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PMG LISTING CRITERIA FOR A PROTECTIVE JACKETED, CORRUGATED STAINLESS STEEL TUBING (A MINIMUM 36 COULOMB CHARGE TRANSFER)

LC1027

Approved February 2011
(Revised July 2016, November 2016)

PREFACE

Plumbing, mechanical and fuel gas (PMG) listings issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the *International Plumbing Code®*, *International Mechanical Code®*, *International Residential Code®*, *Uniform Plumbing Code and Uniform Mechanical Code*. Section 105.2 of the *International Plumbing Code®* reads as follows:

> **Alternative materials, methods and equipment.** The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material or method of construction shall be approved where the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Similar provisions are contained in the Uniform Codes.

ICC-ES may consider alternate listing criteria, provided the listing applicant submits valid data demonstrating that the alternate listing criteria are at least equivalent to the listing criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise demonstrate compliance with the performance features of the codes, ICC-ES retains the right to refuse to issue or renew a listing, if the product, material, or type or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

Listing criteria are developed solely for use by ICC-ES for purposes of issuing ICC-ES PMG listings.

1.0 INTRODUCTION

1.1 Purpose: The purpose of this listing criteria is to establish the effectiveness of an exterior protective jacket system factory-applied to corrugated stainless steel tubing (CSST) which is currently recognized in another ICC-ES PMG listing. The exterior jacket system is intended to protect the inner CSST from leakage due to exposure to arcing (a minimum 36 Coulomb charge transfer) from indirect lightning voltage/currents that may exist inside a building; utilize the appliance bond as the sole bonding method; and to be recognized in an ICC Evaluation Service, LLC (ICC-ES), listing. Two levels of indirect effects are defined. This listing criteria addresses a proposed level of current and energy from lightning and takes into account only indirect effects.

1.2 Scope: This listing criteria defines test methods and performance requirements applicable for evaluating simulated lightning protection of an exterior protective jacket system factory-applied over a CSST which is currently recognized in an ICC-ES PMG listing. The lightning-resistant CSST system, for use in fuel gas piping, is intended for use in normal installations when installed in accordance with the manufacturer's instructions and with Sections 309 and 310 of the *International Fuel Gas Code*© and Sections G2410 and G2411 of the *International Residential Code*©. This listing criteria is for the evaluation of the product from indirect lightning only, and the effect of direct lightning strikes is beyond the scope of the criteria.

1.3 Codes and Referenced Standards:

Note: Any standard referenced herein shall be the current edition of that standard.

1.3.1 2006, 2009, 2012 and/or 2015 *International Residential Code*© (IRC), Chapter 24, Fuel Gas. International Code Council.

1.3.2 2006, 2009, 2012 and/or 2015 *International Fuel Gas Code*© (IFGC). International Code Council.

1.3.3 2006, 2009, 2012 and/or 2015 IAPMO *Uniform Plumbing Code*™* (IAPMO UPC), Chapter 12, Fuel Gas Piping. International Association of Plumbing and Mechanical Officials.

1.3.4 2006, 2009, 2012 and/or 2015 IAPMO *Uniform Mechanical Code*™* (IAPMO UMC), Chapter 13, Fuel Gas Piping. International Association of Plumbing and Mechanical Officials.

1.3.5 ANSI LC 1 / CSA 6.26, Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST). American National Standards Institute.

2.0 BASIC INFORMATION

The following basic information shall be provided:

2.1 Product Description: The product consists of corrugated stainless steel tubing (CSST) for fuel gas piping systems recognized in another current ICC-ES PMG listing as conforming to ANSI LC 1 / CSA 6.26, and satisfying the referenced codes listed in Section 1.3, but with a different covering. The CSST is covered with a protective jacket system.

2.2 Installation Instructions: The product shall be installed in accordance with the manufacturer's instructions and the requirements of the applicable codes and referenced standards listed in Section 1.3.

2.3 Product and Packaging Identification: The unit and the package shall be permanently and legibly marked with the manufacturer's name or trademark, and the model number. The product shall also bear the ICC-ES PMG listing mark. The ICC-ES listing number shall be placed on the listed product's packaging or installation instructions.

