Environmental Profile; Central Offices and Network Data Centers

Version 1.0 May 5, 2008

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1. PURPOSE

As NEPs endeavor to engineer telecommunication systems by drawing upon the COTS ecosystem, they must have a way to qualify the fit of available components for the compliance of the environmental requirements of the world telecommunications market. These environmental requirements are defined by international and national standardization bodies, Network Equipment Providers, and Network Operator requirements. As is common for any set of complex specifications, these documents contain number of options, conflicts and ambiguities. As such, there is little consistency of interpretation of the relevance or content of these specifications, leading to inconsistencies of the compliance levels, or in some cases to non-compliance of the equipment constructed from COTS components with the relevant environmental specifications.

The purpose of this document is to profile the key environmental specifications applicable to network element equipment, and to identify the agreed on minimum set of specifications and specific requirements within those specifications, which need to be supported in each environmental subcategory to be able to address the needs of majority of the world communications equipment markets.

This document addresses indoor environments only, and establishes two subcategories for indoor environments by facility type, as follows:

- “Central Office” facilities: these types of facilities are dedicated facilities, which have been designed to support network infrastructure equipment. CO’s are environmentally controlled telecommunications network facilities often at remote locations. Non CO facilities, like controlled environmental vaults, equipment huts, controlled cabinets and certain customer premises environments may also be applicable installation sites for equipment developed to this environmental class, provided that they control the equipment environment to the extent that it meets the definition of the equipment environment of this class. CO requirements also apply to non-telecom locations which are exclusively used for installations of communication equipment remotely controlled by service providers providing similar environmental controlled environments.

- “Network Data Center” facilities: NDCs are tightly environmentally controlled facilities, which are mainly operated and maintained from locations close to the facility, allowing rapid response time to attend to problems occurring. This environmental class may also be applicable to other spaces, like customer premises, provided that such spaces meet the definition of equipment environment of this class. The equipment designed to this class cannot be installed in typical CO environments without additional control of immediate equipment environment to the extent that it will comply with the requirements of this class.

One major difference between CO and Network Data Center equipment environments is that equipment which meets CO requirement has to be operated over days under worst case surrounding conditions even if the environmental control of the facility fails. This is not necessary for Network Data Center equipment.

While the opportunity exists to establish further subcategories within each class, it is intentionally decided to specify only two categories to minimize COTS ecosystem fragmentation, and to help ensure that the equipment designed to one of these classes have a maximum addressable world market. This also serves to reduce the need by NEPs to develop market specific versions of the equipment, and reduces the inventory requirements at all levels of supply chain. Therefore, Central Office requirements are based on NEBS Level-3 requirements as defined in [TEL5], ETSI and IEC requirements.

Network operators may have both types of facilities in their networks, and the determination of the required category is equipment type and operator specific, and outside the scope of this profile. As a general observation, all equipment designed to “Central Office” environments would generally comply with the relaxed environmental requirements subset for “Network Data Center” type facilities, but the opposite is not generally true.

The scope of this document is on general environmental definitions and equipment building practices only, and does not make any statements specific to equipment form factor specifications, such as AdvancedTCA, MicroTCA or any other specific packaging form factor. The form factor specific additional environmental constraints (if any) are, and will continue to be addressed by the separate SCOPE profiles associated with the specific form factor specifications.

Central office environmental profile includes the requirements of both NEBS, IEC and ETSI environmental specifications, due to certain differences on the requirements, as well as the common requirement for Central Office equipment to be tested to both sets of specifications.

The scope of this document is limited, as much as possible, to primary references that are applicable to majority of the communications equipment market. The normative secondary references in referenced primary reference documents are expected to be applicable, as stated in specific primary reference document. This document is not intended to replace any of the references, and it is assumed that the stakeholders will have access to, or will obtain all the applicable reference documents. The specific requirements from the references are not replicated herein, with the exceptions of the ones identified as needing clarification, or as required to facilitate comparison of the conflicting specifications. Detailed references to primary reference documents are given to help identify the controlling requirements and test procedures.

This document is not intended to be tutorial on *how* to develop equipment that is compliant with the environmental and physical design requirements, but to identify what the associated specifications and requirements are. In some cases, brief rationale is provided on why specific requirement is applicable, for conflict resolution between specifications, or when the gaps on requirements are identified.

2. AUDIENCE

This document is intended for the following audiences:

- ✓ System integrators integrating components from multiple sources onto compliant Carrier Grade Base Platforms
- ✓ Frame and cabinet vendors targeting frame level enclosures for Carrier Grade Base Platforms
- ✓ Enclosure vendors of Carrier Grade Base Platforms
- ✓ Board, module and other component vendors who market their products for use in Network Elements built on Carrier Grade Base Platforms
- ✓ Standardization bodies and related trade associations developing specifications and/or test methodologies associated with equipment building practices or associated environmental specifications targeting the Carrier Grade Base Platform market. This document identifies certain gaps on existing specifications and as such provides input for consideration on the future specification revisions and new specification development.

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4. REFERENCES AND ISSUING ORGANIZATIONS

The following references have been listed alphabetically by issuing source, and subsequently generally in the order they appear in this document. Be advised that the specifications listed below are current as of writing of this document, but stakeholders are advised to check for the latest versions and ongoing updates before designing to these. Pointers for document sources are given here, and pointers for many of the working groups involved on maintaining and issuing these specifications are given later in this document. Additional, operator specific reference documents are listed in Annex-A of this document.

ANSI / ATIS

American National Standards Institute (ANSI) has published a number of environmental specification documents that are referenced by Telcordia NEBS specification, and some that are not referenced therein. ANSI documents most relevant to the scope of this document are presently developed by Alliance for Telecommunications Industry Solutions (ATIS), Network Interface, Power and Protection (NIPP) subcommittee. NIPP homepage is at: http://www.atis.org/0050/index.asp . Documents can be obtained from www.ansi.org, http://webstore.ansi.org/

[ANS1] Engineering Requirements for a Universal Telecom Framework, ANSI T1.336-2003

[ANS2] ANSI/UL60950-1, “Information Technology Equipment – Safety – Part 1: General Requirements”, Underwriters Laboratories, UL60950-1, Second Edition, March 27, 2007 (also known and referenced as CAN-CSA-C22.2 No. 60950-1-07 Second Edition, and ANSI/UL 60950-1-2007)

[ANS3] Voltage Levels for DC-Powered Equipment Used in the Telecommunications Environment, ATIS-PP-0600315.2007 [This replaces old version presently referenced by NEBS GR-1089-CORE and other specifications, which was referred as T1.315-2001. The PP (Pre-Published) version will be updated to ATIS- 0600315.2007 after completion of editing and publication cycles.]

[ANS4] Telecommunications Infrastructure Standard for Network Data Centers, ANSI/Telecommunications Industry Association, ANSI/TIA-942-2005 / TIA 942, April 12, 2005

[ANS5] Cabinets, Racks, Panels, and Associated Equipment, ANSI/EIA-310-D-1992, August 24, 1992

[ANS6] American National Standard for Safe Use of Lasers, ANSI Z136.1-2007

[ANS7] American National Standard; Safe Use of Optical Fiber Communications Systems Utilizing Laser Diode and LED Sources, ANSI Z136.2 (1997)

[ANS8] Equipment Assemblies – Fire Propagation Risk Assessment Criteria, ANSI T1.319-2002

[ANS9] Fire Resistance Criteria – Ignitability Requirements for Equipment Assemblies, Ancillary Non-Metallic Apparatus, and Fire Spread Requirements for Wire and Cable, ANSI T1.307-2003

American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)

ASHRAE has been instrumental on definition of the standardized environments for the DataCenters and Communications Facilities. By the nature of the issuing organization, ASHRAE definitions focus on facility and equipment level environmental contract pertaining to the cooling and heat transfer related aspects. The most relevant ASHRAE subcommittee is Technical Committee TC 9.9, "Mission Critical Facilities, Technology Spaces and Electronic Equipment", which homepage can be found at http://tc99.ashraetcs.org/ . The published ASHRAE documents presently do not define standardized tests to verify compliance to the specified criteria. ASHRAE documents can be obtained from www.ashrae.org

[ASH1] Datacom Equipment Power Trends and Cooling Applications, ASHRAE, 2005, ISBN 1-931862-65-6 (version prior to ASHRAE update that this document is based on can be downloaded from www.uptimeinstitute.org – see 2005-2010 Heat Density Trends whitepaper).

[ASH2] Thermal Guidelines for Data Processing Environments, ASHRAE, 2004, ISBN 1-931862-43-5

[ASH3] Design Considerations for Datacom Equipment Centers, AHSRAE, 2005, ISBN 1-931862-94-X

[ASH4] Liquid Cooling Guidelines for Datacom Equipment Centers, ASHRAE, 2006, ISBN-10: 1-933742-05-4

[ASH5] Structural and Vibration Guidelines for Datacom Equipment Centers, ASHRAE, 2007, ISBN: 987-1-933742-20-5

Cenelec

[EN1] "Information technology equipment including electrical business equipment", European Norm, European Committee for Electrotechnical Standardization (CENELEC), EN60950-1:2006

Code of Federal Regulations (US regulatory)

The latest versions of CFRs can be determined and obtained by following the links from here: http://www.access.gpo.gov/nara/cfr/cfr-table-search.html

[CFR1] "OCCUPATIONAL SAFETY AND HEALTH STANDARDS", Code of Federal Regulations, Title 29 – Labor, Chapter XVII – Occupational Safety and Heath Administration, Department of Labor, Part 1910, 21CFR1910 (requires compliance to ANSI/UL 60950-1 for safety for "information technology" equipment, as "An appropriate test standard")

[CFR2] "PERFORMANCE STANDARDS FOR LIGHT EMITTING PRODUCTS ", Code of Federal Regulations, Title 21 -- Food and Drugs, Chapter I – Food and Drug Administration , Department of Health and Human Services, Subchapter J – Radiological Health, Part 1040, 21 CFR1040.10

[CFR3] "Occupational Noise Exposure", Code of Federal Regulations, Title 29, Part 1910, Subpart 95 (1910.95), U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), 29 CFR1910.95

[CFR4] "RADIO FREQUENCY DEVICES", Code of Federal Regulations, Title 47 -- Telecommunication, Chapter I – Federal Communications Commission, Part 15 – Radio Frequency Devices, 47CFR15.

European Community Documents

[EC1] (noise) DIRECTIVE 2003/10/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of February, 2003 on the minimum heath and safety requirements regarding the exposure of workers to the risks arising from physical agents

[EC2] (RoHS) DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (and latest associated amendments)

[EC3] (WEEE) DIRECTIVE 2002/96/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on waste electrical and electronic equipment (WEEE) (and latest associated amendments)

[EC4] DIRECTIVE 2006/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits (and 2008/C 28/01 for harmonized standards list (and latest associated amendments)

[EC5] (EMC) DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility

European Telecommunications Standards Institute (ETSI)

ETSI is responsible for the development of the specifications pertaining to environmental aspects on storage location, transportation and operational environments, electromagnetic compatibility, cooling, power interfaces, and energy efficiency with focus on European market. The main environmental specification development is carried out by “environmental Engineering” committee, which homepage can be found by following “EE” link at http://portal.etsi.org/Portal_Common/home.asp . ETSI Documents can be obtained from www.etsi.org

[ETS1] Environmental Engineering (EE); European telecommunications standard for equipment practice; Part 1: Introduction and terminology, ETSI EN 300 119-1, V2.1.1, 2004-09

[ETS2] Environmental Engineering (EE); European telecommunications standard for equipment practice; Part 2: Engineering requirements for racks and cabinets, ETSI EN 300 119-2, V2.1.1, 2004-09

[ETS3] Environmental Engineering (EE); European telecommunications standard for equipment practice; Part 3: Engineering requirements for miscellaneous racks and cabinets, ETSI EN 300 119-3, V2.1.1, 2004-09

[ETS4] Environmental Engineering (EE); European telecommunications standard for equipment practice; Part 4: Engineering requirements for subracks in miscellaneous racks and cabinets, ETSI EN 300 119-4, V2.1.1, 2004-09

[ETS5] Environmental Engineering (EE); European telecommunications standard for equipment practice; Part 5: Thermal Management, ETSI EN 300 119-5, V1.2.2, 2004-12

[ETS6] Environmental Engineering (EE); European telecommunications standard for equipment practice; Thermal Management Guidance for equipment and its deployment, ETSI TR 102 489, V1.1.1, 2004-06

[ETS7] Equipment Engineering (EE); Environmental Engineering; Guidance and Terminology, ETSI ETR 035, July 1992

[ETS8] Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-0: Classification of environmental conditions; Introduction, ETSI EN 300 019-1-0, V 2.1.2, ETSI, 2003-09

[ETS9] Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment, Part 1-1: Classification of environmental conditions; Storage, ETSI EN 300-019-1-1, V2.1.4, ETSI, 2003-04

[ETS10] Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment, Part 1-2: Classification of environmental conditions; Transportation, ETSI EN 300-019-1-2, V2.1.4, ETSI, 2003-04

[ETS11] Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weatherprotected locations, ETSI EN 300 019-1-3, v2.2.2, ETSI, 2004-07

[ETS12] Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-0: Specification of environmental tests; Introduction, ETSI EN 300 019-2-0, V 2.1.2, ETSI, 2003-09

[ETS13] Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-1: Specification of environmental tests; Storage, ETSI EN 300 019-2-1, V 2.1.2, ETSI, 2000-09

[ETS14] Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-2: Specification of environmental tests; Transportation, ETSI EN 300 019-2-2, V 2.1.2, ETSI, 1999-09

[ETS15] Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-3: Specification of environmental tests; Stationary use at weatherprotected locations, ETSI EN 300 019-2-3, V 2.2.2, ETSI, 2003-04

[ETS16] Equipment Engineering (EE); Acoustic noise emitted by telecommunications equipment, ETSI ETS 300 753, ETSI, October 1997

[ETS17] Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources, ETSI EN 300 132-1, ETSI, September 1996

[ETS18] Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc), ETSI EN 300 132-2, V2.2.2, ETSI, 2007-10

[ETS19] Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400V, ETSI EN 300 132-3, V1.2.1, ETSI, 2003-08

[ETS20] Equipment Engineering (EE); Earthing and bonding of telecommunications equipment in telecommunication centres, ETSI EN 300 253, V2.1.1, ETSI 2002-04

[ETS21] Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Telecommunications Network Equipment; ElectroMagnetic Compatibility (EMC) Requirements, ETSI EN 300 386, V1.3.3 ETSI, 2005 Note: [ETS21] is anticipated to be replaced by this version after the vote on it has been completed: Electromagnetic Compatibility and Radio

Spectrum Matters (ERM); Telecommunications Network Equipment; ElectroMagnetic Compatibility (EMC) Requirements, ETSI EN 300 386, V1.4.1, ETSI 2008-02 (final draft)

[ETS22] Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Additional Electromagnetic Compatibility (EMC) requirements and resistibility requirements for telecommunications equipment for enhanced availability of service in specific applications, ETSI EN 201 468, V 1,3,1, ETSI, 2005-08

[ETS23] Equipment Engineering (EE); Electrostatic environment and mitigation measures for Public Telecommunications Network (PTN), ETSI ETR 127, ETSI, March 1994

IEC Documents - http://www.iec.ch/

[IEC1] Safety of information technology equipment including electrical business equipment, International Electrotechnical Commission (IEC), IEC 60951-1 2nd edition, 2005-12, IEC 2005

[IEC2] Information Technology Equipment – Radio disturbance Characteristics – Limits and methods of measurement, CISPR 22 (latest version including current amendments)

[IEC3] Information Technology Equipment – Immunity Characteristics – Limits and Methods of measurement, CISPR 24 (latest version including current amendments)

[IEC4] Electromagnetic Compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current <=16A per phase), IEC 61000-3-2, Third Edition, 2005-11

[IEC5] Electromagnetic Compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <=16A per phase and not subject to conditional connection, IEC 61000-3-3, Edition 1.2, 2005-10

[IEC6] Electromagnetic Compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test, IEC 61000-4-2, Edition 1.2, 2001-04

[IEC7] Electromagnetic Compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test, IEC 61000-4-8, Edition 1.1, 2001-03

[IEC8] Electromagnetic Compatibility (EMC) – Part 4-3: Testing and measurement techniques – radiated, radio-frequency, electromagnetic field immunity test, IEC 61000-4-2, Third Edition, 2006-02

[IEC9] Electromagnetic Compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test, IEC 61000-4-4, Second Edition, 2004-07

[IEC10] Electromagnetic Compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test, IEC 61000-4-5, Second Edition, 2005-11

[IEC11] Electromagnetic Compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields, IEC 61000-4-5, Edition 2.2, 2006-05

[IEC12] Electromagnetic Compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests, IEC 61000-4-11, Second Edition, 2004-03

Quest Forum Documents - http://www.tl9000.org/tl_hbks.htm

[QUE1] TL9000 Quality Management System (QMS) Requirements Handbook, Release 4.0, (Quality Excellence for Suppliers of Telecommunications Forum) – QuEST Forum, Effective on and after June 30, 2007.

[QUE2] TL9000 Quality Management System (QMS) Measurements Handbook, Release 4.0, (Quality Excellence for Suppliers of Telecommunications Forum) – QuEST Forum, 2006, Effective on and after January 1, 2007.

SCOPE Alliance Documents

SCOPE alliance documents can be obtained from www.scope-alliance.org

[SCO1] SCOPE AdvancedTCA™ HW Profile, latest version

[SCO2] SCOPE MicroTCA™ HW Profile, latest version

[SCO3] SCOPE Services and Support Profile – Service Availability, latest version

[SCO4] SCOPE Services and Support Profile – Long Life Cycle Support, latest version

Telcordia Documents

Telcordia is responsible for issuing and maintaining a set of environmental specification documents pertaining to Central Office equipment for North American Market, collectively known as “Network Equipment Building System” (NEBS) specifications. These specifications cover all environmental aspects, including mechanics, transportation, operation, electromagnetic compatibility, cooling and power interfaces. NEBS specifications have also been adopted by certain operators in other geographies. Specification development is done in Telcordia coordinated specification development and/or update projects with interested stakeholders (mostly Network Operators and NEPs) participating at fee. Telcordia specifications and information on ongoing and planned specification development activities can be obtained from www.telcordia.com.

