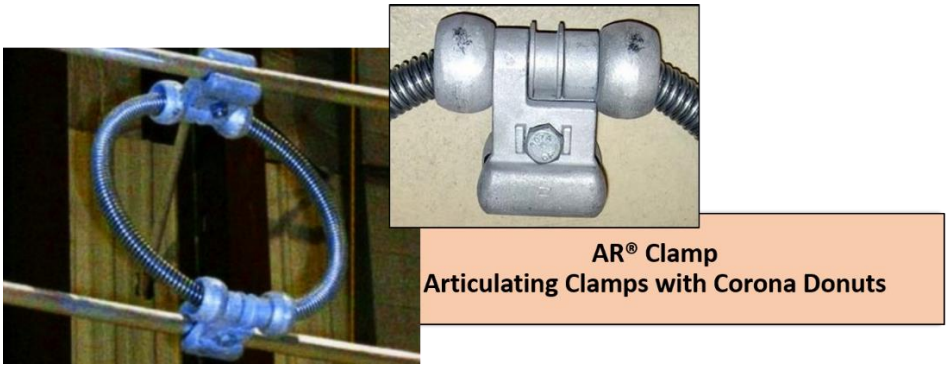
Product Testing

Corona/RFI Testing of the AR®Clamp with Neoprene AR®Spacer Damper

In 2004, the AR Clamp and AR Spacer Damper were tested for RIV measurements and corona photographs. Tests were completed in the independent testing laboratory at NEETRAC, a research center of Georgia Institute of Technology. The series completed a total of 5 tests, including various AR Clamp assemblies and the ring assembly of the AR Spacer Damper product line.

The study evaluated corona performance of the AR Clamp within five different spacer/damper assemblies. RIV measurements and corona photographs were recorded. The RIV measurements unless otherwise specified were recorded using a narrow band 1MHz radio noise meter.



AR® Clamp
Articulating Clamps with Corona Donuts

Subject
One of the test assemblies included insulating neoprene pads installed on one-half of each clamp. Two clamps attach to a conductor. The subject damper of this series of test is the AR Spacer Damper. The AR spacer damper assemblies include two articulating AR Clamps on a powder coat, steel ring spacer.

Purpose
To determine if the test samples will develop corona photographs and radio interference voltage.

Testing
NEETRAC performed corona and RIV testing on five assemblies all in vertical double suspensions. For each of these test assemblies, the RIV level was recorded per the NEMA 107 method from approximately 1.2 times the corona extinction voltage until the RIV level was <50µV.

Equipment
Biddle 700 kV Series Resonant Set CQ2102
Singer-Stoddart NM-21 FFT Radio Noise Meter CQ2124
Princo Barometer CQ2215
Cole-Parmer Psychrodyne CN2157
Stoddart Electro Systems NM-25T Radio Interference and Field Intensity Meter

References and Standards

NEMA 107-1987(R1993)	*Methods of Measurement of Radio Influence Voltage (RIV) of High Voltage Apparatus*
IEEE Std 4-1995	*IEEE Standard Techniques for High Voltage Testing*

Conclusions

Each assembly under test was energized and the voltage raised until the assembly was in full corona. The voltage was lowered in steps, and RIV values recorded using the procedure in NEMA 107 until the RIV levels were in the background noise. The RIV level fell below 50µV at a test voltage of 190kV. All test voltages are line to ground values. The equivalent line voltage value is 330kV.

See Attached NEETRAC Report and Test Data for Neoprene Test Sample (Test Assembly #4)

AR Products available with Neoprene

- **WINDAMPER**
- **MOD2 Spacer Damper**
- **AR Lightweight**
- **AR Twister**

Corona/RFI Testing of AR spacer/damper Neoprene

NEETRAC Project Number: 04-125

June, 2004

Requested by: Al Richardson
AR Products, LLC

Principal Investigator: Caryn M. Riley
Caryn M. Riley, Ph.D.

Reviewed by: Frank C. Lambert
Frank C. Lambert, P.E.

