



**Verizon NEBS™ Compliance: Valve
Regulated Lead Acid (VRLA) Battery
Qualification Test Requirements**
Verizon Technical Purchasing Requirements
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PREPARED BY:

Name, Title, Organization	Date
Mark A. Ali DMTS – NEBS Compliance and Quality Assurance Verizon Corporate Network and Technology Organization Systems Integration and Testing 320 St. Paul Place, Floor 14 Baltimore, MD 21202 Phone: 410-736-5907; Fax: 410-736-5144 E-mail: mark.a.ali@verizon.com	6/2/08

ISSUED BY:

Name, Title, Organization	Date
Vijay Jain M.Tech., M.A.Sc., PMP FOC-ITL Program Manager NEBS & Quality Assurance Verizon Corporate Network and Technology Organization 320 St. Paul Place, Floor 14 Baltimore, MD 21202 Phone: 410-736-7947; Fax: 410-736-5144 E-mail: Vijay.x.jain@verizon.com	6/2/08

APPROVED BY:

Name, Title, Organization	Date
Ludwig C. Graff Director, NEBS Compliance and Quality Assurance Verizon Corporate Network and Technology Organization Systems Integration and Testing 320 St. Paul Place, Floor 14 Baltimore, MD 21202 Phone: 410-736-5904; Fax: 410-736-5144 E-mail: ludwig.c.graff@verizon.com	6/2/08



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1.0 PURPOSE

The purpose of this Verizon Technical Purchasing Requirement (VZTPR) document is to specify the qualification test requirements for Ground Fixed, VRLA Batteries and Battery Strings purchased by Verizon.

2.0 SCOPE

This VZTPR document specifies the Verizon Physical Design, Electrical, Chemical, Environmental, Electromagnetic, Safety, Quality and Reliability requirements for VRLA batteries purchased by Verizon. These batteries are for use in either Controlled (Central Office and CEV) or Uncontrolled (OSP and RT) environment applications.

The “punchlist” of tests contained herein shall be used by suppliers and Verizon approved Independent Test Laboratories as the minimum set of tests for VRLA batteries and battery string qualification. Additional tests may be added as needed to properly exercise the specific materials, technology and design. In all instances of test planning and test execution, the most recent and accepted versions of the GR standards shall be used.

3.0 REFERENCES

GR-63-CORE	NEBS™ Requirements: Physical Protection Issue 3, March 2006
GR-78-CORE	Generic Physical Design Requirements for Telecommunications Products and Equipment Issue 1, September 1997
GR-357-CORE	Generic Requirements for Assuring the Reliability of Components Used in Telecommunications Equipment Issue 1, March 2001.
GR-1089-CORE	Electromagnetic Compatibility and Electrical Safety, Generic Criteria for Network Telecommunications Equipment Issue 4, June 2006.
SR-4228	Special Report VRLA Battery String Certification Levels Based on Requirements for Safety and Performance Issue 1, December 1996



4.0 ACRONYMS

VRLA	Valve Regulated Lead Acid
EOD	End of Discharge
ESD	Electro Static Discharge
EUT	Equipment Under Test
ITL	Independent Testing Laboratory
CO	Central Office
CEV	Controlled Environmental Vault
OSP	Outside Plant
RT	Remote Terminal

5.0 DEFINITIONS

Charging – The conversion of electrical energy, in the form of current from an external electrical source, into chemical energy.

Float Voltage – The continuous, long-term constant voltage of the telephone plant that should maintain the cells in a fully charged condition.

Coup De Fouet – The name given to the transient voltage response of the cell (or battery) when it is taken off float and used to supply the load current.

Cell Matching – A means of assuring the capability of a group of cells so that, when they are installed, they float properly together as a string.

Re-Charge Efficiency (ampere-hour efficiency) – Is the electrochemical efficiency expressed as a ratio of the ampere-hours output to the ampere-hours input required for a recharge.

Short Circuit – A zero impedance connection, internal or external, between the positive and negative terminals of a battery causing a zero voltage across the terminals and an infinite current flowing through the short. In practice, the current is limited by the battery's internal resistance and the resistance of the shorting connection.

C-Rate – The C-rate of a battery is the constant current rate at which the battery is charged or discharged to completely charge or discharge the battery. It is expressed in amperes. For instance, a C/8 rate indicates an 8-ampere rate of charge or discharge.

End of Discharge Voltage (EOD) – The average voltage to which the cells are discharged. Telecommunications service operates at voltages above 42 V. This translates to the average EOD voltage of 1.75 V/cell in a 24-cell string.

