Verizon Laboratories

Systems Integration and Testing

NEBS Compliance & Quality Assurance

Guidelines for Physical Design: Next Generation Network Equipment

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Guidelines for Physical Design of Next Generation Network Equipment

Due to technological advances which have increased semiconductor device speed, reduced component and physical spacing, and, overall, changed the design of next generation network (NGN) equipment, Verizon has made recommendations for both the physical design of next generation central office (CO) equipment and the design of the central offices themselves. The following document provides guidance for manufacturers in designing equipment to meet Verizon's central office requirements.

The areas that are addressed in this document include:

- Frame Depth and Aisle Spacing
- Use of Covers and Doors
- Thermal Management within COs
- HVAC Systems -- Air Conditioning
- Cooling -- Air Flow Direction and Temperature Rise
- Cooling -- Fan Noise
- Weight of Equipment and Impact on Floor Spacing and Loading
- Use of Overhead Cabling
- Use of Front-Access Connectors
- Cable Strain Relief and Circuit Pack Access
- Orientation of Fiber Connectors.

Frame Depth and Aisle Spacing

The NEBS requirements specify a minimum maintenance aisle width of 30", a minimum wiring aisle width of 24", a frame height of 84" and lineup spacing that optimizes the number of lineups in an equipment bay. NEBS require equipment in a lineup to be of consistent depth but allows for wider spacing when equipment more then 12" deep is installed. With our interest in deploying NGN equipment, the physical depth of the frame is becoming an issue. Since some NGN equipment exceeds 24" in depth, equipment can protrude into both the maintenance and wiring aisles and create a safety hazard.

1. **Policy:** Verizon requires that all network equipment must be NEBS compliant and bays should be laid out in accordance with GR-63-CORE specifications. This allows equipment to extend 5" into the maintenance aisle (as measured from the frame upright to the front of the shelf – including doors, covers, and cable guards). A 12" deep shelf design is still preferred, but deeper designs, are acceptable. Cables may not protrude further into the maintenance or wiring aisles. Maintenance and wiring aisle widths must be maintained by placing lineups further apart for equipment exceeding a 12" depth.

Use of Covers and Doors

Much of the NGN equipment is shipped with covers or doors on the shelves and/or cabinets. It is critical that these covers and doors do not cause a safety hazard.

2. **Policy:** Generally Verizon does not recommend the use of doors and covers. When hinged doors and covers are used they must be secured with a latching mechanism for safety purposes. If screws are used to secure the covers, then the manufacturer must use captive screws.

Thermal Management

The heat release from some network equipment that Verizon installs today exceeds the heat release objectives in GR-63. The major reason for this is more heat is generated per equipment floor area as processor speeds increase and more components are placed on larger printed circuit boards. Unfortunately, there are no published heat release requirements, only objectives. This means that equipment vendors do not have a requirement to meet. The only requirement is that they have to report their heat release values in their NEBS report.

Mitigation of excessive heat release typically requires that equipment be spaced farther apart. The average acceptable equipment heat load for a typical CO building is 860 W/m^2 (79.9 W/ft^2) as specified in GR-63, Section 2.9.3. Although GR-63, Section 4.1.4, Requirement R4-13 says, "The maximum heat release and method of cooling (e.g., natural convection or with fans/forced air) shall be documented for all equipment," there is no requirement to meet any specified heat release value. Thus equipment manufacturers can design their equipment to meet any heat release they choose. The maximum number of typical 2'2" frames with 12" deep equipment located in a CO bay (a 20' x 20' area) is 45. Typically the bay is engineered with 5 rows of 12" deep equipment (frame) line-ups as shown GR-63, Section 2, Table - 2-10, with 9 frames per line-up. The typical heat release per frame as shown in GR-63, Section 4, Table 4-6 for a multi-frame assembly is approximately 100 $Watts/ft^2$. The additional wattage above 79.9 W/ft^2 is allowed because the maximum heat release assumes most of the CO equipment in other bays is under the heat release objective. This equates to 889 W/frame (for a 20' x 20' square area; 100 $watts/ft^2$ x 400 ft^2 = 40,000 watts/ 45 frames = 889 Watts/frame). Heat density can be mitigated if Verizon adopts improved HVAC designs and/or wider aisles to spread the heat release over a wider area. Wider aisles also permit easier installation and access to equipment frames by CO technicians.

For a single frame configuration, the heat release objective is raised to 1450 W/m^2 (134.7 W/ ft^2) for natural convection and 1950 W/m^2 (181.2 W/ft^2) with fans because there is an assumption that most other equipment in the bay is under the heat release maximum and the heat release will average out.

