

**Eastoflex™**  
**amorphous polyolefins (APOs)**  
*in hot-melt sealant applications*



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# Eastoflex™ amorphous polyolefins (APOs)

## *in hot-melt sealant applications*

Eastoflex™ amorphous polyolefins have many attractive properties which make them useful in producing hot-melt sealants. Eastoflex APOs are low molecular weight propylene copolymers (APP) or propylene-ethylene copolymers (APE) characterized by low color, ease of processing, chemical inertness, and good adhesion to many of the common substrates encountered in sealant applications. The desirable properties of Eastoflex APOs for sealant applications include:

- High water resistance—Eastoflex APOs are highly hydrophobic and produce excellent sealing against moisture transmission as well as being highly resistant to extraction by water.
- Chemical inertness—Eastoflex APOs are not reactive in most conditions, especially towards oxidation and degradation due to UV light exposure. Additionally Eastoflex APOs are insoluble in many common solvents and only sparingly soluble in most organic solvents.<sup>a</sup>
- Ease of processing—Eastoflex APOs are all thermoplastic polymers with relatively low melt viscosity. In hot-melt sealant productions, Eastoflex APOs produce reductions in melt viscosity as well as reductions in mixer energy requirements and mixing times when used to partially replace other polymers with higher molecular weight and melt viscosity.
- Creep and sag resistance—Even though grades of Eastoflex APOs are available with very low melt viscosities, they do not cold-flow or sag like other low molecular weight polyolefins such as polyisobutylene and ethylene-propylene copolymers.
- Good adhesion—Eastoflex APOs have excellent adhesion properties to many commonly used building materials such as glass, aluminum, and wood.
- Low color—Eastman APOs have low initial color and exhibit very little color change with long-term exposure to oxygen and UV light.

<sup>a</sup> See Eastman publication WA-50, Solubility of Eastoflex™ amorphous polyolefins in various solvents.

## Eastoflex APO product range

Eastman employs a unique production facility to make Eastoflex™ amorphous polypropylene (APP) and amorphous propylene-ethylene (APE) copolymers. The typical properties of the five base polymers produced in Eastman's facility, located in Longview, Texas, are described in Table 1. The values shown in Table 1 and Figures 1 and 2 are for typical properties, included for information only, and cannot be used for setting purchase specifications. Eastman will provide manufacturing specifications for any material supplied as well as Certificates of Analysis for any shipment of Eastoflex™ amorphous polyolefin. However, Eastman makes no representation that the material in any particular shipment will conform exactly to the values shown.

These five grades are maintained in bulk molten form and can be blended in any proportions to produce custom grades on demand. This unique APO blending capability allows great flexibility in the ability to supply Eastoflex™ amorphous polyolefins with properties that precisely match the requirements of a particular application. For sealant applications, this means that Eastman has the capability of producing blends customized to a particular recipe, finished product specification, or processing window for a particular type of mixing equipment with very low lead time.

Advanced mixing technology and mathematical modeling systems allow the plant to use these five base polymers in two- or three-component blends. The predicted viscosity vs. softening point and  $T_g$  vs. needle penetration relationships across the existing range of blending capabilities are shown in Figures 1 and 2.

