MAINCOTE™ IC-1001 Resin

Waterborne acrylic resin for thermal insulation coatings

Description

MAINCOTE™ IC-1001 Resin is an acrylic-styrene copolymer with a high degree of flexibility and a distinct hydrophobic composition. This versatile binder can be combined with low thermal conductivity fillers to form waterborne thermal insulation coatings with high pigment volume concentrations (PVC), high volume solids and low VOC. MAINCOTE IC-1001 Resin offers uniform cure in high build insulation coatings.

Features and Benefits

- Low coalescent demand / low VOC capability
- Excellent flexibility
- Excellent pigment binding capacity
- Hydrophobic backbone composition offers good water resistance
- High film build without mudcracking
- Contributes to excellent corrosion resistance as part of a coating system

Typical Physical Properties

These properties are typical but do not constitute specifications.

Property	Typical Values
Appearance	White milky liquid
Solids (wt %)	47.0
pH	7.0 – 8.0
Viscosity (Brookfield #3, 30rpm)	< 2000 cP
T_g	13 °C
MFFT	9 °C
Density (lb/gal)	8.6

Potential Applications

High performance, high film build, low VOC waterborne thermal insulation coatings for:

- Safe touch coatings for personnel protection
- Surface temperature reduction
- Thermal energy management for process control and/or energy conservation
- Improved management of corrosion under insulation (CUI) issues
- Use on hot and/or cold metal surfaces such as pipes, process equipment and storage tanks
- Easy application on surfaces with complex geometries needing insulation

Introduction to Thermal Insulation Coatings

Thermal insulation is defined as a material which retards the flow of heat. Mechanical thermal insulations are materials that insulate components of mechanical systems in industrial processes, and are installed to control heat gain or heat loss on process piping and equipment, steam and condensate distribution systems, boilers, and storage tanks. Mechanical thermal insulation is also applied to protect workers from hot and cold surfaces. The thermal insulation found in most plant operations includes traditional insulation materials like calcium silicate, perlite, fiberglass, urethane foam, cellular glass and other materials. Moisture can severely limit the performance of traditional insulation materials. Traditional insulation systems require separate moisture barriers, such as metal jacketing, which can degrade over time. The moisture barrier along with the thick layer of insulation also often hides severe maintenance problems, such as corrosion under insulation. One alternative to traditional insulation is a waterborne thermal insulation coating, a thick film coating containing low thermal conductivity fillers that is applied directly to the substrate or a primer. Compared to traditional insulation, the coating thickness is relatively low, usually in the range of only a few millimeters depending on the thermal properties required. The filler imparts the low thermal conductivity necessary for the coating to act as insulation, and the waterborne binder, whether acrylic or epoxy-based, holds the filler together in a coherent film and offers flexibility and adhesion to the surface.

Due to their low thermal conductivity, waterborne thermal insulation coatings can offer thermal insulation, and assist in lowering surface temperature of a hot substrate and offer greater personal protection from burns. Compared to metal-jacketed traditional insulation, they facilitate easier inspection of steel surfaces for CUI problems, and are more easily applied to complex geometries. Waterborne thermal insulation coatings, such as those based on MAINCOTE™ IC-1001 Resin, are liquid materials and can be applied using conventional coating application methods such as airless and air-assisted airless spray. The insulation coating is designed as a functional coating to offer thermal insulation, and should be applied over a suitable primer and can also be topcoated to protect it from exterior weathering. The thermal insulation coating, due to the hydrophobic nature of the resin and certain functional fillers, can also assist the overall coating system in providing barrier properties and corrosion resistance for the steel substrate.

The main polymer technology used for thermal insulation coatings is currently one-component waterborne acrylic resins, which are formulated with low thermal conductivity fillers such as hollow glass microspheres and silica aerogels. The hollow glass microspheres are typically made from borosilicate glass and contain a small amount of air trapped in the micron-scale void space. The silica aerogel particles are extremely porous, hydrophobically treated silica with an open pore structure. Due to their highly hydrophobic nature, water does not enter the pore space of the silica aerogel, which contains air. Hollow glass microspheres and aerogel silica offer low thermal conductivity due to the “still” air present in the voids and pores. Thermal insulation coatings are high PVC and high volume solids coatings containing a large amount of the low density functional fillers, and thus can have quite low densities in the wet state, even less than 5.0 lbs/gal. Due to a low polymer glass transition temperature (T_g), coatings based on MAINCOTE IC-1001 Resin can be formulated at very low VOC. The starting point formulations described in this technical data sheet have calculated VOC levels under 20 g/L.

