C&D TECHNOLOGIES

C&D VRLA Battery Electrolyte Freeze Protection

Please Note: The information in this technical bulletin was developed for C&D Dynasty 12 Volt VRLA products. While much of the information herein is general, larger 2 Volt VRLA products are not within the intended scope.

The C&D VRLA batteries can be exposed to freezing temperatures without catastrophic damage. However, if frozen, there may be hidden damage to the active material of the plates that could result in premature loss of capacity. Charging a "frozen" battery can result in significant localized current density and heating of the plates which could result in additional damage.

The charging voltage should be temperature compensated at a +/-0.0028 volts per cell per degree F (+/-0.005 volts per cell per degree C) when temperature extremes are anticipated. An elevated charging voltage must be used at "cold" temperatures to assure the battery will accept an adequate charging current however, a reduced voltage must be used at "warm" temperatures to prevent excessive charging current acceptance and battery heating. The maximum voltage to be allowed at cold temperature is 2.5 volts per cell while the minimum voltage allowed at hot temperatures is 2.17 volts per cell. Constant current charging schemes should not be used where there is a possibility of charging a battery that is frozen.

Electrolyte Freezing

Water, with a specific gravity of 1.000 will freeze at 32°F (0°C) as shown in Figure 1. The electrolyte in a fully charged VRLA battery, with a specific gravity of 1.280 to 1.300, will not freeze until a temperature of -95°F (-71°C) is reached. Obviously, it is unlikely that the fully charged VRLA battery will be frozen in any inhabited location.

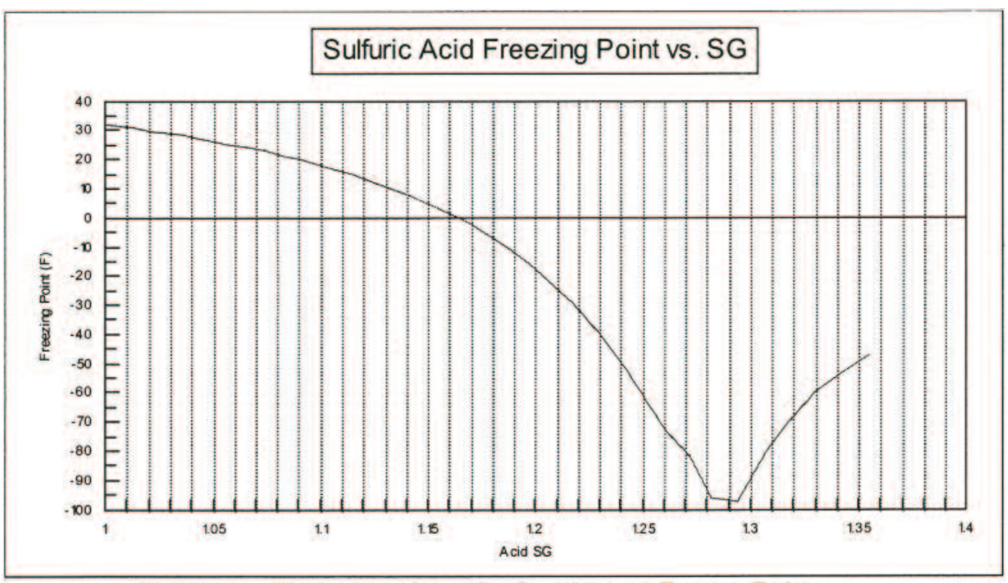

Figure 1 – Electrolyte Specific Gravity and Freeze Point

However, a long duration low rate discharge of a typical VRLA battery can result in an electrolyte specific gravity of less than 1.100. As noted in Figure 1, in this discharged condition with an electrolyte specific gravity of 1.100, the electrolyte would freeze at approximately +20°F (-6.7°C). Naturally this condition will render the battery useless until the electrolyte would thaw thus allowing the battery to be recharged.

