Summary

Molecular Rebar® Pb1100x is a formulated version of Molecular Rebar® that is useful in lead acid batteries to dramatically increase lifetime, charge acceptance, energy efficiency, and useful voltage ranges. Pb1100x replaces a portion of the water routinely used to mix battery pastes and is, therefore, easily implemented into existing production lines. Pb1100x alters the way the battery functions and performs which changes the rules for its design and use. In different applications, it can be used differently than the current design to create value for the battery maker and the battery user.

Suggested Usage

This product, Pb1100x, is used as a negative active material (NAM) additive in Starter-Lights-Ignition (SLI) Lead Acid batteries. As the ratios of various paste components are pre-set, addition of this additive replaces a portion of the water that is regularly added along with the lead oxide, expander, fiber, etc. used in making the paste. Inclusion of this additive does not change paste density as there is only a small amount of active ingredient and the total water used is the same as the current formulation. Furthermore, it does not require any special equipment, being a pourable liquid that is added during the paste mixing step.

Formulation

To ensure correct addition of Pb1100x to the paste without altering the total amount of water in your formulation, please use the following equations:

\[ V_{\text{Pb1100x}} = M_{\text{Lead Oxide}} \times 0.0233 \]  
\[ V_{\text{H}_2\text{O}} = V_{\text{Standard H}_2\text{O}} - 0.9762 \times V_{\text{Pb1100x}} \]

where \( M_{\text{Lead Oxide}} \) is the mass of lead oxide in your paste formulation in kilograms, \( V_{\text{Pb1100x}} \) is the volume of Pb1100x to add to your lead oxide in liters, \( V_{\text{H}_2\text{O}} \) is the amount of additional water to add along with the Pb1100x to the lead oxide in liters, and \( V_{\text{Standard H}_2\text{O}} \) is the amount of water routinely added to your paste formulation in liters. 0.9881 is a correction factor which accounts for the volume of water displaced by the volume of nanotubes and dispersant.
For example, if the paste requires 1000 kg of lead oxide and your existing formula usually requires 117.4 L of water you will add 94.65 L of water and 23.3 L of the Pb1100x:

\[ V_{\text{Pb1100x}} = M_{\text{Lead Oxide}} \times 0.0233 \]
\[ = 1000 \text{ kg} \times 0.0233 \]
\[ = 23.3 \text{ L of Pb1100x to be Added} \]

\[ V_{H2O} = V_{\text{Standard H2O}} - 0.9762 \cdot V_{\text{Pb1100x}} \]
\[ = 117.4 \text{ L} - 0.9762 \cdot 46.7 \text{ L} \]
\[ = 94.65 \text{ L of Water to be Added} \]

**Pre-Mix Protocol and Quality Check**

1) Thoroughly shake the Pb1100x in its container prior to use. The preferred method is vigorous shaking by hand, for 3-5 minutes. Motorized shaking devices can also be used if the container or amount of MR is too large for hand shaking.

   ☛ **MINIMIZE** equipment that will be in direct contact with the Pb1100x as any equipment that is used must be cleaned per local regulations for hazardous materials. Handle any waste as hazardous materials.

2) In order to ensure that the product was shaken appropriately, it must be visually examined by eye or, preferably, via an optical microscope.

   i. Place a thin line (3-5 millimeters by 40-50 millimeters) of shaken, Pb1100x onto a clean microscope slide using a pipette, dropper, or equivalent.
ii. Place a second microscope slide on top of the line and press down such that the liquid is forced to the edges of the slide but not beyond.

iii. When held up to the light, the microscope slide should appear homogenously brown with few, if any black particulates. If such particulates are visible by eye, shake the product again as in Step 1 and repeat Step 2.

iv. If a microscope is available, viewing the sample at 30-50X magnification (usually the minimum setting) will further confirm that the material has been adequately shaken.

v. The liquid should appear as a homogenous brown liquid with few, if any, black particulates (figure below). Localized drying may produce black particulates or streaks towards the edges of the sample and around the initial dropper/pipette loading streak. This is acceptable. If large black particulates are visible elsewhere on the slide, shake the product again as in Step 1 and repeat Step 2.
Addition of Pb1100x to the Paste Mix

1) Complete the Pre-Mix Protocol and Quality Check, above.

2) Calculate the required volumes of Pb1100x ($V_{Pb1100x}$) and Water ($V_{H2O}$) using equations (1) and (2).

3) Add expander, fiber, etc., to the lead oxide as normal.

4) Pb1100x is always added during the water addition step, regardless of whether your process calls for the water to be added to the mixer before or after the lead oxide. This addition should take no longer than the typical water addition and can take place in any one of two ways:

   i. Pb1100x ($V_{Pb1100x}$) can be added directly from its container into the paste mixer and followed by addition of water ($V_{H2O}$). We recommend using a portion of the calculated water allowance (i.e. taken from $V_{H2O}$) to rinse the Pb1100x containers. This rinse water is then poured into the paste mixer to ensure complete addition or product.

   ii. Pb1100x ($V_{Pb1100x}$) can be pre-mixed with the water ($V_{H2O}$) and the diluted volume can be added to the paste in a single step. We recommend using a portion of the calculated water allowance ($V_{H2O}$) to rinse out the Pb1100x containers. This rinse water is then poured into the paste mixer to ensure complete addition or product.

5) Mix paste per the current method.

6) In-house paste quality tests will show normal density and normal or improved paste integrity.

Battery Production and Charging

1) Pb1100x containing paste should be considered normal paste during plate production with no change to the existing process.
2) Pb1100x containing plates should be considered normal plates during assembly of the battery.

Treatment of Pb1100x Containing Waste

All waste and surplus material should be disposed of in accordance to local laws. Product containers can be shipped back to MRD for recycling or can be burned. Contact a licensed professional for off-site disposal.

Treat Pb1100x and waste containing Pb1100x the same way and by the same safety standards that you are required to handle lead. Pb1100x will decompose at the temperatures used to recycle lead (and sulfuric acid) rendering them inert.

Pb1100x deposited in waste water will associate primarily with lead particles, allowing for filtration (5-10μm pore size), lead recycling, and decomposition of the product. Closed loop water systems require no further adaptation. If water is released back into the environment, please consult your local environmental guidelines for additional waste handling direction.

Safe Handling of Pb1100x

For proper handling and storage, refer to the SDS provided with the product.

Disclaimer

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Black Diamond Structures and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product.