Eastoflex Amorphous Polyolefins (APOs) as Bitumen Modifiers in Roofing Formulations

Eastoflex amorphous polyolefins (APOs) are noncrystalline polymers. Characterized by consistent quality, they exhibit low odor, good heat stability, and low initial color. In addition, they are compatible with a wide range of elastomers, polymers, and tackifying resins.

In addition to their use as asphalt modifiers in modified bitumen roofing, *Eastoflex* APOs find application in many other areas such as waterproofing compounds for wire and cable applications; elastomer extenders in caulks and sealants; and base polymers in hot melt adhesives and paper laminating. They can be processed using standard extrusion or roll-coating equipment.

History of APO Production at Eastman

Commercial production of amorphous polypropylene began in 1960 at Eastman's Texas Eastman Division in Longview, Texas. These polymers were by-products of Eastman's process for making isotactic polypropylene (IPP). Over the years, these materials proved to be useful as asphalt modifiers for modified bitumen roofing in addition to other uses.

However, as Eastman's catalyst technology improved, the production efficiency of IPP increased, resulting in the elimination of the amorphous by-products. In 1985, the Company responded to this shortfall by bringing new capacity on-stream to produce *Eastoflex* APOs, not as by-products, but by direct synthesis. This new process allowed for the production of amorphous polyolefins on demand, independent of Eastman's facilities for producing crystalline materials.

The first product from this new process was M-5H, which is now identified as *Eastoflex* P1023. This material, an amorphous polypropylene (APP), has a high softening point and is quite hard for an amorphous polymer. These are important characteristics in a modifier for roofing asphalt.

In 1986, Eastman Chemical Company began producing an amorphous propylene-ethylene copolymer (APE). Initially designated M-5F, this product is now known as *Eastoflex* E1060. It is softer, lower in softening point, and more flexible than *Eastoflex* P1023. Flexibility is another important requirement in a roofing asphalt modifier. Accordingly, in 1987, Eastman introduced custom blends of P1023 and E1060 to provide a balance of properties tailored to meet customers' end-use requirements.

Eastoflex Amorphous Polyolefin Blending Capability

As part of a continuing effort to integrate manufacturing capabilities with customer needs, Eastman Chemical Company has expanded the breadth and flexibility of its *Eastoflex* APO product line. The homopolymer and propylene-ethylene copolymer portions of this line are united in a five-component tank farm strategy.

Typical properties of the five APOs that currently serve as neat blending stocks are shown in Table 1.

Properties shown in tables contained in this publication are for information only. Eastman Chemical Company makes no representation that the material in any particular shipment will conform exactly to the values shown.

Advanced mixing technology and mathematical modeling allows the plant to use these five blending stocks in two- or three-component blends. The predicted viscosity vs. softening point and T_g vs. needle penetration relationships are shown in Figures 1 and 2.

Table 1 **Typical Properties of Five Neat APO Blending Stocks**

	P1010	P1023	E1060	E1003	E1200
Brookfield Viscosity @ 190°C, cP	1,000	2,300	6,000	300	20,000
Ring and Ball Softening Point, °C	155	155	135	120	135
Needle Penetration, dmm	20	20	35	100	30
Glass Transition Temperature (T_g), °C	−10	−10	−23	−33	−22

