LEAD CRYSTAL BATTERIES

SAFETY, STORAGE, OPERATIONS AND MAINTENANCE MANUAL

PUBLICATION | 2017

THIS MANUAL PROVIDES FULL INSTRUCTIONS REGARDING SAFETY, STORAGE, OPERATION, AND MAINTENANCE FOR LEAD CRYSTAL BATTERIES, AS WELL AS CERTAIN INSTALLATION CONSIDERATIONS. FAILURE TO OBSERVE THE PRECAUTIONS AS PRESENTED MAY RESULT IN DAMAGE TO EQUIPMENT, INJURY OR LOSS OF LIFE.

GENERAL SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

IMPORTANT! PLEASE READ THIS MANUAL. THIS MANUAL CONTAINS IMPORTANT INSTRUCTIONS THAT SHOULD BE FOLLOWED DURING STORAGE, INSTALLATION, OPERATION AND MAINTENANCE OF LEAD CRYSTAL BATTERIES. IT WILL HELP TO ACHIEVE HIGHEST PERFORMANCE OF YOUR EQUIPMENT AND EXTEND THE LIFESPAN OF YOUR PRODUCT.

Battery handling and servicing should be performed- or supervised by personnel who have professional knowledge about batteries and precautionary measures. Battery replacement by unauthorized personnel is prohibited. When replacing batteries, please use Lead Crystal batteries of the same capacity and size as originals used in equipment.

Do not misuse or mutilate Lead Crystal Batteries. This could result in human injury or cause damage to the batteries. In no event will Betta Batteries be responsible or liable for either indirect or consequential damage or injury that may result from misuse or mutilation of batteries.

Lead Crystal Batteries contain sulphuric acid (< 5%) Sulphuric acid can be harmful to the skin and eyes. Take precautionary measures as described in this manual.

It is important to handle batteries correctly when returning batteries. As the batteries contain lead, any inappropriate handling of the batteries will have adverse effects on the environment and on persons. Please check local legislation to obtain approved handling procedures, or return batteries to authorized service centers of the manufacturer for replacements.

Do not place batteries in-or near a direct fire.

Do not use an organic solvent to clean batteries.

Batteries may cause electric shock when short circuited. Always use tools with insulated handles when changing batteries or while performing maintenance.

SYMBOLS FOR BATTERY USE AND OPERATIONS

PLEASE READ CHAPTER 5 FOR FURTHER DETAILED SAFETY GUIDELINES

SAFETY
WARNING

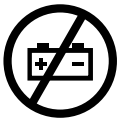
NO OPEN FLAMES OR
SPARKS

ELECTRICAL
HAZARD

RECYCLE

EYE
PROTECTION

DO NOT DISPOSE
BATTERY INTO TRASH



SHORT CIRCUIT
PREVENTION

THIS PRODUCT HAS
PASSED UL SAFETY
CERTIFICATION

ADULT
SUPERVISION

THIS PRODUCT
HAS PASSED
CE CERTIFICATION

READ THE
MANUAL

THIS PRODUCT
HAS PASSED
IEC/EN 60896-21/22

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1 GENERAL INFORMATION

1.1 Introduction

Growing demand for batteries on a global scale
Due to the rapid development of the industry, the application of batteries in transportation, communication, power, military, aviation, marine, commercial facilities as well as in the daily needs of users has become more extensive.

The performance of conventional lead based batteries is not optimal
Because of its inherent structural characteristics, traditional lead-acid batteries suffer from plate sulphation, active material loss, high water loss rate, serious acid pollution, poor low temperature performance, short life cycle, poor transport safety and other flaws. In order to overcome the structural weaknesses in lead-acid batteries, gel electrolyte has been used as replacement in gel batteries. Although it reduces acid mist, reduces water loss rate and self-discharge rate, and improves the discharge performance, it raises new problems such as poor penetration of the gel material, weak compatibility with the AGM separator and a slow reaction to the electrodes.

By its unique technology Lead Crystal batteries have a high performance
To overcome the fundamental flaws of the lead-acid and gel batteries, we have successfully developed five exclusive patented technological innovations in Lead Crystal batteries. Lead Crystalbatteries are ideal products to replace lead acid and gel batteries

In line with the industrial development trend of the 21st century, Lead Crystal batteries pioneered the new concept of environmentally friendlier electrolyte and manufacturing, and marked the iconic innovation of battery technology. The excellent properties of Lead Crystal batteries is well received in many provinces and cities in China, and has successfully entered markets in Southeast Asia, Africa, the Middle East, Europe and other international markets. They are widely used in solar energy, wind energy storage systems, telecommunications, UPS power supply, power stations, railway passenger cars, electric vehicles, electric bikes, beacon signal indicators and other fields. This new type of environmentally friendly product is rapidly blending into the consumer lifestyles of many industries and is widely accepted by institutions and individuals.

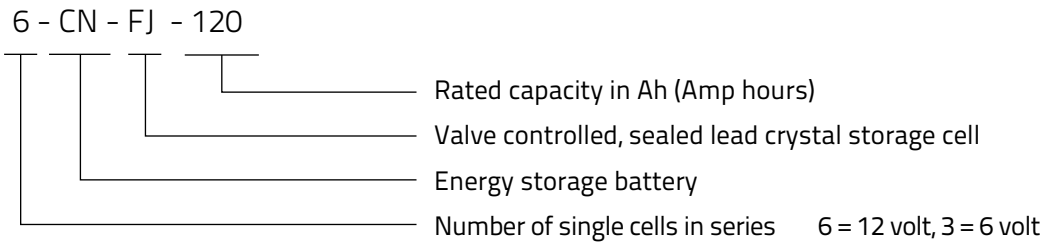
The patented technology found in lead crystal batteries uses a special advanced technology formula, a new type of composite SiO2 electrolyte developed to completely replace traditional sulphuric acid solution. This in turn improves the product's application and safety performance. When the composite electrolyte reacts with the plates during the charging process, crystalline electrolyte salts are formed, and the electrolyte is absorbed into the electrolytic salt. The electrolyte is distributed evenly, in a non- hierarchical manner, and there is no gradient concentration in the upper and/or lower electrode. The electrical properties of the battery are consistent and achieve reliable performance. It effectively overcomes the disadvantages of plate sulphation, active material loss and water loss rate, has good low temperature and overcharge performance, and greatly improves product life.