Service Life (of a cell) – The period of time from installation to when the ampere-hour capacity of the cell has fallen to 80% of its rated capacity.

Shelf Life – The time during which a fully charged battery can be stored in a controlled environment on open circuit and not require recharging.

Oxygen Recombination Efficiency – A measure of the amount of oxygen recombined at the negative terminal to form water.



Gassing – The production of hydrogen, oxygen and other gasses during charging and overcharging.

Grid Corrosion – Oxidation of the positive grid material to lead dioxide which decreases the cross sectional area of the grid and eventually leads to collapse of the plate.

Positive Plate Growth – Corrosion of the lead in the positive grid material to lead dioxide. The lead dioxide occupies more space and is stronger than the lead from which the dioxide is formed. This causes expansion of the positive grid, loss of contact with the active material pellets and eventual cell failure due to low capacity.

Active Material – Dark brown or black lead dioxide forming the positive plate of the battery. It is continuously electrolytically produced through anodic oxidation of the positive grids.

Thermal Runaway – A condition where a cell on charge or discharge destroys itself through internal heat generation.

6.0 GENERAL REQUIREMENTS

Verizon requires that manufacturers submit samples of their VRLA batteries, battery strings and associated documentation to a Verizon approved ITL for testing and verification of conformance to the qualification test requirements specified in this document. For a list of Verizon approved laboratories and locations, consult the Verizon web page at:

<http://www.verizonnebs.com/tcppage.html>.

7.0 VRLA BATTERY QUALIFICATION REQUIREMENTS

Qualification Requirements for VRLA Batteries and Battery Strings are detailed in the ‘Qualification Test Schedule’ (Punch List) detailed in the following pages. This schedule is designed to not only provide the required qualification tests and declarations but to also provide the required format for reporting the design/measured values and summarizing their conformance to requirements.



