C&D TECHNOLOGIES

Capacity Testing of VRLA Batteries (20 to 200 Ampere-Hours Capacity)

The VRLA battery is rated in ampere-hours or watts per cell (w/c) at specific discharge time durations. For example, a TEL series battery may be rated as a 100 Ah battery capable of providing 12.5 amperes for 8 hours to 1.75 v/c. A UPS series battery may be rated as capable of providing 475 watts per cell for 15 minutes to 1.67 v/c.

A capacity test is simply a test designed to determine the actual capability of the battery as compared to the rated capability. If this capacity test is performed at the factory prior to delivery or on site when the battery is first installed it is referred to as an acceptance test. If the test is performed with the battery in an as found condition with no special preparation, it is referred to as a service test. When a capacity test is being performed to determine the battery's percent of rated capacity for service life determination or warranty purposes, it is referred to as a performance test and is conducted exactly as is the acceptance test.

BATTERY PREPARATION FOR ACCEPTANCE TESTING

The battery system should be assembled at the manufacturer's site, simulating the user's installation, or completely installed at the user's location following relevant installation instructions (ref form 41-6965).

1. Measure and record all cells/units open circuit voltage to assure minimum acceptable voltage prior to interconnecting (Ref to Table 2, col. 12).

2. The individual cells/units should be interconnected using the intercell/unit cables or bus bars specified for the application and with which the battery's performance is rated.

It is important that all cell/unit terminals and contact surfaces of the intercell/unit connecting cables and bus bars be properly cleaned and greased prior to installation and the bolted connections be properly torqued per Table 1, column 4. Improper connections can result in low measured capacity due to voltage drop at the connections.

3. Equalize the battery for 24 hours at the recommended voltage (e.g., 2.4 volts/cell) to assure the battery is fully charged (refer to Table 2, column 10).

4. Following equalization, the battery should be placed on float charge at the recommended voltage (e.g. 2.30 volts/cell) for 3 to 7 days prior to acceptance test.

5. Just prior to initiating the acceptance capacity test, measure and record the individual cell/unit float voltages.

ACCEPTANCE TEST TIME AND DISCHARGE RATE CALCULATION

1. The discharge time and end point voltage selected should be one at which the battery has a published rating and is approximately the same as that of the intended application.
2. The discharge rate (amperes or watts/cell) to a specified end point voltage for the selected time, as taken from the published ratings for the battery must be adjusted for battery temperature if outside the range of 75ºF to 80ºF. For elevated temperature, the rate will be increased; while for cooler temperatures, the rate is reduced. The temperature adjustment factors are rate dependent and are noted in Figure 1.

For example, if a cell having a one hour rating of 61.5 amperes to 1.75 V/cell @ 77ºF were tested at 60ºF, the discharge rate used for a 1 hour discharge would be:

61.5 amperes x 0.93 = 57.2 ampere

For accuracy, capacity tests should only be performed between 60ºF and 90ºF, and as close to 77ºF as possible.

ACCEPTANCE CAPACITY TEST PROCEDURES

1. Equipment requirements
   a. Load bank capable of providing the appropriate discharge current and kilowatt load.
   b. Digital voltmeters to monitor full battery discharge voltage.
   c. Amp meter to monitor battery discharge current.
   d. Digital voltmeter to monitor individual cell/unit voltages during the discharge.
   e. Stop watch to monitor time of the discharge.

2. Performance
   a. Assure that the instrumentation is operational and properly connected to the battery to continuously monitor battery discharge voltage and current (Figure 2 or 3). If parallel strings are being tested, the individual string current and total current must both be monitored.
   b. Measure and record the float voltage of each cell/unit and ensure all cells/units are floating properly.
   c. Remove the charging current from the battery.
   d. With the Load Bank OFF, connect it to the battery.
   e. Start the timer and turn the Load Bank ON, adjusting and maintaining it for the appropriate discharge rate (amperes or watts).
   f. Record the battery discharge voltage and current with battery terminals and time at the start and end of the test and periodically throughout the test as many times as practical.