[TEL1] NEBS Requirements: Physical Protection, GR-63-CORE, Issue 3, March 2006, Telcordia

[TEL2] Thermal Management in Telecommunications Central Offices, GR-3028-CORE, Issue 1, December 2001, Telcordia

[TEL3] Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment, GR-1089-Core, Issue 4, Telcordia

[TEL4] Generic Requirements for the Physical Design and Manufacture of Telecommunications Products and Equipment, GR-78-CORE, Issue 2, September 2007

[TEL5] NEBS Criteria Levels, A module of NEBSFR, FR-2063, Telcordia Technologies Special Report, SR-3580, Issue 3, June 2007, Telcordia

[TEL6] Reliability Prediction Procedure for Electrical Equipment, SR-332 Issue 1, May 2001, Telcordia

[TEL7] Reliability Prediction Procedure for Electrical Equipment, SR-332 Issue 2, September 2006, Telcordia

[TEL8] Central Office/Network Environment Equipment Installation / Removal Generic Requirements, GR-1275-CORE, Issue 8, December 2006

[TEL9] Human Factors Requirements for Equipment to Improve Network Reliability, GR-2914-CORE, Issue 4, December 1998, Bellcore (now Telcordia)

[Tel10] Common Language Equipment Codes (CLEI Codes) – Generic Requirements for Processes and Guidelines, GR-485-CORE, Issue 5, April 2004

[TEL11] Common Language Equipment Codes (CLEI Codes) – Generic Requirements for Product Labels, GR-383, Issue 3, February 2006

[TEL12] Central Office / Network Environment Detail Engineering Generic Requirements, GR-1502-CORE, Issue 5, December 2006

[TEL13] Mesh and Isolated Bonding Networks: Definition and Application to Telephone Central Offices, GR-295, Issue 1, November 2004

Other Documents

[DOC1] Electric Current Abroad, U.S. Department of Commerce, International Trade Administration, February 2002.
http://www.ita.doc.gov/media/Publications/pdf/current2002FINAL.pdf

[ICES3] ICES-003 Issue 4 - Spectrum Management and telecommunications Policy- Interference-Causing Equipment Standard - Digital Apparatus, ICES-003, Issue 4, February 2004 (Industry Canada)

5. TERMS AND DEFINITIONS

AC	Alternating Current
ANSI	American National Standards Institute
ASD	Acceleration Spectral Density
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
ATCA	Advanced Telecommunication Computing Architecture. Also known as AdvancedTCA™.
ATIS	Alliance for Telecommunications Industry Solutions
CEV	Controlled Environment Vault
CFR	Code of Federal Regulations (US)
CLEI	Common Language Equipment Identifier
CO	Central Office
COTS	Commercial Off The Shelf
DC	Direct Current
EC	European Community
ECMA	European Computer Manufacturers Associations
EIA	Electronic Industries Alliance
EMC	ElectroMagnetic Compatibility
ETSI	European Telecommunications Standards Institute
FRU	Field Replaceable Unit
HDD	Hard Disk Drive
IEC	International Electrotechnical Commission
NEBS	Network Equipment Building System
NDC	Network Data Center
NEP	Network Equipment Provider
NO	Network Operator
NRTL	Nationally Recognized Testing Laboratory (per 29CFR1910.7)
OSHA	Occupational Safety and Heath Administration (US Dept. of La-bor)
OSP	OutSide Plant
RoHS	Restriction of Hazardous Substances
TCG	Telecommunications Carrier Group
TIA	Telecommunications Industry Association
U	Unit, Short for Rack-Unit, Measure of vertical rack space, 1U=1.75” (44.45mm)
UPS	Uninterruptible Power Supply
WEEE	Waste Electrical and Electronic Equipment

Please consult the referenced source documents for the term definitions. In addition, PICMG web site provides Master Glossary which defines many of the related terms, as well as terms specific to PICMG specifications. This glossary can be found at http://www.picmg.org/v2internal/PICMGGlossary.htm .

6. STAKEHOLDERS, ROLES AND RESPONSIBILITIES

To be able to formulate the roles and responsibilities associated with the successful development of the equipment to this profile, we first need to define the key involved parties.

Network Operator (NO)

Network Operator in context of this document is the operator of the communications network, and usually provider of communications services to end customers, which may be residential customers, businesses or other network operators. Network Operator is the end customer for the Network Equipment, and usually customer of the NEPs. Network operators are responsible for the installation, maintenance and operation of the equipment, and either directly or indirectly responsible for the environmental characteristics of the facilities hosting the equipment.

Network Equipment Provider (NEP)

NEP, in the context of this document is the provider of the Network Equipment to Network Operator. NEPs are sometimes also referred as "Telecommunications Equipment Manufacturer" (TEM). NEPs are building solutions for Network Operators, based on COTS components from CCVs and/or systems from System Integrators and/or own system hardware and/or software components.

System Integrator (SI)

System Integrators are parties responsible for integration of the hardware and software components (often originating from multiple sources) onto single system. System Integrators may also be responsible for the supervision of execution of the environmental compliance testing by Certified Testing Laboratories. Network Equipment Providers may choose to perform all system integration activities themselves, or engage 3rd party system integration to handle some level of the integration work.

COTS Component Vendor (CCV)

CCVs are the parties responsible for the physical design and manufacturing of the components intended for integration in the Network Equipment by SIs and NEPs. CCVs develop hardware and software components according to the requirements defined by their target markets and applications, relevant form factor specifications (such as AdvancedTCA™ or μTCA™), and relevant environmental specifications.

Independent Testing Laboratory (ITL)

Independent testing laboratories are accredited laboratories that are certified by standard specific authorities to conduct all aspects or specific subset of the environmental compliance tests. Independent testing laboratories conduct the final environmental tests on behalf of NEPs or System Integrators to certify the final product to satisfy Network Operator's environmental compliance criteria based on the applicable standards. The tests are usually conducted at network Equipment level for the configuration and environments specified by NEPs and/or System Integrators. Term "Independent" generally means that these test laboratories are not directly affiliated with the NEPs or System Integrators to facilitate the objective and independent testing to the underlying specifications.

7. ENVIRONMENTAL PROFILE

7.1 Introduction and structure

This chapter summarizes the environmental requirements in Central Offices and Network Data Centers, as specified by applicable specifications identified before. On the one hand, the service provider has to guarantee the fulfillment of those conditions, and on the other hand the network equipment provider has to guarantee the contracted system behavior when network equipment is subjected to these environments.

This document is targeted at identifying the small common design and test targets to which all stakeholders can align to serve majority of the world market for the network equipment. As such, this document is not an exhaustive list of all applicable requirements; please refer to referenced source documents for detailed requirements.

It is recognized that profiling the source documents could potentially lead to very high number of the different environmental profiles. It is intentionally constrained to small number (i.e. two environments - Central Offices and Network Data Centers), to avoid the fragmentation of the COTS HW component ecosystem, while at the same time targeting the maximal applicability to world communications equipment market. As such, the profile tends to take the conservative approach and align with the stricter definitions for any given topical domain.

The deviations of the profiled requirements as given here may be acceptable in some situations, but the stakeholders with limited compliance are advised to thoroughly analyze and understand the consequences and extent of limit on market applicability of such decisions.

The source material in which this document is based on is composed of number of specification documents from different sources. As such, this does not strictly follow the structure of any of the source specifications. Instead, the attempt has been made to structure the content in this document in terms of related sub domains, as relevant for either design or test activities.

The following profile material is organized on the subsections, as described in table 7.1, below.

Table 7.1 – Environmental Profile Organization

Section	Title	Description
7.2	**Environmental specification summary**	Provides a summary of the applicable environmental specifications used as an input to this specification profile.
7.3	**Physical construction**	Defines practices related to mechanical interfaces, cabling, airflow protocols, floor loading, and heat release
7.4	**Climatic – transportation and storage**	Defines climatic conditions pertaining to packaged equipment during the transportation and storage
7.5	**Climatic – operation**	Defines climatic conditions during the use of the equipment, including recommended, normal and exceptional temperatures, temperature/altitude conditions, and additional requirements pertaining to forced air cooling and temperature test
7.6	**Surface and air temperatures**	Defines the limits of the equipment surface and flow-through air temperatures
7.7	**Airborne contaminants**	Defines the airborne contamination levels, and requirements associated with air filtering
7.8	**Acoustic emissions**	Defines the limits associated with equipment acoustic emissions
7.9	**Safety**	Defines safety related aspects not defined elsewhere
7.10	**Vibration and shock resistance, transportation, handling & Storage**	Defines vibration conditions pertaining to packaged equipment during the transportation and storage
7.11	**Vibration resistance, use**	Defines vibration conditions pertaining to equipment during use
7.12	**Earthquake resistance**	Defines conditions pertaining to equipment tolerance to earthquakes during use

Table 7.1 – Environmental Profile Organization (Continued)

Sec-tion	Title	Description
7.13	**Power and grounding**	Defines the requirements for power and grounding interfaces of the equipment
7.14	**ElectroMagnetic Compatibility (EMC)**	Defines the requirements for the electromagnetic emission limits and electromagnetic radiation immunity.
7.15	**Design and manufacture**	Defines requirements associated with design and manufacture of equipment.
7.16	**Reliability, Availability and Serviceability (RAS)**	Defines requirements associated with design and test for RAS.
7.17	**Ecological compatibility**	Defines requirements for “green” aspects, like RoHS/WEEE and other such standards.

7.2 Environmental specification summary

This profile focuses on the 1st level specifications, as applicable to the design of *Network Elements* and specifically options and requirements that are subject to interpretation in terms of language and/or applicability and attempts to formulate a collective stand by NEPs on which of numerous “objectives”, “conditional” or “optional” requirements are required and which are not.

This document does not intend to replace any of the identified source specifications, and it is assumed that the stakeholders involved with the design or test activities associated with environmental specifications have access to all relevant specification documents identified here, as well as the 2nd level specifications referred therein as applicable. This document is intended to be read in conjunction of the source specifications, and does not attempt to reproduce them here, except when needed to facilitate highlighting the commonalities and differences between different environments and associated specifications, or otherwise for clarification of source material.

The summary of the applicable 1st level source specifications by subject matter category for the different environments is given in Table 7.2, below.

Table 7.2 Environmental Specifications Summary

Subject Matter	NEBS CO	ETSI CO	Network Data Center
Physical Construction			
Facility	GR-63 [TEL1], GR-3028 [TEL2]	ETSI EN 300 119-1 [ETS1]	ASHRAE DP [ASH1], ASHRAE DC [ASH2] TIA-942 [ANS4]
Frame	GR-63 [TEL1]	ETSI EN 300 119-3 [ETS3]	EIA-310D [ANS5], T1.336 [ANS1]
Subrack	GR-63 [TEL1]	ETSI EN 300 119-4 [ETS4]	EIA-310D [ANS5], T1.336 [ANS1]
Airflow Protocol	GR-63 [TEL1], GR-3028 [TEL2]	EN 300 119-5 [ETS5], TR 102 489 [ETS6]	ASHRAE DP [ASH1], ASHRAE DC [ASH2]
Climatic Environment			
Storage	GR-63 [TEL1]	EN 300-019-1-1 [ETS9] EN 300-019-2-1 (tests) [ETS13]	N/S
Transportation	GR-63 [TEL1]	EN 300-019-1-2 [ETS10] EN 300-019-2-2 (tests) [ETS14]	N/S
Use	GR-63 [TEL1], Shelf Level	EN 300-019-1-3 [ETS11] EN 300-019-2-3 (tests) [ETS15]	ASHRAE DP [ASH1], ASHRAE DC [ASH2], Class 2
Airborne Contaminants (use)	GR-63 [TEL1]	EN 300-019-1-3 [ETS11]	ASHRAE DP [ASH1], ASHRAE DC [ASH2]
Heat Release	GR-63 [TEL1], GR-3028 [TEL2]	N/S	ASHRAE DP [ASH1], ASHRAE DC [ASH2]
Surface & Air Temperatures	GR-63 [TEL1], UL.CSA60950-1	EN 300 119-5 [ETS5], EN 60950-1 [EN1]	IEC60950-1 [IEC1]
Acoustic Emissions	GR-63 [TEL1], 29CFR1910.85 [CFR3]	ETS 300 753 [ETS16], [EC1]	ASHRAE DC [ASH1], 29CFR1910.85 [CFR3], [EC1]

Table 7.2 Environmental Specifications Summary (continued)

Subject Matter	NEBS CO	ETSI CO	Data Center
Safety	IEC60950-1 [IEC1] with all specific national amendments and changes.		
Power Interfaces			
DC power	ATIS 0600315 [ANS3]	EN 300 132-2 [ETS18]	ATIS 0600315 [ANS3]
AC power	GR-1089 [TEL3]	EN 300 132-1 [ETS17], EN 300 132-3 [ETS19]	
Electrical Safety	GR-63 [TEL1], GR-1089 [TEL3]	EN60950-1 [EN1]	IEC60950-1 [IEC1]
Fire Resistance	GR-63 [TEL1]	EN60950-1 [EN1]	IEC60950-1 [IEC1]
Vibration			
Storage	GR-63 [TEL1]	EN 300-019-1-1 [ETS9] EN 300-019-2-1 (tests) [ETS13]	([ASH5])
Transportation	GR-63 [TEL1]	EN 300-019-1-2 [ETS10] EN 300-019-2-2 (tests) [ETS14]	([ASH5])
Use	GR-63 [TEL1]	EN 300-019-1-3 [ETS11] EN 300-019-2-3 (tests) [ETS15]	([ASH5])
Earthquakes	GR-63 [TEL1]		([ASH5])
EMC			
Emissions (All Equipment)	FCC part 15 (47CFR15) [CFR4], CISPR-22 [IEC2]		
Emissions (Telco)	GR-1089 [TEL3]	EN 300 386 [ETS21]	
Immunity (All Equipment)	CISPR-24 [IEC3]		
Immunity (Telco)	GR-1089 [TEL3]	EN 300 386 [ETS21]	
Reliability, Availability, Serviceability (RAS)			
Reliability Predictions	SR-332 [TEL6, TEL7]		
Reliability Field Performance	TL-9000 Metrics [QUE1, QUE2]		
Service Life (Equipment)	10 to 15+ Years		3 to 5 Years
Service Life (FRUs)	5 to 10 Years		3 to 5 Years
Availability	4 to 6+ NINES		3 to 5+ NINES
Ecological Compatibility			

Hazardous Substances	RoHS [EC2]
Waste Management	WEEE [EC3]

7.3 Physical construction

This section deals with the mechanical interfaces, cabling practices, and floor loading and heat release characteristics of equipment.

7.3.1 Facility level introduction

The facility level construction is outside of the scope of this document, and therefore the treatment here is limited to overview of the commonalities and differences between the central office facilities and data communications facilities, as well as pointers to documentation for those that want to read more detailed descriptions about the particular facility types.

Both Central offices and Network Data Centers commonly utilize the cold-aisle – hot-aisle configuration for equipment lineups. Depending on the specific facility, the air supply to cold aisle is typically either from ducting from top down, or from perforated tiles through raised floor, or combination of the two. Hot air recovery from hot-aisle in both environments is usually done through ducting on top.

From the equipment subrack level design perspective, the cooling air supply does not make any substantial difference, and neither does the cabling direction. This profile assumes front-to-back airflow protocol for both environments, and subrack cabling directed towards the left and right edges of the subrack, where the cables can be routed up or down, depending on the installation preferences.

The major differences between these two facility types is the degree of environmental conditions (in terms of temperature, humidity and airborne contaminants), and the requirements imposed to network elements for operation during failure and other worst case conditions. Powering is different in terms of Central Offices utilizing the redundant, battery backed -48VDC power, and datacenters utilizing AC power, usually with generator back up. While there are no need of COs adopting AC power, there is ongoing discussion on DC power use in the DataCenter environments.

The facility level compatibility is the ultimate driving force for the subrack level equipment design, and the subsequent chapters on this profile provide relevant details highlighting the key commonalities and differences on equipment practices for these facility categories.

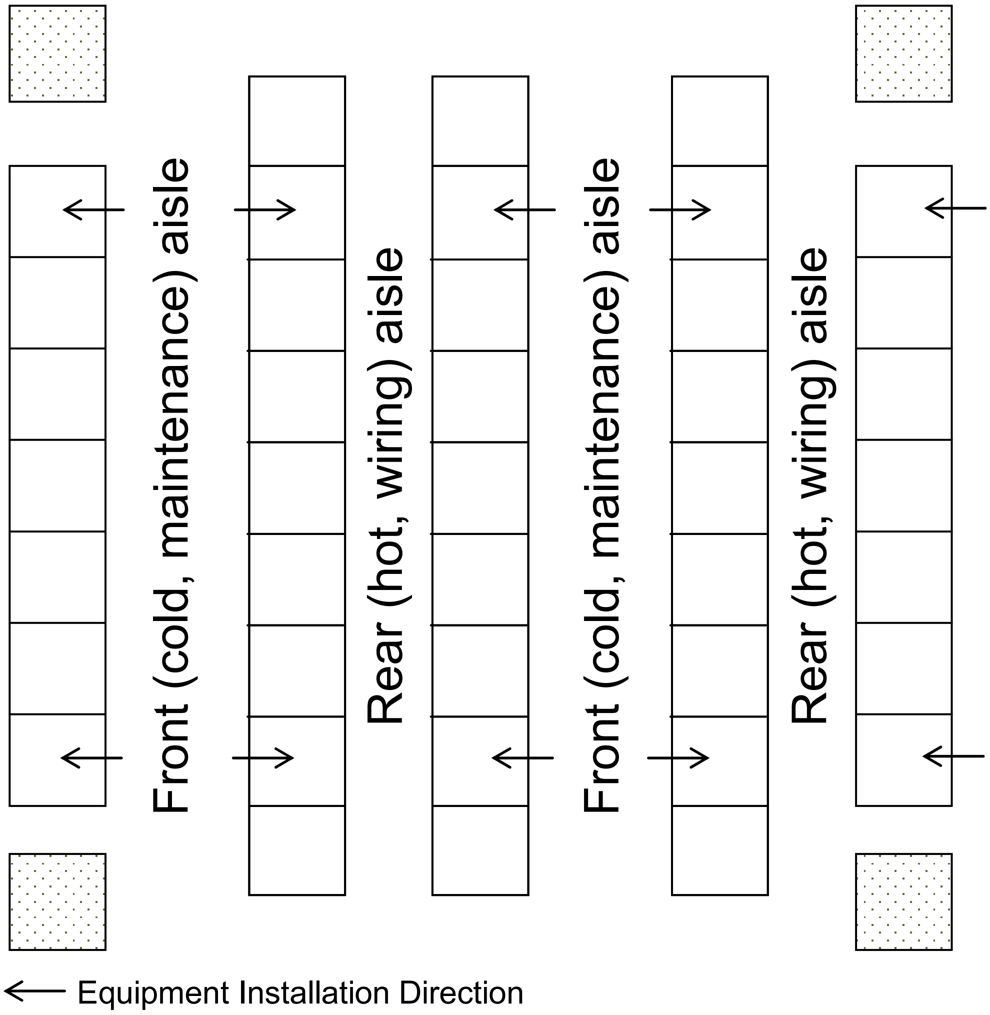


Figure 7.3.1 Example equipment line-up

Detailed descriptions on the facility level implementations and installation practices can be found by consulting references, [ASH1], [ASH2], [ASH3], [ANS1], [ANS4], [ETS5], [ETS6], [TEL1], [TEL2], and [TEL8].

7.3.2 Frame/cabinet mechanical interfaces

Table's 7.3.2-1 and 7.3.2.-2 provide a summary of the frame and shelf interface practices per environment. Note that the focus of this document is on shelf level equipment, and number of additional requirements applies to frames. Consult the source documents for the additional frame level requirements.

