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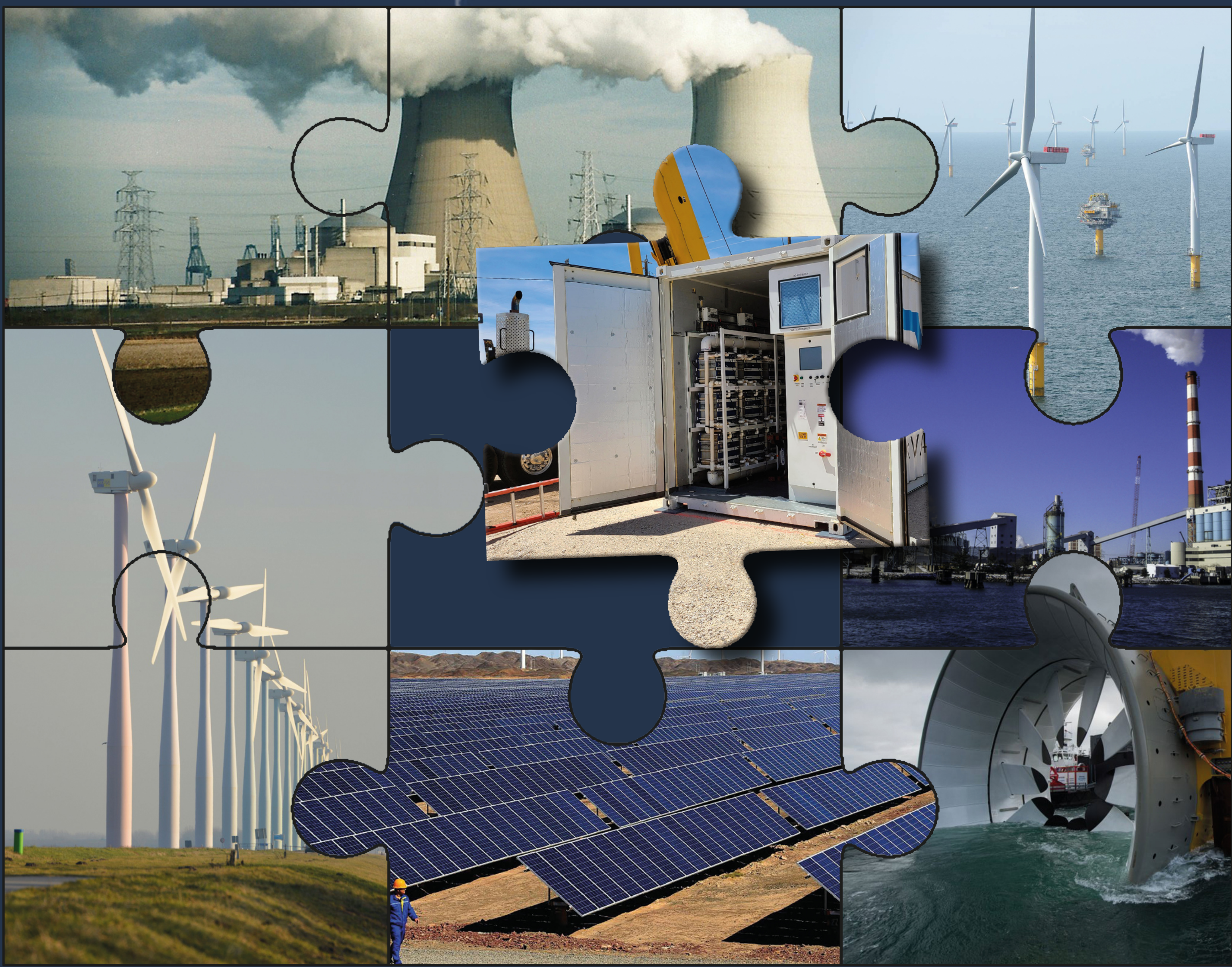

Battery gas recombination vents

A hidden benefit that is right out in the open

Safety is an essential feature of any energy storage system, so reducing the amount of explosive gas released during the charging of lead-acid batteries should be a simple decision. Pete DeMar, co-founder of Battery Research and Testing, Inc. (BR&T), explains how the addition of a passive device can help minimise those gases and reduce maintenance costs.

It is interesting how the concept of recombining hydrogen and oxygen, that is given off from lead-acid (or any aqueous) batteries during charging, is even more important now (2022) than it was back in the early 1900's, when some of the first attempts and processes were developed to do this. Yes, the modern-day battery gas recombination vents are different than the first devices, but they still do the exact same thing—turn hydrogen and oxygen back into water. What is surprising is that many battery users are not familiar with them, or do not understand their universal benefits.

