



Verizon NEBS™ Compliance: Qualification Requirements for Nickel Cadmium (Ni-Cd) Cells, Batteries and Battery Strings

Verizon Technical Purchasing Requirements
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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, Nickel Cadmium (Ni-Cd) 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 Ni-Cd batteries purchased by Verizon. These batteries are for use in either Controlled (Central Office and CEV) or Uncontrolled (OSP and RT) environment applications.

The “punch list” of tests contained herein shall be used by suppliers and Verizon accepted Independent Test Laboratories as the minimum set of tests for Ni-Cd cells, batteries and battery string qualification. Additional tests may be added as needed to properly exercise the specific materials, technology, design and manufacturing processes used.

3.0 REFERENCES

In all cases of test planning and test execution, the specified version of the referenced GR document shall be used. Where no version is specified, the most recent Verizon-accepted version of the referenced GR shall be used.

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
GR-1209-CORE	Generic Requirements for Passive Optical Components, Issue 3, March 2001
GR-1221-CORE	Generic Reliability Assurance Requirements for Passive Optical Components, Issue 2, January 1999
GR-3020-CORE	Nickel Cadmium Batteries in the Outside Plant, Issue 1, April 2000
VZ.TPR.9306	NEBS requirements for the Physical Design and Manufacture of Telecommunication Products and Equipment
IEC/MIL/etc.	Various reference test methods and procedures



4.0 ACRONYMS

Ni-Cd	Nickel Cadmium
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

Ni-Cd – Cell/Module/Battery using Nickel Cadmium technology

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 a lead acid cell (or battery) when it is taken off float and used to supply a load current – included for completeness.

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 Ni-Cd batteries, battery strings and associated documentation to a Verizon certified ITL for testing and verification of conformance to the qualification test requirements specified in this document. For a list of Verizon certified laboratories and locations, consult the Verizon web page at: <http://www.verizonnebs.com/tcppage.html>.

7.0 Ni-Cd BATTERY QUALIFICATION REQUIREMENTS

Qualification Requirements for Ni-Cd Cells, Batteries and Battery Strings are listed in the 'Qualification Test Schedule' (Punch List) detailed in Table 7-1 below. This schedule is designed to not only provide the Verizon required qualification tests and declarations but to also provide the required format for reporting the measured/declared values and summarizing their conformance to the requirements. The requirements are based on several listed Telcordia GR documents, the primary one of which is GR-3020, as well as on Verizon specific requirements based on field experience. The supplier/laboratory completing the report need only populate column 5 with the measured or declared value for the test item together with a reference to the report or document (with number and date) where the full information is located.



