EASTMAN

Spectrum

A wealth of formulating options . . .

with Eastman's spectrum of hydrocarbon resins

Spectrum

Eastman's Spectrum of Hydrocarbon Resins

Hydrocarbon Resins

Eastman has been a major supplier of resins for more than 40 years and, worldwide, currently markets a large and diverse portfolio of tackifier resins.

We offer technology derived from hydrocarbon and rosin resins that satisfies the application requirements of the customer and delivers the desired value to the customer.

This guide presents physical, chemical, and application information for the most commonly used hydrocarbon resins originating from our Jefferson, Pennsylvania, and Longview, Texas, manufacturing plants. Eastman also produces hydrocarbon resins at its European plant in Middelburg, The Netherlands, and in Nanjing, China.

The products featured in this guide are suitable for use in a variety of applications, including adhesives, graphic arts, and rubber and plastic modifications.

We continue to examine worldwide market trends to determine appropriate uses for our products and guide new product development. Focusing on the requirements of major markets as part of our long-range strategy will enable us to sustain our position as a major resin supplier.

Values in this guide are average values of typical samples and should not be interpreted as product specifications. For applications requiring specific FDA clearances, please contact your local Eastman sales representative.

Should you require samples or additional information on these or any other products supplied worldwide by Eastman, please contact your Eastman representative or one of the offices listed on the back cover.

Contact your Eastman representative at:
Corporate Headquarters
Telephone:
U.S.A. and Canada, 800-EASTMAN (800-327-8626)
Fax: (1) 423-229-1193

Other locations
Telephone: (1) 423-229-2000
Fax: (1) 423-229-1193

Typical Properties

	Piccotac 1020	Piccotac 1095	Piccotac 1098	Piccotac 1100	Piccotac 1115
Softening point, R&B, °C	6	95	100	101	112
Color, Gardner	3	2	2	2	2
T_g, °C (midpoint)	—	43	47	46	58
MMAP, °C	92	94	94	96	99
DACP, °C	43	52	57	62	69
OMSCP, °C	<–50	<–40	<–40	<–40	<–40
M_z	3,800	3,500	4,950	8,250	15,900
M_w	1,750	1,700	2,150	2,900	3,800
M_n	800	800	900	950	1,100
M_w/M_n	2.1	2.1	2.4	3.0	3.4

Aliphatic Resins

Aliphatic Resins

Piccotac 1020

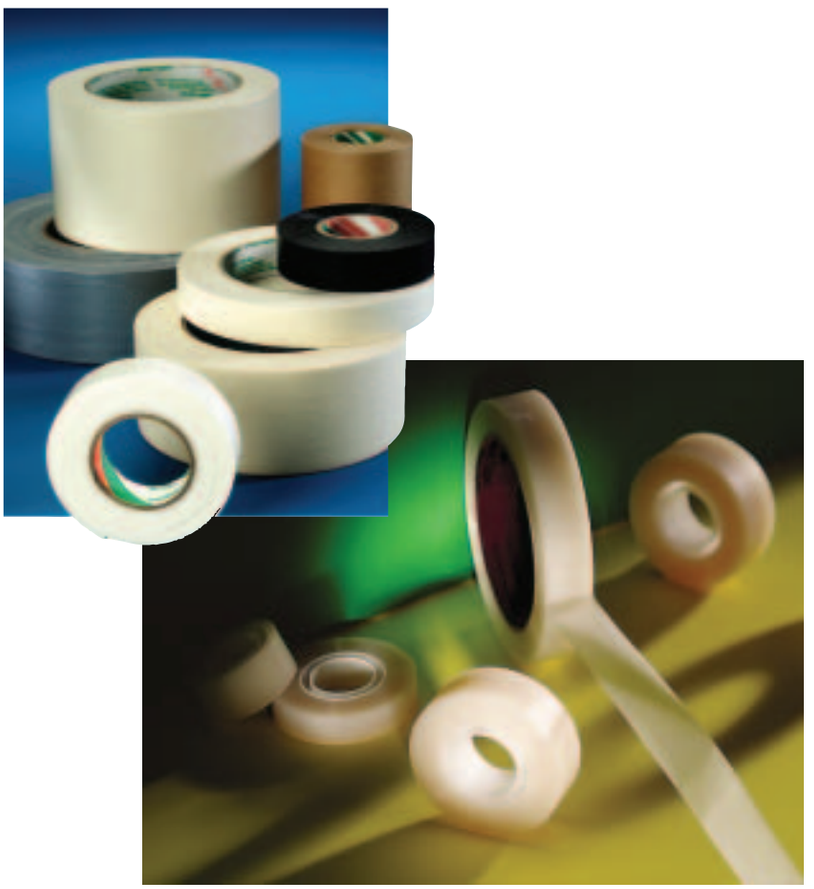
This liquid resin is manufactured from mixed monomers of petroleum-derived origin. *Piccotac* 1020 gives an excellent balance of tack and adhesive properties in pressure-sensitive and hot melt systems. This product is stabilized with 0.05% antioxidant.[1]

Piccotac 1095, 1098, 1100, and 1115

These resins are manufactured from mixed monomers of petroleum origin and are available in softening points ranging from 95° to 115°C (203° to 239°F). Because of their excellent color and unique ranges of molecular weight, they find utility in adhesive, hot melt traffic marking, paint, waterproofing, rubber, paper saturation, and coatings applications. These products are stabilized with 0.1% antioxidant.[1]

General Product Characteristics

These are neutral resins with <1 acid number and <2 saponification number. The relative degree of unsaturation can vary, with bromine numbers ranging from 20 to 40. In general, the specific gravity as measured at 25°C (77°F) will be 0.91 to 0.97. Flash points as measured by COC are >170°C (>338°F). For specific data on individual products, refer to the product data sheet.



