NEBS Certification Design With The Customer In Mind

Planning, Purpose and Patience Will Help You To Achieve Certification The First Time

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If you want to do business with the Incumbent Local Exchange Carriers (ILECs), you are going to have to do NEBS. Yes, it's going to be difficult; an understanding of the basic principles of NEBS is important and there are hundreds of requirements. You may need additional staffing or a NEBS consultant. Yes, it's expensive – testing and samples cost money – but lower warranty costs will offset the expense.

It takes more than know-how and money to guarantee your product's market entry; achieving NEBS certification requires planning, purpose, and patience.

Planning

Let's start off by defining what "NEBS" is. NEBS is an acronym for "Network Equipment – Building System." That doesn't say a whole lot. What is *Network Equipment* and what is a *Building System*? *Network Equipment* is what goes into a telecommunications carrier's network. That network could be in a Central Office (CO) or be part of an Outside Plant (OSP) infrastructure. *Building System* addresses the Central Office part. NEBS describes the environment of a typical ILEC or Regional Bell Operating Company (RBOC) Central Office.

NEBS standards were developed by Bell Labs in the 1970s to standardize equipment that would eventually be installed in a Central Office. The intent was to make it easier for a vendor to design equipment compatible with a typical RBOC Central Office. Compliance with NEBS standards would result in lower development costs and ease the equipment's introduction into the network.

The main NEBS standard is Bellcore (now Telcordia) GR-63-CORE "Network Equipment-Building System (NEBS) Requirements: Physical Protection." A very important sister document is GR-1089-CORE, "Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment." These two documents make up what's known as the "NEBS Criteria."

Another important design document is GR-78-CORE, "Generic Requirements for the Physical Design and Manufacture of Telecommunications Products and Equipment." Half of this document details printed wiring boards (PWB) requirements. The other half deals with materials, connectors, components, repair, various tests, and some design requirements. Please refer to www.nebs-faq.com for more detail on NEBS.

However, it's not enough to meet NEBS requirements; each telecommunications carrier also may expect you to meet additional requirements unique to that provider. In addition to meeting GR-63-CORE and GR-1089-CORE, you must meet the following:

- **Verizon** – Document SIT.NEBS.TE.NPI.2000.004
  - Key areas are fire resistance and EMC
- **SBC** – Document TP76200MP
  - Key areas are DC power and seismic
- **Qwest**
  - Key areas are altitude and heat dissipation
- **AT&T** – Network Equipment Development Standards (NEDS)
  - Key areas are design issues, including air filter, transients, and power.

Purpose

Now that you know what standards to use, let's look at some key design details.

Size Does Matter

The U.S. telecommunications system is more than 100 years old. RBOCs got there first; they own some of the most expensive real estate in the world. The RBOCs are not going to sell their property. It's our job to conform to existing Central Office space when we design network equipment.

An objective specified by GR-63-CORE states:

> "*Equipment designed for traditional applications in established equipment environments should have the following nominal dimensions: Height - 2134 mm (7 ft), Width - 660 mm (2 ft, 2 in), Depth - 305 mm (12 in)*".

GR-63-CORE begins with spatial requirements for a reason – the 12-inch lineup is the most common lineup in a Central Office. RBOCs want to maximize their Central Office space and avoid costly facility modifications. Bottom line; it makes sense for the RBOCs to replace older electronic equipment with equipment designed to be 12 inches deep. The equipment vendor who meets this objective has the edge.