Table 7-1: Qualification Requirements for Ni-Cd Cells, Batteries and Strings

Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
GR-3020 : Section 5 – Physical Design Requirements					
Material Design and Construction Criteria/Declarations					
1	General Physical Design Requirements	All GR-3020 Section 5 Physical Design Requirements	As per GR-3020 Sections 5		
2	Outer cell case material	GR-78: [695], [696] DS	Shall withstand 85°C minimum. (Materials like Polypropylene, and PPO+PS have proven satisfactory in long life applications)		
3	Outer cell cover material	GR-78: [695], [696] DS	Shall withstand 85°C minimum. (Materials like Polypropylene, and PPO/PS have proven satisfactory in long life applications)		
4	Seam between Cell Case and Cell top	GR-3020: [49]	Shall be a permanent leak-proof bond able to withstand internal pressures without damage for life of battery.		
5	Terminal Post and Terminal Insert Material	GR-3020: [53]	All post and insert contacts shall be nickel plated		
6	Terminal Post sealing Gasket Material	GR-3020: [50]	Sealed to prevent electrolyte creepage and gas release		
7	Outer case and cover material glass transition temperature TG	GR-1221: R4-24	> 95°C		
8	Outer case and cover material heat distortion/melt index THDT	DS	≥ 150 °C		
9	Terminal sealing gasket material Tg	GR-1221: R4-24	≥ 95 °C		
10	Label Attach Adhesive. Tg	GR-1221: R4-24	≥ 95 °C		
11	Toxicity	GR-1209: R3-16	Non-toxic to personnel under normal operation		
12	Corrosion resistance	GR-1209: R3-17, R3-18	No significant corrosion		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
13	Dissimilar metals	GR-3020: [39], ; GR-1209: R3-18	No dissimilar metals that could promote galvanic corrosion		
14	Flammability: -Outer case and cover housing -Terminal sealing gasket	GR-3020: [39], [114] GR-63: [90], [91], [92], [92], [96]	UL 94V-0 and OI ≥ 28%		
15	Oxidative Induction Time (OIT) of all Thermoplastic Polymeric materials	ASTM D 4565	20 minutes minimum after aging at 90°C for 14 days		
16	Operating Attitude	GR-3020: [72]	Upright orientation in frames, racks or cabinets		
17	Operating Altitude	GR-3020: [31] GR-63: [74], [75], [76], [136], [137]	Cells shall not be damaged and shall remain operational from 60m below sea level to 3000m above sea level		
18	Electrolyte	GR-3020: Section 3.1	Alkaline (not acidic) Electrolyte to be used		
19	Safety Vent	GR-3020: [22], [54], [55], [56]	1. Flame-arresting safety vent shall be provided 2. Safety vent shall facilitate water addition		
<i>Metrology and Visual Examination (including physical design criteria)</i>					
20	Visual examination	GR-3020: [62], [63], [64], [66], [67]	As per detail spec		
21	Dimensions (outline)	GR-3020: [62], [63], [64], [66], [67]	As per detail spec		
22	Labels	GR-78: R10-1 [747] GR-3020: [68], [128]	Legible and Adherent for life of product		
23	Marking	GR-78: R10-1 [747] GR-3020: [68], [69], [70], [128]	Each battery or cell shall be permanently marked		
24	Marking permanence	GR-78: R10-1 [747]	Mil Std 883, Method 2015.11. Markings shall remain legible		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
25	Container/Cradle	GR-3020: [39], [40], [41], [42], [43], [44], [45], [46]	Container/Cradle shall conform to requirements of GR-3020 Section 5.1		
26	Cell Covers	GR-3020: [47], [48], [49]	Cell and Module covers shall conform to requirements of GR-3020 Section 5.2		
27	Terminal Posts	GR-3020: [50], [51], [52], [53]	Terminal Posts shall conform to GR-3020 Section 5.3		
28	Flame Arresters and Vent Caps	GR-3020: [54], [55]	Flame Arrestors shall Conform to GR-3020 Section 5.4 and 5.5		
29	Plates	GR-3020: [57], [58]	Plates shall conform to GR-3020 5.6		
30	Separators	GR-3020: [59], [60]	Separators shall conforms to GR-3020 Section 5.7		
31	Battery Weight	GR-3020: [61]	Battery weight shall conforms to GR-3020 Section 5.8		
32	Accessories	GR-3020: [62], [63], [64], [65], [66], [67]	Accessories shall conform to GR-3020 Section 5.9		
33	Packaging	GR-3020: [71]	Packaging shall conforms to GR-3020 Section 5.11		
34	Mounting Arrangements	GR-3020: [72]	Mounting shall conforms to GR-3020 Section 5.12		
35	Handling	GR-3020: Section 4.3	Handling shall conforms to GR-3020 Section 4.3		
Other Materials/Process Test Requirements					
36	Resistance to solvents	GR-357: [85]	No visible degradation of physical properties		
37	Polymer Functional Groups of case material (FTIR Analysis)	DS	FTIR spectroscopic analysis to verify material conformity to specification		
38	Case Material Melt Flow/ Melt Volume Index	DS	ASTM D1238; Verify conformity to specification		
39	Case Material Density	DS	ASTM D6683; Verify conformity to specification		