3.0 GENERAL REQUIREMENTS

3.1 Corrugated Stainless Steel Tubing: Corrugated stainless tubing shall be currently recognized in an ICC-ES PMG listing as complying with the requirements of ANSI LC 1 / CSA 6.26.

3.2 A Protective Jacket System: The protective jacket may consist of a single or multi-layers as designed by the manufacturer and shall be tested in accordance with Section 4.0 of this criteria.

4.0 TEST METHOD AND PERFORMANCE REQUIREMENTS

4.1 Testing: Testing shall be performed by a lightning testing laboratory accredited by the International Accreditation Service (IAS) or by a signatory to a Mutual Recognition arrangement to which IAS is also a signatory; or by a lightning test laboratory that is otherwise acceptable to the ICC-ES executive director of certification programs.

4.2 Specimen Conditioning: The specimen used for testing shall be previously subjected to a minimum 96-hour corrosion test conducted in accordance with ASTM B 117. The specimen must include the protective jacket on a section of CSST and be joined to a fitting in accordance with the manufacturer's installation instructions. The entire specimen, including the internal and external surface of the fitting shall not have any evidence of pitting, flaking, cracking or signs of corrosive attack.

4.3 Number of Samples: Samples shall be three each of the smallest and largest diameters and one intermediate diameter to be selected by the laboratory.

4.4 Test Waveforms: The waveforms presented represent idealized environments which are to be applied to the CSST for purposes of analysis and testing. The waveforms are intended to be composite waveforms whose effects on the CSST are those expected from natural lightning. In the waveform descriptions that follow, parameters of particular importance to the effects to be considered are included, whereas other parameters are omitted.

4.4.1 Indirect Effects 1 Waveform:

For the indirect effects testing, a 10x1000 µs waveform is utilized as shown in Figure 1. This waveform should have a current amplitude (5.5–7.0 kA) that will result in a transfer charge of a minimum 10 coulombs (integrating to calculate the area under the curve).

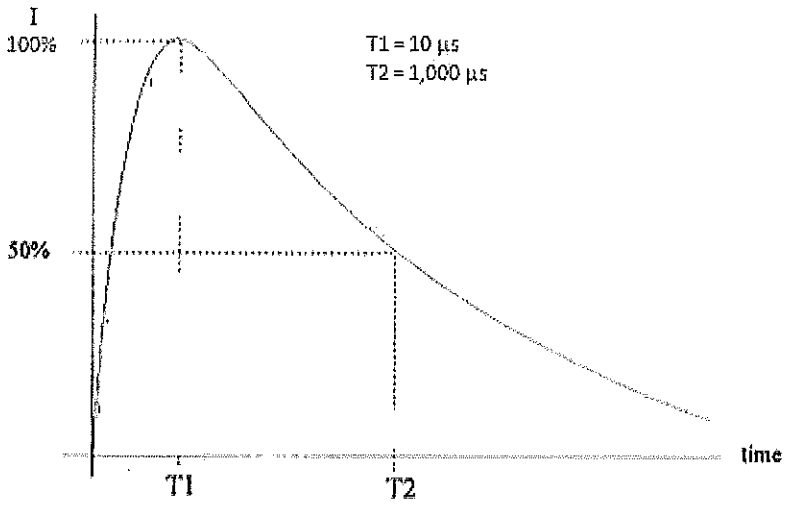

FIGURE 1—10 X 1000 µs WAVEFORM

4.4.2 Indirect Effects 2 Waveforms:

For the purpose of testing under this listing criteria, the indirect effects 2 parameters presented represent the 50 percentile for negative lightning flashes measured at ground. The CSST that resides in a building would have 50 percentile levels below these levels as it does not have a direct attachment to the lightning channel. The current components for evaluating indirect effects 2 are shown in Figure 2, where component:

1) Represents the return stroke.

2) Represents intermediate current.

3) Represents continuing current.