1.2 Applications

Lead Crystal batteries can be used in a wide range of applications where lead acid, Lead Gel batteries or AGM Batteries are used today, including, but not limited to:

- Telecommunications, Communications Exchange And Transmission Systems;
- UPS Uninterruptible Power Supply, PABX And Microwave Relay Station;
- Radio And Broadcasting Stations;
- Power Plants And Transmission Systems;
- Emergency Lighting Systems;
- Railway Signal, Beacon Signalling System;
- Solar Energy, Wind Energy Storage Systems;
- Hotels, Auditoriums and other Applications.

1.3 Product Specification and Model Identification Method



LEAD CRYSTAL BATTERIES

1. CNFJ Battery terminal schematic digram

Item	Model	Voltage /V	10hr Capacity	Dimensions/mm±2				Type	Weight/Kg
				L	W	H	TH		
1	3-CNFJ-4	6	4Ah	70	47.5	100	105	F1	0.7
2	3-CNFJ-7.2	6	7.2Ah	151	35	94	102	F2	1.2
3	3-CNFJ-10	6	10Ah	151	50	94	100	F2	1.9
4	3-CNFJ-12	6	12Ah	151	50	94	100	F2	2.1
5	3-CNFJ-160	6	160	298	172	227	230	F3	25.0
6	3-CNFJ-180	6	180	306	168	222	225	F8	28.0
7	3-CNFJ-200	6	200	323	178	226	230	F10	30.5
8	6-CNFJ-4	12	4Ah	90	70	101	106	F1	1.6
9	6-CNFJ-7.2	12	7.2Ah	151	65	94	102	F2	2.25
10	6-CNFJ-8.5	12	8.5Ah	151	65	94	102	F2	2.55
11	6-CNFJ-10	12	10Ah	151	99	94	100	F5	3.5
12	6-CNFJ-12	12	12Ah	151	99	94	100	F5	4.15
13	6-CNFJ-14	12	14Ah	151	99	98	102	F5	4.35
14	6-CNFJ-18	12	20Ah	181	76	167	167	F6	5.9
15	6-CNFJ-22	12	22Ah	181	76	167	170	F6	6.9
16	6-CNFJ-24	12	24Ah	175	166	125	125	F6	7.8
17	6-CNFJ-28	12	28Ah	175	166	125	125	F6	8.7
18	6-CNFJ-36	12	35Ah	222	105	175	175	F6	11.0
19	6-CNFJ-40	12	40Ah	196	166	176	176	F3	13.0
20	6-CNFJ-45	12	45Ah	222	120	175	175	F7	12.5
21	6-CNFJ-55	12	55Ah	229	138	210	215	F3	16.9
22	6-CNFJ-65	12	65Ah	350	166	175	175	F4	21.0
23	6-CNFJ-70	12	70Ah	260	169	216	220	F3	22.5
24	6-CNFJ-90	12	90Ah	306	174	206	240	F3	28.0
25	6-CNFJ-100	12	100Ah	327	172	206	210	F3	31.5
26	6-CNFJ-120	12	120Ah	408	174	211	234	F4	36.5
27	6-CNFJ-160	12	160Ah	532	207	215	220	F3	50.0
28	6-CNFJ-180	12	180Ah	522	240	219	224	F4	60.0
29	6-CNFJ-200	12	200Ah	522	240	219	224	F4	62.0
30	6-CNFJ-250	12	230Ah	520	269	220	225	F4	70.0
31	CNFJ-100	2	100Ah	172	72	205	210	F3	5.8
32	CNFJ-150	2	150Ah	172	102	205	227	F8	8.2
33	CNFJ-200	2	200Ah	172	110	330	335	F4	13.5
34	CNFJ-300	2	300Ah	175	155	330	335	F4	22.0
35	CNFJ-400	2	400Ah	210	175	330	335	F4	28.0
36	CNFJ-500	2	500Ah	241	175	330	335	F4	31.0
37	CNFJ-600	2	600Ah	301	175	330	335	F4	38.0
38	CNFJ-800	2	800Ah	412	175	330	335	F4	55.0
39	CNFJ-1000	2	1000Ah	480	175	330	335	F4	65.0
40	CNFJ-1500	2	1500Ah	400	351	340	345	F4	98.5

1. CNFJBattery terminal schematic digram

Item	Model	Voltage /V	10hr Capacity	Dimensions/mm±2				Type	Weight/Kg
				L	W	H	TH		
41	CNFJ-2000	2	2000Ah	491	351	342	347	F4	125
42	CNFJ-2500	2	2500Ah	491	351	342	347	F4	141.5
43	CNFJ-3000	2	3000Ah	712	351	341	346	F4	192.0

2.CNFT (Telcom) Battery terminal schematic digram

Item	Model	Voltage /V	10hr Capacity	Dimensions/mm±2				Type	Weight/Kg
				L	W	H	TH		
1	6-CNFT-55	12	55	277	106	223	228	F9	16.8
2	6-CNFT-90	12	95	390	108	286	286	F9	34.5
3	6-CNFT-100	12	100	560	125	228	228	F8	34.5
4	6-CNFT-170	12	170	546	125	320	320	F8	50.0

3. Battery terminal schematic digram

Item	Terminal Type	Model	schematic diagram
1	F1	187	
2	F2	250	
3	F3	Ø16×M6	
4	F4	Ø20×M8	
5	F5	Ø8×M5	
6	F6	Ø10×M5	
7	F7	Ø12×M6	
8	F8	Ø19×M8	
9	F9	Ø13.5×M6	
10	F10	Ø18×M8	

1.5 Product Standards

Lead Crystal batteries are manufactured to meet the following national and international standards and are manufactured under the ISO 9001, ISO 14001 and GB/T 24001 system.

- GB/T22473-2008 lead-acid energy storage battery
- GB/T19638.2-2005 fixed type valve-controlled sealed battery
- Q/TDZG05-2010 fixed type valve control sealed lead crystal battery
- BS 6290 part 4, Telcordia SR 4228, Eurobatt guide, UL, IEC-60896-21/22

1.6 Advantages Summarised

Compared to mainstream rechargeable industrial batteries like lead acid, lead gel and AGM batteries, Lead Crystal batteries perform as follows:

- Lead Crystal batteries can be charged faster
- Lead Crystal batteries can be discharged deeper (even to 0 Volt!)
- Lead Crystal batteries have an operating temperature from -40 to 65 Celsius
- Lead Crystal batteries can be charged below 0 degrees Celsius
- Lead Crystal batteries can be cycled more often (1500 @ 80% DOD)
- Lead Crystal batteries have very low gassing (IEC 60896-21/11)
- Lead Crystal batteries can be used in a partial state of charge
- Lead Crystal batteries can be stored for 2 years without top-up charging
- Lead Crystal batteries hold no cadmium, no antimony and < 5%sulphuric acid
- Lead Crystal batteries require no special ventilation or cooling

2 TECHNICAL SPECIFICATIONS

Lead Crystal batteries are a range of new products that were successfully developed based on existing batteries. It has better performance characteristics compared to a conventional batteries and is the result of new technical breakthroughs. The fundamental issues of serious lead acid battery acid pollution, electrode sulphation, short life cycle, poor low temperature performance and other flaws are resolved, setting a high standard of "efficiency, safety, and long-life".