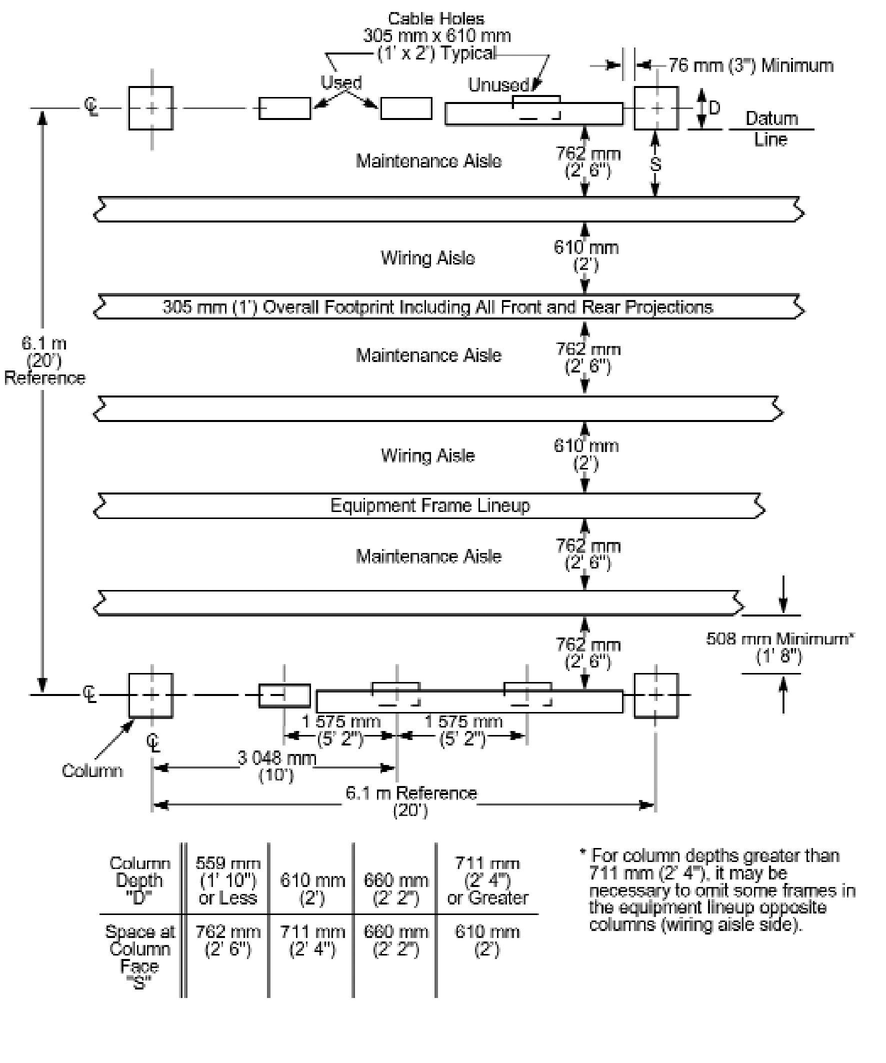

Figure 2-2. Typical 6-Lineup Floor Plan for 305-mm (12-in) Deep Frames

Figure 1: Figure 2-2 from GR-63-CORE (Copyright 2002, Telcordia Technologies Inc.; reprinted and included herein with permission from Telcordia)

The 12-inch depth is preferred, but it is not (as evidenced by the word *should* in GR-63-CORE) an absolute. If you cannot design your equipment to be 12 inches deep, move up to 18 inches deep. Still a problem? Move up to 24 inches deep. These depths – 12, 18, and 24 inches – are standard network equipment lineups. Exceed 24 inches and you'll be placed into a special lineup. Depths greater than 24 inches should be avoided because a competitor with the same features that fits in a traditional lineup will get the nod from the customer.

While your product is in the concept stage, it's a good idea to bring in a NEBS consultant to ensure a NEBS-compliant design.

Power Entry

Network equipment is powered by –48 Vdc. This voltage is derived from the public AC supply that is converted into a low voltage, direct current supply for network equipment. The AC supply is used to charge a bank of batteries that power network equipment in the event of an AC supply outage.

There is a safety reason for the widespread use of –48 Vdc; the voltage had to be less than 50 Volts to meet safety regulations. The negative polarity slows down corrosion of cables in the event they become earthed.

The preferred –48 Vdc termination for network equipment is the two-hole crimp connector (similar to that pictured in Figure 2). This type of connector is preferred because rotation is prevented during ordinary vibration and mechanical shock within the Central Office.

Network equipment should be designed to operate within an emergency voltage range of –60.0 Vdc to –41.75 Vdc. The lower voltage (-60 Vdc) represents the maximum battery charge voltage and also the limit of SELV. The higher voltage (-41.75 Vdc) represents a partially discharged battery supply.

Equipment vendors must design to various transients the network equipment will experience. The values in Table 1 are from Bellcore GR-513-CORE.

Figure 2: Two-Hole Crimp Connector
(photo courtesy of Panduit)

Transient Time Duration	Vdc
5 seconds	-65
10 ms	-75
10 us	-100
1 us	-20

Table 1

Grounding

The preferred main grounding termination for network equipment also is the two-hole crimp connector. When you design equipment that directly connects to OSP (Type 1 and 3 per GR-1089-CORE), it's important to consider how surge currents are returned. Ideally, your design should have an intentional path for current to flow. Early prototype testing pays off to prove your grounding scheme works.

Cooling

Do I use natural convection or forced-air fans? The answer to this question depends on how much power your product dissipates. Keep in mind that GR-63-CORE has objectives for how much heat a product can release, as shown in Table 2.