[1] *Tetrakis[methylene(3,5 di-tert-butyl-4-hydroxyhydrocinnamate)]methane.*

Typical Properties

	Piccotac 9095	Piccotac 9105	Piccotac 8095	Piccotac 7050
Softening point, R&B, °C	94	105	95	50
Color, Gardner	3	2	3	3
T_g, °C (midpoint)	42	52	41	7
MMAP, °C	88	92	76	65
DACP, °C	47	60	38	7
OMSCP, °C	–22/<–50	<–40	<–50	<–40
M_z	4,250	9,750	5,500	1,730
M_w	1,900	3,200	2,200	980
M_n	850	1,000	850	600
M_w/M_n	2.3	3.2	2.6	1.7

Aliphatic/Aromatic Resins

Aliphatic/Aromatic Resins

Piccotac 9095, 9105, 8095, and 7050 Resins

These resins are manufactured with varying proportions of petroleum-derived monomers and are available in softening points ranging from 50° to 105°C (122° to 221°F). This variation in aliphatic and aromatic composition accounts for solubility differences that enable these products to be useful in natural rubber, styrene-butadiene rubber (SBR), nitrile-butadiene rubber (NBR), block copolymers, and ethylene-vinyl acetate (EVA) for hot melt systems. These resins are stabilized with an antioxidant.[2]

General Product Characteristics

These are neutral resins with <1 acid number and <2 saponification number. The relative degree of unsaturation can vary, with bromine numbers ranging from 15 to 30. In general, the specific gravity as measured at 25°C (77°F) will be 0.96 to 1.04. Flash points as measured by COC and Setaflash are >200°C (>392°F). For specific data on individual products, refer to the product data sheet.

[2] *0.10% tetrakis[methylene(3,5 di-tert-butyl-4-hydroxyhydrocinnamate)]methane.*

Typical Properties

	Picco 2100	Picco 5120	Picco 5140	Picco 6100	Picco 2215
Softening point, R&B, °C	103	119	141	104	113
Color, Gardner	12	12	12	11	12
T_g, °C (midpoint)	43	60	84	46	55
MMAP, °C	34	23	23	30	45
DACP, °C	44	10	10	10	49
OMSCP, °C	120/100	75/58	75/58	75/58	95/87
M_z	3,600	5,300	6,000	5,300	3,500
M_w	1,400	1,800	2,300	1,800	1,300
M_n	450	550	750	550	450
M_w/M_n	3.1	3.3	3.1	3.3	2.8

Aromatic Resins

Aromatic Resins

Picco Resins

These products are manufactured using a mixture of petroleum-derived feed streams. Softening points range from 103° to 141°C (217° to 286°F). In general, these products are light amber to dark brown in color. With varying degrees of aromatic content, these resins will find utility in adhesives, rubber compounding, printing inks, coatings, paints, concrete curing, waterproofing, and sealant compounds. They are compatible in useful proportions with styrene-butadiene rubber (SBR), polar elastomers, chlorinated rubber, and chlorinated paraffins. The resins contain an antioxidant.[3]

General Product Characteristics

These are neutral resins with <1 acid number and <2 saponification number. The relative degree of unsaturation can vary, with bromine numbers ranging from 5 to 20 for *Picco* 5000 and 6000 series resins. In general, the specific gravity as measured at 25°C (77°F) will be 1.08 to 1.10. Flash points as measured by COC are >232°C (>450°F). For specific data on individual products, refer to the product data sheet.

[3]*Contains 0.15% Tetrakis[methylene(3,5 di-tert-butyl-4-hydroxyhydrocinnamate)]methane.*

Typical Properties

	Plastolyn 240	Plastolyn 290
Softening point, R&B, °C	121	140
Color, YID	11	13
T_g, °C (midpoint)	43	84
MMAP, °C	8	9
DACP, °C	<–50	–44
OMSCP, °C	>180	>180
M_z	8,500	13,000
M_w	3,800	5,200
M_n	1,150	1,350
M_w/M_n	3.3	4.0

Light-Colored Resins

Light-Colored Resins

Plastolyn 240 and 290 Resins

These are water-white, highly color-stable aromatic resins made from pure monomer feed streams. There are two softening point grades: 120°C (240°F) and 140°C (290°F). They are recommended for use as flow modifiers in such polymers as polyvinylchloride (PVC), acrylonitrile-butadiene-styrene (ABS), and block copolymers. Other applications include paints, caulking compounds, laminating and hot melt adhesives, and coatings.

General Product Characteristics

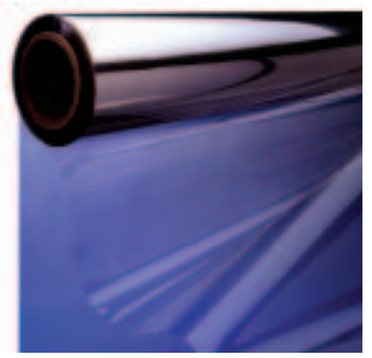
Plastolyn 240 and 290 are neutral resins with <1 acid number and <2 saponification number. The relative degree of unsaturation can vary, with bromine numbers ranging from 2 to 8. Specific gravity as measured at 25°C (77°F) will be 1.04 to 1.10. Flash points are >232°C (>450°F) as measured by COC.

For specific data on individual products, refer to the product data sheet.

Typical Properties

	Endex 155	Endex 160	Kristalex 1120	Kristalex 3070	Kristalex 3085
Softening point, R&B, °C	153	159	119	70	85
Color, Gardner	—	—	—	—	—
Color, YID	5	8	7	7	4
T_g, °C (midpoint)	99	105	60	32	41
MMAP, °C	16	16	5	0	1
DACP, °C	–23	–15	–35	<–50	<–50
OMSCP, °C	129/121	149/140	>180	8/3	36/32
M_z	13,850	18,400	7,600	1,450	1,900
M_w	6,950	8,600	2,800	950	1,150
M_n	2,400	2,500	800	650	650
M_w/M_n	3.0	3.6	3.5	1.5	1.8

Pure Monomer Resins



Pure Monomer Resins

Endex Resins

These resins are manufactured as a copolymer of modified styrenes, with softening points grades of 153° and 159°C (307° to 318°F). The specific molecular weight and solubility of these resins make them particularly suited to reinforce the styrenic domains of block copolymers in hot melt and pressure-sensitive adhesive applications.

Kristalex Resins

These resins are water-white and highly color stable, with softening points ranging from 70° to 139°C (158° to 284°F). They are manufactured as a copolymer of varying ratios of pure monomers. These aromatic resins find utility as reinforcing resins for the styrenic domain of block copolymer systems. Other uses include paints, caulking compounds, laminating and hot melt adhesives, textile dry sizes, coatings, and plastic modification.