40	Case Material Chemical Resistance-Stress Cracking	GR-771: [92]	The material used for cases shall show no evidence of cracking after chemical immersion		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
41	Case Material Chemical Resistance-Immersion	GR-771: [94]	< 10% change after chemical immersion		
42	Case Material Tensile Strength	GR-771: [95]	< 20% change after chemical immersion		
43	Case Material Elongation	GR-771: [95]	< 20% change after chemical immersion		
44	Case Material Thermal Aging	GR-78: [32], [695], [696] GR-771: 6.4.1	90°C for 30 days; 1. No visible deterioration, deformation, melting or cracking. 2. < 20% degradation in mechanical properties.		
45	Case Material Fungus Resistance	GR-326: R3-23 GR1209: R3-19	Materials used shall not support fungus growth		
46	UV Resistance – 90 days	GR-487: R3-40 [19] GR-771: R5-22 [96]	Materials used shall be resistant to 90 days UV exposure		
47	Case Material Hardness	GR-771: 5.5.3	Rockwell Hardness > R87 or equivalent		
GR-3020: Section 6 – Quality and Reliability Requirements					
48	Quality and Reliability Criteria	As per GR-3020 Section 6	Batteries shall conform to GR-3020 Section 6		
49	Fail Safe Operation of Cells	GR-3020: [73]	Cells must not fail ‘open’		
50	Battery String Reliability	GR-3020: [74]	Short circuit failure of three (3) cells shall not cause a catastrophic event		
51	Fail Safe Design	GR-3020: [75]	Battery string failure must not cause a catastrophic event		
52	Bonding and Grounding	GR-1089: Section 9	Cell and battery bonding, grounding and interconnections, both internal and external, shall conform to the applicable requirements of Section 9 of GR-1089		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
GR-3020: Section 7 – Documentation Requirements					
53	Documentation and Training Criteria	As per GR-3020 Section 7	Documentation and Training criteria shall conform to GR-3020 Section 7		
54	Testing Criteria	GR-3020: Section 9	Testing Criteria shall conform to GR-3020 Section 9		
55	Sample Size	GR-3020: [84]	Three (3) smallest replaceable units minimum per test		
56	Accuracy of Measuring Instruments Used	GR-3020: [88]	Accuracy of Measuring Instruments Used shall conform to GR-3020 table 9-1		
Operating Environments					
Controlled Environments (CO & CEV)					
57	Ambient Operating Temperature Range	GR-78: [694] GR-63: [72] GR-1209: Table 3-1 GR-3020: [34]	+5°C to +40°C		
58	Ambient Operating Humidity Range	GR-1209: Section 3.7 & Table 3-1 GR-3020: [30] GR-63: [72]	5% to 85% RH		
59	Ambient Storage Temperature Range	GR-1209: Section 3.7 & Table 3-1 GR-3020: [34]	Batteries shall be capable of being stored from -40°C to +70°C		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
Un-Controlled Environments (OSP, RT & Cabinets without Fans)					
60	Ambient Operating Temperature Range	GR-78: [695] GR-63: [72] GR-1209: Table 3-1 GR-3020: [34]	-40°C to +65°C		
61	Ambient Operating Humidity Range	GR-1209: Section 3.7 & Table 3-1 GR-3020: [30] GR-63: [72]	5% to 85% RH		
62	Ambient Storage Temperature Range	1209: Section 3.7 & Table 3-1 GR-3020: [34]	Batteries shall be capable of being stored from -40°C to +70°C		
GR-3020: Section 2 – Electrical Requirements					
63	Electrical Criteria	As per GR-3020 section 2	Electrical criteria shall conform to GR-3020 section 2		
64	Charging	GR-3020: [6]	1. Designed for continuous float operation 2. Shall be re-chargeable after discharge to 1.10V/cell		
Pre-Testing: Initial Capacity Verification of all Test Modules at 25 °C					
65	Charge	GR-3020: [94]	Charge of each module shall conform to GR-3020 section 2.2 for 24 hours @ Float voltage		
66	Discharge	GR-3020: [89]	Discharge of each Module shall conform to GR-3020 Section 2. Eight-hour rate to 1.10 V/cell		
67	Initial Capacity Verification	GR-3020: [4]	90% minimum rated capacity @ 25°C		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
Single Module Electrical Tests and Criteria					
68	Module Capacity Test	GR-3020: [1], [2], [3], [4], [89], [90] [91], [92]	Shall conform to GR-3020 Section 2. Discharge at C/8 rate. 90% minimum rated capacity.		
69	Recharge Efficiency Test	GR-3020: [9], [96], [97]	Shall conform to GR-3020 Section 2. Charge at float for 24 hours, Discharge at C/8 rate (C1). Recharge to 101%. Discharge @ C/8 (C2); $C2/C1 \times 100 = 90\%$ minimum Recharge efficiency		
70	One-minute External Short Circuit Test	GR-3020: [10], [11], [98], [99], [100], [101], [102]	Short circuit duration = 1 minute; Discharge @ C/8 rate to 1.10 V/cell; Remaining Capacity > 90% of initial value		
71	Zero Volt External Short Circuit Test	GR-3020: [10], [11], [98], [99], [100], [101], [102]	Short circuit duration = 24 hours; No fire or explosion		