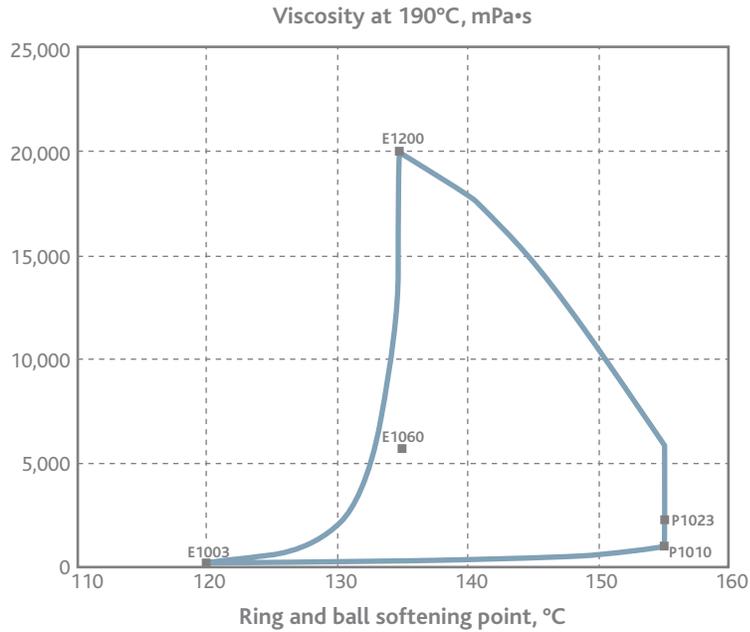
**Table 1**

Typical properties of the five base grades of Eastoflex™ amorphous polyolefins

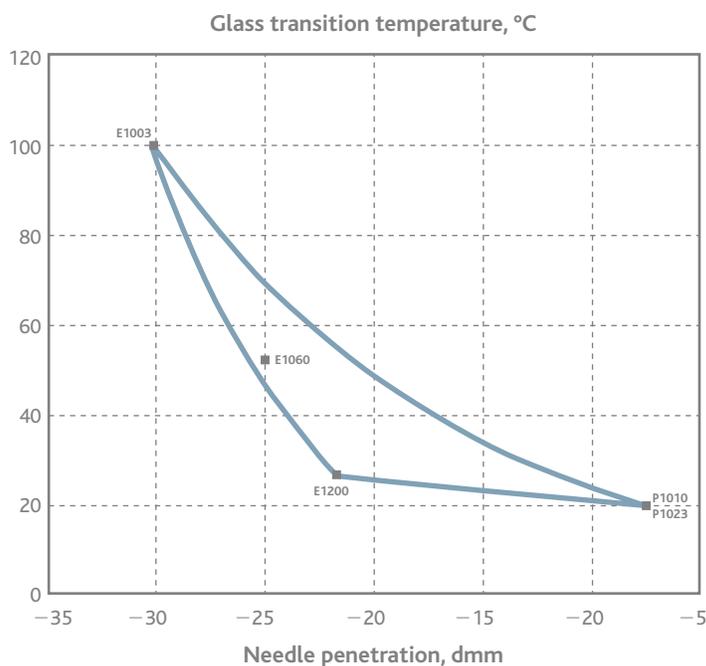
Product property	ASTM test method	Eastoflex P1010	Eastoflex P1023	Eastoflex E1003	Eastoflex E1060	Eastoflex E1200
Brookfield viscosity at 190°C, cps (mPa·s)	D3236	1,000	2,300	300	6,000	20,000
Ring and ball softening point, °C	E28	155	155	120	135	135
Needle penetration, dmm	D5	20	20	100	35	30
Glass transition temperature (T <sub>g</sub> ), °C	D3418	-10	-10	-33	-23	-22

**Figure 1**

Viscosity vs. ring and ball softening point blending space bounded by the Eastoflex APO base grades



**Figure 2**  
**Glass transition temperature vs. needle penetration**  
**blending space bounded by the Eastoflex APO base grades**



For sealant applications, the major defining characteristics distinguishing APP and APE are that APPs have higher softening points, greater heat resistance, a narrow range of viscosities, low tack, greater resistance to penetration, and a  $T_g$  of  $-15^\circ\text{C}$ . APEs have lower softening points, less heat resistance, a wide viscosity range, greater tack, less resistance to penetration, and a  $T_g$  as low as  $-33^\circ\text{C}$  (depending on the grade). For sealants requiring high load-bearing capabilities, resistance to high temperatures, and greater penetration resistance, the use of Eastoflex APP is indicated. If the application requires low temperature resistance and high adhesion, the use of Eastoflex APE types is preferred.

**PHYSICAL FORM**—Eastoflex amorphous polyolefins are available for molten bulk delivery within the continental U.S.A. Most products are also available in pellet form supplied in 50-lb (22.7-kg) bags. Most grades are available in two treatments to avoid clumping or blocking. Eastoflex APOs denoted with “PL” are pellets produced with an antiblocking coating. This coating produces the freest-flowing pellets of material but may present difficulty in melting in some equipment. If indicated, Eastoflex APOs denoted with “PL-1” are produced with polyethylene powder which melts at a lower temperature but provides less resistance to blocking. For more information on handling Eastoflex amorphous polyolefins, consult publication WA-35 *Bulk Handling and Storage of Molten Eastoflex™ Amorphous Polyolefins*.