Kristalex 3100	Kristalex 5140	Piccolastic A5	Piccolastic A75	Piccolastic D125	Piccotex 75	Piccotex LC	Piccotex 100	Piccotex 120
100	139	5	74	126	75	91	98	118
—	—	2	1	2	—	—	—	—
5	4	—	—	—	6	8	6	5
53	85	—	35	64	32	46	50	70
5	9	–6	6	13	1	3	7	11
<–50	–48	<–50	<–50	–32	<–50	<–50	<–50	–35
76/68	>180	—	74/70	>180	–9/–10	–7/–9	26/20	53/46
2,550	12,100	550	2,250	179,000	1,700	2,200	3,600	6,400
1,500	4,900	350	1,300	37,400	1,100	1,350	2,200	3,500
700	1,500	300	700	1,300	650	750	1,000	1,450
2.1	3.3	1.2	1.9	28.5	1.7	1.8	2.2	2.4

Piccolastic Resins

These resins are manufactured from styrenic monomers, with softening points ranging from 5° to 125°C (41° to 257°F). The low molecular weight versions are useful as plasticizers and as paper saturants. Higher softening versions are used in adhesive formulations, shoe construction, hot melt applications, investment castings, and in xerographic applications. In block copolymer systems, they would be compatible with the styrenic phase but would not be expected to generate significant tack.

Piccotex Resins

These products are manufactured as a copolymer of modified styrenes that result in a range of softening points from 75° to 120°C (167°F to 248°F). Aliphatic solubility decreases proportionally as softening point increases. They are used in coatings and adhesives as well as dry size agents and in baking enamels.

General Product Characteristics

These are neutral resins with <1 acid number and <2 saponification number. The relative degree of unsaturation can vary, with bromine numbers ranging from 2 to 8. In general, the specific gravity as measured at 25°C (77°F) will be 1.04 to 1.10. Flash points as measured by COC are >232°C (>450°F) [except for *Piccolastic* A5 at 166°C (330°F)]. Because of their inherent stability, these products do not contain an antioxidant. For specific data on individual products, refer to the product data sheet.

Typical Properties

	Regalrez 1018	Regalrez 1085	Regalrez 1094
Softening point, R&B, °C	19	87	95
Color, YID	6	2	2
T_g, °C (midpoint)	–22	34	40
MMAP, °C	64	87	84
DACP, °C	14	43	59
OMSCP, °C	<–40	–11	<–40
M_z	500	1,500	1,350
M_w	350	1,000	850
M_n	300	600	550
M_w/M_n	1.2	1.6	1.6

Hydrogenated Pure Monomer Resins

Regalrez 1126	Regalrez 1128	Regalrez 1139	Regalrez 6108	Regalrez 3102
124	130	141	108	102
2	4	2	3	3
67	72	84	55	51
92	104	109	53	24
76	—	79	25	–15
<–40	–23/<–40	–10/<–40	–14/<–40	<–40
2,050	3,900	5,200	2,300	2,350
1,250	2,500	3,100	1,400	1,450
700	1,350	1,350	750	800
1.8	1.9	2.3	1.8	1.8

Hydrogenated Pure Monomer Resins

Regalrez Resins

These products are manufactured by selective hydrogenation of base resins polymerized using styrenic-based comonomers. Degrees of hydrogenation range from 30% to 100%. Softening points vary from 19° to 141°C (66° to 286°F). These products are highly UV and oxidative resistant and do not contain any stabilizers.

Regalrez resins generate excellent tack and reduce sealant viscosity without significantly reducing slump resistance. Because of their excellent color and stability, these products are broadly compatible with block copolymers, oils, waxes, alkyds, and plastics. Uses include adhesives, caulks and sealants, film, rubber, plastics, and coatings.

General Product Characteristics

These are neutral resins with <1 acid number and <2 saponification number. (The relative degree of unsaturation can vary, with bromine numbers ranging from 2 to 8.) In general, the specific gravity as measured at 25°C (77°F) will be 0.95 to 1.05. Flash points as measured by COC are >232°C (>450°F) except for *Regalrez* 1018 [149°C (300°F)]. For specific data on individual products, refer to the product data sheet.

Typical Properties

	Eastotac H-100E	Eastotac H-100R	Eastotac H-100L	Eastotac H-100W	Eastotac H-115E
Softening point, R&B, °C	100	100	100	100	115
Color, Gardner	5	1.5	—	—	5
Color, YID	—	—	18	8	—
T_g, °C (midpoint)	44	44	44	41	61
MMAP, °C	77	79	78	81	80
DACP, °C	61	68	65	69	70
OMSCP, °C	<–50	<–50	<–50	<–50	<–50
M_z	2,450	2,550	2,300	2,150	2,600
M_w	1,050	1,050	1,000	1,000	1,050
M_n	450	450	450	450	450
M_w/M_n	2.3	2.3	2.2	2.2	2.3

Hydrogenated Resins—*Eastotac*

Eastotac H-115R	Eastotac H-115L	Eastotac H-115W	Eastotac H-130E	Eastotac H-130R	Eastotac H-130L	Eastotac H-130W	Eastotac H-142R	Eastotac H-142W
115	115	115	130	130	130	130	142	142
1.5	—	—	5	1.5	—	—	1.5	—
—	18	8	—	—	18	8	—	8
53	60	56	66	73	75	78	87	88
82	82	80	78	81	83	83	82	85
76	75	68	72	70	77	76	74	76
<–50	<–50	<–50	<–50	<–50	<–50	<–50	<–50	<–50
2,450	2,400	2,100	2,350	2,400	2,350	2,200	2,300	2,000
1,050	1,000	950	1,050	1,050	1,050	1,000	1,050	950
450	450	450	500	500	500	500	500	500
2.3	2.2	2.1	2.1	2.1	2.1	2.0	2.1	1.9

Hydrogenated Resins—*Eastotac*

Eastotac Resins

Produced from petroleum feedstock followed by hydrogenation, these resins are characterized by low color, low odor, excellent heat stability, and good compatibility with most polymers. Four color levels ranging from 100° to 142°C (212° to 288°F) softening points allow the selection of the most suitable resin for a particular application. These resins are used as tackifying resins for pressure sensitive adhesives, hot melt adhesives, caulks, and sealants.

