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Temperature Ratings for Ethernet Products Deciphered

Different Methods and Standards Yield Different Numbers

by

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Introduction

The Magnum line of Ethernet products from GarrettCom, Inc., covers an unusually broad range of markets and applications. This diversity has given GarrettCom direct experience with different product temperature rating systems, and has provided an unusual laboratory for comparing and contrasting different product temperature rating methods. Beginning with Enterprise (office) ratings in 1991, GarrettCom proceeded to Carrier Class (telecom) ratings as prescribed by the NEBS and ETSI specifications, and then added hardened Industrial Ethernet products for factory floor and temperature un-controlled outdoor applications.

This paper is designed to help purchasers understand what is behind the different temperature rating numbers in use today. It suggests interpretations and meanings users might attach to the different rating numbers in making decisions about the applications suitability of Ethernet products, particularly in the emerging Industrial Ethernet market.

Temperature rating principles

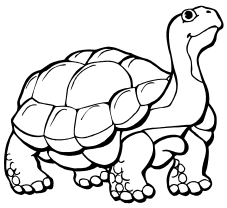
The objective of temperature ratings is to set limits on appropriate operating conditions for a product. Users want a simple yes-or-no answer to the question “will it work at xx degrees?” Suppliers try to oblige with high-limit and low-limit temperature numbers that define the product’s operating range precisely. Unfortunately, the precision is illusory.

Products constructed of electronic parts will operate over a temperature range in a manner that is somewhat analogous to the speed rating of a car. Will it go 70? Will it go 120? Will it go 250? We all know that the faster the speed, the greater the risk of a mechanical failure. Further, you can go fast in a car for a brief period with little enduring stress damage to the vehicle, but if you drive it wide open all the time, it will not last very long. A simple answer to the question “How fast will it go?” is not the whole story. Is the answer meant to be interpreted as a burst-of-speed rating, or a steady-state speed that does not compromise the service lifetime of the vehicle? When measuring the speed, is the car being driven on level terrain, or is a downhill course permitted? Over what distance should the test be conducted? What happens if it rains during the test?

With Ethernet products, the typical way to get consistent answers to complex temperature rating questions is to rely on independent testing and standards. As might be expected in the competitive world we live in, there is more than one rating method, and there are choices of testing standards used and of the parties to do the testing analysis and reporting. A careful buyer will find it useful to know about the testing, analysis, and reporting standards for temperature ratings, as well as the rating numbers themselves.

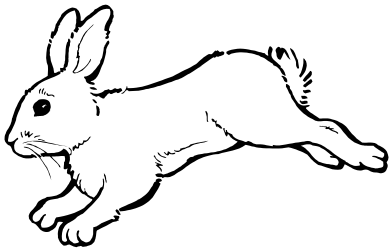
The "Component Parts" Rating Method

The Component Parts method analyzes and tests products to determine if a vendor's rating is within industry norms. The objective of this rating method is to provide guidance on use of the product that will not compromise its durability and operating lifetime. Like the tortoise in the famous race, a product's Component Parts rating indicates how the product is likely to perform over a lifetime of use within the prescribed temperature ratings. The tests take into account the operating ratings of the component parts and the construction of the product. Actual operating measurements using temperature probes are taken as needed. The test uses the component manufacturers' specifications and a Bill-Of-Materials (BOM) for the product. Safety factors are added to component ratings based on industry norms and experience. If all component parts are operating steady state within their specifications plus the safety margins, then the vendor's proposed product temperature rating gets a passing grade.



The "Type Test" Rating Method

Type testing puts one model or type of the actual working product through its paces in a temperature-testing set-up. Like the hare in the race, it is expected to run "all out" for a short time without breaking down (or collapsing in exhaustion). Normally, a Type Test is used in R&D to verify or validate a product design objective. No BOM or analysis of components is required, and no safety factors are involved. It is a real world test. If it works, it works. For a Type Test, the product passes unless it fails to operate during the actual temperature test period.



Let's look at the basics of temperature ratings, and then see how these two temperature-rating methods can be applied to give users the product suitability information they want.