### Eastoflex APO as a partial elastomer replacement in hot-melt sealants

Most hot-melt sealants use various types of olefinic elastomers as the polymeric base for the system. These can be but are not limited to butyl rubber, styrenic block copolymers, polyisobutylene, ethylene-propylene copolymers, and EPDM. Table 2 shows how Eastoflex APOs can be used to replace part of the butyl rubber or styrene-ethylene-butene-styrene (SEBS) block copolymer in sealant formulas. These example formulas use Eastoflex P1023 APP or Eastoflex E1060 APE to replace up to 50% of the butyl rubber in typical formulas. The use of Eastoflex APO improves hardness, and increases adhesion and tensile strength compared to the control formulas. References for the components used are shown in the Appendix.

**Table 2****Partial replacement of butyl rubber elastomers with Eastoflex APO in hot-melt sealants**

Formula number	1	2	3	4	5	6	7	8	9
DESCRIPTION	Butyl-SEBS Low fill control	50:50 Butyl: APP Low fill	50:50 Butyl: APE Low fill	Butyl-SEBS control High fill	50:50 Butyl: APP High fill	50:50 Butyl: APE	Butyl only control	60:40 Butyl: APP	60:40 Butyl: APE
COMPONENTS									
Kraton™ G1652 SEBS[a]	10	10	10	10	10	10	—	—	—
Kalar™ 5214[b]	10	5	5	10	5	5	—	—	—
Lanxess 301 butyl[c] <sup>1</sup>	—	—	—	—	—	—	25	15	15
Eastotac H-130E[d]	20	20	20	20	20	20	30	30	30
Omycarb™ 3[e]	17.5	17.5	17.5	27.5	27.5	27.5	20.5	20.5	20.5
Ti-Pure™ R-101[f]	6	6	6	6	6	6	—	—	—
ZnO[g]	6	6	6	6	6	6	—	—	—
Indopol™ H-300[h]	30	30	30	20	20	20	—	—	—
Indopol™ H-1900[h]	—	—	—	—	—	—	24	24	24
Irganox™ 1010[i]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Eastoflex P1023 APP[d]	—	5	—	—	5	—	—	10	—
Eastoflex E1060 APE[d]	—	—	5	—	—	5	—	—	10
TEST PROPERTIES									
Needle penetration, <sup>2</sup> dmm	54	47	64	41	31	31	55	46	50
Initial 180° peel adhesion, <sup>3</sup> pli Average (std. dev.)	27 (3)	25 (1)	15 (0.7)	17 (3)	53 (12)	41 (12)	19 (3) <sup>4</sup>	20 (3) <sup>4</sup>	19 (2) <sup>4</sup>
Fail mode	Adh.	Coh.	Coh.	Adh. <sup>5</sup>	Adh.	Coh. <sup>6</sup>	Coh.	Coh.	Coh.
21-Day water immersion 180° peel adhesion, pli Average (std. dev.)	24 (5)	23 (6)	17 (3)	—	—	—	—	—	—
Fail mode	Adh.	Coh.	Coh.	—	—	—	—	—	—
Tensile strength, <sup>7</sup> psi Average (std. dev.)	191 (42)	218 (14)	226 (14)	—	—	—	—	—	—

[a–k] See the Appendix for description and supplier information

<sup>1</sup>As-is this uncured butyl rubber will not produce sufficient cohesion for this application. To produce sufficient properties, a cure system comprised of 1.5 phr sulfur, 1.0 phr Methyl Tuads[j], and 1.0 phr Ethyl Sellenac[j] or an equivalent system should be added along with the first charge of the elastomers.

<sup>2</sup>Per ASTM[k] Method D1321. Results expressed in tenths of a millimeter.

<sup>3</sup>Sealants were applied to cold-rolled steel test panels at 177°C (250°F) at 20-mils thickness using a Hardman hot-melt sealant applicator. Strips of heaving 1-inch-wide cotton webbing were then laminated to the sealant using a hot press at 177°C. Samples were aged for 7 days at room temperature before testing in an Instron tensile tester.

<sup>4</sup>T-peel adhesion, ASTM[k] Method C906, aluminum substrate

<sup>5</sup>Adh.—is adhesive failure (compound pulls cleanly away from the steel surface.)