VRLA Battery and Battery String Qualification Test Requirements

Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
<i>SR-4228: Section 7 - Physical Design and Construction Criteria</i>				
<i>Material Criteria/Declarations</i>				
General Physical Design Requirements	As per SR-4228 Section 7		78: Sections 2 and 3 4228: Section 7 [67 through to 104]	
Outer case material	Shall withstand 85°C minimum. (Materials like Polypropylene, and PPO/PS have proven satisfactory in long life applications)		78: [695, 696] DS	
Outer cover material	Shall withstand 85°C minimum. (Materials like Polypropylene, and PPO/PS have proven satisfactory in long life applications)		78: [695, 696] DS	
Seam between Case and Cover	Permanent leakproof bond able to withstand internal pressures without damage for life of battery		DS 4227: [73]	
Terminal Post Material	Lead with threaded brass inserts		DS 4228: [76 through to 79 and 172]	
Terminal Post sealing Gasket Material	RTV Silicone rubber and/or epoxy		DS 4228: [76 through to 79 and 172]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Outer case and cover material T _G	≥ 95 °C		1221: R4-24	
Outer case and cover material T _{HDT}	≥ 150 °C		DS	
Terminal sealing gasket Mtl. T _G	≥ 95 °C		1221: R24	
Label Attach Adhesive. T _G	≥ 95 °C		1221: R4-24	
Toxicity	Non-toxic to personnel under normal operation		1209: R3-16	
Corrosion resistance	No significant corrosion		1209: R3-17, R3-18	
Dissimilar metals	No dissimilar metals	No dissimilar metals used.	1209: R3-18	Yes (example)
Flammability: -Outer case and cover housing -Terminal sealing gasket	UL 94V-0 and OI>28%	-Rated UL94 V-0, 30% min. oxygen index	4228: [67, 169] 78: R3-4 357: 4.4.2.5 [86] 326: R3-24/5 1209: R3-20/1	(example)
Oxidative Induction Time of all Polymeric materials	20 minutes minimum after aging at 90°C for 14 days		ASTM D 4565	
Operating Attitude	Any orientation in frames, racks or cabinets		DS 4228: [103]	
Operating Altitude	Cells shall not be damaged and shall remain operational from 60m below sea level to 3000m above sea level		4228: [58] 63: [74, 75, 76, 136, 137}	
Electrolyte	1. Shall be immobilized. 2. Shall be within plates and separators or between gel and plates 3. No residual free or bulk liquid @ 25°C		1. 4228: [33] 2. 4228: [34] 3. 4228: [34]	
Safety Vent	Flame-arresting one-way, self-sealing pressure-relief valve		4228: [80, 81, 82, 83, 84, 85, 173]	
<i>Metrology and Visual Examination</i>				
Visual examination	As per detail		DS	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
	spec			
Dimensions (outline)	As per detail spec		DS	
Labels	Legible and Adherent for life of product		78: R10-1	
Marking	Each battery or cell shall be permanently marked as per 4228 Sect. 7.11		78: R10-1 4228: [98, 99, 100, 170, 182]	
Marking permanence	Mil Std 883, Method 2015.11. Markings shall remain legible		78: R10-1	
Container	Conform to 4228: Sect. 7.2		4228: [67 through to 72 and 168 through to 170]	
Cell Covers	Conform to 4228: Sect. 7.4		4228: [73, 74, 74, 171]	
Terminal Posts	Conform to 4228: Sect. 7.4		4228:[76 through to 79 and 172	
Flame Arresters	Conform to 4228: Sect. 7.5		4228: [80, 81, 173]	
Plates	Conform to 4228: Sect. 7.7		4228: 86, 87, 88, 178]	
Separators	Conform to 4228: Sect. 7.8		4228: [89, 90, 179]	
Weight	Conform to 4228: Sect. 7.9		4228: 91, 180]	
Accessories	Conform to 4228: Sect. 7.10		4228: [92, 93, 94, 95, 96, 97, 181]	
Packaging	Conform to 4228: Sect. 7.12		4228: [101, 102, 183]	
Mounting Arrangements	Conform to 4228: Sect. 7.13		4228: [103, 184]	
Handling	Conform to 4228: Sect. 7.14		4228: [104, 184]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Other Materials/Process Test Requirements:				
Resistance to solvents	No visible degradation of physical properties		357: 4.4.2.4 [85]	
Polymer Functional Groups of case material	FTIR spectroscopic analysis to verify material conformity to specification		DS	
Case Melt Flow/Melt Volume Index	ASTM D1238; Verify conformity to specification		DS	
Case Material Density	ASTM D6683; Verify conformity to specification		DS	
Case Material Stress Cracking	No evidence of cracking after chemical immersion		771: [92]	
Case Material Weight Change	< 10% change after chemical immersion		771: [94]	
Case Material Tensile Strength	< 20% change after chemical immersion		771: [95]	
Case Material Elongation	< 20% change after chemical immersion		771: [95]	
Case Material Thermal Aging	90°C for 30 days; 1. No visible deterioration, deformation, melting or cracking. 2. < 20% degradation in mechanical properties.		78: [32, 695, 696] 771: 6.4.1	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Case Material Fungus Resistance	Materials used shall not support fungus growth		326: R3-23 1209: R3-19	