Electrolyte Freeze Protection when Discharging at Normal (77°F or 25°C) Temperatures

The most serious condition is when the battery is discharged while at a temperature of 77°F (25°C) or warmer and is then allowed to sit in the discharged condition while the environment cools to some lower freezing temperature. To determine at what temperature the battery electrolyte will freeze following the battery discharge, it is only necessary to determine the end point electrolyte specific gravity and refer to Figure 1 or determine the percent depth of discharge and then refer to Figure 2.

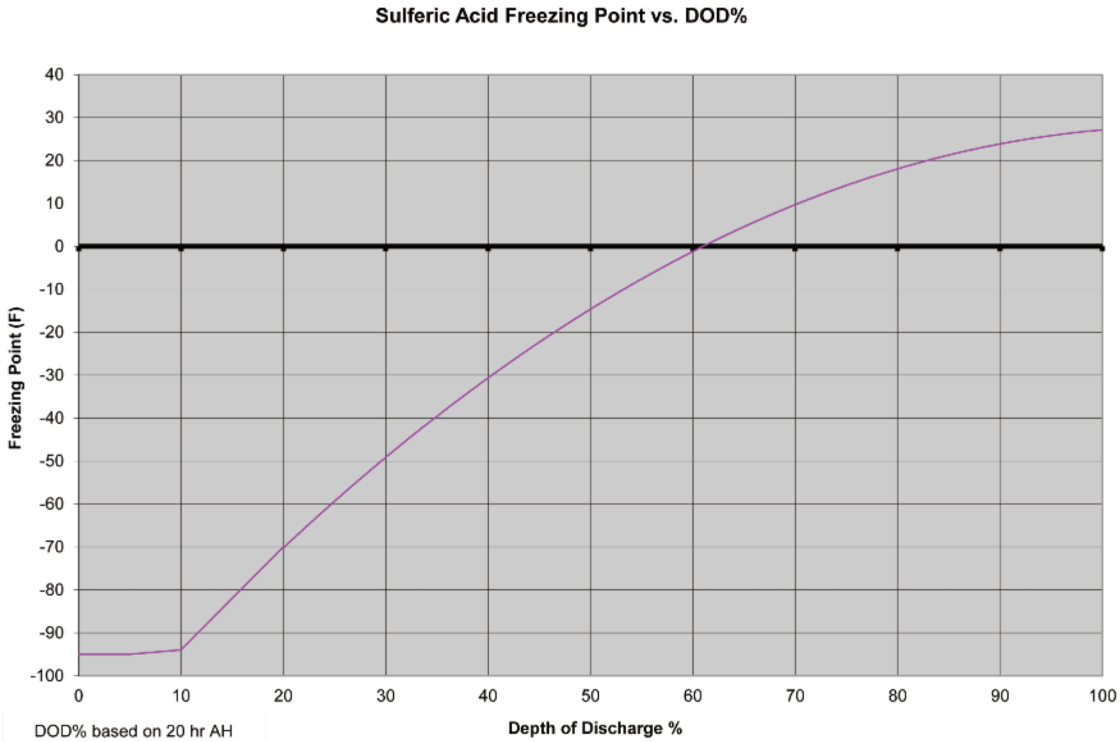

Figure 2 - Depth of Discharge vs. Electrolyte Freeze Point

For example, if a TEL12-70 were discharged at 77°F (25°C) at the 20 hour rate of 3.75 amperes to 1.75 volts per cell, this would be 75 Ah 100% depth of discharge (DOD). This results in a freeze point of the electrolyte as shown in Figure 2 of approximately 28°F (-2.2°C). If discharged at this 3.75 ampere rate for only 10 hours to 2.025 volts per cell (refer to Figure 3) the ampere-hours expended would be 37.5 and the DOD would only be 50% (37.5 Ah/75 Ah). The resulting freeze point would be -15°F (-26.1°C) as noted in Figure 2.

Likewise, if discharged at the one hour rate of 46.8 amperes to 10.5 VDC at 77°F (25°C), the depth of discharge would be 62% (46.8 Ah/75.0 Ah) with a resulting freeze point of +2°F (- 16.6°C) as noted in Figure 2.