Table 7.3.2 – Frame/Cabinet Mechanical Interfaces

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Frame External Width	**600mm (23.62")**			CO installations allow increased width in 150mm increments, upto 750mm. Such configurations are NOT preferred.
Requirement ref.	[ANS1] 5.6.5.1, [TEL1] O2-19	[ETS3] 3.2, [ETS2] 3.2	[ANS4] 5.11.7.8, [ANS1] 5.6.5.1	
Frame Depth	**600mm (23.62")**		**<900mm preferred**	CO installations allow increased depth in 150mm increments, upto 900mm. Such configurations are NOT preferred.
Requirement ref.	[ANS1] 5.6.4.2, [TEL1] O2-19	[ETS2] 3.3, [ETS3] 3.3	[ANS4] 5.11.7.8, [ANS1] 5.6.4.2	
Frame Height	**2133.6mm (84")**	**2200mm (86.62")**	**2133.6mm (84")**	[ANS1] 8.7 calls for height extenders to allow frame height to be brought to 2200mm if needed
Requirement ref.	[ANS1] 5.6.3.1, [TEL1], O2-19	[ETS2] 3.1, [ETS3] 3.1	[ANS4] 5.11.7.3	
Minimum Usable vertical Equipment Space	**44U (77")**	**2000mm (44U)**	**42U (73.5", 1866.9mm)**	
Requirement ref.	[ANS1] 5.6.6.3	[ETS3], Table 1	[ANS4] 5.11.7.5	
Frame Door Depth	**25mm (1") maximum**			
Requirement ref.	[ANS1], 8.1.1.	[ETS2] 3.1, [ETS3] 3.1	[ANS1], 8.1.1.	
Max Packaged Frame Dimensions	**Fit Through etrance of 1219mm (4ft) wide & 2438mm (8ft) high**	**2500mmx1200 mmx900mm**	**Doors minimum 1m (3ft) wide, 2.13m (7ft) high.**	
Requirement ref.	[TEL1], R2-3	[ETS2] 8, [ETS3] 8	[ETS4] 5.3.4.6	

Table 7.3.2-2 Shelf mechanical Interfaces

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Shelf Mounting Aperture (max equipment width, excluding mounting flanges)	**500mm**		**450mm**	Equipment designed to 450mm aperture can be (and routinely will be) installed to wider frames. Suppliers should design alternative mounting flanges or flange extension kits to support such installations.
Requirement ref.	[ANS1], Table 2 (600mm wide frame)	[ETS3], Table 1	[ANS5], Section 1	
Max. Shelf Mounting Flange Width	**535 mm**		**483.4mm (19")**	See above
Requirement ref.	[ANS1], Table 2 (600mm wide frame)	[ETS3], Table 1	[ANS5], Section 1	
Shelf Mounting Hole Pitch (Vertical)	**NxU**	**Nx25mm**	**NxU**	Design Mounting Holes to accommodate both 1U and 25 mm pitch (see [ANS1] 5.6.6.9
Requirement ref.	[ANS1] 5.6.6.9	[ETS3], Table 1	[ANS1] 5.6.6.9	
Shelf Mounting Hole Pitch (Horizontal)	**515mm (20.27")**		**465mm (18.31")**	
Requirement ref.	[ANS1], Table 2 (600mm wide frame)	[ETS3], Table 1	[ANS1], Table 2 (600mm wide frame), [ANS5], Section 1	

Dual pitch mounting holes can only be utilized, if there is enough vertical space. CO equipment mounting holes should be designed for dual pitch, if there is enough vertical space.

Equipment designed to fit on 450mm mounting aperture can be used in all building practices with the support of proper mounting flange options. However, 500mm aperture is preferred by Telco standards (both NEBS and ETSI), and can result in cost benefits due to reduced infrastructure cost to support more of the FRU payload slots in common equipment practices due to space available for extra slots with relatively low incremental increase on the overall enclosure cost over 450mm wide equipment. Therefore, the 500mm options to optimize enclosure and system cost structure should be taken in the account on subrack building practice standards development, and these options should be made available for the NEPs by the Carrier-Grade Base Platform enclosure vendors.

Due to the installed base of the frames in the Central Offices in North America, many of the frames / cabinets in this space are 23” wide. Therefore, optional mounting kits to fit onto this building practice need to be supported by equipment designed to both 450mm and 500mm shelf mounting apertures.

Mounting flange position depends on network element height/depth aspect ratio. It is recommended to have center mounting flange option for COs in addition to front mounting flanges. For the deep equipment with small vertical space (such as deep 1U elements), slides and/or 4 post mounting should be supported. Additionally, for heavy shelves, rear support in addition to front support may be required to meet seismic requirements.

7.3.3 Subrack practices for no-back-access equipment

No-back access installation practices are generally only applicable to Central Office environments, including some auxiliary environments where the adequate environmental conditioning exists, such as some OSP CEVs and equipment huts (and some customer premises locations).

Some equipment, particularly network access and transmission equipment have been, and continue to be commonly designed to 300mm deep (12” deep in North America) practice.

The design and construction of subracks for installation in such practices have some important differences in terms of depth, FRU service and maintenance access and airflow protocols. These are briefly summarized below.

Shelf Depth: maximum 300mm, including all cabling and any front and rear protrusions. Note that the exhaust airflow plenum space may impose further depth restrictions, depending on the airflow protocol and frame level design.

Maintenance and cabling access: all FRUs, cabling, air filters and other parts requiring service access must be accessible at the front of the subrack.

Airflow protocols: Back-to-back installations in 600-750mm deep frames are possible, airflow exhaust is through "chimney" to top of frame/cabinet. Additionally, these equipment can be installed against the walls or other barriers with no back access, airflow exit would be towards the top of frame/cabinet in such cases. Side exhaust may be utilized in some frames/cabinets to facilitate larger exhaust airflow duct cross section and reduced airflow impedance associated with larger duct geometry. See section 7.3.7. for more information on the airflow protocol classes.

7.3.4 Equipment labeling and markings

Chassis and FRU designs must allow the customization of the markings to NEP specific "look and feel" specifications. Preferred way to accomplish this is to design the whole FRU front panel marking set as a plastic overlay, which can be customized to the needs of the individual NEPs, when required. This customization requirement should be taken into account by the standardization bodies that develop equipment mechanics building practices. FRU level designs should leave enough physical space for manufacturer specific markings, in addition to other labels, such as CLEI labels.

Typical labeling requirements per FRU are NEP part and serial numbers and CLEI, in both human readable and bar-code formats. OEM vendors often do not allocate front panel space in their designs for labels. Emerging requirements for 2D bar codes to replace conventional bar codes will require different aspect ratios on labels.

For the North American telecommunications market, the equipment chassis, as well as each FRU shall provide an area to affix a Common Language Equipment Identifier (CLEI) label in addition to any vendor specific labeling practices. The associated labeling processes are specified in [TEL10] (please refer to section 9), and acceptable standard label types are specified in [TEL11]. Not having labeling space, or insufficient space to affix a standard label for any reason (including insufficient FRU physical size) requires each NEP to obtain a waiver on labeling requirements from each of their customers.

7.3.5 Cabling practices

The following table describes the preferred cabling practices for communication equipments which are used in Central Offices and Network Data Centers.

The "Front" on the table refers to the FRU surfaces that face towards the "cold aisle", where equipment air intake is located, also referred as "maintenance aisle". Correspondingly, "rear" refers to the FRU surfaces that are located on "hot" aisle, or where equipment air exhaust is located, also referred as "wiring aisle".

Network elements that are anticipated to support large amount of cabling should have embedded cable trays designed as integral part of the element to facilitate the physical management of the cabling to the frame level cable conduits. Cable tray placement must eliminate or at least minimize the interference to cooling airflow intake and exhaust ports for forced-air cooled equipment.

Table 7.3.5 Preferred Cable Termination and Routing Practices

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Cable Routing, Frame Level	**Either up or down**			Design equipment cable management to accommodate both directions
Requirement ref.	[TEL1] 2.5.1.2 & 2.5.1.3, [ANS1], 6.1 & A1.8	[ETS2], 5 [ETS3], 7	[ANS1] 6.1, [ANS4] 7.x	
Cable termination, Copper	**Rear (Front)**		**Rear**	Rear Preferred
Requirement ref.				
Cable routing - Copper Bend Radius	**5-10x Cable Diameter minimum**			
Requirement ref.	[ANS5]			
Cable termination, Fiber	**Front and/or Rear**		**Rear**	
Requirement ref.				
Cable routing - Fiber Bend Radius	**38.1mm (1.5") minimum**			
Requirement ref.	[ANS5]			
Cable routing - Fiber/Copper Separation	**Routing in Separate Compartments**			Applies to frame cable trays and equipment embedded cable trays
Requirement ref.	[TEL8] R22-4		[ANS4] 7.3.3	
Cable termination - Primary Service Interfaces	**Front**			e.g. commissioning and diagnostics access ports
Requirement ref.	-	-	-	
Cable termination - Power	**Rear**			Front for no back-access only
Requirement ref.				
Cable routing - Power	**Diverse Routing for Redundant Feeds (i.e. Left-Right for A+B feeds)**			
Requirement ref.				
Cable routing - Service Interference	**No interference to FRU replacement**			
Requirement ref.				
Cable routing - Airflow Interference	**No/minimal interference to equipment airflow intake or exhaust**			If cables are placed on the front of intake/exhaust, cooling performance must be assessed with maximum supported cable count installed.
Requirement ref.		[ETS6], 5.1.2		

In the equipment designed for the Network Data Centers, cabling is primarily on rear.

Some carriers have additional requirements on power/metallic signal cable separation. Check carrier specific requirements for references.

7.3.6 Maintenance and service support

The following tables summarize basic recommendations associated with equipment maintenance operations. These requirements are in place to expedite the maintenance operations, to reduce errors while performing maintenance operations and to protect equipment and/or maintenance personnel during maintenance operations.

Since many of these aspects of the equipment design are not well covered by applicable standards, some of the following information is provided as recommendation for the equipment manufacturers based on the best practices from SCOPE member companies.

Table 7.3.6 – Maintenance and Service Support

Criteria	All Environments	Notes
Fan replacement	Front Preferred (Rear also acceptable)	
Filter service	Front	
ESD strap interface	Both Front and Back, snap-in connectors (preferred), see [ETS23], section 4.1, supplemented by ESD bond point labels for quick identification.	Traditional 4mm banana plug interface is considered safety risk in some countries, as it is possible to be inserted on the AC mains connector.
LED Indicators	Min two LEDs each FRU, Red (fault) and Green (OK). Yellow is also nice to have, but not mandatory.	For quick Identification of FRU state, including unit requiring replacement
Alarm Connections	Mandatory for Central Office. Dry 3-pole relay contacts minimum. Consult PICMG 3.0 AdvancedTCA specification for detailed require-	

	ments and example connector & pin-out.	

Telcordia GR-2914-CORE [TEL9] has additional Human Factors Requirements. Compliance with this document is not mandatory, and tests are not required.

7.3.7 Airflow protocols

Telcordia GR-3028 [TEL-2] defines a standard nomenclature to represent an airflow pattern through the equipment, including air inlet and air outlet positions. This nomenclature is referred as “Equipment Cooling Class” (EC-Class). AHSRAE has adopted the same representation on their documents.

EC class description is composed of names for the six equipment surfaces of the box (Front, Side Left, Side Right, Rear, Bottom and Top). Also the vertical space is divided to three equivalent zones (numbered 1 to three). Airflow pattern is then representation of the air intake position(s) followed by air exhaust position(s) using this nomenclature. Figure 7.3.7 below depicts these surface notations and associated level numbering. For detailed description of nomenclature and how to use it, please refer to [TEL2], section 2.2.

Since the equipment layout in both Central Offices and Network Data Centers follows the ‘cold-aisle’ – ‘hot aisle’ pattern, where the cooling airflow is supplied to “front” of equipment on the “cold aisle”, and the hot exhaust air is extracted by room air conditioning systems from “rear” of the equipment, on “hot aisle”, the equipment designed for these spaces need to be compatible with this room layout. This is increasingly important due to escalating heat loads of the high performance communications equipment. Any air-flow patterns that are not compatible with this layout require special installation practices, and cannot be installed on the standard frame layout. Therefore, the equipment airflow for these environments must be designed to follow EC class of F-R. In addition, the airflow protocol for the network equipment that needs to support large volumes of cabling is further restricted to F1-R3 EC-class to ensure that the cabling does not interfere with the equipment airflow.

The only exceptions to this rule are certain frame level equipment, and equipment with heat loads sufficiently low to be cooled by natural convection or forced bottom-top airflow through multiple card cages. The frame level equipment, which have either closed airflow circuit cooling design (possibly with embedded heat exchangers) or dedicated ducting connections to room level air-conditioning systems may implement other airflow protocols (although there are number of cabinets that can enclose equipment following FR protocol, while providing supplemental or closed cooling). Note that the general acceptance of such equipment practices in Central Office installations is presently low, but these techniques are getting deployed in Network Data Center type environments to help deal with higher heat loads.

All shelf and Frame level product documentation must include the description of the air-flow patterns using the EC class airflow protocol nomenclature.

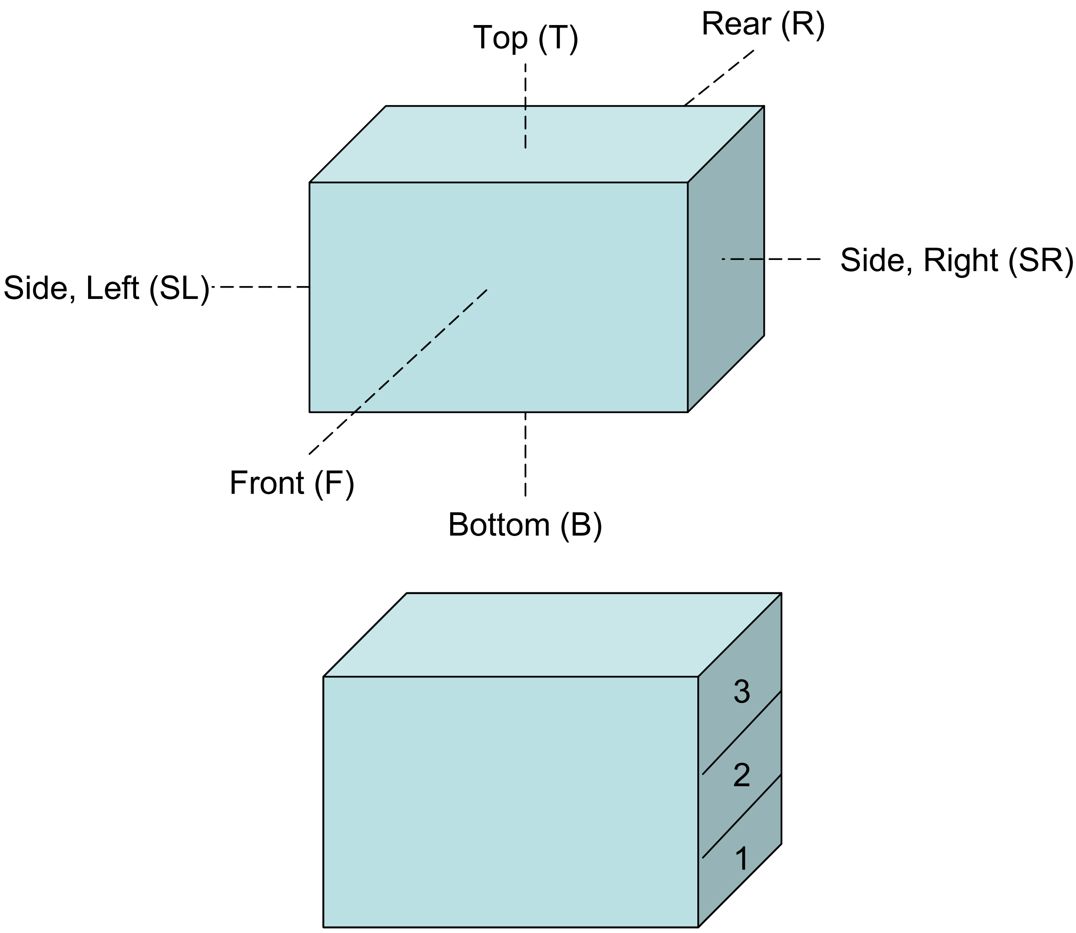


Figure 7.3.7 Equipment Cooling Class Nomenclature

ASHRAE has adopted the Telcordia [TEL2] equivalent methodology for the airflow protocol specification in [ASH2].

Shelf and/or Frame Level vendors must specify the airflow protocol(s) used by the equipment using this nomenclature. This is required reporting requirement both for Central Office and Network Data Center environments.

Table 7.3.7, below summarizes the airflow protocol requirements for the different environments, along with the associated references.

Table 7.3.7 – Airflow Protocols

Criteria	Central Offices	Network Data Centers
Preferred Protocol	F1-R3	Fx-Rx
Acceptable Protocols	Fx-Rx, B-T, B-Rx, Fx-T, Fx-Rx/SLx+SRx, SRx-SLx	SRx-SLx
Not-Preferred	SL-x, SR-x	SL-x, SR-x
Forbidden Protocols	x-F, R-x	x-F, R-x

Note that the equipment must be compatible with the hot/cold aisle configurations, regardless of the environments. The use of non-preferred airflow protocols (including acceptable protocols) generally mandate that the non-standard frame/cabinet design is utilized in installation, and is therefore strongly discouraged. Protocols relying on the direct cabinet connection to facility air handler ducting may require special approvals by network operators. All protocols that are inherently not compatible with the hot/cold aisle configuration (such as front exhaust and rear intake) are **forbidden**.

Central Office equipment utilizing Front to Rear protocols other than F1-R3 are acceptable, provided that there is no cabling interference to airflow. F1-R3 is preferred to allow for both cabling without airflow interference, as well as easy maintenance access.

7.3.8 Floor loading

Floor loading for the purpose of equipment weight allocation is calculated using the average floor loading, taking into account the aisle space around the equipment. Note that the loading obviously is installation dependent, and therefore the requirements are generally only stated as guidelines. Loading can be mitigated by leaving empty space around the equipment, as with the thermal loading.

COTS ecosystem enclosure (frame, cabinet, rack, and shelf) and FRU level component vendors must include the accurate weight data in the product documentation for all components.

Table 7.8.3 shows the floor loading specifications for each environment

Table 7.3.8 Floor Loading

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Equipment Floor Loading	**Max: 560 kg/m2 (114.7 lb/ft2)**	Recmd: 15 kN/m2 (1530kg/m2), Max: 20kN/m2 (2039kg/m2)	**SHALL: 732 kg/m2 (150lb/ft2)** SHOULD: 1221 kg/m2 (250lb/ft2)	Use NEBS limit as CO target
Requirement ref.	[TEL1] O2-25, 2.1.1.	[ETS2], 6.1	[ANS4] 5.3.4.7	

GAP: Organizations involved in the development of the building practice specifications for the equipment targeting these spaces should perform realistic weight allocation allowance guidelines that are compatible with facility capacities for all packaging levels (frame, shelf, FRU).

7.3.9 Heat release targets and cooling technologies

High equipment heat dissipation is challenging the cooling capabilities of Central Office and Network Data Center facilities. Particularly the Central Offices are having difficulties cooling the latest high heat-load equipment due to their generally more limited environmental controls and cooling capacity.

Objectives

Table 7.3.9 represents the heat load objectives for the Central Offices and Network Data Centers. There are no firm requirements for the heat load in any of the specifications, and most of the high-performance network equipment on the market exceeds the present objectives, sometimes as much as by factor of 10 or more. Facility heat load capacity is also considered moving target (increasing over time), with high variation between the capacities of the individual facilities, particularly for Network Data Centers.

Table 7.3.9 Heat Load Objectives

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Facility Heat Load Capacity	**Max, individual frame: 1950 W/m2 (181.2 W/ft2)**	Not Specified	**1884-3229W/m2 (150W-300+W/ft2)**	
Requirement ref.	[TEL1] O4-20, Table 4-5		[ANS4] 5.3.4.7	

Additional information and guidelines for Central Office thermal management is provided in Telcordia GR-3028-CORE [TEL2], and ETSI documents [ETS5] and [ETS6].

As the equipment in <u>all</u> environments is pushing the limits of the facility cooling capacities, the following sections concentrate on discussion of the mitigation measures and possible ways forward. This issue is an industry wide problem, which requires actions and attention of all of the stakeholders for the successful resolution, including CCVs, NEPs, Network Operators and semiconductor vendors.

Central office viewpoint

The Central Office Heat Release targets are specified in NEBS GR-63-CORE [TEL1], with supplementary information on cooling practices and heat load targets given in the GR-3028-CORE [TEL2]. In both documents, the heat release targets are specified as OBJECTIVES (i.e. not as mandatory requirements). However, these objectives have been established on basis of the cooling capacity of the typical Central Office facilities.

These objectives for fully loaded 37.2m^2 (20x20ft) equipment bay (41 racks) yield per rack maximum power of between 990 to 1172W, or 40kW for the whole area. The heat densities of high power equipment often exceed these targets significantly, with factor of 15x or even more. Presently, the network Operators are dealing with high power equipment by decreasing the spatial heat release density of installed equipment by mixing “low” and “high” power equipment so that the averaged heat load stays under or close to objectives, and in extreme cases leaving significant “thermal management space” (i.e. empty rack space with no equipment installed) around the highest power systems.