2.1 Structure Characteristics

2.1.1 Special Electrolyte Composition

A unique complex technology is used to synergize a range of inorganic salts and organic substances, thereby optimizing the reaction between the electrolyte and the active electrode material, effectively preventing the active substance to become salt and fall off, and extending its service life. The electrolyte within the battery crystallizes, leaving no free electrolyte, no leakage, making the battery safe and reliable. The battery may be installed using in a variety of orientations, making it easy to use. This opens a wide range of installation applications, since the risk of electrolyte leakage is eliminated. This reaction also improves the products safety making it less harmful to installers and users alike.

2.1.2 Battery Slot Cover

The battery slot cover is made from strong opaque ABS plastic with a standard V2 flammability rating. It is also available in a V0 and v1 flammability rating on order.

2.1.3 Grid

The grid is made with high quality corrosion-resistant non-antimony alloy, to ensure the excellent performance life of the positive grid, improve the over potential of the anode, and inhibit hydrogen corrosion.

2.1.4 Partition

The partition is made of an ultra-fine fibre separator of high porosity, using cathode absorption technology to create gas recombination. The separator has good acid resistance and stability, which provides sufficient porosity and maintains the smooth passage of the gas while absorbing and storing sufficient volumes of electrolyte (to ensure the battery high performance). The oxygen can rapidly distribute negative electrons to perform cathode absorption and oxygen combination cycle.

2.1.5 Safety Valve

A safety exhaust valve is used that has high sensitivity, and can open or close according to the internal pressure change of the battery. Safety valves are made of corrosion-resistant, anti-aging fluorine rubber, which can retain the air-tightness and liquid-tightness of batteries with long-term use and constant open and close valve pressure. The internal pressure of the batteries is maintained at optimal safety range.

2.1.6 Sealing Performance

Battery compartment and cover are seals made of rubber rings and terminals that are dual-sealed. A sealing material that has small shrinkage is used to ensure that the terminal seals well.

2.1.7 Positive and Negative Plates

The positive and negative plates are the core electrochemical reaction region and the most important components of the battery. The grid is coated with lead paste and formed after curing, drying, and other processes. The following composition are the active material of the positive and negative plates:

- Positive electrode plate: main component - Lead Dioxide (PbO_2);
- Negative electrode plate: main components - Spongy Lead (Pb).

2.1.8 Special Manufacturing Process

Using pressure filling technology in combination with patented gravity filling containers to fill the batteries with electrolyte and the patented terminal connecting equipment, these improvements ensure an even distribution of electrolyte in each cell further enhancing the performance of the batteries and increasing the efficiency.

2.2 Working Principle

DISCHARGE

$$PbO_2 + 2H_2SO_4 + Pb \rightleftarrows PbSO_4 + H_2O + PbSO_4$$

CHARGE

LEAD DIOXIDE	+	DILUTE SULPHURIC ACID	+	LEAD		LEAD SULPHATE	+ WATER +	LEAD SULPHATE
POSITIVE PLATE		COMPOSITE		NEGATIVE PLATE		POSITIVE	WATER	NEGATIVE
ACTIVE MATERIAL		ELECTROLYTE		ACTIVE MATERIAL		DISCHARGE MATERIAL		DISCHARGE MATERIAL

Figure 2.1. The main electrochemical reaction during charge / discharge.

When discharging, the positive and negative active material reacts with the acidic element of the electrolyte and becomes lead sulphate and water, causing the acid density to decrease. When charging, the acid that concentrated in the positive discharge material (during discharge cycles) is released back into the electrolyte. At this time the lead sulphate in the positive and negative plate transforms in to lead dioxide and a spongy type of lead which causes the acid density in the electrolyte to increase.

With conventional lead based batteries, after charging or prior to charge completion, all the charging current is used for electrolyses of the moisture in the electrolyte. The positive plates release oxygen and the negative plate hydrogen gas. If the gas recombination efficiency of the battery is low, a large percentage of the gas will escape leaving less moisture in the battery after every charge. This action causes the electrolyte content to decrease due to water loss, raising the acidity in the battery and shortening the life of the battery. This is known as late charge fluid loss phenomenon.

With Lead Crystal batteries, besides the regular chemical reaction, the composite electrolyte has various additives that participate in the electrochemical reaction. The additives inhabit the oxygen and hydrogen gas during the charging cycle increasing the batteries recombination rate. This in turn reduces the water loss during and after charging. When discharging, the lead sulphate can be totally transformed back into active material, prolonging the battery's use life.

Lead Crystal batteries use a new advanced type of AGM material as a separator. The AGM has much higher electrical conductivity, heat resistant and acid resistant abilities than standard AGM on the market. The crystallized electrolyte in combination with the AGM can effectively protect the plates and prevent the active material from falling off during use. The electrolyte is completely absorbed and stored in the AGM. Since the AGM is completely saturated with electrolyte then crystallized, no free liquid electrolyte will be present in the battery. The battery can now be used in various directional positions without leaking.

3 CHARGE AND DISCHARGE SPECIFICATIONS

3.1 Charge Characteristics

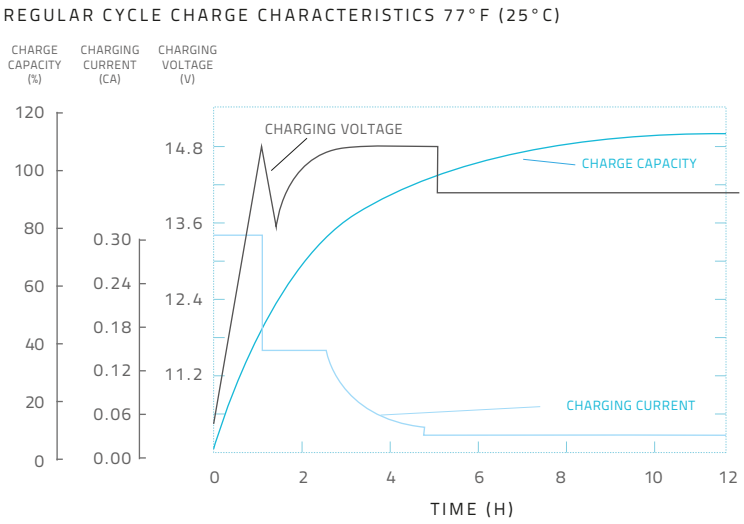
See below charge characteristics for CNFJ, HCNFJ and CNFT Lead Crystal Batteries.

