EPOXY RESINS

PRODUCT STEWARDSHIP MANUAL

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Abbreviations

ACGIH	American Conference of Governmental and Industrial Hygienists
ASTM	American Society for Testing Materials
ECSA	European Chlorinated Solvents Association
EPA	Environmental Protection Agency
EU	European Union
GHS	Global Harmonization System
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HSIA	Halogenated Solvents Industry Alliance
IARC	International Agency for Research on Cancer
IHG	Industrial Hygiene Guideline
LC50	Lethal Concentration 50%
LD50	Lethal Dose 50%
MAK	Maximum Allowable Concentration
MEC	Methylene Chloride
MIR	Maximum Incremental Reactivity
NIOSH	National Institute of Occupational Safety and Health
NTP	National Toxicology Program
ODP	Ozone Depletion Potential
OECD	Organization for Economic Cooperation and Development
OEL	Occupational Exposure Limit
PCE	Perchloroethylene
PPE	Personal Protective Equipment
PTFE	Polytetrafluoroethylene
PVA	Polyvinyl Alcohol
RoC	Report on Carcinogens
SCBA	Self-Contained Breathing Apparatus
SCOEL	Scientific Committee on Occupational Exposure Limits
SDS	Safety Data Sheets
TCA	Trichloroacetic Acid
TCE	Trichloroethylene
TLV	Threshold Limit Value
TWA	Time Weighted Average (8-hour)
VOC	Volatile Organic Compounds

Introduction

As the largest, most integrated Epoxy business in the world, Olin Epoxy provides high-quality products including D.E.R.™ Liquid Epoxy Resins, Solid and Epoxy Resin Solutions, D.E.N.™ Epoxy Novolac Resins, and D.E.H.™ Hardeners and Curing Agents. Olin Epoxy customers also have access to the problem-solving power of our people who have deep industry knowledge and Epoxy technology expertise. Olin has prepared this manual on the Safe Handling and Storage of Epoxy Resins as a service to the Epoxy industry. This manual is part of Olin's ongoing commitment to the industry's growth and success as well as the safe handling of Epoxy Products to protect the environment and the health and safety of those who use them.

Although Olin Epoxy Products have been used successfully for more than six decades, their handling, use, and storage can present certain hazards. This manual contains information on health hazards, precautions for handling, first aid, personnel protection, fire and explosion hazards, resin storage, spills and leaks, disposal, and transportation.

In addition to the information contained in this brochure, Olin offers the advice and assistance of its Technical Service and Development staff, including Product Stewardship and Responsible Care® support. These service groups have extensive experience in the chemistry, formulation, and application of Epoxy Resins.

Solutions for a Wide Range of Applications

Olin Epoxy Resins are high-quality, thermosetting plastic materials that are ideal for industrial applications that require superior strength, excellent adhesion, good chemical and corrosion resistance, and high performance at elevated temperatures. Our experts can help customers with various curing agents, reactive diluents, and modifiers to achieve a wide range and variety of performance properties.

Major applications for Olin Epoxy Resins include:

- **Adhesives.** Olin Epoxy Resins provide excellent adhesion to many surfaces, including composites, metal, concrete, glass, and ceramics.
- **Composites.** Olin Epoxy Resins are used for fiber reinforced pipes, pressure vessels, sports equipment, and for wind turbine applications. The Epoxy Resins provide excellent adhesion to glass and carbon fibers and provide good thermal and mechanical properties.
- **Potting and Encapsulating Media.** For electrical and electronic devices, our resins are essentially inert and provide outstanding performance without affecting encapsulated parts or other delicate components.
- **Coatings.** The chemical and corrosion resistance and strength of Olin Epoxy Resins make them ideal for coatings applications in gas storage vessels, appliances, and other surfaces, including flooring, wall panels, and laminate boards.
- **Civil Engineering.** Epoxy resins are used for industrial flooring, grout, non-skid surfacing, and protection of roads and bridges.
- **And More.** Customers also look to Olin Epoxy Resins for other applications such as filament-wound pipe and pressure vessels, cements and mortars (including special low-temperature mortars), rigid foams, non-skid road surfacing, and for solidification of sandy formations in oil well operations.