Installation of high power equipment represents a significant challenge to Network Operators – for example, installation of single frame of 13kW dissipation by using “thermal management space” takes approximately 1/3rd of the equipment bay area to bring the average load in line with the heat release objectives, i.e. this single rack takes space of approximately 14 compliant racks. Some operators deploy supplementary cooling techniques for high-heat load equipment to improve the facility space utilization.

Note that the rack level values calculated as guidelines represent average rack power dissipation. In practice, much higher power racks are deployed even today (in 8-10kW range). In TCG Energy Summit, the suggested value for the maximum rack level heat dissipation was 6kW, which falls under the present high power equipment dissipations.

Possible heat release mitigation techniques in Central Offices:

- Reduction of installation density (utilize empty thermal management space) - Network Operators
- Utilize supplementary cooling - Network Operators
- Deploy high powered equipment in Network Data Center type facilities instead of Central Offices – Network Operators
- Develop more energy efficient equipment / reduction of equipment power demand – Silicon Vendors, Power Vendors, Equipment Vendors
- Embedded rack level cooling– Equipment vendors and Network Operators
- Room Neutral cooling – Equipment vendors and Network Operators

NDC viewpoint

Network Data Center facilities have more stringent requirements on environmental conditions (from the facility level engineering point of view) than typical Central Office facilities. This allows the equipment designs that are thermally more manageable, and leads to the significant reduction on the airflow needed to cool the equipment, or significantly increased power dissipation capacity with the same airflow due to elimination of the “short-term” exceptional conditions needed in Central Offices.

NDC heat loads are moving target, and are increasing rapidly. Rack level load of server type equipment was at 2kW level at year 2000, rising to 6kW on 2002, and 24-30kW in 2007. Heat loads according to ASHRAE and other industry sources are estimated to keep climbing, with 40+kW for fully populated rack of 1U or BladeServers by 2009. Even the present equipment heat loads exceed the cooling capacities of the typical facilities without supplementary cooling practices.

New state of the art facility designs can support heat loads of 5.4 to 8.6 kW/m^2 (500 to 800W per Sq.Ft), with up to 40kW rack level loads. This is an indication that the deployable solutions exist on the market, but the majority of the existing facilities are still one to two generations behind these levels.

Possible heat release mitigation techniques in Network Data Centers:

- Reduction of installation density (utilize empty thermal management space) - Network Operators
- Utilize supplementary cooling - Network Operators
- Utilize virtualization technology to reduce the total number of servers, while increasing the load of the remaining servers – Equipment Vendors, Network Operators
- Develop more energy efficient equipment / reduction of equipment power demand – Silicon Vendors, Power Vendors, Equipment Vendors
- Embedded rack level cooling– Equipment vendors and Network Operators
- Room Neutral cooling – Equipment vendors and Network Operators

Possible Future directions

Regardless of the type of the facility, it can be assessed that the present and near- future equipment densities commonly exceed the installed facility level cooling capabilities, thus limiting the equipment density that could be installed if only spatial considerations would need to be taken into account. In other words, the achievable space utilization of typical facility is commonly limited by its cooling capacity.

This is an industry-wide problem, which requires attention of all of the associated stakeholders throughout the value-chain, including silicon and other component suppliers, equipment vendors, and network operators. Solutions for managing very high heat loads are available on the market now, with the further opportunities to improve efficiency by more tight integration of the cooling from chip to facility levels. Economics of the alternatives for dealing with escalating heat loads suggests that the most efficient architectures over time need to involve more close association of the liquid cooling loops to the heat sources. The key driver here is the inefficiencies associated with moving large volumes of air across the facility; while the airflow need scales linearly with the heat load, associated losses increase as a square of the airflow, while power required for air movement increase as a cube of the airflow. Other related parameter that is approaching, and in many cases exceeding the limits at the facility level is the amount of the acoustic noise that the high capacity forced air cooling systems produce.

"Liquid Cooling" in this document refers to the equipment practices where the air convection (forced or natural) flow is supplemented by the liquid coolant fluid flow at the rack or at shelf / FRU packaging levels. Note that the embedded "liquid" structures such as heat pipes or other local, closed liquid / air loops are not considered to be "liquid cooled". To be considered "liquid cooled", the equipment enclosure (frame, cabinet, shelf or FRU) must have liquid loop inlet and exhaust interfaces. Liquid may be either water or one of the many potential coolant refrigerants.

The key driver for the liquid cooling is the escalating power dissipation densities of the high-performance equipment over the point where the air cooling is insufficient, too inefficient, or too noisy to remove the heat load from equipment. Liquid cooling practices are transitioning the new data center (including Network Data Center) facility designs already. However, the acceptance of the liquid cooling practices in the Central Office facilities is not yet widespread, and Network Operator preference is to retain the air-cooling practices as long as possible, and preference is to focus efforts on the energy efficient designs of the equipment, whenever possible.

However, moving the liquid cooling closer to the heat source has technoeconomical benefits in terms of lifecycle cost for highest power equipment due to decreased OPEX, and can also help on escalating noise levels caused by the equipment cooling fans.

This SCOPE environmental profile does not take specific position on the liquid cooling practices at this time, but instead provides some guidance in terms of associated terminology and discusses the generic cooling technology roadmap.

The trends of the equipment heat dissipation are well documented in the ASHRAE document "Datacom Equipment Power Trends and Cooling Applications" [ASH1]. Chip level heat dissipation trends that ultimately drive the cooling performance requirements are discussed in International Technology Roadmap for Semiconductors (ITRS) and iNEMI roadmaps (particularly "Thermal Management" section). Inemi documents can be obtained from www.inemi.org, and ITRS documents from www.itrs.org.

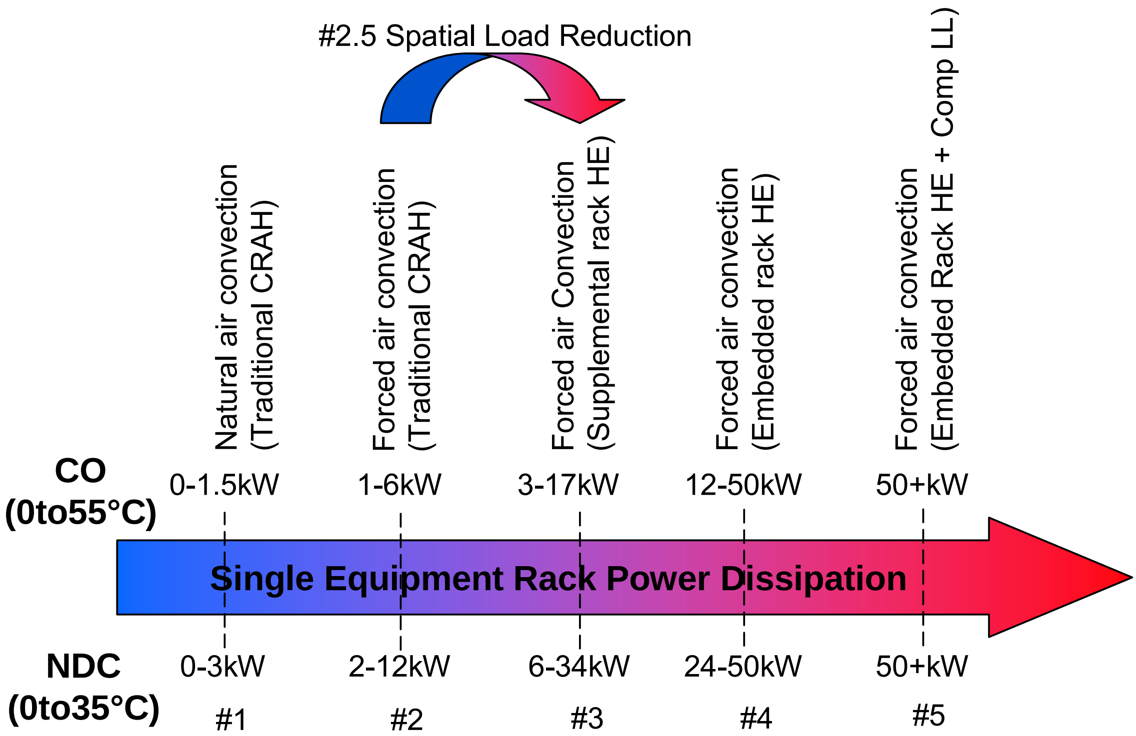


Figure 7.3.10 generic cooling technology roadmap

Figure 7.3.10 above depicts a rough roadmap of the cooling capabilities of the single equipment frame in Central Office and Network Data Center environments (as defined in this profile), along with the cooling technology transition regions. Note that the exact transition points are highly dependent on the facility level design, such as available cooling air volume of the room CRAC systems, hot-cold aisle containment quality (air mixing), overall facility temperatures achieved, maximum acoustic emissions that can be tolerated, and other such conditions. In the open forced air cooling configurations, the cooling capacity that can be accomplished in the Network Data Center is approximately double to that of Central Office, due to significantly relaxed ambient air temperature specifications (i.e. more tightly controlled ambient air temperatures, and no “short term” exceptional conditions).

Gaps

GAP: Equipment building practice/test standards – need to standardize airflow and airflow impedance requirements for forced convection cooling, per environment

GAP: Equipment building practice/test standards – need standardized power dissipation characterization and reporting methodologies at shelf and FRU packaging levels

GAP: Equipment vendors – need to implement power monitoring and management technologies (feed voltage and current sensors, ACPI type specifications, virtualization)

GAP: Equipment and frame vendors – more tightly coupled liquid cooling loops at rack and element level

GAP: Management standards – need standardized protocols and access points to access sensor information (e.g. dynamic power dissipation)

7.4 Climatic - transportation and storage

The following tables summarize the climatic requirements for transportation and storage.

Note that there is no single commonly accepted specification for the transportation and storage associated with the Network Data Center equipment, but if packaging is designed to support NEBS/ETSI transportation and storage climatic specifications, this is considered adequate.

Table 9.3-1 Climatic Conditions - Transportation

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Min. Ambient Temp.	**-40°C**		**-**	
Requirement ref.	[TEL1] R4-3	[ETS10] Class 2.3	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS14] Class 2.3	-	
Max. Ambient Temp.	**70°C**		**-**	
Requirement ref.	[TEL1] R4-5	[ETS10] Class 2.3	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS14] Class 2.3	-	
Max. Relative Humidity	**93%/+40°C**	**95%/+45°C**	**-**	
Requirement ref.	[TEL1] R4-4	[ETS10] Class 2.3	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS14] Class 2.3	-	
Rate of Temp. Change	**-30&+30°C/hr**	**-40&+30°C/hr**	**-**	
Requirement ref.	[TEL1] R4-3, R4-4, R4-5	[ETS10] Class 2.3	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS14] Class 2.3	-	

Table 9.3-1 Climatic Conditions - Storage

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Min. Ambient Temp.	**-40°C**	**-45°C**	**-**	
Requirement ref.	[TEL1] R4-3	[ETS9] Class 1.3E	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS13] Class 1.3E	-	
Max. Ambient Temp.	**70°C**	**45°C**	**-**	
Requirement ref.	[TEL1] R4-5	[ETS9] Class 1.3E	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS13] Class 1.3E	-	
Relative Humidity	**93%/+40°C**	**100%**	**-**	Condensing
Requirement ref.	[TEL1] R4-4	[ETS9] Class 1.3E	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS13] Class 1.3E	-	
Rate of Temp. Change	**30°C/hr**		**-**	
Requirement ref.	[TEL1] R4-3, R4-4, R4-5	[ETS9] Class 1.3E	-	
Test Method ref.	[TEL1] 5.1.1.	[ETS13] Class 1.3E	-	

<u>**Gap:**</u> Requirements and test methods for NDCs are not specified.

7.5 Climatic - operation

The following tables summarize equipment ambient operation temperature and humidity limits for Central Offices and Network Data Centers. All Central office equipment targeting world market must be designed to NEBS and ETSI criteria, and end product needs to be tested to NEBS , ETSI and IEC criteria.

From the Network Equipment perspective, the NEBS and ETSI criteria is generally the most demanding,. Therefore, the equipment that has been developed and tested to fulfill Central Office criteria as defined by NEBS and ETSI can be deployed in the DataCenters, but the equipment developed to DataCenter environment cannot be generally deployed in Central Offices without additional environmental controls in immediate equipment environment.

Other way to think about these environments is that the 'quality' of the facility level environmental control in terms of compatibility with sensitive electronic equipment goes up while moving towards DataCenter environment, moving the compliance burden from equipment level to facility level.

The Central Office requirements are constrained by NEBS Level 3, Shelf-Level requirements, while Network Data Center requirements are based on ASHRAE Class 2. ETSI CO requirements are generally a subset of the corresponding NEBS requirements. Note that ASHRAE has defined Class 1, which is even more tightly controlled than Class-2, but in interest of maximum applicability, and common equipment design practices for DataCenter environments, DataCenter profile is based on ASHRAE Class 2 criteria.

Figure 7.5 and table 7.5-1 below provide a summary of temperatures on the defined environments on recommended, normal and exceptional ranges. Note that there is no definition for "exceptional" temperature range for the Network Data Center environments. The table values for NEBS temperatures are based on test criteria for shelf level equipment.

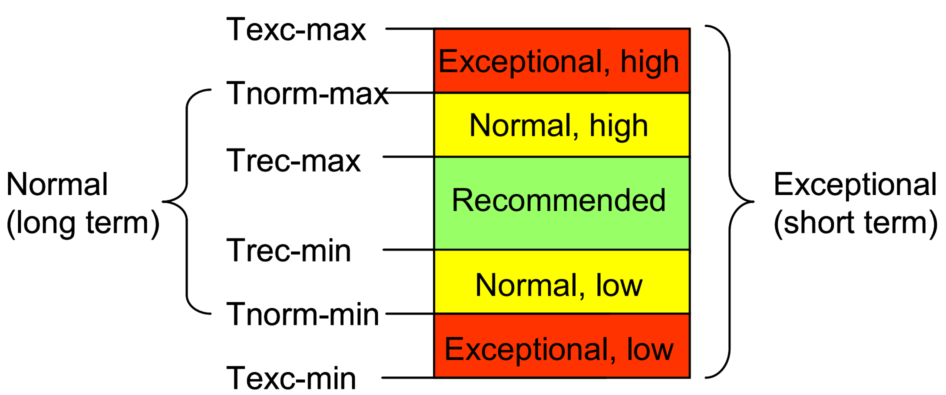


Figure 7.5 Operation Temperature Ranges

Table 7.5-1 Summary of Operation Temperatures

	Central Office	Network Data Center
Texc-max	55°C (per NEBS shelf level requirements)	N/A
Tnorm-max	40°C	35°C
Trec-max	27°C	25°C
Trec-min	18°C	20°C
Tnorm-min	5°C	10°C
Texc-min	-5°C	N/A

The temperature ranges are defined as follows:

Recommended operation temperature and humidity – the long term environmental temperature and humidity climatic conditions, which are recommended to be maintained at the facility level to ensure the long-term reliable operation of the equipment. Acoustic emissions limits, as well as additional NEBS surface temperature limits apply on this range. This is a subset of "normal" operation temperature range, and constitutes "recommendation" only. For the CO's these values are based on the Telcordia [TEL4] wideband protocol values, and facilities are typically run within this band, but due to high heat loads typically close to top end of it. NDC values are aligned with ASHRAE [ASH2] class 1 and class 2.

Normal operation temperature and humidity – the long term environmental temperature and humidity climatic conditions that are normally always met by any facility level installation. Acoustic emissions limits are not applicable on this range (beyond the "recommended" subset. Equipment long term reliability may be reduced if subjected to prolonged exposure to extremes of this range. Any single fan failure conditions must also be met without any performance degradation (as per NEBS) while operating within the high temperature limits of this range.

Exceptional operation temperature and humidity - the short term environmental temperature and climatic conditions, which equipment may be subjected to in certain facility level failure conditions. Equipment is expected to operate normally while subjected to these conditions. There are no "exceptional" range requirements associated with Data-Center environments, as the relevant environmental specifications assume that the facility level HVAC systems have sufficient redundancy and backup/extra capacity to always maintain the environment within the climatic conditions associated with “normal” range.

Following subsections provide details of the requirements associated with these ranges, along with the references of controlling source requirements and test procedure requirements.

The specific requirements associated with the combined temperature/altitude requirements for both normal and exceptional conditions are given after the overall temperature and humidity range requirements.

7.5.1 Normal and recommended operation temperature and humidity

Table 7.5.1 Normal and Recommended operation temperature and humidity

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Normal Operation Conditions, (Mean Sea Level, Z=0m)				
Min. Ambient Temp.	**5°C**		**10°C**	Normal start-up required
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1	[ASH2] Class 2	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1	-	
Recommended Ambient Temp.	**18 to 27°C**		**20 to 25°C**	Acoustics limits apply here
Requirement ref.	[TEL2] Wide-Band	Not Specified	[ASH2] Class 2	
Test Method ref.	Recommendation only at facility level, covered by other tests			
Max. Ambient Temp.	**40°C**		**35°C**	
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1	[ASH2] Class 2	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1	-	
Relative Humidity	**5 to 85%**		**40 to 55%**	Non Condensing
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1	[ASH2] Class 2	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1	-	
Rate of Temp. Change	**30°C/hr**		**5°C/hr**	
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1	[ASH2] Class 2	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1	-	
Atmospheric Pressure	**101325 kPa**			
Altitude	**0m**			

Gap: While Network Data Center climatic requirements are well specified by ASHRAE, there is no associated test protocol specification. IEC-68-2- series of specifications could be used as a basis of definition of such test protocol.

7.5.2 Exceptional operation temperature and humidity

Table 7.5.2 Exceptional operation temperature and humidity

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Exceptional Operation Conditions, (Mean Sea Level, Z=0m)				
Max Duration of Exceptional Conditions	**<=96 Consecutive hr per event, total <=360 hr/y**	**Test duration = 16 hours**	**N/A**	
Requirement ref.	[TEL1] R4-6, note 2	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1E	-	
Min. Ambient Temp.	**-5°C**		**N/A**	Normal start-up not required
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1E	-	
Max. Ambient Temp.	**55°C (shelf) 50°C (frame)**	**45°C**	**N/A**	Design to NEBS Shelf Level for maximum market coverage for COs
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1E	-	
Relative Humidity	**5 to 90%**		**N/A**	Non Condensing
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1E	-	
Rate of Temp. Change	**30°C/hr**		**N/A**	
Requirement ref.	[TEL1] R4-6	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.2	[ETS15] Class 3.1E	-	
Atmospheric Pressure	**101325 kPa**			
Altitude	**0m**			

Exceptional requirements are NOT applicable to Network Data Center equipment.

Note that 55°C NEBS high-end exceptional limit is a test requirement when shelf level equipment are tested independently. Equipment and subassemblies that are developed only for Frame Level applications involving multi-shelf installations may be designed/tested to only 50°C Frame Level criteria, but non-compliance with the 55°C shelf level requirements implies that they can only be deployed in multi-shelf frame level configurations. Therefore, it is recommended that all CO equipment (shelves and FRUs) are designed to comply with the shelf level criteria.

CO Equipment standards (i.e. NEBS and ETSI) *allow* for performance degradation on exceptional conditions (it is up to manufacturer to specify what the behavioral and performance requirements are). While allowed, such behaviors are <u>not preferred</u>. If the equipment is expected to exhibit any deviation of the “normal” performance specifications, this MUST be clearly described in the product documentation, and this information must be available prior of conduction of any testing.

