Mixing of CoolTherm® EP-3500 and EP-2000 Thermally Conductive Epoxy Potting Materials

Technical Tips

CoolTherm® EP-3500 and EP-2000 encapsulant are high thermal conductivity potting materials used for removing heat from devices in applications such as electric motors, transformers, and sensors. Each is a two-component material consisting of a Resin (R) and a Hardener (H) that, when mixed in the correct ratio and heat-cured, forms a strong, rigid, highly thermally conductive connection between the device and the heat sink.

These materials are composed of an organic liquid component with a high volume fraction of a ceramic filler dispersed in it. Because the potting process generally requires low viscosity material for efficient penetration into the device, the filler portion of both the Resin and Hardener will tend to settle over time. The resulting settled sediment can be quite hard, especially for the Hardener components (CoolTherm EP-3500H and CoolTherm EP-2000H). However with the proper techniques the material can be remixed and returned to its homogeneous state. This document provides suggestions for proper mixing techniques and recommendations for confirming that the material is homogeneous.

During processing, it is generally recommended to heat the material gently to lower the viscosity and improve penetration into the device. This can exacerbate the tendency of the filler to separate, but this can also be mitigated by proper choice of mixing equipment for both meter/mix/dispense (MMD) and batch processes. This document also provides some suggestions for optimizing mixing in those processes.

For any questions, concerns, or assistance regarding the use and processing of CoolTherm EP-3500 and EP-2000 encapsulants, please contact your local Parker LORD representative or contact Customer Support at ParkerLORDsupport@parker.com.

General Considerations:

As with any filled material, it is critical to ensure that the material is mixed to homogeneity in its original container before each use, and especially if only a portion of the material is to be used. If the material is not properly mixed, the material transferred out of the container may contain too little filler, and the material remaining in the container will consequently contain too much filler for future use. In both cases, the mix ratio of the material with the other component will be incorrect, which may affect cure times and the final cured properties of the material.

Due to its high room-temperature viscosity, it is recommended to preheat CoolTherm EP-3500 components to 60-90°C before carrying out most of the mixing recommendations. For CoolTherm EP-2000 components, heating material gently to 40-60°C might help, but initial mixing can be achieved at room temperature due to its much lower viscosity.

Any mixing technique will inevitably entrap air into the material, so proper degassing after mixing will be required before potting the device (which is generally also done under vacuum). In lab-scale manual or batch processes, degassing can be done on the individual components or the mixed material (if the material can be applied within the working time), but it is critical that the potting material be degassed before applying to the part to avoid foaming. In MMD units, degassing is typically done on the separate components in the prep tanks.

Storage Tips:

CoolTherm EP-3500 and EP-2000 components are provided in quart and gallon cans. Regardless of the package size, if the materials are to be stored for a prolonged period, there are some storage practices that can help with mixing when the materials are ready to be used:

- **Store at normal room temperatures**: The viscosity of epoxy resins and hardeners decrease exponentially with increasing temperature, so storage at higher temperatures will accelerate the tendency of the material to settle in the container.

- **Avoid vibration during storage**: Vibration can also accelerate the packing of the filler materials into a hard sediment during storage. If possible, the material should be stored away from high-traffic or other areas prone to vibration.
- **Invert the containers weekly during storage**: Regular inversion or rotation of the containers during prolonged storage will keep the filler material moving due to gravity. The material will still settle, but it will be less likely to hard-pack, which will make subsequent mixing easier.

Using a combination of the above practices will give the best performance when it is time to mix the material for use.

Mixing in Original Containers:

There are several approaches to mixing material in the original containers, even if the material seems to be hard-packed (particularly CoolTherm EP-2000H). A material can be considered satisfactorily mixed when it appears smooth and homogeneous visually, and when no sediment is detected on the bottom or sides (especially in the bottom edges of the container) using a manual test with a metal stick or spatula. A wooden stick can also be used, but care must be taken that no splinters or debris from the stick are transferred into the material.

Rolling on a Roll Mill

Rolling the containers on a roll mill at typical moderate speeds (e.g., 1-2 revolutions per second) is a good approach for initial dispersion of settled material, especially if it appears hard-packed. Heating is not necessary during this step for either material. Depending on the degree of settling and how hard-packed the material may be, the rolling can be done anywhere from overnight to 2-3 days in advance of mixing (longer times will help with harder-packed material).