3.1.1 12 volt Lead Crystal Batteries

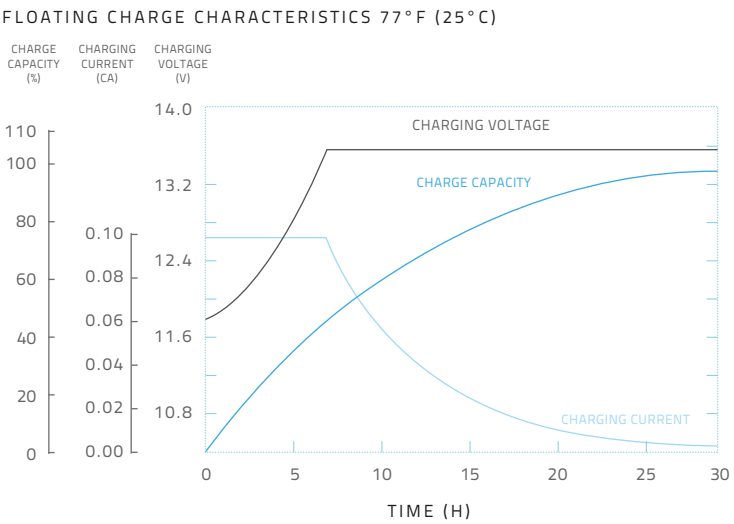
Charge Curves

12 volts

CYCLE CHARGE CHARACTERISTIC (25°C)



FLOATING CHARGE CHARACTERISTIC (25°C)



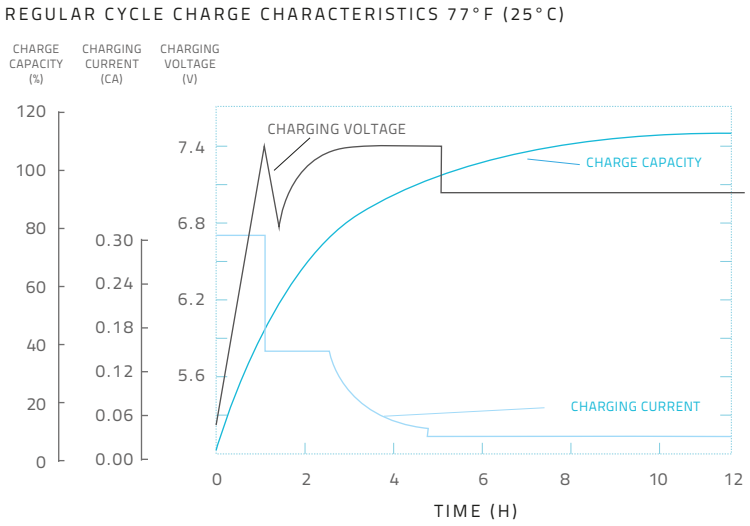
Charger Settings
Lead Crystal Batteries are high-end products that work best with good quality battery chargers.

3.1.2 6 volt Lead Crystal Batteries

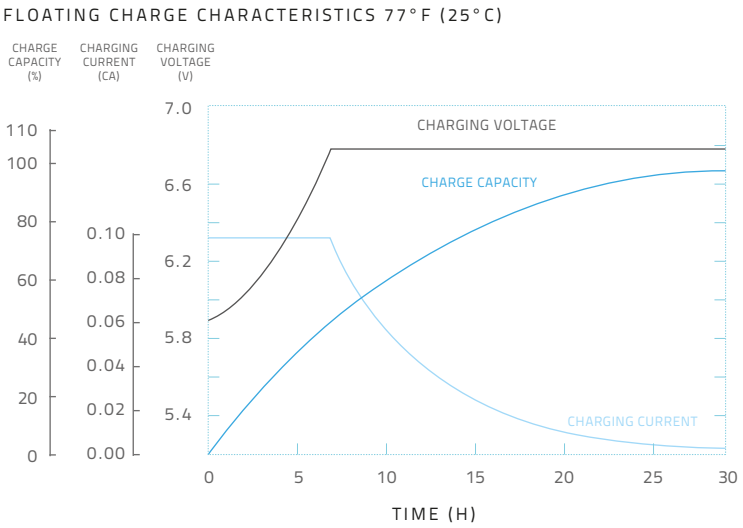
Charge Curves

6 volts

CYCLE CHARGE CHARACTERISTIC (25°C)



FLOATING CHARGE CHARACTERISTIC (25°C)



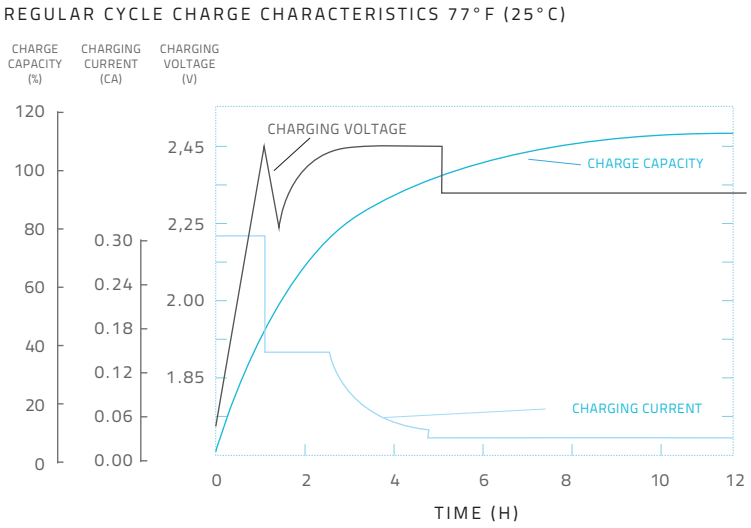
Charger Settings
Lead Crystal Batteries are high-end products that work best with good quality battery chargers.