7.5.3 Normal operation temperature and altitude

Table 7.5.3 Normal operation conditions at reduced and elevated altitudes (long term)

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Normal Operation Conditions at reduced altitudes (Below Mean Sea Level, Z<0m)				
Max. Ambient Temp.	**45°C/35°C (shelf) 40°C/30°C (frame)**	**40°C**	**N/A**	Tests for reduced altitudes are not required, as this improves cooling due to increased air density.
Requirement ref.	[TEL1] R4-8 / R4-9, 5.1.3	[ETS11] Class 3.1	-	
Test Method ref.	-	-	-	
Atmospheric Pressure	-	**106 kPa**	-	
Requirement ref.	-	[ETS11] Class 3.1	-	
Test Method ref.	-	-	-	
Min. Altitude	**-60m**	N/S	-	
Requirement ref.	[TEL1] R4-8	-	-	
Test Method ref.	-	-	-	
Normal Operation Conditions at elevated altitudes (Above Mean Sea Level, Z>0m)				
Max. Ambient Temp.	**45°C/35°C (shelf) 40°C/30°C (frame)**	**40°C**	**27.8°C**	Derating ref. 1°C/300m
Requirement ref.	[TEL1] R4-8 / R4-9, 5.1.3	[ETS11] Class 3.1	[ASH2] Class 2	
Test Method ref.	[TEL1] 5.1.3.	-	-	
Atmospheric Pressure	**80 kPa / 60 kPa**	**70 kPa**	**(~70 kPa)**	
Requirement ref.	[TEL1] 5.1.3.	[ETS11] Class 3.1	-	
Test Method ref.	[TEL1] 5.1.3.	-	-	
Max. Altitude	**1800m / 4000m**	**~3000m**	**3050m**	
Requirement ref.	[TEL1] R4-8 / R4-9	[ETS11] Class 3.1	[ASH2] Class 2	
Test Method ref.	Informational only, pressure (above) defines test conditions			

All specifications *allow* temperature derating at high altitudes, while such derating is not preferred by facility operators. The altitude over which the temperature derating is allowed varies by the specification. For NEBS CO's, the temperature derating is allowed at altitudes over 1800m.

For datacenters, the altitude derating is assumed (i.e. specified as integral part of environmental definition) over the altitudes of 900m. If altitude derating or any other altitude specific installation precautions are required, this must be clearly specified in the product documentation, as per [TEL1] requirement R4-10[75].

Note that ETSI specifications presently do not specify any tests for the altitude requirements, while they do specify the altitude requirements (implicitly through the operation pressure range of 70 kPa to 106 kPa).

To avoid fragmentation of environmental requirements due to possibly differing altitude derating specifications, if derating is required, the derating must be -1°C temperature derating for every 300m increase of the elevation over the specified minimum altitude limit, in accordance of ASHRAE [ASH1] and [ASH2] for Network Data Center environments, as well as [TEL1] for Central Office Environments.

7.5.4 Exceptional operation temperature and altitude

Table 7.5.4 Exceptional operation conditions at reduced and elevated altitudes (short term)

Parameter	**NEBS CO**	**ETSI CO**	**Network Data Center**	**Comments**
Normal Operation Conditions at reduced altitudes (Below Mean Sea Level, Z<0m)				
Max. Ambient Temp.	**55°C (shelf) 50°C (frame)**	**45°C**	**N/A**	
Requirement ref.	[TEL1] R4-8, O4-11	[ETS11] Class 3.1E	-	
Test Method ref.	-	-	-	
Atmospheric Pressure	-	**106 kPa**	-	
Requirement ref.	-	[ETS11] Class 3.1E	-	
Test Method ref.	-	-	-	
Min. Altitude	**-60m**	N/S	-	
Requirement ref.	[TEL1] R4-8, O4-11	-	-	
Test Method ref.	-	-	-	
Normal Operation Conditions at elevated altitudes (Above Mean Sea Level, Z>0m)				
Max. Ambient Temp.	**55°C/45°C (shelf) 50°C/40°C (frame)**	**40°C**	**-**	
Requirement ref.	[TEL1] O4-11 / O4-12	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.3	-	-	
Atmospheric Pressure	**80 kPa / 60 kPa**	**70 kPa**	-	
Requirement ref.	[TEL1] 5.1.3.	[ETS11] Class 3.1E	-	
Test Method ref.	[TEL1] 5.1.3	-	-	
Max. Altitude	**1800m / 4000m**	**3000m**	**-**	
Requirement ref.	[TEL1] O4-11 / O4-12	[ETS11] Class 3.1E	-	
Test Method ref.	Informational only, pressure (above) defines test conditions			

Exceptional requirements are NOT applicable to Network Data Center equipment.

7.5.5 Operation temperature margin

This test determines the equipment behavior over the maximum short term operation temperature limit (i.e. up to 10°C over the maximum short-term ambient limit of 55°C for shelf-level equipment).

The test is required as per [TEL1] R4-13, and test procedure is defined in [TEL1] section 5.1.4. This test must be conducted for all equipment targetting Central Office environments.

Gap: this test should be done for NDC equipment as well (over the 35°C max. temp)

Gap: performance criteria are not defined by NEBS tests. It is SCOPE position that the equipment should not sustain permanent damage when subjected to this test, and should perform graceful shut down before risking permanent damage or fire, and shall autonomously return to service within 30 minutes after the ambient climatic conditions are returned to within the equipment environmental specification. This protection behavior should be configurable on/off with default on (i.e. equipment protects itself).

7.5.6 Fan cooled equipment

The following requirements originate from Telcordia NEBS specification. It is SCOPE position that these need to be applied to all air-cooled equipment targeting mission critical, high availability applications (i.e. '5NINES or higher levels of element level availability), regardless of installation environment. Therefore, these requirements are considered mandatory for both Central Office and DataCenter environments for HA equipment.

The tests are conducted at maximum normal ambient operation temperature of 40°C for the Central Office equipment, and at 35°C (max ambient operation temperature) for DataCenter equipment.

Table 7.5.6 – Fan Cooled Equipment

Parameter	NEBS CO	ETSI CO	Data Center	Comments
Single Fan Failure	**40°C / 96 hrs**		**35°C / 96 hrs**	For DS equipment, design for max ambient temp.
Requirement ref.	[TEL1] R4-14	-	-	
Test Method ref.	[TEL1] 5.1.5	As per NEBS	As per NEBS, 35C	
Remote Alarm	**Remote notification of fan failures**			
Requirement ref.	[TEL1] R4-15	-	-	
Test Method ref.	-	-	-	
Cooling FRU Replacement	**Shall not cause service interruption**			Mandatory for all high-availability equipment
Requirement ref.	[TEL1] O4-16	-	-	
Test Method ref.	-	-	-	
Cooling FRU replacement procedure	**Must be in product documentation**			
Requirement ref.	[TEL1] R4-17	-	-	
Test Method ref.	-	-	-	
Service interruption	**If service interruption possible, replacement time needs to be documented**			Design to meet O4-16, AND minimum replacement time of 5min @40°C(CO)/35°C(NDC) (GAP in NEBS)
Requirement ref.	[TEL1] R4-18	-	-	
Test Method ref.	-	-	-	

Fan predictive failure analysis should be supported by the Network Elements requiring high availability levels.

GAP: there are presently no requirements or established test methods to account for the single point of failures that can affect multiple air mover devices (e.g. failures on fan powering or fan control subsystems associated with multiple air movers). In some air-cooled equipment, such electronics failure modes could cause of the failure of multiple air-mover devices, potentially leading to system outage due to insufficient cooling capacity for high power equipment.

GAP: there are presently no requirements or established test methods defined to account for the non-cooling unit FRU replacement interval. As any FRU is removed from the shelf, the resulting differences on airflow patterns may cause some of the adjacent modules to be inadequately cooled and overheat for high-power FRUs. Designs should ensure that this cannot happen within the 5 minute replacement interval for any FRU at ambient temperatures up to 40°C (Central Offices) / 35°C (DataCenters). Replacement procedures and associated documentation should be designed to ensure that the replacement can be conducted within 5 minutes, and any restrictions required to ensure cooling are documented.

7.6 Surface and air temperatures

Table 7.6 below shows the summary of the surface temperature limits applicable per environment. For the details of the exposure times and temperature limits for other materials, consult the reference documents. [60950-1] safety specification also specifies material temperature limits.

Table 7.6 Surface Temperature limits of Touchable Surfaces

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Test Temperature	**23°C (48°C NEBS limit)** **50°C frame (70°C safety limit)** **55°C shelf (70°C safety limit)**	**45°C ETSI 3.1E Exceptional (70°C safety limit)**	**35°C (70°C safety limit)**	60950 specifies "tested under most adverse actual or simulated conditions permitted in installation instructions".
Requirement ref.	[TEL1] O4-21, R4-22			
Test Method ref.	[TEL1] 5.1.6	[60950-1], 4.5	[60950-1], 4.5	-
Max Surface Temperature – metals	**55°C, <=10s / 48°C, >10s**	**[60950-1], Table 4C, (70°C for "short periods")**	**[60950-1], Table 4C, (70°C for "short periods")**	Metal Handle temperature is limited to 55°C as per 60950. Note also that surfaces exposed during maintenance operations (e.g. heatsinks) may require "hot surface" safety warning labels.
Requirement ref.	[TEL1] O4-21, R4-22	[60950-1], 4.5.4	[60950-1], 4.5.4	
Test Method ref.	[TEL1] 5.1.6	[60950-1], 4.5	[60950-1], 4.5	
Max Surface Temperature - non-metals	**70°C, <=10s / 48°C, >10s**	**[60950-1], Table 4C (75°C for plastic handles, continuously held)**	**[60950-1], Table 4C (75°C for plastic handles, continuously held)**	
Requirement ref.	[TEL1] O4-21, R4-22	[60950-1], 4.5.4	[60950-1], 4.5.4	
Test Method ref.	[TEL1] 5.1.6	[60950-1], 4.5	[60950-1], 4.5	

Note that while there is no direct issuing air temperature limits in any of the referenced specifications (with the exception of 75°C limit specified in [ETS5]), the surface temperatures of the exhaust grilles and cables placed on the equipment exhaust air flow approach the air temperature. Therefore, the system flow-through air temperature must be managed so that it will not cause the safety requirements associated with surface temperatures to be exceeded.

7.7 Airborne contaminants (use)

7.7.1 Contaminant levels

Airborne contaminants in indoor environments are divided to mechanically active substances, and chemically active substances by ETSI [ETS11], while NEBS [TEL1] lumps these together, and ASHRAE divides them to gases, solids and liquids in [ASH3]. We use ETSI division, as it is most helpful of the three from the equipment requirement perspective. [ASH3], section 8 provides a good overview of contaminants, sources and associated effects.

Mechanically active substances can cause problems mostly in heat transfer, and in some cases can cause conduction related problems as these accumulate over electronics assemblies if the particles are conductive. Chemically active substances cause long-term reliability effects like corrosion on the connectors.

Mechanically active substances are generally addressed by filtering the intake air, and in some facilities the filtering is done at facility level to keep the room particle contamination in control. Generally in Central offices, the filtering is mostly done in equipment level, while in Network Data Center type facilities, filtering is mostly done at facility level. Exceptions to 'common' filtering types apply to both environments.

Table 7.7.1.1 Mechanically active substances

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Contaminant Levels	**[TEL1], table 4-12**	**[ETS11], table 3b, Class 3.1**	**[ASH3] section 8**	
Requirement ref.	[TEL1] R4-84	[ETS11] Class 3.1		
Test Method ref.	[TEL1] 5.5	Not Specified	Not Specified	Test to NEBS for CO

Table 7.7.1.2 Chemically active substances

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Contaminant Levels	**[TEL1], table 4-12**	**[ETS11], table 3a, Class 3.1**	**[ASH3] section 8**	
Requirement ref.	[TEL1] R4-84	[ETS11] Class 3.1		
Test Method ref.	[TEL1] 5.5	Not Specified	Not Specified	Test to NEBS for CO

7.7.2 Air filters

As stated in previous section, equipment air filters are generally required to help with air-borne contaminants in Central Office environments, and in some Network Data Center type environments, depending on the facility construction. Typically, Network Data Center equipment does not have embedded air filters.

As only NEBS presently specifies the detailed requirements for air filters, the air filters for all markets, if used, should be designed to comply with the NEBS requirements.

Applicable NEBS filter requirements (all in [TEL1]) are R4-87, R4-88, R4-89, R4-90, R4-91, R4-92,and R4-93 there are also two objectives, O4-94 and O4-95.

[TEL1] R4-92 requires that filter replacement shall have a support for stopping the fans to prevent handling contamination, or otherwise support contamination avoidance. For high power forced-air cooled equipment, it is generally not feasible to turn fans off without risking overheating, so equipment vendors are advised to develop a filter replacement strategy that does not compromise cooling, while eliminating or minimizing the handling contamination.

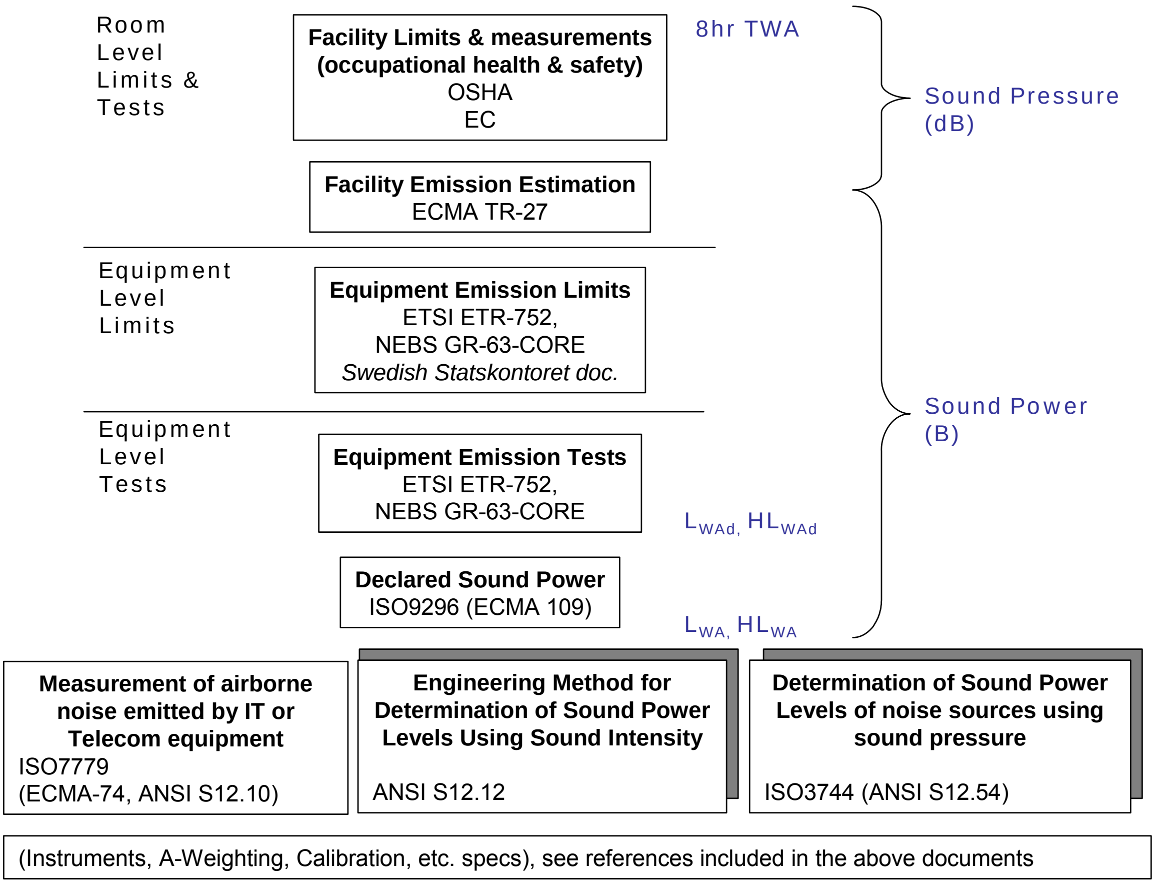
[TEL1] R4-93 requires that filter replacement schedules are to be supplied by vendors. One method to satisfy this requirement is to calculate the blockage rates as a function of air-speed through a filter, filter area, and the contaminant levels referenced in the previous section.

[TEL1] O4-94 states that if possible, equipment should support active alarming indicating that filter replacement is needed. This should be considered by shelf vendors.

Gap: standard test method for assessment of the air filter blockage on the equipment cooling performance (i.e. airflow) should be defined.

7.8 Acoustic emissions

Figure 7.8, below provides an overview of the common acoustic emission standards that are related to telecommunications equipment. At the high level, the specifications are divided to facility level noise emission standards that operators need to meet at the facility level to remain compliant with the applicable regulatory requirements set by the government regulatory requirements (OSHA in US and European Community for European countries). Equipment level limits are specified by ETSI and Telcordia (i.e. in NEBS), as well as other documents. Finally, the set of test method specifications are used to determine the compliance of the equipment to the specified limits.



Note that, the shaded boxes in the Figure 8.1, above are alternative test methods for emitted Sound Power level included in the NEBS. However, the ISO-7779 is the only method referenced in and allowed by the current edition of the ETR-752. Therefore, ISO-7779 is the preferred test method for the sound power measurements at this time.

Table 7.8-1, below provides a summary of the facility level noise exposure action limits for OSHA (US) and European Community facilities.

Table 7.8-1 Occupational Safety Noise Exposure Limits

Parameter	**OSHA (US CO & DC)**	**EC (ETSI CO & DC)**	**Comments**
Emission Limit, Daily Exposure ($L_{EX, 8h}$) Upper Action Value	**85 dB(A) TWA (hearing protection mandatory, hearing checks)**	**85 dB(A) TWA (hearing protection mandatory, hearing checks)**	Data Center limits are as per OSHA or EC, depending on the geographic location of installation.
Requirement ref.	[OSH1] 1910.95©(1)	[EC1], Article 3	
Test Method ref.	[OSH1] 1910.95 App A	[EC1], Article 4	
Emission Limit, Daily Exposure ($L_{EX, 8h}$) Lower Action Value	**Not Specified**	**80 dB(A) TWA (hearing protection must be available, training required)**	
Requirement ref.		[EC1], Article 3	
Test Method ref.		[EC1], Article 4	
Emission Limit, Peak Sound Pressure(P_{PEAK}) - Upper Action Value	**Not Specified**	**140 Pa / 137 dB(C)**	Same actions as in "Upper Action Value" above apply
Requirement ref.		[EC1], Article 3	
Test Method ref.		[EC1], Article 4	
Emission Limit, Peak Sound Pressure(P_{PEAK}) - Lower Action Value	**Not Specified**	**112 Pa / 134 dB(C)**	Same actions as in "Lower Action Value" above apply
Requirement ref.		[EC1], Article 3	
Test Method ref.		[EC1], Article 4	

Note that the occupational safety exposure limits in table 7.8-1 are “action levels”, not absolute limits. This means that facilities may be operated at higher noise emission limits, but in such cases, the hearing protection program to protect employees working on such facilities must be implemented. Limits for EC facilities are somewhat stricter than OSHA, as there are limits for both average exposure and peak sound pressure, as well as lower and upper action limits, instead of single limit for OSHA.

The following table summarizes acoustic limits of the equipment which is used in Central Offices and Network Data Centers.