Performance Data

Thermal insulation coatings based on MAINCOTE™ IC-1001 Resin were formulated with various levels of hollow glass microspheres and silica aerogel fillers, as further described in the Formulation Guidelines section below. The total PVC was kept constant at 75%. Thermal conductivity (k) measurements for the coatings are shown in Table 1, which compares the experimental coatings with some commercial waterborne insulation coatings. The thermal conductivities of the various formulations based on MAINCOTE IC-1001 are similar to the commercial products, and show a slight dependence on the choice of low thermal conductivity filler. In this test, formulations with higher levels of hollow glass microspheres gave lower thermal conductivities than the coatings with high levels of silica aerogel.

Table 1. Thermal conductivity of MAINCOTE™ IC-1001 Resin formulations compared to commercial waterborne acrylic insulation coatings.

Formulation[1]	Hollow glass microsphere %PVC	Silica aerogel %PVC	Thermal conductivity, k (mW/mK)
IC-1001-1	75	0	85
IC-1001-2	50	25	88
IC-1001-3	25	50	127
IC-1001-4	0	75	104
Commercial #1	-	-	70
Commercial #2	-	-	106

[1] Starting point formulations IC-1001-1 through -4 are based on MAINCOTE IC-1001 Resin and are described below

Table 2 demonstrates one of the advantages observed with formulations based on MAINCOTE IC-1001 Resin, which is better flexibility as measured by % elongation. Free films of the coatings at approximately 75 mils DFT were cast on release paper and tested for tensile and elongation using an Instron tester according to ASTM D638. Tensile strength is reported in units of pounds per square inch (psi) at break, and elongation as the percentage elongation at break. The four starting point formulations had much higher elongation than the two commercial products. One of the commercial coatings (Commercial #1) was too brittle to even prepare a free film to measure tensile and elongation, and the second showed only 30% elongation. In contrast, formulations based on MAINCOTE IC-1001 showed at least twice and up to ten times the elongation of Commercial #2. Incorporating silica aerogel into the coating leads to increased elongation, and the two formulas with higher levels of silica aerogel gave percent elongations over 300%.

The ability of the insulation coating to reduce the surface temperature of a hot substrate was evaluated by placing a panel of coated steel on a hot plate, and measuring the surface temperature of both uncoated and coated surfaces with a handheld infrared thermometer. For this evaluation, a piece of smooth cold rolled steel was coated with 75 mils DFT of the insulation coatings and allowed to dry for 7 days prior to testing. Panels were placed directly on a hot plate set to 180°F and allowed to equilibrate. Surface temperature was measured every 10 minutes until an equilibrium value was achieved. A side-by-side comparison with an uncoated piece of steel was done in every instance. The results are given in Table 3. All of the insulation coatings based on MAINCOTE™ IC-1001 Resin and the commercial insulation coatings lowered the surface temperature to approximately 140°F, which is the temperature determined to produce a first degree burn after five seconds of contact with skin. Use of the thermal insulation coatings for personnel protection (i.e., safe touch coatings) will depend on several factors, including the thermal conductivity of the coating and film thickness.

Table 2. Tensile and elongation of MAINCOTE™ IC-1001 Resin formulations compared to commercial waterborne acrylic thermal insulation coatings.

Formulation	Hollow glass microsphere %PVC	Silica aerogel %PVC	Tensile strength (psi)	Elongation at break (%)
IC-1001-1	75	0	113	73
IC-1001-2	50	25	137	93
IC-1001-3	25	50	182	325
IC-1001-4	0	75	182	300
Commercial #1	-	-	brittle	brittle
Commercial #2	-	-	169	30

Table 3. Surface temperature reduction of MAINCOTE™ IC-1001 Resin formulations compared to commercial waterborne acrylic insulation coatings. Coated panels were placed on a hot plate and heated to 180°F.