Battery gas recombination vents have many common names, "recombiners, recombination vents, recombination plugs, gas recombiners, catalysts"—and probably others that I am not familiar with. They only do one thing and that is, recombine the hydrogen and oxygen gases that are given off from the cells during charging, back into water.

While the basic knowledge and understanding of these devices were known about on both sides of the pond (Europe and North America) for many years, they were not initially adopted or as well accepted in the US as they were in the EU. I will explain the reasons for that difference later in this article. It does need to be understood

The benefit of recombiners can be demonstrated by a simple experiment that there is now a better understanding of the benefits of utilising these recombiners in the US as there has been in the EU for many decades.

Recombiner benefits

Why am I interested in these devices, and why should anyone be? BRI started its investigation into recombiners with a question from a technician. The question was, **"How do I know how much gas is being released when a battery is in a high-rate charge?"** A good question, but we had no answer— and that was the beginning of our investigation into battery gas recombination vents.

We are now extremely interested in these devices because, as we have learned, they can provide two results that are extremely beneficial to all users of stationary batteries.

Those two benefits are:

1. They improve the safety in the battery room or area by recombining most of the hydrogen and oxygen gasses that are generated within the cells before they can be released into the atmosphere. Reducing those gasses— by whatever the amount of gas that would be— is a safety improvement. Anything that improves safety is a good thing
2. They reduce the labour hours required over the life of the battery, by greatly reducing the need for adding water to the cells

It seems to make sense that everyone with a stationary battery would want the battery area to be as safe as possible, and reducing the cost of maintaining the battery is just an added value.

> "We are now extremely interested in these devices because, as we have learned, they can provide two results that are extremely beneficial to all users of stationary batteries"

The most self-serving benefit that we see to our company is the reduction in the time required for our technicians to add water to the batteries, where we have preventative maintenance contracts. By reducing the time required for water additions, it increases the overall profit of a contract.

Market differences

Why the difference in acceptance or usage between the US and the EU market? Battery gas recombiners have been utilised in Europe since at least 1971, when they were first offered by Hoppecke for usage in their cells. As best we can learn, they were the first to introduce them for commercial usage in Europe. Today there are three major manufacturers of these devices in Europe. Between them, they provide their recombiners to a number (if not all) of the battery manufacturers in Europe, as well as resellers here in the Americas.

Recombiners did not find their way into the Americas until Hoppecke began to offer their batteries here in the US, and their recombiners were an option they offered for those batteries. The oldest paper I could find on recombiners that was published here in the US, was presented at the Battcon 2008 conference. The title of that paper was "Hydrogen Gas Management for Flooded Lead-Acid Batteries" and was presented by Carey O'Donnell of Mesa Technical Associates and Michael Schiemann of Hoppecke.

To understand why recombiners have a much greater history in Europe than in the US, we need to understand that Europe's primary battery design is a lead-selenium design, and in the US the primary design is lead-calcium.

Lead-calcium batteries have a lower float current requirement, and that requirement does not increase much over the life of the battery. Lead-selenium batteries require a little higher float current, and that requirement increases over time and can double near the end of its life.

This higher float current requirement results in a higher amount of gas being generated, which results in the need for more frequent water additions, as compared to a lead-calcium design.

By recombining most of the gasses back into water, these devices have proven to yield substantial savings in labour over the life of the batteries. Equally, if not more important, is the fact that by preventing most of the hydrogen and oxygen from escaping into the area around

Fig 1: The test setup using recombiners from five different manufacturers

the batteries, they improve the safety of the system.

The value of the reduction of these gasses is verified by the UNE-EN IEC 62485-2 Safety Requirements for Secondary Batteries and Battery Installations, Part 2: Stationary Batteries, 7.2 Ventilation Requirements, note 2, which states that when recombiners are installed in the cells, as compared to standard vents, the ventilation required may be reduced by 50%. In addition, the newest revision of the IEEE StdP1635-2022/ ASHRAE Guideline 21-2022 IEEE/ASHRAE 'Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications' (which is still in its balloting stage), now includes explanations regarding the benefits of using recombination vents in vented cells.

Most recombiner manufacturers state that their devices are more than 80% efficient at recombining the gasses, with some documents stating "up to 99%" efficient. With the IEC allowing a 50% reduction in the ventilation requirements, it indicates they took a very conservative position with their 50% allowance.