Table 7.8-2 Equipment Acoustic Emission Limits

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Test Temperature	**27°C±1 (max. from 23°C to 27°C)**	**23°C±2**	**23°C±2**	ETSI emission limits are harder than NEBS limits, even accounting for lover test temp.
Requirement ref.	[TEL1] R4-96	[ETS16] 5.2.1 & 6., Class 3.1		
Test Method ref.	[TEL1] 5.1.6	[ETS16] 4.	ISO 7779	Use CO tests for NDCs
Emission Limit - Attended Space	**7.8B Sound Power (L_{WAd})**	**7.2B Sound Power (L_{WAd})**	*Design to NEBS*	No official standard for NDC's
Requirement ref.	[TEL1] R4-96	[ETS16] 6., Class 3.1		
Test Method ref.	[TEL1] 5.1.6	[ETS16] 4.		
Emission Limit – Unattended Space	**8.3B Sound Power (L_{WAd})**	**7.5B Sound Power (L_{WAd})**	*Design to NEBS*	No official standard for NDC's
Requirement ref.	[TEL1] R4-96	[ETS16] 6., Class 3.1		
Test Method ref.	[TEL1] 5.1.6	[ETS16] 4.		
Maximum Emissions	**Maximum Sound Power Level (HL_{WAd}) Must be tested**			"high temperature" test, air mover devices operating at maximum speed for equipment with fans
Requirement ref.	[TEL1] R4-97	[ETS16] 5.2.2		
Test Method ref.	[TEL1] 5.1.6	[ETS16] 4.		

The limits on table 7.8 are associated with "equipment", which is representative of the specific system configuration, as sold to the end customer (Network Operator). Limits apply to "equipment" configuration of up to 1 full frame, even if the "equipment" configuration is composed of more than one frame as per [TEL1] section 4.6 and [ETS16] section 6. Test is to be performed at representative "full load", i.e. at maximum operational power dissipation.

For the frame level equipment tests, the test is conducted with full frame, with any frame level noise mitigation structures (e.g. doors, mufflers etc.) installed. If frame has doors, the test is conducted with doors closed. This allows additional frame level noise mitigation measures to be utilized by high power / high noise network elements.

Central office equipment is typically located in unattended space. For equipment located in attended spaces, the corresponding attended acoustic noise limits apply. Note that whether the facility is considered attended or unattended space, the OSHA/EC regulatory limits associated with hearing conservation apply to the employees working on such facilities, such as maintenance personnel.

SCOPE alliance does not recommend compliance to any specific limits other that ALL equipment should be able to pass at least NEBS unattended limit as a minimum. This is due to the fact that the applicable limits are highly dependent on market, installation, equipment design and end-system composition, and results may be impacted by inclusion of additional structures such as frames and doors.

Obviously, the less noise is better, and exceptionally good airflow / noise performance combination could be considered competitive advantage for the enclosure/equipment manufacturers.

GAP: equipment level emissions for forced air cooled equipment are dependent on the cooling airflow needs of the system, which are primarily determined by the airflow needs of FRU level assemblies. Therefore open equipment specifications must require tests for the noise vs. airflow, and specifications should also specify the recommendations for FRU level airflow levels that result in acoustic emission compliant systems, as well as the guidelines on how the FRU level temperature sensors must be set and used to help assure that the equipment level acoustic emissions are not exceeded.

GAP: to facilitate the fair comparison of the acoustic emission performance of the forced convection cooled equipment, the noise vs. airflow test results of documented building practice specific test procedure need to be available from enclosure manufacturers. See [SCO1] and [SCO2] for more information on the test and reporting requirements for ATCA and uTCA, respectively.

GAP: no universally accepted normative reference for the acoustic emissions could be identified for the Network Data Center environments (ASHRAE refers to Swedish "StatsKontoret noise spec" as "de-facto" spec. for acoustic emissions).

7.9 Safety

Safety requirements are not profiled in detail, due to large volume of material, as well as to avoid any possible liability concerns, except where required to point out some of the key differences on applicable specifications. This profile focuses to identifying the key applicable specifications related to safety aspects in different environments. Vendors should be aware that all applicable safety requirements must be met, with no exceptions.

If the safety subject matter expects are not available internally within the organization, vendors are encouraged to seek advice from the safety consulting services early on in the design process. These services are also commonly provided by the laboratories that perform safety certification testing services.

Note that some of the other sections of this profile document do also contain specific requirements and references that can be considered safety related, such as physical construction, surface and air temperatures, acoustic noise, earthquake, and power sections.

7.9.1 Safety of Information Technology equipment

Table 7.9-1, below contains the references to Safety Specifications for IT equipment, covering most of the world market. Note that in addition to the listed documents, there are still a number of national deviations that need to be complied with. See the latest CB Bulletin for detailed information on the national deviations.

IEC document [IEC1] is the baseline document for the safety standards, but the associated national versions of the specification contain certain national deviations that are geography specific. These deviations are identified in the national versions. For the safety coverage of world market, the equipment must comply with all documents, including all national deviations. Further, authorized testing bodies and labeling requirements vary by geography.

IEC CB mark is designed to help on compliance of the worldwide Safety regulations, including the national deviations. For information of the CB Scheme, consult http://www.cbscheme.org/ web site.

Table 7.9.1-1 IT Equipment Safety Specifications

Market	NEBS CO	ETSI CO	Data Center	Comments
Safety of Information Technology Equipment				All equipment, regardless of installation environment must comply with all applicable clauses
CB Mark (International)	**IEC 60950-1 [IEC1]**			
US/Canada	**UL60950-1 [ANS2]**			
Europe	**EN 60950-1 [EN1]**			
Australia/New Zealand	**AS/NZS 60950-1 [ANZ1]**			

Safety testing must be performed by authorized and recognized test laboratory (or laboratories) approved by the governing bodies associated with each market. Similarly, the product safety markings must follow the specific requirements for each market.

Note that NEBS GR-63-CORE [TEL1] and GR-1089-CORE [TEL3] contain additional electrical and fire safety related requirements that must be met by Central Office equipment. Those are included in references in other sections of this document.

7.9.2 Laser safety

Lasers commonly utilized in the communications equipment are subject to safety requirements to avoid worker exposure to (typically) invisible laser radiation, which can lead to eye damage at the worst case. The marking and other safety requirements are dependent on the laser power.

Table 7.9.2 Laser Safety

Parameter	NEBS CO	ETSI CO	Data Center	Comments
Laser Safety				All equipment utilizing lasers, regardless of installation environment must comply with all applicable clauses
International/Europe	IEC 60825 [IEC2]			
US/Canada	OSHA 21CFR1040.10 [CFR2], ANSI Z136.1 [6], ANSI Z136.2 [7], IEC 60825 [IEC2]			

Please consult the referenced documents for the laser classification and associated marking requirements.

A good overview of the labeling requirements can be found in Verizon document "Verizon NEBS™ Compliance: Labeling Requirements for Light Emitting Equipment".

7.9.3 Fire safety

Baseline Fire Safety related requirements for all equipment are covered in IEC60950 and associated safety specifications, and references therein. NEBS GR-63-CORE [TEL1] have a number of additional fire safety related requirements and tests, which must be met by all Central Office equipment.

Fire safety requirements address issues like materials selection, fire propagation, fire extinguishment, ignitability, \smoke emission and smoke corrosivity. A summary of references to fire safety requirements is provided in table 7.9.3.

Table 7.9.3 Fire Safety

Parameter	NEBS CO	ETSI CO	Data Center	Comments
Fire Safety - all Equipment	IEC 60950-1 [IEC1] and all national deviations, see table 7.9.1-1			Design and test CO Equipment to NEBS compliance, and <u>all</u> equipment to IEC60950 compliance
Fire Safety - CO Equipment	NEBS GR63-CORE, section 4.2			

Operator specific documents, such as [ATT1] and [VZ2] provide additional operator specific information on requirements and test methods with respect to CO fire safety. These documents should be consulted before conducting the test.

Note that as per [VZ3], Verizon considers NEBS fire safety requirements (GR-63-CORE [TEL1] section 4.2) to be also applicable to “Data Center Locations”.

Operators may request detailed material information sheets for fire risk analysis, see example in section 3.2.6.10 in [VZ1]. This information should be made available by equipment and component suppliers if requested. Suppliers should routinely gather and retain this data along with the other component data (such as RoHS compliance data).

7.10 Vibration and shock resistance – transportation, handling & storage

This section covers vibration and shock requirements associated with transportation, storage and handling. The purpose of these requirements is to ensure that the equipment arrives to the installation site fully functional after being subjected to typical transportation handling. This is important for both the Network Operators, and equipment vendors. From operator’s perspective, non-functional equipment may be cause of increased downtime (in case of spares), or affect network deployment schedules, and will add extra handling and shipping work and delays. From equipment manufacturer’s perspective, the equipment damaged during shipment will cause extra warranty costs, as these typically need to be replaced at manufacturer’s expense.

The associated requirements cover vibration and shock levels for packaged equipment, as well as the less severe drop test for unpackaged equipment.

Central Offices

<u>NEBS/ETSI Central Office equipment Transportation Vibration (packaged equipment)</u>

The following table summarizes vibration resistance severity and associated test requirements for the communication equipment during transportation.

Table 7.10-1 – Vibration resistance (transportation)

Specification		**Criteria**				**References**
		Detail parameter	**Characteristic Severity**	**Test severity**	**Dura-tion**	
NEBS	Random	ASD (m^2/s^3)	1 0.3	1.0	3× 30minutes	[TEL1], R4-83, Tests: [TEL1] 5.4.3
		(dB/oct)	-	-3		
		Frequency range	10-200 200-2000	5-20 20-200		
		Axes of vibration	3	3		
ETSI	Sinusoidal	Displacement (mm)	3.5	None	-	[ETS10] 5.5, Table 5, Class 2.3, Tests: [ETS14] 3.3, Table 6, Class 2.3
		Acceleration(m/s2)	10 15			
		Frequency range (Hz)	2-9 9-200 200-500			
	Random	ASD (m^2/s^3)	1 0.3	1.0	3× 30minutes	
		(dB/oct)	-	-3		
		Frequency range (Hz)	10-200 200-2000	5-20 20-200		
		Axes of vibration	3	3		

Notes:

1.) NEBS requirements are based on ETSI Class 2.3 (Public Transportation). The test requirements for NEBS and ETSI are therefore equivalent.

2.) No test is required for ETSI sinusoidal vibration

NEBS/ETSI Central Office equipment Handling Shocks (packaged equipment)

The following table summarizes shock resistance severity and associated test requirements for the packaged communication equipment during transportation and storage.

Table 7.10-2: Free fall test severities for packaged equipment

	Free fall test drop height [mm]	
References	**Gross Mass, kg (lb)**	**Drop Height, mm (in.)**
[TEL1] 4.3.1. & 4.3.1.2 Tests: [TEL1] 5.3.1, [ETS10] 5.5, Table 5, Class 2.3 Tests: [ETS14] 3.3, Table 6, Class 2.3	< 10 (<22.1 lb)	1000 (39.4 in)
	< 15 (<33.1 lb)	1000 (39.4 in)
	< 20 (<44.1 lb)	800 (31.5 in)
	< 30 (<66.2 lb)	600 (23.6 in)
	< 40 (<88.2 lb)	500 (19.7 in)
	< 50 (110.3 lb)	400 (15.7 in)
	< 100 (220.5 lb)	300 (11.8 in)
[TEL1] 4.3.1. & 4.3.1.2 [ETS10] 5.5, Table 5, Class 2.3 Tests: [TEL1] 5.3.1 [ETS14] 3.3, Table 6, Class 2.3	> 100 (220.5 lb) or any weight for palletized container (NEBS Category-B Container)	100 (3.9 in)

Notes:

1.) NEBS and ETSI requirements for packaged equipment shock (drop) tests are equivalent (NEBS requirements are based on ETSI specifications), with the exception that NEBS [TEL1] has more specific test procedure requirements for palletized containers. [TEL1] test profile is sufficient to demonstrate compliance to both standards.

2.) ETSI transportation Class 2.3 has shock tolerance and test requirements in addition to above drop tests (see below)

ETSI Handling Shocks (packaged equipment)

Table 7.10-3: ETSI shock test severities for packaged equipment

Specification		Criteria				
		Detail parameter	**Characteristic Severity**	**Test severity**	**Dura-tion**	**References**
ETSI	Shocks	Shock Spectrum	Type-I Type-II	Half sine	6x100 shocks	[ETS10] 5.5, Table 5, Class 2.3, Tests: [ETS14] 3.3, Table 6, Class 2.3
		Duration (ms)	11 6	6 11		
		Acceleration (m/s^2)	100 300	180 100		
		Mass (kg)		<=50 >50		
		Number of Bumbs		100 in each direc-tion		
		Direction of Bumbs		6		

Notes: Shock test is not required for masses >500 kg. These shock tests are not referenced by NEBS [TEL1].

NEBS Handling Shocks (unpackaged equipment)

Unpackaged equipment must not sustain any damage or performance degradation, when subjected to the drops detailed in the table 7.10-4, as per NEBS [TEL1] R4-67.

Table 7.10-4: NEBS drop test severities for unpackaged equipment

Mass, kg (lb)	**Drop Height, mm (in)**	**References**
0 to <10 (0 – 22 lb)	100 (3.9 in)	[TEL1], R4-67, Tests: [TEL1], 5.3.2
10 to <25 (22-55.1 lb)	75 (3 in)	
25 to < 50 (55.1 – 110.2 lb)	50 (2 in)	
50 or greater (>110.2 lb)	25 (1 in)	

Network Data Centers

No commonly accepted normative specification that could be referenced for network Data Centers could be identified, therefore NDC equipment should be designed and tested to Central Office equipment transportation and handling test levels, as per tables 7.10-1, 7.10-2, 7.10-3, and 7.10-4 above.

7.11 Vibration resistance - use

Central Offices

The following table and paragraphs summarize vibration resistance severity and associated test requirements for the communication equipment during use for Central Offices and Network Data Centers.

Table 7.11 Vibration resistance levels, CO (use)

Specification		**Criteria**				**References**
		Detail parameter	Characteristic Severity	Test severity	Duration	
NEBS	Sinusoidal (frame)	Acceleration(m/s^2)	0.98 (0.1g)	0.98 (0.1g)	3 x 1 sweep cycles	[TEL1], R4-81, R4-82, Tests: [TEL1] 5.4.2 (Frame)
		Rate(octave/minute)	0.1	0.1		
		Frequency range(Hz)	5-100-5	5-100-5		
		Axes of vibration	3	3		
NEBS	Sinusoidal (subassemblies) See Note #2	Acceleration(m/s^2)	9.8 (1g)	9.8 (1g)	3 x 1 sweep cycles	[TEL1], R4-81, R4-82, Tests: [TEL1] 5.4.2 (Subassemblies)
		Rate(octave/minute)	0.25	0.25		
		Frequency range(Hz)	5-100-5	5-100-5		
		Axes of vibration	3	3		
ETSI	Sinusoidal	Velocity (mm/s)	-	5	3 x 5 sweep cycles	[ETS11], 5.5, Table 5, Class 3.2; Tests: [ETS15], 3.2, Table 5, Class 3.2
		Displacement (mm)	1.5			
		Acceleration (m/s^2)	5	2		
		Frequency range (Hz)	2-9 9-200	5-62 62-200		
		Axes of vibration	3	3		
	Random	ASD (m2/s3)	-	0.02	3 x 30 minutes	
		(dB/oct)		+12 -12		
		Frequency range		5-10 10-50 50-100		
		Axes of vibration	3	3		

Notes:

1.) Vibration specifications of NEBS and ETSI are substantially different, and tests are required to both profiles. ETSI requirements are stricter than NEBS requirements.

2.) According to GR-63 [TEL1], NEBS subassembly test (see second line in table 7.11) is not considered substitute for Frame level testing, but "may provide some indication of subassembly's resistance to office vibrations, prior to frame-mounted testing."

Network Data Centers

Additional information on vibration levels on Network Data Center environments can be obtained from ASHRAE document “Structural and Vibration Guidelines for Datacom Equipment Centers”, [ASH5], but while this document provides good guidance on vibration related issues, particularly at facility level, it is sufficiently loosely written that it cannot be considered as a good candidate as normative reference for equipment vibration resistance requirements at this point. Document refers to NEBS for vibration and earthquake requirements and tests, but does not mandate compliance. Additionally, TIA-942 [ANS4], Section 5.3.5.5. refers back to NEBS for vibration tests.

7.12 Earthquake resistance

NEBS defines four earthquake zones (Zone 1 to Zone-4) with increasing severity levels. Network operators require that the equipment is tested to minimum of Zone where the equipment is to be installed. Because some of the equipment will likely be installed on Zone-4 area, all equipment should be tested to Zone-4 requirements to eliminate deployment restrictions and need to maintain multiple versions tested to multiple severity levels.

AT&T requires <u>all</u> mission-critical Central Office equipment to be tested to Zone-4 (high seismic risk). Verizon requires testing “to the minimal specification of the Earthquake Zone where the product will be installed. NTT allows for NEBS earthquake test report to be submitted in place of NTT tests.

Network Data Center equipment test severity levels are not well defined. Some guidance, but not strong enough to be considered as good normative reference is provided in AHSRAE document “Structural and Vibration Guidelines for Datacom Equipment Centers” [AHS5]. Verizon “NEBS Requirements By Location” document requires NEBS Earthquake tests for equipment that is targeted for deployment in “Data Center Location”, but does not specify the severity levels.

Table 7.12 Earthquake Resistance Requirements

Parameter	**NEBS CO**	**ETSI CO**	**Data Center**	**Comments**
				If vibration testing is
Severity Level	**Zone-4 (7.0 - 8.3 Richter)**		**Not**	

		Specified	conducted for NDC, use NEBS test methods.
Requirement Ref.	**[TEL1], Section 4.4.1**		
Test Method ref.	**[TEL1], Section 5.4.1**		

Note that NEBS GR-63-CORE [TEL1] have additional requirements and tests that apply to Frame Level enclosures and/or equipment in terms of construction and anchoring that are related to earthquake resistance. These requirements are given in [TEL1], Sections 4.4.2 and 4.4.3., and must be met if applicable to given Central Office equipment.

Note: there is also ETSI EN 300 019-2-3 section 4 earthquake test.

Gap: earthquake resistance levels and tests are not defined for the Network Data Center environments.

7.13 Power and grounding

Power and grounding infrastructure and associated interfaces are critical to the high service availability levels associated with the critical infrastructure network elements and for electrical safety of the installation. Therefore, the power system interfaces are subject to strict requirements in terms of connection to facility power infrastructure. These requirements generally address the following aspects of the interface:

1. Redundant network element connections to facility power infrastructure,
2. network element connections to facility Bonding network (Ground)
3. ability of network element to tolerate certain transients in power inputs without loss of service or damage to equipment,
4. maximum levels of interference and disturbances that network element may transfer back to power infrastructure, and
5. safety aspects of the power interfaces.

Facility level powering infrastructure implementations can vary significantly, both between the implementations of different facilities, even within same operator's network, between operators, and between different types of facilities (i.e. Central offices vs. Network Data Centers).

Presently, almost all Network elements deployed in Central Office type facilities connect to -48V DC power, and network elements deployed in Network Data Center facilities connect to AC power (levels depend on power dissipation, facility type and geography).

Exceptions to both schemes do exist – in some cases certain elements in CO's utilize AC power (which is strongly discouraged by operators, as these will require separate support infrastructure, such as inverters), and some new data center installations utilize DC power for equipment.

7.13.1 48V DC Power interfaces

Normally, -48VDC power system consists of AC power distribution, power converters, DC power distribution and Batteries.

There are no 48V DC power interface requirement specifications specifically targeting Network Data Centers. If NDC equipment is designed to connect to -48V power distribution system, all of the requirements of this section apply to power interface of such equipment.

Additional immunity requirements of CISPR-22 [IEC3] table 3 may apply to the DC interfaces in Network Data Center spaces in some markets, but these are equivalent to and therefore covered by the EN 300 386 [ETS21] requirements, which are included in ETSI CO column..

Tables 7.1.3.1-1 and 7.1.3.1.-2 list the requirements applicable to the power interfaces. Note that all of these requirements are associated with the equipment power input terminals (Interface "A" as per ETSI terminology).

Note that the network elements (including power input, power distribution and other parts of embedded power subsystem) are also subject to additional regulatory safety requirements (see section 7.9) and EMC requirements (see section 7.14). Section 7.3.5 gives additional information on the power feed inlet placement and power cable routing practices.