Introduction

Health and Safety

As a leading producer of Epoxy Products, Olin has devoted considerable resources to promote the safe and effective use of Olin Epoxy Resins, as well as correct storage and disposal. But everyone has a role in achieving high standards in environmental care, health and safety. Olin recommends that every individual who handles, stores or is regularly exposed to these resins read and familiarize themselves with the contents of this manual.

Broadly speaking, direct contact with these materials should be avoided. This is best accomplished through the use of a "closed" system. However, since customer/user needs vary so widely, such systems must be individually designed to meet the specific needs of each plant site. And while Olin resources and expertise are available to customers on an individual basis, Olin can make no warranty of any kind. Thus, final judgments on systems, procedures, and safe handling practices in use, storage, transportation and disposal must be the sole responsibility of the customer/user.

To be of service in this regard, Olin publishes and continually updates a Safety Data Sheet (SDS) for each of its Epoxy Products. These sheets should be obtained and read before any of the various Olin Epoxy Products are used. They are designed to help customers meet their safe handling and disposal needs. For current copies of SDSs for Olin Epoxy Products, contact your Olin representative. See the back page for country-specific contacts and telephone numbers. Reference materials issued by federal and state regulatory agencies and trade associations should also be consulted.

WARNING: Curing agents, solvents, diluents, and other common "Epoxy" formulating ingredients may present certain hazards. Data and recommendations on the handling and storage of each of these products must be provided by the suppliers. Product Bulletins and Product Stewardship Manuals are available from Olin and should be requested and read before using or storing these products. Also, unless stated otherwise, all references to specific governmental regulations on health, safety, handling, shipment, disposal, etc., are based on U.S. laws and regulations.

Product Stewardship

At Olin, our Product Stewardship program is guided by our core values of Integrity, Customer Success, Innovation, and People. We are committed to the safe handling and use of our products – and enabling all of our collaborators throughout the value chain to do the same. As a Responsible Care® company, we assess the safety, health, and environmental information on our products, and then take appropriate steps to protect employees, public health, and the environment. Ultimately, the success of our product stewardship program rests with each and every individual involved with Olin products – from the initial concept and research to the manufacture, sale, distribution, use, disposal, and recycling of each product.

Responsible Care®

Olin has a long-standing policy to ensure that its operations do not have an adverse impact on the community or the environment. To uphold this policy, Olin is committed to Responsible Care®, a continuing effort by the chemical industry to improve the responsible management of chemicals.

Under Responsible Care, Olin complies with 10 Guiding Principles and Codes of Management Practices that cover all aspects of research, development, manufacture, distribution, transportation, use and disposal of products. The Principles also extend to prompt reporting, customer counseling, community awareness, support of external research, participation with government and others, and promotion of Responsible Care worldwide.

Olin recognizes that no single entity can protect the quality of all of our air and water. However, by working together on a global basis, the public, industry, and government can make the future brighter and safer.

Olin Epoxy Resins and ISO 9001 Certification

The extraordinarily high quality of the large and varied family of Olin Epoxy Resins is now further assured by the achievement of ISO 9001 Certification. The awarding of this certification confirms that Olin Epoxy Resins conform to the highest standards of quality established by the International Organization for Standardization (ISO), standards that are recognized in more than 145 countries around the world.

ISO 9001 Certification encompasses all aspects of product development, from the early stages of design through product manufacturing, including research and development activities, Epoxy Resin and intermediate product and process research laboratories, pilot plants, and commercial manufacturing processes and facilities.

Physical Properties

WARNING: The comments made in this bulletin on hazards, etc., are relevant only to the listed products. Do not assume that the comments in this bulletin are valid for other commercial resins or other Olin Epoxy Resins than those listed.