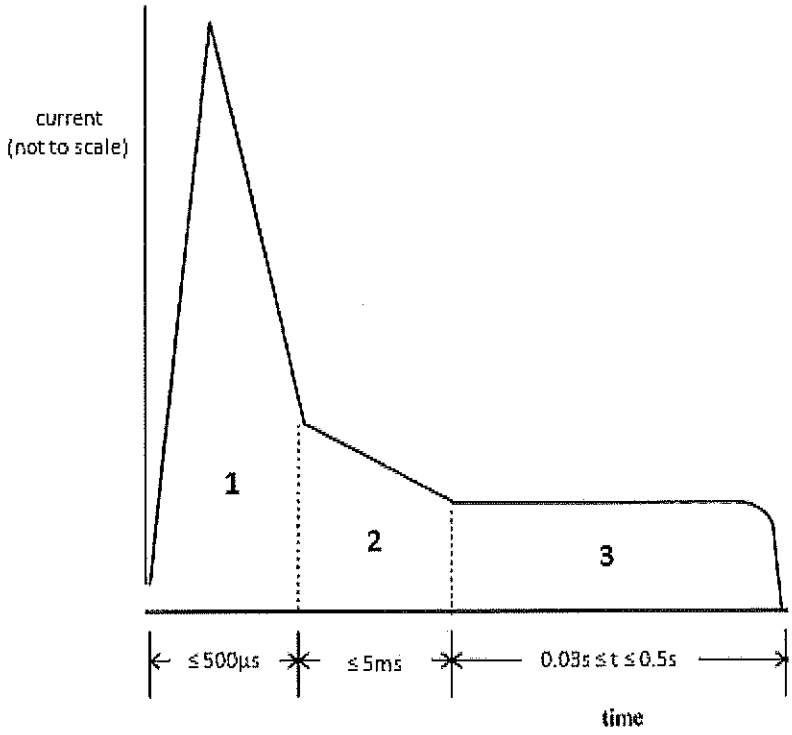

FIGURE 2—CURRENT COMPONENTS FOR INDIRECT EFFECTS 2 TESTING

COMPONENT 1 (Return Stoke)	
Peak Amplitude	30 kA, minimum
Action Integral	0.055×10^6 A^2s, minimum
Time Duration	≤ 500 µs
COMPONENT 2 (Intermediate Current)	
Maximum Charge Transfer	10 coulombs (±10%)
Average Amplitude	2 kA (±20%)
Time Duration	≤ 5 ms
COMPONENT 3 (Continuing Current)	
Amplitude	200–800 A
Charge Transfer	26 coulombs, minimum

Current Component 1 – Return Stroke

Component 1 can be simulated by either oscillatory or unidirectional waveforms as shown in Figure 3 and Figure 4, with a total time duration to 1% peak value less than 500 µs. The current amplitude shall

be a minimum of 30 kA and the rise time shall not exceed 25 µs (time between 10% and 90% of the amplitude). The action integral shall be a minimum of 0.055 x 10^6 A^2s.

