FLOODED PRODUCT

BATTERY TRAINING HANDBOOK AND MAINTENANCE GUIDE

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Battery Life

There is no clear-cut life span that can be applied to the motive power battery for use in the industrial lift truck. For practical purposes, it can generally be expected that the average lift truck battery provide a minimum of 1500 cycles. A cycle being a full discharge of 80% of the battery capacity with a proper and full recharge.

300 Cycles Per Year X 5 Years = 1500 Cycles

Many factors affect the life span of a battery, both in cycles and years. Some of these factors can be, but are not limited to, the following:

Proper Charging

1. Undercharging not only reduces the battery capacity in day to day work activities, but causes accelerated sulfation leading to further reduction of capacity and early cell failure.

   Undercharging can result from improper sizing of the battery charger, a malfunctioning charger, over discharging of battery, bad battery cables, damaged connectors and improper operator setting of non-automatic chargers.

2. Overcharging will not only create unnecessary utility expense, but will cause high temperatures, and over gassing resulting in premature cell failure.

   Overcharging can result from improper sizing of the battery, charger and, though not as common anymore, improper operator setting of non-automatic chargers. The operator error results in a battery only partially discharged that gets a full eight hour charge (or more) from an operator selected timer control.

3. High temperatures will expand grids and loosen the active material from the plates causing accelerated shedding of active material which falls to the sediment space in the bottom of the battery. Also, the high temperatures accelerate the normal corrosion that occurs on the positive plates. Both reactions can contribute greatly to premature cell failure. Overcharging is the greatest contributor to high temperatures, but is by no means the only cause. It is most desirable for a battery to be used only on one shift. This then allows eight hours for charging, eight hours time to allow the battery to cool and eight hours operating time.

4. Cool down time of eight hours is crucial to the long-term health of the battery. A three shift operation that is using only two batteries for the three shifts will have batteries operating at very high temperatures by mid-week. Heat is generated within the battery both on charge and during discharge. Additionally, the battery is actually producing 1½ cycles per day. Because battery life is measured in cycles rather than years the life expectancy in years is reduced.

Battery Life

Maintain Electrolyte Levels (See section 28.00 for watering)

1. Maintain Electrolyte Levels
    a) Over watering causes overflow of electrolyte solution. The loss of the electrolyte solution means loss of sulfuric acid. As time goes on and water is added, eventually the electrolyte solution becomes more dilute, hence, low gravity readings and a loss of battery capacity. Additionally, external corrosion and ground shorts are accelerated, increasing problems with the forklift electronics and to some extent, affecting the longevity of the battery.

    b) Under watering causes rapid corrosion of the upper portion of the positive plate structure, reducing the life span of the battery.

2. Damaged cables and connectors, as covered earlier, can lead to undercharging as well as operational problems in the lift truck.

3. Periodic monitoring of the battery with maintenance records can be useful for early detection of internal irregularities. Early detection and corrective action is necessary for battery longevity. Recommended procedure is to take specific gravity readings, and on charge voltage readings after equalize charge. This should be done quarterly with results recorded and compared to previous readings. If a problem is suspected, these measurements and comparisons should be done more frequently. Monthly or weekly would be more appropriate until an accurate indication of the health of the battery has been determined.

4. Before performing cleaning and washing of battery, test for ground shorts to tray. Use a digital voltmeter with leads from positive terminal to tray and then negative terminal to tray. If satisfied that no ground shorts exist, record on monthly maintenance sheet. If ground shorts exist, clean and dry battery and recheck for ground shorts. If ground short cannot be cleared, consult the battery Manufacturer’s Representative.

Battery Identification

Model Designation

Nearly all batteries are marked with a type or model designation and a serial number that normally contains a coded date of manufacture. Nearly all battery manufacturers stamp this information on the inter-cell connector strap joining the first two cells at the positive end of the battery. They read like this:

18	125	DL	13
Quantity of cells	Amp hour	Manufacturer	Number of plates in

The type of model contains the information necessary to determine voltage and amp hour capacity of the battery. Following is a description:

18-125DL-13

18 ➡ First two digits indicate an 18-cell battery. At two volts per cell, this is a 36-volt battery. 18 cells x 2 volts/cell = 36.

125 ➡ Indicates the capacity of the positive plates within a cell. In this example, we have 125 Ah capacity per each positive plate within a given cell.

DL ➡ Unique to the manufacturer. In this case "Douglas Legacy®". All other digits included in this example are universal to the industry.

13 ➡ Total number of plates per cell. There are always an odd number of plates within any cell; one more negative than positive plate. In this example, there are seven negative and six positive plates.

Amp Hour (Ah) Capacity

In the example above, each cell is made up of 125 Ah positive plates and there are six positive plates per cell. Six positive plates x 125 Ah per positive plate = 750 Ah capacity.