Corona/RFI Testing of AR spacer/damper

NEETRAC Project Number 04-125

Test #4 - Neoprene

SECTION 1.0 EXECUTIVE SUMMARY

The corona performance of five different spacer/damper assemblies was evaluated in this project. RIV measurements and corona photographs were recorded for the test assemblies. The RIV measurements unless otherwise specified were recorded using a narrow band 1MHz radio noise meter. A summary of the results is contained in Table 1. For test assemblies 1-4, the RIV levels were below the recommended minimum level of 50 microvolts at an energized voltage of at least 150kV (~260kV phase to phase voltage). Test assembly #5 utilized a spacer/damper with insulating neoprene pads on each clamp. This dielectric layer resulted in increased corona and RIV levels at lower energized voltages. The spacer/damper in this test assembly is only able to achieve less than 50 microvolts of RIV when the energized voltage is below 70kV (120kV phase to phase voltage). The corona photographs and specific RIV measurements for each test assembly are contained in the Results section of this report.

Table 1: ≤ 50μV RIV level voltages for all assemblies when suspended 12' from the ground plane. All voltages are phase-to-ground.

Test Assembly	Spacer/Damper Used	Voltage in kV where RIV Level ≤ 50μV
1	N/A	235
2	Item #5	150
3	Item #7	165
4	Item #4	190
5	Item #1	70

AR Products, LLC had received a complaint that the products in test assembly #2 were generating interference when in installed in the field on a 138kV line. This assembly had two additional tests performed on it: RIV measurements in the 10MHz band and corona/RIV evaluation under vibration conditions. No RIV was detectable in the 10MHZ band above the background levels when the assembly was energized at 80kV (equivalent line to ground voltage of 138kV). No change in the corona or RIV characteristics of this assembly were noted when the assembly was shaken while energized at 80kV as well.

SECTION 2.0 SCOPE

NEETRAC performed corona and RIV testing for AR Products, LLC on five separate test assemblies. The products tested included four versions of a spacer/damper all in vertical double suspensions. A complete listing of the hardware is contained in the following section. For each of these test assemblies, the RIV level was recorded per the NEMA 107 method from approximately 1.2 times the corona extinction voltage until the RIV level was <50 µV. This report includes identification of each product tested including the hardware, corona photographs and RIV measurements when requested by the customer witness.

SECTION 3.0 TEST SAMPLES

AR Products, LLC supplied the hardware listed in Table 2 for evaluation in this project. In total, five different hardware test assemblies were constructed and built. NEETRAC supplied 18' spans of 1.25" outer diameter aluminum tubing and 18" end spacers for use in the testing. Photographs of each piece of hardware tested are shown in Figure 1 - Figure 5.

Table 2: Sample description of tested hardware

Item Number	Description	Used in Test Assembly
4	15" hoop with MOD VI-1.25" clamp with corona donuts, with one steel washer inside donut, with 21" spring, with one spool between each half-clamp fitted on ring so that bolts point in opposite directions. Insulating neoprene pads are installed on one half of each clamp.	4

Figure 3: Item #4 Ring Spacer with insulating neoprene insert on one-half of each clamp.

SECTION 4.0 PROCEDURE

Five different vertical double test assemblies were constructed at the NEETRAC High Voltage Laboratory during the test period. The hardware for each test assembly was assembled as specified by the customer and centered on the 18' span length. The complete assemblies were then positioned 12' from the ground plane. Care was taken to eliminate corona from all sources other than the test samples.

A test voltage was applied using a 60 Hz, 700kV Biddle series resonant test set. In a darkened laboratory, the voltage was raised to a level where substantial corona activity was detected. RIV measurements were taken for the assemblies using the procedure specified by NEMA 107-1987(R1993). The voltage was lowered in steps until the RIV levels were in the background noise. RIV measurements were taken at each step. A Singer Stoddard NM21 FFT Radio Noise Meter was used to measure the RIV level in the 1MHz narrow band. An RIV factor of 0.286 was used to refer the RIV meter reading to the level actually present on the sample. This factor compensates for the attenuation through the voltage divider and power separation filter. The next section includes the RIV datasheets, charts and test assembly photographs. Corona photographs were recorded for four of the five assemblies. The corona photographs were taken with a professional Polaroid camera using instant black and white film with an ASA rating of 3000 and a print size of 3" x 4". The lens aperture setting and exposure time are noted at the bottom of each corona photograph. A light intensifier was used to locate noise sources not visible to the naked eye. The light intensifier was a Javelin Model 222. This model is a second-generation unit with a gain of up to 70,000.

