Nilfisk Advance
setting standards

Informational Bulletin – Batteries and Chargers

ATTENTION SERVICE MANAGER / PARTS DEPARTMENT

Ever wonder why your customers are having so much trouble with their batteries? Aren't batteries just a simple commodity? What's the big deal?

Actually today's batteries have evolved to be complex chemical "banks," where electrons are deposited and withdrawn like cash from a bank account.

Draw for a minute the analogy that today's smart chargers are similar to an ATM. An ATM needs you to give it correct instructions in order to withdraw the cash from your account. If those instructions aren't given, you won't get the cash out of your account. If you don't give the battery charger the correct instructions, the electron "cash" won't be withdrawn, manifested as degraded performance and premature battery failure.

Just like an ATM operates on specific information in order to access money in your account, a battery charger also operates on specific information in order to correctly charge a battery.

Today's state-of-the-art batteries need to be given certain commands by the charger in order to provide the user with their "account" of electrons, which in turn is used to operate the machine.

If improper commands are given, the batteries will not charge properly and will not provide the service that users require.

Case in point: the maintenance-free "gel" or AGM batteries. They are popular due to ease of use – no maintenance, no watering, no spilling. However, given commands from their charger geared for a traditional wet battery, maintenance-free batteries wear out very quickly due to structural damage to their internal components. Refer to the ***Batteries*** section for more details on differences between wet lead acid, gel, and AGM batteries.

So, how does a user make sure their batteries are being given the right commands to produce the expected "cash" or run-time?

1) By using the recommended charger for a given battery type.
2) By correctly programming the charger (if programmable) with the recommended **charging profiles,** referred to as charging **algorithms**.
3) By setting the correct **Depth of Discharge (Low Voltage Cutoff)** setting on the machine keypad.

Charger algorithm settings are controlled via switches on the charger or a programmable interface. These settings must be matched to the battery model in order to optimize battery performance and prevent premature battery failures. Refer to the following chapters for algorithm changing procedures.

Why is this necessary?

Today's batteries are engineered chemical systems that must be given the correct electrical energy in a specific sequence or they will degrade and eventually prematurely fail, or provide shorter machine runtimes on a charge. *The expected runtime will not be provided if the batteries are not charged in the correct manner.*

Of primary significance in determining which algorithms to use is:

1) **What type of battery is it? (Wet/Flooded, Gel, AGM)**
2) **What Amp-hour (Ah) rating does it have?**

Nilfisk-Advance works closely with both battery and charger manufacturers to provide a charging system that is optimally designed for the batteries used in our products.

USING THE WRONG ALGORITHM CAN SERIOUSLY REDUCE RUNTIME BY CAUSING PREMATURE BATTERY FAILURE ! !

Before installing a new battery that is different from what is offered by Nilfisk-Advance…

contact the Tech Service Team at 1-800-989-2235.

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Batteries

SEALED…GEL… AGM…VRLA…FLOODED…WET??

I just want a good battery – how do I choose?

In order to make an informed battery buying decision, you need to understand some fundamental differences in the way batteries are constructed. These differences result in performance advantages that will be more or less important to you. The parameters may be cleanliness, ease of use, run time, initial cost, environmental factors, hazardous gases causing explosion hazards, and other criteria.

Wet batteries consist of lead plates mounted in a liquid sulfuric acid solution. Due to their internal chemical reactions and heating during charging, they inherently lose water that must be replaced through regular maintenance, or damage to the batteries will occur.

Gel and **AGM** batteries belong to a family of batteries called **VRLA**, or Valve Regulated Lead Acid. They are sealed and do not lose water during charging, and therefore are referred to as being "maintenance free." Although wet and VRLA batteries are similar in key design fundamentals (a lead surface and a sulfuric acid electrolyte), they differ in construction and application.

Wet / Flooded Batteries:

Advantages

- They have the lowest cost for a given runtime / amp hour.
- They tend to have the longest life span if properly maintained and not abused.
- Most use Lead-Antimony plates, which have improved plate strength, an important feature for electrical vehicles that are subject to abrupt stops and starts, bumps, and vibration.
- They can tolerate frequent charge/discharge cycles.

Disadvantages

- Lead-Antimony plates, although stronger than the Lead-Calcium plates used in VRLA batteries, inherently have a much higher self-discharge rate. This means that wet batteries cannot be stored for any length of time without supplemental charging to make sure the plates do not sit in a discharged state, which will allow sulfation, battery degradation and premature battery failure.
- Care must be taken while handling wet batteries so as not to expose personnel, other equipment, or delicate surfaces to sulfuric acid that may spill when the fill ports are uncapped or if the battery tips.

- During the charge process, an explosive mixture of oxygen and hydrogen is produced that may accumulate in pockets outside the battery, so wet batteries need to be properly ventilated and are subject to shipping restrictions.
- They must be kept in an upright position to prevent leaking and spilling.
- There are associated costs and inconveniences related to the required regular servicing needs of wet batteries, such as damaged and/or special clothing, hazardous material handling and transport requirements, shipping restrictions, damage to service areas from acid, and other personnel-related costs that should be considered when choosing a battery. However, by far the biggest cost is incurred by not maintaining the batteries.
- Freezing – A fully discharged wet lead acid battery will freeze at temperatures close to -10°F. The expansion of the electrolyte can damage the plates, separators or even crack the battery case. If freezing should occur, you must let your battery thaw, physically inspect the case for leakage, fully recharge it in a well ventilated area, remove the surface charge, and load test the battery and charging system to determine if there is any latent or permanent damage.

Valve Regulated Lead Acid (VRLA) Batteries:

- Encompass both gelled electrolyte (**gel**) and absorbed glass mat (**AGM**) batteries.
- Battery housing is sealed with pressure relief valves that typically cannot be modified or removed.
- No maintenance – you do not add water to the cells.
- According to industry experts, the shelf life of a VRLA battery is seven times higher than the shelf life of a comparable wet battery.

Overcharging is especially harmful to VRLA batteries because it dries out the electrolyte by driving the oxygen and hydrogen out of the battery through the pressure relief valves, where it cannot be recovered. A battery can be overcharged even though it is not fully "charged." That is why using the proper charger and charger algorithm is critical for battery performance.

Battery manufacturers consider the **battery warranty void if improperly charged**. Refer to the charging instructions and battery charger algorithms found on the following pages.

To avoid damaging your batteries, **do not mix wet and VRLA batteries on the same machine!**

Gelled Electrolyte

Gelled batteries contain sulfuric acid that has been gelled by the addition of Silica gel, turning the acid into a solid mass the consistency of petroleum jelly that coats the lead plates.

Advantages

- Gelled batteries are sealed, have special pressure relief valves and should never be opened.
- Since they require no maintenance, they don't have the costs and inconvenience of regular servicing associated with wet batteries.
- It is impossible to spill acid even if the battery case is broken; therefore it can be operated in virtually any position other than upside down.
- They are very safe at sea - no chlorine gas can form due to sulfuric acid and salt water mixing.
- Gelled batteries can be stored at sub-freezing temperatures as low as -25° to -35°F, as long as they are fully charged prior to storage.
- Gelled batteries use a recombination reaction to prevent the escape of hydrogen and oxygen gases that are normally lost in wet batteries under normal operating conditions. However, the batteries should still be ventilated.
- Because of their "acid-starved" design, gelled batteries are better suited for deep-discharge applications that would otherwise damage the plates of wet or some standard AGM batteries (not the Discover AGM batteries offered by Nilfisk-Advance).
- According to industry experts, the chance of explosions for gel batteries is as little as 1 in 1,000,000 compared with 1 in 1000 for wet acid batteries.

Disadvantages

- Gel batteries must be charged at a slower rate to prevent excess gas from escaping and damaging the cells.
- They must be charged at lower voltages than flooded or AGM. If overcharged, voids can develop in the gel which will never heal, causing a loss in battery capacity.
- Although gel batteries are sealed, there is some water loss, and in hot climates, water loss can be enough over 2-4 years to cause premature battery failure.
- Their initial cost is higher than wet batteries for a similar amp hour capacity.
- They are heavier than comparable wet batteries.

AGM

Absorbed Glass Mat batteries utilize a very fine fiber Boron-Silicate glass mat between the plates. This mat can take more abuse than gel.

Advantages

- AGM batteries are sealed, have special pressure relief valves and should never be opened.
- Since they require no maintenance, they don't have the costs and inconvenience of regular servicing associated with wet batteries.
- The sulfuric acid cannot spill, even if the battery is severely overcharged or broken, because it is contained in the glass mats.

- They are very safe at sea - no chlorine gas can form due to sulfuric acid and salt water mixing.
- AGM batteries can be stored at sub-freezing temperatures as low as -25° to -35°F, as long as they are fully charged prior to storage.
- Most types are recombinant, where Oxygen and Hydrogen recombine *inside* the battery – this results in efficiency of over 99% and almost no water loss.
- Internal resistance is extremely low, so there is almost no heating of the battery during the charging process.
- AGM batteries have a very low self-discharge – from 1 – 3% per month, so they can sit without charging in storage for much longer periods without damage than wet batteries.
- Since the lead plates are tightly packed and rigidly mounted, AGM batteries withstand shock and vibration.
- AGM batteries excel for high-current, high-power applications and in extremely cold environments.
- Compared with the same size gel battery, AGM's will have a higher amp hour rating and therefore deliver longer run times.
- Classified as non-hazardous, thus their shipping costs are lower.
- They don't have the maintenance costs associated with wet batteries.

Disadvantages

- AGM batteries cost 2 to 3 times as much as flooded batteries of the same capacity.
- Where there is adequate ventilation and no leakage concerns, flooded batteries are a better economic choice.
- AGM batteries can be susceptible to thermal runaway during charging because of their recombination reaction. This is another reason why it's so important to match batteries with the appropriate charger and algorithm.

CAUTION!

Lead-acid batteries contain sulfuric acid, a highly corrosive poison that may produce explosive gasses when the battery is recharged. This can hurt you! Therefore, when charging or working with batteries:

- Make sure they are well ventilated. If accessible, open the machine battery compartment cover or seat and **leave it open during the charging process**.
- Remove your jewelry, wear safety goggles and wear protective gloves and clothing.
- Be careful with your tools so you don't drop a metal tool across exposed battery terminals – the resultant spark may cause an explosion.
- Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce chlorine gas that can kill you.
- Refer to the ***Charging Do's and Don'ts*** section for more instructions on charging specific battery types.

Battery Chargers

Traditional Chargers

Traditional charger circuitry typically includes a step-down transformer and a bridge rectifier to convert the AC signal into a DC-like rectified output current. This DC-like signal is actually a pulse current that has a high RMS value that tends to overheat battery plates. This is tolerated by wet batteries because they can dissipate the heat in the liquid, but is not suitable for gel or AGM batteries that would be permanently damaged.

Traditional chargers are an economical charging option for wet lead acid batteries. Nilfisk-Advance offers the **APA** automatic tapering-type chargers that provide for automatic line voltage compensation while limiting output current. They utilize a *Compu-Time* electronic timer plus state-of-the-art CMOS integrated circuits to provide an extremely accurate method of determining full charge, regardless of battery condition. APA chargers monitor the rate of voltage rise instead of the voltage level, and are thus unique from other automatic chargers.

High-Frequency Chargers

High-frequency chargers utilize a bridge rectifier and DC to DC converter, plus MOSFET technology, to produce a flat DC output current. Since the output is true DC, there is no AC signal component, common in traditional chargers, which contributes to heating of the battery during the charging process. This makes them ideal for gel and AGM batteries, which do not tolerate that extra heat due to their internal construction and lack of a liquid electrolyte to disperse extra heat. High-frequency chargers operate at 50,000 Hz compared with 60 Hz operating frequency of traditional chargers. This contributes to their **greater efficiency as compared with traditional charger technology**: high frequency charger efficiency is >85%, compared with 50-60% efficiency on traditional chargers. **This saves energy during the charging process because high-efficiency chargers use less input power to deliver the same output.** Traditional chargers create losses in the power conversion process that do not charge the battery, but are wasted as heat. By utilizing more efficient power electronics, high-frequency chargers don't create those losses**.** A microprocessor controls the charging process, which allows for a number of charging profiles optimized for battery longevity and performance. Nilfisk-Advance offers both vented and non-vented high-frequency chargers. Refer to the charts in the following sections to match batteries with charger styles.

