Title: CAVITY SEALANT AND METHOD OF MAKING THE SAME

Abstract: A thermally flowable sealant (10) for sealing floor pan cavities (73) of motor vehicles is provided. The sealant (10) is vacuum-formed from a thermoplastic material utilizing a mold configured to provide a sealant (10) whose overall size and shape corresponds to that of the cavity (73) to be sealed. The formed sealant (10) is flexible and has a high tensile strength and a viscosity of at least about 2 x 10^4 cP when heated to a temperature of about 325 °F. In use, the sealant (10) is disposed within the subject cavity (73) where it is maintained by gravity during the various stages of the manufacturing process. When the sealant (10) is exposed to heat (e.g., such as during the powder bake stage of the automobile manufacturing process), it begins to flow under the force of gravity and in some embodiments moderately expand into the various crevices of the floor pan (71) structure forming the cavity (73) so as to seal the cavity (73).
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
FIELD OF THE INVENTION

The present invention relates generally to thermally flowable expandable sealants and thermally flowable non-expandable sealants used to seal cavities in floor pans of motor vehicles. More particularly, the sealants are vacuum-formed from a thermoplastic composition in shapes and sizes corresponding to the respective cavities in which they will be utilized. Upon thermal activation, the sealant will flow and expand so as to fill the crevices and contours of the surfaces defining the cavity as well as to cover and block all openings.

DESCRIPTION OF THE PRIOR ART

Motor vehicles such as minivans and SUV's commonly include at least one chair or bench seat which can be removed when necessary to provide additional cargo space. The floor pan of a vehicle equipped with this option generally includes at least two cavities formed therein, with the cavities being at least partially defined by respective opposing side margins. A so-called "seat striker" comprising an elongated bar or rod formed of a high-strength material (e.g., steel) extends between the opposing side margins. The base of the removable seat includes protruding locking mechanisms in locations which correspond to the locations of the cavities on the floor pan. To install the seat, it is positioned above the floor pan cavities so that one locking mechanism is partially inserted into each cavity and latched to the seat striker, thus removably attaching the seat to the floor of the motor vehicle in a secure and stable manner.

When motor vehicles containing this removable seat option were initially manufactured, the cavity did not include any type of seal. Thus, moisture and contaminants were allowed to enter the vehicle via the cavity, often causing corrosion to parts of the vehicle. Furthermore, the cavities allowed road noises to enter the vehicle, which is distracting and annoying to the vehicle occupants.

There have been attempts to mold parts via vacuum forming and injection molding. For example, some minivans include vacuum-formed sealants in their floor pan cavities. However, these prior art vacuum-formed and injection molded sealants are lacking in several ways. For example, the prior art sealants usually flow too much, resulting in a sealant having an uneven thickness or thinned areas. Conversely, the prior art sealants sometimes flow too little, resulting in a part that does not sufficiently seal the cavity. Furthermore, many prior art sealants shrink upon thermal exposure, leading
to a sealant which pulls away from the cavity walls leaving openings through which moisture and contaminants can enter. Finally, other prior art sealants expand excessively upon thermal exposure. When the sealant overly expands, it tends to interfere with normal operations of the seat striker and seat locking mechanism.

There is a need for floor pan cavity sealants which do not interfere with the seat striker while preventing moisture, contaminants, and noise from entering a vehicle.

SUMMARY OF THE INVENTION

The instant invention overcomes these problems by broadly providing a sealant which effectively seals floor pan cavities without interfering with seat strikers or other mechanisms.

In more detail, the sealant comprises a thermoplastic composition (e.g., an ethylene vinyl acetate-based composition preferably modified with an elastomer) which is formed into a size and shape corresponding to that of the cavity to be sealed. Preferably, this is accomplished by vacuum molding a sheet of the thermoplastic composition to obtain the final sealant, although injection molding of the sealant can be utilized instead.

In use, the sealant is positioned in the target cavity during manufacturing of the motor vehicle. In many applications, a striker rod is tangent to the floor pan and received within the cavity for securing a removable seat within the motor vehicle in cooperation with a locking mechanism on the base of the seat. In such instances, it is preferable that the sealant include openings therethrough corresponding to the size, shape, and location of the striker rod so that the sealant will not interfere with normal operation of the rod.

The positioned sealant is held in place by gravity and subjected to the various stages of the manufacturing process. Because the sealant is formed of a composition having an activation temperature of at least about 250°F, the sealant will not be affected by these manufacturing stages. The sealant will be activated at a pre-determined, specific point in the manufacturing process (e.g., such as during the paint or powder bake stage) where the sealant will be exposed to an elevated temperature for a predetermined period, for example, above 325°F for a period of about 20 minutes. Upon thermal exposure, the sealant will simultaneously flow under the force of gravity and may moderately expand into and against the cracks, crevices, corners, etc. of the structure defining the cavity. Additionally, due to the selection of the size and shape of the sealant, the material will flow over, and thus seal, all openings so as to prevent moisture, noise, and contaminants from entering the vehicle.
BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a vacuum-formed, floor pan sealant according to the invention;

Fig. 2 is an end view of the sealer of Fig. 1;

Fig. 3 is a side view of the sealer of Fig. 1;

Fig. 4 is a plan view of the sealer of Fig. 1;

Fig. 5 is a vertical cross-sectional view taken along line 5—5 of the sealer depicted in Fig. 4

Fig. 6 is a perspective view of a floor pan cavity to be sealed with the inventive sealer;

Fig. 7 is a plan view of the floor pan cavity of Fig. 6 having the inventive sealer of Fig. 1 disposed therein, after thermal exposure; and

Fig. 8 is a graph depicting the viscosity vs. temperature profile of the runs described in Example 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 1-5 illustrate a preferred cavity sealant according to the invention. The sealant 10 is a one-piece, flexible structure which is configured to correspond to the overall shape and size of the floor pan cavity in which it will be installed.