General Product Characteristics

These are neutral resins with <1 acid number. The relative degree of unsaturation is low. In general, the specific gravity measured at 25°C (77°F) will be 1.04. Flash points as measured by COC are >243°C (>470°F). For specific data on individual products, refer to the product data sheet.

Neat Resin Viscosity

Formulated adhesive viscosity with temperature behavior is affected by 2 main factors: 1) the viscosity of each individual component, and 2) the interactions between the components. Although it is somewhat difficult to predict formulated viscosity without considering component interactions, there is an occasional need for viscosity data of the resins themselves. Viscosity data for *Eastman* resins with temperature is highly dependent on the softening point. Figure 1 provides the approximate viscosity of a resin with a certain softening point and at a certain temperature.

Neat Resin Color

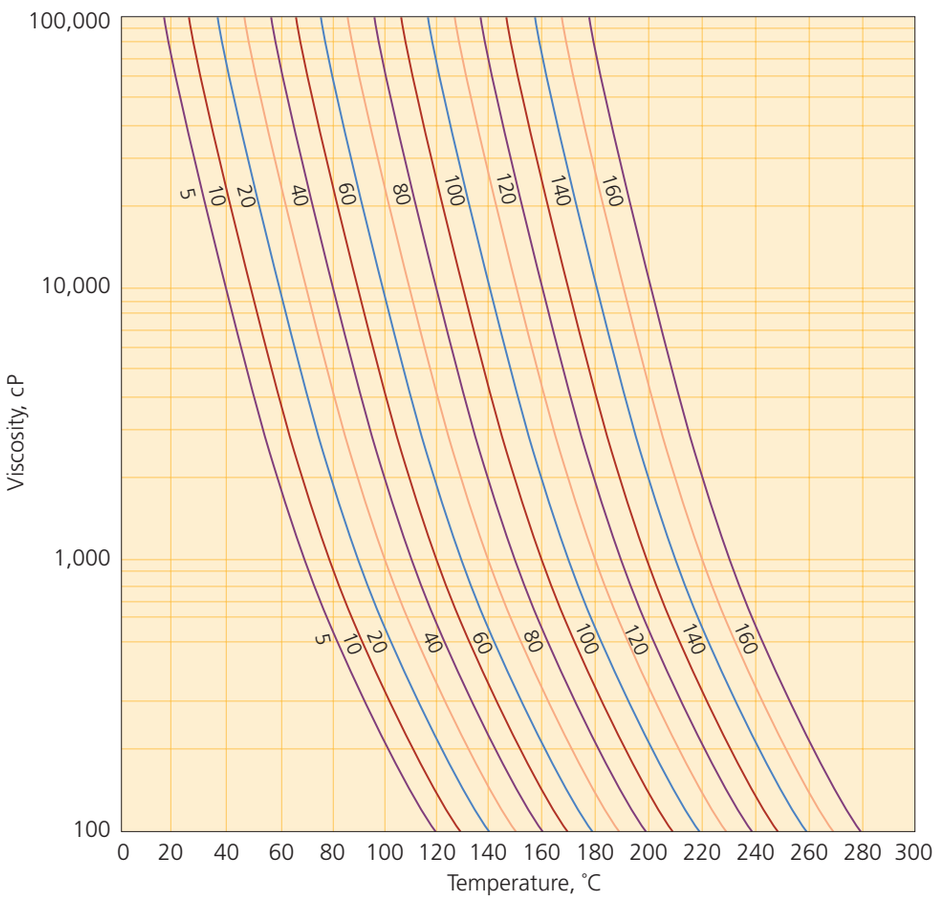
All resin color measurements were conducted by dissolving the resins in a 50% toluene solution (by weight), placing the solution in a 5 cm pathlength cell and measuring with a colorimetric method.

Cloud Points and Their Applications

Compatibility

The performance characteristics of a resin in an adhesive are directly related to the compatibility characteristics of the resin in the polymer. To produce an adhesive having aggressive tack, for example, a resin must be found that has good compatibility with a suitable polymer. When a compatible resin is added in the correct concentration to the polymer, tack will be produced. An incompatible resin may also be added to a polymer system to impact other desirable properties, but incompatibility will not produce tack properties in a polymer system. The "fine-tuning" of adhesive systems is often made by the addition of a resin having limited compatibility, thus producing perhaps a lower tack level with higher cohesive strength characteristics than a fully compatible resin.

Figure 1. Viscosity vs. Temperature and Softening Point (R&B)



The Cloud Point Concept

Softening point and resin concentration are familiar concepts that are recognized by the formulator as being essential information, but this alone will not determine the influence the resin has on performance. Compatibility data is also required to complete the picture. A convenient method to characterize resin compatibility is by determination of cloud points in suitable solvent systems. From the cloud point values obtained, the resin may be characterized as being aliphatic, aromatic, or a combination of both, polar or nonpolar, and having a high or low molecular weight. Unlike rosin resins, hydrocarbon resins display wide variation in cloud point values. Thus, the cloud point concept is a useful method to characterize hydrocarbon resins.

Choice of Solvent Systems

Eastman uses three solvent systems to determine cloud points of hydrocarbon resins. They are:

- 1:2 mixture of methylcyclohexane and aniline (MMAP).
- 1:1 mixture of xylene and 4-hydroxy-4-methyl-2-pentanone (DACP).
- Odorless mineral spirits, a mixture of various aliphatic mineral solvents (OMS).

The determination of MMAP, DACP, and OMS cloud points gives rise to values measured in °C. The method is the same for all three solvent systems.

A standard weight of resin is dissolved in the solvent at high temperature and allowed to cool with mixing. The temperature at which the resin begins to separate out as an extra phase is determined to be the cloud point. This may be seen in the mixture as a cloudiness in the previously clear solution.

