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Evaluation of Available Testing Criterion for Arc Protective Jacketed CSST When Considering Lightning Attachment to Structures

Position Paper V1

AK95_2_CSST tests_Position paper V1

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This paper mainly concentrates on CSST testing described in ANSI LC 1-2014 CSA 6.26-2014 "Fuel gas piping systems using corrugated stainless steel tubing (CSST)" and how it represents the lightning stress for a CSST sample.

There are many tests described in this ANSI standard but the most important one for our concern related to lightning risk is given in 5.16. "Arc resistant jacket or covering system". This is an optional set of tests and 5.16.3 describes the electrical tests. This test is performed using a 10 / 1000 µs waveform and is covering indirect lightning. A minimum charge of 4.5 C should be impressed by an arc generated between the generator and the CSST sample rim and the sample must show no puncture of the exposed stainless steel tubing.

Other documents provide CSST testing protocols. For example, ICC Evaluation Service has a set of two such documents.

- LC 1024: "PROPOSED PMG LISTING CRITERIA FOR CORRUGATED STAINLESS STEEL TUBING UTILIZING A PROTECTIVE JACKET" that was approved in February 2010 and revised on February 2012.
- LC 1027: "PMG LISTING CRITERIA FOR MULTI-LAYER, CONDUCTIVE, JACKETED, CORRUGATED STAINLESS STEEL TUBING" that was approved in February 2011.

LC 1024 tests are described in section 4.0 "TEST METHOD AND PERFORMANCE REQUIREMENTS" and are very similar to the ANSI LC1 tests but additional tests with a simulated appliance are also performed.

LC 1027 tests are also described in section 4.0 "TEST METHOD AND PERFORMANCE REQUIREMENTS" but are more complete than those of LC 1024. They include 2 tests waveforms: a single impulse 10/1000 µs and a more complex waveform very similar to what is used for airplanes. The first waveforms is given for a 10 C charge that is more than two times bigger than the one required in LC 1024. The second waveform includes three components:

Component 1, represents the return stroke.

Component 2, represents intermediate current.

Component 3, represents continuing current

The continuing current is known to be very severe whenever an arc is involved. For example, when we refer to lightning parameters for lightning engineering, it is important to consider the influence of each parameter on a specific damage mechanism. IEC 62305-1 the Lightning Protection System standard, gives the following table for typical components of a LPS.

Component	Main damage mechanism	Parameters
Air-termination	Erosion at attachment point (e.g. thin metal sheets)	Q_{LONG} (C)
Down- conductor	Ohmic heating	W/R MJ/Ω
	Mechanical effects	I kA
Ground-termination	Erosion at attachment point	Q_{LONG} (C)

Table 1 : main damage mechanism for LPS components

Q_{Long} is in that standard similar to the continuing current. As it can be seen from that table, at the impact point the main problem is coming from the charge due to the arc creating erosion. When current is circulating in conductors it is creating a mix of heating and mechanical forces. But when the current is flowing to ground and then leaving the metal conductor or rod, an arc is created again and the charge becomes predominant.

The continuing current seems then crucial for the testing of CSST regarding the arc erosion effect.

LC 1027 gives the following charges for component 2 and 3 respectively: 10 C and 26 C. An equivalent charge can be calculated for component 1: 4 C. This leads to a total charge of 40 C where the most stressful part for CSST is due to the 26 C continuing current. This is a stress 9 times bigger than the one generated under LC 1024 protocol. LC 1027 notes that the second waveform parameters represents the 50 percentile for negative lightning flashes measured at ground.

When we consider the international approach used for the rating of Surge Protective Devices installed at the entrance of the electrical installation to provide equipotential bonding between the grounding and the LPS, it appears that a suitable rating for CSST would be around 32 C for the total flash with a value of 25 C for the continuing current.

When we compare these values with those contained in LC 1027 (respectively 40 C and 26 C), LC 1027 seems then to be a suitable testing procedure with respect to the fact that houses do get struck by lightning and that indirect lightning should not be the only concern, when establishing a protective jacketed CSST minimum performance level.

We do then recommend to consider LC 1027 testing procedure (mainly the second waveform) when the ANSI LC 1 standard will be revised to include specific arc protective jacketed CSST tests.

About SEFTIM

SEFTIM is an independent study and engineering company working in the field of lightning and Electo-Magnetic Compatibility since almost 50 years. SEFTIM started its business in the Aeronautic domain but since then is also working in many fields including Oil&Gas, Nuclear, Chemical, data centers, explosive areas etc. SEFTIM is a French based company having offices in many parts of the world prone to lightning (Indian Ocean, Caribbean, Asia, Polynesia …). Our activities include Lightning Risk Assessment, Technical Studies, Lightning Protection System inspection and Site Surveys. We are actively participating in national, European and International standard activities for lightning and surge protection including the chairmanship of International Electrotechnical Commission for Surge Protective Devices standards. In 2011-2012 SEFTIM was hired, following an international tender, by the U.S. Fire Protection Research Foundation on behalf of the National Fire Protection Association (NFPA), to evaluate CSST bonding effectiveness. The outcome of the study was the Phase-1 report. This report was used as the basis for the next phase of the study (Phase 2) in order to perform tests able to show the efficiency of bonding measures. This second phase mainly concentrated on induced and indirect lightning stress. SEFTIM performed on its own, using its laboratory capability, direct lightning tests on CSST that led to an international publication.