EVERY CONNECTION COUNTS

WHITE PAPER

MAG-MATE TERMINALS FOR OVER-MOLDING APPLICATIONS IN APPLIANCE MOTORS

Application methodology and Engineering guidance

INTRODUCTION

Magnet-wire termination is a critical process step in appliance and motor manufacturing, in general. TE Connectivity's (TE) **MAG-MATE** insulation displacement connection (IDC) terminals are widely used to create reliable solderless joints for copper and aluminum magnet wires.

As OEMs move toward green, lightweight, and lower-noise motor designs, traditional metal housings are increasingly replaced with bulk molding compound (BMC) resin materials. Combined with IDC technology, this shift simplifies motor manufacturing by removing coil impregnation steps and improving thermal/acoustic performance.

Key benefits of BMC, a thermosetting composite made from unsaturated polyester resin, mineral fillers, and long glass fibers:

- High thermal stability
- Good electrical insulation
- High damping and acoustic absorption
- Good heat dissipation
- Reduced system weight
- Lower overall manufacturing cost due to simplified processing

As a result, BMC-molded stators increasingly integrate over-molded **MAG-MATE** terminals, help in enabling new mechanical and electrical integration approaches and helping to deliver the ***low-noise application requirements***, so important for household appliances.

MAGNET-WIRE CONNECTION METHODS

Historically, magnet-wire termination in motors uses several techniques:

SOLDERING

Melts a solder alloy to mechanically and electrically join conductor ends. Reliable but process-intensive and sensitive to contamination.

WELDING

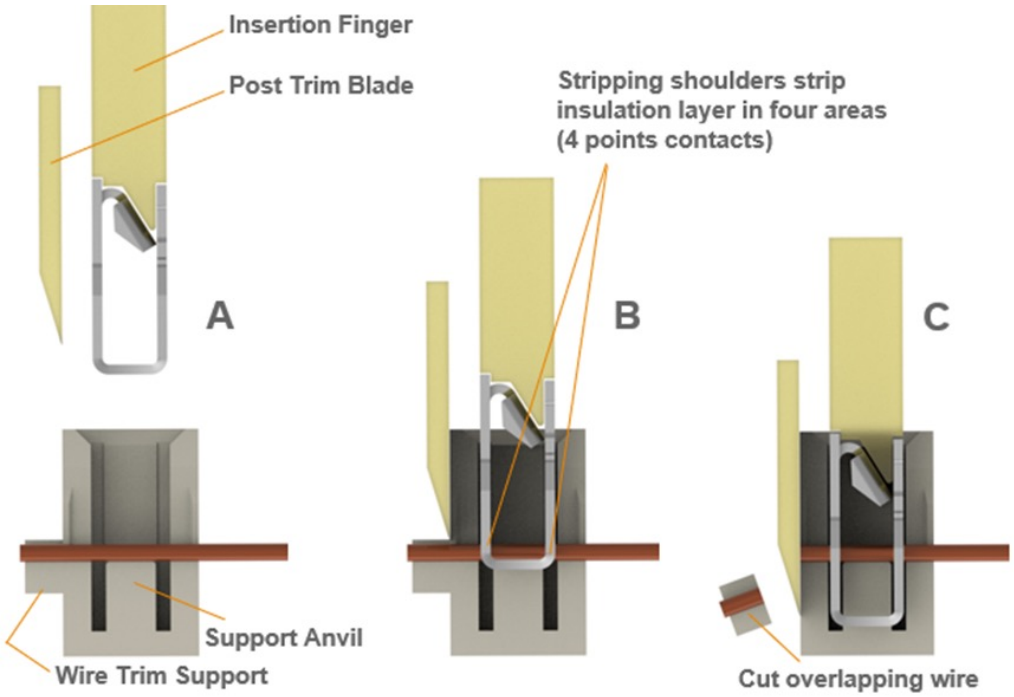
Fuses wires using thermal or electrical energy. Produces strong joints but adds complexity and is harder to automate at scale.

SOLDERLESS TERMINATION

TE provides solderless solutions for magnet wire connections which helps eliminate the need to pre-strip the magnet wire insulation layer. After terminal assembling, a virtually reliable and permanent connection is created.

BMC OVER-MOLDING WITH MAG-MATE TERMINALS

TE offers several types of solderless solutions for magnet wire. MAG-MATE terminal is one of most popular. It has two IDC slots with inlet chambers on the input points of slots. The terminal is positioned over the magnet wire in the plastic cavity and then inserted into the cavity and onto the magnet wire. Terminals “clean” the insulation film from the wire surface during the insertion process. When the terminal is finally positioned, the wire is fixed inside two IDC slots, creating a virtually reliable and permanent termination.