Figure 1

Viscosity vs. Ring and Ball Softening Point for APO Tank Farm Formulas

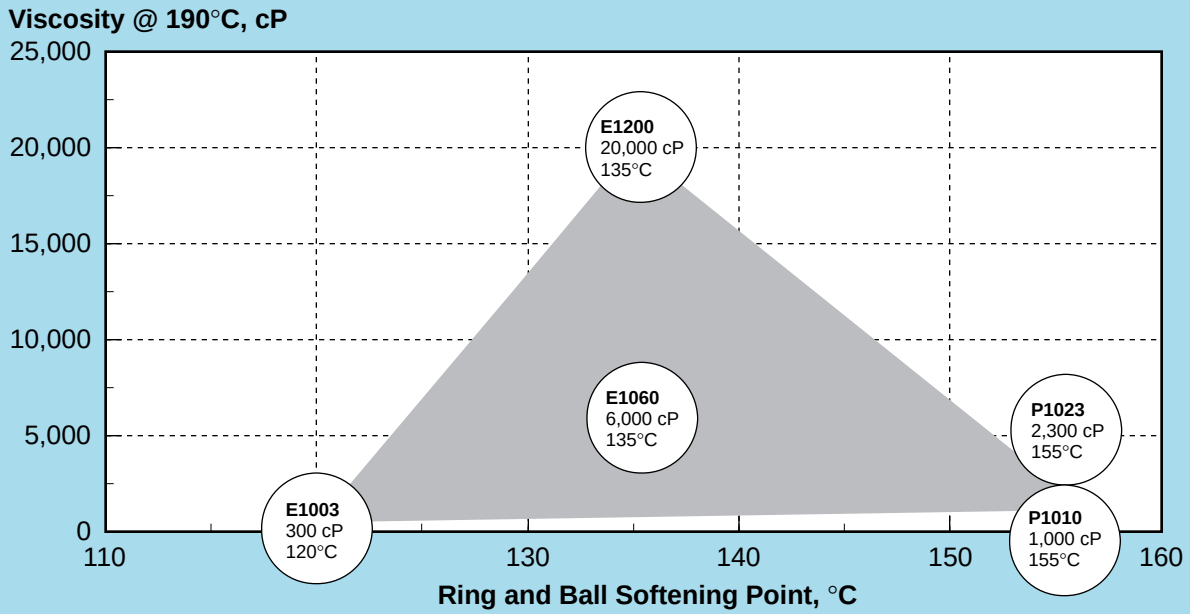
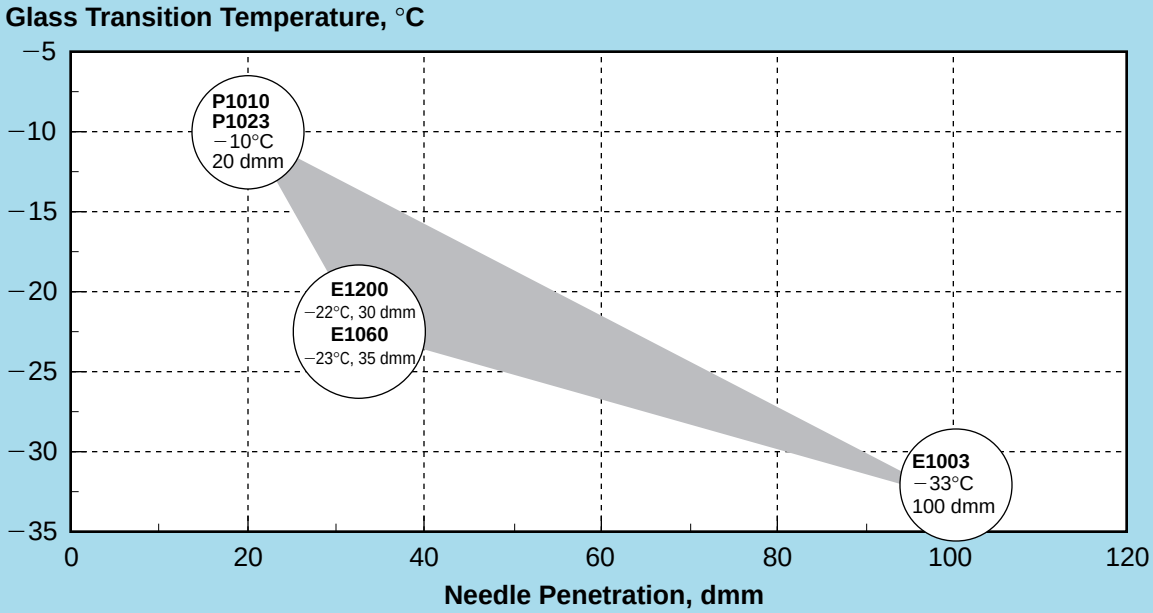


Figure 2

T_g vs. Needle Penetration for APO Tank Farm Formulas



Accelerated Weathering Study on *Eastoflex* APO-Modified Roofing Compositions

Samples of several asphalt roofing blends were made containing various levels of *Eastoflex* E1060, an amorphous propylene-ethylene copolymer (APE).