   The individual cell/unit voltages shall also be measured and recorded as often as is practical during the discharge. The number of sets of discharge readings must be 3 or more. The longer the test duration, the more readings should be taken so the capacity of individual cells can be analyzed.

   Continue the discharge beyond the required battery end point voltage (e.g., 1.85 V/C) to a lower rated voltage (e.g. 1.75) when possible to assure most cells actually discharge to the required end point.

   Terminate the capacity test when the battery is discharged to the predetermined system end point voltage, a cell or unit is going into reversal, or a safety hazard is noted.

CALCULATING BATTERY CAPACITY

The ampere-hour rating is the product of the number of amperes of current the battery can supply multiplied by the number of hours (or fraction thereof) over which the current is supplied to a specified end point voltage. For example, a TEL12-125 series is rated as a 127.2 Ah battery at the 8 hour discharge rate of 15.9 amperes (15.9 Amperes x 8 hours = 127.2 Ah) to 1.75 v/c when new and at 100% of rating. It is also rated capable of providing 23.4 amperes for 5 hours (117 Ah) and 28.4 amperes for 4 hours (113.6 Ah) to 1.75 v/c. Notice that as the load current increases, the battery becomes less efficient.

The percent of rated capacity would be the ratio of the Ah provided at a given discharge rate for the actual operating time to the rated Ah capacity for the same period and operating conditions. For example, if the TEL12-105 were discharged at the 5 hour rate of 23.4 amperes and it reached the end point voltage of 1.75 v/c at the 4 hour mark, the resulting Ah delivered would be 93.6 (23.4 amperes x 4 hours = 93.6 Ah). Since the 4 hour rated capacity is 113.6 Ah the percent rated capacity at the 4 hour discharge rate is 82.4% (100% x 93.6 Ah/113.6 Ah) rather than 80% as would be deduced from the ration of the operating time to the rating time (100% x 4 hours/5 hours).

Since the ratios of Ah's are both at the same time duration, the percentage rated capacity can also be considered the ratio of the actual load current for the actual test duration to the rated ampere load for that same actual test time.

This is a very important concept in that the greater the discharge rate, the greater will be the difference between the ratio of Ah's (or currents) obtained verses the operating times. This situation is illustrated more dramatically when testing UPS batteries at maximum discharge rates for rating times of less than one hour.

For example, a UPS 12-400MR is rated as capable of 391 w/c for 15 minutes (5865 watts-minutes or 97.75 watt-hours) and 505 w/c for 10 minutes (5050 watt-minutes or 84.17 watt-hours) to 1.67 v/c. Assume the battery were discharged at the 391 w/c rate with the expectation of 15 minutes of operating time to 1.67 v/c but only 10 minutes were attained. The actual percentage rated capacity of the battery would then be calculated as 77.4% (100% x 391 w/c / 505 w/c) rather than 66.6% which would be indicated by the ratio of the actual 10 minutes operating time to the expected 15 minute duration.

It is this ratio of the batteries actual to rated amperes or wattage for a test duration that reflects the true percent of rated capacity and condition of the internal components of the battery. It is on this basis that the aging factor used in sizing a battery is used as a multiplier with respect to the load current rather than the operating time.

The percent rated capacity is then calculated as:

$$\text{\% rated Ah capacity} = 100\% \times \frac{\text{Ampere test load for the test time duration}}{\text{Rated Ampere load with the test time duration}}$$

OR

$$\text{\% rated w/c capacity} = 100\% \times \frac{\text{w/c test load for the test time duration}}{\text{Rated w/c load with the test time duration}}$$

Note that the VRLA batteries are typically guaranteed to provide 90% of their rated Ah capacity and 100% of their rated watts/cell capacity when new and properly installed.

When the battery tests at 80% of the rated capacity, even though it may still meet the users operating time requirements, it should be replaced. This is because the loss of capacity reflects the actual deterioration of the internal components of the battery. If the low capacity battery is not replaced, the eventual result could be shorted or open cells, which could result in system shutdown during a commercial power loss or other hazards.