MAG-MATE terminals application in BMC over-molding

With rising environmental expectations and increasing levels of production automation, more motor manufacturers are adopting MAG-MATE terminals for BMC over molding processes. As this application is relatively new, some customers may feel uncertain about how the terminals will perform in this type of molding environment. This paper provides an in depth analysis of the opportunities and challenges associated with integrating MAG-MATE terminal products into BMC over molded motor designs and presents engineering solutions to address these concerns. Because most customer designs fully encapsulate the termination area in BMC, our evaluation covers the entire MAG-MATE terminal interface region. The connector system is functionally divided into two sections: the permanent IDC connection to magnet wire and the detachable interface for tab mating.

The connection between the magnet wire and the MAG-MATE terminal serves as a permanent interface. Simulation work using a representative motor size (Ø210 × 87 mm) shows that the IDC connection strength for both copper and aluminum wires exceeds the forces generated during BMC filling. From an application standpoint, the permanent joint is therefore not expected to be affected by molding pressure. However, care must still be taken in the tooling design—particularly the gate orientation—to help avoid external mechanical influence on the termination area (e.g., resin flow directed toward the wire-terminal interface). See Figure 1.

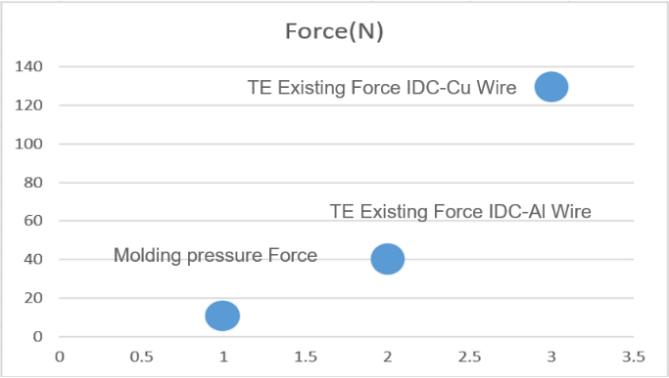


Figure 1 Permanent connection force comparison

In addition to the permanent IDC joint, some applications require a detachable interface between the MAG-MATE terminal and a power tab. This interface uses a leaf-spring structure, which can be sensitive to deformation during molding. Although testing confirms that the current design withstands BMC flow conditions, design enhancements were developed to improve robustness: replacing the cantilever with a simply supported beam configuration or adding a protective cap to shield the spring from direct flow. Analysis comparing leaf-spring retention force with BMC filling pressure (same motor size: Ø210 × 87 mm) shows that the spring force remains higher than the molding load and is suitable for use in over-molding conditions. See Figure 2.

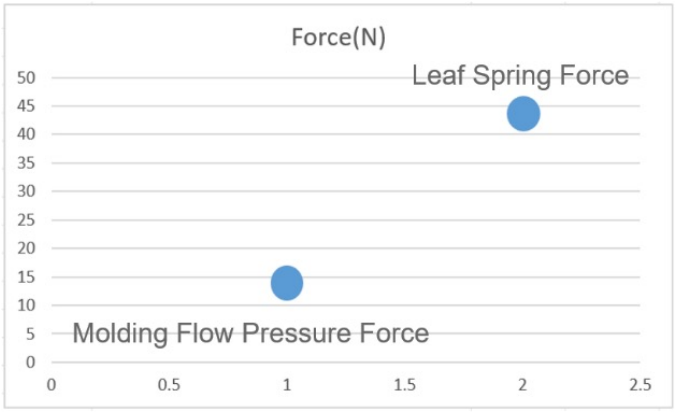


Figure 2 Detachable connection force comparison

To further evaluate application performance, testing was conducted across multiple wire diameters: 0.32 mm and 0.91 mm aluminum, and 0.25 mm and 0.81 mm copper samples were compared before and after over-molding, as well as before and after environmental test, while varying gate location and flow velocity/ pressure. Results indicate that small-diameter wires (0.25 Cu, 0.32 Al) are not significantly affected by molding conditions (P ≥ 0.05), suggesting they are well suited for over-molding. See Figure 3 Larger-diameter wires show greater sensitivity to process conditions.

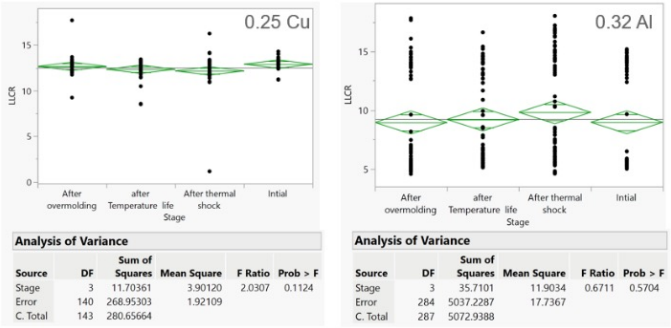


Figure 3 Small-diameter wires show stable resistance data before and after environmental test(unit: mΩ)*

For copper wires, post-molding data is generally equal to or slightly better than initial values, suggesting that encapsulation can further stabilize the connection. Gate location has a more pronounced effect than velocity or pressure. See figure 4.