Increased efficiency means less damaging heat generated in my batteries and a lower energy bill!

IT DOES NOT MEAN my batteries charge faster…

High Frequency Non-Vented Chargers

Delta-Q - Nilfisk-Advance provides **Delta-Q** non-vented on-board chargers as an option to shelf chargers on many of our walk-behind scrubbers and extractors. They are sealed (have no air vents) and dissipate any internal heat generated during the charging process into the surrounding air via their metal case. Delta-Q chargers can be conveniently operated by plugging in their AC cord into a 3-prong wall outlet in a hallway, closet, or other room away from where unauthorized personnel can access the open battery compartment during charging. Refer to the ***Delta-Q*** sections for instructions on how to operate a Delta-Q charger.

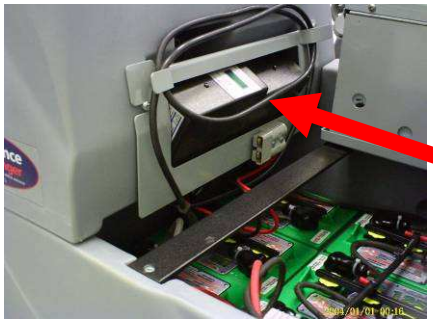
Delta-Q on-board charger on Advance walk-behind scrubber

High-Frequency Vented Chargers

Many of our machines come with **SPE** on-board vented chargers as an option. Vented chargers have limited ingress protection and should not be sprayed with water or they may be damaged.

These chargers are designed with internal fans to provide adequate airflow to cool the charger. While some are located where airflow can't be increased…

on those machines where airflow *can* be increased, like the riders, **you can improve the performance and reliability of the charger by increasing airflow**. On riders, this is done by placing the seat in the raised position.



SPE on-board charger mounted behind seat, shown with seat in raised position to increase airflow.

SPE vented chargers can be conveniently operated by plugging the AC cord into a 3-prong wall outlet in a hallway, closet, or other room away from unauthorized personnel. Refer to the ***SPE*** sections for more information on SPE charger models.

Delta-Q

Delta-Q chargers, in a 24V and a 36V model, are available on our walk-behind scrubbers and extractors as an on-board charging option because of their ease of use, sealed design, and passive cooling, which makes them ideally suited for those applications. Before operating your machine with a new set of batteries,

1. Program the Delta-Q charger for wet, gel, or AGM batteries in accordance with the instructions found in the following sections.

2. Consult your machine Operator or Service Manual for instructions on how to program the machine keypad for the correct Low Voltage Cutout (Depth of Discharge) setting. Use the "gel" setting for gel and AGM batteries.

The following charts represent improved charging algorithms for the batteries shown. These charts supersede any previous documentation you may have received.

N-A Battery Part Number	Where used	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h	Rate	Delta Q Algorithm			
								36V Model 56315204	Est. Chg. Time Hrs **	24V Model 56315124	Est. Chg. Time Hrs **
56206078	---	Trojan	J185…	Wet	12	195	20	3 *	10.9	3	9.0
		US Battery	US-185	Wet	12	195	20	11*	10.9	11	9.0
56206079	Convertamatic Warrior	Trojan	T-125	Wet	6	235	20	3	12.2	3	10.0
		US Battery	US-125	Wet	6	235	20	11	12.2	11	10.0
56206117	Convertamatic Warrior	Trojan	T-605	Wet	6	195	20	3	10.9	3	9.0
		US Battery	US1800	Wet	6	208	20	11	11.3	11	9.3
56026200		Trojan	J-250…	Wet	6	250	20	3	12.6	3	10.4
		US Battery	US250HC	Wet	6	275	20	11	13.4	11	11.0
56206987	Convertamatic Warrior	Nilfisk (East Penn / MK Battery)	56206987 (8GGC2 / T881)	Gel	6	180	20	26	10.5	26	8.6

* Algorithms 3 and 11 were created to negate the need for temperature monitoring at the battery, as was required for algorithms 1 and 4.

N-A Battery Part Number	Where used	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h	Rate	Delta Q Algorithm			
								36V Model 56315204	Est. Chg. Time Hrs **	24V Model 56315124	Est. Chg. Time Hrs **
56315772	AquaPlus Adphibian Convertamatic	Discover	EVGT6A	AGM	6	255	20	43	12.8	43	10.5
	---	Discover	EV250A-A	AGM	6	260	20	43	12.9	43	10.7
56315959	Warrior	Discover	EV305A-A	AGM	6	312	20	43	14.5	43	12.0
56317154	AquaPlus Adphibian	US Battery	US-145XC	Wet	6	251	20	72	12.6	72	10.4
	---	Discover	EVL16A-A	AGM	6	390	20	43	16.9	43	14.0
56388582	---	Trojan	L16…	Wet	6	395	20	Not Recom-mended	N/A	Not Recom-mended	N/A
		US Battery	L16HC	Wet	6	415	20	73	16.6	73	14.6
56391391	Warrior 34 RST Adhancer	Trojan	J-305G	Wet	6	285	20	7	13.7	7	11.3
		US Battery	US-305	Wet	6	305	20	72	14.3	72	11.8
56393912	---	Discover	EV185A-A	AGM	12	234	20	43	12.1	43	10.0
European Batteries											
00200020	BA	Exide	3 ET 174	Wet	6	174	5	51	10.3	51	6.6
00190050	BA, BHS, SR	Enersys	6 TP 175	Wet	6	175	5	21	10.3	21	8.5
00190032	AW, B, SR, SW	Enersys	6 XP 180	AGM	6	180	5	21	10.5	21	8.6
00190121	BA	Exide	3 DF 180	Gel	6	180	5	51	10.5	51	8.6
00200050	BA	Exide	FF 06 200	Wet	6	200	5	21	11.1	21	9.1
80561500	---	Exide	18-5PZB210		36	210	5	21	11.4	21	9.4
00196122	---	Exide	DF 06 240 V		6	240	5	12	12.3	12	10.1
00200651	---	Exide	FF 06 255		6	255	5	21	12.8	21	10.5

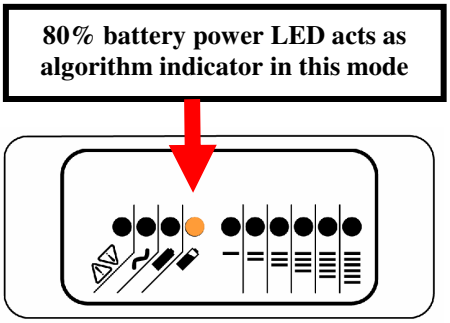
** based on 80% depth of discharge

These charging algorithms have been optimized to provide the most reliable operation of the noted batteries, and may differ from earlier documentation that came with your machine or charger.

Setting Charger Algorithms on a Delta-Q Charger

The Delta-Q chargers come pre-loaded with ten algorithms for different makes and models of batteries. If your specific battery is not shown in the previous charts, please call the Nilfisk-Advance Tech Service Team at **1-800-989-2235** for the correct algorithm to use with your battery.

Each time AC power is applied with the battery pack *not* connected, the charger enters an algorithm select/display mode for approximately 11 seconds. During this time, the current algorithm number is indicated on the **80% battery power LED** (see diagram) by a blinking sequence. For example, the LED blinks twice, then pauses, then blinks 6 times, then a longer pause, and repeats within that 11 second window. In this example, the blinking sequence above would indicate that the charger is programmed for algorithm "26."



Preferred Method

Call the Nilfisk-Advance **Tech Service Team at 1-800-989-2235** to obtain a copy of **TSB US 2007-979**. This new bulletin describes in detail how to utilize the Delta-Q QuiQ software and USB Interface Module Kit (56315732) to quickly and easily program your charger with the latest algorithms for all Nilfisk-Advance batteries currently supported.

For a demonstration of how to set the Delta-Q charger algorithm, view the videos at **www.advance-us.com**, then follow the links to **Authorized Sign In** and **Secure Downloads**. Note: the algorithms shown in the videos may not be the most up-to-date. **Use the algorithms shown on the preceding pages or call 1-800-989-2235**.

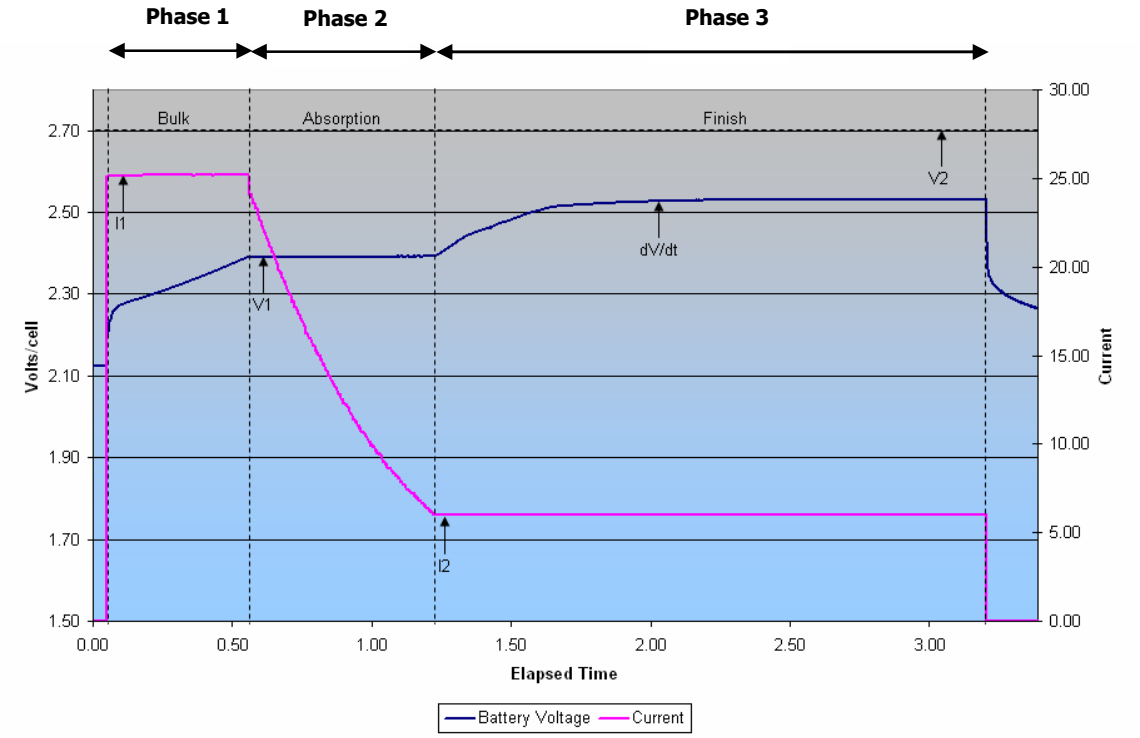
Manual "Telegraph" Method

1) Disconnect the charger positive connector from the battery pack.
2) Plug in the AC power cord.
3) Observe the LEDs on the Delta-Q charger – after the LED test, the algorithm number will display for 11 seconds.
4) To change the algorithm, during the initial 11-second period, touch the previously disconnected positive connector to the battery pack's positive terminal for 3 seconds and then remove. The algorithm number will advance after three seconds, by successive blinks and pauses.
5) Repeat until the desired algorithm number is indicated. A 30 second timeout is extended for every increment.
6) After you see the desired algorithm number, touch the charger connector to the battery pack positive terminal until the output relay clicks (~10 seconds). The charger has now been programmed.
7) Unplug the AC power cord.
8) Reconnect the charger positive connector to the battery pack.

Delta-Q Charging Curves - Wet

Algorithms 3 and 7

- These algorithms do not compensate for changes in battery temperature. Regardless, on Nilfisk-Advance machines the temperature sensor is molded into the battery connection termination, and is therefore connected to the black negative battery terminal.
- The charger determines when the charging process is over by monitoring the change in voltage per unit time every hour during the finish phase. When the voltage levels out to a certain limit, the charger turns off.
- As a safety precaution during the finish phase, if the battery voltage ever exceeds 2.7 Vpc (volts per cell), the charge cycle is terminated.
- **Deep discharge recovery:** if the charger senses battery voltage to be less than 2.0 Vpc, it will trickle charge at 5.0 A for a maximum of 18 hours until the battery is at 2.0 Vpc, then begin the normal charge process shown below.
- **Maintenance mode:** if the charger is left plugged into AC, it can be used in a stored battery maintenance program to restart the charging process indicated below every 30 days or any time it senses the battery voltage to be less than 2.08 Vpc.