Table 1: Typical Properties[(1)] of Olin Liquid Epoxy Resins and Epoxy Novolac Resins

Liquid Epoxy Resins	Viscosity Range mPa•s @ 25˚C (77˚F) [(2)]	Specific Heat @ 25˚C (77˚F) [(3)]	Specific Gravity 25/25˚C (77˚F) [(4)]	Relative Density (20/20˚C (68˚F))	Weight @ 25˚C (77˚F) (lbs/Gal)
D.E.R.™ 317	16,000 – 25,000	0.5	1.16	1.16	9.7
D.E.R. 321	500 – 700	0.5	1.14	1.11 – 1.16	9.5
D.E.R. 324	600 – 800	0.5	1.1	1.11 – 1.14	9.2
D.E.R. 325	850 – 2,800	0.5	1.16	1.11 – 1.14	9.7
D.E.R. 329	900 – 1,300	0.5	1.16	1.1 – 1.18	9.7
D.E.R. 330	7,000 – 11,000	0.5	1.16	1.16	9.7
D.E.R.™ 331	11,000 – 14,000	0.5	1.16	1.16	9.7
D.E.R. 332	5,000	0.5	1.16	1.16	9.7
D.E.R. 336	9,400 – 11,000	0.5	1.16	1.16	9.7
D.E.R. 337	>14.000	0.5	1.16	1.16	9.7
D.E.R. 351	4,500 – 6,500	0.5	1.1	1.1-1.18	9.2
D.E.R. 352	5,700 – 7,700	0.5	1.16	1.1-1.18	9.7
D.E.R. 353	800 – 1,000	0.5	1.12	1.16	9.3
D.E.R. 354	3,400 – 4,200	0.5	1.1	1.2	9.2
D.E.R. 356	6,500 – 8,000	0.5	1.15 – 1.17	1.1 – 1.18	9.6 – 9.8
D.E.R. 358	600 – 750	0.5	1.15	1.11 – 1.16	9.6
D.E.R. 361	11,000 – 14,000	0.5	1.16	1.16	9.7
D.E.R. 383	10,400 – 12,200	0.5	1.16	1.16	9.7
D.E.R. 732(P)	58 – 83	0.4	1.1	1.06 – 1.1	9.2
D.E.R. 736(P)	30 – 60	0.4	1.1	1.14	9.2
D.E.N.™ 425	9,500 – 12,500	0.5	ND[(7)]	1.16 – 1.22	9.6 – 10.2
D.E.N. 431	1,100 – 1,700[(6)]	0.5	1.21[(5)]	1.22	10.1
D.E.N.™ 438	31,000 – 40,000[(6)]	0.5	1.18	1.22	9.8

(1) Typical properties; not to be construed as specifications

(2) ASTM D-445

(3) Differential scanning calorimeter

(4) ASTM D-4052

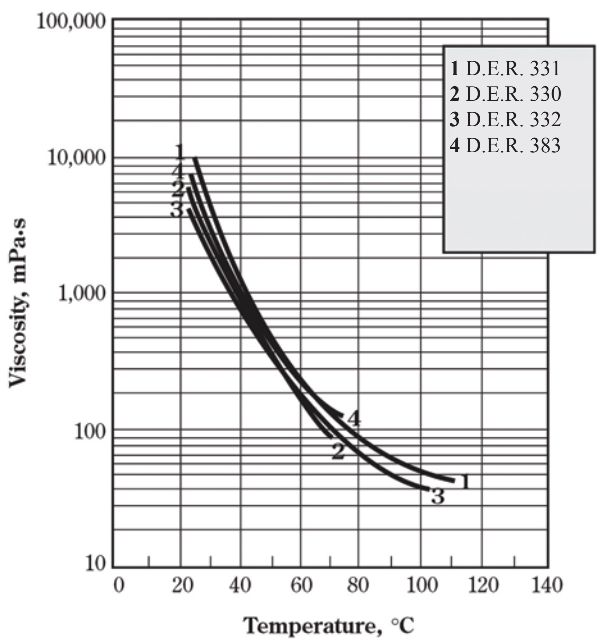
(5) ASTM D-1963

(6) Determined at 51.7°C or 125°F

(7) Not Determined (ND)

