

# NEBS Compliance Testing:

## Thermal Management

### Introduction

To meet contractual and design requirements, telecom equipment destined for certain networks in the North American market must be tested to the Network Equipment Building System (NEBS) standard and comply with its requirements. NEBS describes the environment of a typical Regional Bell Operating Company (RBOC) Central Office (CO). Telcordia GR-63-CORE is a NEBS standard that governs the spatial and environmental hardware requirements of products for use in a CO [2]. Adherence to the requirements is deemed essential to the reliability, availability and durability of the Public Switched Telephone Network (PSTN) [1].

Testing and complying with NEBS requires a concerted effort among various design organizations from the start of a design cycle. Because NEBS compliance testing is done at the end of the design cycle, noncompliance with the standard will have detrimental effects on a product's time to market (including cost penalties). Of the various NEBS requirements, those that apply to thermal specifications are among the most stringent [1].

### What is NEBS?

NEBS was developed by a division of Bell Labs (now called Telcordia) in the 1970s to standardize equipment that would eventually be installed in the CO of an RBOC. The intent was to make it easier for a vendor to design equipment compatible with a typical RBOC CO. This would result in lower development costs and ease the equipment's introduction into the network [2].

The NEBS requirements and test methods are specified in the Telcordia GR-63-CORE, GR-1089-CORE, GR-3109 and GR-3208 documents [3]. Table 1 lists the general topics of each document. Compliance to NEBS is demonstrated by testing products in a Nationally Recognized Testing Laboratory (NRTL), sanctioned by an RBOC, or in the manufacturer's test facility, supervised and witnessed by an NRTL. Depending on the application and the customer, compliance can be demonstrated on a tiered system defined in the Telcordia SR-3580 document as NEBS Levels 1, 2 and 3, where level 3 is for Central Office (CO) grade equipment. NEBS Level 1 is mandated by the Federal Communication Commission (FCC) for co-location of Competitive Local

GR-63-CORE Issue 2	GR-1089-CORE Issue 3	GR-3109	GR-3208
<ul style="list-style-type: none"> <li>• Fire resistance</li> <li>• Temperature &amp; humidity (operating, storage &amp; transportation)</li> <li>• Shock, vibration &amp; earthquake (operating, storage &amp; transportation)</li> <li>• Airborne contaminants (corrosive &amp; hygroscopic dust)</li> <li>• Acoustic</li> <li>• Altitude</li> <li>• Lighting</li> <li>• Floor loading, physical &amp; spatial requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Electrical safety</li> <li>• EMI emissions</li> <li>• EMI immunity</li> <li>• Lightning immunity</li> <li>• ESD (operation &amp;, installation)</li> <li>• Bonding &amp; grounding</li> <li>• AC power fault</li> </ul>	<ul style="list-style-type: none"> <li>• Fire resistance</li> <li>• Temperature &amp; humidity (operating, storage &amp; transportation)</li> <li>• Shock, vibration &amp; earthquake (operating, storage &amp; transportation)</li> <li>• Airborne contaminants (corrosive &amp; hygroscopic dust)</li> <li>• Salt fog exposure</li> <li>• Acoustic</li> <li>• Altitude</li> <li>• Lighting</li> <li>• Applicable GR-1089 requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Equipment cooling classifications</li> <li>• Room cooling classification</li> <li>• Environmental criteria</li> <li>• Heat release targets</li> <li>• Equipment specifications</li> </ul>

Table 1. General Topics under the NEBS Requirements [1].

Exchange Carrier (CLEC) equipment in the Incumbent Local Exchange Carrier (ILEC) spaces [1].

Many equipment vendors build their equipment to NEBS standards, even when they do not intend for their equipment to be placed in a Central Office. Equipment vendors do this because compliance with the NEBS standards shows buyers that the equipment is well built [4].

**Bellcore Document GR-63-CORE**

The main Bellcore (Telcordia) document is GR-63-CORE, "Network Equipment-Building System (NEBS) Requirements: Physical Protection". This document identifies the minimum spatial and environmental criteria used for new telecommunications equipment to be used in an RBOC's CO.

**The spatial criteria cover:**

- 1.Cable distribution systems
- 2.Distributing and interconnecting frames
- 3.Power equipment
- 4.Operations support systems
- 5.Cable entrance facilities

**The environmental criteria cover:**

- 1.Temperature, humidity and altitude
- 2.Fire resistance
- 3.Equipment handling
- 4.Earthquake
- 5.Office vibration & transportation vibration
- 6.Airborne contaminants
- 7.Acoustic noise
- 8.Illumination

Other documents are found in the NEBS standard, such as the GR-1089-CORE, which details the electromagnetic compatibility and safety requirements. This article's focus is on some of the temperature, humidity and acoustic noise criteria of the GR-63-CORE document. The aforementioned criteria directly affect the thermal management of the product.