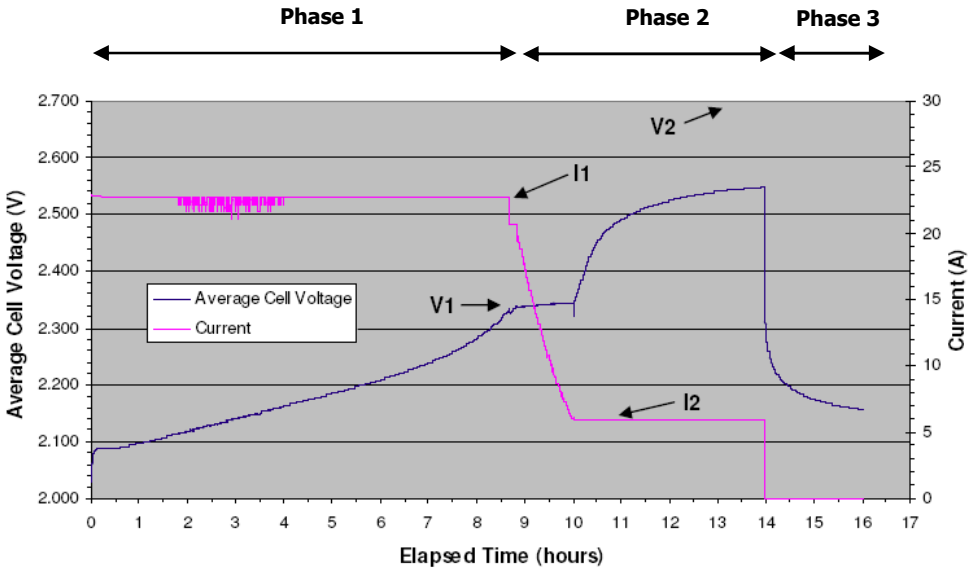


Phase	Duration	Range	Control factor that causes it to change ranges…
1	0 – 18 hrs Timeout	Full current output of charger: 25 A on 24 V charger 21 A on 36 V charger	Voltage reaches 2.35 Vpc
2	0 – 6 hrs Timeout	Alg. 3: Full current output to 6.0 A Alg. 7: Full current output to 9.3 A	Algorithm 3: Current reaches 6.0 A Algorithm 7: Current reaches 9.3 A
3	1 – 6 hrs Timeout	2.35 ≤ voltage ≤ 2.70 Vpc	Change in voltage V1 that is < 0.035 Vpc / hr Global timeout if charging exceeds 24 hrs

Delta-Q Charging Curves – Wet

Algorithms 11, 72 and 73

- These algorithms do not compensate for changes in battery temperature. Regardless, on Nilfisk-Advance machines the temperature sensor is molded into the battery connection termination, and is therefore connected to the black negative battery terminal.
- The charger determines when the charging process is over by monitoring the change in voltage per unit time every hour during Phase 3, although to a tighter tolerance than algorithms 3 and 7. When the voltage levels out, the charger turns off.
- As a safety precaution during Phase 3, if the battery voltage ever exceeds 2.7 Vpc (volts per cell), the charge cycle is terminated.
- **Deep discharge recovery:** if the charger senses battery voltage to be less than 2.0 Vpc, it will trickle charge at 5.0 A for a maximum of 18 hours until the battery is at 2.0 Vpc, then begin the normal charge process shown below.
- **Maintenance mode:** if the charger is left plugged into AC, it can be used in a stored battery maintenance program to restart the charging process indicated below every 30 days or any time it senses the battery voltage to be less than 2.08 Vpc.

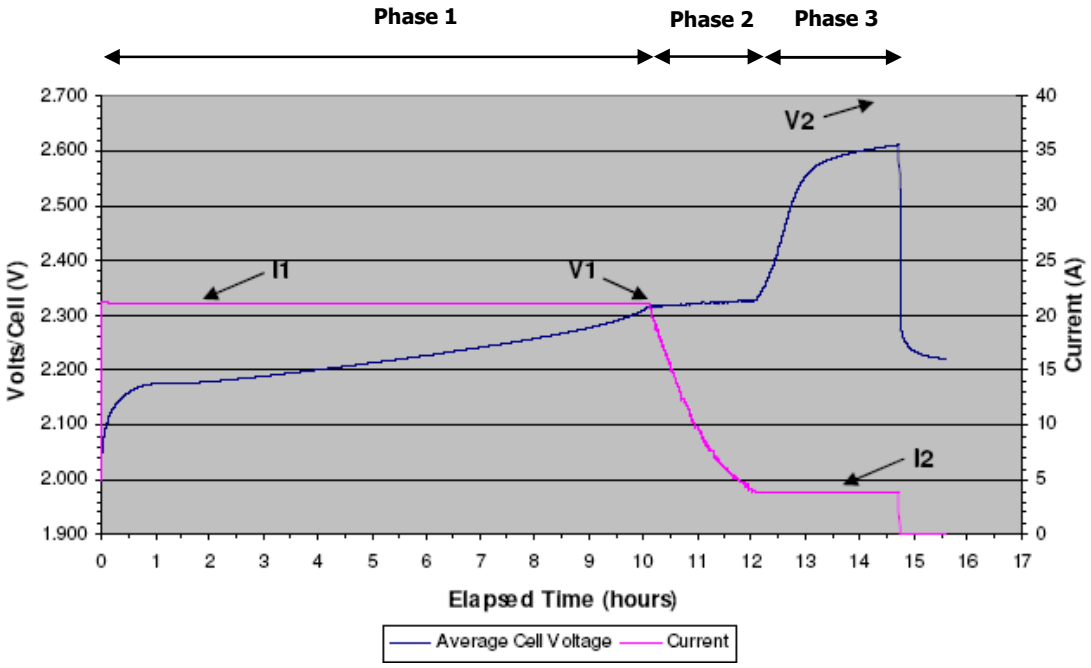


Phase	Duration	Range		Control factor that causes it to change ranges…	
1	0 – 18 hrs Timeout	Full current output of charger: 25 A on 24V charger 21 A on 36V charger		11	Voltage reaches 2.35 Vpc
				72	Voltage reaches 2.35 Vpc
				73	Voltage reaches 2.45 Vpc
2	0 – 6 hrs Timeout	11	Full current output to 5 A	11	Current reaches 6 A
		72	Full current output to 6 A	72	Current reaches 5 A
		73	Full current output to 8.5 A	73	Current reaches 8.5A
3	1 – 8 hrs Timeout	Voltage is between 2.35 & 2.70 Vpc		Change in voltage that is < 0.010 Vpc / hr Global timeout if charging exceeds 24 hrs	

Delta-Q Charging Curves - Gel

Algorithm 26

- This algorithm is temperature compensated at -0.005Vpc / °C higher or lower than a reference temperature of 20°C.
- It must be used with a battery temperature sensor. On Nilfisk-Advance machines the temperature sensor is molded into the battery connection termination, and is therefore connected to the black negative battery terminal. If the over molding of the ring terminal is removed, the white wire must still be connected to the black negative battery terminal to provide a ground reference for the temperature monitoring circuit in the charger.
- This algorithm terminates at a1hr, 2hr, or 4hr "finish" phase, depending upon the amount of charge returned in Phases 1 and 2.
- As a safety precaution during Phase 3, if the average cell voltage ever exceeds 2.80 V, the charge cycle is terminated.
- **Deep discharge recovery:** if the charger senses battery voltage to be less than 2.0 Vpc, it will trickle charge at 5.0 A for a maximum of 18 hours until the battery is at 2.0 Vpc, then begin the normal charge process shown below.
- **Maintenance mode:** if the charger is left plugged into AC, it can be used in a stored battery maintenance program to restart the charging process indicated below every 30 days or any time it senses the battery voltage to be less than 2.08 Vpc.

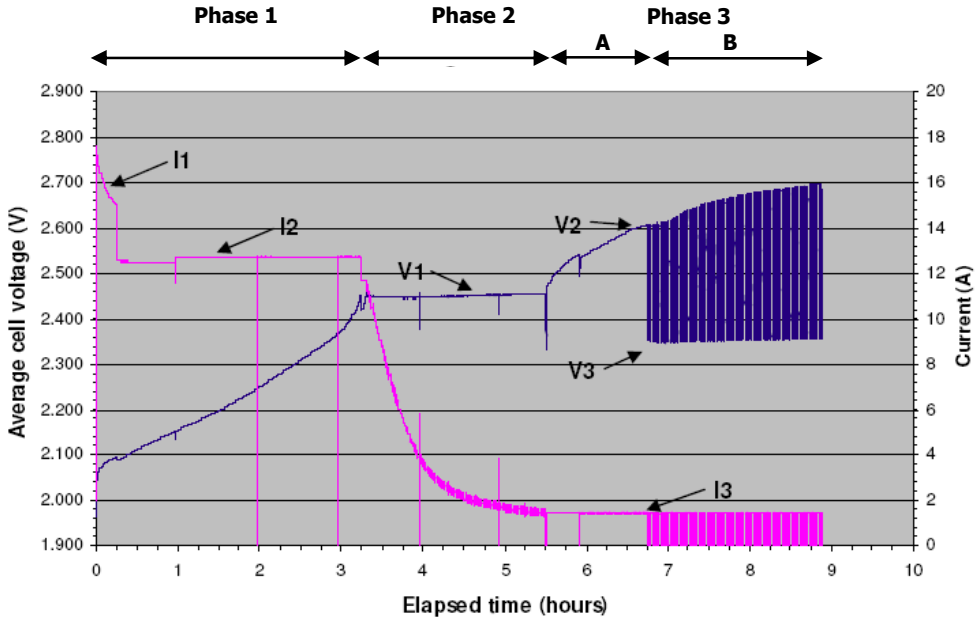


Phase	Duration	Range	Control factor that causes it to change ranges…
1	0 – 22.5 hrs Timeout	Constant full current output of charger: 25 A on 24V charger 21 A on 36V charger	Voltage reaches 2.33 Vpc
2	0 – 6 hrs Timeout	Full current output to 4.0 A	Current reaches 4.0 A
3	1, 2, 4 hrs Timeout 4 hrs	2.33 Vpc to 2.65 Vpc	At low DoD, <48 Ah returned to battery, 1 hr At medium DoD, 48 – 95 Ah returned to battery, 2 hrs At high DoD, >95 Ah returned to battery, 4 hrs Global timeout at 32.5 hrs

Delta-Q Charging Curves – AGM

Algorithm 43

- This algorithm is temperature compensated at -0.005Vpc / °C higher or lower than a reference temperature of 25° C.
- It must be used with a battery temperature sensor. On Nilfisk-Advance machines the temperature sensor is molded into the battery connection termination, and is therefore connected to the black negative battery terminal. If the over molding of the ring terminal is removed, the white wire must still be connected to the black negative battery terminal to provide a ground reference for the temperature monitoring circuit in the charger.
- This algorithm uses a pulse termination criterion instead of a constant current or voltage.
- During the 2nd part of Phase 3, if the average cell voltage exceeds 2.6 Vpc and the charger output has been on more than 30 seconds, the output shuts off until the cell voltage falls to 2.35 Vpc. Then it turns on again, and this pulsing continues until the target overcharge of 2.7 Vpc is reached, after which it shuts off (see diagram below).
- **Deep discharge recovery:** if the charger senses battery voltage to be less than 2.0 Vpc, it will trickle charge at 5.0 A for a maximum of 18 hours until the battery is at 2.0 Vpc, then begin the normal charge process shown below.
- **Maintenance mode:** if the charger is left plugged into AC, it can be used in a stored battery maintenance program to restart the charging process indicated below every 30 days or any time it senses the battery voltage to be less than 2.08 Vpc.