Our experiment

In the fall of 2020, we decided to run some tests to see if we could observe any substantial differences between the different recombiner manufacturers. This included companies that are not so well known and those that only deal with certain segments of the stationary battery market. Based on what we learned from those initial tests, we decided to run a longer-term test to see if we could gain some sort of an understanding of what the difference would be. We looked at how many refills of water would be required on cells within the same battery, between cells with recombiners, and those with standard vents.

Fig 1 shows recombiners from five different manufacturers that were used in our initial experiments. Some of these units have pressure relief valves and some do not. The amount of difference in off-gassing that we observed between recombiners from the same manufacturers, with or without having a pressure relief valve, was very educational, and gave us thoughts on another experiment. We used these in multiple different test configurations, just trying to gain knowledge.

Three interesting observations were: firstly, the differences in the pressure relief mechanisms one to the other; secondly, the impact of a pressure relief mechanism on the cell's electrolyte levels in cells that have sample tubes; and thirdly, how some recombiners can, temporarily, be negatively impacted by continuously operating at or above their upper limits. We are still trying to understand this, and have plans for some future tests to investigate this further.

Fig 2: A visual demonstration of the amount of gas that recombiners can prevent from being released overnight

Fig 2 shows an overnight experiment we used to gain an understanding of the differences in gas released by each cell—those with recombiners, from two different manufacturers, and a straight-through shipping plug. The voltage of the battery was 7.05 volts (2.35Vpc).

After gathering a substantial amount of information and knowledge from these initial experiments, we assembled a nine-cell battery (three of the three-cell units) and, on 29 December 2020, started a long-term test with the objective of gaining a rough understanding of the water-loss/off-gassing differences. The battery model we selected to perform this testing on was an Enersys 3CA-05M unit. That is a 100-amp-hour lead-antimony design. We selected this model because of its relatively small size and because it was lead-antimony, which we could easily make generate substantial gas, as compared to a lead-calcium design.

To be able to have an elevated float current, we maintained the individual cell voltages (ICV) at 2.35 volts per cell. By keeping the average ICV at this value, we were able to keep the float current between 0.9 amps and 1.8 amps.

It needs to be understood that this testing was going on during the COVID-19 period and everyone was working remotely unless they had to go to the shop for a specific action. The area where the test was set up was semi climate-controlled, and the charger held a fixed voltage. It did not adjust the voltage based upon a temperature change.

From the three units shown in ***Fig 3***, we selected the unit in the centre (2A, 2B, 2C) for the comparison test between cells with or without a recombiner. We installed a standard vent in the middle cell, a recombiner from one manufacturer in the cell to the right and one from a different manufacturer in the cell to the left.

We filled all cells to the high lines and commenced charging. We averaged twenty-one days before the middle cell, the one with a standard vent, needed to be re-filled. Each time, when the cell reached the low-level line, we would fill it to the high-level line.

Results reported

At Battcon 2021 we reported the results of the test (up to the time when the paper was submitted). At the time of Battcon, the recombiner-equipped cells had not yet reached the low-level line. However, after Battcon, the right side (recombiner-equipped) cell did reach the low line.

We had refilled the standard cell 17 times, before the recombiner-equipped cell needed to have water added. Just for the sake of discussion,

and if you used simple math, if a battery normally required water replenishments once a year, and recombiners were added to the cells, you could operate for 17 years without having to add water. Simple math says yes, but I think that under normal operating conditions the time interval would be something less than that. Based on what we have observed, I believe that it would be reasonable to achieve eight to ten years between needing to refill, if the levels were brought to the high lines and operated until the low lines.

Fig 3: The test arrangement has units with and without two-way valves

New experiment

From what we observed, regarding efficiencies between recombiners that did or did not have a pressure relief system, we decided to try and gain a better understanding of this. We are presently beginning a new experiment that is going to be comparing the efficiency of identical model recombiners, with half that have pressure relief valves and half that do not. All the recombiners are from the same manufacturer.

We are using the same three units of the Enersys 3CA-05M cells that we used in the previous experiment. Each 3CA-05M unit will have a standard vent assembly in the middle cell and a recombiner on either end of that unit— one with a valve and one without. Because we want to accelerate the off-gassing, we will be charging the cells at about 2.35Vpc. We are using this high ICV because we want to push somewhere between 0.8 and 1.2 amps continuously through the cells to accelerate the off-gassing.

> “Just for the sake of discussion, and if you used simple math, if a battery normally required water replenishments once a year, and recombiners were added to the cells, you could operate for 17 years without having to add water”

We anticipate that this experiment should provide us with enough data to make some conclusions as to the efficiency differences by the end of the year, or by early 2023. If anyone would like to follow along observing the results, just contact me and we will provide you with ongoing results/data.

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