Case Material Hardness	Rockwell Hardness > R87 or equivalent		771: 5.5.3	
<i>SR-4228: Section 8 – Quality and Reliability Criteria</i>				
Quality and Reliability Criteria	As per SR-4228 Section 8		4228: Section 8	
Fail Safe Operation of Cells	Cells must not fail ‘open’		4228: Section 8.2	
Battery String Reliability	Short circuit failure of two (2) cells shall not cause a catastrophic event		4228: [106]	
Fail Safe Design	Battery string failure must not cause a catastrophic event		4228: [107]	
Bonding and Grounding	Cell and battery bonding, grounding and interconnections, both internal and external, shall conform to the applicable requirements of Section 9 of GR-1089		1089: Section 9	
<i>SR-4228: Section 9 – Documentation and Training Criteria</i>				
Documentation and Training Criteria	As per SR-4228 Section 9		4228: Section 9	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
SR-4228: Section 10 – Testing Criteria				
Testing Criteria	As per SR-4228 Section 10		4228: Section 10	
Sample Size	Three (3) smallest replaceable units minimum per test		4228: [113]	
Accuracy of Measuring Instruments Used	As per SR-4228 Table 10-1		4228: [116]	
Operating Environments				
Controlled Environments (CO & CEV)				
Ambient Operating Temperature Range	+5°C to +40°C		78: [694] 63: [72] 1209: Table 3-1	
Ambient Operating Humidity Range	5% to 85% RH		1209: Section 3.7 & Table 3-1	
Ambient Storage Temperature Range	-40°C to +85°C		1209: Section 3.7 & Table 3-1	
Un-Controlled Environments (OSP, RT & Cabinets without Fans)				
Ambient Operating Temperature Range	-40°C to +65°C		78: [695] 1209: Section 3.7 & Table 3-1	
Ambient Operating Humidity Range	5% to 85% RH		1209: Section 3.7 & Table 3-1	
Ambient Storage Temperature Range	-40°C to +85°C		1209: Section 3.7 & Table 3-1	
SR-4228: Section 4 – Electrical Criteria				
Electrical Criteria	As per SR-4228 Section 4		4228: Section 4	
Charging	1. Designed for continuous float operation 2. Shall be re-chargeable after discharge to 1.75V/cell		4228: [5]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
<i>Pre-Testing: Initial Capacity Verification of all Test Modules at 25 °C</i>				
Charge	Each Module. 7 days @ Float voltage		4228: [114]	
Discharge	Each Module. Eight-hour rate to 1.75 V/cell		4228: [117]	
Initial Capacity Verification	90% minimum rated capacity @ 25°C		4228: [114]	
<i>Single Module Electrical Tests and Criteria</i>				
Module Capacity Test	Discharge at C/8 rate. 95% minimum rated capacity		4228: [1, 2 ,3, 4, 114, 117]	
Recharge Efficiency Test	Discharge at C/8 rate. Recharge to 101%. Discharge @ C/8 and re-charge at float for 7 days; 90% minimum Recharge efficiency		4228: [14, 129, 130]	
Coup De Fouet Voltage Test	Discharge @ C/5. Recharge at C/8 rate for 7 days; Analyze discharge data. C de F @ C/5 rate shall be > 1.89 V/cell for new, 1-year old and 3-year old batteries.		4228: [8, 124, 125]	
One-minute External Short Circuit Test	Short duration = 1 minute; Discharge @ C/8 rate to 1.75 V/cell; Remaining Capacity > 90% of initial value		4228: [15, 131, 132, 133, 134, 135, 136, 137]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Zero Volt External Short Circuit Test	Short duration = 24 hours; No fire or explosion		4228: [15, 131, 132, 133, 134, 138, 139]	
Charge/Discharge Cycling Test	Discharge to 1.75 V/cell @ 3, 5 and 8-hour rates; recharge for 24 hours after each discharge; Number of cycles > 10 or # years warranted. Remaining capacity = 80% rated		4228: [17, 140, 141, 142]	
Shelf Life and Charge Retention of Module Test	Fully charge module. Store on open circuit at 25°C. Shelf life = 183 days minimum. After 183 days capacity @ C/8 rate > 50% and > 90% after 1 week recharge		4228: [29, 31, 32, 146,]	
Full String Electrical Behavior Tests and Criteria				
Float Voltage Test	Float Charge for 7 days. Voltage of smallest accessible group of cells shall be < 0.05 V of average volts/cell x number of cells in group		4228: [7, 123]	
Capacity Matching of Modules in String Test	Capacity of all cells in string shall be > 90% rated capacity.		4228: [5, 9, 12, 13, 126, 128]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Voltage Matching of Modules in String Test	Difference between highest and lowest float voltage in string shall be ≤ 0.10 V and average cell voltage shall be within specified float voltage		4228: [7, 10, 123, 127]	
End of Discharge Voltage of String Test	Discharge to 1.75 V/cell @ C/8-hour rate; recharge for 24 hours at limiting current = value used for C/8 discharge; All cells and modules shall reach 90% capacity in 24 hours; cell voltage range < 0.30 V; lowest cell < 0.25 V below average; weakest cell . 1.5 V; no cell reversal.		4228: [22, 23, 24, 144]	