Phase	Duration	Range	Control factor that causes it to change ranges…
1	0 – 18 hrs Timeout	Full output of charger: 25 A (24V charger), 21A (36V charger) 15 min pulse; then holds approx. 12.5 A, dropped to 0 once per hour; voltage rises from 2.0 V	Voltage reaches 2.41 Vpc
2	0 – 5 hrs Timeout	12.5 A to 4.0 A dropped to 0 A once per hour; Voltage held at 2.41 Vpc	Pulsed current drops to 4.0 A
3	0 – 6 hrs Timeout	Phase 3A: Current held at 4.0 A to drive voltage up to 2.60 V Phase 3B: Current pulses 4.0 or off, drives voltage between 2.35 Vpc and 2.6 Vpc gradually up to 2.70 Vpc in pulses	Voltage reaches 110% overcharge value of 2.70 Vpc Global timeout if charging exceeds 24 hrs

Understanding Your Delta-Q Charger

If a battery is already charged and you hook it up to a Delta-Q charger, the charger will quickly go through Phase 1, the bulk phase, and the Ammeter  LEDs will be lit.

Once the charger reaches its voltage trigger point, in 5 minutes or less it will initiate Phase 2, the absorption phase. During Phase 2, which may be rapid for a fully charged battery, the 80% battery power LED will be **ON**,  letting you know that the charger is in Phase 2.

Once the trigger current point is reached, the 100% battery power LED  will start **FLASHING**.

It will continue flashing until the minimum time or level that tells the charger to stop, at which time the 100% battery power LED will be **ON**. The charger can not rush through this last phase with accelerated current levels because that will damage the battery.

If you are using algorithms 3, 7, 11, 26, 72, or 73 and your batteries are fully charged…

the charger will stay in Phase 3 with the 100% battery power LED FLASHING for its minimum time of 1 hour.

Your clue that the batteries were already fully charged is that the charger quickly went through phases 1 and 2. You should be able to turn off the charger and feel confident that your batteries are charged if you have verified that you are charging the battery with the recommended algorithm.

According to the Delta-Q Operating Instructions…

1. The charger will automatically turn on and go through a short LED indicator self-test (all LEDs will flash in an up-down sequence for two seconds). If the charger is connected to a battery pack, a trickle current will be applied until a minimum voltage is reached. If the charger is used in an off-board application and the charger is waiting to be plugged into a battery pack, the charging algorithm number will be displayed for 11 seconds before ultimately displaying an under-voltage fault that will disappear when plugged into the battery pack.

2. Once a minimum battery voltage is detected, the charger will enter Phase 1, the bulk charging constant-current stage, and the current to the battery will be displayed on the bar graph. The length of charge time will vary by how large and how depleted the battery pack is, the input voltage (higher is better), and the ambient temperature (lower is better). If the input voltage is less than 108 VAC, the charging power will be reduced to avoid high input currents (AC LED will flash yellow). If the ambient temperature is too high, then the charging power will also be reduced to maintain a maximum internal temperature (bar graph will flash yellow).

3. When the battery is approximately 80% charged, Phase 1, the bulk stage, completes and a > 80% charge indication is given by the 80% battery power LED turning on. In Phase 2, the absorption phase, the last 20% of the battery's charge will be replaced by a constant voltage phase. The charging could be terminated at this phase if the vehicle requires immediate usage. However, it is highly recommended to complete the charge process to ensure maximum battery life.

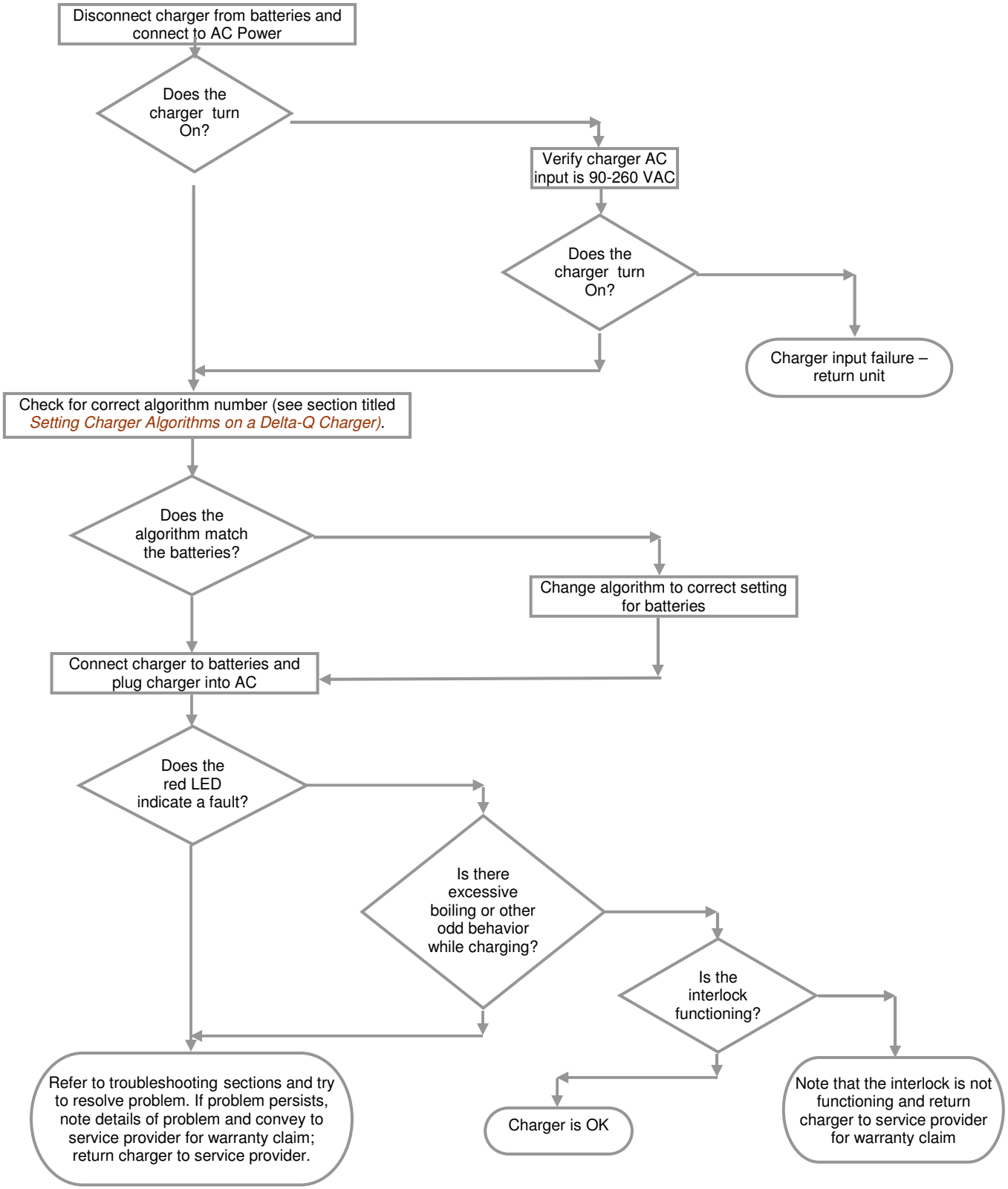
4. A low-current "finish phase" is applied next to return the battery to its 100% charged state; the 100% LED will flash.

5. When the 100% LED is continuously green, the batteries are completely charged. You can now unplug the charger (grasp at plug, not cord, so you don't damage the cordset).

6. If left plugged in, the charger will automatically restart a complete charge cycle if the battery pack voltage drops below a minimum voltage or 30 days have elapsed.

Refer to the charts on the following pages for charging fault indications.

Troubleshooting the Delta-Q Charger



Delta-Q Error Codes and Conditions

CHARGING ERROR CONDITIONS	
AC ON LED Lit, charger won't start charging	**Charger has detected a condition that does not allow it to charge** • Confirm battery connections are good. • The nominal voltage for a lead acid battery is 2 volts per cell (Vpc). For example, a 48V battery will have 48/2 = 24 cells. If the battery voltage is greater than 2.5 Vpc, the charger will not start charging. If the battery voltage is less than 0.5 Vpc, the charger will not start. • For software revisions 0.81 or lower, the charger will not start charging if the battery voltage is less than 1Vpc. Refer to the lower right hand corner of the back of the Product Manual to determine the software revision. • Check for any fault codes that might be set and refer to the descriptions above.
Excessive Battery Watering or Strong Sulphur (Rotten Egg) Smell	**Overcharging or high battery temperature**. These symptoms are unlikely to be caused by too high a charge current since the maximum charge current of the charger will be small compared to even a moderately sized battery pack. The most likely cause for this problem is incorrect charge algorithm setting and/or high ambient temperatures. • Confirm that the battery pack is not too small – usually > 50Ah. • Confirm that the nominal battery voltage matches the charger output voltage. • Confirm the correct battery charge algorithm. If the battery pack is new, the algorithm will need to be changed if the pack is not the same as the old one. Refer to preceding pages for information on setting the algorithm. If the output voltage of the charger seems excessive, return the charger to the Nilfisk-Advance service provider. **Service Provider**: Go to the Warranty Claim link at www.advance-us.com, and follow the links to **Authorized Sign In** and **Warranty Claim.**
Difficulty Changing the Default Battery Charge Algorithm	The mode to change the battery charge algorithm can only be selected during the first 10 seconds of operation. (For instructions on setting the algorithm, refer to the chapter titled ***Setting Charger Algorithms on a Delta-Q Charger***). If the 10 second window is missed, cycle AC power by unplugging the charger, waiting 30 seconds, and reconnecting AC power. To extend Battery Charge Algorithm Change Mode by 30 seconds (120 seconds on newer models), connect the charger output to a good battery for approximately 1 second and then disconnect the battery again.

Ammeter		**Solid**	Displays approximate scale of current output during bulk phase (Phase 1). Also indicates algorithm #1-6 for 11 seconds if no battery is connected.
		Flashing	**Internal charger temperature high.** Current output reduced. • Provide better airflow to the charger. • Try to move the charger to a cooler location. • Confirm that dirt or mud is not blocking the cooling fins of the charger. • Clean the charger. • Rinse charger with low pressure hose if required. Do not use high pressure. Do not use a pressure washer.
80% battery power		**Solid**	Phase 1, bulk charge phase, is complete and battery is 80% charged. Phase 2 has begun – now in absorption phase.
		Flashing	With no battery connected, indicates algorithm # selected by number of flashes.
100% battery power		**Solid**	Charging complete – charger in Maintenance Mode
		Flashing	Phase 2, absorption phase, is complete. Phase 3 has begun.
AC ON		**Solid**	AC power good
		Flashing	Low AC voltage – check voltage and extension cord length: 12 AWG 100 ft max; 14 AWG 50 ft max
Fault		**Flashing**	Charger error – check flash codes below
Fault Flashes		**High Battery Voltage Detected** • Check that the battery charger voltage is consistent with the battery pack voltage. The first two digits of the four digit model name indicate the battery voltage the charger supports. • Check for wiring errors. • High battery voltage could also occur if there is another source charging the battery. Disconnect any other sources during charging. • If this problem does not clear after the battery voltage is confirmed to be less than 2.4 Vpc, return the charger for service. • This fault will automatically clear and the charger will restart charging when this problem is removed.	
Fault Flashes	 	**Low Battery Voltage Detected** • Check the battery and connections to the battery. • Check the nominal battery voltage. The first two digits of the four digit model name indicate the battery voltage the charger supports. Confirm that a nominal battery voltage is the same as the charger voltage. • If this problem does not clear after the battery voltage is confirmed to be higher than 1 Vpc and all connections are good, return the charger for service. • This fault will automatically clear when the low battery voltage problem is rectified.	