The number of cells makes no difference. One cell could have 750 Ah capacity or six cells could have 750 Ah capacity. The only thing that changed with the additional cells is the voltage.

Further Examples:

6-125DL-13	Indicates a six cell or 12-volt battery. It contains 125 Ah per positive plate cells with 13 plates per cell or six positive and seven negative plates. Therefore, it is a 750 Ah capacity battery.
6-85DL-23	Indicates a six cell or 12-volt battery. 85 Ah per positive plate with 23 plates or 11 positive and 12 negative plates. 85 amp per positive plate x 11 positive plates = 935 Ah capacity.

Battery Performance

Batteries are typically expected to perform a minimum of 1500 work cycles in 60 months. This allows for 25 cycles per month at the end of which time the battery would be expected to produce 80% of its rated capacity as a minimum.

The performance testing to determine compliance should be conducted at the six hour rate. This closely resembles actual operating conditions.

The manufacturer should be expected to provide factory level support to resolve technical and application problems. Additionally, the manufacturer should be expected to provide your company with a list of names that include phone numbers of factory level technicians who can be called upon to provide this support.

The manufacturer must agree to dispose of batteries at the end of their useful life. It is best that the manufacturer disposes spent batteries in accordance with all local, state and federal regulations in force at that time.

Battery Charge Characteristics and Controls

Battery charging should be accomplished with an electronically controlled charger that will regulate current and voltage.

Figure A1

Battery Type (charge type)	Flooded (8 HR charge)	VRLA - GEL (8 HR charge)	Flooded (Opportunity Charge)	Flooded (Rapid Charge)
Start Charge Rate*	16%	16%	25% (max)	26% - 50%
Finish Charge Rate*	4.0% - 5.0%**	1.0% - 2.0%	4.0% - 5.0%	4.0% - 5.0%
Charge Interval	Daily	Daily	Opportunity	Opportunity
Equalizing Charge Rate*	4.5% - 5.0%	1.0% - 2.0%	4.5% - 5.0%	2.0% - 3.0%
Equalize Time on Charge	3 Hours	3 Hours	3-7 Hours	10-12 Hours
Equalize Interval	Weekly	Weekly	Weekly (min)	Weekly (min)

*Percentage of battery is six-hour nameplate ampere-hour capacity rating (ampere output).
**Nominal recommendation - 4.5%.

When the discharged battery is placed on charge, the battery will draw a relatively high current which will be at or close to the maximum output of the charger. Within a few minutes, the current will adapt itself to the state of discharge of the battery, remaining high if the battery is considerably discharged or decreasing to a low rate if only partially discharged.

When charging any industrial battery, only use an approved charger that is capable of returning a discharged battery's specific gravity back to its nameplate rating within an eight hour period. Properly sized chargers, offered by Douglas Battery™, will accomplish this requirement. Contact your local Douglas Battery representative for more details.

To maximize life, charging should not result in excessive gassing during the initial stages of charge. Every effort should be made to ensure that the battery receives the proper amount of charge. Consistent undercharge and/or excessive overcharge will contribute to internal battery problems that will cause a loss of capacity and reduction of life.

1. Sulfation - Residual sulfate remains in the plates if the battery is not fully charged to nameplate specific gravity or allowed to remain partially discharged for an extended period of time.
2. Stratification - Caused by insufficient gassing at end of charge. Little or no mixing of electrolyte will create a higher concentration of electrolyte at the bottom of the cell compared to the top.

Overcharging wastes electrical energy while running the risk of permanent damage to the battery. Excessive gassing not only increases the frequency of water additions to the battery but also increases a hydrogen ignition. Overcharging also creates dangerously high battery temperatures which significantly shortens battery life. When the battery reaches a full state of charge, the charge should be stopped. No amount of overcharging can increase battery capacity.

Equalize charge is necessary to bring a battery to a state of full charge in order to avoid excessive sulfation and unbalanced cells. Equalize charge must be done according to Douglas Battery specifications and excessive overcharge must be avoided. Ensure battery temperature is below 90°F before initiating an equalize. Equalize charge should be performed once weekly according to Figure A1.

Specifications for Battery Chargers

1. All battery chargers should be UL 1564 listed.

2. The charger must be capable of full recharge of an 80% discharged battery in a period of eight hours.

3. The finish rate shall be determined by the instruction plate on the battery. See Figure A1.

4. The temperature of the electrolyte during a charge cycle must not exceed 125°F (51°C).

5. Adequate instructional manuals must be shipped with each charger. These manuals must contain initial set-up, installation procedures, troubleshooting and repair instructions, parts lists and wiring schematics.

6. The manufacturer will be expected to provide factory level support to resolve technical and application problems and should include a complete listing of area or regional sources for service and warranty coverage throughout the U.S. and Canada.