Cloud Points and Resin Compatibility

For practical purposes, the cloud points may be related to compatibility as follows:

- **MMAP** is a measurement of aromatic solubility and determines the aliphatic/aromatic character of the resin. The lower the MMAP value, the more aromatic the resin.
- **DACP** determines the polarity of the resin due to the highly polar nature of the solvent system. Since specific adhesion is related to the polarity of a resin, the DACP cloud point can be used as a specific adhesion indicator. The lower the DACP value, the better the specific adhesion of a resin.
- **OMS**—This determination is only meaningful for aromatic resins since other resin types give OMS values lower than –30°C (–22°F). Most laboratories are not equipped to operate at such low temperatures, therefore the method becomes impracticable.

The OMS value is related to molecular weight and molecular weight distribution. In addition, OMS can determine compatibility characteristics of a resin/polymer system, especially in ethylene-vinyl acetate (EVA) polymer. For any one generic type of resin, the higher the OMS cloud point, the greater the molecular weight and the molecular weight distribution. In particular, high OMS values can indicate the presence of high molecular weight material (M_z).

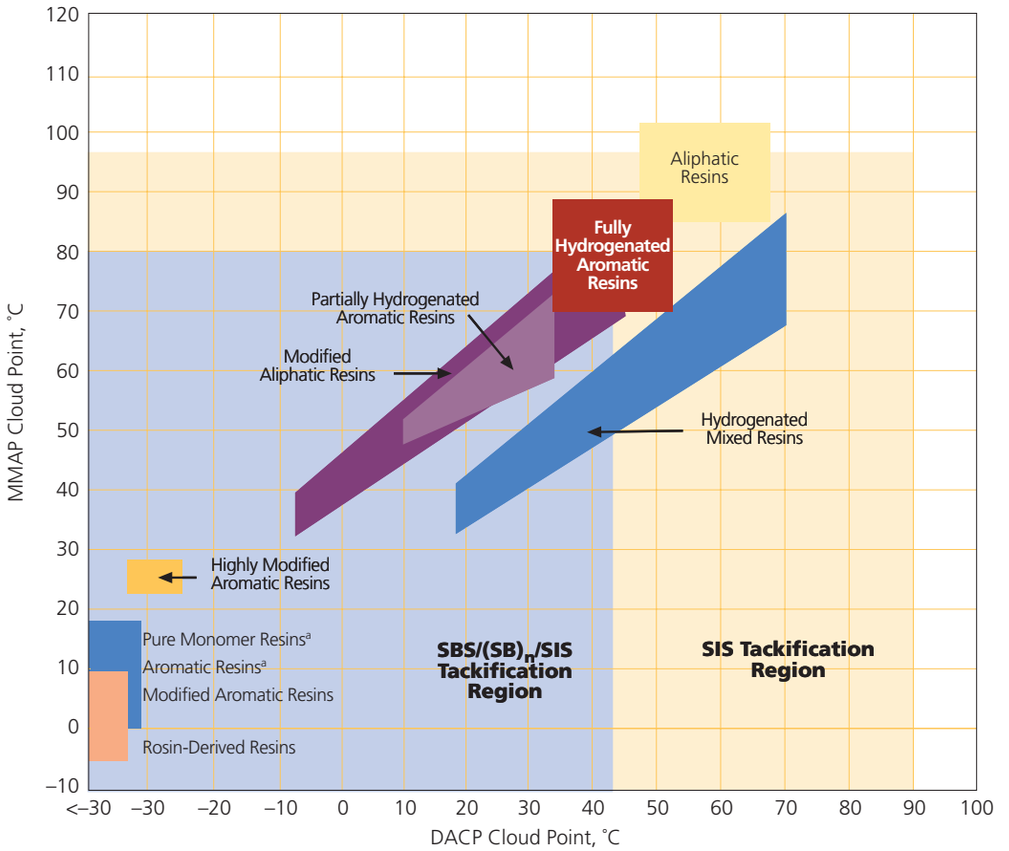
Cloud Point Compatibility

When cloud point values are graphically displayed, compatibility application windows may be determined for resin compatibility with various polymers.

Cloud Point Mapping

Figure 2 displays the MMAP and DACP cloud point regions for hydrocarbon resins. A region for rosin-derived resins is shown for comparison. Tackification regions for SBS/$(SB)_n$ and styrene-butadiene-styrene (SIS)-type block copolymers have been identified that indicate the resin type required to produce tack in the respective polymer. It should be noted that the pure monomer, styrene-based resins and the aromatic resins are compatible only with the styrene end block in the block copolymer and do not produce tack in block copolymers, while the modified aromatic resins act in a similar manner to rosin-derived resins, producing tack.

Figure 2. MMAP and DACP Cloud Point Regions for Hydrocarbon, and Rosin-Based Resins

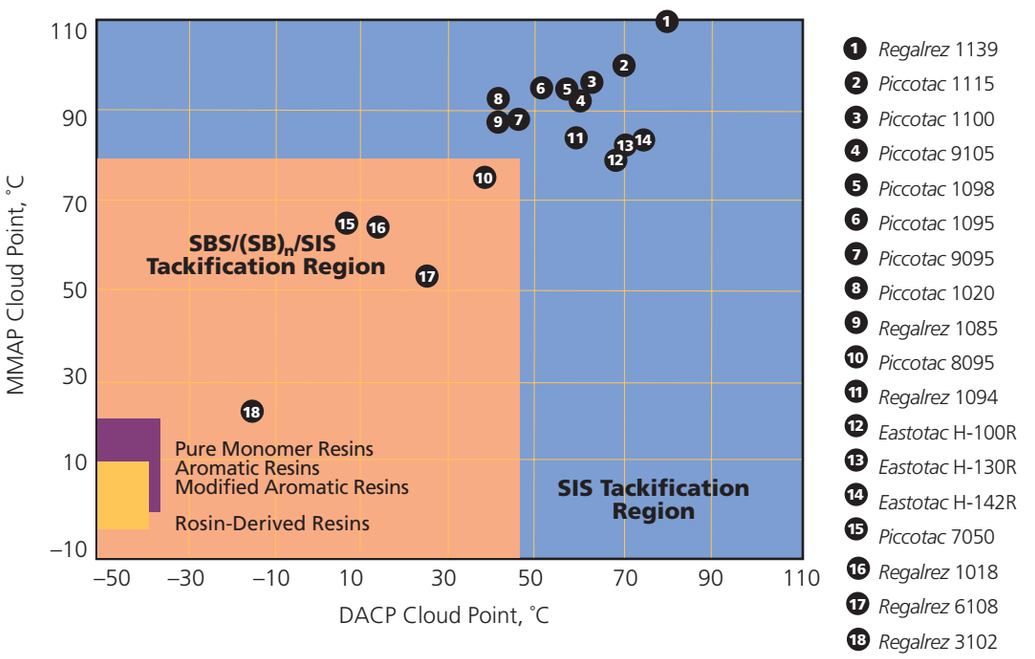


[a] *These groups of resins are styrene-compatible only. The resins do not produce tack in block copolymers. Some may produce tack in EVA.*