To assure the electrolyte will not freeze in the "discharged " condition the battery must be sized such that the electrolyte specific gravity does not fall below its freezing point at the end of the discharge. This would normally be done by "oversizing" the battery and/or using an elevated endpoint voltage. For example, if a battery were to be used in an environment that could drop to as low as -20°F (-28.9°C) following discharge of the battery, the DOD could not be allowed to decline to less than 47% without the danger of freezing (ref. Figure 2). To limit the DOD the end point voltage would be selected per Figure 3 for the intended discharge rate.

In the case where the battery must deliver 12.5 amperes for 4 hours (50 Ah) at 77°F (25°C), a battery capable of 106.4 ampere hours (50 Ah / 47%) at the 4 hour rate or larger should be selected. However, the depth of discharge must be limited by utilizing a higher than normal end point voltage. To limit the depth of discharge to 47% at 77°F (25°C) at the 4 hour discharge rate, the end point voltage would be set to approximately 1.98 volts per cell as noted in Figure 3.

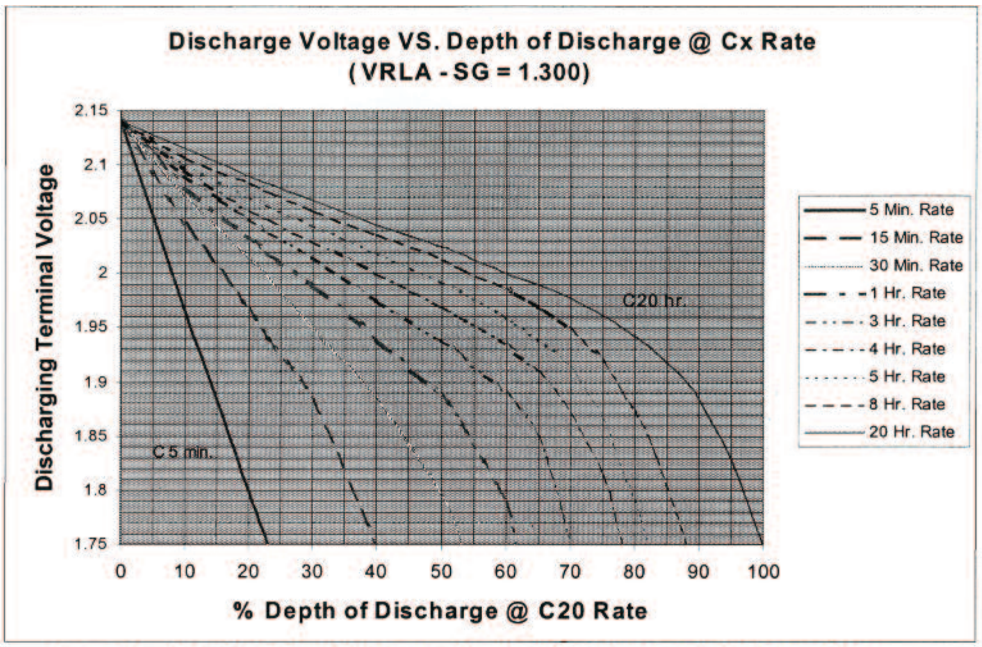

Figure 3 - End Point Cell Voltage vs. Depth of Discharge and Discharge Rate

Electrolyte Freeze Protection When Discharging at Freezing Temperatures

When discharging the battery at a freezing temperature, the battery offers a degree of freeze protection due to its inefficiency at the colder temperature. For example, when discharging a battery at a temperature of -10°F (-23.3°C) at the 5 hour discharge rate it is only 40% efficient as noted in Figure 4. Therefore to deliver the required current at -10°F (-23.3°C) the battery would be sized to deliver the required current X 1/40% at 77°F (25°C).