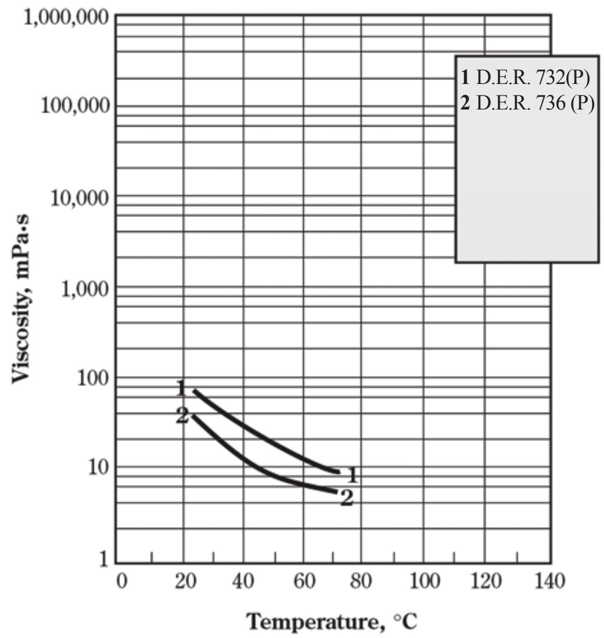
Physical Properties

Figure 1: Typical Viscosity of Olin Liquid Epoxy Resins(1)



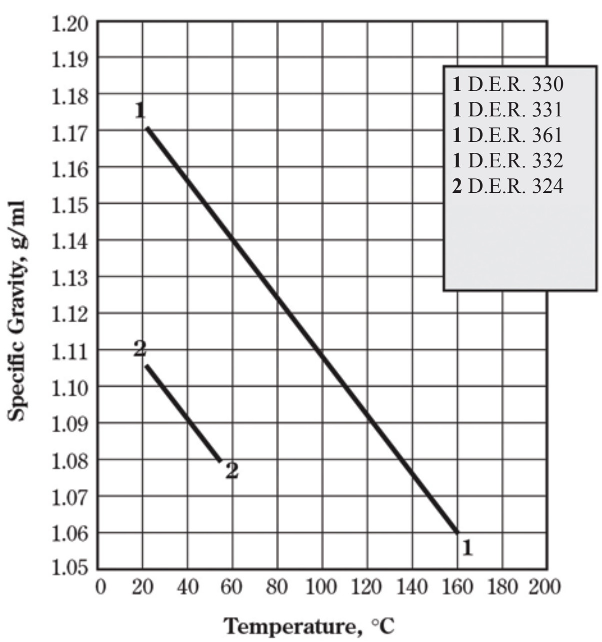
(1) Typical properties; not to be construed as specifications

Figure 2: Typical Viscosity of Olin Flexible Epoxy Resins(1)



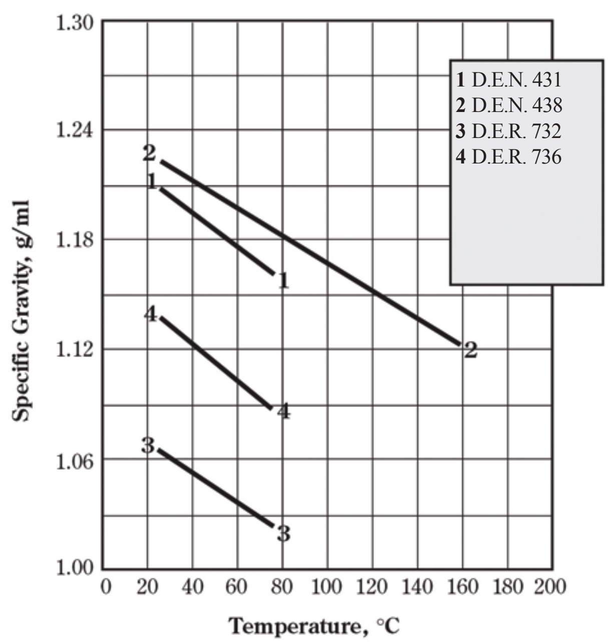
(1) Typical properties; not to be construed as specifications

Figure 3: Typical Specific Gravity of Olin Liquid Epoxy Resins(1)