3.1.3 2 volt Lead Crystal Batteries

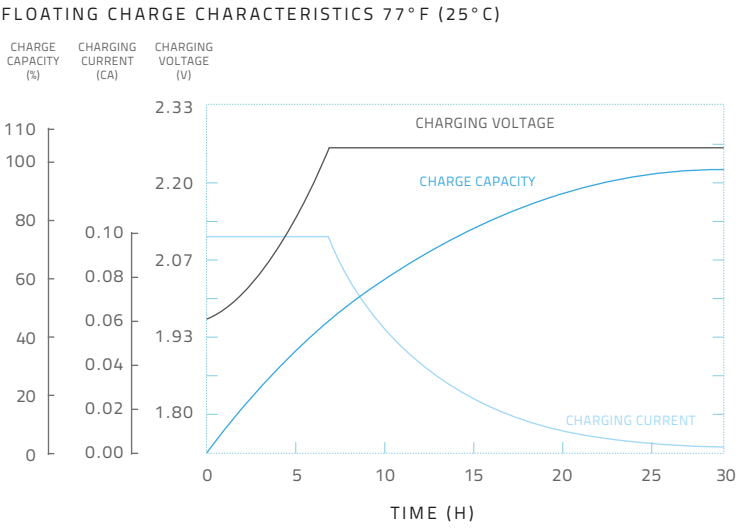
Charge Curves

2 volts

CYCLE CHARGE CHARACTERISTIC (25°C)



FLOATING CHARGE CHARACTERISTIC (25°C)



Charger Settings
Lead Crystal Batteries are high-end products that work best with good quality battery chargers.

3.1.4 Temperature Compensation

The charge voltage has to be adjusted according to the change in ambient temperature according to below table.

TEMPERATURE	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
CYCLE CHARGE	2.66	2.64	2.62	2.60	2.58	2.56	2.54	2.52	2.50	2.48	2.47	2.47	2.45	2.45	2.43	2.41	2.39	2.37	2.35	2.33	2.31	2.29	2.27
FLOAT CHARGE	2.46	2.44	2.42	2.40	2.38	2.36	2.34	2.32	2.31	2.30	2.29	2.29	2.29	2.27	2.26	2.24	2.23	2.23	2.23	2.23	2.23	2.23	2.23

Table 3.1 Battery voltage setting for di erent temperatures.

3.1.5 Introduction EVFJ

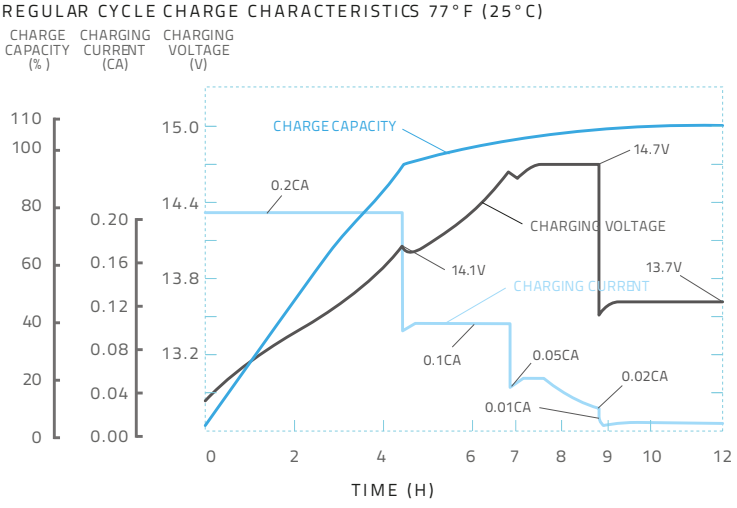
EVFJ range is our light traction range, specifically designed for demanding power needs like Electric vehicles, internal transport systems, industrial cleaning machines, golf carts and many more. The light traction batteries mostly have the same high outstanding characteristics. However, there are a few differences to be noted. The EVFJ range has a slightly thicker plate structure for high cyclic applications and to be able to deliver a high amount of power more easily. The light traction range also has a different charge profile compared to the regular range. In addition, the capacity is measured on a 3 hour discharge instead of the usual 10 hour discharge for the regular range.

The light traction range includes 6V-8V and 12V batteries which vary from 27Ah to 265Ah in capacity.

How do you determine the right charging current for the light traction range?
The EVFJ range is charged with less power than the regular range. To calculate the charging current, use the following formula:

Available capacity on 10 hour discharge (in datasheet) x 0,2 (C). For example: 6-EVFJ-120 delivers 140Ah on 10h discharge x 0,2 = 28A. The best choice here would be a 30A charger.

CHARGE CHARACTERISTIC 77°F (25°C)



3.2 Discharge Characteristics

3.2.1 Battery Capacity

Batteries under certain discharge conditions will release a certain amount of current. This amount of current released is called the capacity. The symbol used to identify the capacity is "C". The commonly used unit of measure is Amp Hours (Ah).

The battery capacity can be defined in two parts, namely rated capacity and actual capacity under different discharge conditions. The actual capacity of the battery under certain discharge conditions is calculated by the current (A) multiplied by the discharge time (h). The resulting unit is Ah.

3.2.2 Battery Discharge Rate

The battery discharge rate uses rated hours to determine the discharge time. This time is influenced by the amount of current drawn from the battery. If the discharge current increases, the discharge time will decrease and also affect the rated capacity.

Hour rated discharge:
C 10 = 10 hour rated capacity (Ah)
C120 = 120 hour rated capacity (Ah)

Rate of discharge:
1C = 1 multiplied by the 10 hour rated capacity used for the discharge current (A)
0.01C = 0.01 multiplied by the 10 hour rated capacity used for the discharge current (A)

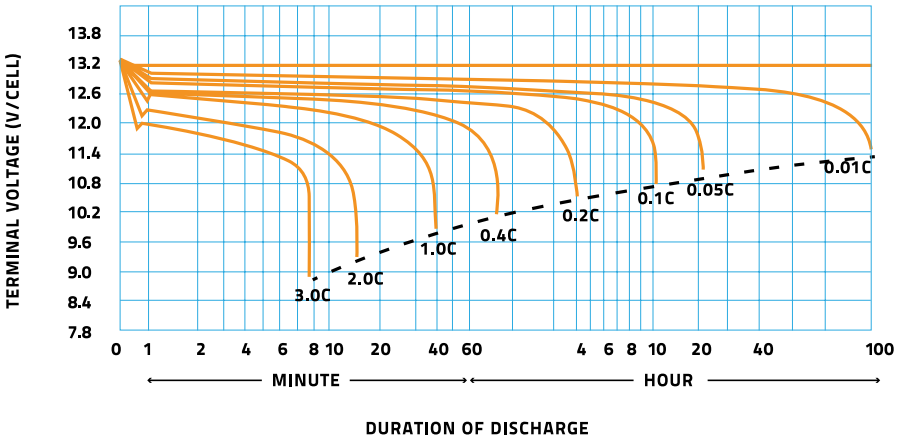


Figure 3.2 Generic curve of different discharge rates of a Lead Crystal battery at 25°C. For discharge values of a specific battery model we revert to the constant current discharge tables in the datasheets.