Formulation	Hollow glass microsphere %PVC	Silica aerogel %PVC	Surface temperature (°F)
IC-1001-1	75	0	139
IC-1001-2	50	25	138
IC-1001-3	25	50	140
IC-1001-4	0	75	141
Commercial #1	-	-	140
Commercial #2	-	-	140

Waterborne thermal insulation coatings also offer potential energy savings. This has been demonstrated in the laboratory by measuring the amount of energy required to maintain a constant temperature with coated and uncoated steel vessels. One-gallon metal containers were coated with 125 mils DFT of an insulation coating based on MAINCOTE IC-1001 , then filled with a high temperature silicone fluid, which was heated to varying temperatures

(180, 250 or 325°F). While maintaining the silicone fluid at a constant temperature for a period of 6 hours, the total amount of energy was measured, thus providing the energy consumption at a steady state temperature. This data is provided in Figure 1 for a container without a coating and compared to identical containers coated with starting point formulas IC-1001-1 (only hollow glass sphere filler) and IC-1001-4 (only silica aerogel filler). At each temperature, the results show a notably lower energy usage for containers coated with an insulation coating compared to no coating. The formulation containing silica aerogel performed slightly better than the coating based on hollow glass sphere filler.

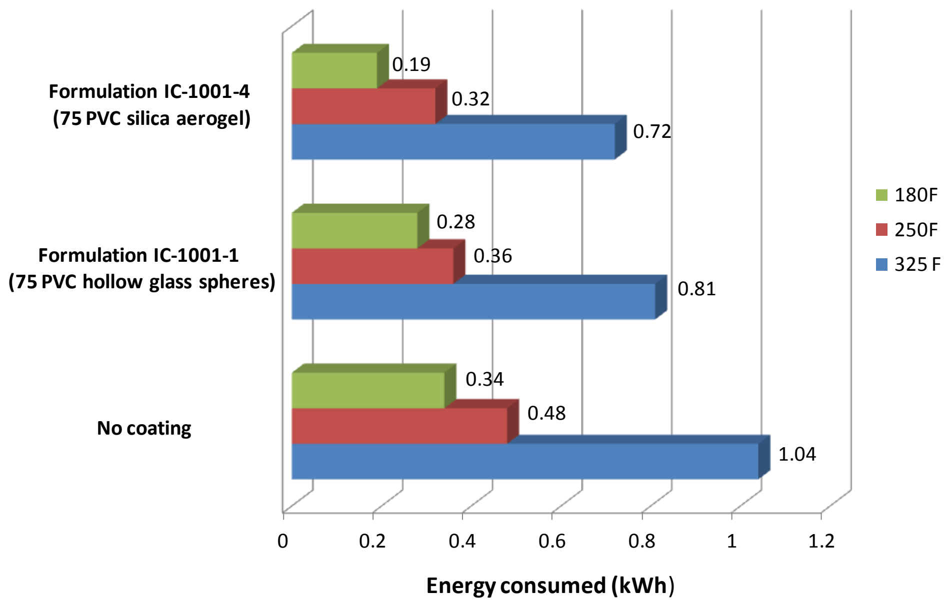


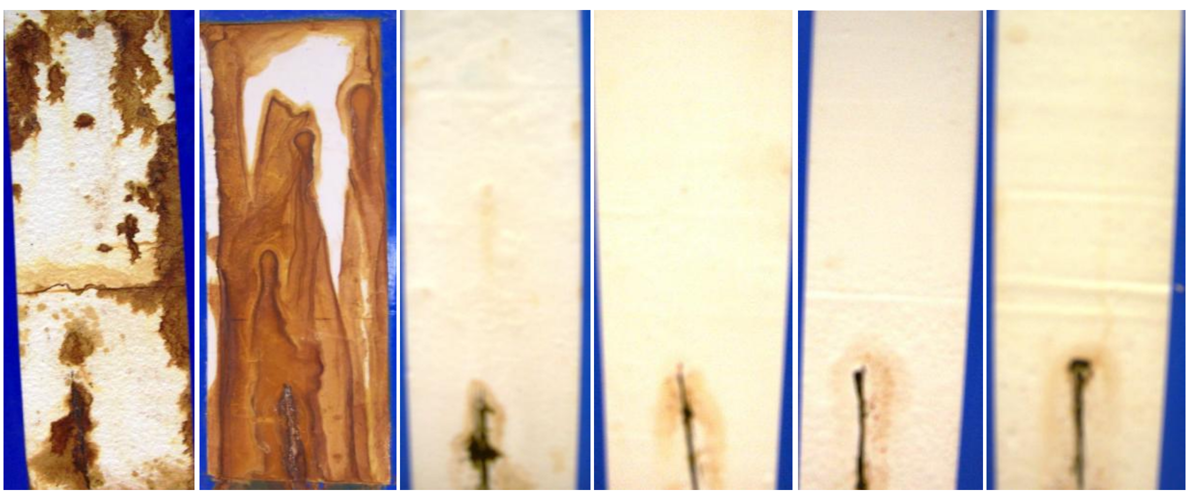
Figure 1. Effect of insulation coatings on amount of energy consumed in maintaining a one gallon metal container at a constant temperature.