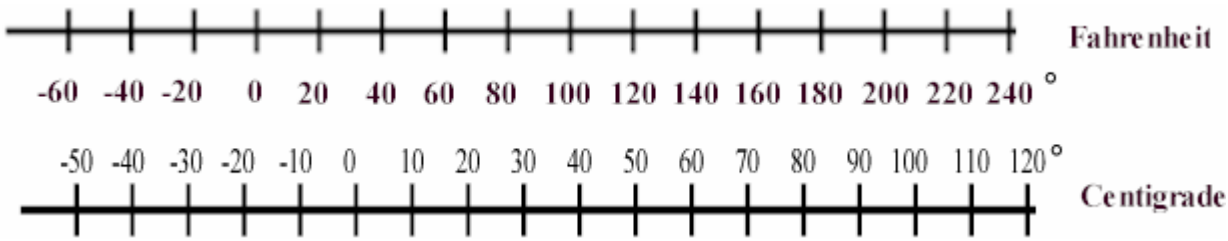
Temperature ratings, the basics

For all rating methods, the rating numbers are expressed as an ambient temperature. The ambient is the temperature of the surrounding environment. For the user, the ambient is the temperature at the place where the product is to be installed and operated. During a test the ambient temperature is measured 30 to 40 cm from the product's exterior surface to allow for the effects of heat and airflow in the immediate vicinity of the product.

The ambient temperature and the applicable temperature rating numbers cover a range, from a minimum or low ambient temperature to a maximum or high ambient temperature. For the product in operation, as long as the ambient operating temperature is within the range, the unit is being used within its temperature specifications.

The rating numbers are normally expressed in degrees Centigrade, the international temperature standard. For the United States and others who prefer degrees Fahrenheit, the

formula F=9/5C+32 will convert the numbers. A graphic shows how the two temperature scales compare.



High Temperature Considerations

The high number in the range rates products by their ability to withstand ambient heat and still perform. In addition, products consume power during operation and thus produce heat, which must be removed and dissipated into the surrounding environment. High temperature rating considerations include both the ability to withstanding heat and to get rid of heat.

Heat may be removed by conduction, convection, radiation, forced air movement (fans), or combinations of these. The design and construction of any product addresses these techniques in various ways, always recognizing that heat naturally flows from hot to cold. Radiation and convection need a differential temperature against the ambient in order to remove heat. Forced air lowers the temperature differential required to remove equivalent heat and greatly improves cooling, but fan noise and / or reliability can be problems.

Low Temperature Considerations

The low end of the temperature range indicates the product's ability to operate in cold conditions. Because products produce heat during normal operation, they tend to keep themselves warm. A special issue is "cold start," where the product is left in a low ambient temperature to cool for an extended time period and then suddenly powered on. Low temperature ratings are often separate numbers for "operating" vs. "cold start" ambient conditions.

Product design techniques for addressing cold temperature conditions are less well known than those for addressing heat. Equally components with very low temperature ratings are not as available as high temperature components. With the increasing popularity of Ethernet in Industrial applications with uncontrolled temperature environments – especially in outdoor or remote facilities where maintaining an expensive temperature-controlled chamber for human comfort is not required, cold is an issue that

must be addressed. Cold temperatures also can cause moisture in the form of condensation to occur. Electronic equipment does not respond well to getting wet, so product design precautions must be taken.

Enterprise Ratings

In the Enterprise market sector, the dominant location for LAN products is in an office environment. Ethernet LANs were born and grew up in office applications. Mass-market enterprise uses are so pervasive that they form the basis for what most people know and understand about Ethernet LAN products.