In more detail, the illustrated sealant 10 comprises a substantially rectangular lip 14 having upper and lower surfaces 16, 18 and inner and outer peripheries 20, 22. Sealant 10 further includes sidewalls 24a,b and endwalls 26a,b. Sidewalls 24a,b include respective leftward sections 28a,b, respective midsections 30a,b, and respective rightward sections 32a,b.

Each of sections 28a,b, 30a,b, and 32a,b extend in a downwardly sloping direction from inner periphery 20 of lip 14. Leftward sections 28a,b include upper sloping portions 34a,b and lower sloping portions 36a,b. Upper sloping portions 34a,b slope downwardly from inner periphery 20 at a substantially constant angle to respective diagonal ridges 38a,b where lower sloping portions 36a,b begin, slightly offset from the path of slope of portions 34a,b in a direction towards the opposing sidewall 24a or 24b. Likewise, rightward sections 32a,b include corresponding upper sloping portions 40a,b, lower sloping portions 42a,b, and intermediate diagonal ridges 44a,b. Midsections 30a,b have a substantially constant slope along their respective
lengths to the point of intersection of midsections 30a,b with leftward sections 28a,b and rightward sections 32a,b.

Endwalls 26a,b includes respective upright walls 46a,b and respective angled walls 48a,b. Upright walls 46a,b extend downwardly and substantially vertically from inner periphery 20 so that walls 46a,b are substantially parallel to one another. Angled walls 48a,b slope downwardly from upright walls 46a,b in a direction towards the opposing endwall 26a or 26b. Finally, endwalls 26a,b are joined with leftward sections 28a,b and with rightward sections 32a,b at respective rounded corners 50a-d.

Sealant 10 also includes a bottom portion 52. Bottom portion 52 comprises first and second ends 54, 56 separated by an opening 58. Referring to Figs. 1 and 4, each of ends 54, 56 include respective lower, flat portions 60a,b and respective raised ledges 62a,b. Ledges 62a,b comprise respective substantially horizontal, upper surfaces 64a,b and downwardly sloping bridges 66a,b. Finally, ledges 62a,b include respective sloped walls 68a,b which extend downwardly from upper surfaces 64a,b and bridges 66a,b to join ledges 62a,b with flat portions 60a,b and angled walls 48a,b of endwalls 26a,b. Sidewalls 24a,b and first and second ends 54, 56 cooperate to define the periphery 70 of opening 58.

The sealant 10 is preferably vacuum-formed from a starting thermoplastic composition. Vacuum molding is the preferred method (although injection molding is also acceptable and may be preferred in some applications) due to the ease of manufacturing and lower costs associated with vacuum forming. In the vacuum-forming process, from about 150-225 g of the starting material is pressed into a sheet having a thickness of from about 1.5-2.5 mm, and preferably about 2.0 mm. During pressing, it is preferred that the press platens have a temperature of from about 140-260°F, and more preferably about 200°F. Pressing is preferably carried out for a time period of from about 10-60 seconds, and preferably about 20 seconds, at a pressure of from about 6-12 tons/ft², and preferably about 10 tons/ft². The pressed sheet can either be formed into a sealant part immediately or can be stored for later use.

The pressed sheet is then placed over a mold having a cavity formed therein whose overall configuration is chosen according to the size and shape of the floor pan cavity in which the final sealant will ultimately be utilized. Next, the starting material is heated to a temperature above the softening point of the material (e.g., from about 140-260°F, and preferably about 200°F) while a vacuum of from about 6-12 psig, and preferably about 9 psig is applied to the mold. Thus, as the material softens, the vacuum pulls it into and along the crevices and contours of the mold. The molded material is then allowed to cool after which excess pieces are trimmed, and the final

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formed sealant removed from the mold.

Any thermoplastic material capable of being vacuum-formed can be utilized as the starting composition to form the inventive sealant 10. However, the material should be chosen so that the final sealant 10 exhibits certain physical properties, with one of the most preferred properties being controlled flow upon thermal exposure. That is, the formed sealant must be flowable at the desired bake stage. When heated to a temperature of about 325°F, the sealant should have a viscosity of from about 2 x 10⁴ - 1 x 10⁷ cP, and preferably from about 9 x 10⁴ - 8 x 10⁶ cP.

The final sealant may also have a low percent expansion (i.e., less than about 250%, preferably from about 50-150%) when heated to a temperature of about 325°F for about 30 minutes, wherein the percent expansion (as used herein) is defined as:

\[100 \times \frac{[(\text{specific gravity of the sealant 10 before heating}) - (\text{specific gravity of the sealant 10 after heating})]}{\text{(specific gravity of the sealant 10 after heating})}\].