Humidity resistance was evaluated by casting films on clean, smooth cold rolled steel, drying for a week at room temperature, and then testing the panels in a Cleveland condensation cabinet according to ASTM D4585. Results after 1000 hrs exposure showed no blistering for any of the coatings tested (Table 4).

Corrosion resistance was evaluated for coating systems including the thermal insulation coatings as a topcoat over a waterborne two-component epoxy anti-corrosive primer. The primer was applied at 3 mils DFT on smooth cold rolled steel and cured for 1 week at room temperature, then topcoated with 50 mils DFT of insulation coating and dried for an additional week. Panels were scribed prior to exposure in salt spray (ASTM B117) and rated for blistering and rusting. No blistering was observed for any of the systems after 2016 hr exposure, but varying degrees of rust was observed to bleed through the coatings, as shown in Figure 2. Most of the corrosion protection is due to the primer, but clearly differences in the insulation coating affects the barrier properties and corrosion protection. The two commercial insulation coatings displayed poor protection, while the experimental coatings based on MAINCOTE™ IC-1001 Resin had much improved performance.

Table 4. Humidity resistance (Cleveland condensation cabinet) of MAINCOTE™ IC-1001 Resin formulations compared to commercial waterborne acrylic thermal insulation coatings.

Formulation	Hollow glass microsphere %PVC	Silica aerogel %PVC	1000 hrs Humidity Resistance blister rating
IC-1001-1	75	0	none
IC-1001-2	50	25	none
IC-1001-3	25	50	none
IC-1001-4	0	75	none
Commercial #1	-	-	none
Commercial #2	-	-	none



Formulation					
Commercial #1	**Commercial #2**	**IC-1001-1**	**IC-1001-2**	**IC-1001-3**	**IC-1001-4**
% PVC (Hollow glass sphere / silica aerogel)					
unknown	unknown	75 / 0	50 / 25	25 / 50	0 / 75

Figure 2. Salt spray panels after 2016 hr exposure, comparing the corrosion resistance of primer/topcoat systems, with insulation coatings as the topcoat layer over a waterborne epoxy primer.

Formulation Guidelines

Several starting point formulations for waterborne thermal insulation coatings based on MAINCOTE™ IC-1001 Resin are shown below. In general, insulation coatings are formulated at high PVC due to the high amount of low thermal conductivity fillers necessary to achieve insulating properties. We have found approximately 75% PVC to be a good starting point. The formulations shown below are also at high volume solids, which is necessary to minimize shrinkage of the film during drying, which could result in cracking of the film.

MAINCOTE IC-1001 Resin can be formulated with common additives available for waterborne coatings. The process used in making the insulation coatings is nearly identical to the conventional paint making process, using a high speed Cowles disperser. In our evaluations, a one step process was utilized where the filler was dispersed directly in the resin, instead of separate grind (pigment dispersion) and resin let down steps. The liquid mill base materials such as water, surfactant, dispersant, defoamer, and coalescent were added first and mixed under low speed for 15 minutes, followed by addition of the waterborne polymer and mixing for 30 minutes. A pre-dispersed TiO_2 slurry was then added and mixed for 15 minutes, followed by addition of the low thermal conductivity fillers. Silica aerogel was dispersed at 2500 rpm, and hollow glass microspheres at 1000 rpm. Adjustment of pH was done with ammonium hydroxide, followed by addition of a non-ionic HEUR rheology modifier and defoamer.

Low thermal conductivity fillers

Our studies have focused on two types of low thermal conductivity fillers, hollow glass spheres and silica aerogel. Low density hollow glass spheres, such as Sphericel 25P45 hollow glass spheres from Potters Industries, disperse easily into the resin under fairly low shear. Very high shear should be avoided to control any cracking of the glass spheres. Enova aerogel IC-3100 (2 – 40 μm) from Cabot is a small particle size silica aerogel that is easily incorporated into formulations using slightly higher shear than needed for the glass spheres. This particular grade of silica aerogel tends to produce finishes that are smooth. Larger particle size versions such as Enova aerogel IC-3110 (0.1 – 0.7 mm) can also be used and tends to produce a rougher surface texture.