3. **Policy:** Verizon requires that GR-63 and GR-3028 objectives be followed. Today's equipment requirements assume Vertical Overhead Cooling (VOH) and that such equipment continue to operate in the event of a loss of HVAC. In this environment, equipment must

continue to be designed to meet current heat density objectives and assume that all equipment will be mounted on a tiled, concrete floor.

4. **Policy:** Verizon requires that manufacturers must still meet "surface contact" temperature restrictions to avoid injury to personnel in the equipment aisle. Although less of a problem than total heat release, the surface temperature of frames can be an issue. GR-63's Objective O4-15 specifies that aisle-facing surface temperature should not exceed 38°C (100°F) at a room ambient temperature of 26°C (79°F). Higher temperatures pose a burn hazard to CO personnel.

5. **Policy:** Verizon recommends that equipment layouts for VOH cooling place a 2U high baffle between different network elements that are located in the same frame to assist with equipment cooling and fire suppression.

HVAC Systems -- Air Conditioning

Given that many vendors are introducing "hotter" equipment, Verizon has considered the impact of placing NGN equipment within CO space that is constantly supplied with chilled air even in the event of loss of commercial power.

6. **Policy:** CO-based equipment must be designed for continuous operation over an ambient temperature range of 5°C to 40°C, and short term range of -5°C to 50°C for a period of not more than 15 days in one year. Remote terminals can be either environmentally controlled or uncontrolled. Environmentally controlled remote terminal equipment must be able to withstand the same temperature limits as CO-based equipment. For environmentally uncontrolled remote terminals, equipment must operate over an extended ambient temperature range from –40°C to 46°C with solar loading. Equipment must also be designed to operate at 40°C at an altitude of 1800 m. Equipment designs should meet current heat density requirements (100 W/ft^2) and assume "direct-contact," frame-to-frame spacing (i.e., no "dead space" around hot frames). Equipment not meeting these guidelines requires an exception from Verizon's Technology Organization's NEBS and Quality Assurance Team.

Cooling -- Airflow direction and Temperature Rise

Airflow design within a shelf, frame or cabinet is manufacturer driven. An industry best practice is to have the airflow intake at the bottom of equipment and the exhaust at the top or back. However, some designs exhaust hot air in the front – with the risk that a higher shelf in that same frame draws that same air for cooling. Airflow designs are not standardized.

As stated previously, Verizon has generally adopted VOH cooling techniques because of the typical installations it has in the field. However, for NGN equipment, this may not be the most effective way to cool equipment due to high heat dissipation values. Although GR-3028 provides guidelines on a variety of air conditioning techniques to handle the hot exhaust from CO equipment, it requires proactive communication between Verizon and vendors regarding the target CO environment – before equipment is designed. The Telecommunication Carriers NEBS Checklist and GR-3028 provide a method of reporting equipment heat release for CO floor space.

7. **Policy:** Verizon prefers that all equipment be designed for an airflow intake at the lower front or bottom of equipment with exhausts to top and back of the equipment.

8. **Policy:** Verizon requests that manufacturers boldly mark the location of fan filters on all equipment for easy replacement from the maintenance aisle. Filters are required when shelves are equipped with fans.

Cooling -- Fan Noise

The NEBS "flow through" temperature rise used to meet equipment reliability requirements is 20°C. Due to the increased heat generated in new network equipment, equipment manufacturers have often increased the size and speed of cooling fans used in network equipment. This has created excessive noise levels in the CO environment. The maximum allowable sound level is 60 dBA as specified in GR-63, Section 4.6, Requirement R4-72, for individual equipment frames that may be located in a line-up with other equipment. A significant amount of the equipment Verizon places in COs today exceeds current limits.

Various manufacturers have shown an ability to meet current NEBS noise requirements – often by using several smaller fans and smart design practices. One acceptable strategy is to use variable speed fans that do not exceed 65 dBA at ambient temperatures up to 30°C but run at higher speed and noise levels when ambient temperatures exceed 30°C. Fan units should include alarms for monitoring fan speed, fan failures, missing fans, and high temperatures.

9. **Policy:** Verizon will enforce current NEBS noise requirements. Equipment measuring higher than the noise limit may be conditionally accepted with approval from Verizon's Technology Organization's NEBS and Quality Assurance Team. Verizon will consider up to +5 dBA over the GR-63 requirements of 60 dBA as an exception to its NEBS requirements when the equipment is tested between 25°C and 30°C ambient temperature. In addition to reporting the acoustic results measured between these temperatures, acoustic values shall be reported with the fans operating at their maximum speed. The pass/fail criterion is applicable when testing is performed between 25°C and 30°C. It is not applicable when the fans are made to operate at their maximum speed. Equipment should not malfunction at 40°C ambient temperature even with a single fan failure or clogged filter.