BATTERY SYSTEM PERFORMANCE CAPACITY TESTING

The performance capacity test is run periodically on in service battery systems to compare their aged capacity with that obtained at the acceptance capacity test. It is conducted under the identical condition of the acceptance capacity test.

TABLE #1 – HARDWARE AND TORQUE REQUIREMENTS

Hardware and Torque Requirements						
Battery	Bolt Size	Wrench Size	Initial Torque		Annual Retorque	
			in.-lb.	N-m	in.-lb.	N-m
UPS12-100MR	#10-32	3/8"	40	4.5	32	3.5
UPS12-150MR	#10-32	3/8"	30	3.4	30	3.4
UPS12-210MR	#10-32	3/8"	30	3.4	30	3.4
UPS12-300MR	1/4-20	7/16"	110	12.4	110	12.4
UPS12-350MR	1/4-20	7/16"	110	12.4	110	12.4
UPS12-400MR	1/4-20	7/16"	110	12.4	110	12.4
UPS12-490MR	1/4-20	7/16"	110	12.4	110	12.4
UPS12-490MRLP	1/4-20	7/16"	110	12.4	110	12.4
UPS12-540MR	1/4-20	7/16"	110	12.4	110	12.4
UPS12-615MRF	1/4-20	7/16"	110	12.4	110	12.4
UPS6-620MR	1/4-20	7/16"	110	12.4	110	12.4
UPS12-700MRF	1/4-20	7/16"	110	12.4	110	12.4
TEL12-30/SLC	#10-32	3/8"	25	2.8	25	2.8
TEL12-45/SLC	#10-32	3/8"	25	2.8	25	2.8
TEL12-70	1/4-20	7/16"	110	12.4	110	12.4
TEL12-80/SLC	1/4-20	7/16"	110	12.4	110	12.4
TEL12-90	1/4-20	7/16"	110	12.4	110	12.4
TEL12-105FS	1/4-20	7/16"	110	12.4	110	12.4
TEL12-105FNSG	M8	13mm	160	18.0	160	18.0
TEL12-115FNG	M6	10mm	110	12.4	110	12.4
TEL12-125	1/4-20	7/16"	110	12.4	110	12.4
TEL12-145FW	M6	10mm	110	12.4	110	12.4
TEL12-155F/FG	M8	13mm	160	18.0	160	18.0
TEL12-160FW	1/4-20	7/16"	110	12.4	110	12.4
TEL12-160F	1/4-20	7/16"	110	12.4	110	12.4
TEL12-170F/FG	M8	13mm	160	18.0	160	18.0
TEL12-180F	1/4-20	7/16"	110	12.4	110	12.4
TEL12-190F/FG	M8	13mm	160	18.0	160	18.0
TEL12-210F/FG	M8	13mm	160	18.0	160	18.0
TEL6-180	1/4-20	7/16"	110	12.4	110	12.4
DCS-33IT/HIT	#10-32	3/8"	30	3.4	30	3.4
DCS-50IT	#10-32	3/8"	30	3.4	30	3.4
DCS-75IT/HIT	1/4-20	7/16"	110	12.4	110	12.4
DCS-88HIT	1/4-20	7/16"	110	12.4	110	12.4
DCS-100HIT	1/4-20	7/16"	110	12.4	110	12.4