In one embodiment, sealants which have the foregoing properties and controlled flow characteristics, and which expand only slightly upon heating, are preferably formed from a composition comprising a polymeric base which includes ethylene vinyl acetate (EVA) and an elastomer. The sealant composition should comprise from about 10-90% by weight EVA, and preferably from about 20-45% by weight EVA, based upon the total weight of the sealant composition taken as 100% by weight. The chosen EVA preferably has a melt index of from about 1-150 dg/min., and preferably from about 3-50 dg/min. (at an extrusion pressure of 2.16 kg and temperature of 190°C as defined by ASTM D-1238). The preferred EVA is from about 18-38% by weight vinyl acetate, and preferably from about 26-30% by weight vinyl acetate, based upon the total weight of EVA taken as 100% by weight.

In a particularly preferred embodiment, the sealant composition comprises a mixture of two EVA compounds, with the first EVA compound having an ASTM D-1238 melt index of from about 1-150 dg/min., preferably from about 6-10 dg/min., and the second EVA compounds having an ASTM D-1238 melt index of from about 1-150 dg/min., preferably from about 1-5 dg/min. When two EVA compounds are included in the sealant composition, the first EVA compound should be present at a level of from about 1-70% by weight, and preferably from about 10-55% by weight, and the second EVA compound should be present at a level of from about 1-65% by weight, and preferably from about 10-45% by weight, based upon the total weight of the sealant.
composition taken as 100% by weight. Preferred first and second EVA compounds for use in this embodiment are Elvax® 450 and Elvax® 265, respectively (available from DuPont).

The elastomer utilized in the sealant composition is preferably a cross-linked rubber (either chemically or physically cross-linked) and preferably has a glass transition temperature of at least about -29°C, preferably from about -40°C to about -70°C, and more preferably from about -50°C to about -60°C. The rubber should be included in the composition at a level of from about 5-25% by weight, and preferably from about 10-20% by weight, based upon the total weight of the sealant composition taken as 100% by weight. Preferred rubbers include copolymers of styrene, butadiene, and ethylene. Particularly preferred rubbers are styrene butadiene rubber (SBR) with a weight ratio of styrene to butadiene of from about 1:2.12 to about 1:4.39, and preferably from about 1:2.93 to about 1:3.58, and styrene ethylene butylene styrene rubber (SEBS) with a weight ratio of styrene to ethylene and butylene of from about 1:2.25 to about 1:2.65.

The sealant composition can also include other compounds as necessary to control or modify the properties of the final sealant part. For example, the sealant composition can include a colorant such as carbon black or carbon black dispersed in EVA (preferably with a carbon black to EVA ratio of about 1:1). The colorant should be present in the sealant composition at a level of up to about 2.0% by weight, and preferably from about 0.10-2.0% by weight, based upon the total weight of the sealant composition taken as 100% by weight.

Various types of fillers (e.g., calcium carbonate) can also be incorporated into the sealant composition. The sealant composition typically comprises from about 1-70% by weight filler, and more preferably from about 30-50% by weight filler, based upon the total weight of the sealant composition taken as 100% by weight. A wax can also be included in the sealant composition at a level of up to about 10% by weight wax, and preferably from about 2.5-7.5% by weight wax, based upon the total weight of the sealant composition taken as 100% by weight. Preferred waxes have a softening point of from about 70-130°C, and preferably from about 95-105°C.

Preferably, the sealant compositions further comprise from about 0.1-15% by weight, and preferably from about 2.5-7.5% by weight, of a tackifier which is preferably a hydrocarbon tackifying resin. The softening point of the tackifier is preferably from about 45-125°C, and more preferably from about 65-105°C.

The sealant composition should also contain a blowing agent. The blowing agent is preferably present in the composition at a level of up to about 2.0% by weight,
and preferably from about 0.10-0.75% by weight, with diazocarbonamide being the most preferred blowing agent. The sealant composition further comprises a system for activating the blowing agent. One preferred such system includes zinc oxide, stearic acid, and urea. The preferred concentrations of the activation system components are set forth in Table A.

Table A.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Broad Range&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Preferred Range&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>zinc oxide</td>
<td>up to about 5.0%</td>
<td>about 1.0-3.0%</td>
</tr>
<tr>
<td>stearic acid</td>
<td>up to about 5.0%</td>
<td>about 1.0-2.0%</td>
</tr>
<tr>
<td>urea</td>
<td>up to about 2.0%</td>
<td>about 0.10-0.75%</td>
</tr>
</tbody>
</table>

<sup>a</sup> Percent by weight, based upon the total weight of the sealant composition taken as 100% by weight.

An example of one such preferred material is SikaSeal 750 (available from Sika Corporation, Michigan).

In another embodiment, a sealant composition can be utilized which has controlled flow characteristics and essentially no expansion when heated to a temperature of about 325°F for about 20 minutes. This is accomplished by eliminating the blowing agent from the formulation. In this embodiment, the polymer system of the composition is an EVA-based system and can optionally be modified with a rubber (such as SBR or other styrene-based copolymers and terpolymers) as discussed above. As discussed above, mineral fillers can be used to reduce flow and waxes can be utilized to induce flow and to facilitate wetting. Finally, a tackifier is preferably included to improve adhesion to the various substrates. The preferred sealant composition according to this embodiment is formulated according to Table B.
Table B.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Broad Range&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Preferred Range&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVA&lt;sup&gt;b&lt;/sup&gt;</td>
<td>about 10.0-90.0%</td>
<td>about 30.0-75.0%</td>
</tr>
<tr>
<td>SEBS block polymer or SBR</td>
<td>up to about 20.0%</td>
<td>about 5-15.0%</td>
</tr>
<tr>
<td>Colorant&lt;sup&gt;c&lt;/sup&gt;</td>
<td>up to about 5.0%</td>
<td>about 0.1-2.0%</td>
</tr>
<tr>
<td>Fillers&lt;sup&gt;d&lt;/sup&gt;</td>
<td>up to about 70.0%</td>
<td>about 5.0-45.0%</td>
</tr>
<tr>
<td>Wax&lt;sup&gt;e&lt;/sup&gt;</td>
<td>up to about 15.0%</td>
<td>up to about 7.5%</td>
</tr>
<tr>
<td>Tackifier&lt;sup&gt;f&lt;/sup&gt;</td>
<td>up to about 20.0%</td>
<td>about 5.0-15.0%</td>
</tr>
</tbody>
</table>