Specific Gravity

Specific gravity is a measurement comparing the density of a liquid to the density of water, water being 1.000. An electrolyte solution consisting of sulfuric acid and water weighing 1.3 times an equal volume of water would have a specific gravity of 1.300.

Examples:

Pure Sulfuric Acid (Vitriol)	1.835
Typical lift truck battery	1.270-1.290
Douglas Battery Co. specs	1.285
Typical Automotive battery	1.260
Practical discharged (lift-truck)	1.130
Theoretical discharge	1.100
Water	1.000

During the discharge process, sulfuric acid combines with sponge lead of negative plate and lead dioxide of positive plate to form lead sulfate. The sulfuric acid combining with plate material leaves a solution of very nearly water, hence, gravities closer to the gravity of water or 1.000.

In the charge process direct current is sent through the cell in the opposite direction of current flow during the discharge cycle. This restores the active materials to their respective original conditions. The sulfate is driven from the plate material, combining again with water to raise the specific gravity.

The decrease in specific gravity is directly proportional to the amount of amp hours removed from the battery. The sulfuric acid quantity within the electrolyte decreases as the battery is discharged. The state of discharge can then be determined by taking gravity readings with a hydrometer.

State of Discharge by Gravity in %

Standard Flooded (Figure A2)		**Arctic** (Figure A3)	
1.285	0%	1.340	0%
1.270	10%	1.326	10%
1.250	20%	1.312	20%
1.235	30%	1.298	30%
1.220	40%	1.284	40%
1.200	50%	1.270	50%
1.185	60%	1.256	60%
1.165	70%	1.242	70%
1.150	80%	1.228	80%
1.135	90%	1.214	90%
1.120	100%	1.200	100%

Specific Gravity

For all practical purposes 20% state of charge or 1.150 (1.228 for Arctic) should be considered the maximum discharge of a lift truck battery. (30 to 60 minutes is required for electrolyte to stabilize before the above gravity readings can be used to determine state of discharge.) During the charge process, the specific gravity readings in Figures A2 and A3 would not be an accurate indicator of the state of charge.

The sulfuric acid, having a specific gravity of 1.835, immediately goes to the bottom of the cell. The weak water solution is all that would be drawn from the top of the battery for gravity tests while charging. When the battery voltage reaches 2.37 volts per cell, gassing becomes evident within the cell. This gassing is the giving off of gasses (hydrogen and oxygen gas) from the plates during final electrolysis. This gassing can be very mild or non-existent if a low finish rate exists, or the gassing can be severe from a high finish rate. It does take gassing, however, to mix the sulfuric acid and water to get an accurate gravity indication of state of charge. The gassing develops at about 80% state of charge. The battery could be 80% charged yet gravity might not have begun to rise in value. Shortly after gassing develops, the gravity will begin to rise sharply, but is not a linear rise to the actual state of charge.

This mixing of electrolyte at gassing points out the importance of proper finish rate of any charger. The finish rate of the charger is probably the most important aspect of the charger output curve. Too low a finish rate and the electrolyte will not mix, leaving strong solution to deteriorate the lower end of cell plates and upper end of plates not producing to their potential for lack of sulfuric acid. Too high a finish rate will create excess gassing and overheating leading to early cell failure. The finish rate most desired from battery manufacturers seems to be about three to five amps per 100 Ah capacity of the battery or 3% to 5% of the battery rated capacity.

Battery State of Charge by Gravity

Discharge below 1.150 specific gravity (80% discharged) will cause low operating voltages and high heat. This will cause excess wear of electrical components on the lift truck.

NOTE: The 1.150 specific gravity indicated as 80% discharge is an average of several battery manufacturers and models. The actual specific gravity at 80% or 100% discharged state will vary per manufacturer and will even vary from one type to another within a particular manufacturer's range of models. The variations are relatively insignificant… a range from 1.140 to 1.165 could be considered as an acceptable approximation of 80% discharged state for all batteries.

Moist Charged Batteries

1. Moist charged batteries are electrically live upon receipt, even before filling with electrolyte. Do NOT lay any metallic objects on the battery.

2. Moist charged batteries or cells should be activated (unsealed, filled with electrolyte and charged) only when ready to be placed in service. Until ready for use, they must be stored in a cool, dry, low humidity location with the pressure relief valves/vent plugs tightly in place, Moist charged cells must be activated immediately after the loosening/ breaking of the seal of the pressure relief valves/vent plugs.

   CAUTION: IF THE EXISTING VENT PLUG HAS A LABEL MARKED “DO NOT REMOVE”, STOP ALL ACTIVITY AND CALL YOUR LOCAL SERVICE CENTER.