The rolling step should loosen the material, but it may not be fully homogeneous upon manual testing or there may still be some larger lumps of material that require further mixing (using the techniques below) to disperse completely.

Shaking on a Paint Shaker

Commercially available, dual-arm paint shakers are the easiest way to mix materials to complete homogeneity. Dual-arm shakers are preferred because the Resin and Hardener can be mixed simultaneously.

The basic process is to shake the material for about 5-10 minutes, then check the material manually using a metal spatula. Be sure to scrape the bottom, sides, and especially the bottom corners of the container to check for any sediment. Also check for any lumps in the material. Sediment or lumps should be loosened manually using a spatula and then the material should be shaken for another 5-20 minutes. Repeat this process until the material is homogeneous. For hard-packed material, this may take several iterations.

Before shaking, CoolTherm EP-3500 Resin and Hardener should be preheated to 60-90°C in a standard lab oven, and it will be necessary to occasionally re-heat the material to keep it at a workable viscosity. Heating CoolTherm EP-2000 Resin and Hardener to 40-60°C is optional; it will lower the viscosity, but it may also accelerate re-settling of the material between mix steps.

Mixing with a Disperser Blade

Use of a paint shaker following the above process is usually sufficient, but if a paint shaker is not available or if there are persistent small lumps in the material, a disperser blade (either on a mixer or a drill) can be helpful. It is recommended to use carbide or ceramic-coated blades due to the abrasive nature of the filler materials, to extend blade life, and to also prevent contaminating the materials with traces of metal from the mixing blade.

A disperser blade will NOT be as helpful if the material is hard-packed because the hard-pack will damage the blade relatively quickly. Either rolling or shaking to loosen the material is strongly recommended before using a disperser blade.

Keeping Material Homogeneous During Use:

Once the material is homogeneous in the original container, the required amount can be transferred to a secondary container or prep tank for preheating and degassing as needed. It is important to keep the material well-dispersed during these steps as the filler will tend to settle more quickly with lower-viscosity materials.

For production scale, whether using a batch process or MMD equipment, it is generally recommended to have separate prep tanks for the Resin and Hardener component. In this way, the Resin and Hardener can be preheated and degassed independently before mixing, so that the maximum working time is achieved once the materials are mixed.

Mixing in the prep tanks can be best achieved using a mixing system that can bring material from the bottom of the container toward the top and can minimize packing of material into the bottom edges of the container, such as an anchor blade with a propeller mixer operating at sufficient speed. Consult your mixing equipment supplier for recommendations of specific suitable equipment. The mix tank should also be equipped for heating material to the desired temperature and capable of achieving and maintaining a vacuum of no more than about 15 torr. Care should be taken not to leave the material under dynamic vacuum for long time periods (e.g., overnight or over a weekend) to avoid evaporating organic components.

Since the Hardener component for both CoolTherm EP-2000 and EP-3500 is lower viscosity than the associated Resin, the Hardener can be preheated to a lower temperature so that the viscosities of Resin and Hardener are approximately the same. This will optimize mixing of the materials in a blend tank or through a static mixer of MMD equipment. Consult your Parker LORD Application Engineer for more information about choosing the appropriate temperatures for your process.

On the lab or prototype scale using a manual process, it may be advantageous to mix the Resin and Hardener components first, immediately after homogenizing in the original containers, and then degas the mixed material before applying to the part to be potted. This is possible because the working life of the mixed materials in the 60-100°C range is several hours. This approach will minimize any issues with settling of the separate components during the preheating process and better ensure a proper mix ratio.

Cautionary Information:

Before using this or any Parker LORD product, refer to the Safety Data Sheet (SDS) and label for safe use and handling instructions.

For industrial/commercial use only. Must be applied by trained personnel only. Not to be used in household applications. Not for consumer use.

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Parker LORD
Engineered Materials Group

111 LORD Drive
Cary, NC 27511-7923
USA

phone +1 877 ASK LORD (275 5673)

www.lord.com