All blends contained 15% calcium carbonate and 4% 20 flow rate, isotactic polypropylene (IPP). The remainder of each blend was composed of AC-5 asphalt and *Eastoflex* E1060. APO levels from 14% to 24% were used in this test.

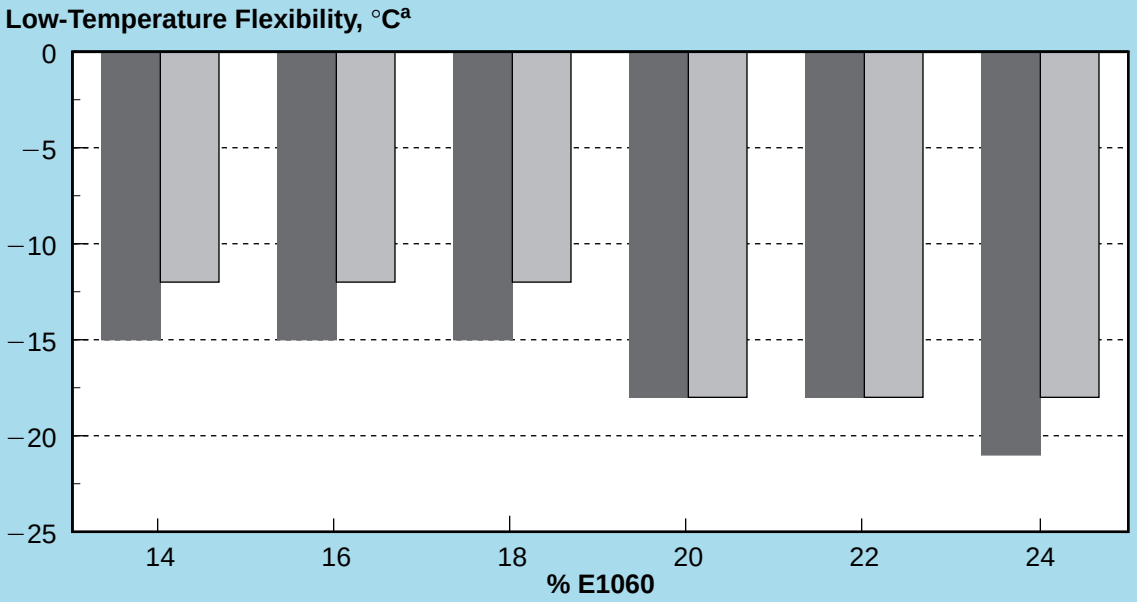
Each sample was evaluated initially for viscosity, needle penetration, and low-temperature flexibility.

Stability to ultraviolet light was determined by exposing the samples in a carbon-arc *Weather-Ometer* for 1,000 hours per ASTM D 1499. Each sample was then retested for low-temperature flexibility. The flexibility temperature of these samples was found to have changed no more than 3°C. These results are shown in Table 2 and Figure 3.