Fault Flashes		**Global Charge Timeout** Indicates the battery failed to charge within the allowed time. This could occur if the battery is of larger capacity than the algorithm is intended for. In unusual cases it could mean charger output is reduced due to high ambient temperature. It can also occur if the battery is damaged, old, or in poor condition. • Check the battery for damage such as shorted cells and insufficient water. • Try the charger on a good battery. If the same fault occurs on a good battery, check the connections on the battery and connection to AC power and AC voltage. • Confirm that the nominal battery pack voltage is the same as the battery charger voltage. • If a charger displays this fault on a battery pack, and the pack is of questionable status, reset the charger by disconnecting AC power for 30 seconds, and then reconnect the AC to start a new charge cycle. After a few charge cycles this problem could stop occurring as the pack "recovers." • This fault must be cleared manually by unplugging the AC, waiting 30 seconds and reconnecting the AC power.
Fault Flashes		**Check Battery** - This fault indicates the battery pack could not be trickle charged up to the minimum level required for the normal charge cycle to be started. • Check that none of the battery pack connections between modules is reversed or incorrectly connected. • Check that one or more cells in the battery are not shorted. • Confirm that the nominal battery pack voltage is the same as the battery charger voltage. • Try the charger on a good battery. If this fault occurs the battery pack is likely in poor condition. Try to recover the pack with a charger that can charge the individual cells, such as an automotive charger. Be sure to set this charger to the appropriate voltage – 6V per 6V battery, 12V per 12V string/battery.
Fault Flashes		**Over Temperature -** This fault indicates the charger has become too hot during operation. This extra fault indication (as opposed to the flashing ammeter described above), indicates an even higher temperature was reached inside the charger. Though not damaging to the charger, charge time will be extended significantly. • This fault indication will not clear automatically, but the charger will restart charging automatically when the temperature drops. The fault indication must be cleared manually by unplugging the AC power, waiting 30 seconds and reconnecting the AC. • If possible, install the charger in a cooler location or increase cooling air flow to the cooling fins. • Confirm that dirt or mud is not blocking the cooling fins of the charger. If required, clean the charger by rinsing it with a low pressure hose. Do not use high pressure. Do not use a pressure washer.

Fault Flashes		**Charger Internal Fault:** This fault indicates that the batteries will not accept charge current, or an internal fault has been detected in the charger. This fault will nearly always be set within the first 30 seconds of operation. If it occurs after the charger has started charging normally, be sure to make a note of it. • Try to clear the fault by unplugging AC power, waiting 30 seconds and then reconnecting the AC. • Check all battery connections. Look for a high-resistance connection. The most likely reason for this fault is a bad battery connection, an open cell, or insufficient water. • This fault will occur if an internal fuse inside the charger blows. If the green wire is shorted to ground even momentarily this fuse will blow. To check the fuse, measure with an ohmmeter between the green and red wires with the AC disconnected. If a short circuit is not measured, the fuse has blown. Return unit to a service provider to have this fuse replaced. • For software revision 0.81 or older, this fault may indicate that the input or output voltage went out of range. Check input and output connections before returning the unit to the Nilfisk-Advance service provider. Refer to the lower right hand corner on the back of the Product Manual to determine the software revision. • If this fault occurs after battery charging has started, confirm that AC power was not interrupted and that all battery connections are good. • If all battery connections are good, an internal fault has been detected and the charger should be returned to the Nilfisk-Advance service provider. **Service Provider**: Go to the Warranty Claim link at www.advance-us.com, and follow the links to **Authorized Sign In** and **Warranty Claim.**

SPE

SPE chargers are commonly used on Nilfisk-Advance machines due to their variety of styles and output current, high accuracy, and efficiency. However, they must be handled properly and programmed correctly or damage may result to the batteries or the charger.

1) Program the SPE charger to the correct algorithm for the style of battery using either the switch on the front panel, or DIP switches located under the label or under a small cover. Use the following charts for the most up-to-date DIP or front-panel switch algorithm settings for wet, gel, or AGM batteries used on Nilfisk-Advance floor machines with SPE charger options. Refer to the ***DIP Switch Location on SPE Chargers*** section for switch locations.

2) Consult your Operator or Service Manual for instructions on how to program the machine keypad for the correct Low Voltage Cutout (Depth of Discharge) setting. Use the "gel" setting for gel and AGM batteries.

All machines with the batteries and charger *pre-installed* are set for the batteries installed in the machine.

For those on-board chargers that are shipped loose (for example, on Advenger, Adgressor, AquaRide, Adhancer, etc.) the charger is left at the **default "wet" setting. When you mount the charger and install AGM or gel batteries, you need to check the charger for the correct algorithm setting. Failure to have the charger correctly programmed will result in premature battery failure for gel and AGM batteries.**

This caution note applies to all charger kits shipped prior to January 1, 2008. Effective with all machines shipped after January 1, 2008, a new process was implemented in which all chargers shipped in kits are programmed to match the batteries shipped with the machine.

N-A Battery Part Number	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h C20	(where used) N-A Charger Part Number	Style	SPE MODEL #	Front Switch Setting	DIP Switch 1-4 / Charging Curve / LED Indication
56025782	Trojan	30XHS	Wet	12	130	(Micromax 20D) 08812996		CBSW1-NA 24V 13A	Wet	Default
										1
										001
	US Battery	31TMX				(Adfinity Razor) 9096541000		CBHF1-NA 24V 13A	Wet	Default
										1
										001

N-A Battery Part Number	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h C20	(where used) N-A Charger Part Number	Style	SPE MODEL #	Front Switch Setting	DIP Switch 1-4 Charging Curve LED Indication
56206078	Trojan US Battery	J185… US-185	Wet	12	195	(Terra 3700) 1462132000 (9095409000) ***		CBHF2-NA 24V 25A	N/A	OFF-ON-ON-ON *** 1 001
56206079	Trojan US Battery	T-125 US-125	Wet	12	235	(Terra 128/132) 1460670000		CBSW2-NA 12V 20A	Wet	default 1 001
						(Aquaride Advenger) 56314750		CBHF2-NA 36V 25A	N/A	OFF-ON-ON-ON *** 1 001
						(Razor Plus) Ref:TSB_IT_2006-012US 9095478000 (9096721000)		CBHF2-BA 24V 25A	Wet	default 1 001
						(Razor Blade) 9096257000 ***		CBHF2-BR 24V 25A	Wet	default 1 001
56206117	Trojan US Battery	T-605 US1800	Wet	6	195 208	(Blue 32) 1460670000		CBSW2-NA 12V 20A	Wet	default 1 001
						(Advenger) 56314750		CBHF2-NA 36V 25A	N/A	OFF-ON-ON-ON *** 1 001
						(Razor Plus) Ref:TSB_IT_2006-012US 9095478000 (9096721000)		CBHF2-BA 24V 25A	Wet	default 1 001

N-A Battery Part Number	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h C20	(where used) N-A Charger Part Number	Style	SPE MODEL #	Front Switch Setting	DIP Switch 1-4 / Charging Curve / LED Indication
56206962	Trojan US Battery	27TMX 27TM	Wet	12	105	(Razor Micromax BA5321) 08812996		CBSW1-NA 24V 13A	Wet	default 1 001
						(Terra 128/132) 1460670000		CBSW2-NA 12V 20A	Wet	default 1 001
						(Adfinity Razor) 9096541000		CBHF1-NA 24V 13A	Wet	default 1 001
56206984 (US replace-ment)	Nilfisk (East Penn / MK Battery)	56206984 (M22NF SLD G)	Gel	12	50	(Edge 28) 1463051000		CBHD1 12V 6A	N/A	2 DIP switches default setting Gel/AGM 6 006
1463049000 (comes on machine from Italy – we replace with 56206984 or 56206988)	Crown	12CE55 M6	Gel	12	50	(Edge 28) 1463051000		CBHD1 12V 6A	N/A	2 DIP switches default setting Gel/AGM 6 006
56206985	Nilfisk (East Penn / MK Battery)	562060985 (8G30H / T876)	Gel	12	98	(Razor Micromax BA5321) 08812996		CBSW1-NA 24V 13A	Gel	default 6 000 **
						(Adfinity Razor) 9096541000		CBHF1-NA 24V 13A	Gel	default 6 006

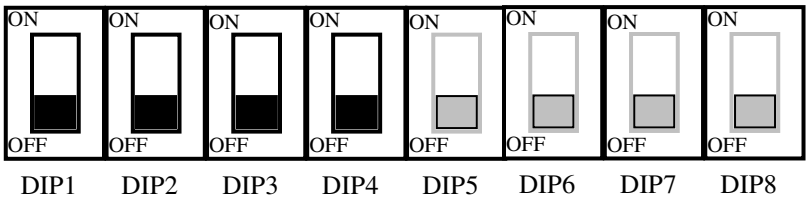
N-A Battery Part Number	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h C20	(where used) N-A Charger Part Number	Style	SPE MODEL #	Front Switch Setting	DIP Switch 1-4 Charging Curve LED Indication
56206987	Nilfisk (East Penn / MK Battery)	56206987 (8GGC2 / T881)	Gel	6	180	(Blue 32 / Terra 128/132) 1460670000		CBSW2-NA 12V 20A	Gel	default 6 000 **
						(Aquaride Advenger) 56314750		CBHF2-NA 36V 25A	N/A	ON-OFF-OFF-ON 6 006
						(Razor Plus) Ref:TSB_IT_2006-012US 9095478000 (9096721000)		CBHF2-BA 24V 25A	Gel	default 6 006
						(Razor Blade) 9096257000 ***		CBHF2-BR 24V 25A	Gel	Default 6 006
56206988 (US replace-ment for both Edge and Terra machines)	Nilfisk (East Penn / MK Battery)	56206988 (8G27MM / T876	Gel	12	87	Micromatic M17B Razor SV17 9097046000		CBHD1-NA 24V 8A/9A	N/A	2 DIP switches default setting Gel/AGM 6 006
						(Terra 28 Edge 28 option) 1463051000		CBHD1 12V 6A	N/A	2 DIP switches default setting Gel/AGM 6 006
00190083 (comes on machine from Italy – we replace with 56206988)	Crown	12 MFP 77	Gel	12	98	Terra 28 1463051000		CBHD1 12V 6A	N/A	2 DIP switches default setting Gel/AGM 6 006
56315772	Discover	EVGT6A	AGM	6	255	TBD 56314750 Serial break: 309194		CBHF2-NA 36V 25A	N/A	ON-OFF-OFF-OFF 14 014

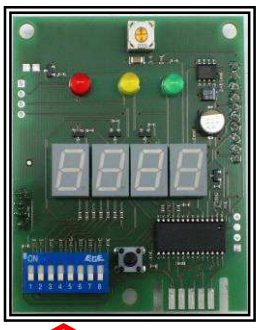
N-A Battery Part Number	Battery Mfr.	Battery Model Number	Wet Gel AGM	V	A-h C20	(where used) N-A Charger Part Number	Style	SPE MODEL #	Front Switch Setting	DIP Switch 1-4 Charging Curve LED Indication
56315959	Discover	EV305A-A	AGM	6	312	(Adhancer Advenger Aquaride Adgressor) 56314750 Serial break: 309194		CBHF2-NA 36V 25A	N/A	ON-OFF-OFF-OFF 14 014
						(Terra 4300) 1462132000 (9095409000		CBHF2-NA 24V 25A	N/A	ON-OFF-OFF-OFF 14 014
56388582	Trojan US Battery	L16H L16HC	Wet	6	395 415	(Adgressor) 56314750		CBHF2-NA 36V 25A	N/A	OFF-ON-ON-ON 1 001
						(Advolution 2710) 56422145 ***		CBHF2 36A 25A	N/A	OFF-ON-ON-ON 1 001
56391391	Trojan US Battery	J305G US-305	Wet	6	285 305	(Terra 4300) 1462132000 (9095409000		CBHF2-NA 24V 25A	N/A	OFF-ON-ON-ON 1 001
						(Aquaride Adhancer Advenger Adgressor) 56314750		CBHF2-NA 36V 25A	N/A	OFF-ON-ON-ON 1 001
56393912	Discover	EV185A-A	AGM	12	234	(Terra 3700) 1462132000 (9095409000		CBHF2-NA 24V 25A	N/A	ON-OFF-OFF-OFF 14 014
---	Discover	EV250A-A	AGM	6	260	TBD	** CBSW series chargers indicate 000 for charging curve 6 Gel switch setting			
---	Discover	EVL16A-A	AGM	6	390	TBD				

*** Chargers updated with new AGM algorithm 14: 56422145 CBHF2 36V 25A serial break 320562; 9096257000 CBHF2-BR 24V 25A serial break 315494; 1462132000 (9095409000) CBHF2-NA 24V 25A serial break 316004; 56314750 CBHF1-NA 36V 25A serial break 309194. Charger S/N is found on charger ID label; you may have to remove charger from machine housing to access ID label and serial number.

DIP Switch Location on SPE Chargers

Peel back lower left corner of label to expose row of 8 DIP switches; switches 1 – 4 set algorithms. Refer to charts on preceding pages for appropriate switch settings.