SECTION 5.0 RESULTS

5.1 **Test Assembly #4**

The fourth test assembly consisted of a 15" hoop spacer damper installed approximately 4' away from the corona ring at the end of the assembly. It was installed on the side of the configuration furthest away from the voltage supply. This spacer damper was installed between the two conductors on a diagonal. Before installing on the conductors, an insulating neoprene pad was placed on one half of each clamp. The corona sources from the line guards were covered with putty to remove their effects from the evaluation of the spacer damper unit (see Figure 14.). Corona rings were mounted at the ends of the 18' span to eliminate corona from the aluminum tubing. Figure 15 contains a picture of the test as assembled in the laboratory.

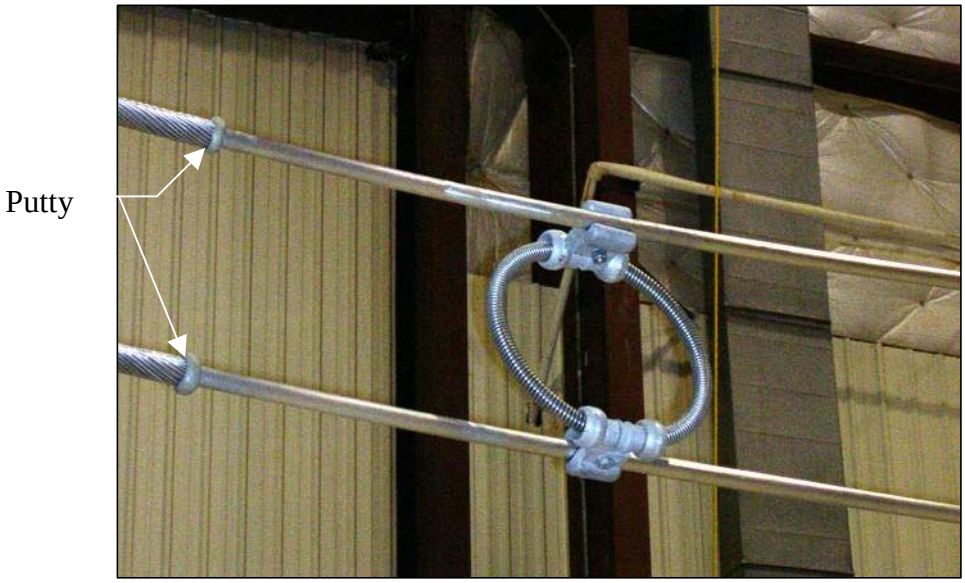


Figure 14: Close up view of Test Assembly #4 in Diagonal Configuration

The corona inception and extinction levels for this assembly were 255kV and 250kV respectively when the unit was 12' from the ground plane. The RIV levels were recorded for the assembly at 12' above the ground plane and are contained in Datasheet 4 and Figure 16. The corona photographs taken are presented in Figure 17.