Table 2 **Effect of Accelerated Aging on APO-Modified Roofing Compositions**

Component	Weight %					
E1060	14	16	18	20	22	24
Isotactic Polypropylene, 20 Flow Rate	4	4	4	4	4	4
Calcium Carbonate	15	15	15	15	15	15
AC-5 Asphalt	67	65	63	61	59	57
Initial Properties						
Viscosity @ 190°C, cP	1,025	1,075	1,290	1,800	2,100	2,375
Needle Penetration, dmm	41	38	35	39	33	31
Low-Temperature Flexibility, °C	−15	−15	−15	−18	−18	−21
Flexibility After 1,000 hr in a Carbon-Arc *Weather-Ometer* per ASTM D 1499						
Low-Temperature Flexibility, °C	−12	−12	−12	−18	−18	−18

Figure 3 **Ultraviolet Stability of *Eastoflex* E1060-Modified Asphalt Blends**



Initial
After 1,000 hr UV aging

[a]*90°, 2-sec bend*

Blends contain:
AC-5 asphalt (57%–67%)
Isotactic polypropylene, 20 flow rate (4%)
Calcium carbonate (15%)

Properties of *Eastoflex* APO-Modified Bitumen Roofing Compositions

In another test, several blends were made to determine the range of physical properties available when using various *Eastoflex* APOs as roofing asphalt modifiers.

The blends were made using *Eastoflex* P1023 (APP), E1060, and E1200 (APEs). Each blend contains either APP, APE, or a combination of both. Typical properties of the APOs used in this study are shown in Table 3.

Physical properties such as viscosity, softening point, needle penetration, and low-temperature flexibility were measured for each formulation. The results of these tests are shown in Table 4.

Table 3 **Typical Properties of APOs Used in Blend Study**

	P1023	E1060	E1200
Brookfield Viscosity @ 190°C, cP	2,300	6,000	20,000
Ring and Ball Softening Point, °C	155	135	135
Needle Penetration, dmm	20	35	30
Glass Transition Temperature (T_g), °C	−10	−23	−22

Composition of Blends in Table 4 and Figures 4–9

Component	Wt %
Eastoflex APO from Eastman	20
Exxon AC-5 asphalt	60
Tenite P4-027 polypropylene homopolymer from Eastman	5
Calcium carbonate	15
Total	100

Table 4 **Physical Properties of APO-Modified Roofing Compositions**

APO Component	Ring and Ball Softening Point °C	Needle Penetration dmm	Viscosity @ 190°C cP	Low-Temperature Flexibility[a] °C
1 20% E1200	154	25	2,395	−29
2 20% E1060	153	35	1,730	−21
3 20% P1023	153	25	1,225	−9
4 5% P1023, 15% E1060	153	35	1,505	−18
5 10% P1023, 10% E1060	153	30	1,405	−21
6 10% P1023, 10% E1200	154	24	1,915	−21
7 5% P1023, 15% E1200	153	24	2,030	−23