Most modern network equipment will go the forced-air fan route due to the increased power consumption of its integral components. The penalty for forced-air fans is the required use of fan filters. GR-78-CORE defines what specifications the fan filter must meet, including:

- A minimum dust arrestance of 80%
- A minimum fire rating of Underwriters Laboratories (UL) Class 2
- Construction and system fit of equipment fan filters shall prevent any air bypass

Fire Resistance

You don't want to spend tens of thousands of dollars testing your equipment only to repeat the tests when your equipment fails. Always do the fire test first.

GR-63-CORE requires that fans remain operational during the fire test. Running fans during a fire test can get a little tricky because you're feeding oxygen into the flames. The increased oxygen makes it difficult to pass the test. (Note that eliminating a fan from your design and relying on natural convection does not guarantee a pass.) Early prototype testing is essential to passing this test.

Proper material selection is key to a successful fire resistant design. Use components with the best flame rating you can obtain, 94V-0 as a minimum. Component placement is important, because a 94V-0 part will burn with prolonged contact to a flame. The GR-63-CORE line burner profile lasts for 5-1/2 minutes, enough time to deplete any flame-retardants and to support combustion.

Understanding how the test is run will help you design a proper fire mitigation strategy. A methane line burner is inserted into a 3/4 inch hole at points determined to pose the greatest fire propagation potential. The burner profile continues for 5-1/2 minutes, peaking at 1-1/2 minutes.

You are allowed to remove a line card and put the line burner in its place. The

Table 4-6. Equipment Area Heat Release Objective

Individual Frame	
Natural convection	1450 W/m^2 *(134.7 W/ft^2)*
Forced-air fans	1950 W/m^2 *(181.2 W/ft^2)*
Multi-Frame	
Entire System	860 W/m^2 *(79.9 W/ft^2)* *
Any 6.1-m by 6.1-m (20-ft by 20-ft) square area within a larger system	1075 W/m^2 *(99.9 W/ft^2)* *
Shelf	
Natural convection	225 W/m^2 per meter *(20.9 W/ft^2/ft)* of vertical frame space the equipment uses.
Forced-air fans	300 W/m^2 per meter *(27.9 W/ft^2/ft)* of vertical frame space the equipment uses.

*Systems totally comprised of forced-air cooled equipment may increase these levels to 1075 W/m^2 *(99.9 W/ft^2)* and 1290 W/m^2 *(119.8 W/ft^2)*

Table 2: Table 4-6 from GR-63-CORE, Equipment Area Heat Release Objective

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line burner, in theory, simulates a burning line card. The line burner outlined in GR-63-CORE was developed based on earlier line cards used in standard channel banks. It may not be appropriate for newer network equipment. Technical subcommittee T1E1.8 of Committee T1 (www.t1.org) is working on the proposed ANSI Standard T1.319-2002, *American National Standard for Telecommunications – Equipment Assemblies-Fire Propagation Risk Assessment Criteria*. This standard addresses network equipment that does not fit the channel bank line card profile and offers alternate fire resistance test procedures.

Understanding the width, length, and height of the flames during this test goes a long way towards designing compliant equipment. When used in conjunction with proper material selection, i.e., high flammability rating components, fire spread is mitigated.

EMC

Here's another potential design trouble spot. Unlike the FCC procedure of testing to multiples of the highest clock frequency, the RBOCs want you to test from 10 kHZ to 10 GHz. With good EMC design practice, this range is not a problem - at least the limits are Class A in a Central Office. Here are some areas to consider during your design:

- Proper component placement
- Proper multi-layer board stackup definition
- Early and on-going EMC design reviews
- Put hooks in for signal line filtering
- Enclosure shielding considered from the beginning
- It also helps to have each board reviewed multiple times by an EMC rule based application

EMC is an area that should not be left to chance. If you don't have an in-house EMC engineer, use an experienced EMC consultant.

Seismic

A GR-63-CORE Zone 4 seismic event is approximately equivalent to an 8.2 earthquake. That's a lot of shaking. I've seen power supplies fly out of equipment because one positive latch was used instead of two.

You don't want to redesign your equipment at this stage of testing. To pass the seismic test, you have to think about what parts of the equipment will become unstable. Anything that is not mechanically secure can be a trouble spot.

It's a requirement that the equipment function properly after the test. GR-63-CORE states:

> "*The equipment shall sustain operation without replacement of components, manual rebooting, or human intervention.*"

Make sure that there is play in your installed cables during the test. You don't want to fail because a cable broke because it was held too snugly to the frame.