3. To prepare for use, carefully remove the sealed PRV (pressure relief valve) using an approved tool or if necessary a wide grip pliers, taking care not to damage the cell vent well exterior. THROW AWAY THE PRESSURE RELIEF VALVE/VENT PLUG. Fill all cells with electrolyte 0.015 specific gravity lower than the nominal operating gravity.

4. Give the battery an equalizing charge, but keep resetting the charger to the equalize position until the specific gravity remains constant for a period of three hours. At no time should battery temperature be allowed to exceed 110°F (43°C).

5. At the completion of the charge, the specific gravity of all cells corrected to 77°F (25°C) should be as specified on the battery nameplate. If the specific gravity is higher, remove some electrolyte and replace with water. If the specific gravity is lower, remove some electrolyte and replace with higher specific gravity electrolyte. Any specific gravity adjustments should be made with the charger on equalize in order to mix the electrolyte properly. Removed electrolyte must be disposed of in strict accordance with all environmental regulations.

6. Upon completion of the above steps, apply a standard vent cap to all cells.

Battery Maintenance

The following maintenance is necessary to gain optimum performance and life from your batteries:

1. Keep idle batteries charged
2. Charge properly
3. Do not over discharge
4. Maintain proper electrolyte level
5. Keep clean and dry
6. Perform periodic testing
7. Keep battery records and analyze data
8. Repair immediately when needed

1. Keep Idle Batteries Charged

Two very common occurrences are receiving a new battery several months earlier than the receipt of a new forklift which are under utilized or when spare batteries are available for a forklift. A battery will generally remain healthier when properly cycled (normal 80% discharge/proper recharge) than when allowed to stand idle and not receive the proper maintenance. A clean battery could be expected to self discharge up to .005 specific gravity points per week and a battery that is wet and dirty could self discharge even more. The more deeply the battery becomes discharged, the greater the amount of sulfation. Additionally, high heat will accelerate the rate of self-discharge. Also, a discharged battery could possibly freeze in an unheated ware-house. (1.210 will freeze at –26°F (-32°C), 1.175 will freeze at –6°F -21°C) and 1.150 will freeze at
5°F (-15°C).

The following procedures should be used when storing a battery or when a battery is going to be idle for a period of a month or more.

a. Clean and neutralize the battery. Mix a solution of 1 lb. baking soda or sodium bicarbonate to one gallon of warm water, apply with a clean brush similar to paint brush, work around all terminal and connectors until fizzing stops and wash down with clean water. Be sure all caps are on securely prior to beginning the cleaning. If this solution were allowed to get into any of the cells, electrolyte would be neutralized. Also, if caps are not sealing properly, electrolyte level could become too high if water leaks into cell while rinsing.

b. Equalize charge the battery prior to placing in storage.

c. Store in a cool dry location.

d. Check the gravity in all cells monthly. Recharge if the gravity falls to 1.240 or below. A freshening charge of about three hours at finish rate administered monthly should be sufficient to keep the battery at a full charge.

2. Do Not Over Discharge

The battery should not be discharged more than 80% of its Ah capacity. Discharging more than 80% causes the following problems:

a. Many of the chargers in use are not capable of returning greater than 80% of the battery A.H. capacity in an eight hour charge period. Therefore, a battery might not become fully charged if the charge time available is no more than eight hours and the battery is too deeply discharged.

b. The return of 100% capacity generates considerably more heat than the return of 80% of capacity.

c. The battery operating efficiency is reduced drastically as it nears the end of its capacity. The low voltages present below 80% discharged will generally cause damage to lift truck components such as: motors, contact tips and charger components.

3. Maintain Proper Electrolyte Level

Over watering causes over flow of the electrolyte solution. The loss of the electrolyte solution means loss of sulfuric acid. As time goes on, water is added and eventually the electrolyte solution becomes more dilute, hence low gravity readings and loss of battery capacity.

Under watering causes rapid corrosion of the upper portion of the positive plate structure, reducing the life span of the battery.

The Following Factors Affect the Watering Time Schedule:

- Age and condition of the battery. Older batteries and those in poor condition consume water more rapidly than newer batteries and those in good condition.

- Dependent on battery model, some batteries have more free water storage space above the plates than others.

- The frequency of charge, depth of discharge and characteristics of the battery charger all affect water consumption.

It is recommended that a regular weekly schedule be set-up to water all batteries. After a period of time, it will be determined that some batteries will need water at different intervals than others. From this experience, variations in water frequencies can be established for different batteries.

An alternate method would be to spot check two or three cells at the completion of each charge cycle then add water when needed. Caution should be used with this method as some cells will use more water than others. If the cells that are spot checked are using the least amount of water, other cells might actually be in need of water when the electrolyte level of the spot checked cells was adequate.