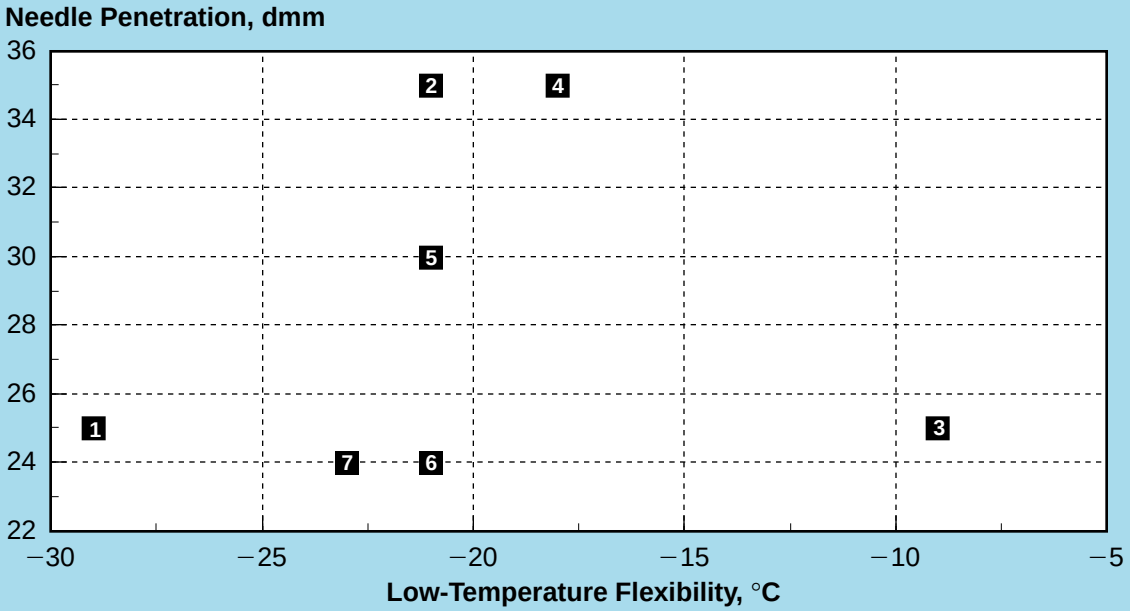
[a] *108°, 7-sec bend*

Needle penetration vs. low-temperature flexibility and needle penetration vs. viscosity graphs are shown in Figures 4 and 5. These graphs represent the range in hardness, flexibility, and viscosity of all the *Eastoflex* APO-modified roofing blends made in this study.

Figure 6 is a graph of softening point vs. percent copolymer. This graph shows that the softening point of each APO-modified asphalt blend is greater than 150°C.

Because the isotactic polypropylene dominates the softening point of the blends, the type of APO used has little or no effect on the softening point of the final blend.

Figure 4 **Needle Penetration vs. Low-Temperature Flexibility[a] of *Eastoflex* APO-Modified Asphalt Blends**

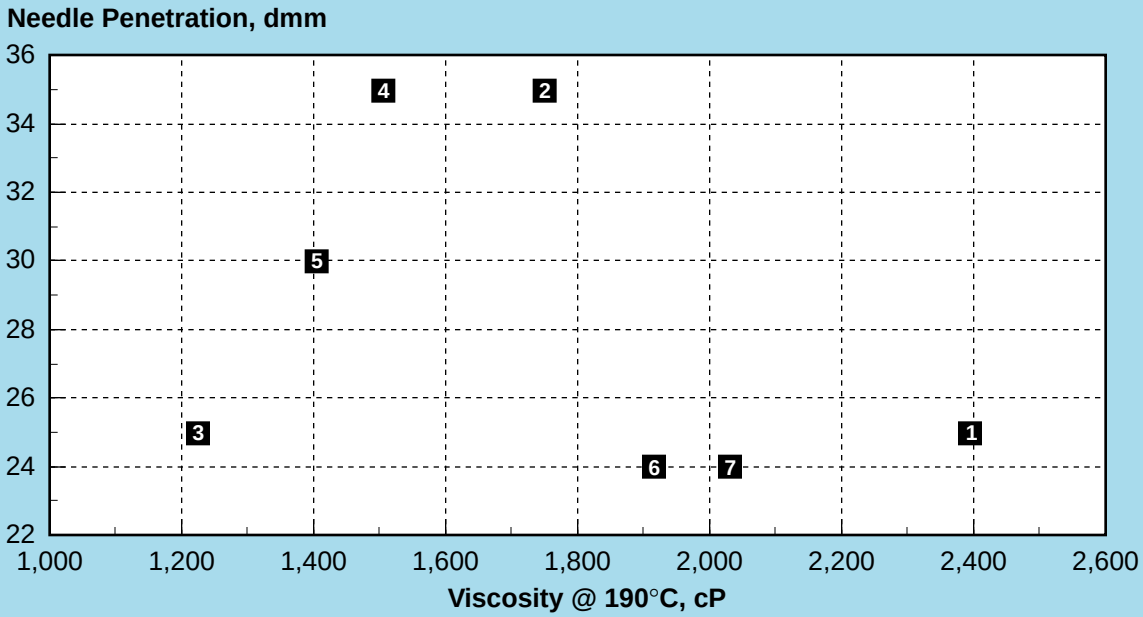


[a] *108°, 7-sec bend*

Note: Refer to Table 4 for corresponding APO components.