3.2.3 Influence of Temperature on Capacity

The discharge characteristics and temperature of batteries are closely related. When the temperature is low, the discharge capacity of the battery will be reduced. For example, when the temperature is dropped from 25°C to 0°C, the capacity of the battery will drop to about 95% of its rated capacity.

As the ambient temperature rises, the battery capacity will increase within a certain range, for example, the battery capacity will rise to about 105% of the rated capacity when the temperature rises from 25°C to 40°C, however if the temperature continues to rise, the capacity increase will slow down, and ultimately not increase further.

In Figure 3.3 you will notice the effect of temperature on the capacity of the CNFJ, HCNFJ and CNFT series lead crystal batteries. To calculate the capacity of the battery when the environmental temperature is not 25°C, the below formula is used:

$$Ce = \frac{Ct}{1 + K(t-25)}$$

Ct = the actual capacity at a certain temperature
t = the environmental temperature at the time of discharge (°C)
K = the temperature coefficient (10 hour rate coefficient is 0.006)

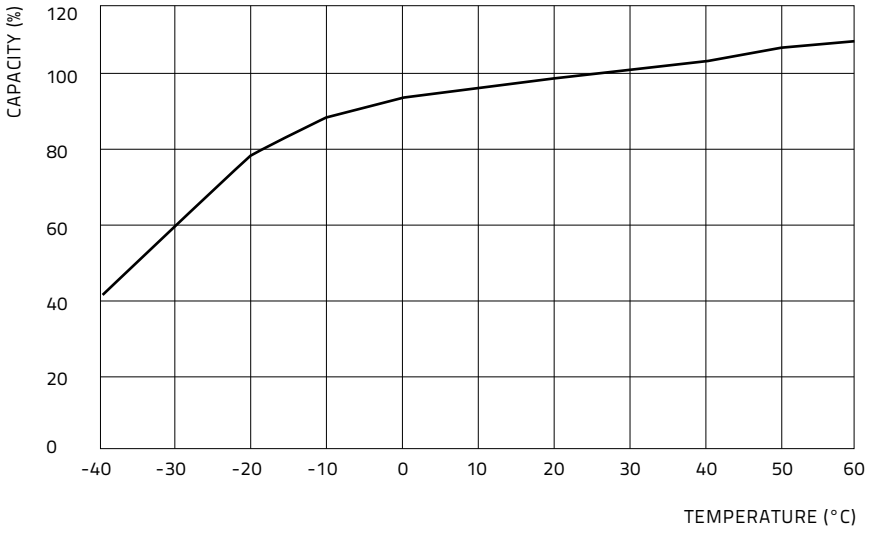


Figure 3.3. Lead Crystal relationship between discharge capacity and temperature.

3.2.4 Discharge Voltage

The termination voltage refers to the battery voltage dropping during discharge to the minimum working voltage required for operation. The termination voltage and the discharge current are closely related. Generally during high current discharge the termination voltage of the battery should be set lower.

During long term operation at small discharge currents, the battery will form a thin layer of sulphation on the plates, increasing their size. This could cause deformation of the active material and cause it to fall off the plates. To prevent this and also to protect the battery during small current operations, the termination voltage should be set higher.

Over discharging below the termination voltage should be avoided since the over discharging could only gain a small amount of additional capacity, but drastically reduce the battery's service life.

DISCHARGE CURRENT (A)	DISCHARGE VOLTAGE (V/CELL)
0.05C or less than the discharge gap	1.9
0.05C or similar to this value	1.85
0.1C or similar to this value	1.8
0.2C or similar to this value	1.75
0.2C - 0.5C	1.7
0.5C - 1C	1.6
1C - 3C	1.5
3C	1.3

Table 3.4 Termination voltage of Lead Crystal batteries when discharged at different current.

4 TRANSPORT, STORAGE AND INSTALLATION

4.1 Battery Transport

Lead Crystal Batteries are considered normal goods for airfreight and shipping. Lead Crystal Batteries are not restricted to IATA Dangerous Goods Regulation (special provision A67) and not restricted to IMO International Maritime Dangerous Goods code (special provision 238).

4.2 Battery Storage

Arrival

All Lead Crystal batteries have been fully charged prior to shipping to activate the crystallization of the electrolyte in the batteries. Precautions have been taken to pack the battery units, individual cells or cabinets containing batteries for shipment to ensure their safe arrival.

However, upon receipt, you should inspect for evidence of damage that may have occurred during transit. If damage is noted, make a descriptive notation, and file a damage report. If you have any questions concerning potential damages, contact your nearest Lead Crystal batteries authorised dealer or dealer.

WARNING
During inspections take precautions against electrical shock.

Storage

Lead Crystal batteries should be stored in a clean, wellventilated and dry environment.

Avoid direct exposure of Lead Crystal batteries to the sun.

The optimum storage temperature of Lead Crystal batteries is 15°C- 25° C. The minimum storage temperature is -20°C, the maximum storage temperature is +40°C. Storage at higher temperatures will result in accelerated rates of self-discharge and possible deterioration of battery performance and life.

The maximum relative humidity for storage of Lead Crystal batteries is 95%.

The highest elevation for storage of Lead Crystal batteries is 6000m above sea level.

Self-Discharge
The self-discharge characteristics of a battery changes with environmental temperatures, the higher the temperature the higher the self-discharge, so the batteries should not be stored in an environment that is subjected to extremely high temperature conditions for long durations of time.

Due to the use of our unique crystal composite electrolyte and alloy grid plate technology, the self-discharge consumption of Lead Crystal Batteries is efficiently reduced. At a constant 25°C environmental temperature Lead Crystal Batteries can be kept on a shelf for up to two years without constant top up charging. The batteries will maintain over 80% of their rated capacity after 12 months.

STORAGE CAPACITY (25°C)/%	3 months storage	95
	6 month storage	85
	1 year storage	80

Table 4.1 Self-discharge characteristics of Lead Crystal Batteries.