The proper time to add water to a battery is immediately after the charge cycle. As the battery discharges, the electrolyte level lowers. If water is added before charging, the electrolyte level may then rise during the charge cycle enough to overflow. Because of this, the electrolyte levels should only be high enough to cover the plate separator protectors before charging and then the electrolyte level should be adjusted after completion of the charge cycle. Then, only fill to within 0.125” to 0.25” of the lower end of the filler tube. The use of an automatic battery watering fill gun is recommended.

4. Keep Clean and Dry

When electrolyte moisture develops on top of the battery either due to over filling or excess gassing, the water will evaporate away leaving a highly concentrated acid solution. This concentrated solution will appear as dampness and if allowed to remain, will cause tray corrosion and ground shorts to develop. Multiple ground shorts can create external shorts through the case of the battery resulting in some or all of the cells to continually self-discharge. If the condition is not corrected, jar leakage, overheating, cell failure, etc., can occur.

A build-up of foreign material on the battery consisting of dust, dirt, lint and sometimes paper clips and pencils create a fire potential. The frequency of cleaning depends upon how quickly electrolyte spillage, oil dust, dirt and other foreign materials accumulate on the battery. This could be as often as every two weeks or as infrequent as every six months depending on the environment. The average battery needs a general cleaning once every two to three months. We recommend cleaning and neutralizing schedules be set-up once every two months. By inspecting and evaluating the batteries over a period of time, it can be determined how often they will need to be cleaned. It is not uncommon for some batteries to require cleaning more often than two months, while others may only require cleaning every three to four months.

TIP: During any cleaning, but especially when using a neutralizer or detergent solution, be sure that all vent caps are tightly in place to prevent solution of water from entering the cells.

Mix a solution of one pound baking soda or sodium bicarbonate in one gallon of warm water. Add to this some type of detergent, a liquid or powdered household detergent. Caustic detergents are not recommended. Move the battery to an approved washing area with floor drain. Rinse the bulk of foreign material from battery with water hose (warm water is preferable). Using a brush, apply the solution to the top of the battery. Scrub around the caps, around and under the inter-cell connectors and wash down the sides of the battery. As long as a ‘fizzing’ continues, keep working the solution into the area as this indicates corrosion of acid is still present. When all the ‘fizzing’ stops, rinse the battery down with clear water from a low pressure hose (high pressure can drive water under the cap seals or through vents). After rinsing, use a low pressure air hose to blow the battery dry.

NOTE: Check with local ordinances, the discharge of the wastewater created by these cleaning procedures direct in to the sewage system may be prohibited.

5.Keep Battery Records and Analyze

It could be considered unusual for a battery or cell to suddenly fail. Deficiencies in cells or the charging routine usually create very gradual changes in battery cell health and capacity. Only by periodic testing, the recording of test data and analyzing or comparing the data, can most problems be detected before irreparable harm is done. Many times, the results of a single test can be quite meaningless. Comparison of a series of ongoing test data is most beneficial in making a determination of the health of a battery.

It is recommended that a file be set-up on all new batteries the day they are received. This file should contain a copy of the shipping papers with a notation of the date of receipt. Personnel should become familiar with the terms of this warranty. The warranty can vary depending upon brand and type. The battery should be tested for specific gravity and open circuit voltage immediately upon receipt and before being put into service. The results should be recorded and inserted in the file. The data from the recommended testing, as described in the following pages, should also be recorded and inserted into the files. Many battery manufacturers require periodic testing of both the battery in question and also of the charger to keep the battery warranty in force.

NOTE: When recording test data or when consulting with other technicians for information, always refer to cell #1 as being the first cell at the positive end of the battery. From there follow the cell connectors in series toward the negative end of the battery referring to the other cells in a numerical series.

A vast array of inspection forms are available from the various battery manufacturers. Full size forms are located at the end of this handbook for future use. There are advantages to each form. For example, **Form A** might be used during regular, monthly maintenance testing.

FORM A

Monthly Battery Test

Unit # _____ By _____ Test Date _____

Cell	Gravity	Volts
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Total Volts		

Equalize charge _____
Wash _____
Water level _____
Cable Condition _____
Tar Condition _____
Case & Cover _____
Cell Caps _____
Cell Connectors _____
Volt - Ground + _____
Volt - Ground - _____

Note On charge volts at _____ amps.
Center cell temp. _____ deg. F.

Comments:

Form B has proven to be very useful when repetitive testing is done and the results are to be compared, such as load banking or extending the charge when attempting to bring a low battery up to a proper state of charge as will be discussed later in this chapter.

FORM B

Repetitive Testing Form

Unit #_____ Date_____ Model _____ S/N_____

Cell #	Gravity	Volt	Gravity	Volt	Gravity	Volt	Gravity	Volt	Gravity	Volt	Cell #
1											1
2											2
3											3
4											4
5											5
6											6
7											7
8											8
9											9
10											10
11											11
12											12
13											13
14											14
15											15
16											16
17											17
18											18
	Temp	TV	Temp	TV	Temp	TV	Temp	TV	Temp	TV	

Note: Always record temperature of a center cell and total battery voltage.