72	Charge/Discharge Cycling Test	GR-3020: [12], [103], [104]	Discharge to 1.10 V/cell @ 3, 5 and 8-hour rates; recharge for 24 hours after each discharge; Number of cycles > 3x per year for the operating life. Remaining capacity = 80% rated		
73	Shelf Life and Charge Retention of Module Test	GR-3020: [18], [19], [20], [21], [106], [107], [108]	Discharged module. Store on open circuit at 25°C. Shelf life = 1 year minimum. Fully charged. After 183 days capacity @ C/8 rate > 50% and > 90% after 24 hours recharge		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
Full String(48-Volts) Electrical Tests and Criteria					
74	Float Voltage Test	GR-3020: [8], [95]	Float Charge for 7 days. Voltage of smallest accessible group of cells shall be less than or equal to +0.050 V and greater than or equal to -0.100 V of average volts/cell x number of cells in group		
75	Capacity Matching of Cells in String	This document	Cells in a string shall be capacity matched such that all cells in a string have a minimum capacity of 90% of their rated capacity. The difference between the lowest and the highest cell capacities in the string shall not exceed 8% of rated capacity.		
76	Voltage Matching of Cells in String	This document	Cells in a string shall be matched such that the difference between the highest and the lowest cell float voltage shall not exceed 0.10 volts and the average float voltage for each cell shall be within the manufacturers specified float voltage		
77	End of Discharge Voltage of String Test	This document	The string shall be capable of being discharged to 1.10V/cell. The EOD voltage for the string shall not be higher than this cell value. After discharge to this EOD voltage all cells in the string shall be capable of being recharged to at least 90% of their rated capacity at the recommended float voltage in a time period not to exceed 24 hours.		
Service Life Test and Criteria					
78	Accelerated Life Test	GR-3020: [15], [16], [17], Section 9.2.8	Life Requirement = 20 years min. @ 25°C.		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
Pressure Relief Valve Tests and Criteria					
79	Relief Valve Opening and Closing Test	GR-3020: [54], [55], [56]	1. Opening Pressure shall be ≥ 1.0 psi 2. Closing Pressure shall be ≥ 0.0 psi		
80	Relief Valve Sealing Against Atmospheric Oxygen Test	GR-3020: [54], [55], [56]	1. Valve shall seal in in the closed position 2. Negative(sealing) pressure tests shall incur no damage		
SR-4228: Section 5 and GR-3020 Section 3 – Chemical Tests and Criteria					
81	Electrolyte Leak Test	4228: [33, 34, 147]	1. $\frac{1}{4}$ inch opening at bottom corner; 45° tilt from horizontal; 72 hrs. 2. $\frac{1}{4}$ inch opening at top; 3. No loss of electrolyte in either case		
82	Specific Gravity/Open Circuit Voltage Tests	4228: [35, 36, 148]	SG before electrolyte immobilization. Verified by open circuit voltage measurement after 24 hours minimum.		
83	Oxygen Recombination Efficiency	4228: 37, 149]	Recombination efficiency shall be: > 99% C/10000 to C/1000 > 95% C/1000 to 9 C/100 > 85% C/100 to C/10 > 75% C/10 to C/4		
84	Gassing	GR-3020: [22], [109]	1. Total gassing rate and the rate of hydrogen release shall be reported for 25°C 35°C and 45°C and at 1.40, 1.45, 1.50, 1.55, 1.60 and 1.65 Vpc. 2. Data shall include effect of up to 5 shorted cells per string.		
85	Grid Corrosion	4228: [42, 43, 151]	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 pre-mature failure		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
86	Positive Plate Growth	4228: [44, 152]	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 crack 3. Cell shall fail catastrophically		
87	Active Material Flaking	4228: [45, 153]	Disassemble and inspect cells after 70°C life test. There shall be no evidence of potential shorting from flaking of active material		
88	Operating Internal Cell Pressure	4228: [46]	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		
89	Pressure Withstand	GR-3020: [119]	Cells shall withstand 125% of the highest manufacturer specified pressure for 10 minutes		
90	Dry-Out and Water Loss	GR-3020: [23], [24], [25], [26], [27], [110]	The rate of water loss shall be measured by weight loss.		
91	Thermal Runaway of Cells and Modules	GR-3020: [28], [29], [111]	No thermal runaway for: 1. When Up to 5 cell shorted to zero volts at 40 deg C 2. When operated normally throughout its useful life 3. When operated abnormally at 1.65 Vpc and 55 °C.		
92	Thermal Runaway of String	GR-3020: [28], [29], [111]	No thermal runaway for: 1. When Up to 5 cell shorted to zero volts at 40 deg C 2. When operated normally throughout its useful life 3. When operated abnormally at 1.65 Vpc and 55 °C.		



