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Single-point watering of lead/acid batteries

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Abstract

Banks of flooded-electrolyte lead/acid batteries of conventional (antimonial) design require periodic additions of water. This is most easily accomplished by means of single-point watering systems. A discussion is given of the many technical problems facing designers of such systems in order to provide a service that is both totally reliable and safe. Other advantages of single-point watering systems are also highlighted.

Keywords: Lead/acid batteries; Single-point watering

1. The value of water

The earth is called the blue planet with good reason. Around 75% of the surface is water. Virtually, the same is true about its inhabitants – the human body is ~65% water. Water is the reason for much happiness and also many a disaster on this planet. On the other hand, water is one of the most important of the elements. Nothing can readily live without water, nothing can grow, nothing can be boiled, no drink can be poured.

As much as 97% of all water on earth is salt water – good for fish and ships but not for human beings, nor batteries for that matter. The remaining 3% of all available water is the so-called drinking or fresh water. But this does not mean that it is ready at hand for human consumption. Two of these remaining 3% are stacked away in huge ice fields (the North and South Poles), together with glaciers. Greenland and Iceland come to mind. All considered, very impressive reserves, but no technology has yet made these vast blocks of ice available to people in need of water. If all the ice and snow would melt away, all land would be buried under 3 km of water. In other words, nothing of the remaining 25% of our planet would be left dry. Our entire planet would be one vast ocean.

2. Adding water to batteries

It is no easy task to water batteries, especially when it comes to adding water to the 7300 cells at the standby installation of BEWAG in Berlin, or the 6000 cells of PREPA in Puerto Rico, or even the 8300 cells at the Chino plant near Los Angeles. It would be impossible to accomplish this task by hand with the old watering can, opening one cell after the other. And consider the danger involved in such an activity.

Furthermore, it is by no means easier to water a fleet of fork-lift trucks, where often batteries have to be changed with every new shift, where control over the battery itself is nearly impossible: a fork-lift truck comes in, changes old batteries or new, hooks up to the charger, and powers off with a fresh battery. Who is going to control the level of electrolyte, let alone the acid gravity? How would anybody know which of the cells needs water, how much and when? Life without single-point watering has become impossible. The classic lead/acid battery needs single-point watering systems.

Manufacturers of such single-point watering systems have the battery factories as their customers who have delegated the task of watering battery cells to the end-users long ago. As can be seen from this situation, a single-point watering system has to be absolutely fool-proof and above all, maintenance-free.

3. Development of single-point water systems

It all started some 16 years ago. Traction cells as well as standby batteries consume a certain amount of water each day. This results in dry cells in a matter of weeks if there is no refilling. Watering by hand, as

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explained earlier, is impossible. It is too expensive, too time-consuming, too dependent on personnel, too dangerous, too unreliable. That is why single-point watering had to be invented. Way back in 1975, the first designs were emerging. Trials started in 1976, sales began in 1978 and since that day, single-point watering has taken off.

The battery industry told everyone in the single-point watering business: "If you ever want to be successful, the topping-up has to be to the mm of the electrolyte levels".

Every time a cell is connected to the main water-supply line, the topping-up must be to the same level, time and time again, and on all types of cells that are produced, i.e., bayonet, threaded or push-in.

Cells in Japan are different from those in Italy. The UK has its own Standard, so does the USA. Europe, however, is DIN in some countries, bayonet in others. All have to be included in the single-point watering design. There is also the problem that every cell has a different head space between the jar cover and the moss or splash-shield, the so-called T1 measurement. Thus, the obstacles faced by people developing single-point watering systems included different types of cells, different T1 measurements plus the entry of the jar cover, all different from battery company to battery company and from country to country.

Some batteries leave sufficient space for plugs and hoses, but others have their cell connectors running where it is intended to fit the plugs of the watering device. Concentrating on the traction battery (that is where the market was and is), heat dirt, overcharging, oils from the separators, negligence and user abuse is what is in store for single-point watering installations. Every manufacturer of single-point watering products is prepared for the absolute worst!

4. Requirements for watering-system design

How then, must a reliable watering plug be designed, if it is to perform in the expected harsh surroundings? The priorities are: (i) acid-proof material; (ii) a size that is small enough to fit the ever-decreasing size of the cells; (iii) resistance against any hydraulic oils spilled from the fork-lift trucks; (iv) heat resistance; (v) unaffected by any dirt, either from the inside of the cell or from the outside; (vi) able to handle even dirty battery water; (vii) fitted with adaptators for all different jar openings; (viii) suitable for security applications such as mining batteries; (ix) acceptable for electric vehicles where explosive gasses have to be diverted out into the open; (x) applicable to traction and standby cells; (xi) able to avoid any thermal runaway. Above all, single-point watering has to last for as long as the battery itself is in operation. After this list of accomplishments, logically the system has to be absolutely maintenance-free. Last, but not least, user abuse: everything hitting a battery will first hit the single-point watering plugs, so they must be strong.

4.1. Thermal runaway

Single-point watering connects all cells of a given battery. In order to avoid thermal runaway, the plugs have to incorporate a water trap to keep the gasses originating during charge in the cells away from the watering hoses, where they could accumulate and cause quite some damage should there ever be an explosion. On the other hand, single-point watering systems offer protection against thermal runaway by maintaining a constant level of electrolyte and thus avoiding dangerous temperatures and eventual ignitions.