(1) Typical properties; not to be construed as specifications

Figure 4: Typical Specific Gravity of Olin Epoxy Resins(1)



(1) Typical properties; not to be construed as specifications

Physical Properties

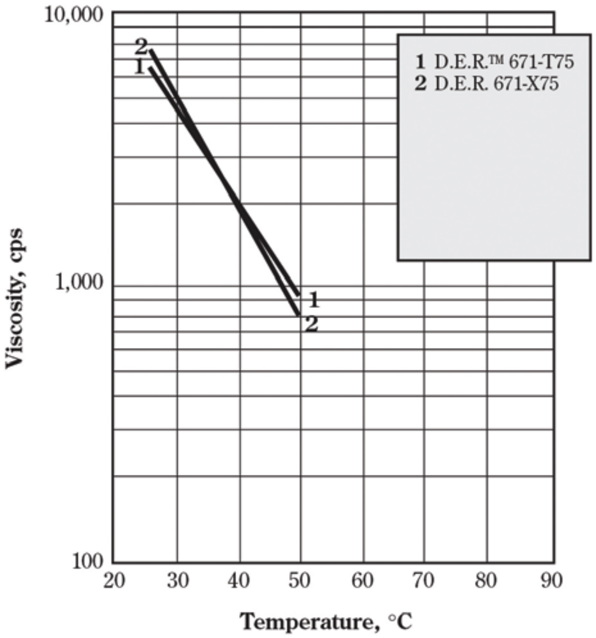
Table 2: Typical Properties[1] of Olin Solutions Epoxy Resin

Solution Epoxy Resins	Viscosity Range mPa•s @ 25°C (77°F) [6]	Specific Heat @ 25°C (77°F) [2]	Specific Gravity 25/25°C (77°F) [3]	Weight @ 25°C (77°F) (lbs/Gal) [4]	Percent Non-Volatile[5]	Solvent
D.E.R.337-X80	500 – 1,200	ND[7]	1.1	9.16	75 – 85	Xylene
D.E.R. 337-X90	5,000 – 15,000	0.4	1.14	9.5	85 – 95	Xylene
D.E.R. 538-A80	800 – 1,800	0.4	1.2	10.2	75 – 85	Acetone
D.E.R. 539-EK80	1,500 – 2,000	ND[7]	1.25	ND[7]	79 – 81	MEK[8]
D.E.R. 539-A80	1,000 – 1,600	ND[7]	1.23	ND[7]	75 – 85	Acetone
D.E.R. 592-A80	1,200 – 2,880	ND[7]	1.21 – 1.23	ND[7]	79 – 81	Acetone
D.E.R. 593	480 – 1,320	ND[7]	1.19 – 1.23	ND[7]	70 – 80	Acetone
D.E.R. 660-B80	2,300 – 6,200	0.4	1.08	9.03	79 – 81	Butanol
D.E.R. 660-X80	3,500 – 7,000	0.4	1.09	9.1	79 – 81	Xylene
D.E.R. 661-A80	3,500 – 8,500	0.4	1.1	9.16	79 – 81	Acetone
D.E.R. 671-MAK75	3,000 – 15,000	0.4	1.08	9.0	74 – 76	Amyl methyl ketone[9]
D.E.R. 671-PM75	9,500 – 15,000	0.4	1.1	9.3	70 – 80	Propylene Glycol Monomethyl Ether
D.E.R. 671-T75	2,200 – 10,000	0.4	1.1	8.9	70 – 80	Toluene
D.E.R. 671-X75	7,500 – 11,500	0.4	1.09	9.1	74 – 76	Xylene
D.E.R. 671-XM75	2,500 – 9,000	0.4	1.08	9.0	70 – 80	Xylene, MIBK[9]
D.E.R. 684-EK40	576 – 2,400	0.4	0.96	8.0	30 – 50	MEK[8]
D.E.N. 438-A85	500 – 1,200	0.4	1.14	9.5	84 – 86	Acetone
D.E.N. 438-EK85	600 – 1,600	0.4	1.1	9.5	84 – 86	MEK[8]
D.E.N. 438-X80	1,200 – 2,000	ND[7]	1.16	ND[7]	79 – 81	Xylene
D.E.N. 439-EK85	4,000 – 10,000	0.4	1.15	9.6	84 – 86	MEK[8]