TABLE #2 –
INDIVIDUAL BATTERY ELECTRICAL CHARACTERISTICS

Individual Battery Electrical Characteristics											
Battery	Volts DC (Nominal)	Number of Cells	15 Min Watts/Cell to 1.67 VPC	Amp Hr Capacity @ 8hr rate to 1.75 VPC	Maximum Discharge (Amps)	Short Circuit Amperes	Impedance @ 60Hz	Float Voltage (VDC)	Equalize Voltage (VDC)	Minimum Float Voltage (VDC)	Minimum Voltage at Installation (VDC)
UPS12-100MR	12	6	90.9	24	500	1750	0.0060	13.5-13.8	14.4-14.8	13.3	12
UPS12-150MR	12	6	148	32	500	2500	0.0060	13.5-13.8	14.4-14.8	13.3	12
UPS12-210MR	12	6	206	50	600	3000	0.0045	13.5-13.8	14.4-14.8	13.3	12
UPS12-300MR	12	6	300	73	800	3600	0.0040	13.5-13.8	14.4-14.8	13.3	12
UPS12-350MR	12	6	350	88	800	4200	0.0030	13.5-13.8	14.4-14.8	13.3	12
UPS12-400MR	12	6	400	95	800	5000	0.0025	13.5-13.8	14.4-14.8	13.3	12
UPS12-490MR	12	6	488	129	800	5000	0.0023	13.5-13.8	14.4-14.8	13.3	12
UPS12-490MRLP	12	6	488	109	800	6000	0.0022	13.5-13.8	14.4-14.8	13.3	12
UPS12-540MR	12	6	537	132	800	5000	0.0023	13.5-13.8	14.4-14.8	13.3	12
UPS12-615MRF	12	6	614	176	800	4500	0.0020	13.5-13.8	14.4-14.8	13.3	12
UPS6-620MR	6	3	620	175	800	4350	0.0012	6.75-6.90	7.20-7.40	6.65	6
UPS12-700MRF	12	6	700	190	800	4500	0.0026	13.5-13.8	14.4-14.8	13.3	12
TEL12-30/SLC	12	6	--	31	500*	2150	0.0100	13.5-13.8	14.4-14.8	13.3	12
TEL12-45/SLC	12	6	--	46	600*	2500	0.0060	13.5-13.8	14.4-14.8	13.3	12
TEL12-70	12	6	--	69	800	3100	0.0050	13.5-13.8	14.4-14.8	13.3	12
TEL12-80/SLC	12	6	--	79	800*	3300	0.0040	13.5-13.8	14.4-14.8	13.3	12
TEL12-90	12	6	--	88	800	3600	0.0035	13.5-13.8	14.4-14.8	13.3	12
TEL12-105FS	12	6	--	100	800	4000	0.0034	13.5-13.8	14.4-14.8	13.3	12
TEL12-105FNSG	12	6	--	104	800	4000	0.0030	13.5-13.8	14.4-14.8	13.3	12
TEL12-115FNG	12	6	--	108	800	4000	0.0030	13.5-13.8	14.4-14.8	13.3	12
TEL12-125	12	6	--	127	800	5000	0.0023	13.5-13.8	14.4-14.8	13.3	12
TEL12-145FW	12	6	--	145	--♦	--♦	0.0023	13.5-13.8	14.4-14.8	13.3	12
TEL12-155F/FG	12	6	--	155	800	4700	0.0031	13.5-13.8	14.4-14.8	13.3	12
TEL12-160FW	12	6	--	160	--♦	--♦	0.0027	13.5-13.8	14.4-14.8	13.3	12
TEL12-160F	12	6	--	157	800	4700	0.0031	13.5-13.8	14.4-14.8	13.3	12
TEL12-170F/FG	12	6	--	169	800	4700	0.0033	13.5-13.8	14.4-14.8	13.3	12
TEL12-180F	12	6	--	181	800	4500	0.0037	13.5-13.8	14.4-14.8	13.3	12
TEL12-190F/FG	12	6	--	190	800	4500	0.0035	13.5-13.8	14.4-14.8	13.3	12
TEL12-210F/FG	12	6	--	202	800	4500	0.0040	13.5-13.8	14.4-14.8	13.3	12
TEL6-180	6	3	--	176	800	4350	0.0012	6.75-6.90	7.20-7.40	6.65	6
DCS-33IT/HIT	12	6	--	30	600	2150	0.0070	13.5-13.8	14.4-14.8	13.3	12
DCS-50IT	12	6	--	46	600	2500	0.0060	13.5-13.8	14.4-14.8	13.3	12
DCS-75IT/HIT	12	6	--	70	600	3100	0.0045	13.5-13.8	14.4-14.8	13.3	12
DCS-88HIT	12	6	--	79	800	3300	0.0045	13.5-13.8	14.4-14.8	13.3	12
DCS-100HIT	12	6	--	89	800	3600	0.0035	13.5-13.8	14.4-14.8	13.3	12
*Excludes models with SLC											

♦ Contact C&D for more information.