Figure 5

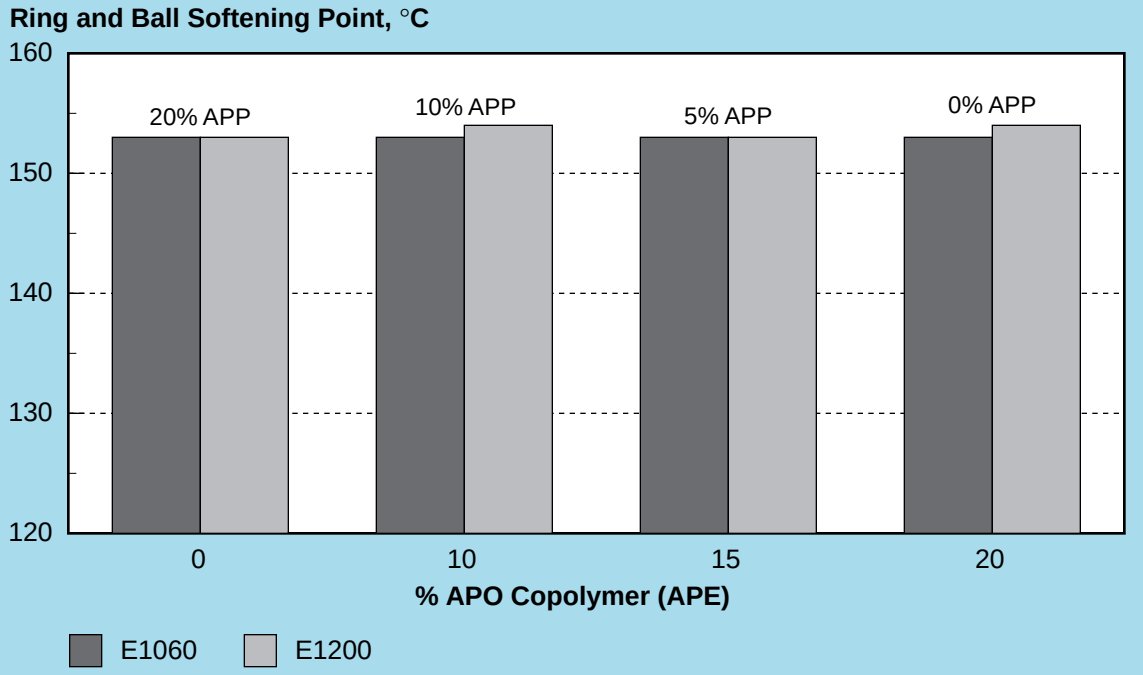
Needle Penetration vs. Viscosity of *Eastoflex* APO-Modified Asphalt Blends



Note: Refer to Table 4 for corresponding APO components.

Figure 6

Softening Point vs. % Copolymer of *Eastoflex* APO-Modified Asphalt Blends



Figures 7, 8, and 9 show viscosity vs. percent copolymer, needle penetration vs. percent copolymer, and low-temperature flexibility vs. percent copolymer.

These figures show that by increasing the amorphous propylene-ethylene copolymer (APE) component, an increase in viscosity and flexibility of the blend is achieved along with a reduction in hardness.

Figure 7 **Viscosity vs. % Copolymer of *Eastoflex* APO-Modified Asphalt Blends**