[1] Typical properties; not to be construed as specifications
[2] Differential Scanning Calorimeter
[3] ASTM D-4052
[4] ASTM D-1963
[5] Reference is from Section 3 of the Safety Data Sheet (SDS)
[6] ASTM D-445
[7] Not Determined (ND)
[8] Methyl ethyl ketone
[9] Methyl isobutyl ketone

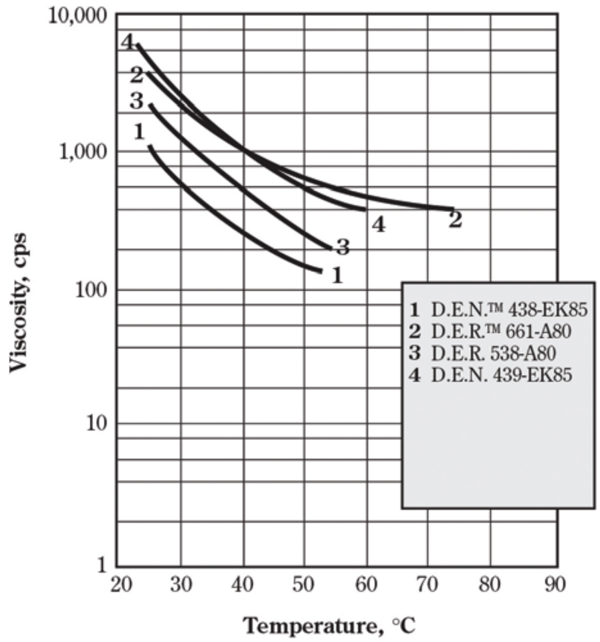
Physical Properties

Figure 5: Typical Viscosity of Olin Epoxy Resin Solutions [(1)]



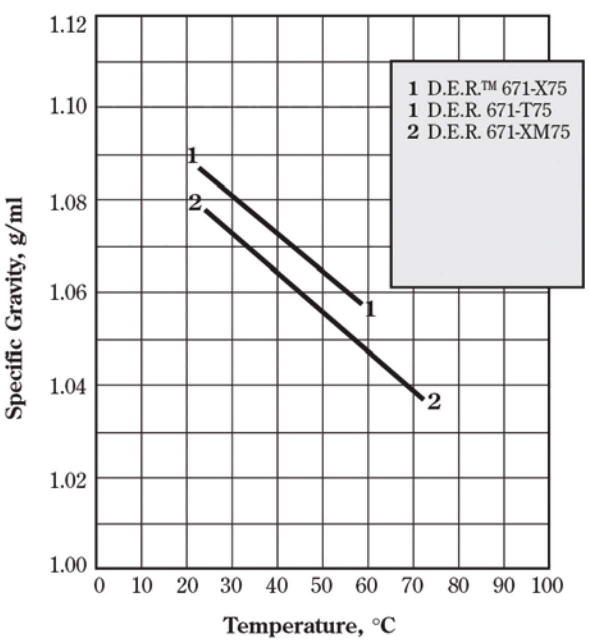
[(1)] Typical properties; not to be construed as specifications

Figure 6: Typical Viscosity of Olin Epoxy Resin Solutions [(1)]



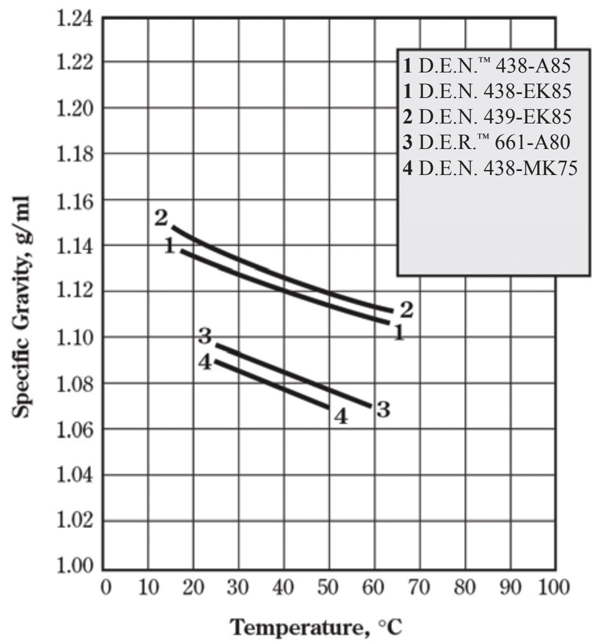
[(1)] Typical properties; not to be construed as specifications