Patience

A NEBS test program can last from six weeks to three months or more depending on:

- Up front compliance design work
- Level of pre-compliance testing
- Number of samples provided

All areas of NEBS must be kept in mind during the design of the equipment. Failure in any area could cause a redesign resulting in retesting, both potentially costly outcomes. For example, a failure in fire testing causes a redesign of the enclosure. The EMC profile of the enclosure is now changed and must be retested. The thermal profile may be changed and also require a retest. As mentioned earlier, do the fire test first in your formal NEBS test program.

Pre-compliance testing pays off. This is especially true for fire, EMC, surge, acoustics, and seismic requirements, and even packaging. Passing these early tests gives you a feeling of confidence going into the final tests. Failure in any of these areas during the final NEBS

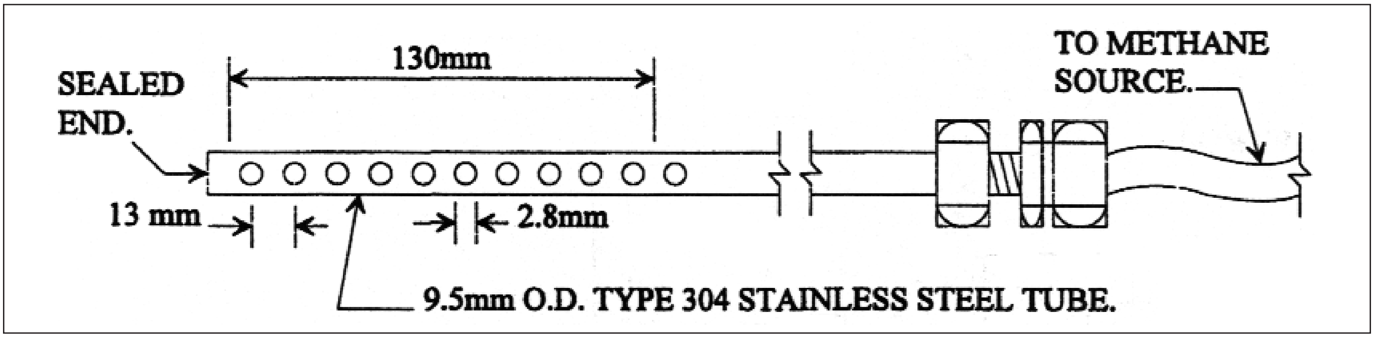

Figure 3: Line burner drawing

testing can cause a redesign that will potentially delay market entry of your product.

One sample or more? The answer has a direct impact on the completion of the NEBS test program. One sample is fraught with so many problems that it should not be contemplated. Two samples can work, but you risk failure of the fire test. If you burn it first, you're left with one sample and more risk. Three samples are the best minimum. If you connect to OSP, surge testing can be performed first then you can burn it; the other two can follow paths for GR-63-CORE and GR-1089-CORE.

You, a technical member of your staff, or a NEBS consultant should be present during NEBS testing. Problems and questions arise during testing – having a knowledgeable person in the test lab to respond to problems on the spot ensures a smooth test program.

Conclusion

With proper planning, purpose, and patience you can get through the NEBS process. Designing for NEBS must be considered from the start and be carried throughout a product's development. Follow these guidelines for a successful NEBS program:

- Know what the customer wants – full compliance to GR-63-CORE, GR-1089-CORE, and their own requirements
- Design your product to these requirements
- Perform pre-compliance testing, especially fire testing and EMC
- Have a minimum of three samples ready for final NEBS testing
- Understand how the tests are run and be present during the tests. ■

About The Author

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References

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Telcordia GR-63-CORE *Network Equipment-Building System (NEBS) Requirements: Physical Protection*

Telcordia GR-78-CORE *Generic Requirements for the Physical Design and Manufacture of Telecommunications Products and Equipment*

Telcordia GR-1089-CORE *Electromagnetic Compatibility and Electrical Safety—Generic Criteria for Network Telecommunications Equipment*

Verizon SIT.NEBS.TE.NPI.2000.004 *NEBS Compliance Checklist*

Dave Lorusso, "What Every Startup Needs to Know About NEBS", *EE-Evaluation Engineering*, May 2002, pp. 74-80. www.evaluationengineering.com/archive/articles/0502emc.htm

Additional NEBS Resources

www.lorusso.com (Home page of Lorusso Technologies, LLC, "*Your NEBS, Product Safety and EMC Solution*")

www.nebs-faq.com (Resource for NEBS Compliance information)

www.curtis-straus.com/nebs.html (Source of ILEC/RBOC Requirement Documents)

www.verizonnebs.com (Verizon's NEBS Compliance Web Page)

www.telcordia.com (The creator and keeper of NEBS documents)