The Whys Of GR-1089-CORE Lightning And AC Power Fault Requirements

A closer look at these important NEBS functional issues

Dave Lorusso, Lorusso Technologies, LLC

If you're a compliance engineer like me, I'll bet you spend an inordinate amount of time looking up at power and phone lines. Well, I do anyway. I've always found it fascinating how power and telecommunications lines are distributed.

However, being way up there and so exposed does have its problems. The Regional Bell Operating Companies (RBOCs) require network equipment vendors to pass a set of rigorous surge tests in GR-1089-CORE *Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*. Passing these tests is a primary reason why you'll have dial tone the next time you pick up a phone.

GR-1089-CORE covers lightning and AC power fault issues in 49 of its 195 pages, or more than 25% of the standard. From this alone you can see that the RBOCs take this subject very seriously. The latest revision extensively changed this section.

Figure 1: Power Lines (photo by Kathy Jane King)

The Elements

Many parts of the world are subject to lightning, but telephone poles are just begging to be hit by a jolt from the blue. A direct hit to a telecommunications line will cause significant damage as energy is transferred down the line. If not hit directly, voltage could couple to the phone lines also transferring energy down the line. Either situation is not good.

Lightning or an earthquake could knock down a telephone pole. Other natural disasters like hurricanes and tornados can also wreak havoc on telephone poles. The upper wires are carrying high voltage, while the lower wires are for telephone service. When an exposed power line comes into contact with an exposed telephone line, high energy is transferred. This is known as an AC power fault in GR-1089-CORE, or more commonly known as a power cross.

By the way, buried telecommunications and power lines are not immune from lightning. When lightning strikes an area where lines are buried, energy transfer still takes place and protection is needed.

Man Made Disasters

I remember when I was working at Alcatel in Petaluma, California (no, this is not an earthquake story, although heavy impact is involved). Early one Monday morning, a pick-up truck smashed into a high-tension line tower. This accident caused about 50 kV to come into contact with about 10 kV. This event caused the 120 VAC outlets in our building to rise to about 600 VAC just long enough to take out half of everything plugged in. The point here is that power lines can also fall through man-made events. Incidents in which vehicles hit telephone poles are quite common. Sooner or later, a power line will contact a phone line and protection is required.

A hunter could be trying to bag a bird on the wire and end up hitting the wire. Not too bright I know, but a power line could be taken out this way and come into contact with a telecommunication line. In fact, GR-487-CORE has a section on firearms resistance. (See *Conformity*, December 2002, for an article on this subject.)

A backhoe or a shovel could inadvertently short out buried telecommunication lines. The equipment has to be designed to handle this event without causing a fire or electrical hazard. Section 4 of GR-1089-CORE tests for short circuits on telecommunications ports.

Fault Conditions

As we've noted above, power lines and telecommunications lines are often found in close proximity of each other. This is due primarily to economics, since it makes sense to run these lines in parallel when sharing common rights-of-way. Magnetic fields are created by the current in power lines and are significant in fault conditions. A phase-to-ground fault can produce large voltages that are coupled into the telecommunications lines.

Primary Protection

GR-1089-CORE addresses these situations by presenting tests designed to ensure network equipment remains functional and/or safe. A first line of defense is required to minimize transients entering network equipment. This first line of defense is called primary protection. GR-1089-CORE assumes that primary protection is present at a facility's entrance. Let's take a quick look at primary overvoltage protection.

Carbon blocks are the oldest device used to protect against overvoltage in telephone installations. They work by forming a spark gap with two pieces of carbon in close (3 to 6 mils) proximity. This gap will conduct at around 600 V. One side is tied to earth and the other to the circuit being protected. Impress a voltage approximately greater than 600 V and the gap conducts, shunting the energy to earth. The major problem with carbon blocks is that they degrade with each use, and the only indication that they are not working is equipment damage.

Next comes gas tubes. These devices are sealed and rely on electrodes and a mixture of noble gases (argon, neon, etc.). They can handle large transient currents, are inexpensive, and have a small shunt capacitance. Drawbacks include slow time to conduct, difficulty turning them off at the end of a transient, and a high dI/dt when switching from an insulating to a conducting state. Still, the benefits outweigh the drawbacks so gas tubes are still widely used for primary protection.

Solid-state crowbar devices are used to clamp transient voltages. They have a fast response time, low capacitance, and high reliability. They are an excellent choice in protecting telecommunication lines.

The three devices mentioned above take care of overvoltage conditions. Overcurrent conditions are sometimes handled by fuse links. Fuse links are coordinated with the current carrying capability of primary protectors. A fuse link may be a section of 24 or 26 AWG wire. Fuse links are not intended to provide a current limiting function for network equipment. That's the job of secondary protection.

Secondary Protection

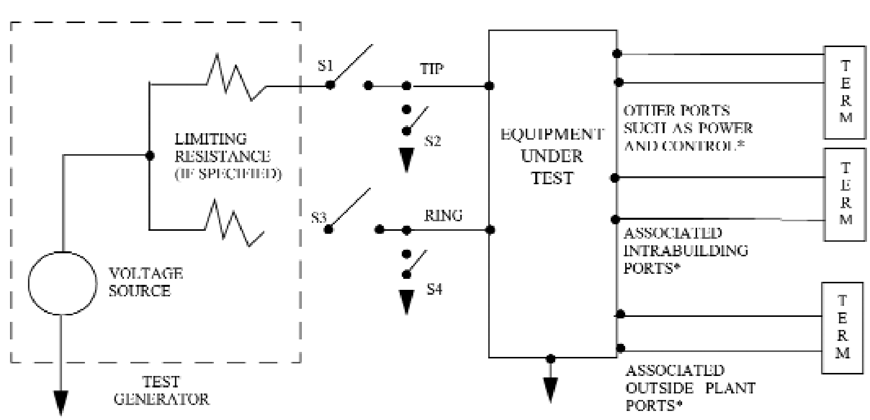
Even with primary protection, some energy is going to sneak by. Section 4 of GR-1089-CORE specifically addresses secondary protection. Secondary protection involves the use of overvoltage and overcurrent devices. An overvoltage device is used to shunt harmful transients away from the protected circuit. Examples are solid-state crowbar devices, gas discharge tubes, and metal oxide varistors. Overcurrent devices are used to interrupt harmful currents, or to provide a high impedance to the protected circuits. Examples are fuses, PTCs, power/line feed resistors, or flameproof resistors.