Only cells low on electrolyte will be critical. If the total level of electrolyte is as it should be, the thermal management is taken care of and next to perfect. Cells with single-point watering, therefore, are under a better thermal management than cells without, which means single-point watering adds to the security of battery cells, either traction or standby.

4.2. Security

With respect to security: the most important improvement in single-point watering is the redesign into a double-barrel plug some two years ago.

Batteries are topped-up with battery water after charge, that means the electrolyte level is at its highest and at its warmest, but it also means that the amount of hydrogen is also at its highest. These gasses have to have a separate way out into the open through the watering plug, exactly at the moment when water is to enter the battery cell. Conventional watering plugs flush the water into the cell through the same barrel these critical gasses should escape from. Modern designs, however, have divided these two actions into two separate barrels. One is for the water to pour down and into the cell, the other is for the gasses to escape, without ever hitting the incoming water. Completely separated from each other, water never gets in touch with gas. Maximum safety during topping-up is the result. This is what single-point watering should aim for: safety and total reliability. As mentioned above, single-point watering is topping-up batteries to the exact level of electrolyte, it manages thermal aspects, and it adds to the safety of operation.

4.3. Electrolyte level

To control the level of the electrolyte, the system installed must have a clearly visible indicator of what is happening underneath the jar cover. The chosen watering system must provide a level indicator, the 'spy' inside the cell. Once a single-point watering system has been installed on the battery, the cells are closed and inaccessible. To know anything about the electrolyte

level, the plugs must be removed, if no visible indicator for the electrolyte level is incorporated in the plugs. Good watering systems, therefore, come with a level indicator.

The item to look out for is the degas opening in each plug. As the cells do emit large amounts of gas during charge, the watering plugs have to allow for a very good venting. Quality watering plugs have a large degas opening, allowing hydrogen to escape freely and air to enter easily. To avoid any pressure build-up inside the cell, or any accumulation of dangerous gasses in the water-supply hoses, where gasses are eventually pushed into, a large degas opening is imperative. It is essential on each watering plug.

4.4. Shut-off valve

Next in the line is the shut-off valve inside the plug, the most delicate part of any watering system. It must be reliable, yet simple in its function. Most importantly, the valve design has to be in the direction of the flow of water, to guarantee that the incoming water is going to help with the shut-off action. Yet the design must be simple enough to handle all the difficulties of the trade, mainly dirt. All single-point watering systems are judged by their shut-off valve design and how they react to dirt. The latter is a very serious problem – dirt comes from inside the cell itself and from the water-supply side.

Not all operators use battery water to exact specifications. Often tap water is taken directly from the mains to the battery, with next to no filters installed. Thus, the shut-off valve has to be of such a design that it will not get stuck through dirt brought to the plug from the town or well water. This is why the shut-off valve must be of a self-cleaning design. This is the most difficult part for the watering plugs. The valve has to close off the flow of water, has to be very precise (up to the mm), has to manage all dirt thrown its way and has even to clean itself, plus work universal water pressures day-in, day-out.

4.5. Water pressure

Water pressure is of the utmost importance when it comes to single-point watering. Some end users do their filling with gravity water, others have pumps which means that manufacturers of single-point watering plugs cannot tell their customers as to what pressure is best. The end users will apply the pressure available at their installations. Thus, the watering plugs must accept everything coming their way, be it 3 or be it 30 psi. Pressure reducers are often installed, but as service, care and maintenance are not the top priority in any battery-charging station, these tend to get misaligned. Therefore, the filling pressure applied to the plugs can be anywhere.

For electric vehicles (EVs), most battery installations are going to be used with a gravity fed source of water. The pressure generated here is never more than 2 or 4 psi, compared with fork-lift truck charging stations, which may often run at 30 psi. Yet one and the same watering plug must be able to handle these differences in pressure.

The volume of water rushing through the plug must be just right, too much would wash the active mass of the plates away. On the other hand, time is important too, an 80 V battery cannot take for ever to fill, 5 min is the maximum allowed. A water entry opening of 1.5 mm, therefore, is required for the pressure scale on offer. As mentioned, 2 or up to 30 psi of water, pressure may be coming through the plugs. If the water entry is too large, plate damage is possible.

In order to work the wide range of head spaces worldwide on offer inside the cells, one of the most important issues in single-point watering is the variety of floats.

Every battery manufacturer offers several cell types in its line of batteries, every one of these cells has a different head space, the T1, as mentioned before. This means a different float for each cell. It is good to have a watering system that allows the use of one basic watering plug, just using different size floats for different head spaces. This keeps cost down and inventory low.

Floats are the heart of the system anyway. A float must react quickly and precisely to the desired level of electrolyte. This is why a lever-operated plug has so many advantages: floats pushing in the direction 'up' will act with more power through a lever operation, and will respond to the slightest increase in electrolyte. In fact, they work with an increment in connection with the shut-off valve, compared with non-lever operated plugs.

4.6. Specific gravity

Readings of acid specific gravity are a daily job for the persons responsible for the batteries. On the other hand, once the watering system is installed, the one and only entry port to the acid is closed, unless the watering plug allows a hydrometer to go through. This feature adds tremendously to the security of any battery, and it assures that the battery will operate for the designed period.

5. Conclusions

In conclusion, reliability and security is the issue when it comes to single-point watering from the very complex mining battery with all its special certificates, right down to the very large standby operations and charging stations for fork-lift trucks. Every flooded-electrolyte lead/acid cell of traditional design should be equipped with a single-point watering system.