Coalescents

Approximately 7% (on polymer solids) of Texanol ester alcohol is included in the starting point formulations to insure good film formation. Other suitable coalescents include DOWANOL™ DPnB Glycol Ether or faster coalescents such as DOWANOL DPM Glycol Ether and Butyl CELLOSOLVE™ Glycol Ether. Some insulation coatings may be applied to hot surfaces, and less or no coalescent may be necessary for film formation in those instances. However, use of coalescent should be considered if the product will be applied under colder conditions.

Dispersants

A low level of pigment dispersant was found useful in lowering the viscosity during grinding of the pigments. Copolymer dispersants such as TAMOL™ 165A and TAMOL 681, or the low VOC alternative TAMOL 2002, at 1.5 to 2% solids on pigment solids are recommended as starting points.

Titanium Dioxide

A low level of titanium dioxide was used in the starting point formulations to provide color to the insulation coating. It is not necessary for the insulating properties of the coating, and could be left out of the formulation. Ti-Pure R-746 titanium dioxide slurry was used in our studies, but other slurry grades of TiO_2 can be used for easy incorporation. If the insulation coating will not be topcoated and is intended for use in an exterior environment with exposure to sunlight, a durable TiO_2 grade is recommended.

Defoamers

Foam is a major concern in waterborne coating formulation design. Defoamers are needed to eliminate foam during manufacture and film application. Suitable defoamers for MAINCOTE™ IC-1001 Resin include Tego Foamex 1488 and Byk-022 defoamers.

Viscosity Control

In order to apply a high film build without sagging, and minimize water resistance problems, a nonionic HEUR rheology modifier should be used. ACRYSOL™ RM-12W or ACRYSOL RM-995 Rheology Modifiers are effective at increasing the low shear viscosity necessary for good sag resistance, and are shear thinning to facilitate good mixing and spray application.

Flash Rust Inhibitors

In waterborne coatings designed for steel substrates, the aqueous phase should contain flash rust inhibitors to control the rapid rusting (flash rust) that can occur as the coating is drying. If the insulation coating is intended to be applied directly to steel, a flash rust additive will be necessary. The recommended additive is sodium nitrite ($NaNO_2$), which is effective at low use levels of 1 to 2 lbs/ 100 gallons. Addition in a diluted form (15% aqueous solution) to the resin is recommended to control stability problems and grit formation. Commercial flash rust inhibitors are also available, such as Halox Flash-X 150 or Raybo 60.

Starting Point Formulation IC-1001-1

Thermal insulation coatings based on MAINCOTE™ IC-1001 Resin and hollow glass spheres

Material Name	Pounds	Gallons
Water	28.68	3.44
Texanol ester alcohol	11.00	1.39
TRITON™ CF-10 Surfactant	2.00	0.23
Ammonia (28%)	2.20	0.29
TAMOL™ 165 Dispersant	2.20	0.25
Byk-022 defoamer	2.00	0.24
Ti-Pure R-746 titanium dioxide slurry	50.00	2.57
Mix well for 15 minutes then add:		
MAINCOTE™ IC-1001 Resin	330.00	38.37
Mix well for 15 minutes, then add:		
Sphericel 25P45 hollow glass spheres	110.00	52.82
Mix for 15 minutes at 1000 rpm, then add:		
ACRYSOL™ RM-12W Rheology Modifier	3.00	0.34
Tego Foamex 1488 defoamer	0.50	0.06
Totals	541.58	100.00
Level without additives	Volume Solids	71.0%
	Weight Solids	56.0%
	PVC	76.0%
	Density(lb/gal)	5.42
	VOC(g/L)	17
Level with additives	Volume Solids	71.6%
	Weight Solids	57.0%

Starting Point Formulation IC-1001-2

Thermal insulation coatings based on MAINCOTE™ IC-1001 Resin and a blend of hollow glass spheres and silica aerogel (approx. 2 : 1 by volume)