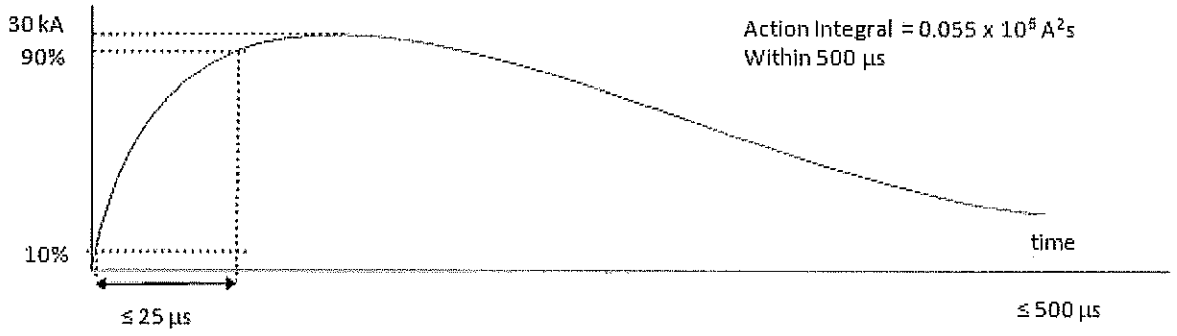

FIGURE 3—UNIPOLAR PULSE

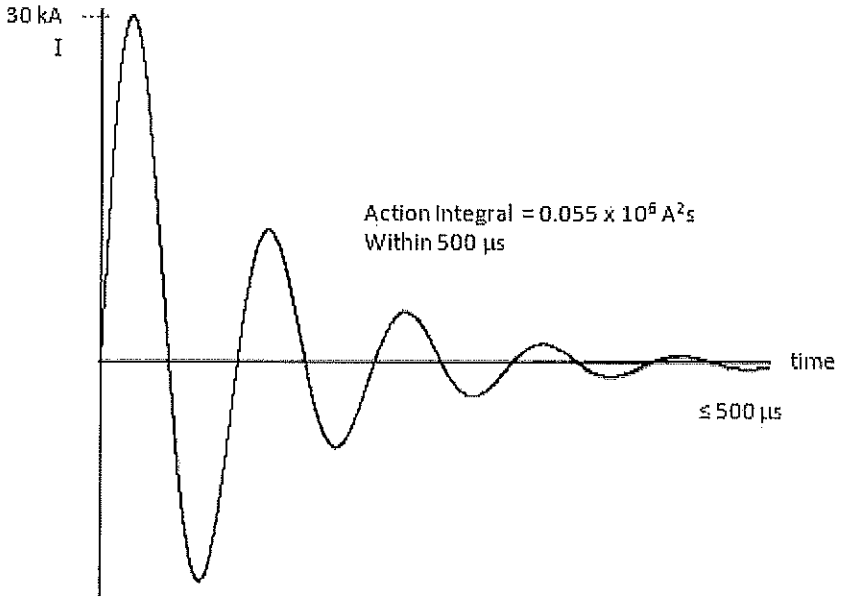

FIGURE 4—DAMPED SINUSOIDAL CURRENT

Current Component 2 – Intermediate Current

This component should be unidirectional as shown in Figure 5. The average current amplitude must be 2 kA (±20%) flowing for a duration of 5 ms (±10%) with a charge transfer of 10 coulombs (±10%).

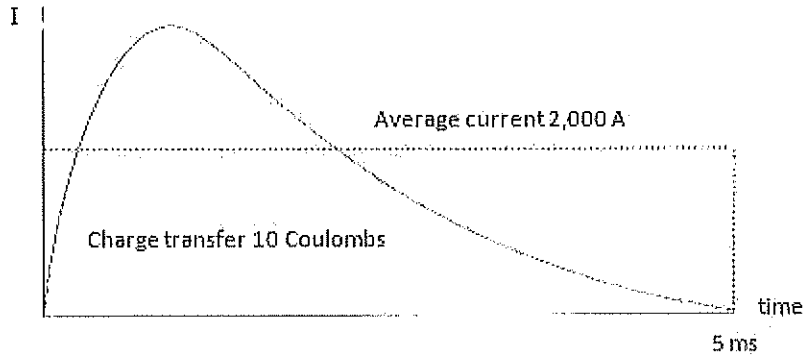

FIGURE 5—CURRENT COMPONENT 2

Current Component 3 – Continuing Current

Component 3 should have a unidirectional waveform as shown in Figure 6 (example). This waveform should have a current amplitude between 200 and 800 A and a corresponding time duration that will result in a transfer charge of a minimum 26 coulombs.