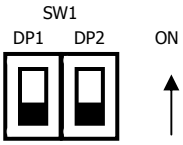




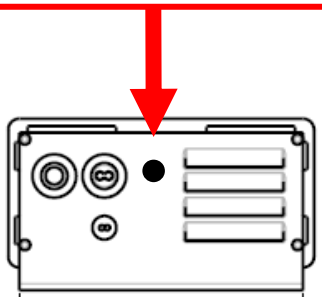
Location of DIP switches under label

These 8 DIP switches are found on the ***CBHF2 family of chargers…***

The CBHD1 chargers *have 2 DIP switches that must be set…*



Pry off round cover with screwdriver to expose 2 DIP switches located directly behind the access hole.



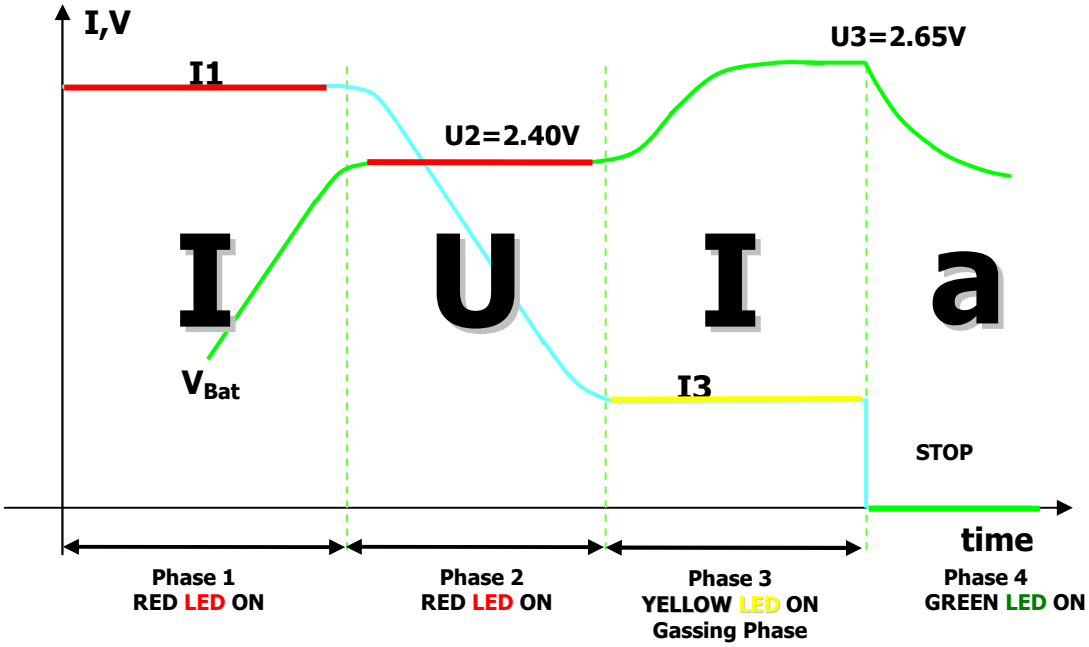
		DIP Switch Settings	
	CBHD1-NA 24V 8/9A	Wet/Flooded Gel/AGM	ON-OFF ON/OFF-ON*
		* DP2 in ON position overrides DP1 switch setting	
	CBHD1 12V 6A	Wet/Flooded Gel/AGM	ON-ON OFF-ON

SPE Charging Curve – 12/24 V Chargers - Wet

The following charging curve for **wet lead acid batteries** applies to 13A, 20A, and 25A chargers.

The curve is called IUIa. The succession of steps is:

I 1st phase at constant current, battery voltage increases.
U 2nd phase at constant voltage, charging current decreases.
I 3rd phase at constant current, battery voltage increases.
a stop



Phase	Duration	Range	Control factor that causes it to change phases…
1	0 - 15 hrs	Voltage could be severely depleted (ex. 2V on 24V pack) to 2.4Vpc	Voltage reaches 2.4 Vpc
2	0 – 10 hrs	25A charger: 25A – 7.5A 20A charger: 20A – 6A 13A charger: 13A – 3.9A	Current drops to 30% of initial current
3	1, 2, or 3 hrs	Voltage would be 2.4Vpc to 2.65Vpc	Timeout based on length of phase 1 and phase 2. If phase 3 arrives in less than 1 hr, phase 3 will last 1 hr. If phase 3 arrives in 2 hrs, phase 3 will last 2 hrs. If phase 3 arrives in 3 hrs, phase 3 will last 3 hrs. If phase 3 arrives in more than 3 hrs, it will still only last 3 hrs.
STOP	N/A	Charging current drops to 0A	End of phase 3

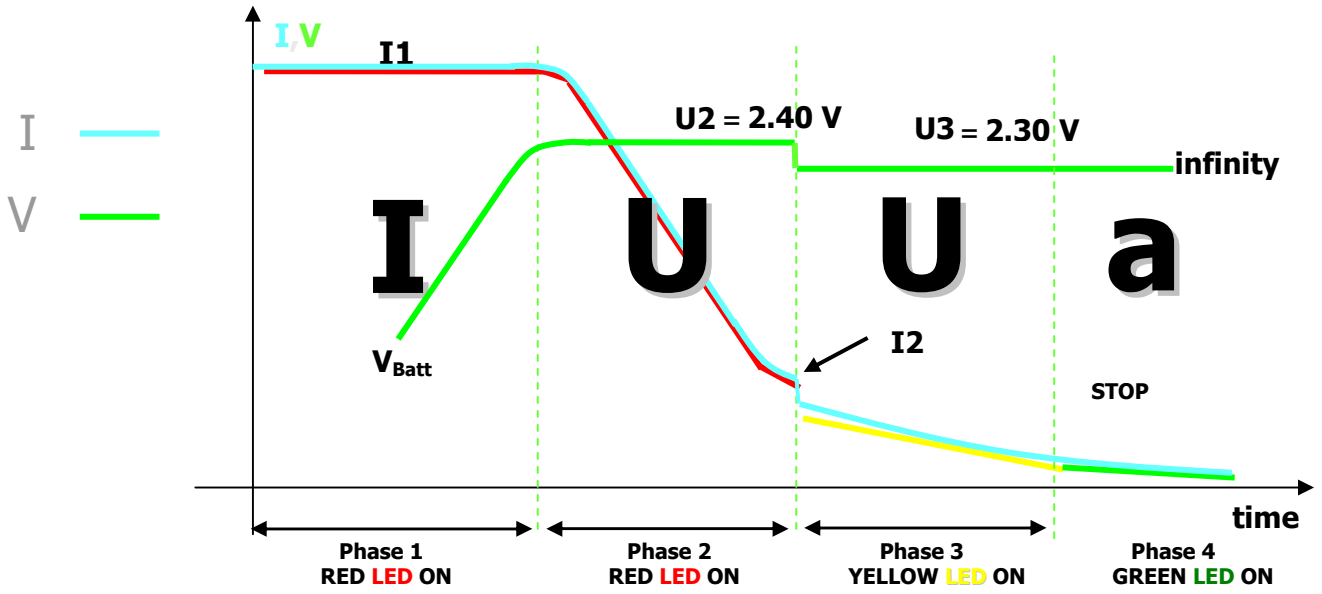
Gassing Phase – Phase 3, also called the Gassing Phase, is the bubbling or "boiling" state of a wet battery during which time the bubbles generated mix the electrolyte for uniformity across the full surface of the plates. There can be a smell of sulfur; hydrogen and oxygen will be released and vented into the room. As a wet battery ages, more Antimony migrates out of the plates and the battery "boils" at a lower voltage. Gassing becomes easier over time, and you may smell more sulfur during the charging process.

SPE Charging Curve – 12/24 V Chargers - Gel

The following charging curve for **domestic gel batteries** applies to 6A, 9A, 13A, 20A, and 25A chargers.

The curve is called IUUa/0-Gel. The succession of steps is:

I 1st phase, constant current, battery voltage increases.
U 2nd phase, constant voltage, charging current decreases.
U 3rd phase, lower level constant voltage, charging current decreases slowly to 0.
a infinite (with float charge)



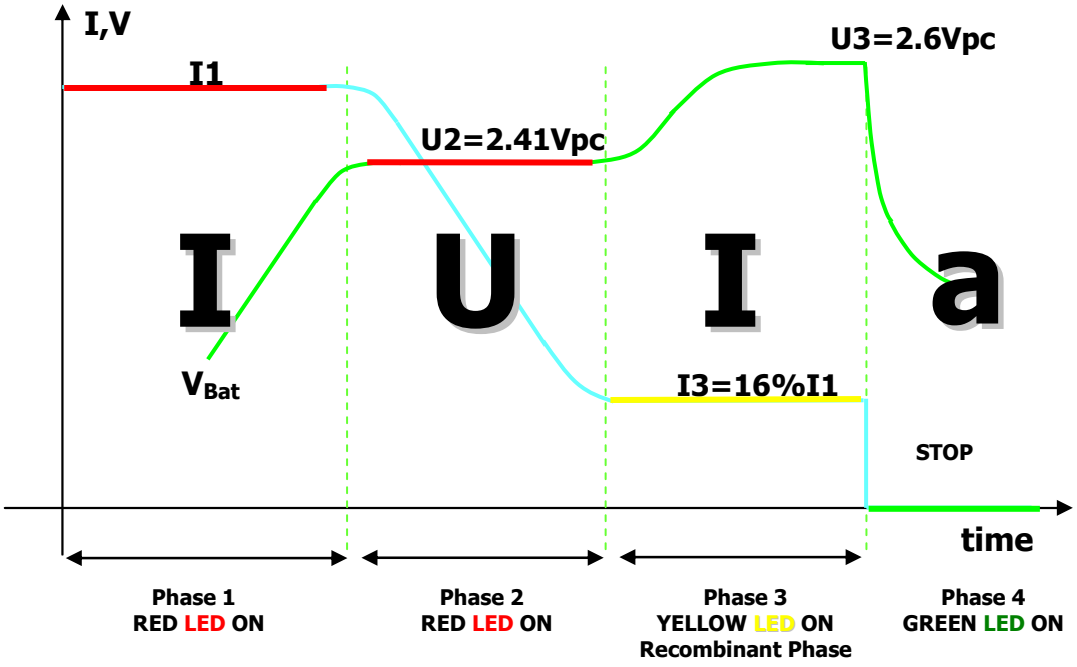
Phase	Duration	Range	Control factor that causes it to change phases…
1	0 – 10 hrs	Voltage could be severely depleted (ex. 2V on 24V pack) to 2.4 Vpc	Voltage reaches 2.4 Vpc
2	0 – 10 hrs	25A charger: 25 A – 4.5 A 20A charger: 20 A – 3.6 A 13A charger: 13 A – 2.34 A 9A charger : 9 A – 1.62 A 6A charger: 6 A – 1.08 A	Current drops to 18% of initial current
3	3 hrs	Current slowly drops as voltage held indefinitely at 2.3 Vpc	Timeout after 3 hrs
No stop	N/A	Current slowly drops as voltage held indefinitely at 2.3 Vpc	Unplugging charger

SPE Charging Curve – 24 V Chargers - AGM

The following charging curve for **Discover AGM batteries** applies to 25A chargers.