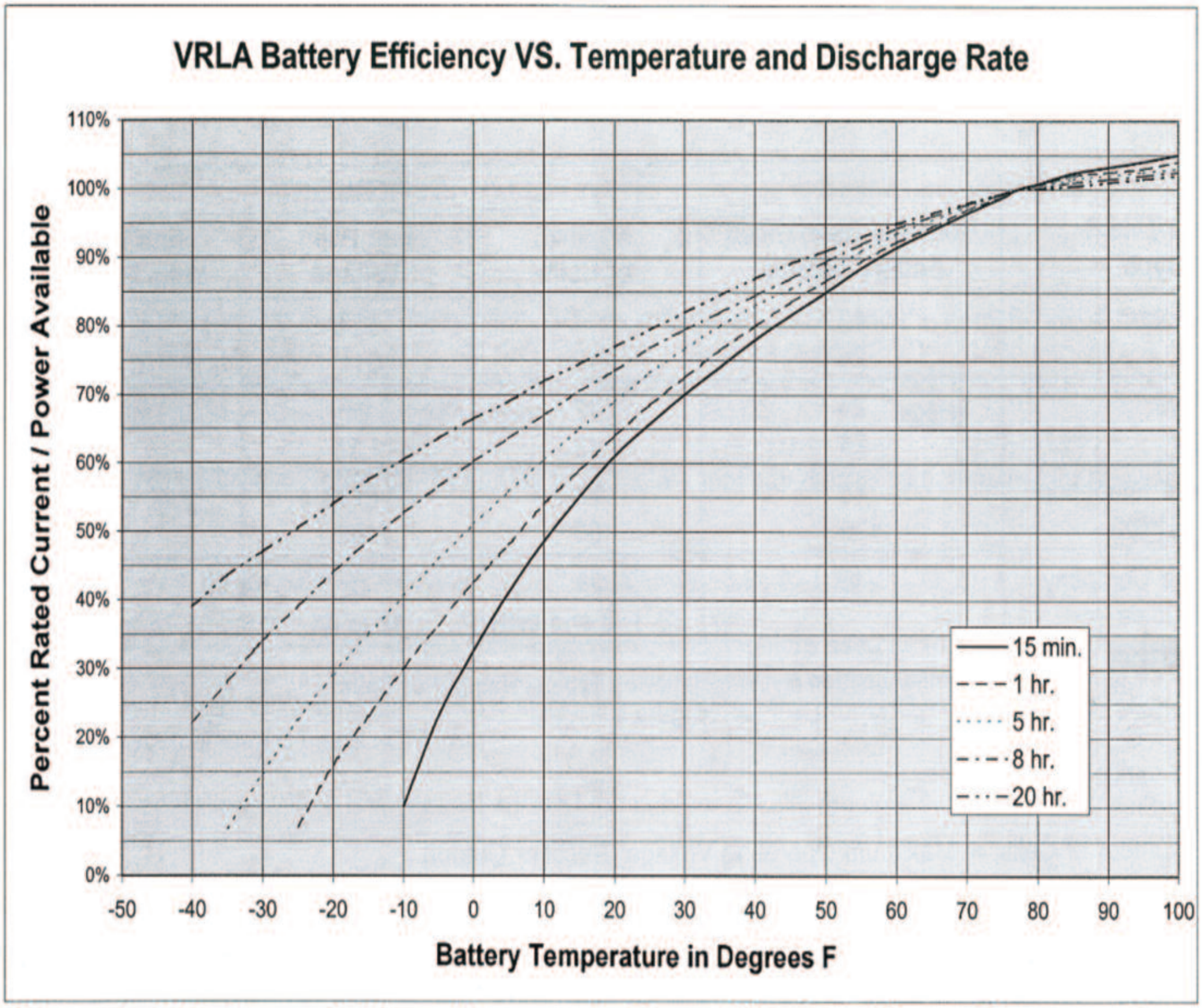

Figure 1 - Watts per Cell and Ampere's Capability Derating vs Temperature for TEL, UPS, and MPS AGM Batteries

NOTE:

1. Perform acceptance tests only in the range of 60˚ to 90˚F and preferably as near 77˚F as possible.
2. When conducting constant power (watts) capacity tests, the battery load in watts is equal to the discharge terminal voltage multiplied by the discharge current in amperes.

