INTRODUCTION

Faced with legislative mandates requiring strict adherence to Corporate Average Fuel Economy (CAFE) standards, the automotive industry has been searching for means of improving the fuel efficiency of their fleet. Methods such as improving engine efficiency and design changes to give the best aerodynamic air flow have already been implemented. Another widely used approach is that of downsizing. As cars are made smaller, body weights decrease, improving fuel efficiency. However, to maintain adequate passenger comfort requirements in the interior of the vehicle, downsizing can only be carried to a practical limit.

To achieve further weight reductions of some 1000-1500 lbs., auto makers are considering tradeoffs to lower weight materials. Exterior automotive body panels are one such area where replacement of the traditionally stamped steel parts by plastic are being seriously considered. For example, a typical steel fender will weight 13 lbs. whereas a comparable plastic fender will weight only 6 lbs. Likewise, when one considers energy usage over the life of the part, including energy required to form the part, plastics once again emerge as clear winners. Potential automotive applications for plastic replacement parts include fenders, deck lids and door panels. Plastics for use in such applications must meet demanding requirements before their application can be considered. These include:

1. Sufficiently rigid to be self supporting.

2. Thermal dimensional stability to allow normal processing operations at elevated temperatures.
3. Low coefficient of thermal expansion (CTE).
4. Class A surface and good paintability.
5. Good impact characteristics at low temperature.

These requirements can be largely met by Reaction Injection Molded (RIM) polyurethanes. The rigidity requirement can be met in various ways. The part may be designed with ribs or other structural modifications so as to increase part stiffness. A higher modulus RIM system can be employed. Milled glass or other fillers can be added to the raw materials.

Low CTE is not inherent in polyurethanes. To achieve CTE's approaching that of aluminum \(27 \times 10^{-6} \text{ in/in, } ^\circ\text{F}\), milled glass or other fillers must be introduced into the polymer matrix. In an exterior body panel application this is a very key property which can be met by addition of fillers.

Class A surface and good paintability are properties inherent to RIM polyurethanes. Even the addition of various fillers presents no problem toward achieving this requirement.

Impact properties of RIM urethanes are also very good. While addition of fillers will give somewhat poorer impact properties, they will still be good.

This leaves only Thermal Dimensional Stability as a key requirement requiring development work. The following discussion will address itself primarily to RIM formulations having good thermal dimensional stability.

EARLY DEVELOPMENT

All major components comprising a RIM system were investigated with regard to thermal stability:

1. Chain extenders.
2. Polyol.
3. Isocyanate.

The most widely used chain extenders in RIM systems are butanediol and ethylene glycol. Both extenders were evaluated in terms of their thermal stability. It was found that ethylene glycol is superior to butanediol in terms of thermal stability. When using the heat sag test detailed later, systems containing butanediol consistently had much greater sag than samples prepared using ethylene gly-