Item Ref. #	Parameter/Test Item	Item Source Ref. GR/SR/DS	Requirement/ Required Value	Measured/Declared Value	Conforms? Y/N/NA/ Acceptable
GR-3020: Section 4 – Environmental Requirements					
93	Mechanical Shock (Drop Test) – (Packaged and Un-Packaged)	GR-3020: [32], [115] GR-63: [108], [109]	Cells shall not be damaged and shall remain operational		
94	Mechanical Vibration - Office (Unpackaged)	GR-3020: [33] GR-63: [122], [123]	Cells shall not be damaged and shall remain operational		
95	Mechanical Vibration – Transportation (Packaged)	GR-3020: [33] GR-63: [124]	Cells shall not be damaged and shall remain operational		
96	Earthquake Resistance	GR-3020: [36], [116] GR-63: [110], [114], [115]	Cells shall not be damaged and shall remain operational		
97	Low Temperature Exposure and Thermal Shock	GR-3020: [30], [34], [112] GR-63: [69], [72] GR-3108: [133]	Cells shall remain operational and floatable from -40°C to + 25°C		
98	High Relative Humidity Exposure	GR-3020: [35] GR-63: [71]	Cells shall remain operational and floatable from 5% to 90% RH		
99	High Temperature Exposure and Thermal Shock	GR-3020 [30], [34], [112] GR-63:[70], [72] GR-3108: [133]	Cells shall remain operational and floatable from +25°C to +70°C		
100	Airborne Contaminants	GR-3020: [37], [117] GR-63: [127]	Cells shall remain operational for the intended service life		
101	Electrostatic Discharge	GR-3020: [38], [118] GR-1089: [3], [4]	1. Apply 15 kV on surfaces likely to be touched during field operation. 2. All cells shall remain operational		
Other Tests Performed by Supplier on their Ni-Cd Batteries					
102	Add as available				
103	Add as available				

END OF Ni-Cd BATTERY QUALIFICATION REQUIREMENTS