Comments:

We suggest that operators be required to fill in the pertinent information on **Form C** each time a battery change is made. If it is desired that the form be kept on the truck we advise that *Part I* be used. If the form is kept at a battery charging station, consider using *Part II*. There are advantages to both. A form dedicated to a single battery might show how some trucks get more hours out of a given battery than other trucks. This could be attributed to differences between trucks, i.e. excess amp draw. There could be differences in the types of operation. It could also point out that “lift interrupts or low voltage cut outs” were not adjusted properly.

FORM C

Daily Equipment Testing Form

Part I

Truck #

Battery #	Date In	H.M. In	Date Out	H.M. Out	Elapsed Hours

Part II

Battery

Truck #	Date In	H.M. In	Date Out	H.M. Out	Elapsed Hours

A form dedicated to a single truck would show the length of time one battery versus another lasted in a given truck. Either way, a system such as this will give some insight as to how the batteries are holding up in the lift trucks. It can be determine which equipment is not performing either due to being poor quality batteries, maybe charger problems or possibly a problem with the lift trucks.

Some locations like to include a space for the operator's initials at each change interval. This is especially helpful if the operator is responsible for watering the battery. Supervisory staff can spot check water levels and if any are found to be low, check sheets to see who made the last change.

Some facilities require operators to measure gravity of one pilot cell as they are installing a freshly charged battery. The advantage of this is that a malfunctioning charger would be located immediately as the cell gravity would be low. The disadvantages are:

1. You could be mislead by operator error due to inexperience.
2. The added exposure to injury from acid splash is possible because of lack of mechanical aptitude of most operators.

On a Monthly Basis the Following Testing is Recommended:

1. Check the specific gravity of all cells after the charger has terminated and record results. Take and record the temperature of one cell (at center of the battery) and use temperature correction chart to correct gravity. Use only high quality hydrometer. Use only a thermometer designed for battery use. *The battery should stand idle a minimum of 30 minutes to allow stabilization of the chemical reaction that continues after charger termination.*

   The specific gravity of most standard Motive Power batteries (fully charged) will be from 1.275 to 1.285. Some "hi output" batteries will have gravities ranging from 1.310 to 1.325. Most batteries will have their specific gravity specification either stamped on an inter-cell connector or printed on some type of specification tag affixed to the battery.

   Uniformity of gravity between cells is an indication of both the health of the battery and the abilities of the charger.

   Example #1:

	#1	**#2**	**#3**	**#4**	**#5**	**#6**
1st Month	1.285	1.285	1.285	1.285	1.285	1.285
2nd Month	1.285	1.285	1.285	1.285	1.285	1.285
3rd Month	1.285	1.285	1.285	1.285	1.285	1.285

   It is unlikely that you would have test results look as good as those above but if so, you could consider this exceptional. The only thing you might be concerned about is whether you are actually overcharging. Excessive gassing, high temperatures and excessive water consumption would indicate this.

Example #2:

	#1	#2	#3	#4	#5	#6
1st Month	1.280	1.275	1.280	1.280	1.275	1.275
2nd Month	1.280	1.270	1.275	1.280	1.270	1.275
3rd Month	1.280	1.265	1.275	1.280	1.270	1.275
4th Month	1.280	1.255	1.270	1.280	1.270	1.275

The above example is very characteristic of what is found in battery fleets. Manufacturing processes do not allow the production of a battery with all cells identical in ability to accept a charge.

Cell #1, #4 and #6 are all being fully charged by whatever time and rate of charge they are being exposed to. Cells #2, #3, and #5 are gradually deteriorating but at varying degrees. It is possible that this battery is being over watered in these particular cells and that sulfuric acid has been flushed out of battery on different occasions, lowering the specific gravity. It is unlikely, however, that the same cells are flushed repeatedly. Quite likely, this battery has needed more frequent equalize charging. The variation in the second month could have been caused by error reading the hydrometer but the third month should have prompted immediate corrective action consisting of more charge time or increased charge rate. At the fourth month, the need for corrective action is critical. Sulfation has been occurring that probably can be reversed at this time, but if allowed to continue the battery will be permanently damaged.

The above condition might be corrected by repeating equalize charge several times in succession. Restart the charger to gain additional hours charge time rechecking the gravities each hour to determine if gravity is improving. Continue to charge and recheck as long as gravities continue to improve. **Caution** – do not allow electrolyte temperature to exceed 125°F (51°C). If this temperature is reached, stop the charge process and allow the battery to cool to 90°F then resume the process. It might also be necessary to charge the battery at a higher finish rate on a constant current battery charger. Additionally, it is sometimes necessary to discharge and recharge two to three times to break the sulfation.