4.3 Battery Installation

BEFORE INSTALLATION READ THIS SECTION THOROUGHLY. TO ENSURE CORRECT INSTALLATION ACCORDING TO REQUIRED APPLICATION AND EQUIPMENT SETTINGS

Prior to Installation
Ensure that the batteries remain in the shipping packaging until it arrives on the installation site. After the batteries are unpacked, check for any visible damage to the product. Batteries should be handled with great care during transportation and installation to avoid risk of electrical shock, high voltage, short-circuit and reverse connection. You are dealing with a live battery.

Electrically insulated equipment and clothing should be used when working with or connecting batteries.

DO NOT lift any cell by the terminal posts as this will void the warranty. Always lift the batteries by the supplied handles or from the bottom of the batteries in the event that the battery is not designed or supplied with the required lifting handles.

DO NOT attempt to remove the pressure relief valves or vent covers as this will void the warranty. Attempted removal may also damage the vent and prevent proper functioning of the battery.

When there are multiple batteries connected together in a group (series or parallel), ensure that the voltage of the batteries in the group match prior to connecting.

Before connecting the equipment to the batteries, use a piece of fine grit sandpaper to sand the contact area of the terminal and the connecting lug. This will ensure good contact between battery and lug and reduce the risk of oxidation.

Before connecting the load, charge the batteries to a state of full charge to ensure all the batteries are on the same level.

Batteries should be installed away from direct sunlight, heat sources (1 meter and above), organic solvents, corrosive gas and locations where sparks may occur, such as transformers, power switch and fuses.

At this point it is safe to connect the batteries.

Installation and Connection

- Wrap metal installation tools (such as wrenches) with insulating tape, to create insulation.
- Ensure that all heating and cooling ducts are directed away from the batteries. The installation site should be kept clean, dry and well ventilated at all times.
- To prevent a temperature rise of the batteries when used in the equipment, the batteries should preferably be stored at the lowest section of the equipment. In addition, avoid contact between the batteries and with the inner walls of the machine.
- First establish connection between the batteries, then connect the battery pack with a charger or with connections loading.
- Smudgy, oily and loosely connected connections could cause contact problems and lead to faults on the equipment. Ensure that all contacts are clean from oil and grease and that all connections are securely fastened.
- Terminals should be torqued to individual battery specifications, but not exceed 10 N.m. Excessive tightening will cause damage to the thread on or inside the battery terminal. Terminal connections should be checked periodically during the life of the battery to ensure that there are no loose connections.

TERMINAL	TORQUE
M5 (F5)	1.8 - 2.5Nm
M6 (F3)	3.8 - 5.4Nm
M8 (F4)	7.8 - 9.8Nm

Table 4.2 Torque Settings of Lead Crystal Batteries.

- When making parallel connections with multiple batteries, connect the batteries in series first and then in parallel. To ensure good heat distributing conditions, maintain 10mm or more space between batteries; and 35mm and above space between each row and column of battery series;

- Ensure that the batteries are connected in the correct way. Ensure that reverse polarity are eliminated by connecting positive to positive and negative to negative on the equipment. Also ensure that the correct size of wire diameter is used according to current drawn requirement. If incorrect wires are used, it will heat rapidly and cause damage to both the battery and the equipment that it is connected to.

- After connection, coat the battery terminal with anti-rust coating;

- When the battery is installed in place, check that the total voltage measuring system and the positive and negative polarity of the battery is connected correctly. Load charge only when connections are verified.

- In order to achieve optimum battery life, please use quality automatic current limiting voltage charging equipment that has overvoltage, under voltage, overcurrent protection devices and alert settings. Equipment charge should reach regulation accuracy ± 1%, ripple ≤ 1%, steady flow accuracy ≤ 1%.

5 OPERATIONS AND MAINTENANCE

5.1 Float applications

For applications that are constantly connected to the electrical grid and where the batteries are in constant charged state, and only discharged when there is a break in or loss of grid supply, the charging equipment should be set to the float charging mode. The equipment should be set and monitored so that strict control can be maintained over charging, to ensure a constant charging voltage and current.

Recommended floating charge voltage should be between 2.27 - 2.3V/Cell and the floating current should be between 0.005 - 0.01C.

In long term float charging applications a quarterly balanced 70%-80% deep discharge and charge are is recommended as part of battery maintenance. Such a maintenance cycle should however be performed at least once every six months. The balanced cycles should be no more than 8 - 12 hours in duration.

During the initial charge and discharge cycles on new installations the charge current should be limited to 0.1C - 0.25C (not to exceed 0.3C) and the temperature not more than 35°C. During this stage of operation if an increase of temperature is noticed the charge current should be reduced.

5.2 Battery Life and Temperature

The best application temperature for the Lead Crystal battery is 15°C - 25°C. Operating temperature range is the battery meter. When the ambient temperature is at a constant 40°C the battery cycle life decreases with 23%. Every 10°C additional increase in temperature, means an additional 13% reduction in cycle life.

Therefore, the ambient temperature of battery, must be controlled when it is in use. If the temperature is too high and is not effectively controlled, the heat that is built-up to a certain level will damage the battery.

Although Lead Crystal Batteries can withstand operation in extreme temperatures, the battery room should preferably be air conditioned and/or properly ventilated to improve the ambient temperature. The gap in between batteries should not be less than 10mm, while the float voltage and cycle charging voltage should be adjusted according to the requirements listed on the manual.

STATUS	OPERATING TEMPERATURE	OPTIMUM OPERATING TEMPERATURE
Discharge	-40°C - 65°C	15°C - 25°C
Charge	-40°C - 65°C	15°C - 25°C
Storage	-20°C - 40°C	15°C - 25°C

Table 3-2 Operating temperatures Lead Crystal Batteries.

5.3 BATTERY MAINTENANCE

Lead Crystal Batteries are maintenance free, but accurate battery inspection and maintenance ensures or improves battery life. Battery handling and maintenance should be performed- or supervised by personnel who have professional knowledge about batteries and precautionary measures. Battery replacement by unauthorized personnel is prohibited.

WARNING
During maintenance take precautions against electrical shock.

WARNING
Lead Crystal Batteries contain sulphuric acid (< 5%) Sulphuric acid can be harmful to the skin and eyes. Take precautionary measures as described in this manual.

Avoid constant over-charging or over-discharging of Lead Crystal Batteries.