<sup>a</sup> Percent by weight, based upon the total weight of the sealant composition taken as 100% by weight.

<sup>b</sup> Preferably the EVA comprises from about 18-38% by weight vinyl acetate and preferably from about 16-20% by weight vinyl acetate, based upon the total weight of the sealant composition taken as 100% by weight.

<sup>c</sup> Such as carbon black dispersed in EVA with a weight ratio of carbon black to EVA of about 2:1.

<sup>d</sup> Preferably calcium carbonate, talc, and/or silica.

<sup>e</sup> Preferably with a softening point of from about 70-130°C, and more preferably from about 95-105°C.

<sup>f</sup> Preferably a hydrocarbon tackifying resin.

In the case of an expandable material, the sealant composition is prepared in laboratory-scale by mixing all of the ingredients except the accelerator and blowing agent at elevated temperatures (e.g., at least about 200°F, and preferably at least about 220°F) until a substantially homogenous mixture is obtained. The mixture temperature is then lowered to about 150°F at which time the accelerator and blowing agent are added and mixing is continued. Once the mixture becomes homogeneous, the material is pressed into sheets, and the parts are then vacuum formed (Example 1 below provides a detailed description of this process).

In the production-scale preparation of an expandable material according to the invention, the sealant is compounded through a pelletization process. This process involves feeding the ingredients of the formulation into a continuous compounder which mixes the ingredients and pelletizes the material. Pellets can be prepared via strand pelletization or underwater pelletization processes. Pellets can be extruded into sheet stocks which can then be vacuum formed into the desired parts. In addition, pellets can be injection molded directly into the desired parts.

Referring to Fig. 6, a conventional floor pan 71 having a cavity 73 formed therein is depicted. Cavity 73 is defined by bottom surface 72, sidewalls 74a,b, and endwalls 76a,b. As illustrated, sidewalls 74a,b include varying contours and angles which result in a complex surface. Endwalls 76a,b include respective lips 80a and 80b (not shown) which extend downwardly from the floor plan 71. The lip 80a,b cooperate
with sidewalls 74a, b and bottom surface 72 to form openings 82a and 82b (not shown). If the cavity 73 is not properly sealed, openings 82a, b serve as a passageway for moisture, contaminants, noise, etc. to enter the motor vehicle from the outside.

Finally, a steel, rod-shaped seat striker 84 is fixedly secured to each of sidewalls 74a, b at striker base portions 86a, b. Striker 84 further comprises a horizontal upper bar 88 whose longitudinal axis is substantially perpendicular to sidewalls 74a, b. The removable seat or chair includes a locking mechanism which is secured around bar 88 and thus to striker 84.

In use, the sealant 10 is deposited into cavity 73 (preferably after E-coat bake and prior to the application of the powder primer coating), with seat striker 84 passing through opening 58 of sealant 10. Advantageously, there is no need to apply an adhesive strip or layer to the underside of lip 14 (or to any other part of the sealant 10) in order to improve adherence of the sealant 10 to the floor pan 71. Furthermore, unlike prior art sealants, it is not necessary to apply a coating to the outer surfaces of the sealant 10 in order to strengthen the sealant 10 and prevent collapsing during subsequent heat exposure.

Any of a number of process or manufacturing steps may be carried out on the vehicle body prior to thermal exposure of the sealant 10 without affecting the ability of the sealant 10 to flow, sag, and may very moderately expand. As the motor vehicle is baked and the sealant exposed to heat, the activation temperature of the sealant 10 is reached, the sealant 10 begins to flow and, by virtue of gravity combined with expansion (in instances where the sealant 10 is formed of an expandable composition), is substantially directed into all crevices and contours formed by the structure that defines cavity 73.

Referring to Fig. 7, it can be seen that, upon activation, the respective ledges 62a, b and endwalls 26a, b flow and "sag" towards openings 82a, b so as to create substantially flat, sealed portions 90a, b over openings 82a, b. Likewise, sidewalls 24a, b flow and adhere to cavity sidewalls 74a, b while lip 14 flows and forms a seal with the surfaces of floor pan 71 immediately adjacent cavity 73. Simultaneous to the above-described flowing, the sealant 10 may expand somewhat (in instances where the sealant 10 is formed of an expandable composition) to assist in forming an effective seal.

The seal formed between the sealant and the floor pan surfaces should be sufficiently strong so that moisture is substantially prevented from penetrating the seal. To determine whether leakage is substantially prevented by the seal, a top plate is secured to the upper portion of a floor pan having a cavity sealed according to the invention (after thermal activation). This assembly is then submerged in a water tank,
and the pressure in the tank is varied sequentially as follows:

(1) the pressure is increased to about 1 psig and held for about 2 minutes;

(2) the pressure is increased to about 2 psig and held for about 2 minutes; and

(3) the pressure is increased to about 3 psig and held for about 2 minutes.

