Energy At Maximum Voltage	40 kJ
Capacitance Per Stage	100 nF
Impulse Voltage Divider	1.2 MeV
Commission Dates	Divider 1967, Control Desk/Trigatron 1986, Generator 1988
Calibration Cycle	Yearly or after repair or maintenance, whichever comes first.
Measuring System	Haefely Digital Impulse Analyzing System, HIAS 743-2

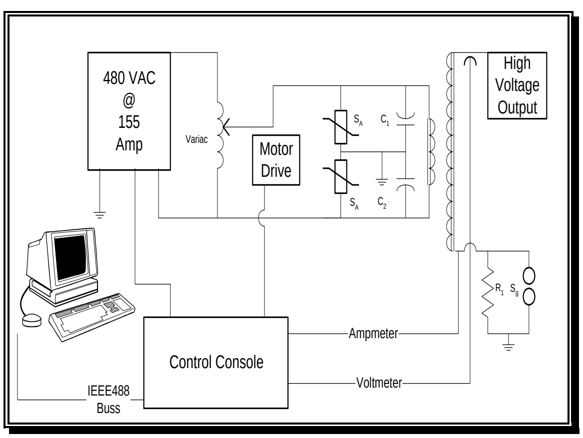

Generator

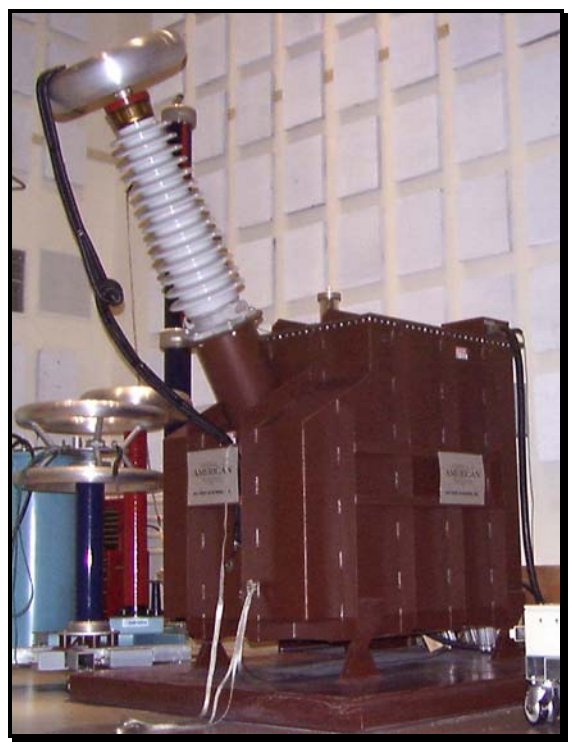


Diagram

AC Dielectric Test Set

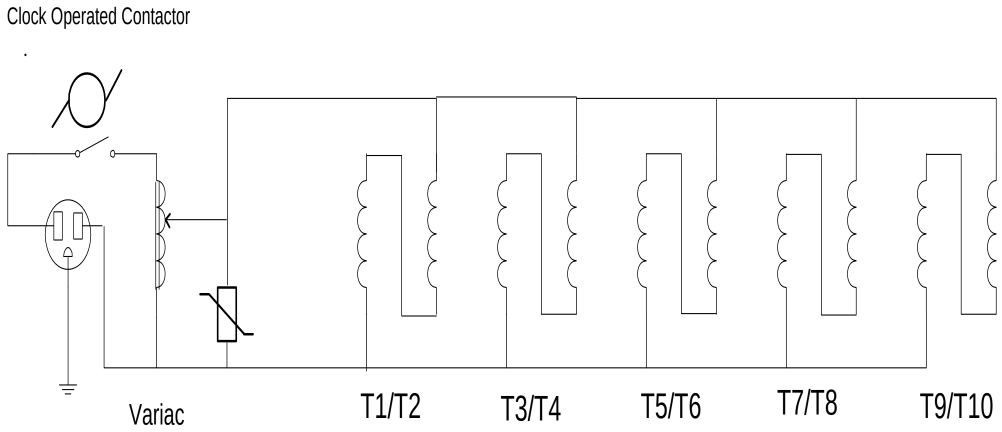
Manufacturer	Phenix Technologies (Formerly American High Voltage Test Systems)
Output Rating	250 kV @ 500 MA, Partial Discharge Free Winding (<2 pC)
High Voltage Metering	Capacitive Tapped High Voltage Bushing
Duty Cycle	1 hour on/1 hour off rating 125 kVA, Continuous Rating 100 kVA
Calibration Cycle	Yearly or after repair or maintenance, whichever comes first
Discharge Level	< 2 pc at 250 kV
Distortion	< 5%
Impedance	< 15% at rated current
Options	4 1/2 Digit Panel Meters, accurate to 2% of full scale Multiple function timer circuit IEEE 488 GPIB for control, meter reading functions, and automated testing Input power RF filtering
Commission Date	August, 1988





Current Source

Power Source: Variable AutoTransformer (Variac).
Current Source: Specimens connected in a loop configuration through 1000:5 Window Type Metering Transformers.
Configuration: Whatever combination of series/parallel window type metering transformers required to produce the desired current.
High Voltage Source: Impulse Generator or AC Test Set, as needed.



T1 Thru T10 = 1000:5
Metering Transformers

A typical test setup consists of five window-type metering transformers connected to a variable transformer. Various series / parallel combinations of window-type metering transformers can be selected depending on the magnitude of the current required for the specimen under test. We have several variable transformer power sources available for testing from 115VAC/5Amp to 480VAC/60Amp. Loop current measurements are taken with a handheld digital ammeter.

Typical Current Source:
There are a number of sets/configurations in the laboratory.

Equipment Utilization List

Test Equipment:	3M Instrument Number:	Calibration Due:
Digital Partial Discharge Detector DDX7000, Hipotronics	139776	6/13/2008
AC Test Set, American High Voltage, 250 kV-RMS	67567	10/12/2008
DC Test Set, Phenix	139826	10/12/2008
Impulse Analyzing System HiAS 743, Hafely	158870	8/3/2008
Impulse Generator, Haefely	132444	8/3/2008
Omega Psychrometer	123497	11/28/2008
Ammeter, AW Sperry	96891	3/29/2008
Scotch Trac ™ Heat Tracer	159200	5/27/2008

Calibrations are done by the 3M Metrology Laboratory, Haefely Test Systems Inc., or Rothe Development. All calibrations are traceable to NIST. The equipment is calibrated yearly, after repair, if suspect, or found to be off during a spot comparison.

Original data and oscillograms are on file in the 3M Electrical Markets Division, High Voltage Laboratory Master File. Some original data maybe in the form of electronic files as some tests are computer driven.

Important Notice

The information we are furnishing you is being provided free of charge and is based on tests performed at 3M laboratory facilities. While we believe that these test results are reliable, their accuracy or completeness is not guaranteed. Your results may vary due to differences in test types and conditions. This information is intended for use by persons with the knowledge and technical skills to analyze, handle and use such information. You must evaluate and determine whether the product is suitable for your intended application. The foregoing information is provided "AS-IS". In providing this information 3M makes no warranties regarding product use or performance, including any implied warranty of merchantability or fitness for a particular use.

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