<sup>6</sup>Coh.—is cohesive failure (compound splits between steel plate and cotton webbing). Average results compiled from five specimens of each compound tested.

<sup>7</sup>Per ASTM Method D623.

The formulations shown in Table 2 were all prepared in a 5-liter capacity laboratory sigma-blade mixer at 350°F (177°C). The elastomers were added first and masticated until they were completely mixed and heated to 350°F. The hydrocarbon tackifying resin, antioxidant, and fillers were then added in a second charge, followed by the polybutene. The entire batch was then mixed for 1 hour to ensure thorough dispersion of all components.

The first observation to make from the testing of the experimental sealants shown in Table 1 is that the use of Eastoflex APO to partially replace butyl rubber is not detrimental to the properties with the exception of the needle penetration measured for Formula 3. This is a significant observation since Eastoflex APO is less expensive than butyl rubber, so formulas 2, 3, 5, 6, 8, and 9 all are lower cost than the control formulas 1, 4, and 7.

In the first set of three formulas, half of the butyl rubber was replaced by Eastoflex APO. The needle penetration hardness was lower than the control for Formula 2 and higher for Formula 3. This is not surprising since Eastoflex E1060 is a much softer material than Eastoflex P1023, so it is expected that the compound using APE would be softer.

The initial peel adhesion for Formula 3 is significantly lower than that of the control or Formula 2, but after 21-day water immersion, the variability of the results has widened to the point that the differences are no longer significant. It is also notable that while the peel adhesion compared between the first three formulas is not significantly different, the failure mode for both Formulas 2 and 3 is cohesive compared to adhesive failure for the control. This is important because cohesive failure is a requirement included in many sealant specifications.

When part of the polybutene is replaced by calcium carbonate filler in formulas 4–6, the formulas made with Eastoflex APO are clearly superior to the control. The needle penetration of Formulas 5 and 6 are 10 dmm lower than the control, which is desirable. The peel adhesions for both formulas 5 and 6 are significantly higher than the control, Formula 4. It is also important to note that the additional filler used between control Formulas 1 and 4 causes a significant drop in adhesion compared to Formulas 5 and 6 which have significantly better adhesion than either of the controls or Formulas 2 and 3. This is interesting because the use of APO coupled with an increase in filler loading both represent cost reductions compared to the Formula 1 control.

Formulas 7–9 demonstrate the use of APO in a simplified system containing only butyl rubber with no block copolymer or pigments. The results show that using either APP or APE in the compound both result in properties unchanged compared with the control. In this case, 40% of the cross-linked butyl rubber was replaced with APO, and the needle penetration and T-peel adhesion were not significantly different than the control. Since APO is significantly less expensive than butyl rubber, the APO-modified versions should be lower cost than the control using only cross-linked butyl rubber.

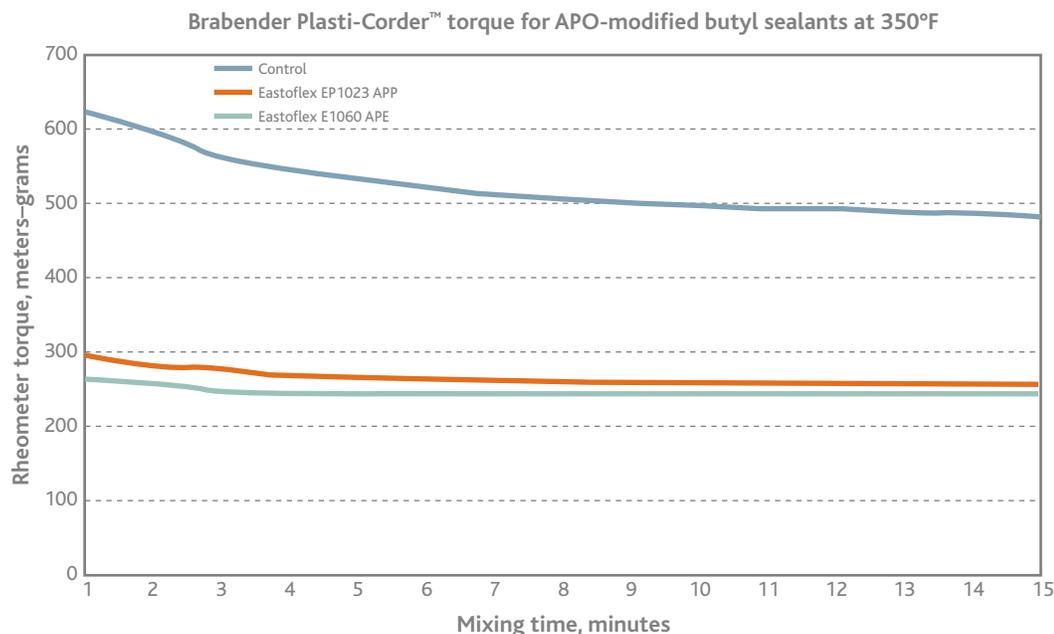
## Processing energy and mixing time reduction using Eastoflex APO as a partial elastomer replacement