During this test (hereinafter referred to as the "water pressure test"), essentially no water should enter the cavity through the portions sealed according to the invention.

Finally, although sealant 10 has been depicted and described as having a very specific size and shape, it will be appreciated that this size and shape were as chosen to correspond to the size, shape, contours, etc. of cavity 73 as well as the locations of openings 82a,b. Thus, the size and shape of sealant 10 can be modified as desired, depending upon the cavity in which it will be utilized.

There are other variations which can also be made to the instant invention. For example, the sealant can be vacuum-formed from two starting pieces formed of different materials. Additionally, a composition can be applied to the sealant prior to thermal exposure in order to assist in maintaining the thickness of the sealant walls upon activation. Such a chemical assist could include a composition that is coated or sprayed on the sealant as well as a material which is actually bonded (e.g., via pressure-sensitive adhesion) to the sealant.

EXAMPLES

The following examples set forth preferred compositions and methods in accordance with the invention. It is to be understood, however, that these examples are provided by way of illustration and nothing therein should be taken as a limitation upon the overall scope of the invention.

EXAMPLE 1

1. Preparation of Material

A sigma blade mixer (BP Processing, USA) was used to prepare the sealant composition. The mixer temperature was set to 220°F, and styrene-butadiene rubber (SBR 1009), ethylene vinyl acetate polymer (Elvax® 240), and carbon black filled ethylene vinyl acetate (B 22237 Black) were initially added to the mixer. Mixing was
commenced and continued until the mixture was homogeneous at which point the
temperature of the mixture was at least 220°F. Next, calcium carbonate (Quincy 325)
was slowly added in small increments. Mixing was continued until the mixture was
homogenous at which point the temperature of the material exceeded 250°F. Zinc
oxide, stearic acid, and hydrocarbon tackifying resin (Piccopale 100) were then added
to the mixer and mixing was recommenced and continued until the mixture was
homogenous. Finally, wax (Microsere 5999) was slowly added in small increments,
and the mixture was mixed for approximately 15 minutes until the mixture was again
homogenous. The material temperature was lowered to 150°F after which
diazocarbonamide (Unicell D 1100) and urea (BIK-OT) were added, and the material
was mixed until it was flux and uniform.

2. Preparation of Parts

Approximately 220 g of the material prepared in Part 1 above was pressed to a
thickness of 2.25 mm by platens heated to 200°F. The press was set to exert 10 tons/ft²
of pressure for 20 seconds. The heated sheet stock having a temperature of about 200°F
was immediately placed on the desired vacuum mold, a vacuum of 9 psig was drawn,
and the part was formed. The formed part was then hand-cut to the desired dimensions.

3. Evaluation of Molded Parts

The parts formed in Part 2 were tested. A mock cavity which very closely
reflected the actual application was prepared. Specifically, application segments of the
vehicle floor pan and rail were cut out in order to test the sealer. The floor pan was
clamped to the rail so that the opening in the floor pan lined up with the rail cavity, thus
providing an assembly comprising a floor pan segment forming a pocket over the rail
at the seat anchor position. The previously formed part was placed on the assembly so
that it fit snugly into the pocket. The entire assembly was then baked for 20 minutes
at 325°F in a forced air oven. To make certain that the material exhibited versatility in
fluctuations of time and temperature, the process was repeated on other parts with a
nominal bake of 15 minutes at 300°F (underbake) and a maximum bake of 45 minutes
at 375°F (overbake). Multiple cavities were baked to ensure that the material sealed
pockets having different depths and configurations.

After the part was baked, it was visually examined. It is important that the part
flow and seal the desired openings. At the same time the part must not flow so much
that the material thins and subsequently tears. After a visual inspection, the part was
tested for water leaks.
Two tests were used to ensure the part sealed the cavity completely - a water leakage test and a water pressure test. In the water leakage test, water was poured into the opening or cavity. If any water leaked, the seal was deemed to be inadequate. If water did not leak, the part was deemed to adequately seal the opening.

In the water pressure test, the fixture was placed in, and secured to, a water tank. Once firmly secured and attached to the tank, the water pressure of the tank was increased as follows, in order:

1. The pressure was increased to 1 psig and held for 2 minutes;
2. The pressure was increased to 2 psig and held for 2 minutes; and
3. The pressure was increased to 3 psig and held for 2 minutes.

If the part leaked the seal was deemed to be inadequate. If the seal remained essentially leak-free, the seal was deemed to be acceptable.

4. Test Properties of Molded Parts

Several physical properties of the formed parts were determined. These properties included specific gravity and volume expansion of the part, as well as the viscosity and modulus of the material of which the part was formed. Additionally, the adhesion to E-coat was tested after a 20-minute bake at 325°F. In the case of the adhesion test, a 1-inch x 10-inch sample was baked out on a 4-inch x 12-inch E-coat panel. After bake a 1-inch strip was cut across the material sample all the way through to the E-coat substrate. The strip was then pulled off with pliers, and the failure mode (adhesive/cohesive) noted.