Figure 7: Typical Specific Gravity of Olin Epoxy Resin Solutions [(1)]



[(1)] Typical properties; not to be construed as specifications

Figure 8: Typical Specific Gravity of Olin Epoxy Resin Solutions [(1)]



[(1)] Typical properties; not to be construed as specifications

Physical Properties

Table 3: Typical Properties [1] and Handling Characteristics of Olin Solid Epoxy Resins

Solid Epoxy Resins	Bulk Density [2] kg/m³/lbs/cu ft	Melt Specific Gravity/Cast Density [3] lbs/gal	Mettler Softening Point °C [4]	Form
D.E.R.™ 542	NA/NA[5]	1.8/14.9	52 – 62	Solid
D.E.R. 560	ND[6]	1.8/14.2	78 – 85	Flake
D.E.R. 6155	600/38	1.18/9.9	105 – 125	Flake
D.E.R. 6330-A10	650/41	1.18/9.9	98 – 106	Flake
D.E.R. 642U	625/39	1.18/9.9	90 – 98	Flake
D.E.R. 6508	ND[6]	1.18/9.9	95 – 105	Flake
D.E.R. 661	690/43	1.18/9.9	75 – 85	Flake
D.E.R. 6615	ND[6]	1.16/9.9	78 – 86	Flake
D.E.R. 662E	675/42	1.16/9.9	84 – 94	Flake
D.E.R. 662UH	675/42	1.18/9.9	90 – 98	Flake
D.E.R. 663U	650/41	1.18/9.9	92 – 102	Flake
D.E.R. 663UE	650/41	1.18/9.9	98 – 104	Flake
D.E.R. 664U	625/39	1.18/9.9	98 – 108	Flake
D.E.R. 664UE	635/39	1.18/9.9	98 – 108	Flake
D.E.R. 667-20	590/37	1.16/9.9	125 – 138	Flake
D.E.R. 667E	590/37	1.16/9.9	120 – 135	Flake
D.E.R. 669-20	590/37	1.18/9.9	142 – 162	Flake
D.E.R. 669E	590/37	1.18/9.9	142 – 162	Flake
D.E.R. 671	690/43	1.16/9.9	75 – 85	Flake
D.E.R. 672U	605/38	1.18/9.9	110 – 120	Flake
D.E.R. 672U-20	ND[6]	1.18/9.9	110 – 120	Flake
D.E.N.™ 439	NA/NA[5]	1.22/9.9	48 – 58	Viscous Liquid

[1] Typical properties; not to be construed as specification

[2] ASTM D-1895

[3] ASTM D-792

[4] ASTM D-3104

[5] Not Applicable (NA)

[6] Not Determined (ND)

Health and Handling

Introduction

Olin publishes and regularly updates a Safety Data Sheet (SDS) for each Epoxy Resin it produces. These documents are designed to help those handling these materials to meet both their own safe handling and disposal needs and the regulations of various governmental agencies, including Occupational Safety and Health Administration (OSHA) in the United States, and Workplace Hazardous Material Information System (WHMIS) in Canada. Current copies of these sheets should be carefully read before any of the various Olin Epoxy Products are handled, used, stored, or disposed. SDSs should also be consulted for information and instructions on containing and/or cleaning up spills and leaks, personal protection, and administering first aid. For current copies of SDSs, contact your Olin representative.

NOTE: D.E.R.™ Epoxy Resins and D.E.N.™ Epoxy Novolac Resins vary considerably in the degree of health hazard they present. While general comments are made in this section about the health hazards presented by broad chemical groups, it is essential that each specific product be further identified for its particular characteristics.