When batteries are discharged, the termination voltage should be set according to the discharging current requirement. The over discharge protection should be set to be ±0.05V lower than the termination voltage to ensure good operation and long life of the batteries and equipment. After the battery is discharged, it should be immediately be charged again.

When abnormalities or damage is noticed, the problem should be investigated immediately. If the battery was the cause it should be replaced immediately to prevent further damage.

When charging the battery the controllers charge voltage accuracy should be less than ±1% to prolong battery service life.

All display instrumentation should be regularly checked and calibrated to ensure accurate reading of measurements. If the equipment can't read an error the equipment could cause damage to the batteries.

The following maintenance process by Lead Crystal batteries series is recommended.

5.3.1 Quarterly Maintenance

- Keep the battery room clean.
- Measure and record the ambient temperature of the battery room.
- Check the cleanliness, terminal damage and signs of overheating, or signs of damage or overheating on the case and covers of each battery.
- Check if there are any loose connections and tighten according to specification.
- Measure and record float voltage of each battery line. If there are two or more batteries with voltage falling below 2.18V/cell after temperature correction, a maintenance charge should be conducted to the battery series. See section 4.4.1.
- Conduct an actual load discharge test of the battery series at least twice a year and release 70% - 80% of the rated capacity DOD of the battery.

5.3.2 Annual Maintenance

- Repeat all quarterly maintenance inspection.
- Check for loose connecting screws annually and tighten them if they are loosen.
- Conduct an actual load discharge test of the battery series at least twice a year and release 70% - 80% of the rated capacity DOD of the battery.

6 SAFETY

6.1 General

YOU SHOULD BE TRAINED IN HANDLING, INSTALLING, OPERATING AND MAINTAINING BATTERIES BEFORE YOU WORK ON ANY BATTERY SYSTEM.

You must understand the risk of working with batteries and be prepared and equipped to take the necessary safety precaution. If not, contact your nearest Lead Crystal® batteries authorised distributor or dealer to clarify any of the noted safety precautions.

6.2 Safety equipment and clothing

When working with a Lead Crystal Battery system, be sure you have the necessary tools and safety equipment, including but not limited to:

- Insulated tools
- Rubber gloves
- Fire extinguisher
- Rubber apron
- Safety goggles

ALWAYS

- Remove all jewellery (i.e., rings, watches, chains, etc.)
- Keep sparks and flames away from the battery

NEVER lay tools or metallic objects on the battery modules.

Using the correct tools and wearing proper safety equipment will help prevent injury should an accident occur.

6.3 Safety Precautions

6.3.1 Sulphuric Acid Burns

Lead Crystal Batteries are sealed batteries with an electrolyte that solidifies into a non-dangerous white crystalline powder. Although there is no direct acid danger, Lead Crystal Batteries do contain <5% sulphuric acid. Since sulphuric acid can cause burns and other serious injuries, below guidelines have to be observed.

ALWAYS WEAR PROTECTIVE CLOTHING AND USE THE CORRECT SAFETY TOOLS.

In case of SKIN CONTACT with sulphuric acid, IMMEDIATELY
1. REMOVE contaminated CLOTHING
2. FLUSH the area THOROUGHLY with WATER
3. Get MEDICAL ATTENTION, if required

In case of eye contact with sulphuric acid, IMMEDIATELY
1. FLUSH THOROUGHLY for at least 15 minutes with large amounts of WATER
2. GET MEDICAL ATTENTION

In case of sulphuric acid contact with clothing or material, IMMEDIATELY
1. Remove contaminated clothing
2. Apply a solution of sodium bicarbonate solution (0.5kg/ 5.0 1.0lb/1.0gal liters of water on the clothing or material
3. Apply the solution until bubbling stops, then rinse with clean water

6.3.2 Explosive Gases

According to IEC 60896-21/22 Lead Crystal Batteries have very low gassing compared to conventional lead based batteries. Only after extended and severe overcharging gas is observed. For safety purposes below guidelines have to observed.

Batteries can generate gases, which when released can explode, causing blindness and other serious personal injury. Always wear protective clothing and use the correct safety tools. Eliminate any potential of sparks, flames or arcing.

IN CASE OF FIRE:
To extinguish a fire in a battery room containing Lead Crystal batteries, use a CO_2, foam or dry-chemical extinguishing medium. Do NOT discharge the extinguisher directly onto the battery. The resulting thermal shock may cause cracking of the battery case/cover.

SPECIAL PROCEDURES:
If batteries are on charge, shut off power. Use positive-pressure, self-contained breathing apparatus.

TOXIC FUMES:
Burning plastic may cause toxic fumes. Leave area as soon as possible if toxic fumes are present. Wear breathing apparatus if required to remain in the area.

6.3.3 Electrical Shocks and Burns

Multi-cell battery systems can attain high voltage and/or currents. Do NOT touch uninsulated batteries, connectors or terminals. To prevent serious electrical burns and shock, use EXTREME CAUTION when working with the system.

Always wear protective clothing and use nonconductive or insulated safety tools when working with ANY battery system.

Remove all jewellery that could produce a short circuit.

BEFORE working on the system:

1. Disconnect ALL loads and power sources to the battery. Use appropriate lockout/tag out procedures.

2. If working on an assembled battery system, sectionalize (interrupt the battery sections) into safe working voltage levels.

3. Check the battery system grounding. Grounding of the battery system is NOT recommended. However, grounding of the rack is recommended.

IF BATTERY SYSTEM IS GROUNDED: (system is intentionally grounded by connecting a battery terminal to ground).

1. An increased shock hazard exists between the terminal of opposite polarity and ground, (i.e., dirt and acid on top of battery cell touching rack).

2. If an unintentional ground develops within the already grounded system, a short circuit may occur and cause explosion or fire.

IF BATTERY SYSTEM IS GROUNDED:

1. If an unintentional ground develops within the system, an increased shock hazard exists between the terminal of opposite polarity and ground.

2. If a second unintentional ground develops within the already unintentionally grounded system, a short circuit may occur and cause explosion or fire.

Therefore, should you be required to work on a grounded battery system, make absolutely sure you use the correct safety precautions, equipment and clothing.

IMPORTANT
IF YOU HAVE ANY QUESTIONS CONCERNING SAFETY WHEN WORKING WITH THE BATTERY SYSTEM, CONTACT YOUR NEAREST LEAD CRYSTAL BATTERIES AUTHORISED DISTRIBUTOR OR DEALER TO CLARIFY ANY OF THE NOTED SAFETY PRECAUTIONS.