EXAMPLE 2

Parts were prepared and tested following the procedures described in Example 1. The formulations followed are set forth in Table 1. The properties of each of these samples are set forth in Table 2.
Table 1

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>Run 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBR 1009</td>
<td>12.40%</td>
<td>14.93%</td>
<td>13.54%</td>
<td>11.28%</td>
<td>13.54%</td>
</tr>
<tr>
<td>Elvax® 240</td>
<td>37.00%</td>
<td>38.11%</td>
<td>34.55%</td>
<td>19.87%</td>
<td>17.27%</td>
</tr>
<tr>
<td>Elvax® 265</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>19.87%</td>
<td>17.27%</td>
</tr>
<tr>
<td>B22237 Black</td>
<td>1.60%</td>
<td>1.65%</td>
<td>1.49%</td>
<td>1.72%</td>
<td>1.49%</td>
</tr>
<tr>
<td>Microsere 5999</td>
<td>3.17%</td>
<td>3.26%</td>
<td>2.96%</td>
<td>3.40%</td>
<td>2.96%</td>
</tr>
<tr>
<td>Zinc Oxide</td>
<td>2.00%</td>
<td>2.06%</td>
<td>1.87%</td>
<td>2.15%</td>
<td>1.87%</td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>1.40%</td>
<td>1.44%</td>
<td>1.31%</td>
<td>1.50</td>
<td>1.31%</td>
</tr>
<tr>
<td>Piccopale 100</td>
<td>4.86%</td>
<td>5.01%</td>
<td>4.54%</td>
<td>5.22%</td>
<td>4.54%</td>
</tr>
<tr>
<td>Calcium Carbonate</td>
<td>37.00%</td>
<td>32.95%</td>
<td>39.21%</td>
<td>34.38%</td>
<td>39.22%</td>
</tr>
<tr>
<td>Unicell D1100</td>
<td>0.38%</td>
<td>0.39%</td>
<td>0.35%</td>
<td>0.41%</td>
<td>0.35%</td>
</tr>
<tr>
<td>BIK OT</td>
<td>0.19%</td>
<td>0.20%</td>
<td>0.18%</td>
<td>0.20%</td>
<td>0.18%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

*a Percent by weight of ingredient, based upon the total weight of all ingredients in the composition taken as 100% by weight.

Table 2

<table>
<thead>
<tr>
<th>Test Property</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>Run 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravitya</td>
<td>1.28</td>
<td>1.22</td>
<td>1.30</td>
<td>1.27</td>
<td>1.29</td>
</tr>
<tr>
<td>Percent Expansion</td>
<td>128.64%</td>
<td>134.89%</td>
<td>130.01%</td>
<td>119.55%</td>
<td>110.47%</td>
</tr>
<tr>
<td>Adhesion to E-coat</td>
<td>CFb</td>
<td>CF</td>
<td>CF</td>
<td>CF</td>
<td>CF</td>
</tr>
<tr>
<td>Water Leakage Test</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Water Pressure Test</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

*a Specific Gravity with reference to water.
b "CF" refers to cohesive failure meaning that the material itself failed rather than the adhesion between the material and the substrate.

EXAMPLE 3

1. Preparation of Material

A sigma blade mixer (BP Processing, USA) was used to prepare the sealant composition. The mixer temperature was set at 220°F, and styrene-ethylene-butylene-styrene block polymer (Kraton 1652), ethylene vinyl acetate polymer (Elvax® 450), ethylene vinyl acetate polymer (Elvax® 265), and carbon black filled ethylene vinyl
acetate (B 22237 Black) were initially added to the mixer. Mixing was commenced and continued until the mixture was homogeneous at which point the temperature of the mixture was at least 220°F. Next, precipitated silica (HiSil 233) was slowly added in small increments, and mixing was continued until the mixture was homogenous at which point the temperature of the material exceeded 250°F. A hydrocarbon tackifying resin (Wingtack 95) was added to the mixer, and mixing was recommenced. Mixing was continued until the mixture was homogenous, and a wax (Microsere 5999) was slowly added in small increments. The mixture was further mixed for approximately 15 minutes until the mixture was again homogenous.

This procedure was followed multiple times utilizing the formulations set forth in Table 3.

2. Part Preparation and Testing

The molded parts were prepared using the material prepared in Part 1 of this Example and following the procedures described in Part 2 of Example 1. The resulting parts were then tested as described in Part 3 of Example 1. The test results are set forth in Table 4. The viscosity of each part is depicted in Fig. 8, with the diamonds referring to Run 6, the squares referring to Run 7, and the inverted triangles referring to Run 8.
Table 3

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Run 6</th>
<th>Run 7</th>
<th>Run 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elvax® 265</td>
<td>10.00%</td>
<td>0.00%</td>
<td>10.00%</td>
</tr>
<tr>
<td>Elvax® 450</td>
<td>53.50%</td>
<td>47.00%</td>
<td>50.00%</td>
</tr>
<tr>
<td>Bynel E418b</td>
<td>0.00%</td>
<td>5.00%</td>
<td>11.00%</td>
</tr>
<tr>
<td>SBR 1009</td>
<td>0.00%</td>
<td>8.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Kraton 1652</td>
<td>10.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Quincy 325</td>
<td>0.00%</td>
<td>14.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Talc 9910c</td>
<td>0.00%</td>
<td>15.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Hisil 233</td>
<td>10.00%</td>
<td>0.00%</td>
<td>10.00%</td>
</tr>
<tr>
<td>B22237 Black</td>
<td>1.50%</td>
<td>1.00%</td>
<td>1.50%</td>
</tr>
<tr>
<td>Marcus 200d</td>
<td>0.00%</td>
<td>0.00%</td>
<td>5.00%</td>
</tr>
<tr>
<td>Be Square 195e</td>
<td>5.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Wingtack 95f</td>
<td>10.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Nevital 100f</td>
<td>0.00%</td>
<td>10.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Piccopale 100f</td>
<td>0.00%</td>
<td>0.00%</td>
<td>10.00%</td>
</tr>
<tr>
<td>Araldite GT9654e</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.50%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

*a Percent by weight of ingredient, based upon the total weight of all ingredients in the composition taken as 100% by weight.