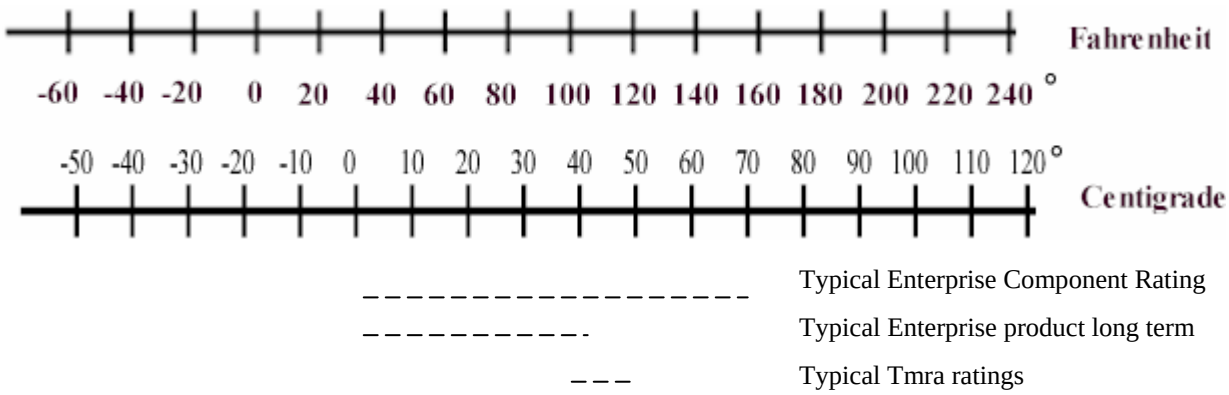
Temperature ratings are easily derived and totally non-controversial for Enterprise uses. Enterprise products are installed where people are at work. Regular commercial-grade electronic parts are used in Enterprise LAN products. Enterprise LAN products use commercial-grade electronic components and standard product construction methods that yield a typical product temperature rating of 0° to 40°C (32° to 104°F). In Enterprise wiring closets where temperatures can approach the high end of the range, LAN products routinely use fans for cooling efficiency. In office and lab workspaces, small units use external power supplies and convection cooling to reduce cost and avoid fan noise. There is no incentive for the product designers and manufacturers who cater to this arena to work to extend the temperature range because typical Enterprise equipment would not benefit.

As noted, products for Enterprise use are usually rated at 0° to 40°C ambient temperature. The commercial-grade electronic parts used are rated by their manufacturers at 0° to 70°C, which means that there is a 30°C temperature differential between the high-temperature rating of the component parts inside and the ambient rating for the product package. This differential has proven to be adequate for Enterprise-product thermal designs for years, and has become an industry norm.

Agency testing experience shows that a 20°C high-temperature differential is good to adequate; a 25°C differential is desired to provide for safety margins; and a 30°C differential offers extra margins. Since an office environment does not approach the low-temperature rating of 0°C, it is of little concern. The T_{mra} number (pronounced tee-sub-emm-are-aaa, the manufacturer's recommended ambient temperature) is reported only for the high-side rating; the low side is ignored.

For the Enterprise market, product temperature testing for safety is done by independent testing labs (for example, UL). They analyze and test for T_{mra} as it relates to safety, and pay little or no attention to the low-temperature side. For commercial use, temperature ratings, currents and voltages, and materials used are an essential part of the product evaluation for the potential risk of fire, burns and electrical shock related to insulation degradation. Enterprise product manufacturers are not pushing their temperature ratings, so the Component Parts temperature rating method is adequate for Enterprise LAN products.

Enterprise Temperature rating numbers are summarized graphically here :



Carrier Class Ratings

Carrier Class products are designed and tested to meet demanding telecom industry standards. The telecommunications market has emphasized high product quality and reliability for decades in order to produce telephone service that is "always available." Telecommunications standards cover a number of product characteristics that are applicable to the use of the product in communications central offices, key network communications facilities that must stay in operation even in the event of calamities.

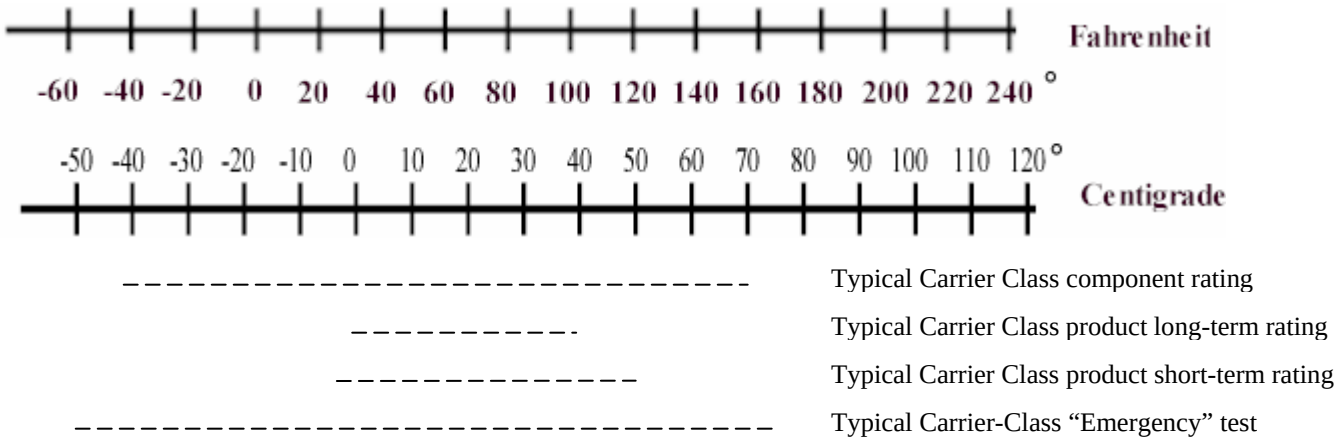
Some of the critical Carrier Class product characteristics include non-flammability, emissions levels, vibration and shock resistance, reliability, resistance to lightning, and extended temperature range. The required specifications are embodied in documents such as NEBS (Network Equipment Building Standards) requirements for physical protection in North America and ETSI in Europe. Products designed to meet these standards and specifications are rigorously analyzed and tested by licensed testing facilities.