For example if a telecommunications load required 8.0 amperes for 5 hours at a -10°F (-23.3°C) a battery would be selected that could deliver 20.0 amperes (8 amperes/40% efficiency) at 77°F (25°C). In this case a TEL12-125 which is capable of 23.4 amperes at 77° F (25°C) could be selected. When discharged at 8.0 amperes at -10°F (-23.3°C) for 5 hours to 10.5 VDC the TEL12-125 would be discharged 40 Ah to a 30% depth of discharge (40 Ah/132 Ah @ 20 hour rate). The 30% DOD would result in an electrolyte freeze point of -50°F (-45.5°C) which is lower than the operating temperature of -10°F. Note that when the battery low voltage disconnect is set to the 77°F (25°C) end point value of 1.75 volts per cell, freeze protection is naturally provided through appropriate sizing of the battery capacity for the low temperature discharge.

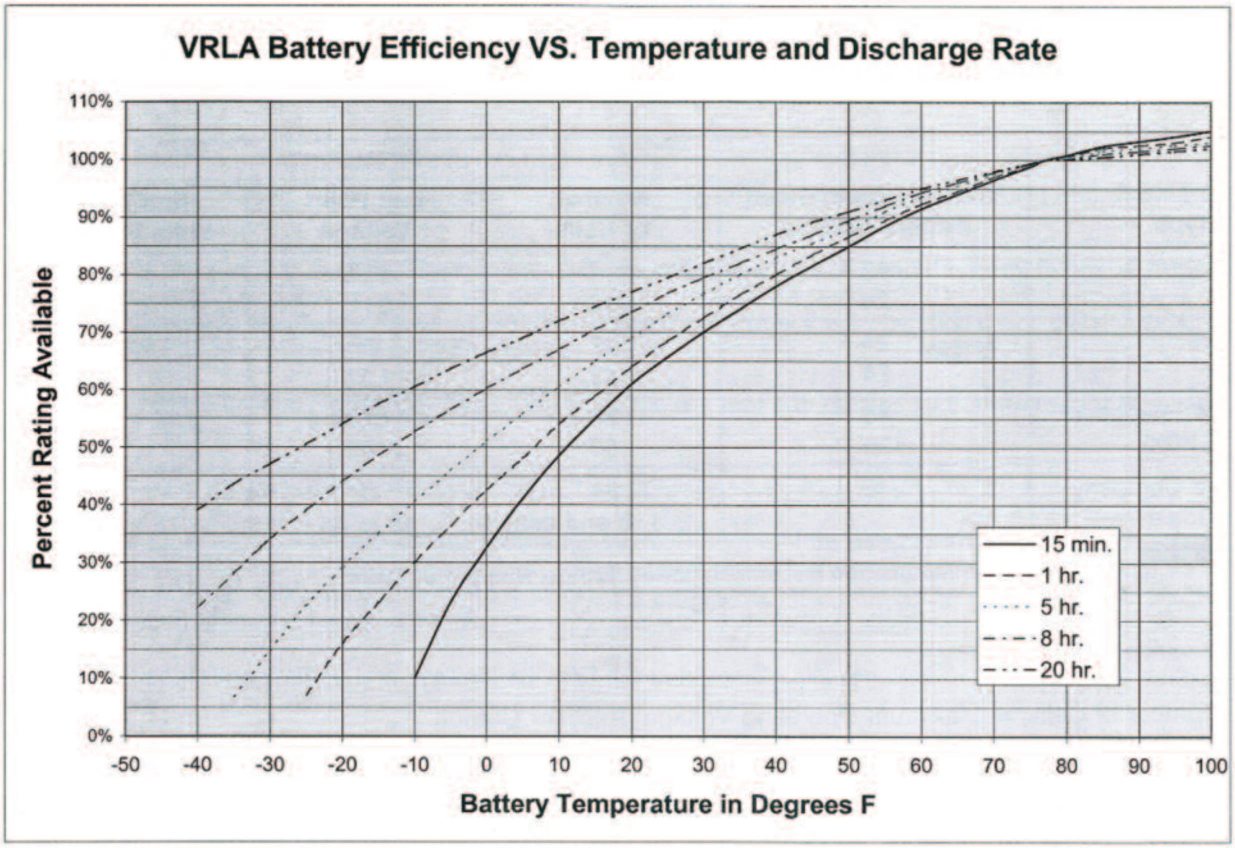

Figure 4 – VRLA Battery Efficiency VS. Battery Temperature

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