*b Ethylene vinyl acetate grafted with maleic anhydride.

c Talc powder.

d Wax.

e Wax.

f Tackifier.

g Epoxy resin.
<table>
<thead>
<tr>
<th>Test Data</th>
<th>Run 6</th>
<th>Run 7</th>
<th>Run 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity*</td>
<td>0.98</td>
<td>0.98</td>
<td>1.23</td>
</tr>
<tr>
<td>Percent Expansion</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Adhesion to E-coat</td>
<td>CF</td>
<td>CF</td>
<td>CF</td>
</tr>
<tr>
<td>Water Leakage Test</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Water Pressure Test</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

* Specific Gravity with reference to water.
We Claim:

1. A method of sealing a cavity in a floor pan of a motor vehicle, said cavity having a size and shape, said method comprising the steps of:
   providing a sealant having a size and shape substantially corresponding to said cavity size and shape, said sealant being formed from a thermoplastic composition and having a viscosity of from about $2 \times 10^4 - 1 \times 10^7$ cP when heated to a temperature of about 325°F;
   positioning said sealant within said floor pan cavity; and
   heating said sealant positioned within said cavity to a temperature of at least about 250°F so as to cause said sealant to soften and sag within said cavity.

2. The method of claim 1, wherein said cavity is defined by a pair of sidewalls, and a rod is secured to at least one of said sidewalls.

3. The method of claim 2, wherein said sealant includes an opening therethrough configured to receive said rod during said sealant positioning step.

4. The method of claim 2, wherein said rod is configured to cooperate with a locking mechanism on a seat so as to removably secure said seat to said floor pan.

5. The method of claim 1, wherein said heating step comprises heating said sealant to a temperature of at least about 300°F so as to cause said sealant to expand, said sealant having a percent expansion of less than about 250% during said heating step.

6. The method of claim 1, wherein said composition comprises EVA.

7. The method of claim 6, wherein said composition comprises a crosslinked rubber.

8. The method of claim 6, wherein said EVA has an ASTM D-1238 melt index of from about 1-150 dg/min.
9. The method of claim 6, wherein said EVA comprises from about 18-38% by weight vinyl acetate, based upon the total weight of the composition taken as 100% by weight.

10. The method of claim 6, wherein said composition comprises from about 10-90% by weight EVA, based upon the total weight of the composition taken as 100% by weight.

11. The method of claim 7, wherein said composition comprises from about 5-25% by weight rubber, based upon the total weight of the composition taken as 100% by weight.

12. The method of claim 7, wherein said rubber is SBR.

13. The method of claim 12, wherein said SBR has a weight ratio of styrene to butadiene of from about 1:2.12 to about 1:4.39.

14. The method of claim 7, wherein said rubber comprises a terpolymer of styrene, butylene, and ethylene.

15. The method of claim 14, wherein said terpolymer has a styrene to ethylene and butylene weight ratio of from about 1:2.25 to about 1:2.65.

16. The method of claim 6, wherein said composition comprises from about 0.1-15.0% by weight of a tackifier, said percent by weight being based upon the total weight of the composition taken as 100% by weight.

17. The method of claim 1, wherein said composition comprises:
   from about 10-65% by weight EVA;
   from about 5-25% by weight of a cross-linked rubber;
   from about 0.1-15% by weight of a tackifier;
   from about 0.1-2.0% by weight of a blowing agent;
   from about 1-70% by weight of a filler; and
   up to about 10% by weight of a wax.
18. The method of claim 1, wherein said composition comprises:
   from about 10-90% by weight EVA;
   up to about 20% by weight of a cross-linked rubber;
   up to about 5.0% by weight of a colorant;
   up to about 70% by weight of a filler;
   up to about 20% by weight of a tackifier; and
   up to about 15% by weight of a wax.

19. In combination, a floor pan including structure defining a cavity therein,
    and a sealant disposed in said cavity, said cavity having a size and shape and said
    sealant being configured to substantially conform to said cavity size and shape, said
    sealant being formed from a thermoplastic composition and having a viscosity of from
    about $2 \times 10^4 - 1 \times 10^7$ cP when heated to a temperature of about 325 °F.

20. The combination of claim 19, said floor pan further comprising a rod
    secured to said cavity-defining structure.

21. The combination of claim 20, wherein said sealant includes an opening
    therethrough and said rod is received by said opening.

22. The combination of claim 20, wherein said rod is configured to
    cooperate with a locking mechanism on a seat so as to removably secure said seat to
    said floor pan.