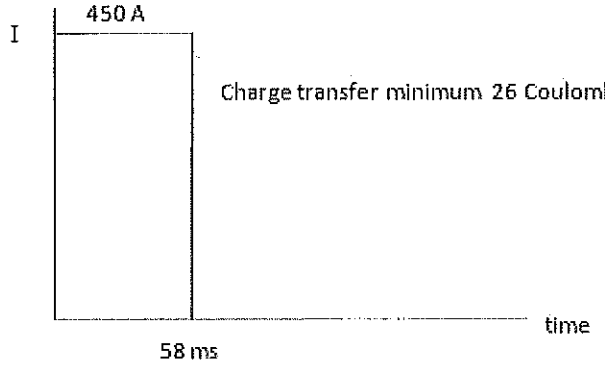

FIGURE 6—CURRENT COMPONENT 3

4.5 Test Procedures: The procedures noted below shall be used to evaluate the performance of CSST piping. Testing shall be conducted on three samples each of the smallest, largest and an intermediate diameter tubing to qualify all sizes. Testing shall be conducted utilizing the waveforms and parameters outlined in Section 4.4. Following exposure to this level of current and energy, the sample shall be pressure-tested to 7.5 psi and the pressure held for five minutes without signs of leakage.

4.5.1 Calibration: A test generator is configured to produce and measure the desired current waveforms. The generator is charged to the appropriate levels. The generator is then discharged

through a copper pipe, and the applied current waveforms are recorded. The waveforms are verified to confirm the test configuration is producing the desired current waveforms. The waveform shapes are captured using an oscilloscope and calculations are made to verify the desired current levels, action integral, rise times, decay times, duration, and charge levels are achieved. This information is recorded along with the oscilloscope graphs. If the high current generator does not yield the desired levels and waveforms, the generator setup is reconfigured, and the calibration procedures are repeated. Once the calibration yields the desired levels and waveforms, the copper pipe is removed from the generator.

4.5.1.1 Indirect Effects 1 Calibration Setup: An appropriately sized copper pipe is installed $^1/_8$ inch underneath the generator's rod electrode (¼ inch diameter) and grounded to the generator return via a braided strap (adequately sized to handle the current). The rod electrode is connected to the generator.

4.5.1.2 Indirect Effects 2 Calibration Setup: An appropriately sized copper pipe is installed vertically $^1/_8$ inch away from the generator's ground plate (electrode – rectangular cross-section $^1/_2$ inch in thickness) and connected to the generator via a braided strap (adequately sized to handle the current). The pipe shall be constrained to a 1-inch movement on both sides and opposite the ground plate as shown in Figure 7. The ground plate (electrode) is grounded to the generator return.

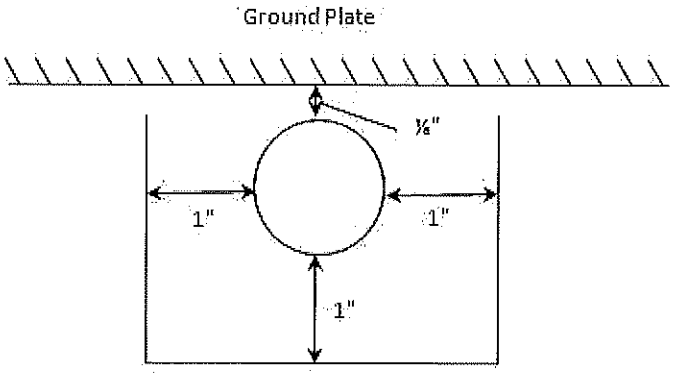

FIGURE 7—TOP VIEW OF COPPER PIPE/TEST ARTICLE AND CONSTRAINT SPACING

4.5.2 Testing:

4.5.2.1 Arcing Resistance, Indirect Effects 1: A minimum 3-foot-long CSST test article is installed at least $^1/_8$ inch beneath a $^1/_4$-inch-diameter test electrode. The test article is to be assembled on one end with the manufacturer's fitting. The electrode shall be placed at least 12 inches from the ends of the test