The temperature rating requirements for Carrier Class products are more demanding than those for Enterprise products. Long-term ambient temperature ratings are 5°C to 40°C, with short-term operation from –5°C to 50°C to cover applications where the equipment must operate in un-manned central offices packed with gear. Under such conditions, heat build-up is allowed to save on air conditioning costs. "Short term" is defined in the NEBS standard as a period of not more than 96 consecutive hours and a total of not more than 15 days in one year.

In addition to the long-term and short-term ambient temperature ratings, the equipment in telecommunications central offices must operate under abnormal or emergency conditions for periods of up to a few days. This is to allow for continued communications services during natural disasters such as earthquakes, fires, hurricanes and floods. The desired temperature ratings for the emergency requirements are -25°C to 75°C, and it is understood that product lifetime may be impaired by operating outside of the normal long-term and short-term temperature ratings but within the extremes of the emergency range.

When rating for the long-term telecommunications requirements, the testing facilities use the Component Parts rating method. For the short-term and emergency telecommunications requirements, the Type Test rating method is used as a part of the NEBS testing or ETSI testing procedures. Additionally, international standards such as IEC 60068 and HALT tests (Highly Accelerated Lifetime Testing), which cycle the temperature up and down in a prescribed pattern while varying vibration is applied, to increase stress on the product. Stress testing is done for the specific purpose of condensing years of normal operations into a week or two of actual test time in order to identify product design weaknesses and improve product quality.

Note that different testing and rating methods for telecommunications products, all part of the same comprehensive test suite, produce different temperature rating numbers for the exact same product. The practice for telecommunications equipment manufacturers has been to rate products in published specifications according to the NEBS rating method, which is indicative of the normal service and lifetime of the products.



Note: for ETSI, the Class 3.1 ambient requirements are 5°C to 40°C for temperature controlled locations, Class 3.2 ambient is –5°C to 45°C for partly temperature controlled locations, Class 3.3 is –25°C to 55°C for temperature-uncontrolled weather-protected locations, and Class 3.4 is –40°C to 70°C for uncontrolled locations with a heat trap.

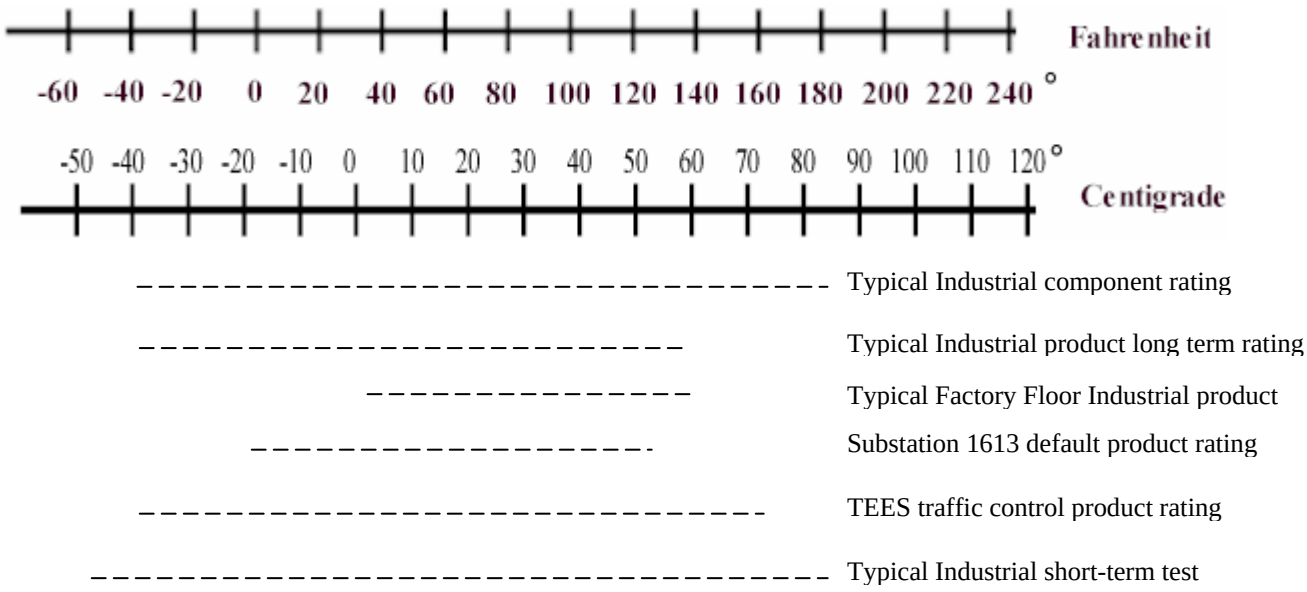
Industrial and Hardened Products Ratings