In preparing the compounds detailed in Table 2, it was noted that using APO appeared to make processing easier as well as apparently drawing less motor power to perform the mixing. To quantify this difference, the formulas shown in Table 2, numbers 7–9 were measured using a Brabender Plasti-Corder™[1] rheometer to measure the torque required over 15 minutes of mixing. The results are shown in Figure 3. The results demonstrate that replacing 40% of the cross-linked butyl rubber with Eastoflex APO significantly reduces the torque required to mix the compound. In production, this indicates that using Eastoflex APO as part of the elastomer system for a hot-melt sealant should reduce the energy requirements for mixing. It also suggests that the mixing time could be reduced since the compounds with Eastoflex APO reach an equilibrium viscosity in about 5 minutes compared to about 12 minutes for the control compound.

The conclusion that can be drawn from these experiments is that Eastoflex™ amorphous polyolefins can be successfully used in place of up to 50% of the butyl rubber in hot-melt sealant applications without any sacrifice in properties. There does not appear to be a significant difference between the amorphous propylene homopolymer and propylene-ethylene copolymer, however, there may be requirements for specific applications beyond the scope of this study, which might indicate the use of one grade of APO versus another.

**Figure 3**

**Brabender Plasti-Corder™ torque for APO-modified butyl sealants at 350°F**



## Replacement of polyisobutylene with Eastoflex amorphous polyolefins

Low molecular weight isobutylene polymers (PIB) have been commonly used in sealants for insulated glass and window glass bedding applications. PIB has many properties that indicate its use in window sealants such as low temperature flexibility, high resistance to oxidation and UV light degradation, and water impermeability. Since Eastoflex™ amorphous polyolefins also possess these properties, it follows that APO could be used in this application in place of polyisobutylene with the advantage of lower cost. In particular, Eastoflex E1003 amorphous propylene-ethylene copolymer (APE) is especially interesting to evaluate because it is distinct among the portfolio of amorphous polyolefins due to its low melt viscosity and low glass transition temperature. Among the available APO products, Eastoflex E1003 has properties closest to those of the PIB grades used in window sealant. The formulas shown in Table 3 demonstrate the use of Eastoflex E1003 in insulated glass sealants and window bedding compounds compared to Vistanex™ LM-MH[m] PIB. Physical and adhesive

property testing results indicate that the formulations containing Eastoflex E1003 APE have slightly lower tensile strength and lap shear compared to those made with PIB, while peel adhesion, volatility, moisture vapor transmission rate, and UV weathering results show improved properties for the APE formulas compared to PIB. The results for glass transition temperature ( $T_g$ ) measurement do not show an identifiable trend between APE and BIB. The  $T_g$  for the insulated glass sealant made with Eastoflex E1003 is higher than the compound made with PIB, whereas the trend is reversed for the window bedding compound. The difference may be attributed to the greater complexity of the insulated glass sealant formula where there are interactions between elastomers, tackifier, and plasticizer compared to only the APO or BIB determining the  $T_g$  of the window bedding compound. The conclusion to be drawn from these experiments is Eastoflex E1003 APE can successfully be used to replace Vistanex™ LM-MH polyisobutylene in hot-melt sealants.

