

PHENOLIC MOLDING COMPOUNDS **Processing Guide**

Chemistry and Features: **PHENOLIC**

Phenolic molding compounds were first commercialized in the early 1900's and used in applications that require good heat resistance and good mechanical strength retention at elevated temperature. From this basic reaction with phenol and formaldehyde two distinct base resin systems can be produce:

- 1) Resole – This is known as a single stage resin system were the cure reaction takes place without the addition of cross linking agents.
- 2) Novolac – This is known as a two stage resin system were Hexamethylene Tetramine is used as the cross linking agent.

An extensive number of formulations have been derived from these base resin systems. These compounds, based on combinations of various reinforcements include; wood flour, mineral, cotton flock, chopped fabric, short glass, long glass, carbon fiber, Teflon and nylon were designed to meet specific application needs. These applications include knobs, handles and appliance bases for the wood flour filled compounds. Mineral and glass filled compounds are generally designed into high performance application such as electric motor commutators, brush holders and transmission components. Applications that require no ammonia out-gassing such as hermetically sealed devices and encapsulated switches and coils are best suited for a resole based compound.

Storage

Compounds based on Resole resin possess greater reactivity, and therefore cold storage of these materials is recommended. Normal storage life is about 12 months when kept at or below 40°F (4°C). The material should be brought to room temperature before containers are opened to prevent the

introduction of condensed moisture from the atmosphere.

Novolac compounds exhibit excellent shelf life under normal factory storage conditions, and no special precautions are necessary beyond keeping them in closed containers and avoiding exposure to temperatures over 90°F (32°C). Moldability and molded properties are generally not significantly affected for at least 1 year provided that the material is stored at or below 70°F (21°C).

Flow Rheology

Most SBNA phenolic molding compounds are designed to process well in compression, transfer and screw injection molding equipment. Compounds are available in a range of flows, from stiff for compression molding to softer grades for transfer and screw injection molding. Their plasticities can be measured by special molding procedures known as the Mesa Spiral Flow test (Figure 1), Cup Close Flow (Figure 2) and Orifice Flow (Figure 3) test. These melt flow tests provide an indication of the relative ability of the compound to flow and fill mold cavities.



Figure1: Mesa Spiral



Figure 2: Cup Close

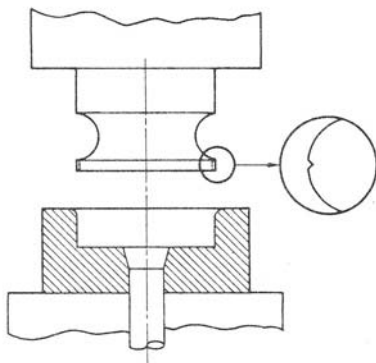


Figure 3: Orifice Flow

Preforming

Phenolic molding compounds can be charged directly into the mold cavity in loose form. This practice may be desirable in the case of single cavity compression molds for large components, additionally, oven preheating should be considered. The compound should be accurately weighed for each molding cycle.

For the production of small and medium-sized parts with multi-cavity compression molds or transfer molds, preforms are generally preferred. Preforms can be made into a variety of shapes and sizes by compaction of the molding material in a die. Preforms are easier to handle and can be more readily preheated than loosely packed bulk material.

Phenolic molding compounds can be preformed by any of the usual types of hydraulic or mechanical preforming presses.

Automatic performer machines require free-flowing granular compounds in order to maintain weight consistency and rapid cycles. Materials with the lowest bulk densities, such as those containing long glass fibers, cannot usually be preformed automatically in conventional equipment. These often require auxiliary feeding equipment or a manual weighing and pressing operation.

Preheating

The molding compounds should be heated before being loaded into the mold. This reduces the time required to bring the material to a plastic state and allows shorter molding cycles than are possible with cold material. Preheating can increase productivity by 20 to 40% depending on the geometry of the part and the material being molded. The preheated material also flows more easily and uniformly and generally requires less pressure to fill the cavity. Other benefits of preheating include smoother molded surfaces and enhanced physical properties.