Network element DC power interfaces must be clearly marked for the feed polarity, and Network elements should support feed reverse polarity protection (i.e. no permanent damage to element if the feed leads are connected in reverse).

Maximum 2-way loop voltage drop budget from the main power bars (located in DC generation / battery string area) through all secondary distribution systems components (distribution components and wiring) to Network Element DC power input terminals is 2.0V. The voltage specifications in the following tables apply to input terminals of the Network Element.

All voltage drop budgeting from the equipment power interface to the equipment power converters is responsibility of the equipment manufacturer. Note that for the Frame/Cabinet Level equipment, this must take in the account any integrated distribution components, such as breakers, filters, bus bars/wiring embedded within the frame.

Equipment voltage drops must be engineered using current drain associated with minimum voltage input and maximum equipment load.

Table 7.13.1-1 48V DC Power Interface Voltage and Current Levels

Parameter	NEBS CO	ETSI CO	Comments
Composite Req. (min.)	**-40 VDC**		Design to -40VDC at equipment power interface, no performance degradation
Min. Steady-State Voltage	-40 VDC	-40.5 VDC	
Requirement ref.	[TEL3], O10-1, O10-2 (M), [ANS3], Tbl. 1, line 4	[ETS18], 4.2	
Test Ref.	[TEL3] 10.3	Not Specified	
Composite Req. (max.)	**-72V (<u>required</u> for compatibility with installed base of -60V systems)**		
Maximum Steady-State Voltage	-56.7 VDC	-57.0 VDC / -72VDC (Annex A, -60V nominal)	
Requirement ref.	[TEL3], O10-1(M), [ANS3], Table 1, line 4	[ETS18], 4.2, Annex-A (-60V systems)	
Test Ref.	[ANS3], 5.3.1 to 5.3.3		
Recovery from steady-state abnormal input voltage conditions	**No damage to equipment and no operation of any protective devices (such as fuses or breakers). Automatic recovery with no manual intervention, back in full service in 30 minutes.**		
Requirement ref.	[TEL1] O10-2(M)	[ETS18], 4.3.2	
Test Ref.	[TEL1] 10.2, [ANS3], 5.2.1.1		
Turn off voltage	38.5VDC ±1VDC, >20s – Network Element must reduce power to 20% or less of nominal power		For maximum installation compatibility (e.g. with 60V systems), this may need to be configurable parameter
Requirement ref.	[ANS3], 5.2.2		
Test Ref.	[ANS3], 5.2.2.1 to 5.2.2.3		
Voltage change rate tolerance		[ETS18], 4.4	
Requirement ref.		[ETS18], 4.4	
Test Ref.		[ETS18], 4.4	
Maximum input current drain		No more than 1.5x max continuous normal drain at -48V for >1s	
Requirement ref.		[ETS18], 4.6	
Test Ref.			
Inrush Current		[ETS18], 4.7.1, Figure 3	
Requirement ref.		[ETS18], 4.7.1	
Test Ref.		[ETS18] 4.7.2	
Safety	**See section 7.9.1**		

Table 7.13.1-2 48V DC Power Interface Immunity

Parameter	NEBS CO	ETSI CO	Comments
Electrical Fast Transient	**0.5 kV**		
Requirement ref.	[TEL3], 2.2, O2-8 (M)	[ETS21].2.1.5.1	
Test Ref.	[TEL3], 2.2.1	[ETS21].2.1.5.1	
Undervoltage Transients	**-5V 10us fall, 10ms transient, 5us rise**		Recover within 30min with redundant feed disabled, no effect for operation when re-dundant feed con-nected.
Requirement ref.	[TEL3], O10-3, O10-4 (M), table 10-1 [ANS3], Figure 4		
Test Ref.	[TEL3], 10.3, [ANS3]		
Overvoltage Transients	**-75V <2us rise, 10ms transient, 10V/ms Slope**	[ETS18], 4.3.3	
Requirement ref.	[TEL3], O10-5(M) & Table 10-2, [ANS3] Figure 3	[ETS18], 4.3.3	
Test Ref.	[TEL3], 10.4, [ANS3]	[ETS18], 4.3.3	
Impulse Tran-sient	**-100V, rise <2us, fall to half 50 uS**		
Requirement ref.	[TEL3], O10-6(M) & Table 10-3, [ANS3] Figure 2		
Test Ref.	[TEL3], 10.5, [ANS3]		
Composite (Sin-gle) Transient	(this is a composite transient to test under, over, and impulse parts above)		
Requirement ref.	[TEL3], 10.6, CO10-7		
Test Ref.	[ANS3] annex C.1, Fig C.1		
Conducted Emissions	**See [TEL3], 3.2.2.2 and 10.7**	[ETS18], 4.9	
Requirement ref.	[TEL3], R3-11, O10-8 to O10-10(M) & Tables 3-5 & 10-3, [ANS3] 5.5.2	[ETS18], 4.9 & Figure 7	
Test Ref.	[TEL3], 10.7, [ANS3] 5.5.2	[ETS18], 4.9	
Conducted Im-munity	**See [TEL3], 3.3.2 & 10.8**	[ETS18] 4.8.1, [ETS21[7.2.1.5.2	
Requirement ref.	[TEL3], R3-20, O10-11 to O10-13(M) [ANS3] 5.5.1	[ETS18] 4.8.1, [ETS21[7.2.1.5.2	
Test Ref.	[TEL3], 10.8, [ANS3] 5.5.1	[ETS18] 4.8.1 & Annex C	

The DC distribution should support N+M power feeding as well as power system with N+M power redundant power modules, 2(N+1) at least. Typical DC power feed configuration is 2N to facilitate the connection to redundant A and B battery feeds of the office. Any redundant feed configuration must support powering the whole equipment at minimum operation voltage in the absence of the redundant feed(s).

7.13.2 High-Voltage DC Power interfaces

For further consideration.

7.13.3 AC Power interfaces

AC power system typically consists of UPS including Input/Output distribution and batteries, and load distribution equipment (wiring and circuit protection devices).

AC power systems are not used in Central Office facilities, and therefore AC powering is not required for Network Elements targeting CO facilities. All equipment targeting Central Office must support -48V DC power, and if AC power is supported, it must be equipment configuration option. AC power for equipment for Central Office installation requires AC generation using inverter that takes its feed from the CO -48V DC power plant feed(s), and is only used if there is no any other alternative.

The AC power feed support is desirable if the same equipment is designed to support deployment in BOTH Central Office and Network Data Center facilities. This may also be accomplished using an intermediate AC/-48VDC conversion stage, which does not necessarily need to be embedded to Network Element.

Similarly to above, the predominant power feed infrastructure in the Network Data Centers is based on AC power distribution. Therefore, the equipment targeting these environments must support AC power feed inputs. -48VDC may be provided as configuration option (some Network Operators are deploying DC powered equipment in Network Data Centers).

The predominant nominal AC voltage levels commonly used are between 220 and 240V (Europe and Asia – in Europe, “nominal” voltage is 230V, while systems with 220 and 240V nominal are widely used), and 100 to 130V (“low” nominal voltage varies widely by country, and at least systems with nominal of 100,110,115,120, 125 and 127V are in use – in US, “nominal” voltage is 120 V). Similarly, nominal AC frequency is either 50Hz or 60Hz, depending on the market. There are number of resources available on-line that give details on country specific voltages, frequencies and plug-types. Example of such reference is [DOC1].

The following Network Element AC input specifications are intended to serve the world market, and therefore some of the AC interfaces for lower power equipment require auto-ranging AC power supply (or dual-range support). For high power equipment, only "high line voltage" supply support is needed.

Table 7.13.3-1 AC Power Interfaces

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Composite Req.	**90-264Vrms (Autoranging) or 90-135 Vrms /198-264 Vrms (selectable) or 198-264 Vrms AC (high-line only)**			Autoranging (preferred) or user selectable
Low-line range	**90 Vrms to 135 Vrms AC (115V nominal)**			
Requirement ref.				
Test Ref.				
High-line range	**198 Vrms to 264 Vrms AC (230V nominal)**			
Requirement ref.				
Test Ref.				
Line Frequency	**47 to 63Hz (50±3 Hz / 60±3 Hz)**			Covers both nominal 50 and 60 Hz systems
Requirement ref.				
Test Ref.				
Turn-off Voltage	**82±2 Vrms AC (low-line off), 285±5 Vrms AC (high-line off)**			
Requirement ref.				
Test Ref.				
Turn-on Voltage	**90 Vrms AC (198 Vrms AC for hi-line only)**			
Requirement ref.				
Test Ref.				
Power Factor	**0.9 minimum (regardless of whether high or low line)**			
Requirement ref.				
Test Ref.				
Efficiency	**85% minimum for 1st stage AC/DC converter (higher is desirable)**			Applies to power converters, not strictly to power *interface*
Requirement ref.				
Test Ref.				
Recovery from steady-state abnormal input voltage conditions	**No damage to equipment and no operation of any protective devices (such as fuses or breakers). Automatic recovery with no manual intervention, NE back in full service within 30 minutes.**			
Requirement ref.				
Test Ref.				
Maximum feed current	**See section 7.13.5**			Depends on voltage and plug type
Inrush Current				
Requirement ref.				

Test Ref.				
Safety	**See section 7.9.1**			

Table 7.13.3-2 AC Power Port, Conducted Emissions

Parameter	**NEBS CO**	**ETSI CO**	**Network Data Center**	**Comments**
Power Port Noise Emission	See [TEL3], 3.2.2.1 (Table 3-3 Class-A) and 3.2.2.2	.15-.5 Mhz, 79 dB(uV) Q-p, 66 dB(uv) average, / 5-30 MHz 73 dB(uV) Q-p, 60 dB(uV) average		Class A limits (mandatory)
Requirement ref.	[TEL3], R3-10, R3-11	[ETS21], 6.1	[IEC2], 5.1, table 1	
Test Ref.	[TEL3], 10.7	[IEC2], 9	[IEC2], 9	

Parameter	**NEBS CO**	**ETSI CO**	**Network Data Center**	**Comments**
Power Port Noise Emission	See [TEL3], 3.2.2.1 (Table 3-4 Class-B) and 3.2.2.2	.15-.5 Mhz, 66 to 56 dB(uV) Q-p, 56 to 54 dB(uv) average, / .5-5 MHz 56 dB(uV) Q-p, 46 dB(uV) average / 5-30 MHz 60 dB(uV) Q-p, 50 dB(uV) average		Class B limits (desirable)
Requirement ref.	[TEL3], R3-10, R3-11	[ETS21], 6.1	[IEC2], 5.1, table 1	
Test Ref.	[TEL3], 10.7	[IEC2], 9	[IEC2], 9	

Table 7.13.3-3 AC Power Port, Immunity

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Conducted Immunity	See [TEL3], 3.3.2	0.15 to 80 MHz 3V		Design/test to CISPR24 [IEC3]
Requirement ref.	[TEL3], R3-20	[ETS21] Table 4, 7.2.1.4.3	[IEC3], Table 4, 4.1	
Test Ref.	[TEL3] 3.3.2	[ETS21] Table 4, 7.2.1.4.3	[IEC3], Table 4, 4.1	
Performance Criteria		Criterion A		
Test Spec.		IEC/EN 61000-4-6 [IEC11]		
Voltage Dips	Not Specified		>95% red/0.5 period (Criterion B), 30% red/25 period (Criterion C)	Design/test to CISPR24 [IEC3]
Requirement ref.			[IEC3], Table 4, 4.2	
Test Ref.			[IEC3], Table 4, 4.2	
Performance Criteria			See above	
Test Spec.			IEC/EN 61000-4-11 [IEC12]	
Voltage Interruptions	Not Specified		>95% red/250 periods	Design/test to CISPR24 [IEC3]
Requirement ref.			[IEC3], Table 4, 4.3	
Test Ref.			[IEC3], Table 4, 4.3	
Performance Criteria			Criterion C	
Test Spec.			IEC/EN 61000-4-11 [IEC12]	

Table 7.13.3-3 AC Power Port, Immunity (continued)

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Surges	See [TEL3], 4.12.1 (±2kV)	.5kV (line to line), 1kV (line to earth)	1kV (line to line), 2kV (line to earth)	Design/test to CISPR24 [IEC3] severity (1&2kV)
Requirement ref.	[TEL3], R43-89, R4-90, R4-91	[ETS21] Table 4, 7.2.1.4.2	[IEC3], Table 4, 4.4	
Test Ref.	[TEL3] 4.12.1	[ETS21] Table 4, 7.2.1.4.2	[IEC3], Table 4, 4.4	
Performance Criteria		Criterion B		
Test Spec.		IEC/EN 61000-4-5 [IEC10]		
Electrical Fast Transient	0.5 kV (CO)	**1kV**		Design/test to CISPR24 [IEC3] severity (1kV)
Requirement ref.	[TEL3], 2.2, O2-8 (M)	[ETS21] Table 4, 7.2.1.4.1	[IEC3], Table 4, 4.5	
Test Ref.	[TEL3], 2.2.1	[ETS21] Table 4, 7.2.1.4.1	[IEC3], Table 4, 4.5	
Performance Criteria	Criterion B			
Test Spec.	IEC/EN 61000-4-4 [IEC9]			

The AC distribution should support N+M power feeding as well as power system with N+M power redundant power modules, 2(N+1) at least. Typical AC power feed configuration is 2N to facilitate the connection to redundant A and B feeds. Any redundant feed configuration must support powering the whole equipment at minimum operation voltage in the absence of the redundant feed(s).

There is also possibility of having dual-redundant power supplies with two feeds each (see e.g. SSI Forum entry-redundant AC PSU specification, available from www.ssiforum.org). This facilitates the decoupling of the power supply input from the single feed voltage supply systems, such as UPSes. Such configuration is not required, and if used care must be taken that any failure mode in the single supply that is dual-fed from redundant AC sources cannot affect both sources.

7.13.4 Grounding interfaces

All equipment , regardless of installation location must implement dual-lug grounding terminal. The size of the terminal must allow connection to cable that can carry the maximum fault current (determined by the ratings of the overcurrent protection devices).

If the equipment is AC powered, and has DC connection configuration option, this connection is also required in addition to AC feed plug ground connection. For AC powered equipment, AC plug ground pin(s) shall be connected to safety ground (power supply/equipment enclosure).

Safety specifications have additional requirements for grounding, in terms of connection and associated markings. Consult references listed in section 7.9.1 for details.

Central office grounding requirements are covered by the following specifications:

- GR-1089-CORE [TEL3], section 9
- GR-295-CORE [TEL13]
- ETSI ETS 300 253 [ETS20]

Grounding interface must be two-hole compression type connector (like the DC system power feed), as per [TEL3] section 9.9.3.

Central Office equipment must be designed to be compatible with both star and mesh Isolated Ground Plane (star and star-mesh / Isolated Bonding Network) and Integrated Ground Plane (mesh / Common Bonding Network) architectures. This is to allow installations on the commonly used different grounding architectures.

Network Data Center

NDC powering and grounding systems are covered by applicable national and/or regional specifications, such as NEC in US. Please consult the references associated with target markets, as well as safety requirements in section 7.9 for the grounding schemes and requirements of equipment connections to facility grounding network in Network Datacenter spaces (particularly applicable to AC powering systems).

7.13.5 Power Feed Connections, Diameters and Ampacities

Minimum required equipment power feed cable diameter depends on the maximum per feed current, length of the cable, allowable voltage drop, cable temperature ratings, number of power cables bundled together, and maximum allowable operation ambient temperature.

GR-1052-CORE [TEL12], section 10 provides information for the dimensioning of the power feed cables.

In addition, there are a number of associated requirements in the safety specifications, as well as in other regional and/or national standards that regulate the power feeds. In US, the cable diameters must comply with National Electrical Code.

Equipment vendors must determine the maximum required feed currents (determined at minimum voltage), and design the feed termination points to allow for the connections of the cable of sufficient diameter that meets all the applicable safety and market specific code requirements.

Equipment power feed designs, especially due to potentially large diameter cabling and often large bend radius requirements must pay particular attention to the cable management associated with power feed cables, taking into account the redundant feed routing requirements, cable bending radius requirements, and no-interference to FRU replacement requirements. See section 7.3.5. for more information about applicable cable management practices.

Additional safety related requirements apply to these interfaces, please consult the safety specifications references listed in section 7.9 for associated references.

DC Power Feeds

Dual-terminal power lug connection is preferred DC power connector type, and is required for all DC Power Feed connections >24 A. The specific lug type depends on the ampacity of the connection (must be large enough to accommodate the cable diameter). For low ampacity connections ≤24 A, separable connectors may be specified, such as power connector specified in uTCA, section “Power Module Input Connector”.

DC power feed connections with protection devices of ≤70A can be connected to secondary DC distribution elements in Central Offices. Connections with larger ampacities must be connected directly to primary power distribution elements, and typically require the operator power engineer’s approval.

AC Power Feeds

The recommended network Element AC power feed connections should use one of the following connectors. This allows simple support for the different country specific connectors using the appropriate power feed cable.

The power that can be supplied through this interface is determined by ampacity of the selected connector, and the feed voltage (i.e. if “low”, “selectable” or “autoranging”, or “high” AC feed is specified).

- IEC 60320-1/C14 Appliance Inlet – 10Arms ≤ 250Vrms / 15Arms ≤ 125Vrms

- IEC 60320-1/C20 Appliance Inlet – 16Arms ≤ 250Vrms / 20Arms ≤ 125Vrms

7.13.6 Power Dissipation Reporting Requirements

Accurate power dissipation data is required for three major purposes at the equipment level:

- Comparisons of the energy efficiency of the similar equipment
- Dimensioning of the power distribution infrastructure, including feed capacities, protection devices, and cable diameters
- Dimensioning of the cooling capacity to remove the heat from the equipment

To support these activities, NEBS GR-63-CORE [TEL1], GR-3028-CORE [TEL2], AHSRAE [ASH1], [ASH2] and operator specific documents all have the power reporting requirements. Note that the equipment "maximum rated power" is only useful for power distribution system design, but is insufficient for cooling capacity planning purposes, due to generally being too conservative. The requirements in the abovementioned references contain additional reporting requirements to address this gap.

GAP: FRU level power reporting requirements and test processes should be specified in the relevant equipment building practice and/or test specifications. As a minimum, the SW load and support environment (test environment, including equipment such as traffic generators) used in power dissipation tests must be documented. These must follow and be compatible with the equipment level reporting requirements outlined above (typical and maximum power dissipation). If the power dissipation changes over 5% across the specified operation temperature range (which is typical due to small device geometry semiconductor processes), then table of power dissipation over temperature should be provided.

GAP: Shelf level power reporting requirements and test processes should be specified in the relevant equipment building practice and/or test specifications. As a minimum, the shelf power dissipation should be tested at "nominal" fan speed, associated with 25°C temperature, and at maximum fan speed (associated with maximum specified operation temperature – exceptional temperature of 55°C for CO equipment, and 35°C for NDC equipment) without the payload. Shelf documentation must also include number of power feeds, and maximum ampacity of each feed (associated with maximum dissipation at minimum feed voltage).

7.14 Electromagnetic compatibility (EMC)

7.14.1 EMC overview

Tables in the following subsection provide an overview of the EMC specifications associated with network elements intended for installation in Central Offices and Network Data Centers. Summary of applicable specifications is provided in tables 7.14-1 and 7.14-2. Note that the CO requirements in table 7.14.-2 are **additional requirements** to baseline requirements of table 7.14-1.

Note that the number of additional and many cases equipment type dependent and geographic market specific specifications apply to “intentional emitters”, such as radio equipment. Such specifications are not covered in this profile.