In the Industrial Ethernet market, many applications require products that will operate reliably under extended temperature conditions, some up to 100 percent of the time. Product temperature ratings are, therefore, a matter of great concern. System designers study vendors' published specifications to find equipment suitable for operating under extreme conditions. Unlike the Enterprise LAN market or the Carrier Class (telecommunications) equipment market, which have been around for more than a decade, Industrial Ethernet is a dynamic new field with new players and new products appearing almost monthly. Industry norms for product ratings are in the early stages of being defined and established, and the few norms that do exist are not uniform across industrial market

sectors. For example, factory floor is different from 1613 for power utility substations; both are different from TEES used for traffic control.

Some suppliers of Industrial Ethernet equipment have long experience in the Enterprise market and tend to adopt the practices and methods used there. The Component Parts temperature rating method is typically used by these vendors. Often their Industrial Ethernet products are designed using premium-grade 85ºC-rated components. When the normal packaged product 25ºC differential to the internal components' ambient is applied, the result is a product high-temperature rating of 60ºC. The products are tested to UL 60950 and IEC specifications by independent testing organizations such as Underwriters Labs.

Suppliers focused only on the Industrial Ethernet market tend to see an advantage in having the broadest temperature ratings numbers possible. They use the Type Test rating method. Their Industrial Ethernet products typically are designed using the same commercially-available premium-grade 85ºC-rated components (there are none rated higher), however, they ignore the operating temperature difference between the outside product package and the internal components' ambient, and do not subtract any differential. These manufacturers cite the IEC 60068 standard, which specifies vendor-performed direct product-sample tests covering only a few hours duration can be reported.



Different Rating Methods Yield Different Numbers

The different rating methods, as noted above, produce different rating numbers. In determining which products to purchase and install, users may want to compare products with different reported ratings. Since the difference between a typical Component Parts rating and a Type Test rating for the same product design is about 25ºC on the high-temperature side, the differences are significant.

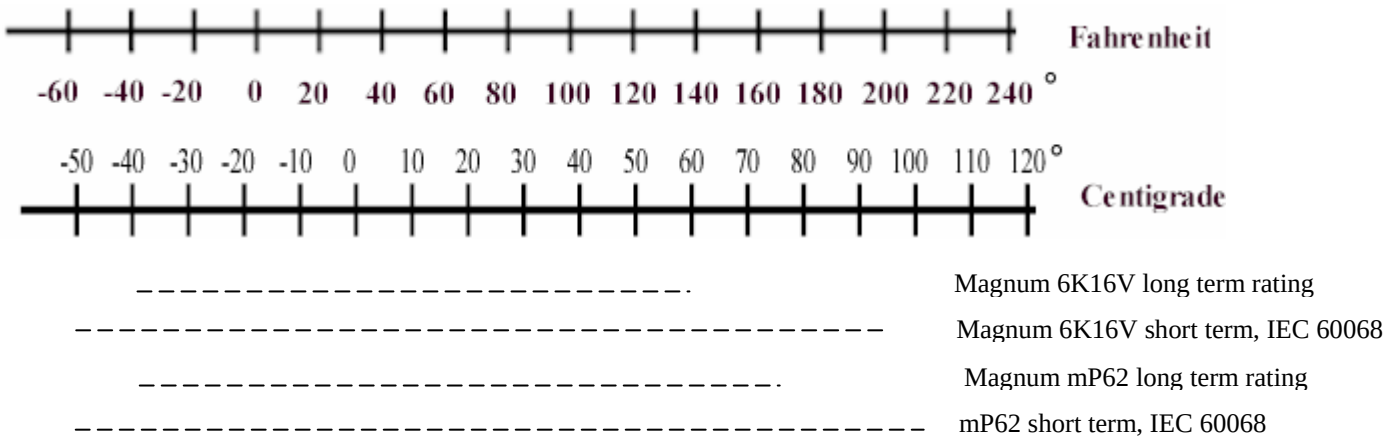
Numbers from the Components Parts method such as UL 60950 and IEC 60950 are indicative of the allowable steady-state ambient temperature for a normal service lifetime for the product. In this sense, the numbers are consistent with those widely and historically used in the Enterprise LAN products industry. If you are making decisions about long-term use conditions, it is prudent to only use the Component Parts rating method.