**Table 3****Hot-melt sealant formulations comparing Eastoflex E1003 amorphous propylene-ethylene copolymer to polyisobutylene**

COMPONENTS, wt%	Insulated glass sealant		Window bedding compound	
Eastoflex E1003 APE[d]	14	—	35	—
Vistanex™ LM-MH PIB[L]	—	14	—	35
Kalar™ 5217 butyl rubber[b]	21	21	—	—
Calcium carbonate[e]	25	25	60	60
Eastotac H130L[d]	35	35	—	—
Indopol™ H-1900[h]	5	5	—	—
HiSil™ 233[n]	—	—	5	5
Irganox™ 1010[i]	0.5	0.5	0.1	0.1
PHYSICAL PROPERTIES				
Needle penetration, dmm <sup>1</sup>				
Initial	37	30	38	44
7 days 1t 140°F (60°C)	36	28	45	42
Tensile strength, psi <sup>2</sup>	7	13	—	—
Percent elongation	961	13	—	—
Volatility at 220°C 1 hour, %	0.46	0.56	0.40	0.34
Standard deviation	0	0	0.07	0.04
Moisture vapor transmission rate, g/m <sup>2</sup> /24 hours <sup>3</sup>	13.02	20.85	—	—
DMA Glass transition temperature, °C	-17	-23	-31	-24
ADHESIVE PROPERTIES				
Lap shear, mPa <sup>4</sup>	0.15	0.25	—	—
Standard deviation	0.03	0.04	—	—
Failure mode	Cohesive	Cohesive	—	—
180° peel adhesion, g/mm <sup>5</sup>				
Aluminum to glass	—	—	149	121
Standard deviation	—	—	4.4	7.5
Failure mode	—	—	Cohesive	Cohesive
1,000 hour carbon-arc Weather-O-Meter™[o] aging, <sup>6</sup> appearance	No cracks, slight yellowing	Chalking, strong yellowing	No cracks, slight yellowing	Cracking

[a-o] See the Appendix for descriptions and supplier contact information.

<sup>1</sup>ASTM Method D1321

<sup>2</sup>ASTM Method D412

<sup>3</sup>ASTM Method E96

<sup>4</sup>ASTM Method C961

<sup>5</sup>ASTM Method C794

<sup>6</sup>ASTM Method C793

## Partial replacement of SEBS block copolymer in a hot-melt sealant

It is also possible to formulate a sealant with only styrene-ethylene-butylene-styrene (SEBS) block copolymer elastomer. The advantages of using only SEBS are greater UV resistance, lower application viscosity, and shorter mixing cycles by avoiding the need to cure butyl rubber during mixing. It is possible to replace up to 50% of the SEBS block copolymer in such a formula with Eastoflex™ amorphous polyolefins and maintain or improve on the

performance of the hot-melt sealant. Table 4 shows a comparison of hot-melt sealants using only Kraton™ G-1652 SEBS as the elastomer, and replacement of 50% of the SEBS with Eastoflex P1032 APP or Eastoflex E1060 APE. The tests show that the use of APO to replace part of the SEBS results in some increase in needle penetration and maintaining or increasing adhesion to metal. Eastoflex P1023 APP appears to improve adhesion and Eastoflex E1060 appears to produce results similar to the control formula.

**Table 4**  
Partial replacement of SEBS elastomer with Eastoflex™ amorphous polyolefins in a hot-melt sealant formulation

Ingredients, wt%	Control	Eastoflex P1023	Eastoflex E1060
Kraton™ G-1652[a] SEBS	20.0	10.0	10.0
Eastotac H-130E[d]	20.0	20.0	20.0
Indopol™ H-300[h]	30.0	30.0	30.0
Omyacarb™ 3[e]	17.5	17.5	17.5
Ti-Pure™ R-101[f]	6.0	6.0	6.0
Zinc oxide[g]	6.0	6.0	6.0
Irganox™ 1010[i]	0.5	0.5	0.5
Eastoflex P1023[d]	—	10.0	—
Eastoflex E1060[d]	—	—	10.0
<b>TEST PROPERTIES</b>			
Needle penetration, dmm <sup>1</sup>	32	39	43
Initial peel adhesion, g/mm <sup>2</sup>	196	375	161
Standard deviation	36	36	71
Failure mode	Adhesive	Cohesive	Cohesive
12-day water immersion, g/mm	179	375	161
Standard deviation	36	89	54
Failure mode	Adhesive	Cohesive	Cohesive

[a-o] See the Appendix for descriptions and supplier contact information.

<sup>1</sup>ASTM Method D1321[o]

<sup>2</sup>See footnote 2, Table 2 for test description.