Table 7.14.1-1 EMC Requirement Summary - All Environments

Criteria	Primary	Secondary	References
FCC Part 15 (emissions)	Class A Required	Class B Desirable	FCC CFR47 PART15 [CFR4]
CISPR-22 (emissions)	Required		CISPR 22 [IEC2]
CISPR-24 (immunity)	Required		CISPR 24 [IEC3]

Table 7.14.1.-2 Additional EMC Requirements Summary – CO’s

Criteria	Primary	Secondary	References
EN 300 386	Required		EN 300 386 [ETS21]
ES 201 468		Desirable	ES 201 468 [ETS22]
GR-1089 (Emissions)	Class A Required	Class B desirable	GR-1089 [TEL3]
GR-1089 (Immunity)	Required		GR-1089 [TEL3]

EMC requirements are divided to five categories in the following subsections:

1. Emission requirements (enclosure port)
2. Immunity requirements (enclosure port)
3. Equipment / port type specific emission requirements
4. Equipment / port type specific immunity requirements
5. Additional EMC related requirements

Requirements in categories 1 and 2 apply to all equipment. Requirements in categories 3-5 are equipment, installation environment and/or port type specific. For a summary of NEBS requirements associated with specific port types, consult GR-1089-CORE [TEL3], Appendix B. For ETSI requirements, please consult EN 300 386 [ETS21].

Since, as a minimum, all equipment has the power interface of some kind, the Conducted Emissions and other requirements that apply to the specific power interface type apply to all equipment. Please consult section 7.13 for EMC related requirements that are associated with power interfaces.

System level requirements given in categories 1 and 2 apply to the whole equipment, including the power supplies.

Some of the EMC specifications include requirements related to Electrical Safety. These requirements are covered in sections 7.9 (safety) and 7.13 (power and grounding) of this document.

7.14.2 EMC emissions requirements – enclosure port

Radiated Emissions Limits are based on the following specifications:

- **North America – all equipment:** FCC Part 15 [CFR4]
- **North America, CO's:** GR-1089-CORE [TEL3] – refers to FCC part 15
- **Canada – all equipment:** ICES-003 [ICES3] – refers to CISPR-22 [IEC2]
- **European Community – all equipment:** EN 55022 (CISPR-22 [IEC2])
- **European Community, CO's:** EN 300 386 [ETS21], refers to EN 55022 (CISPR22 [IEC2])
- **Japan:** VCCI [VCCI] – refers to CISPR-22 [IEC2]

Table 7.14.2 – EMC Emissions, Enclosure Port, Class-A

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Radiated Emissions	Up to 10GHz, see [TEL3] 3.2.1	30-230 MHz 40 dB(uV/m), 230-1000 Mhz 47 dB(uV/m), 1-3GHz 76 dB(uV/m), 3-6 GHz 80 dB(uV/m)		Class A compliance is **mandatory,** but Class B compliance is **desirable.** See additional comments and gap below.
Requirement ref.	[TEL3] 3.2.1	[ETS21], 7.1.1 ---> [IEC2], Class-A Table 5 & Table 8	[IEC2] Class-A, Table 5, Table 8	
Test Ref.	[TEL3] 3.4	[IEC2] 10	[IEC2] 10	

Since telecommunications equipment may consist of the multiple components integrated together to compose an “equipment”, which is tested as a composite entity, the emission limits associated with individual components (i.e. subsystems) need to be subjected to sufficient derating that the whole integrated equipment will be able to pass Class-A limits at the system level. See [SCO1] for example of the applicable derating requirements in the context of AdvancedTCA.

It is a strong objective that the EMC emission limits should be met with the cabinet doors open (or without doors), and absolute requirement that the class-A limits must be met with doors closed, at the very minimum. Note that many of the typical installations may not have cabinets with doors, and the use of cabinet doors is not preferred by many operators. Additionally, the additional shielding performance that may be attributable to doors is dependent to specific cabinet design, and if the equipment relies on the additional shielding by doors, testing in potentially many different cabinets may be required to demonstrate compliance. Reliance on doors is also not preferred due to the potential exposure of the equipment environment to potentially excessive emissions during the service operations.

<u>**GAP:**</u> Radiated emission limits and test procedures need to be extended to help ensure that the end equipment configurations meet the specified equipment/frame level limits. This should be taken down to FRU level on open equipment building practice specifications. IEEE and ECMA have developed, or are in process of development of applicable test procedures.

7.14.3 EMC immunity requirements – enclosure port

Table 7.14.3 EMC Immunity (Enclosure Port)

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
RF Electro-Magnetic Field, Amplitude Modulated	10kHz-10GHz 8.5V/m	80-800Mhz 3V/m, 800-960Mhz 10 V/m, 960-1000Mhz 3V/m, 1400-2000Mhz 10 V/m, 200-2700MHz 3 V/m; 80% AM (1 kHz)	≤80-1000MHz, 3V/m, 80% AM (1 kHz)	NEBS has it's own method and criteria, ETSI and NDCs are tested to IEC61000-4-3, but different limits
Requirement ref.	[TEL3], R3-15, R3-18	[ETS21] 7.2.1.1.2	[IEC3] Table 1 / 1.2	
Test Ref.	[TEL3] 3.5.5	[ETS21] 7.2.1.1.2	[IEC3] Table 1 / 1.2	
Performance Criteria		Criterion A		
Test Spec.		IEC-61000-4-3 [IEC8]		
ElectroStatic Discharge (ESD)	8kV (Contact), 4/15kV (Air Discharge)	4kV (Contact), 4kV (Air Discharge)	4 kV (Contact Discharge), 8kV (Air Discharge)	ESD warning labels are required for all equipment with ESD sensitive components [TEL3] R2-5.
Requirement ref.	[TEL3] 2.1.2	[ETS21] 7.2.1.1.1	[IEC3] Table 1 / 1.3	
Test Ref.	[TEL3] 2.1.4	[ETS21] 7.2.1.1.1	[IEC3] Table 1 / 1.3	
Performance Criteria	Criterion B			
Test Spec.	IEC-61000-4-2 [IEC6]			
Power-Frequency Magnetic Field	Not Applicable		50/60 Hz, 1A rms	Applies only to equipment containing devices susceptible to magnetic fields.
Requirement ref.			[IEC3] Table 1 / 1.1	
Test Ref.			[IEC3] Table 1 / 1.1	
Performance Criteria			Criterion A	
Test Spec.			IEC-61000-4-8 [IEC7]	

7.14.4 Port specific EMC emissions requirements

Port specific emission requirements specify the conducted emission limits for all interfaces utilizing metallic cabling (conducted emissions requirements are not applicable to optical interfaces due to dielectric nature of the medium).

Table 7.14.4 Port Specific EMC emissions requirements

Telecom Port Emissions	NEBS CO	ETSI CO	Network Data Center	Comments
Requirement ref.	GR-1089, 3.2.3	CISPR-22 [IEC2] - Table 3 (Class A), Table 4 (Class B)		Class A Mandatory, Class B desirable
Test Ref.	GR-1089	CISPR-22 [IEC3]		

For NEBS Central office requirements, consult Appendix B, and Table B-3 in GR-1089-CORE [TEL3] for the details of the port type definitions and requirement applicability for different port types.

7.14.5 Port specific EMC immunity requirements

Table 7.14.5 Port Specific EMC Immunity requirements

Parameter	NEBS CO	ETSI CO	Network Data Center	Comments
Conducted Immunity				Performance Criterion A
Requirement ref.	[TEL3] 3.3.3	[ETS21], 7.2.1.2, 7.2.1.3	[IEC3], Table 2, 2.1	
Test Ref.	[TEL3] 3.3.3	IEC 61000-4-6 [IEC11]		
Surges				Performance Criterion B
Requirement ref.	[TEL3] 4.6	[ETS21], 5.3.1	[IEC3], Table 2, 2.2	
Test Ref.	[TEL3] 4.6	IEC 61000-4-5 [IEC10]		
Electrical Fast Transient burst (EFT)				Performance Criterion B
Requirement ref.	[TEL3], 2.2	[ETS21], 7.2.1.2, 7.2.1.3	[IEC3], Table 2, 2.3	
Test Ref.	IEC 61000-4-4 [IEC9]			
AC Power Faults				
Requirement ref.	[TEL3] 4.6			

Test Ref.	[TEL3] 4.6			

Limits and associated performance requirements vary by the specific port type (most significant differences are associated with whether the lines are connected to outdoor environments, and if so, what kinds of protection scheme is used). Consult the references [ETS21], and [TEL3], Appendix B for the detailed applicability of the requirements and limits for the specific port types.

7.14.6 Additional NEBS EMC related requirements

GR-1089-CORE [TEL3], contains additional requirements related to Steady state power induction (section 5, related to OSP metallic interfaces), DC potential Difference (section 6, related to gound referenced metallic interfaces) and Corrosion Section 8, related to metallic OSP cable voltage levels). These requirements may be are applicable to Central Office equipment.

7.15 Design and manufacture

7.15.1 Quality

Equipment design and manufacture, including the components and subsystems that are integrated as a part of the equipment should be covered by ISO-9000 and/or TL-9000 (additional criteria specifically targeting Network Equipment and associated subsystem vendors) comparable quality standards.

7.15.2 Telcordia GR-78

Telcordia document GR-78 [TEL4], “Generic Requirements for the Physical Design and Manufacture of Telecommunications Product and Equipment” establishes set of compliance criteria in areas of Materials & Finishes, Separable Connectors, Wires and Cables, Printed Wiring Boards, assembly, Electro-Static Discharge, identification, marking, packaging and repairs.

Assessment of the Network Element compliance to this specification is required by many North American Network operators as part of expected set of Telcordia specifications for Central Office equipment. As such, the stakeholders should consider the implications of this specification on design and manufacture of the component or equipment.

Compliance statement for the present GR-78 criteria is required as part of section ‘G’ of the Telecommunications Carrier Group (TCG) NEBS Compliance Checklist document [VZ1].

7.16 Reliability, Availability and Serviceability (RAS)

7.16.1 Reliability predictions

CCVs must perform SR-332 Issue-1 [TEL6] or SR-332 Issue-2 [TEL7] reliability predictions for all electronics assemblies, for each FRU. If specific FRU has configuration options, such as mezzanine cards, disk drives, memory options or any other configuration options that substantially affect the reliability predictions these need to be represented either as options or be subjected to separate reliability prediction report with enough information on how the configurations can be combined to get reliability of the resulting assembly.

Baseline reliability prediction values must be stated at reference component ambient temperature of 40°C using the SR-332 "Method I-D Black-Box Technique" without any additional re-/derating factors to facilitate the comparison of the assemblies between supplies based on the known baseline assumptions. In addition to this, manufacturers must have available prediction over the operation ambient temperature range (5°C to 65°C average component ambient for assemblies for Central Office use, and 5°C to 45°C for Network Data Center use). Above temperature ranges are provided as a guidance based on 10C temperature average air temperature rise over ambient, with exception that the prediction temperature range only needs to be extended to maximum allowed immediate component ambient temperature for given FRU.

Additionally, as the reliability predictions tend to be inherently conservative, manufacturers are encouraged to utilize methods to facilitate better correlation of the predicted values to expected field performance, such as utilizing scaling factors based on field performance experience of similar values, and/or utilizing more accurate component temperature information for predictions. If such methods are utilized, manufacturer should have available description of the assumptions and supporting justification for the scaling / temperature scaling factors.

Additionally, manufacturers must state whether component reliability data used is based on Telcordia (or other) reliability models, manufacturer data and/or field reliability performance data. In case of mix, this information must be available on individual component, or component group basis (component group basis statement may only be used if same method is applied to given component group, such as specific type of capacitors).

FRU level reliability prediction reports must be made available to NEPs by CCVs, upon request for use as basis for selection, availability modeling, sparing strategy planning, warranty cost estimations and other processes that rely on reliability information.

Over time, it is expected that the predictions should be done using SR-332 Issue-2, but both methods are allowed at the transition period. All reliability prediction reports must state the standard version used.

7.16.2 Service life predictions

Manufacturers of electronic or electromechanical sub-assemblies should perform and make available to NEPs a service life prediction report for each assembly.

The service life predictions should use physics of failure based analysis for known limited life component groups. Such component groups include, but are not limited to electro-mechanical components (Fans, Hard Disk Drives), optical components (e.g. optocouplers, lasers), certain capacitors (electrolytics, supercapacitors), non-volatile memory devices with frequent write access, and separable connectors.

The purpose of this analysis is either to help demonstrate that the subassembly will meet its associated service life requirements, or that the assembly or some parts of it are anticipated to require replacement before the typical target service life will be reached.

GAP: no standardized process is available that could be referenced for the service life predictions.

7.16.3 Reliability Field Performance

Manufactures should collect and retain reliability field performance metrics according to TL-9000 reliability related metrics and procedures specified in [QUE1], [QUE2].

GAP: equipment should collect and store information of accurate reliability and availability information at FRU level to help get accurate field reliability performance report data. The associated data structures and procedures should be addressed in hardware management standards.

GAP: life cycle management processes across multiple stakeholders (Network Operators, NEPs, and equipment manufacturers) to facilitate collection and transfer the failure information to satisfy TL-9000 metrics collection, while addressing the security and confidentially issues associated with the metrics transfer should be addressed. There is an opportunity to automate these processes using standardized protocols and data semantics. Presently most NEPs implement proprietary and disparate systems for the R&A data collection.

7.16.4 Availability

Availability performance of many network elements remains to be important for the Telecommunications network operators. Due to network convergence to IP based networks, the availability aspects of the IP network equipment are also increasing in importance, in some cases including the element internal redundancy and availability improvement techniques instead of prevalent equipment level redundancy models.

The availability performance attributable to equipment hardware and low level software designs can be mostly attributable to the following factors:

- Highly reliable hardware designs
- High run-time hardware fault detection coverage for both transient and persistent failure modes. The transient failure modes are expected to be increasing and become dominant HW failure modes, as the semiconductor process technology geometries keep shrinking, requiring particular attention.
- Support for latent fault detection of redundant resources (i.e. to ensure that the redundant equipment will be fully functional and available in the event of the need of fail-over to such resources).
- Fault containment techniques (i.e. systematic elimination of the fault effect propagation beyond containment region boundaries, particularly to the redundant resources)
- High-confidence diagnostics support (i.e. high probability of the detection of the existing faults, as well as correct identification of fault location, at least to the level of the faulty FRU)
- Support of Hardware redundancy schemes, including redundant interconnects
- Elimination of all “Single Points Of Failures” (i.e. failure modes that can affect more than one FRU or subsystem that is essential for the service availability)
- Support of hot-swappable FRUs, including support for other aspects of design required to achieve FRU level replacement without disturbing other FRUs on the system
- Support of redundant Firmware and SW images

Subsystem vendors for high-availability hardware are expected to address all of these areas, as pertaining to specific subsystem design. The design practices of high-availability equipment are not well covered by the present standards, so specific standards references cannot be given here. Practitioners should consult the large body of literature associated with high-availability system design, including the material in SCOPE references [SCO1, SCO2] and references therein.

The present COTS building practices and key subsystem and interface specifications do address the associated HW aspects quite well. The key problem is the lack of SW support for enabling the associated fault detection and other fault handling HW, as well as standardized reporting interfaces and message semantics for propagation of fault event indications to fault management, middleware and other associated SW layers that need to be able to take actions based on the fault indication events.

Verification processes associated with these techniques are inherently very complex, and include modeling and analysis techniques such as Reliability and Service Life analysis, Reliability Block Diagrams, (RBDs) and Markov Reward Models, Failure Modes Effects and Criticality Analysis (FMECA), and verification techniques such as Hardware & Software Fault Injection Testing. Unfortunately, many of these techniques are not well addressed by existing standards we could refer here.

7.16.5 Serviceability

Please refer to “physical construction” section of this document for specific serviceability requirements related to equipment construction.

7.17 Ecological Compatibility

7.17.1 Materials and waste management

Environmental concerns associated with the management of waste of electronics and electrical equipment are gaining attention of the regulatory bodies worldwide, due to relatively short lifespan and subsequently high quantities of the associated electronics waste products. European Community has been leading the regulatory efforts on this area by implementation of “RoHS/WEEE” directives. There is large number of different ecological standards worldwide at country and state levels, but the requirements of many (or most) of these can be satisfied by meeting the RoHS/WEE compliance requirements.

It is SCOPE position that all Network Elements, regardless of the installation environment are required to comply with ROHS/WEEE directives. Please refer to [EC2] and [EC3].

RoHS 6/6 compliance is preferred by NEPs as SCOPE consensus position (i.e. equipment is to be designed to not take lead exception).

Component and subsystem vendors must gather and retain the detailed materials compliance information for all products. This information must be available to NEPs as required to demonstrate the compliance to these directives. Similarly, information on the lead free processes (if used), and associated reliability should be available to support the acceptance of the lead-free assemblies by NEPs end-customers.

7.17.2 Energy efficiency

For further consideration

8. ANNEX-A: OPERATOR SPECIFIC DOCUMENTS

Many Network Operators have their own specifications that either profile or supplement the specifications developed by the primary specification development organizations listed above. While the observed common trend has been to better align with the primary specifications, there are still operator specific differences that stakeholders may need to be aware of. As such, these documents are not considered primary documents, and are not generally taken as normative input to this profile unless specifically stated otherwise. In addition to providing input from end user perspective, some of these documents provide a great deal of useful information for Central Office building and installation practices. Note that this list is not exhaustive, and does not cover all of the known operator specific requirements and/or test documents that may be applicable.

AT&T Documents – available at https://ebiznet.sbc.com/sbcnebs

[ATT1] Network Element Power, Grounding and Physical Design Requirements, ATT-TP-76200, Issue 11a, November 2, 2007

[ATT2] Common Systems Equipment Interconnection Standards for the ATT Local Exchange Companies and AT&T Corporation, ATT-TP-76450, 8/31/2007

[ATT3] Detail Engineering Requirements, AT&T Techical Publication ATT-TP-76400, January 1, 2008

NTT DoCoMo documents

[NTT1] Power-Supply Requirements Guideline, Version 2.0, June 2004, NTT DoCoMo

[NTT2] Earthquake Resistance Test Specifications for General-Purpose Equipment (Cabinet Racks), Edition 1, April 2004, NTT DoCoMo

[NTT3] NTT Communications, Guidelines for Green Procurement, Second Edition, January 2006, NTT Communications

QWEST Documents – available at : http://www.qwest.com/techpub/

[QW1] QWEST Communications International Inc. Technical Publication; QWEST Engineering Standards, General Equipment Requirements, Module 1; QWEST 77351, Issue F, June 2001

[QW2] QWEST Technical Publication, Power Equipment and Engineering Standards, QWEST 77385, Issue H, September 2003

[QW3] QWEST Technical Publication, Telecommunications Equipment Installation Guidelines, Qwest 77350, Issue N, January 2007

[QW4] QWEST Technical Publication, Grounding – Central Office and Remote Equipment Environment, QWEST 77355, Issue G, June 2006

Verizon & TCG Documents – available at www.verizonnebs.com

[VZ1] Network Equipment Building Systems (NEBS™) Compliance Checklist, April 4, 2006, Telecommunications Carrier Group

[VZ2] Verizon NEBS™ Compliance Clarification Document, SIT.NEBS.RQS.NPI,2004.019, February 27, 2006, Verizon

[VZ3] Verizon NEBS™ Compliance: NEBS Requirements By Location, Verizon Technical Purchasing Requirements, VZ.TPR.9203, Issue 1, February 2007\[VZ4]

[VZ4] Verizon NEBS™ Compliance: Heat Release Calculation and Mitigation Planning, Verizon Technical Purchasing Requirements, VZ.TPR.9601, Issue 1, September 10, 2007

[VZ5] Verizon NEBS™ Compliance: Labeling Requirements for Light Emitting Equipment, Verizon Technical Purchasing Requirements,VZ TPR.9204, Issue 1, October 2007