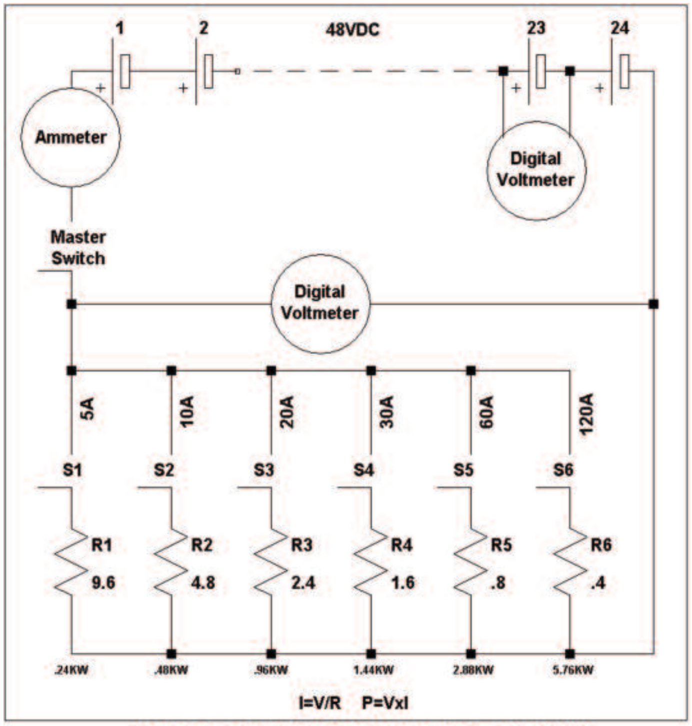

FIGURE 2 - Typical 48VDC-245 Amp Load Bank (11.76KW)

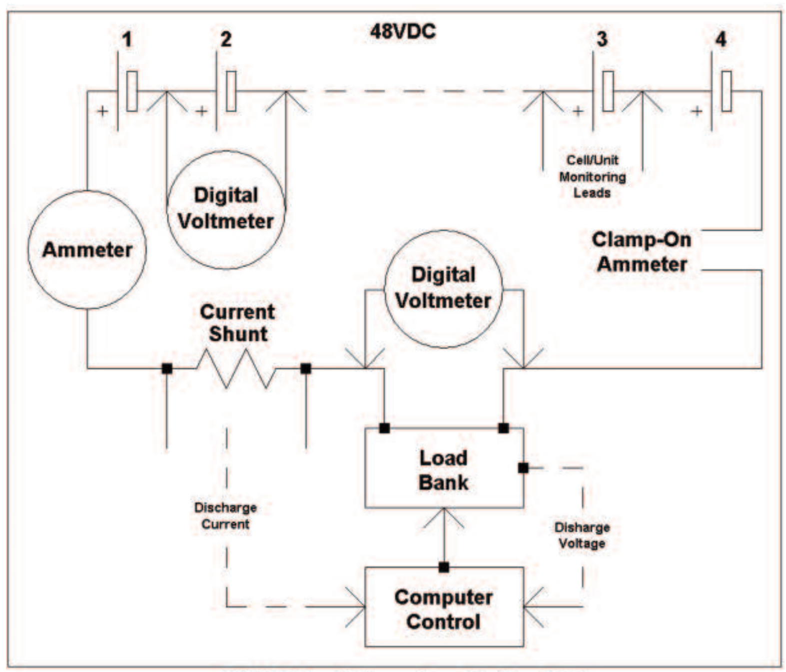

FIGURE 3 - Battery Capacity Test Setup

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