## Conclusion

Eastoflex™ amorphous polyolefins have many properties that make them attractive materials for sealants. Amorphous polyolefins resist water, oxidation, and degradation by UV light exposure. They are low viscosity thermoplastic polymers which are easy to handle and can decrease energy consumption by reducing both motor power and mixing cycle times. Eastoflex APOs are low in color, odor, and volatility. Eastoflex APOs are also compatible with many of the olefinic components commonly used in sealant applications such as butyl rubber, SEBS block copolymers, and polyisobutylene elastomers.

Amorphous polyolefins are also relatively low in cost with stable raw material supplies compared to other elastomers used in hot-melt sealant formulations. All of these properties suggest that Eastoflex amorphous polyolefins are well suited for sealant applications. This publication demonstrates the use of Eastoflex APOs in six different types of formulas and shows that the use of amorphous polyolefins either maintains or improves the performance compared to the control compositions. The examples shown here are only an introduction to the possibilities of formulating hot-melt sealants using Eastoflex APOs. Eastman's ability to produce custom-blended APOs tailored to a specific application makes Eastoflex™ amorphous polyolefins uniquely positioned to serve the hot-melt sealant industry. Eastman stands ready to assist in formulation requirements through any of our global sales organizations in the locations shown on the back of this publication.

**To find out more about Eastoflex™ amorphous polyolefins, contact your Eastman representative or visit [www.eastoflex.com](http://www.eastoflex.com).**

## Appendix Materials and equipment references

- [a] Styrene-ethylene—butylene-styrene block copolymer—Kraton Polymers LLC, Houston TX, U.S.A.—[www.kraton.com](http://www.kraton.com)
- [b] Cross-linked butyl elastomer—Royal Elastomers, South Bend, IN, U.S.A.—[www.royalelastomers.com](http://www.royalelastomers.com)
- [c] Butyl rubber—Lanxess Corporation, Cologne, Germany—[www.lanxess.com](http://www.lanxess.com)
- [d] Amorphous polyolefins, hydrogenated hydrocarbon resins—Eastman Chemical Company, Kingsport, TN, U.S.A.—[www.eastman.com](http://www.eastman.com)
- [e] Calcium carbonate filler—Omya AG Oftringen, Switzerland—[www.omya.com](http://www.omya.com)
- [f] Titanium dioxide pigment—I. E. DuPont de Nemours Co. Wilmington, DE, U.S.A.—[www2.dupont.com/Titanium\\_Technologies/en\\_US/](http://www2.dupont.com/Titanium_Technologies/en_US/)
- [g] Zinc oxide pigment—U.S. Zinc Division of Votorantim Metais, Votorantim, São Paulo, Brazil—[www.uszinc.com](http://www.uszinc.com)
- [h] Polybutene oligomeric plasticizer—Ineos Oligomers, Rolle, Switzerland—[www.ineos.com/en/businesses/INEOS-Oligomers/](http://www.ineos.com/en/businesses/INEOS-Oligomers/)
- [i] Antioxidant—BASF, Ludwigschafen, Germany—[www.basf.com/group/corporate/en/brand/IRGANOX](http://www.basf.com/group/corporate/en/brand/IRGANOX)
- [j] Rubber processing chemicals—R. T. Vanderbilt Holding Company, Inc. Norwalk, CT, U.S.A.—[www.rtvanderbilt.com/](http://www.rtvanderbilt.com/)
- [k] Standards available from ASTM International, W. Conshocken, PA, U.S.A.—[www.astm.org](http://www.astm.org)
- [l] Recording rheometer—C. W. Brabender Co. S. Hackensack, NJ, U.S.A.—[www.cwbrabender.com/](http://www.cwbrabender.com/)
- [m] Polyisobutylene elastomer—BASF, Ludwigschafen, Germany—[www.basf.com/group/corporate/en/brand/VISTANEX](http://www.basf.com/group/corporate/en/brand/VISTANEX)
- [n] Fumed silica filler—PPG Silica Products—Pittsburgh, PA, U.S.A.—[www.ppg.com/specialty/silicas](http://www.ppg.com/specialty/silicas)
- [o] Controlled environmental exposure equipment—Atlas Material Testing Solutions—Chicago, IL, U.S.A.—[www.atlas-mts.com](http://www.atlas-mts.com)



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