**Temperature, Humidity, and Altitude Criteria**

This section provides criteria for temperature, humidity and altitude robustness of network equipment. The criteria cover the following:

- 1.Transportation and storage environments
- 2.Operating temperature and humidity environments
- 3.Altitude

**Transportation and Storage Environmental Criteria**

During transportation or while in storage, equipment may be exposed to extremes in temperature and humidity. The criteria in this section apply to equipment in its normal shipping container. After exposure to the given environment, the equipment is unpackaged and operated. Conformance is based on its ability to operate as intended.

NEBS requirements R4-3 and R4-4 state that "the packaged equipment shall not sustain any damage or deteriorate in functional performance after it has been exposed to the environment". Requirements R4-3 and R4-4 are non-humidity controlled tests. R4-5 lists the requirements for transportation and storage for high relative humidity.

Temperature*	Event	Duration/Rate of Change
23°C to -40°C	Temperature transition	30°C/hr
-40°C	Temperature soak	72 hr (minimum)
-40°C to 23°C	Temperature transition	Less than 5 minutes

\* Any humidity (or uncontrolled humidity)

*Table 2. Low Temperature Exposure and Thermal Shock.*

Temperature*	Event	Duration/Rate of Change
23°C to 70°C	Temperature transition	30°C/hr
70°C	Temperature soak	72 hr (minimum)
70°C to 23°C	Temperature transition	Less than 5 minutes

\* Any humidity (or uncontrolled humidity)

*Table 3. High Temperature Exposure and Thermal Shock.*

Temperature*	Event	Duration/Rate of Change
23°C to 40°C, any RH*	Temperature transition	30°C/hr
40°C	Transition to 90% to 95% RH	< 4 hr
40°C, 90% to 95% RH	Temperature/humidity soak	96 hr
40°C to 23°C, any RH	Temperature transition	30°C/hr

\*RH = relative humidity

Table 4. High Relative Humidity Exposure.

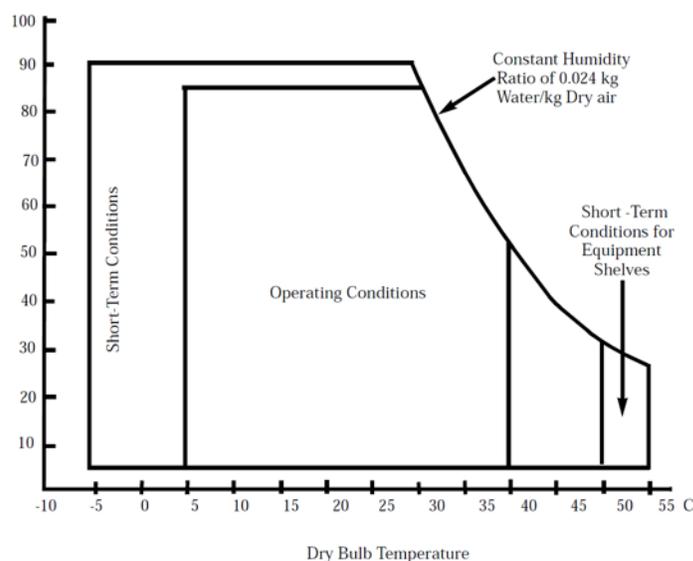


Figure 1. Ambient Temperature and Humidity Limits [5].

### Operating Temperature and Humidity Criteria

Figure 1 shows the normal operating temperature/humidity levels and short-term operating temperature/humidity levels in which network equipment is required to operate. To fulfill the requirements, the equipment must not sustain any damage or deterioration of functional performance when operated at conditions set in Figure 1 (NEBS requirement R4-6).

Conditions Limits	
Temperature Operating Short term	5°C to 40°C -5°C to 50°C
Rate of temperature change	30°C/hr
Relative Humidity • Operating • Short term	5% to 85% 5% to 90%, not to exceed 0.024 kg water/kg of dry air

Table 5. Ambient Temperature and Humidity Limits.

### Altitude

As altitude increases, air density decreases due to the low pressure. A lower air density results in an increase in the temperature rise through the system. This will then increase the component temperatures. NEBS GR-63-CORE has various altitude requirements, for example, NEBS R4-8 states that “all equipment shall be functional when installed at elevations between 60 m below sea level and 1800 m above sea level at aisle-ambient temperatures of 40°C.” There are also other requirements for higher altitudes and higher aisle-ambient temperatures.

NEBS requirement R4-10 also states that the manufacturer must provide any special requirements for installations above 1800 m in the product documentation.