Other testing procedures address short-term or emergency conditions, where it is understood that operating at extended ambient temperatures will affect product lifetime and reliability. Temperature ratings from the Type Test method such as IEC 60068 or IEEE 1613 are indicative of the product's ability to withstand the rated temperature for the brief test period such as a few hours. These test results are valid as a product development tool and when users want to know if a product will operate short term under adverse extended-temperature conditions for emergency situations. Type Tests are not reliable for long-term use decisions where the application requires exposure at the high or low extremes.

It behooves the purchaser to consider who performed the rating test as well. Independent testing agencies have a public duty and a reputation to protect. Vendors who perform their own tests and report the results may tell the truth, the whole truth, and nothing but the truth . . . but, then again, they may not.

GarrettCom's Temperature Ratings for Industrial LAN Products

To help avoid confusion in the Industrial Ethernet market, GarrettCom publishes two temperature ratings. One set of high-low numbers is a long-term rating, using independent agency testing with Component Parts data, and test methods such as UL 60950. Another set of high-low rating numbers is for short term and emergency duty, using in-house Type Test methods such as IEC 60068. (Where there are other temperature test results, such as NEBS or ETSI, they are available in the applicable agency test report).



Summary

GarrettCom's experience of more than a decade in designing Ethernet products for the Enterprise, Telecommunications and Industrial markets has shown that each temperature rating method has value for a range of applications. Component Parts rating methods are appropriate for long lifetime decisions; Type Test ratings are only appropriate for short term and emergency use decisions.

The Industrial Market for Ethernet is new and volatile. Product temperature ratings among various vendors are in a state of flux. By offering – and distinguishing between – two sets of temperature ratings for Industrial Ethernet products, GarrettCom is setting a standard that helps users identify products that best suit their operating environments . . . long term and short term. The differences in the methodologies and the bases for different temperature rating numbers – if not well understood – may lead users to make non-optimum product selection decisions. In sensitive Industrial environments, where the emphasis on reliability and availability is high, an error in interpreting the effective operating temperature can be costly. Buyer beware.

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Bibliography

International Electrotechnical Commission (IEC) Standard IEC60950:Third Edition 1999-04:- Safety of Information Technology Equipment.

Institute of Electrical and Electronic Engineers (IEEE) Standard 1613/D7 November 29 2002:- Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations.

Underwriters Laboratories (UL) Standard UL60950-1 December 2 2002:- Information Technology Equipment-Safety-Part 1 General Requirements.

Network Equipment Building Standards (NEBS) Requirements Physical Protection, Generic Requirements GR-63-CORE Issue 1, October 1995, Bellcore (aka Telcordia).

European Telecommunications Standards Institute (ETSI) Standard ETS 300-019-1-2 February 1992:- Environmental conditions and environmental tests for telecommunications equipment.

California State Department of Transportation Transportation Electrical Equipment Specifications (TEES) November 19 1999.

International Electrotechnical Commission (IEC) Standard IEC60068-2-1 Fourth Edition:- Basic environmental testing procedures - Tests A- Cold.

International Electrotechnical Commission (IEC) Standard IEC60068-2-2 Fourth Edition:- Basic environmental testing procedures - Tests B- Dry Heat.