The most commonly used preheating methods are dielectric (HF) heating of a densely packed preforms for phenolic resin based compounds. Screw plasticizing of phenolic molding compounds is also common place with multi-cavity transfer molding equipment. Air circulating oven preheating of loose granular material is also an option for applications when preformed material is not desired. Preheat temperature is one of the most critical molding parameters. The temperature should be optimized to provide the easiest flow. This usually means raising the temperature of the compound until obvious precure or short shots occur in molding, and then dropping back 10 to 15°F.

Molding Methods

In general, phenolic molding compounds are processed by conventional thermoset molding methods; compression, transfer or screw injection molding. Most thermoset molding machines are suitable for these materials without the need for special equipment.

Compression molding is a predominant method used with high bulk factor

compounds. This method is particularly useful for larger parts. Higher molded part strength and overall lower shrinkage rates may be somewhat lower than that of parts molded by the transfer method. The magnitudes of these differences are dependent on sprue, runner and gate design plus the flow pattern in the mold cavity.

In transfer molding, an optimally molded part requires complete cavity filling and adequate packing before gelation. Mold filling time should neither be too short to avoid trapping air nor overheating material through friction, nor too long, to avoid gelation before the cavity is completely packed. If molding conditions do not allow sufficient packing pressure, part strength will be compromised. Other properties including dimensions are affected by cavity packing pressure as well. The curing time should be long enough for the part to be ejected from the mold without distortion.

Mold cavities should be well polished and plated with hard chrome to ensure easy release. A draft of ½ degree on cavity surfaces that are perpendicular to the mold parting line will facilitate easy part demolding. All transfer molds must be properly vented at the parting line, and knock-out pins may need axial flat faces to provide more venting for deep recesses.

Suggested Start-Up Conditions

Molding conditions may vary depending on the shape of the part, mold design, and composition of the material. Suggested start-up conditions for Phenolic molding compounds along with approximate curing times and a trouble shooting guide are provided in Figures 4, 5, 6 and 7.

Postcuring and Degassing

Molded parts normally do not attain complete cure under standard process conditions. In most cases, conditions are established which produce an acceptable degree of cure and attendant physical properties when the parts are removed from the mold. It is not necessary to post-cure molded parts unless a specific application requires that resistance to high-temperature or chemical exposures be maximized or that the by-products of the curing initiators be driven off. The retention of physical properties at elevated temperatures is governed by the T_g . For maximum thermal stability and retention of physical properties at high temperatures, molded parts can be postcured. This should be performed in a forced-draft oven having good temperature control and outside venting.

Optimum postcuring conditions are determined by the specific application requirements. When determining the oven temperature cycle, it is important to note that lower temperatures generally result in less thermal stress and less discoloration of the part. Most cycles begin at 275°F (135°C) and the temperature is gradually raised to avoid exceeding the T_g . The rate of temperature rise should be as fast as permissible without visual signs of degradation such as blistering or cracking. A final oven temperature of 175°C is usually sufficient to complete the crosslinking reactions without significant discoloration. For applications requiring minimum outgassing, the final oven temperature should be at least equal to the maximum service temperature and the parts should be baked from 4 to 6 hours at this final temperature or until the rate of weight loss is negligible.

Technical Assistance: Please contact your Sumitomo Bakelite representative if technical assistance is desired.

Figure 7: Injection Molding Trouble Shooting Guide

	Non Fills	Porosity	Staining	Gas Burns	Parts Stick	Blisters	Warpage	Excessive Flash	Excessive Shrinkage	Erratic Injection	Nozzle Cure	Sprue Sticking
Injection Pressure	↑	↑			↓	↑	↑	↓	↑	↑		↓
Back Pressure (Plasticizing)		↓	↓			↑			↑		↓	
Clamp Pressure								↑				
Material Feed Setting	↑	↑				↑		↓				
Nozzel Temperature		↓								↓	↓	↑
Barrel Temperature										↓	↓	
Mold Temperature	↓	↓	↓	↓	↓	↑			↓			↑
Injection Pressure Time							↑					
Injection Hold Pressure Time									↑			
Cure Time			↑		↑	↑	↑		↑			↑
Screw Plastication Delay											↑	
Material Flow	↑						↓	↓		↓	↓	
Poillish Sprue Bushing												↑
Gates Size	↑					↑	↑					
Venting		↑	↑	↑		↑						
Injection Speed		↓		↓								
Polish Mold			↑		↑							