Eastman Hydrogenated and Aliphatic Resins

In Figure 3, the MMAP-DACP cloud points of hydrogenated, aliphatic, and modified aliphatic hydrocarbon resins are shown as point values for individual resin grades. These values are averaged, and in reality, there is a small spread of values for each resin. Compatibility application windows for SBS and SIS block copolymers have been added to demonstrate the usefulness of the concept.

Figure 3. MMAP and DACP Cloud Point Values of *Eastman* Hydrogenated and Aliphatic Resins



Note: The values displayed are typical values and may not represent shipments of resin received.

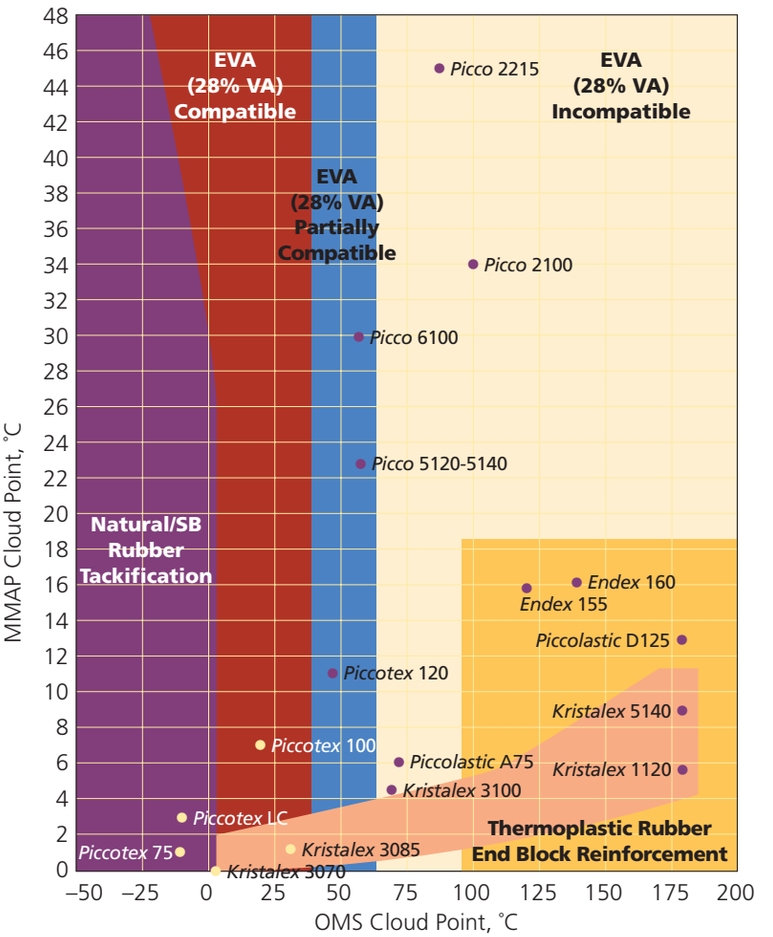
Eastman Aromatic Resins

Figure 4 displays the MMAP and OMS cloud points of aromatic and modified aromatic hydrocarbon resins. Similar to other cloud points, an individual resin type does not have a single definite cloud point value but a small spread. This is illustrated using the *Kristalex, Endex, Piccotex*, and *Picco* resin ranges.

The practical usefulness of the cloud point concept may be shown by the *Kristalex* region. The MMAP cloud point values have little spread due to a constant aromaticity, while the OMS values vary due to differences in molecular weight distribution. A higher OMS cloud point would indicate a greater contribution of higher molecular weight material in the resin.

Figure 4 also shows regions of polymer compatibility for natural rubber, SBR, and EVA containing 28% vinyl acetate (VA). In addition, there is a region of thermoplastic rubber end block reinforcement. Resins in this region will reinforce the cohesive strength of a thermoplastic block-copolymer-based adhesive.

Figure 4. MMAP and OMS Cloud Point Values of *Eastman* Aromatic Resins



Molecular Weight and Weight Distribution

The molecular weight and weight distribution of any one generic type of resin has a strong influence on its compatibility in any polymer. In general, a resin with a similar chemistry to a polymer will be compatible with that polymer only when the molecular weight is not too great and the molecular weight distribution not too broad. In addition, a resin with dissimilar chemistry may well be compatible with the polymer when the molecular weight is low enough and its distribution narrow.

Gel Permeation Chromatography (GPC)

GPC is a chromatographic method that measures the molecular weight and molecular weight distribution by comparing resin samples to a polymer of known parameters. The method involves using a thin metal column packed with a special gel, having a specified volume and distribution of pore sizes. The resin is injected as a solvent solution into the column and allowed to diffuse under pressure through the gel medium. During diffusion, the larger molecules are not captured by the gel pores and travel quickly through the gel. The smaller molecules permeate into the pores and are thus hindered. They eventually emerge from the column after the larger molecules.

The emerging molecules are measured by special detectors and a chromatogram is produced of the molecular weight distribution. In theory, the chromatogram should have the form of a Gaussian curve (Figure 5), but in practice, a typical molecular weight distribution curve would look similar to Figure 6.