The curve is called IUIa-Discover. The succession of steps is:

I 1st phase, constant current, battery voltage increases.
U 2nd phase, constant voltage, charging current decreases.
I 3rd phase, constant current, battery voltage increases.
a stop



Phase	Duration	Range	Control factor that causes it to change phases…
1	0 – 18 hrs	Voltage could be severely depleted (ex. 2V on 24V pack) to 2.41 Vpc	Voltage reaches 2.41 Vpc
2	0 – 5 hrs	25 A – 4 A	Current drops to 16% of initial current
3	0 – 4 hrs	Voltage: 2.41 – 2.6 Vpc	4 hrs elapsed or voltage reaches 2.6 Vpc
STOP	N/A	Current drops to 0A	End of phase 3

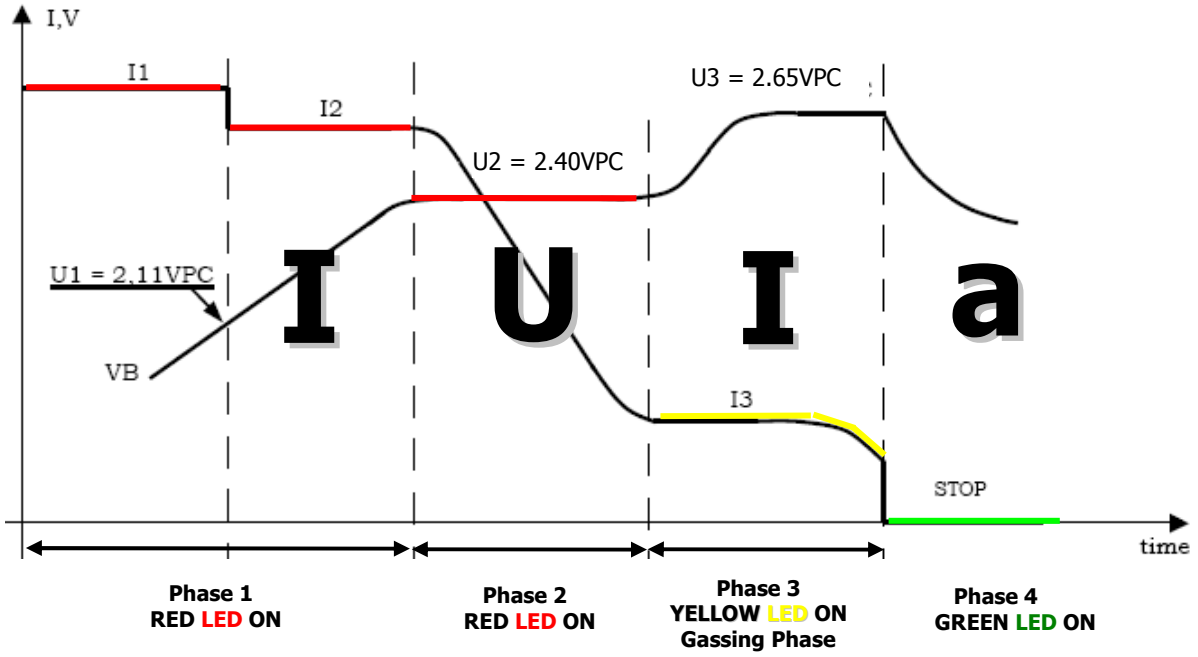
SPE Charging Curve – 36 V Chargers - Wet

To meet UL input power requirements, SPE 36 V chargers split the initial bulk charging phase, Phase 1, into two segments, one at the maximum current output, the next at a slightly lower value, until the average volts per cell reaches 2.40 V. The following charging curve for Wet batteries applies to CBHF2-NA 36V 25A (56314750) and CBHF2 36V 25A (56422145) chargers. Other than the initial bulk charging phase, the curve is very similar to the curve for 24 V units. Initial battery voltage can be as low as 2.0 V total on 36 V battery pack.

The charging curve for **wet lead acid batteries** is called IUIa.

The succession of steps is:

I 1st phase at constant current, battery voltage increases;
step down to lower constant current, battery voltage increases.
U 2nd phase at constant voltage, charging current decreases.
I 3rd phase at constant current, battery voltage increases.
a stop



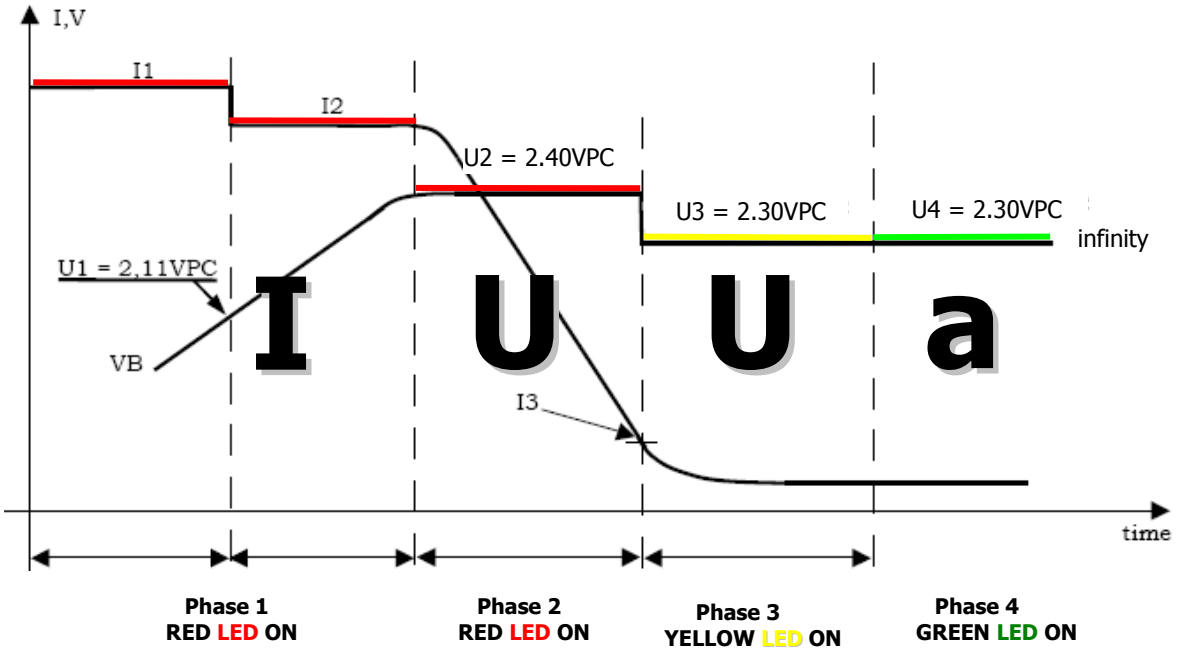
Phase	Duration	Range	Control factor that causes it to change phases…
1a **1b**	0 – 10 hrs 0 – 15 hrs	25 A constant; voltage to 2.11 Vpc 22 A constant; voltage 2.11 – 2.40 Vpc	Voltage reaches 2.11 Vpc Voltage reaches 2.4 Vpc
2	0 – 10 hrs	22 A – 7.5 A	Current drops to 30% of initial current
3	1, 2, or 3 hrs	Voltage rises from 2.4 Vpc to 2.65 Vpc (43.2 – 47.7 V total)	Timeout based on length of phase 1 and phase 2. If phase 3 arrives in less than 1 hr, phase 3 will last 1 hr. If phase 3 arrives in 2 hrs, phase 3 will last 2 hrs. If phase 3 arrives in 3 hrs, phase 3 will last 3 hrs. If phase 3 arrives in more than 3 hrs, it will still only last 3 hrs.
STOP	N/A	Charging current drops to 0 A	End of phase 3 or global safety timeout of 20 hrs

SPE Charging Curve – 36 V Chargers - Gel

To meet UL input power requirements, SPE 36 V chargers split the initial bulk charging phase, Phase 1, into two segments, one at the maximum current output, the next at a slightly lower value, until the average volts per cell reaches 2.40 V. The following charging curve for Gel batteries applies to CBHF2-NA 36V 25A (56314750) and CBHF2 36V 25A (56422145) chargers. Other than the initial bulk charging phase, the curve is very similar to the curve for 24 V units. Initial battery voltage can be as low as 2.0 V total on 36 V battery pack.

The SPE charging curve for **domestic gel batteries** is called IUUa/0-Gel.

I 1st phase, constant current, battery voltage increases;
step down to lower constant current, battery voltage increases.
U 2nd phase, constant voltage, charging current decreases.
U 3rd phase, lower level constant voltage, charging current decreases slowly to 0.
a infinite (with float charge)



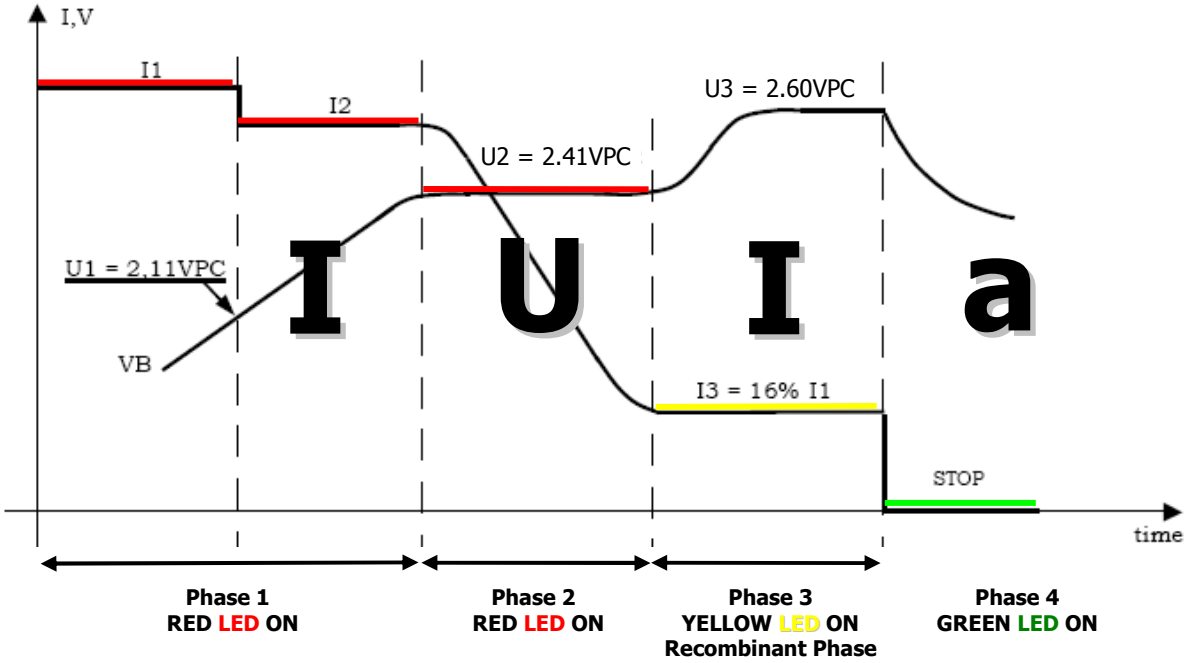
Phase	Duration	Range	Control factor that causes it to change phases…
1a **1b**	0 – 10 hrs 0 – 15 hrs	25 A constant; voltage to 2.11 Vpc 22 A constant; voltage 2.11 – 2.40 Vpc	Voltage reaches 2.11 Vpc (38.0 V total) Voltage reaches 2.40 Vpc (43.2 V total)
2	0 – 10 hrs	22 A –4.5 A	Current drops to 18% of initial current
3	3 hrs	Current slowly drops as voltage held at 2.3 Vpc (41.4 V total)	Timeout after 3 hrs
No stop	N/A	Current settles out as voltage held indefinitely at 2.3 Vpc	Unplugging charger

SPE Charging Curve – 36 V Chargers - AGM

To meet UL input power requirements, SPE 36 V chargers split the initial bulk charging phase, Phase 1, into two segments, one at the maximum current output, the next at a slightly lower value, until the average volts per cell reaches 2.41 V. The following charging curve for AGM batteries applies to CBHF2-NA 36V 25A (56314750) and CBHF2 36V 25A (56422145) chargers. Other than the initial bulk charging phase, the curve is very similar to the curve for 24 V units. Initial battery voltage can be as low as 2.0 V total on 36 V battery pack.

The SPE charging curve for **Discover AGM batteries** is called IUIa AGM-Discover.