How far do you go with protection? The line has to be drawn somewhere to ensure product integrity. Telcordia handles this with the terms first-level and second-level.

- First-level - the equipment must survive and be functional after the test.
- Second-level - the equipment can be destroyed, however, prevention of fire and electrical hazards are the goal.

Let's take a basic look at each level. I am not going to go into the specific voltage and current requirements, as this would be a repetition of the standard. I'd like to just touch on the intent of each test. Please refer to the standard for greater detail.

Figure 4-2 Application of Lightning and AC Power Fault Test Voltages



CONNECTIONS TO TEST GENERATOR

	S1	S2	S3	S4
T TO GENERATOR, R TO GROUND (Condition A1 of Table 4-1)	CLOSED	OPEN	OPEN	CLOSED
R TO GENERATOR, T TO GROUND (Condition A2 of Table 4-1)	OPEN	CLOSED	CLOSED	OPEN
T TO GENERATOR, R TO GENERATOR, SIMULTANEOUSLY (Condition A3 to Table 4-1)	CLOSED	OPEN	CLOSED	OPEN

* PORTS ASSOCIATED WITH THE UNIT SHOULD BE TERMINATED AS DESCRIBED IN SECTION 4.6.1

Figure 2: Application of Lightning and AC Power Fault Test Voltages (Figure 4-2 from GR-1089-CORE) Copyright © 2002, Telcordia Technologies, Reprinted with Permission.

Number Of Samples

Three ports of the equipment under test (EUT) in each operating state are tested. This means that the battery of tests is carried out on each of three samples, and not that you can spread the tests out once over three different samples. This area of GR-1089-CORE can consume the most time. Proper test planning at this point really pays off. Try to use a lab with multiple surge generators that can perform testing around the clock.

First-Level Lightning Surge And AC Power Fault Tests

The EUT is set up to operate normally. Proper operation is verified with monitoring equipment. The port under test is checked before and after surges. Manual intervention or power cycling is not allowed when verifying the port. Longitudinal and metallic surges are applied per the respective tables in Section 4 of the standard. All EUT operating states are verified.

Network equipment will be subject to ongoing transient events. Without primary and secondary protection, there would be no telecommunications network. Bellcore (now Telcordia) developed a series of tests that go beyond the upper voltage and current limits equipment will normally see. This adds margin to the test requiring a robust piece of network equipment. The idea is that, if a piece of network equipment can survive the Telcordia tests, it will survive in the field for many years.

First-Level Intra-Building Lightning Surge

Network equipment not connected to outside plant does not get a waiver when it comes to surge testing. There are indirect effects of lightning and AC power faults to contend with. Keep in mind that testing is applied to all types of telecommunications ports. It doesn't matter what function these paired-conductor ports perform. 10BaseT and 100BaseT Ethernet and similar ports must be tested. There is no second-level intra-building lightning surge test. The destructive forces of lightning are found in outside plant.

Second-Level Intra-Building AC Power Fault Tests For Customer Premises

Telecommunication lines are often found next to power lines on customer premises. For this reason, the second-level intra-building AC power fault test is set to 120 VAC. The idea here is that 120 VAC is present through a person's home and may come into contact with telecommunication lines. This test ensures that there is no fire, fragmentation, or electrical safety hazard.

Second-Level Lightning Surge And AC Power Fault Tests

The EUT does not have to function after this test. It must not, however, become a fire, fragmentation, or electrical safety hazard. This is verified by using cheesecloth as a fire indicator. There is a "current-limiting protector test" identified in GR-1089-CORE. This test can be grouped with second-level tests because the object is the same, no fire, fragmentation, or electrical safety hazard.

Conclusion

The RBOCs and interexchange carriers (IXCs) maintain their reliable networks by requiring robust equipment from network equipment vendors. Section 4 of GR-1089-CORE goes a long way towards that objective. The elements, man-made disasters, and fault conditions are anticipated and dealt with by rigorous tests. A quarter of the standard addresses lightning, short-circuits, and power cross events for a reason – these are real world events. The next time you're looking up at those telephone poles, think about how the telecommunication network is protected. ■

About The Author

__Dave Lorusso__ is a specialist in NEBS design and testing. He can be reached by phone at 512-695-5871, or by e-mail at dave@lorusso.com.

References

1. Telcordia GR-1089-CORE *Electromagnetic Compatibility and Electrical Safety—Generic Criteria for Network Telecommunications Equipment*
2. Roland B. Standler, *Protection of Electronic Circuits From Overvoltages*, J. Wiley & Sons, 1989
3. Dave Lorusso, "NEBS Certification – Design With The Customer In Mind," *Conformity*, October 2002, pp. 12-19.

Resources

1. www.lorusso.com (Home page of Lorusso Technologies, LLC, "*Your NEBS, Product Safety and EMC Solution*")
2. www.nebs-faq.com (Resource for NEBS compliance information)
3. www.creepage.com (Creepage and clearance calculators)
4. www.telcordia.com (The creator and keeper of NEBS documents)
5. www.teccor.com (Teccor Electronics, manufacturer of transient voltage suppression devices)