### Acoustic Noise

The sound level limits apply to operating conditions, whether loaded or unloaded, partial or full power that produce the loudest noise [5]. This includes all components, applicable accessories, and any acoustic shields or other apparatus that will be part of the equipment. The NEBS criteria R4-72 states that “equipment shall not produce sound levels above the limits when installed in network facilities” [5].

Equipment Sound Level	(dBA)
Equipment to be located in power rooms	83
The maintenance control center of an equipment system where normal speech and telephone communications are required.	65
An individual equipment frame that may be located in a lineup with other equipment.	60
All other equipment	75

Table 6. Maximum Sound Level Limits.

The maximum indoor level of 83 dBA is slightly below the US Federal Government level established to prevent hearing damage [5]. Lower levels are desirable, however, because they interfere less with speech and are less annoying. For example, at 65 dBA, the distance for communicating reliably in a normal voice is about 1.2 m with a speaker and a listener facing each other.

### EMC – Electromagnetic Compatibility

Although not directly related to the thermal management simulations, EMI (electromagnetic interference) shielding is commonly done by using a plate with a pattern of holes as an airflow entrance grill. However, this will add an extra air flow resistance. An increase in flow resistance will decrease the system airflow. This will have a negative effect on the air temperature rise through the product and also on the component temperatures.

Choosing an appropriate hole pattern will have a beneficial effect on the airflow rate. As an example, increasing the free flow area ratio,  $F_0/F_1$  (as shown in Figure 2) from 30% to 60% decreases the pressure loss coefficient,  $K$ , from 9.13 to 1.02. This can have a significant impact on the system airflow resistance curve.

### Summary

This article has discussed why and how the NEBS standards are applied to network equipment. Using the requirements of the NEBS thermal design standard as the boundary conditions for a product will decrease the thermally associated risk. As stated in [7], the ultimate goal of a system's thermal design is not for predicting component temperatures, but rather for reducing thermally associated risk to the product. Table 7 gives an overview of the thermal requirements of the GR-63-CORE document, along with the GR-3108-CORE standard for outside equipment.

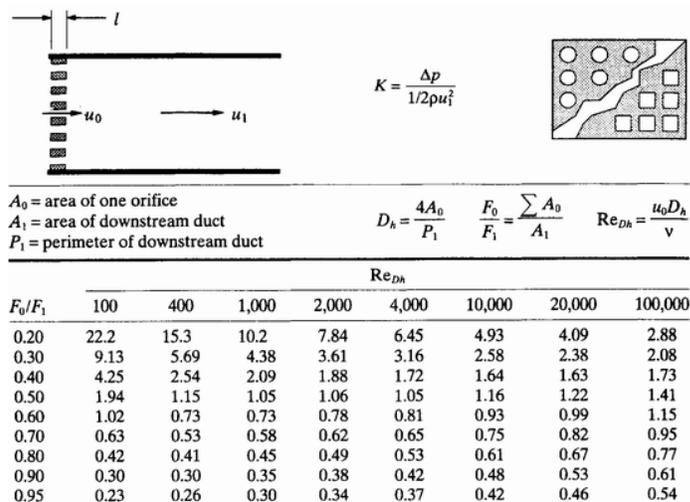


Figure 2. Pressure Loss Coefficient  $K$  for Entrance Flow Through a Thin-Wall Grid ( $l/D_h < 0.015$ ) with Sharp-Edge Orifices of Differing Shapes [6].

Requirement	GR-63-CORE Indoor Equipment	Standard In Progress Indoor Equipment	GR-3108-CORE Outdoor Equipment		
	CO, MSC Environment	Data Center	Class 1 (Controlled)	Class 2 (Partially Controlled)	Class 3 (Uncontrolled)
Normal Operating	5°C to 40°C 5 to 85% RH	18°C to 22°C 5 to 85% RH	5°C to 40°C 5 to 85% RH	-40°C to 65°C 5 to 85% RH	-40°C to 85°C 5 to 95% RH
Short Term Operation	-5°C to 49°C *	-5°C to 33°C	-5°C to 49°C *	NA	NA
Cold Start	-0°C	NA	-0°C	-20°C (required) -40°C (objective)	-40°C
Altitude	1829 m	NA	NA	NA	NA
Altitude, Temperature Adjusted	55°C	NA	NA	NA	NA
Heat Dissipation Objectives	1810 W/m <sup>2</sup>	NA	NA	NA	NA
Design Life	25 years <sup>†</sup>	contract specification	contract specification	contract specification	contract specification
Acoustic Objectives	60 dBA shelf, 65 dBA systems	85 dBA per OHSA	NSA	NSA	NSA
Fan Failure	1 fan failure <sup>‡</sup>	NA	NA	NA	NA

- \* Add 5°C for shelf level equipment
- ‡ This is a requirement of GR-512
- † Not a NEBS requirement yet

Table 7. Operational Thermal Related Requirements [1].

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