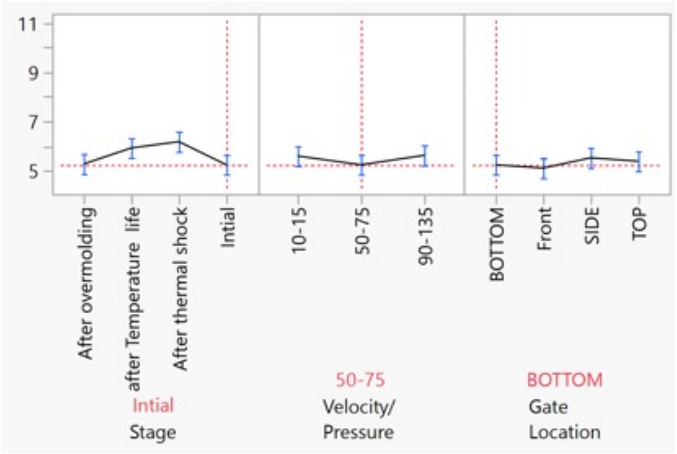


Figure 4 Copper wire data based on different gate locations, during environmental test(unit: mΩ)*

Aluminum wires, due to their lower mechanical strength, are influenced by both gate location and flow parameters, and are therefore more susceptible to variation during the process. See figure 5.

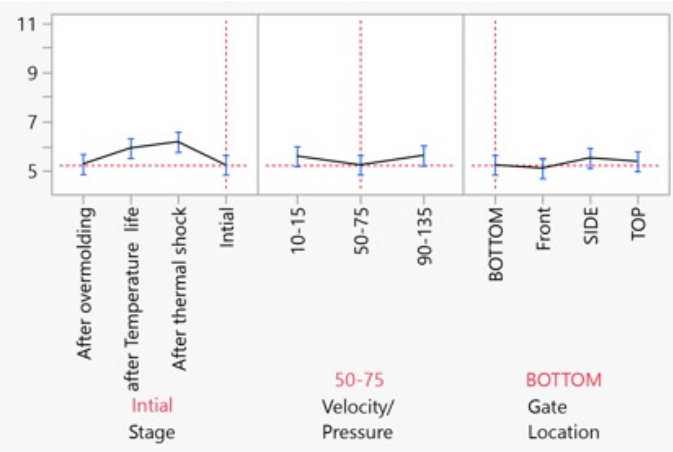


Figure 5 Aluminum wire data based on different gate locations, during environmental test(unit: mΩ)*

Both aluminum and copper terminations show minor changes after temperature-life and thermal-shock testing, consistent with normal and expected material behavior.

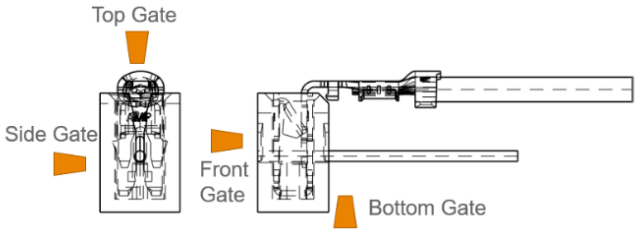
Tests were done following Electronics Industry Alliance (EIA-364) standard for environmental test

BMC over-molding product design guidelines

When developing over-molded products, it is recommended to fully encapsulate the winding-wire connection area—or, where possible, the entire terminal region. This helps minimize the tensile stresses generated during post-molding cooling that could otherwise influence the wire connection.

For applications that include external mating features, these interfaces should be positioned inside the cavity to shield them from direct molding pressure.

The filling gate placement is also an important consideration. See figure 6.



For copper-wire applications: top or bottom gate locations are generally suitable.

For aluminum-wire applications: bottom or front gates are preferred, due to material sensitivity.

In all cases, the gate should not direct resin flow straight onto the MAG-MATE terminal. Because aluminum wire has comparatively lower mechanical strength, the injection velocity and pressure should remain well-balanced to guard against unnecessary stress on the termination.

CONCLUSION

Mechanical, electrical, and environmental evaluations confirm that TE products can be successfully applied in BMC over-molding processes. However, overall performance is still influenced by molding conditions, including gate size and placement, as well as tooling pressure and velocity. The results presented here serve as general guidance for customers when defining their own over-molding processes.

For application-specific recommendations or design evaluations, please contact a TE Product Engineer.

CONNECT WITH US

We make it easy to connect with our experts and are ready to provide all the support you need.
Visit www.te.com/support to chat with a Product Information Specialist

Alvin Wang
Product Manager

Trevis L Benchoff
Senior Director Engineering

Tim Ding
Senior Manager Engineering

Justin Huang
Manager Engineer

Jimmy Zhang
Manager Engineer

Chunjie Hu
Senior Product Development Engineer

TE Connectivity
Connected Living Solutions

te.com/consumer-solutions-magnet-wire-campaign

02-26