Example #3:

	#1	#2	#3	#4	#5	#6
1st Month	1.285	1.285	1.285	1.285	1.285	1.285
2nd Month	1.285	1.285	1.285	1.285	1.285	1.285
3rd Month	1.220	1.225	1.215	1.220	1.225	1.220

This example shows that this battery demands immediate attention. This is not a battery problem but a charger problem. Check charger input line fuses, controls, diodes, etc. As battery gravities are even, just uniformly low indicating undercharge.

Example #4:

	#1	#2	#3	#4	#5	#6
1st Month	1.285	1.285	1.285	1.285	1.285	1.285
2nd Month	1.285	1.270	1.285	1.285	1.285	1.285
3rd Month	1.285	1.190	1.285	1.285	1.285	1.285

Test results here indicate a severe problem with cell #2. All other cells are consistently good eliminating the possibility of a slight undercharge. The cell has internal problems and will require services by an experienced battery repairman. This should be taken care of immediately as harm could be done to small lift trucks and to other cells of the battery if usage is continued. If concerns exist over characteristics of batteries as a result of this testing, you should consult your Douglas Battery representative.

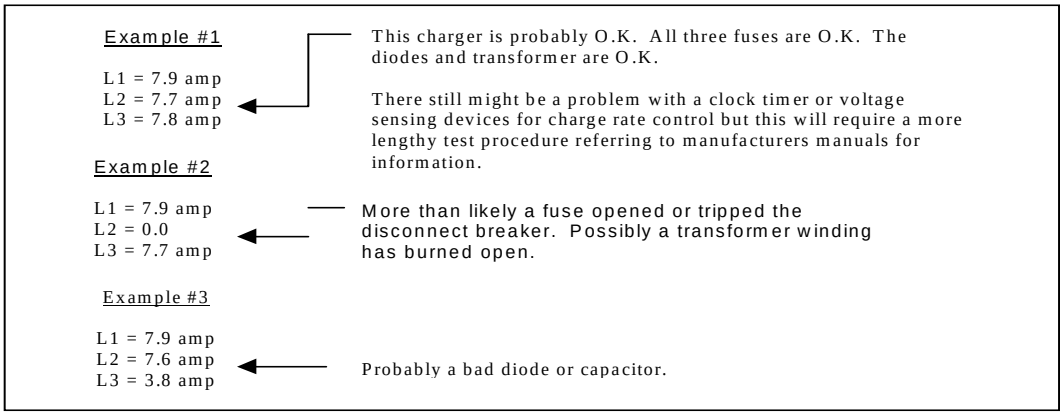
2. Measure on charge voltage of each cell and battery terminal voltage (total voltage across + to – posts). This should be done after the battery has received an equalize charge and the charge cycle has terminated. Restart the charger and allow to charge a minimum of 15 minutes before taking readings.

   While the charger is operating record cell voltage and record amp output of charger. Newer cells will have a higher on charge voltage than older cells. Also, some battery brands will have a higher on charge cell voltage than others. Refer to battery service manuals for your specific brand of battery for normal top of charge, on charge and cell voltages. By this being an ongoing testing procedure, look for uniformity and changes. A cell voltage variation of .05 to .08 volts is not of great concern, but if the voltage continues to develop a wider spread of up to .15 volts the health of the battery should be questioned. Again, an older battery is quite likely to have these large variations. It would not be uncommon to find a voltage spread from 2.43 to 2.55 on a four, five or six year old battery, but this same reading should be cause for concern on a one or two year old battery.

   Excessive voltage variations should be looked at with the gravity readings when trying to determine the cause. Improper charge rates, infrequent equalize charging, acid loss from over filling or overcharging and defects within the cell could be contributory. Corrective action should be attempted in the same manner as correcting gravity variations. Try to reduce the variations by extending charge period and comparing test data to determine if improvements have been achieved. If not, it is recommend that a representative of the manufacturer be consulted.

3. Check the charger. The previously outlined battery testing procedures should normally indicate that the chargers are working properly. If you rely only upon battery test data a problem may not become apparent until it has existed for some time.

   Assuming that at some previous time the chargers had been determined to be charging adequately, there is a simple, quick method to determine that the charger is probably performing properly. On three phase chargers, use an accurate clamp-on amprobe (should be digital capable of reading in 1/10's of an amp) to check L1, 2 and L3 line draw. This is best done while the charger is charging a low or discharged battery.



In either example #2 or #3 above, the charger will appear to the average operator to be functioning properly when the charger is turned on. The charger will start and jump to a fairly healthy charge rate. Due to the fact that most charger ammeters are fairly inaccurate the reduced amp output probably will not be noticed. The actual output, however, may only be 50-70% of normal.