Figure 15: Test Assembly #4

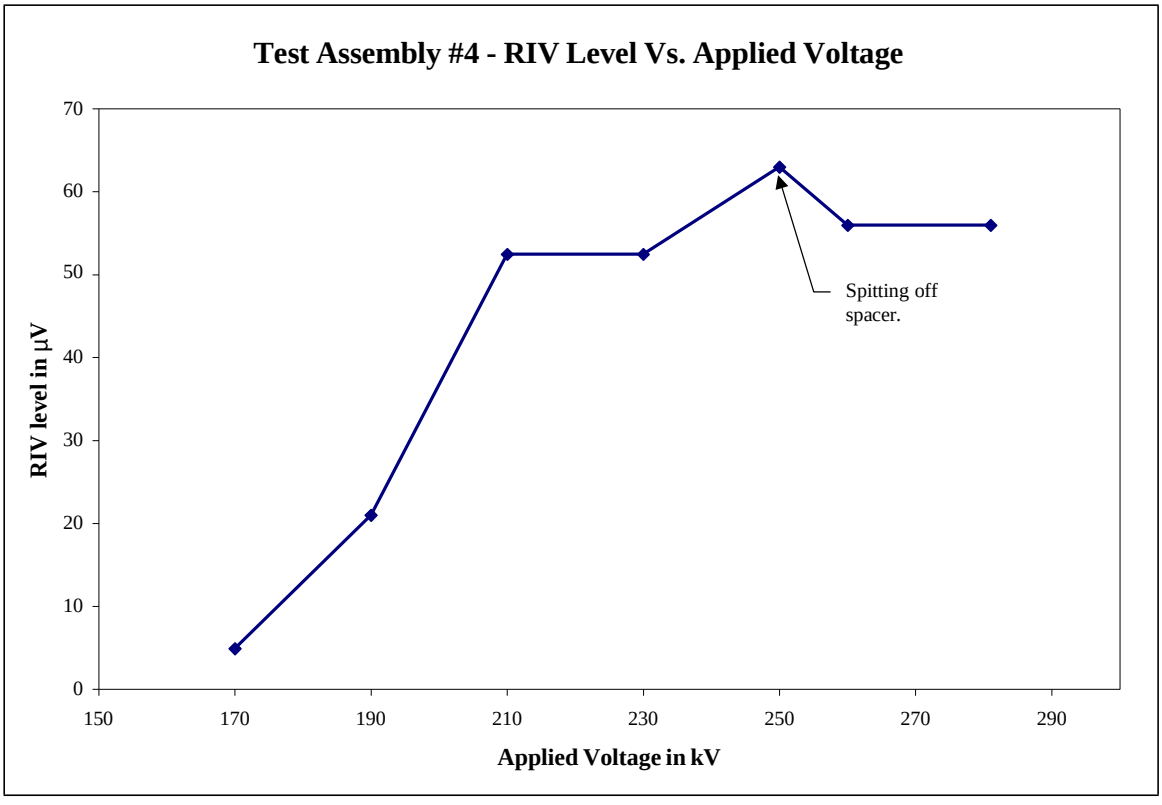


Figure 16: RIV Level Vs. Applied Voltage (Phase to Ground) for Test Assembly #4

NEETRAC Project Number 04-125
AR Products, LLC Hardware RIV Test
Test Assembly #4

Performed By: Caryn M. Riley & David Harwell
Date: 6/10/2004

Equipment Used: CQ2102 - 700kV Series Resonant Test Set RIV Factor: 0.286
CQ2124 - Singer Stoddart NM21FFT Radio Noise Meter

Atmospheric Conditions: 736.4 mmHg 63.5 °F Wet 74 °F Dry
Distance to Ground: 12' from bottom of lowest conductor to ground

Test Voltage (kV) L-N	RIV Meter Reading (uV)	Attenuation (dB)	RIV Level (uV)
281	16	0	56
260	16	0	56
250	18	0	63
230	15	0	52
210	15	0	52
190	60	-20	21
170	14	-20	5
Background	12	-20	4

Configuration Notes: Vertical Double Assembly
Two conductors - 1.25" OD Aluminum tubing
Item (4) - 15" hoop spacer with MOD VI-1-11/16" clamp with corona donuts with one steel washer inside donut, with 21" spring, with one spool between each half-clamp fitted on ring so that bolts point in opposite directions.
Spacer/Damper is inside of bundle across the diagonal.
One side of each clamp has neoprene pad insulator.