Figure 5. Idealistic Molecular Weight Distribution Curve of a Resin

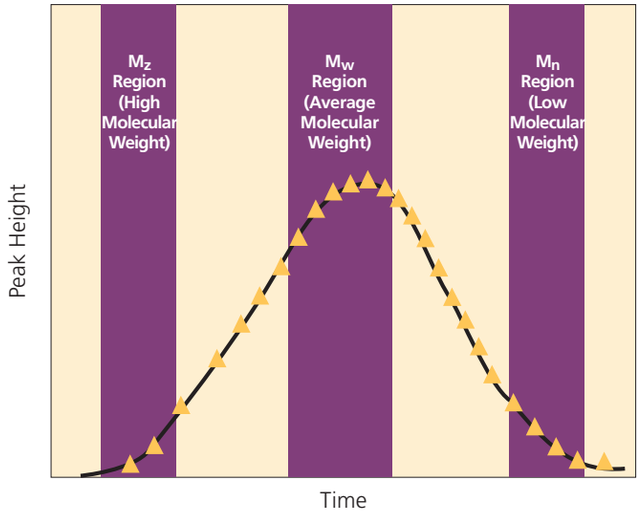
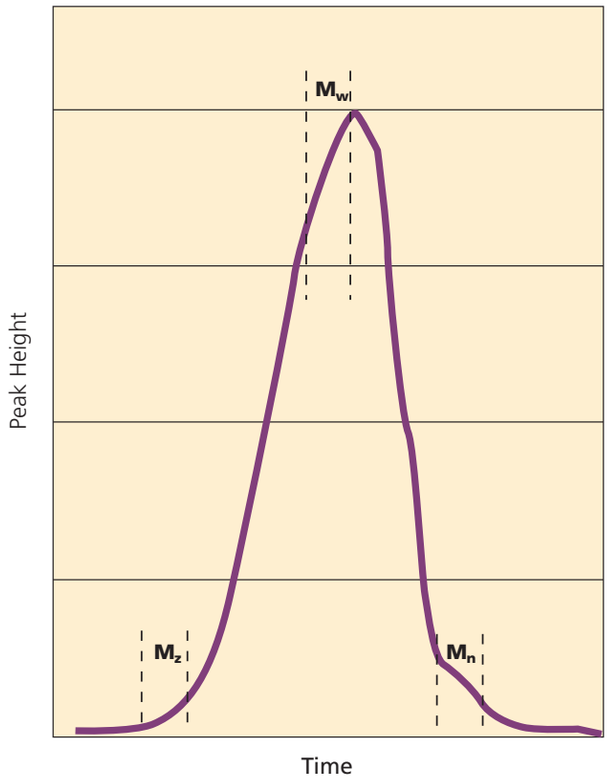


Figure 6. Typical Molecular Weight Distribution Curve of a Resin



Calculation of Molecular Weight Parameters

M_n, M_w, M_z, and P_d

The numerical results obtained are reported as M_n, M_w, M_z, and P_d values. These values give specific information concerning the molecular weight and distribution of the resin.

- M_n (Number Average)—This is a simple arithmetical average and provides information about the lower molecular weight parts of the resin.
- M_w (Weight Average)—This indicates the average molecular weight of the resin. This value would be quoted when the molecular weight of the resin is requested.
- M_z (Z-Average)—This value is used as an indication of the high molecular weight tail in the resin, which has a very pronounced effect on compatibility and, hence, adhesive properties.

As mentioned on the previous page, gel permeation chromatography is a comparative method using a known molecular weight standard polymer as reference. Thus, GPC results may only be compared with each other if one single reference sample has been used for all resin measurements. GPC analyses made at different times using a different reference sample will show a considerable random error, especially in the M_z value calculation. Consequently, a spread of 10%–15% in M_z values should be regarded as normal.

- P_d (Poly-Dispersity)—This value describes the broadness of the molecular weight distribution and is calculated as the ratio M_w/M_n; the greater the value, the broader the molecular weight distribution.

The values of M_n, M_w, M_z, and P_d are calculated by the following equations:

$$M_n = \frac{\Sigma(ni \times Mi)}{\Sigma(ni \times Mi^{1-1})}$$

$$M_w = \frac{\Sigma(ni \times Mi^{2})}{\Sigma(ni \times Mi^{2-1})}$$

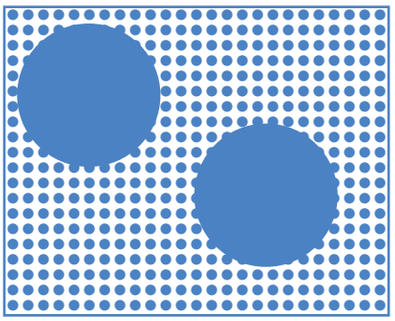
$$M_z = \frac{\Sigma(ni \times Mi^{3})}{\Sigma(ni \times Mi^{3-1})}$$

$$P_d = M_w/M_n$$

Where:
ni is the number of molecules; and
Mi is the mass of the molecules with number ni.

Figure 7. Illustration of Molecular Weight Distribution

Resin A



500 molecules at 1 mg = 500
2 molecules at 250 mg = 500
Total weight = 1,000 mg

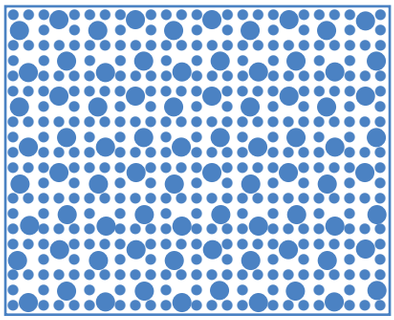
$$\frac{(500\times1)}{500}+\frac{(2\times250)}{2}=\frac{1{,}000}{502}=1.99\ M_n$$

$$\frac{(500\times1^2)}{(500\times1)}+\frac{(2\times250^2)}{(2\times250)}=\frac{125{,}500}{1{,}000}=125.5\ M_w$$

$$\frac{(500\times1^3)}{(500\times1^2)}+\frac{(2\times250^3)}{(2\times250^2)}=\frac{31{,}250{,}500}{125{,}500}=249.0\ M_z$$

$$\frac{125.5}{1.99}=63.07\ P_d$$

Resin B



400 molecules at 1 mg = 400
100 molecules at 6 mg = 600
Total weight = 1,000 mg

$$\frac{(400\times1)}{400}+\frac{(100\times6)}{100}=\frac{1{,}000}{500}=2.0\ M_n$$

$$\frac{(400\times1^2)}{(400\times1)}+\frac{(100\times6^2)}{(100\times6)}=\frac{4{,}000}{1{,}000}=4.0\ M_w$$

$$\frac{(400\times1^3)}{(400\times1^2)}+\frac{(100\times6^3)}{(100\times6^2)}=\frac{22{,}000}{4{,}000}=5.5\ M_z$$

$$\frac{4.0}{2.0}=2.0\ P_d$$

The difference between M_n, M_w, and M_z may be illustrated by the example of two hypothetical resin samples with the same total mass of 1,000 mg but with a different size distribution. (See Figure 7.)