Material Name	Pounds	Gallons
Water	29.20	3.49
Texanol ester alcohol	11.00	1.39
TRITON™ CF-10 Surfactant	2.00	0.23
Ammonia (28%)	2.20	0.29
TAMOL™ 165 Dispersant	4.00	0.45
Byk-022 defoamer	2.00	0.24
Ti-Pure R-746 titanium dioxide slurry	50.00	2.57
Mix well for 15 minutes then add:		
MAINCOTE™ IC-1001 Resin	328.00	38.14
Mix well for 15 minutes, then add:		
Enova Aerogel IC-3100 silica aerogel	19.00	17.27
Sphericel 25P45 hollow glass spheres	74.00	35.53
Mix for 15 minutes at 1000 rpm, then add:		
ACRYSOL™ RM-12W Rheology Modifier	3.00	0.34
Tego Foamex 1488 defoamer	0.50	0.06
Totals	524.90	100.00
Level without additives	Volume Solids	70.9%
	Weight Solids	54.4%
	PVC:	
	Total	76.1%
	glass spheres	50.1%
	aerogel	24.4%
	Density(lb/gal)	5.25
	VOC(g/L)	17
Level with additives	Volume Solids	71.5%
	Weight Solids	55.4%

Starting Point Formulation IC-1001-3

Thermal insulation coatings based on MAINCOTE™ IC-1001 Resin and a blend of hollow glass spheres and silica aerogel (approx. 1 : 2 by volume)

Material Name	Pounds	Gallons
Water	27.50	3.29
Texanol ester alcohol	11.00	1.39
TRITON™ CF-10 Surfactant	2.00	0.23
Ammonia (28%)	2.20	0.29
TAMOL™ 165 Dispersant	4.00	0.45
Byk-022 defoamer	2.00	0.24
Ti-Pure R-746 titanium dioxide slurry	50.00	2.57
Mix well for 15 minutes then add:		
MAINCOTE™ IC-1001 Resin	330.00	38.37
Mix well for 15 minutes, then add:		
Enova Aerogel IC-3100 silica aerogel	38.50	35.0
Sphericel 25P45 hollow glass spheres	37.00	17.77
Mix for 15 minutes at 1000 rpm, then add:		
ACRYSOL™ RM-12W Rheology Modifier	3.00	0.34
Tego Foamex 1488 defoamer	0.50	0.06
Totals	507.70	100.00
Level without additives	Volume Solids	71.0%
	Weight Solids	53.0%
	PVC:	
	Total	76.0%
	glass spheres	49.3%
	aerogel	25.0%
	Density(lb/gal)	5.07
	VOC(g/L)	17
Level with additives	Volume Solids	71.6%
	Weight Solids	54.0%

Starting Point Formulation IC-1001-4

Thermal insulation coatings based on MAINCOTE™ IC-1001 Resin and silica aerogel

Material Name	Pounds	Gallons
Water	29.50	3.54
Texanol ester alcohol	11.00	1.39
TRITON™ CF-10 Surfactant	2.20	0.25
Ammonia (28%)	2.20	0.29
TAMOL™ 165 Dispersant	4.00	0.45
Byk-022 defoamer	2.00	0.24
Ti-Pure R-746 titanium dioxide slurry	50.00	2.57
Mix well for 15 minutes then add:		
MAINCOTE™ IC-1001 Resin	328.00	38.14
Mix well for 15 minutes, then add:		
Enova Aerogel IC-3100 silica aerogel	58.0	52.73
Mix for 15 minutes at 1000 rpm, then add:		
ACRYSOL™ RM-12W Rheology Modifier	3.00	0.34
Tego Foamex 1488 defoamer	0.50	0.06
Totals	490.40	100.00
Level without additives	Volume Solids	70.8%
	Weight Solids	51.1%
	PVC:	
	Total	76.1%
	aerogel	74.4%
	Density(lb/gal)	4.90
	VOC(g/L)	17
Level with additives	Volume Solids	71.5%
	Weight Solids	52.2%

Handling Precautions

Before using this product, consult the Material Safety Data Sheet (MSDS)/Safety Data Sheet (SDS) for details on product hazards, recommended handling precautions and product storage.

Storage

Store products in tightly closed original containers at temperatures recommended on the product label.

Disposal Considerations

Dispose in accordance with all local, state (provincial) and federal regulations. Empty containers may contain hazardous residues. This material and its container must be disposed in a safe and legal manner.

It is the user's responsibility to verify that treatment and disposal procedures comply with local, state (provincial) and federal regulations. Contact your Dow Coating Materials Technical Representative for more information.

Product Stewardship

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products - from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Customer Notice

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

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