I 1st phase, constant current, battery voltage increases;
step down to lower constant current, battery voltage increases.
U 2nd phase, constant voltage, charging current decreases.
I 3rd phase, constant current, battery voltage increases.
a stop



Phase	Duration	Range	Control factor that causes it to change phases…
1a **1b**	0 – 10 hrs 0 – 15 hrs	25 A constant; voltage to 2.11 Vpc 22 A constant; voltage 2.11 – 2.41 Vpc	Voltage reaches 2.41 Vpc
2	0 – 5 hrs	22 A – 4 A	Current drops to 16% of initial current
3	1, 2, 3, or 4 hrs	Voltage rises from 2.41 Vpc to 2.60 Vpc (43.5 – 46.8 V total)	Timeout based on length of phase 1, phase 2, and phase 3. If phase 3 arrives in less than 1 hr, phase 3 will last 1 hr. If phase 3 arrives in 2 hrs, phase 3 will last 2 hrs. If phase 3 arrives in 3 hrs, phase 3 will last 3 hrs. If phase 3 arrives in 4 hours, phase 3 will last 4 hrs. If phase 3 arrives in more than 4 hrs, it will still only last 4 hrs.
STOP	N/A	Current drops to 0 A	End of phase 3 or global safety timeout of 25 hrs

SPE Error Codes and Conditions

SIGNAL (LED)	MEANING
Red **LED** on	First and second phases of charge in progress
Yellow **LED** on	Third phase of charge in progress
Green **LED** on	End of charge or maintenance phase
INITIAL TEST	
Green **LED** 2 flashes	Battery charger configured for recharging Gel or AGM batteries
Red **LED** 2 flashes	Battery charger configured for recharging Wet batteries
NORMAL INDICATIONS	
GEL	Charger is set for gel or AGM batteries
Acd	Charger is set for wet batteries
ERROR INDICATIONS	
Red **LED** flashing	Safety time-out exceeded **-** INTERNAL SHORT CIRCUIT
Yellow **LED** flashing	Unsuitable battery or battery not connected
bat	Battery connection error – battery not connected, or reversed polarity, or wrong voltage
E01	Maximum voltage admissible by battery has been exceeded; charging interrupted
E02	Maximum temperature has been exceeded; charging interrupted
E03	Maximum time for charging phase has been exceeded; charging interrupted. Often caused by sulfated battery plates because voltage seen by charger includes voltage drop across sulfate layer. Since voltage reading isn't accurate, current won't reach 30% mark and will time out.
SCt	Total safety timer has interrupted the charging (global timeout).
Srt	Possible internal short

Charging DO's and DON'Ts

Wet / Flooded Batteries

DO:

- Verify your Nilfisk-Advance machine keypad Low Voltage Cutout is set for "wet."
- Verify your charger is set for the correct algorithm for your battery if you are using a programmable SPE or Delta-Q charger. APA chargers sold with current floor machine models are designed for wet batteries and are not adjustable.
- Check acid level of all cells before charging – plates should not be exposed. If a cell has exposed plates, fill with distilled water to no more than 1/8" above top of plates.
- Keep acid level below ¼" from bottom of fill well or battery acid may boil over during charging.
- Check specific gravity of each cell using a hydrometer after charging. If there is more than .050 difference, the cell is bad and the battery should be replaced (this test may be more accurate if done after 1-2 hours of machine use, with the battery at ¼ discharge).
- Open the machine battery compartment cover while charging.
- Allow the battery charger to run through its complete cycle so it equalizes the battery plates. Equalizing is necessary to mix the electrolyte consistently across each plate surface to help eliminate stratification and sulfation. It is an "over voltage – over charge" performed by the charger in its final charging phase.
- Keep battery terminals clean and free of corrosion. Clean top of battery with baking soda and water paste, then use a battery post cleaning tool or emery cloth to remove any corrosion from the terminals.

DON'T:

- Overfill battery cells. Besides causing a contamination hazard, it will dilute the electrolyte resulting in reduced run-time.
- Undercharge **–** if a battery is continually undercharged (see ***Opportunity Charging***),
    1. lead sulfate crystals will form on the positive plates (see ***Preventing Sulfation***)
    2. the positive grids will corrode and the plates will shed
- Charge a hot battery – an electrolyte temperature over 95°F can damage the battery components and cause premature failure.
- Charge a frozen battery.
- Add acid to the cells.
- Smoke or have an open flame in proximity to batteries while charging.
- Mix battery types within a set of batteries.
- Put in a different type of battery than what was originally shipped with the machine without calling the Nilfisk-Advance Tech Service Team at 1-800-989-2235.
- Install a battery that has been in storage without checking the specific gravity of each cell.

VRLA Batteries

DO:

- Verify your Nilfisk-Advance machine keypad Low Voltage Cutout is set for "gel."
- Verify your charger is set for the correct algorithm for your battery.
- Open the machine battery compartment cover while charging.

DON'T:

- Use a traditional shelf charger to charge a VRLA battery. This will overcharge the battery, causing the oxygen that is released from the positive plates and the hydrogen that is released from the negative plates to be driven out of the pressure relief valves faster than they can be recombined back into water. This dries out the electrolyte and causes premature battery failure.
- Use a high-frequency charger set for the wrong algorithm. This will also overcharge the battery. Refer to the ***Delta-Q*** and ***SPE*** sections for the correct algorithms for your battery.
- Undercharge **–** if a battery is continually undercharged (see ***Opportunity Charging***),
    1. lead sulfate crystals will form on the positive plates (see ***Preventing Sulfation***)
    2. the positive grids will corrode and the plates will shed
- Mix battery types within a set of batteries.
- Put in a different type of battery than what was originally shipped with the machine without calling the Nilfisk-Advance Tech Service Team at 1-800-989-2235.

A common misconception is that lead acid batteries have a "memory" – this is FALSE. Fully discharging a battery below the Low Voltage Cutout on a regular basis will lead to early battery failure.

Opportunity Charging

Opportunity charging is defined as top-off charging at every convenient opportunity or after any significant discharge. In other words, ***plugging in your charger while you're on a break,*** *on lunch, or leave at the end of your shift and two hours later the next operator starts using the machine.*

Our battery manufacturers recommend opportunity charging for the following reasons:

1. Opportunity charging can be used to increase the overall runtime in most applications by charging during breaks in use.
2. Opportunity charging can be used to decrease the depth of discharge which will increase the expected cycle life.

   For example: Cycle life at 80% depth of discharge is ~675 cycles and cycle life at 40% depth of discharge is ~1475 cycles. Not only would the cycle life more than double but the overall runtime would also increase by ~9%: (1475 hours vs. 1350 hours at an average discharge rate of 75 amps.)
3. Opportunity charging will help to prevent excessive sulfation by assuring the highest possible state of charge during unexpected periods of inactivity.

Our AGM battery manufacturer recommends a minimum of ½ hour of charge time should be facilitated, followed by a ½ hour cool-down time prior to the equipment being put back into service on any opportunity charge.

However…

To prevent premature battery failure, our battery manufacturers recommend that batteries should be fully recharged according to the following:

1) as soon as possible after every full discharge
2) at least once during a 24 hr period or prior to the next shift
3) immediately prior to any planned or unplanned period of storage or inactivity.

Fully charged means allowing a charger with the correct algorithms to run a complete cycle without interruption to fully recharge and condition the battery.

You will ruin your batteries if you rely solely on opportunity charging!

Battery Maintenance

Batteries in storage should be fully charged prior to their rated shelf life to avoid sulfation and premature failure.

Battery Type	Shelf Life at 68° - 72° F
Wet / Flooded – US Battery	60 days
Gel – Nilfisk (MK Battery / East Penn)	6 months
AGM - Discover	8 – 12 months

Wet Batteries:

Check specific gravity and top off electrolyte if needed:

Use a hydrometer such as this one to test the specific gravity (SG) of the battery acid in each cell. This will indicate the amount of recharge a battery needs. A cold battery in storage will self-discharge slower than a hot one, so the 60-day interval may be less if the battery is hot.

When a battery is self discharged the water level will drop in the battery due to the electrolyte being absorbed into the plates. If the plates are exposed, use distilled water to cover only the exposed portion of the plates. Do not fill to the bottom of the fill well. The charging process will drive the absorbed electrolyte back out of the plates into the solution and raise the water level in the battery. If the water level is below the fill well after a full charge then top off with distilled water. **Do not add acid!**

Level of Charge	SG 1.300 Initial Full Charge	SG 1.280 Initial Full Charge	SG 1.265 Initial Full Charge
100%	1.300	1.280	1.265
75%	1.255	1.240	1.225
50%	1.215	1.200	1.190
25%	1.180	1.170	1.155
Discharged	1.160	1.140	1.120

NOTE: If there is 0.050 difference in SG between any two cells after charging, the battery should be replaced.

VRLA Batteries:

VRLA batteries are sealed and do not require filling or checking with a hydrometer. You can tell if a VRLA battery has a bad cell in it because the battery voltage will drop slightly after charging. A difference in voltage of more than 0.4 V between cells indicates a problem with the battery; this is measureable as a difference between that battery and the others in the pack shortly after charging (ex. 12.7 V – 12.7 V – 12.2 V). When **gel** batteries are first put into use it may take 15 – 20 cycles for them to reach maximum performance level. Gel batteries that are older than 6 months can be used when properly maintained, although the capacity will be less than their original specifications.

Preventing Sulfation

Sulfation is a natural by-product of the battery discharge cycle. Lead and lead oxide, which are the active materials on the battery's plates, react with sulfuric acid in the electrolyte to form lead sulfate, water, and electricity at 2.12 Volts per cell. Initially the lead sulfate is in a non-crystalline form, which is easily converted back to lead, lead oxide, and sulfuric acid when the battery is recharged.

Over time, the lead sulfate converts to a more stable crystalline form that coats the battery's plates. Crystalline lead sulfate does not conduct electricity and cannot be converted back into lead and lead oxide under normal charging conditions. This process is known as sulfation.

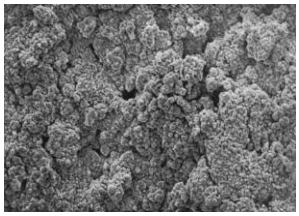
Since the crystalline lead sulfate does not re-dissolve completely, not all the lead is returned to the plates, and the amount of active material needed for electricity generation decreases over time. In addition, the sulfate portion of the lead sulfate doesn't return to the electrolyte as sulfuric acid. This accumulation of lead sulfate crystals can also clog the grids and can eventually expand and crack the plates.

Eventually sulfation results in longer charging times, less efficient and incomplete charging, and higher battery temperatures, which cause longer cool-down times and can accelerate corrosion.

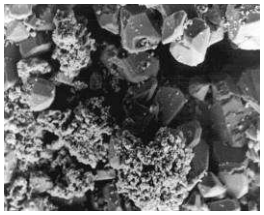
1. **To prevent sulfation during storage, follow the battery manufacturers recommended maintenance charging schedule found in the previous *Battery Maintenance* section.**

2. **To prevent sulfation during periods of regular usage, allow the battery chargers to finish a complete charging cycle:**

    a. as soon as possible after every full discharge
    b. at least once during a 24 hr period or prior to the next shift
    c. immediately prior to any planned or unplanned period of storage or inactivity.



Surface of new lead plates under SEM microscope



Lead sulfate crystals on plates

Industry experts state that permanent sulfation kills approximately 85% of all lead-acid batteries not in weekly service.

Health and Environmental Concerns Related to Lead Acid Batteries

California Proposition 65 Warning

Battery posts, terminals and related accessories contain lead and lead compounds, and other chemicals known to the state of California to cause cancer and birth defects or other reproductive harm. Wash hands after handling.

All lead acid batteries, no matter what type, fall under state and federal environmental laws and must be surrendered to authorized recycling or reclaiming facilities at the end of their usable lives. Failure to do so may result in huge fines and criminal penalties. According to Battery Council International, although battery production utilizes 80% of the lead produced in the US, less than one percent of the country's lead emissions come from battery manufacturing, where processes are tightly controlled.

Batteries fall under the federal Hazardous Waste Superfund Clean-up Regulations Act (a.k.a. SARA), and are subject to Tier II Chemical Inventory Reporting. Owners or operators of facilities storing lead-acid batteries are required to determine whether Tier II reporting thresholds are exceeded for batteries stored at their facility. The chemicals of concern are lead and sulfuric acid. Sulfuric acid is classified as an Extremely Hazardous Substance (EHS) – the reporting threshold is 500 lbs. (For calculation, an estimated 18% of a battery's weight is pure sulfuric acid.) Lead is a hazardous substance and the reporting threshold is 10,000 lbs. The EPA list and additional instructions are accessible at:

http://www.epa.gov/oem/content/epcra/tier2.htm

If the threshold is exceeded at any time during the year, you must report the materials that exceed the threshold on a Tier II by March 1 of the following year.

According to Battery Council International, a typical lead acid battery contains 18-20 lbs of lead, 11 pounds of sulfuric acid, and three pounds of plastic, all of which are reclaimable, recyclable or reusable.

RoHS Compliance

Delta-Q battery chargers: **56315124 -** 24V chargers manufactured after December 2006
56315204 - 36V chargers manufactured after March 2007.

For technical questions about batteries and chargers offered on Nilfisk-Advance machines,
please call the Tech Service Team at
1-800-989-2235