article. The fitting end of the test article is grounded to the generator return using a braided strap (adequately sized to handle the current) as shown in Figure 8. A dielectric may be required underneath the test article to ensure the test currents flow along the length of the test article and not to the test bench or other support equipment. The lightning generator is charged to the appropriate level, and is then discharged to the test article. If the test generator does not discharge to the test article, it shall be confirmed that sufficient voltage is present to achieve dielectric breakdown of the jacket (attachment to metallic layers or tubing), and adjustments are made accordingly. It is verified that the test current did not arc to the exposed tubing or fitting on either end of the test article. If all or a portion of the test current arced to the exposed ends of the test article, the test is invalid and must be repeated. The applied current waveform is recorded using an oscilloscope; calculations are made to verify the desired current levels, rise times, decay times, and charge levels are equal or greater than the values stated in Section 4.4.1. If the calculated levels are equal to or greater than the values stated in Section 4.4.1, the levels are recorded. The jacket is cut away from the test article at the test location and a visual inspection of the tubing is made to determine if the stainless steel tubing is punctured. If no puncture of the tubing is noted on visual inspection, the test article shall be pressure-tested to the requirements of Section 4.5. If the test article fails visual inspection or pressure testing after being subjected to the required levels, the test article fails. If the calculated levels are less than the values stated in Section 4.4.1, the test is performed again on a new test article from the same production lot, until the required levels and parameters are satisfied. The test article is deemed to have passed if all of the requirements are met. See Figure 8 for test schematic.

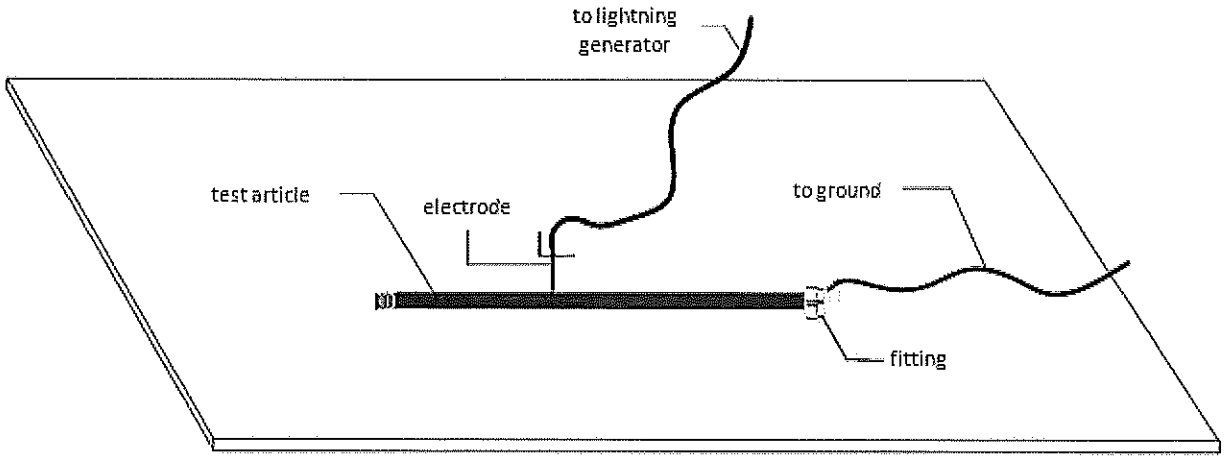

FIGURE 8—INDIRECT EFFECTS TEST SETUP

4.5.2.2 Arcing Resistance, Indirect Effects 2: A minimum 3-foot-long CSST test article is installed at least $^1/_8$ inch away from the generator's ground plate (electrode – rectangular cross-section $^1/_4$ inch in thickness) and constrained as shown in Figure 7. The test article is to be assembled on one end with the manufacturer's fitting. The electrode shall be placed at least 12 inches from the ends of the test article. The fitting end of the test article is connected to the generator using a braided strap (adequately sized to handle the current). A dielectric may be required underneath the test article to ensure the test currents do not flash over to the floor or other support equipment. The lightning generator is charged to the appropriate levels, and is then discharged to the test article. If the test generator does not discharge to the test article, it shall be confirmed that sufficient voltage is present to achieve dielectric breakdown of any air gaps in the test setup, and adjustments are made accordingly. It is verified that the test current did not arc to the exposed tubing on the end opposite the fitting. If all or a portion of the test current arced to the exposed end of the test article, the test is invalid and must be repeated. If metallic layers are present in addition to the tube inner core, separation between the metallic tube and metallic layers may be necessary on the end opposite the fitting to prevent flashover. The three current waveforms are captured using an oscilloscope and calculations are made to verify the desired current levels, action integral, rise times, decay times, duration, and charge levels are equal or greater than the values stated in Section 4.4.2. If the calculated levels are equal to or greater than the values stated in Section 4.4.2, the levels are recorded. The jacket is cut away from the test article at the test location and