23. The combination of claim 19, wherein said composition comprises EVA.

24. The combination of claim 23, wherein said composition comprises a
    crosslinked rubber.

25. The combination of claim 23, wherein said EVA has an ASTM D-1238
    melt index of from about 1-150 dg/min.

26. The combination of claim 23, wherein said EVA comprises from about
    18-38% by weight vinyl acetate, based upon the total weight of the composition taken
    as 100% by weight.
27. The combination of claim 23, wherein said composition comprises from about 10-90% by weight EVA, based upon the total weight of the composition taken as 100% by weight.

28. The combination of claim 24, wherein said composition comprises from about 5-25% by weight rubber, based upon the total weight of the composition taken as 100% by weight.

29. The combination of claim 24, wherein said rubber is SBR.

30. The combination of claim 29, wherein said SBR has a weight ratio of styrene to butadiene of from about 1:2.12 to about 1:4.39.

31. The combination of claim 24, wherein said rubber comprises a terpolymer of styrene, butylene, and ethylene.

32. The combination of claim 31, wherein said terpolymer has a styrene to ethylene and butylene weight ratio of from about 1:2.25 to about 1:2.65.

33. The combination of claim 23, wherein said composition comprises from about 0.1-15.0% by weight of a tackifier, said percent by weight being based upon the total weight of the composition taken as 100% by weight.

34. The combination of claim 19, wherein said composition comprises:

   from about 10-65% by weight EVA;
   from about 5-25% by weight of a cross-linked rubber;
   from about 0.1-15% by weight of a tackifier;
   from about 0.1-2.0% by weight of a blowing agent;
   from about 1-70% by weight of a filler; and

   up to about 10% by weight of a wax.
35. The combination of claim 19, wherein said composition comprises:
   from about 10-90% by weight EVA;
   up to about 20% by weight of a cross-linked rubber;
   up to about 5.0% by weight of a colorant;
   up to about 70% by weight of a filler;
   up to about 20% by weight of a tackifier; and
   up to about 15% by weight of a wax.

36. A sealant presenting an outer surface and having a size and shape
    substantially conforming to the size and shape of a cavity to be sealed by the sealant,
    said sealant being formed from a thermoplastic composition comprising EVA, having
    a viscosity of from about $2 \times 10^5$ - $1 \times 10^7$ cP when heated to a temperature of about
    325°F, and being free of a coating layer on its outer surface.

37. The sealant of claim 36, wherein said composition comprises a
    crosslinked rubber.

38. The sealant of claim 36, wherein said EVA has an ASTM D-1238 melt
    index of from about 1-150 dg/min.

39. The sealant of claim 36, wherein said EVA comprises from about 18-
    38% by weight vinyl acetate, based upon the total weight of the composition taken as
    100% by weight.

40. The sealant of claim 36, wherein said composition comprises from about
    10-90% by weight EVA, based upon the total weight of the composition taken as 100%
    by weight.

41. The sealant of claim 37, wherein said composition comprises from about
    5-25% by weight rubber, based upon the total weight of the composition taken as 100%
    by weight.

42. The sealant of claim 37, wherein said rubber is SBR.
43. The sealant of claim 42, wherein said SBR has a weight ratio of styrene to butadiene of from about 1:2.12 to about 1:4.39.

44. The sealant of claim 36, wherein said composition comprises from about 0.1-15.0% by weight of a tackifier, said percent by weight being based upon the total weight of the composition taken as 100% by weight.

45. The sealant of claim 36, wherein said composition comprises:
   from about 10-65% by weight EVA;
   from about 5-25% by weight of a cross-linked rubber;
   from about 0.1-15% by weight of a tackifier;
   from about 0.1-2.0% by weight of a blowing agent;
   from about 1-70% by weight of a filler; and
   from about 2.5-7.5% by weight of a wax.

46. The sealant of claim 36, wherein said composition comprises:
   from about 10-90% by weight EVA;
   up to about 20% by weight of a cross-linked rubber;
   up to about 5.0% by weight of a colorant;
   up to about 70% by weight of a filler;
   up to about 20% by weight of a tackifier; and
   up to about 15% by weight of a wax.

47. The sealant of claim 37, wherein said rubber comprises a terpolymer of styrene, butylene, and ethylene.

48. The sealant of claim 47, wherein said terpolymer has a styrene to ethylene and butylene weight ratio of from about 1:2.25 to about 1:2.65.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

- IPC(7) : B29C 65/00
- US CL : 156/212, 245, 285, 309.6; 106/33

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

- U.S. : 156/212, 245, 285, 309.6; 106/33

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 3,872,548 A (BRYANT et al.) 25 March 1975 (25.03.1975), entire patent.</td>
<td>1-48</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,276,082 A (FORRY et al.) 04 January 1994 (04.01.1994), column 2, lines 17-55, column 3, lines 14-60.</td>
<td>1-48</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,731,069 A (DELLE DONNE et al.) 24 March 1998 (24.03.1998), column 5, line 20 to column 7, line 50.</td>
<td>1-48</td>
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<tr>
<td>Y</td>
<td>US 4,379,190 A (SCHENCK) 05 April 1983 (05.04.1983), entire patent.</td>
<td>1-48</td>
</tr>
</tbody>
</table>

[ ] Further documents are listed in the continuation of Box C.  [ ] See patent family annex.

**Special categories of cited documents:**

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

**Date of the actual completion of the international search**

05 July 2001 (05.07.2001)

**Date of mailing of the international search report**

01 Aug 2001

**Name and mailing address of the ISA/US**

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Form PCT/ISA/210 (second sheet) (July 1998)