Single-phase chargers will not operate with an open fuse, but could have reduced output due to a bad diode or capacitor. Again, L1 and L2 line draw should be near equal.

Observe the batteries close to the end of the charge. During the finish charge the cells will begin to show mild gassing activity at 2.35 – 2.38 volts per cell. As the voltage rises the gassing activity will become more vigorous. It is important that some activity be present to stir the electrolyte, but it is harmful to the battery if the gassing activity is vigorous enough that the electrolyte is quite turbulent and a strong acid, rotten egg odor is present. Temperature is a key factor at this point. If the temperature is rising above 125°F (51°C), the charge should be terminated and the cause found.

The Douglas DataTrac™ device can strengthen your capability to manage battery life. It can track the following important information:

a. Battery usage
b. Charge return
c. Water level
d. Temperature
e. Equalization

A battery should only be discharged 80% of its rated capacity. The charger then needs to put back what has been removed. The DataTrac device can be attached to the battery cable. If truck is equipped with a 720 Ah capacity battery, 80% of 720, or 576 Ah is the maximum that should have been removed. Then could check to see that the lift truck's low voltage cut out circuits are adjusted properly. (**Note:** Specific gravities before and after would also have to be checked to be sure that battery was actually at a full state of charge at beginning of test and to be sure that the battery is actually capable of producing its rated capacity.

Battery and Charger Safety Measures

DO

1. Do wear safety glasses while working on or around your battery.
2. Do keep caps on all cells while operating, charging and washing.
3. Do keep water level above splash guard at all times.
4. Do add water, if necessary, as soon as possible after a full recharge.
5. Do check that charger is operating after hook-up to the battery.
6. Do use proper OSHA approved equipment and methods for changing and lifting batteries.
7. Do wash hands after working on or around your battery.
8. Do use distilled or deionized water.
9. Do use charger for equalize option at least once per week.
10. Do use automatic start/stop charge control(s) to prevent overcharging and undercharging.

DON'T

1. Don't smoke in the charging area.
2. Don't disconnect or connect battery to charger while charger is operating.
3. Don't overfill battery cells with water.
4. Don't discharge more than 80% or below specific gravity of 1.150.
5. Don't allow discharged battery to sit long periods before recharging.
6. Don't leave battery cover in closed position during recharge.

MONTHLY AND SEMI-ANNUAL PREVENTIVE MAINTENANCE

1. M — Take specific gravity reading on every cell - AFTER CHARGE!
   If one or two cells read 20 points or more below the average reading, mark those cells and check at next monthly reading. If the cells do not improve and if the specific gravity reading average is outside of the 1.275—1.285 range, call your distributor.
2. M — Inspect cable leads and connector for fraying, loose connections or burned contact areas. If necessary, contact your distributor.
3. SA — Wash battery down. Use solution of one pound baking soda to one gallon of water to neutralize before rinsing with water. Never use ammonia.

Douglas Battery
1255 Creekshire Way, Suite 221
Winston-Salem, NC 27103
1-800-DOUGLAS

Index

FORM A - MONTHLY BATTERY TEST

Unit # _____ By _____ Test Date_____

Cell	Gravity	Volts
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
Total Volts		

Equalize charge _____

Wash _____

Water level _____

Cable Condition_____

Tar Condition _____

Case & Cover _____

Cell Caps _____

Cell Connectors_____

Volt – Ground + _____

Volt – Ground - _____

Note On charge volts at _____ amps.

Center cell temp. _____ deg. F.

Comments:

_____
_____
_____
_____
_____

Douglas Battery, 1255 Creekshire Way, Suite 221, Winston-Salem, NC 27103

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FORM B - REPETITIVE TESTING FORM

Unit # _____ Date_____ Model_____ S/N_____

Cell #	Gravity	Volt	Gravity	Volt	Gravity	Volt	Gravity	Volt	Gravity	Volt	Cell #
1											1
2											2
3											3
4											4
5											5
6											6
7											7
8											8
9											9
10											10
11											11
12											12
13											13
14											14
15											15
16											16
17											17
18											18
	Temp	TV	Temp	TV	Temp	TV	Temp	TV	Temp	TV	

Note: Always record temperature of a center cell and total battery voltage.

Comments:

_____
_____
_____
_____
_____
_____
_____

Douglas Battery, 1255 Creekshire Way, Suite 221, Winston-Salem, NC 27103

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FORM C - DAILY EQUIPMENT TESTING FORM

Part I

Truck #

Battery #	Date In	H.M. In	Date Out	H.M. Out	Elapsed Hours

Part II

Battery

Truck #	Date In	H.M. In	Date Out	H.M. Out	Elapsed Hours