a visual inspection of the tubing is made to determine if the stainless steel tubing is punctured. If no puncture of the tubing is noted on visual inspection, the test article shall be pressure-tested to the requirements of Section 4.3. If the test article fails visual inspection or pressure testing after being subjected to the required levels, the test article fails. If the calculated levels are less than the values stated in Section 4.4.2, the test is performed again on a new test article from the same production lot, until the required levels and parameters are satisfied. The test article is deemed to have passed if all of the requirements are met. See Figure 9 for test schematic.

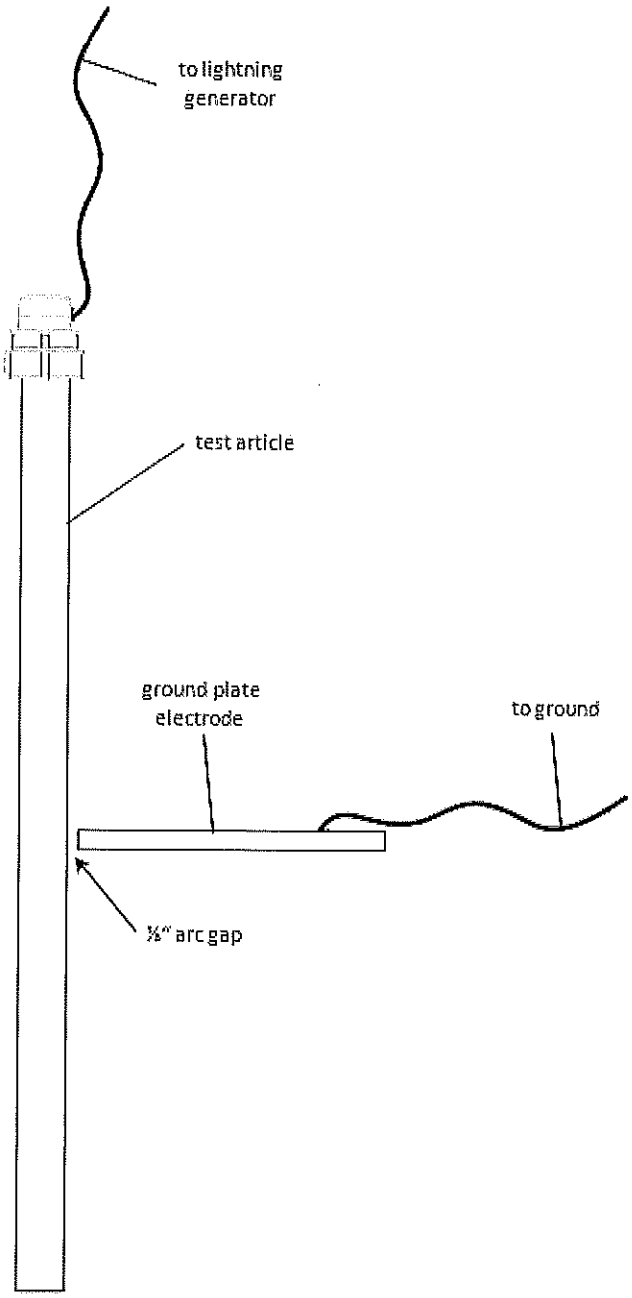

FIGURE 9—INDIRECT EFFECTS 2 TEST SETUP

4.5.2.3 Bonding Equivalence: For the purpose of evaluating the protective jacket system for resistance to transient arcing (indirect effects) using different bonding methods, testing in accordance with this section shall be performed utilizing the testing protocol stated in Section 4.5.2.1 while using a simulated appliance consisting of:

1. A steel sheet metal chassis
2. An NPT connection point for the CSST
3. An electrical box with a minimum 10-foot-long, #14 AWG bonding conductor attached
4. A bonding clamp attached to the fitting on the free end of the CSST and a minimum 10-foot-long, #6 AWG bonding conductor

A minimum of two samples of an intermediate size of CSST shall be tested using the following configurations:

1. The #14 AWG conductor as the bond
2. The #6 AWG conductor as the bond
3. Using both as the bond

If the test results for all three configurations comply with Section 4.5.2.1, bonding of the protective jacketed corrugated tubing, using a #14 AWG appliance bond, shall be deemed equivalent to using a #6 AWG bond required by IFGC 310.1.1. See Figure 10 for a test schematic.

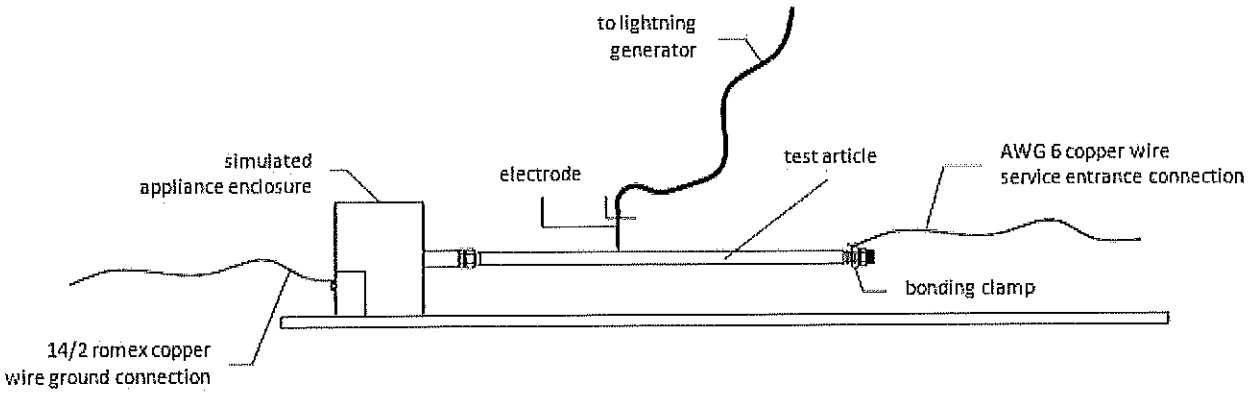

FIGURE 10—BONDING EQUIVALENCE TEST SETUP

5.0 LISTING RECOGNITION

5.1 Installation shall be in accordance with the manufacturer's instructions and the applicable code.

5.2 The listing shall state the product complies with the minimum performance threshold for indirect effects lightning testing.

1) Indirect Effects 1 Threshold: 10 coulombs minimum utilizing a 10x1000 µs current waveform

2) Indirect Effects 2 Threshold:

COMPONENT 1 (Return Stoke)	
Peak Amplitude	30 kA, minimum
Action Integral	0.055×10^6 A^2s, minimum
Time Duration	≤ 500 µs
COMPONENT 2 (Intermediate Current)	
Maximum Charge Transfer	10 coulombs (±10%)
Average Amplitude	2 kA (±20%)
Time Duration	≤ 5 ms
COMPONENT 3 (Continuing Current)	
Amplitude	200 – 800 A
Charge Transfer	26 coulombs, minimum

5.3 Upon documentation of satisfactory passing of tests noted in Section 4.5.2.3 of this criteria, the listing shall state the following: "Electrical Bonding: The Protective Jacketed, Corrugated Stainless Steel Tubing System is electrically continuous and is considered to be bonded where it is connected to appliances that are connected to the equipment grounding conductor of the circuit supplying that appliance. Additional bonding prescribed by Section 310.1.1 is not required for A Protective Jacketed, Corrugated Stainless Steel Piping Systems when installed in accordance with this listing."

5.4 The listing shall state the protection is from indirect lightning only, and the effect of direct lightning strikes is beyond the scope of the listing.

5.5 Product must be installed in accordance with the manufacturer's instructions.