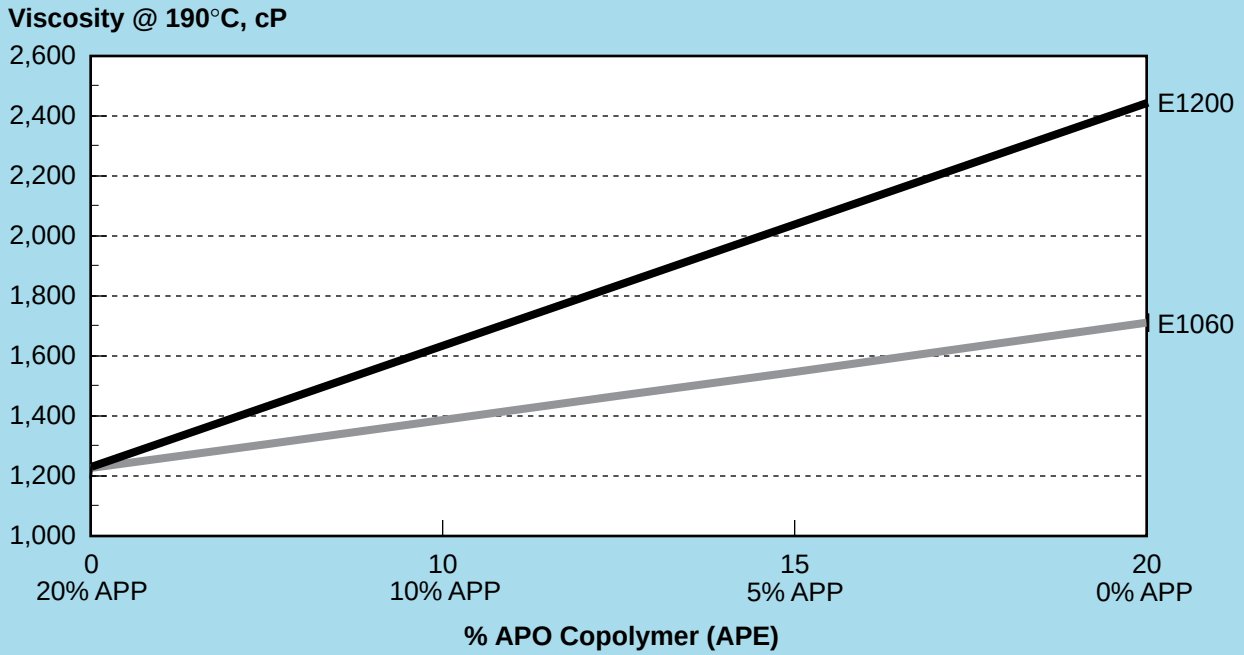


Figure 8

Needle Penetration vs. % Copolymer of *Eastoflex* APO-Modified Asphalt Blends

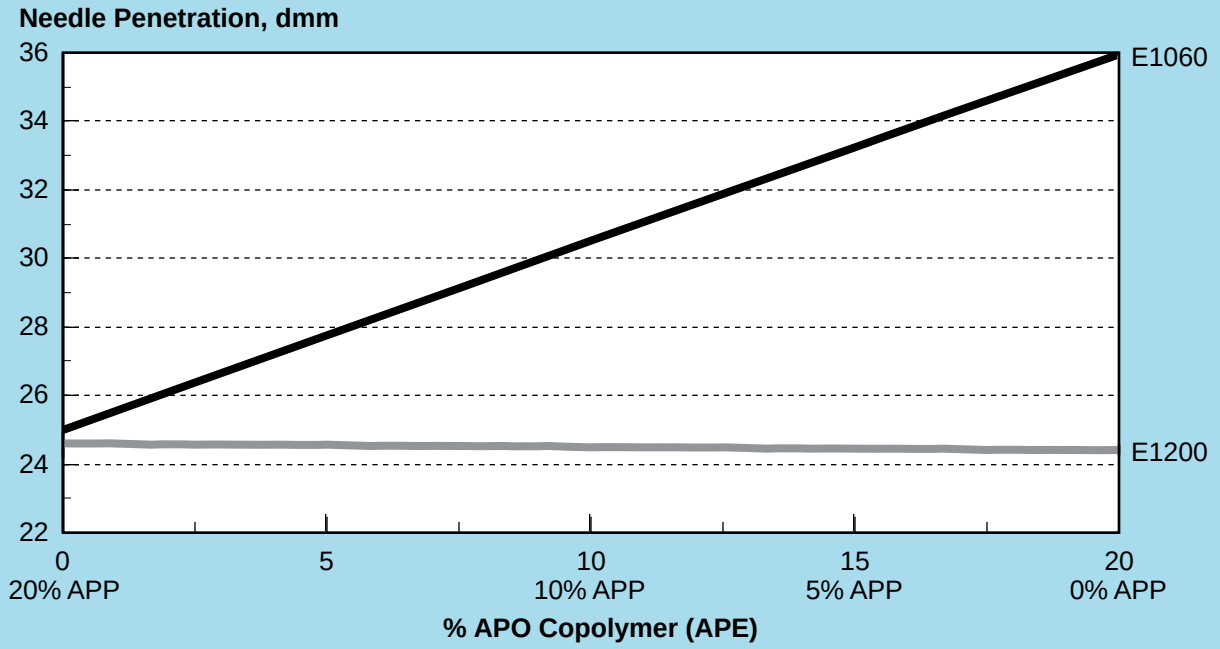
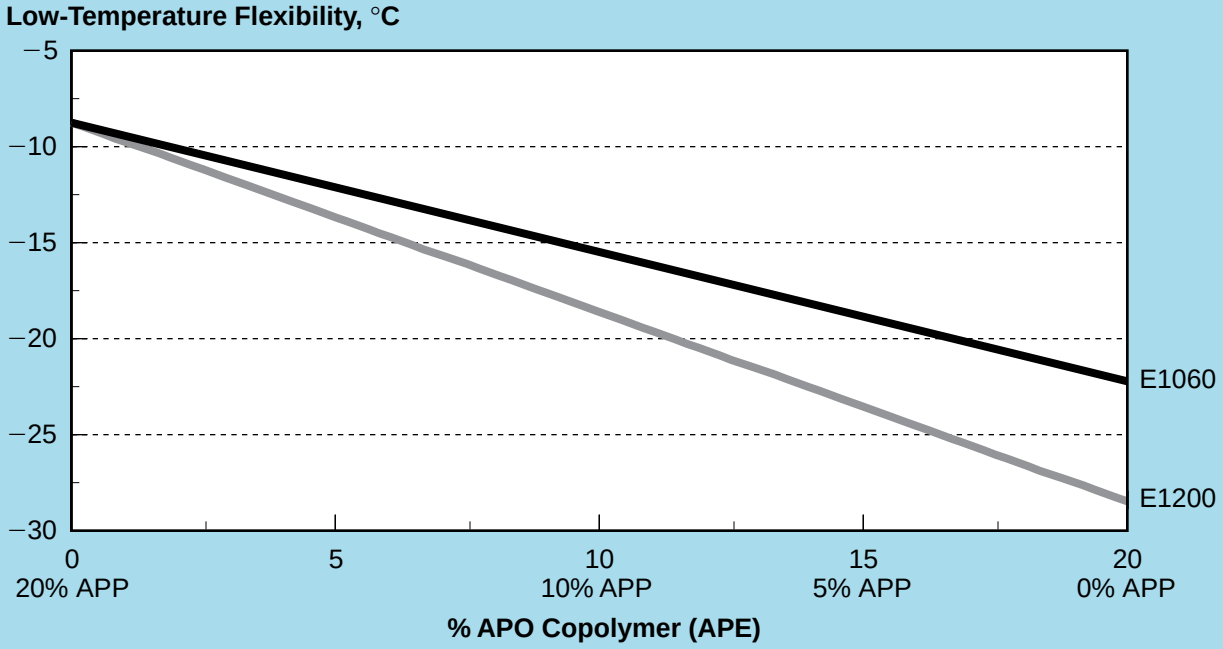


Figure 9

Low-Temperature Flexibility[a] vs. % Copolymer of *Eastoflex* APO-Modified Asphalt Blends



[a] *108°, 7-sec bend*

Information

Eastman Chemical Company
World Headquarters
P.O. Box 431
Kingsport, TN 37662-5280
U.S.A.

Telephone:

U.S.A. and Canada
800-EASTMAN
(800-327-8626)

Other Locations
(1) 615-229-2000

Facsimile:

615-229-1673

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