The M_n values of both resins are very similar, indicating both have similar low molecular weight fractions; five hundred 1-mg molecules versus four hundred 1-mg molecules.

The Mw values show large value differences, 125.5 versus 4. The average molecular weight of Resin A is considerably influenced by the two, very large molecules present; while that of Resin B is less affected by the large, 6-mg molecules.

The M_z value of Resin B is close to its M_w value. Thus, the system has little high molecular weight material. Resin A has a very high M_z value and thus a large mass of high molecular weight material.

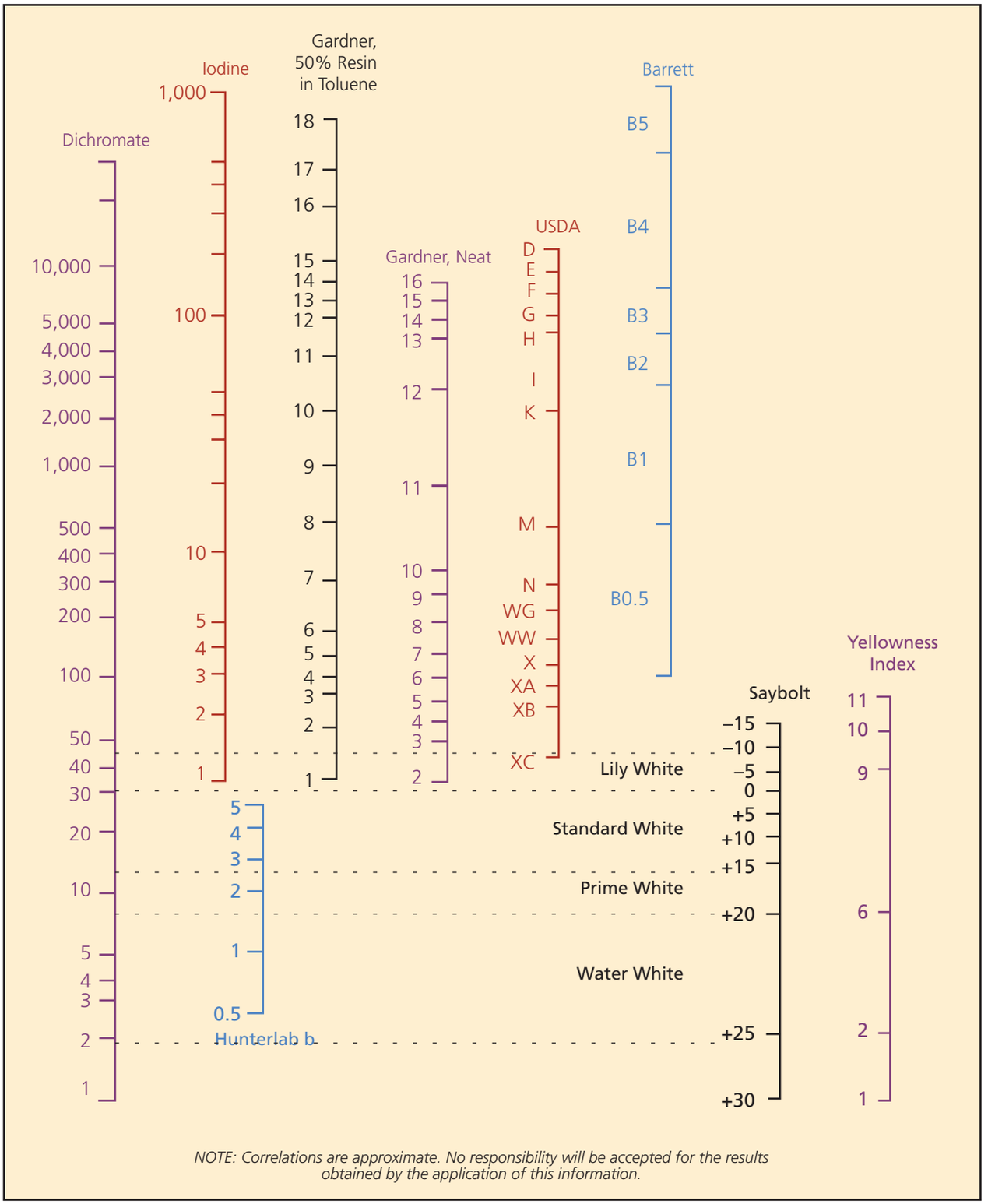
The P_d value of Resin A is very large, indicating a broad molecular distribution; while the value of Resin B shows its narrower molecular weight distribution characteristics.

Resin A could be described as a high molecular weight, with a very broad molecular weight distribution, resin; while Resin B has a low molecular weight with a narrow molecular weight distribution.

Practical Aspects

It may be envisaged that both resins are of the same generic type, i.e., of similar chemistry. Resin B, due to its low molecular weight together with a very low M_z value, would be compatible with a certain polymer. Resin A, although it has the correct chemistry to be compatible, would be incompatible. This is due to the very high molecular weight material preventing the resin from mixing intimately with the polymer molecules.

Figure 8. Eastman Correlation Chart of Various Color Scales



NOTE: Correlations are approximate. No responsibility will be accepted for the results obtained by the application of this information.

Test Methods:
Dichromate: mg/1,000 ml H_2SO_4, H-90-2c
Saybolt: ASTM D156
Iodine: mg/100 ml H_2O
Gardner: ASTM D1544-80
Hunterlab: ASTM E450
USDA: R-25-4a
Yellowness Index: ASTM D1925

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Publication WA-86A
December 2004

Printed in U.S.A.