Datasheet 4: RIV Levels for Test Assembly #4

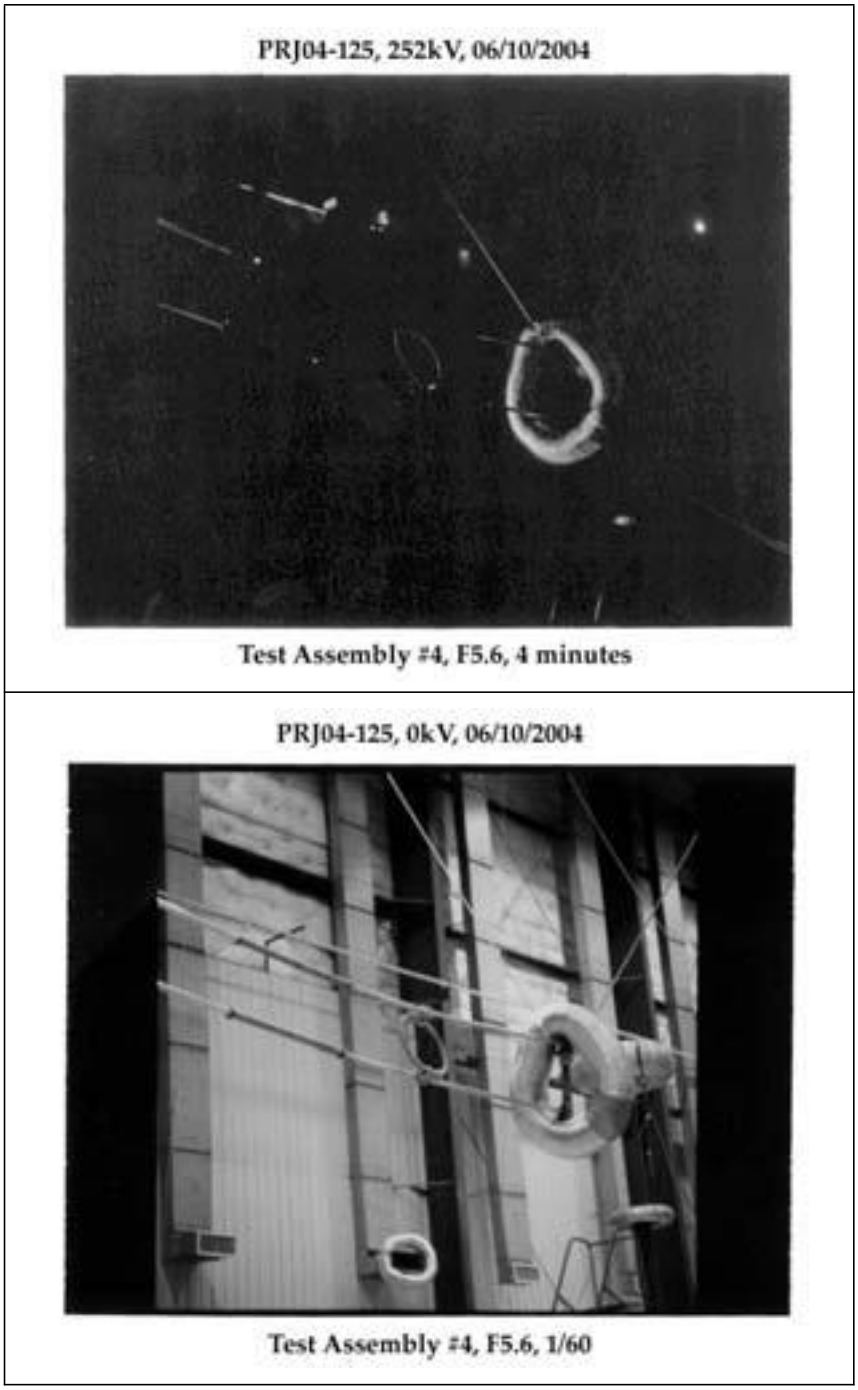


Figure 17: Corona photographs with test assembly #4 in corona. Corona source is at the lower clamp washer area.

SECTION 6.0 CONCLUSIONS

The corona and RIV properties of five hardware configurations including four different spacer/damper designs were observed in this testing. Each assembly under test was energized and the voltage raised until the assembly was in full corona. The voltage was lowered in steps, and RIV values recorded using the procedure in NEMA 107 until the RIV levels were in the background noise. For test assemblies #1-#5, the RIV level fell below 50μV at a test voltage of 235kV, 150kV, 165kV, 190kV and 70kV respectively. All test voltages are line to ground values. Test assembly #5 was a spacer/damper with insulating neoprene pads on either side of the clamps. This material resulted in the higher RIV levels and visible corona at much lower energized voltages than the other four test assemblies.

SECTION 7.0 EQUIPMENT USED

Biddle 700 kV Series Resonant Set CQ2102 Singer-Stoddart

NM-21 FFT Radio Noise Meter CQ2124 Princo Barometer

CQ2215

Cole-Parmer Psychrodyne CN2157

Stoddart Electro Systems NM-25T Radio Interference and Field Intensity Meter

SECTION 8.0 REFERENCES & STANDARDS

NEMA 107-1987(R1993) *Methods of Measurement of Radio Influence Voltage (RIV) of High Voltage Apparatus*

IEEE Std 4-1995 *IEEE Standard Techniques for High Voltage Testing*