Service Life Test and Criteria

Accelerated Life Test ($E_A = 0.63$ eV).	Age at 70°C and 20% RH in 28 day increments. Charge at float voltage specified for 25°C. Measure battery capacity @ 25°C 1. Life Requirement = 10 years min. @ 25°C and 2. Life Objective = 20 years min. @ 25°C.		4228: [25, 26, 27, 28, 145]	
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Pressure Relief Valve Tests and Criteria

Relief Valve Opening and Closing			4228: [82, 83, 84,	
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Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Test			174, 175]	
Relief Valve Sealing Against Atmospheric Oxygen Test			4228: [83, 174, 175, 176, 177]	
SR-4228: Section 5 – Chemical Tests and Criteria				
Electrolyte Leak Test	1. 1/4 inch opening at bottom corner; 45° tilt from horizontal; 72 hours 2. 1/4 inch opening in cover. 3. No loss of electrolyte in either case.		4228: [33, 34, 147]	
Specific Gravity/Open Circuit Voltage Tests	SG before electrolyte immobilization. Verified by open circuit voltage measurement after 24 hours minimum.		4228: [35, 36, 148]	
Oxygen Recombination Efficiency	Recombination efficiency shall be: > 99% C/10000 to C/1000 > 95% C/1000 to C/100 > 85% C/100 to C/10 and > 75% C/10 to C/4		4228: [37, 149]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Gassing	1. Hydrogen release shall be < 200 ppm/cell 2. Gassing rates between 25°C and 65°C shall be provided. 3. Data shall include effect of 1 thru 5 shorted cells per string. 4. Hydrogen evolution shall be: > 5% C/10000 to C/1000 > 8% C/1000 to C/100 > 17% C/100 to C/10 and > 26% C/10 to C/4		4228: [38, 39, 40, 41, 150]	
Grid Corrosion	Average reduction of grid wire cross section at end of 70°C life test from 'as cast' value shall be: 1. ≤ 0.05 mm per year. 2. Not cause premature failure		4228: [42, 43, 151]	
Positive Plate Growth	Disassemble, measure and inspect the horizontal and vertical grid growth of plates from samples after 70°C life test. Average plate growth shall be: 1. ≤ 8% of area of each plate 2. Cell shall not		4228: [44, 152]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
	crack 3. Cell shall not fail catastrophically.			
Active Material Flaking	Disassemble and inspect cells after 70°C life test. There shall be no evidence of potential shorting from flaking of active material		4228: [45, 153]	
Operating Internal Cell Pressure	Measure internal cell pressure under normal operating conditions. Pressure shall: 1. Be sufficient for $\geq 99\%$ recombination efficiency. 2. Shall not crack case or cause excessive deformation.		4228: [46]	
Pressure Withstand	Cell shall sustain 125% of highest mfr. specified pressure for 10 minutes		4228: [154, 168, 171]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Dry-Out and Water Loss	Measure average weight loss during accelerated life testing at 70°C and calculate: 1. SG Increase and 2. OCV per cell Compare to specified float voltage to verify water loss rate is in range for expected cell lifetime.		4228: [47, 155]	
Thermal Runaway of Cells and Modules	1. Generate Tafel Curve for each module at 25°C over manufacturer recommended float voltage range. 2. Select modules that are fully recombinant, i.e., have Tafel slopes below 90 mV/decade/cell 3. Monitor module voltage, module current temperature of cells and ambient air 4. Apply linearly increasing float voltage at rate of 0.04 mV/minute/cell 5. Determine onset of thermal runaway (T _{cell} – T _{amb} > 15°C) at 25°C, at -40°C		4228: [6, 48, 49, 51, 156, 158]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
	and at +65°C			
Thermal Runaway of String	1. Generate Tafel Curve for each module in string at 25°C over manufacturer recommended float voltage range. 2. Select modules that are fully recombinant, i.e., have Tafel slopes below 90 mV/decade/cell 3. Monitor string voltage, string current temperature of four center cells and ambient air 4. Apply linearly increasing float voltage at rate of 0.04 mV/minute/cell 5. Determine onset of thermal runaway (T _{cell} – T _{amb} > 15°C) at 25°C, at -40°C and at +65°C		4228: [6, 48, 49, 50, 157]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
<i>SR-4228: Section 6 – Environmental Tests and Criteria</i>				
Mechanical Shock (Drop Test) – (Packaged and Un-Packaged)	Cells shall not be damaged and shall remain operational		63: [107, 108, 109] 4882: [60]	
Mechanical Vibration - Office (Unpackaged)	Cells shall not be damaged and shall remain operational		63: [122, 123, 124] 4882: [61]	
Mechanical Vibration – Transportation (Packaged)	Cells shall not be damaged and shall remain operational		63: [122, 123, 124] 4882: [61]	
Earthquake Resistance	Cells shall not be damaged and shall remain operational		63: [114, 5.4.1] 4882: [64]	
Low Temperature Exposure and Thermal Shock	Cells shall remain operational and floatable -40°C to + 25°C		63: [5.1.1.1] 4228: [62]	
High Relative Humidity Exposure	Cells shall remain operational and floatable from 10% to 95% RH		63: [5.1.1.2] 4228: [63]	
High Temperature Exposure and Thermal Shock	Cells shall remain operational and floatable +25°C to +70°C		63: [5.1.1.3] 4228: [62]	
Airborne Contaminants	Cells shall remain operational for the intended service life		4228: [65] 63: [127, 185]	



Parameter/Test	Test Method / Requirement	Measured/Design Value	GR/SR/DS Ref.	Conforms? Y/N
Electrostatic Discharge	1. Charge for 24 hours 2. While on charge, apply 15 kV on each side, four upper corners and each terminal 3. Repeat ESD application after battery is disconnected from charger 4. Recharge battery @ C/8 for 7 days 5. Discharge battery @ 8-hour rate to 1.75V/cell and recharge with C/8 current for 7 days. All cells shall remain operational		78: [721, 722, 723] 1089: [3, 4] 4228: [66, 167]	

END OF VRLA QUALIFICATION TEST REQUIREMENTS DOCUMENT