Weight of Equipment and Impact on Floor Spacing and Loading

Some NGN equipment designs pose concerns over the increased weight of some products. Some new equipment may exceed Verizon's floor spacing and loading requirements although average load within a building bay is acceptable. Some evaluation "shelves" in SIT's laboratories have exceeded 700 pounds in weight with frame loadings approaching 1500 pounds.

10. **Policy:** Verizon will continue to follow to existing floor loading limits for network equipment. GR-63 specifies a total floor loading limit of 735 kg/m^2 (150.6 lb/ft^2). The total load is the sum of a 560-kg/m^2 (114.7-lb/ft^2) equipment frame load, plus a Cable Distribution Systems and lighting fixture load of 125-kg/m^2 (25.6-lb/ft^2) and a 50-kg/m^2

(10.2-lb/ft^2) transient load. GR-63 does not specify specific weight limits on shelves or frames and allows the weight of heavy units to be spread over a larger area.

Use of Overhead Cabling

Verizon's COs use an overhead wiring scheme, bringing power and telephony cables from the cable trays above the equipment. For an individual CO frame, the typical copper cabling design is from the cable rack, down the wiring channels at the sides of equipment frames, and across to the plug-ins in each shelf. This is also suggested in GR-63, Section 2.5.1.2, Objective O2-33, "System Cable Distribution Systems [CDS] should provide adequate clearance for transporting frames in an erect position through the maintenance aisle."

For cabling under a raised floor, GR-63, Section 2.5.1.3, Requirement R2-34 states, "Cabling under the raised-floor shall conform to the requirements of the NEC (National Electrical Code) and applicable state and local codes." Requirement R2-35 states, "The underfloor CDS shall provide for monitoring with smoke detectors and for protecting the cables against…water leaks and dampness."

11. **Policy:** Verizon prefers overhead cabling even when the equipment is installed over a raised floor. Power, copper, and fiber cables shall not be mixed in overhead cable trays.

Use of Front-Access Connectors

Many "traditional" CO vendors attach cables to the rear of their equipment – such that circuit packs and other removable components are easily accessed from the equipment front. This creates a very efficient situation for the technicians who maintain and service the equipment. However, with the deployment of fiber, many vendors have started connecting fiber cables to the equipment faceplate on the front of equipment while continuing to attach copper cables to the rear. Additionally, with the proliferation of vendors and manufacturers with experience in data communications equipment design (without a "telephony" background) and the introduction of equipment designed for European and international markets, Verizon has seen many equipment designs that employ front access for both copper and fiber cables and circuit packs.

12. **Policy:** Given the worldwide market for telecommunications equipment, associated economies of scale and scope, and the endorsement by other countries of "front access" designs, Verizon will accept "front access" designs for connecting both copper and fiber cables – subject to other recommendations contained herein. Rear-facing cabling, however, remains our preferred design.

    Test access connectors shall be mounted on the front of equipment (maintenance aisle side).

Cable Strain Relief and Circuit Pack Access

After examining Verizon's technical documentation for COs (GR-63/GR-1089/GR-78/IP 72201), SIT determined that Verizon has no stated "official" policy as to how cables are to be wired in a CO space. The only noted objective regarding cable entry access is in IP 72201, Section 13.2.6, which indicates, "Cable and wire shall enter into equipment bays/frames/cabinets/units at the location specified per manufactures drawings and/or cabling specification."

13. **Policy:** Verizon recommends that cables be dressed downwards from associated circuit packs in order to facilitate easy removal of the circuit pack. They should then be run horizontally to the wiring channel at the sides of the mounting frame (rack). The cables should then be run up the mounting frame (rack) and into the cable trays. The cables shall be secured to the frame (rack) in a neat and organized manner.

Operations personnel favor those physical designs (e.g., with strain relief, covers or guards) that safeguard both personnel and the cables and connectors from harm.

Orientation of Fiber Connectors

The orientation of fiber connectors on new equipment that Verizon has tested has varied from pointing up, level, and down and appears largely driven by a designer's previous experience. At the same time, the power level of some light sources has increased. Although eye safety has not been an issue to date, some fiber connector orientations are inherently better than others. In many traditional telecommunications designs, fiber connectors are typically oriented in a downward direction, causing little concern for safety; such designs also help protect sensitive optics from dust. Generally, downward pointing wire and fiber connectors also reduce the bending of cables and risk of breakage.

14. **Policy:** Verizon prefers that front-mounted, fiber connectors be oriented downward and be situated in a manner that minimizes the possibility of direct or reflected viewing of coherent laser light.

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