Liquid Epoxy Resins and Epoxy Novolac Resins

Skin Contact

Although skin irritation potential is slight, all skin contact with Olin Epoxy Resins (including D.E.R. Solid and Epoxy Resin Solutions and D.E.N. Epoxy Novolac Resins) should be avoided.

Most D.E.R. Liquid Epoxy Resins and D.E.N. Liquid Epoxy Novolac Resins listed in Table 1, page 7, may cause skin irritation. This information is derived from both human experience and laboratory animal tests. The sticky character of many of these resins can exacerbate this irritation potential due to prolonged contact.

The lower molecular weight D.E.R. Epoxy Resins are capable of causing skin sensitization (H317). The D.E.N. Epoxy Novolac Resins may be mild sensitizers according to animal tests, but when patch-tested in humans, several were not found to have sensitizing potential. Susceptibility to skin irritation and sensitization varies from person to person. In a sensitized individual, allergic dermatitis may appear rapidly or take several days. Avoid frequent or prolonged contact, as this may induce sensitization. In a study of 151 human volunteers, nine individuals (5.8%) developed a skin reaction after seven applications of undiluted D.E.R.™ 331 Epoxy Resin under a bandage left in place for 24 hours.

NOTE: Once sensitization has occurred, exposure of the skin to even very small quantities of the material may elicit erythema and edema at the site.

Eye Contact

Eye contact with liquid D.E.R. or D.E.N. Epoxy Resins should be avoided, but is expected to result in only slight transient pain and irritation.

Inhalation

For D.E.R.™ Liquid Epoxy Resins and D.E.N.™ Liquid Epoxy Novolac Resins, spray applications can result in potential for inhalation exposure to vapors and aerosols, although for other applications the low vapor pressures at room temperature would be expected to limit this exposure route.

Ingestion

All D.E.R. Liquid Epoxy Resins and D.E.N. Liquid Epoxy Novolac Resins listed in Table 1, page 7, are low in acute oral toxicity. The single oral LD50 value (i.e. the lethal dose for 50% of the laboratory rats) is greater than 2,000 mg/kg of body weight (the highest dose usually tested).

Health and Handling

Epoxy Resin Solutions

The D.E.R. and D.E.N. Epoxy Resin Solutions listed in Table 2, page 9, are solutions of Epoxy Resins in non-reactive solvents, such as acetone, methyl ethyl ketone, toluene, xylene, etc. Due to the hazards of the solvents used, solutions of resins may be more hazardous to handle than the pure resins alone. Exposures to these non-reactive solvents should be maintained in accordance with existing OELs (see Table 5).

Skin and Eye Contact

All skin and eye contact should be avoided as such solutions may be much more irritating to the skin and eyes. Dermal sensitization (H317) potential varies depending on the components.

Inhalation

Inhalation exposures to Solutions Epoxy Resins from spray applications can result in upper respiratory tract irritation. These solutions are hazardous from inhalation due to the potential for central nervous system depression (including signs such as dizziness and drowsiness followed by unconsciousness or even death) and other systemic effects, mostly stemming from the solvents that are used to formulate these resin solutions. The solvents have exposure guidelines from the American Conference of Governmental Industrial Hygienists (ACGIH), which are determined based on available information for the specific solvent, and which should be respected (see Table 5, Exposure section). The resin solutions containing solvent are more flammable than solid resins alone, with fire and explosion hazard again related to the solvent used.

Ingestion

Hazard from accidental ingestion of Epoxy Resin Solutions is generally low, but several of the solvents used in these formulations may cause chemical pneumonia if aspirated into the lung.

Threshold Limit Values (TLVs)

Table 4: Threshold Limit Values for Solvents Used in D.E.R.™ Epoxy Resin Solutions

Solvent	TWA[(1)],ppm (2018)	STEL[(2)], ppm (2018)
Acetone	250	500
Butanol		
n-Butanol	20	NE[(3)]
sec-Butanol	100	NE[(3)]
tert-Butanol	100	NE[(3)]
Diacetone Alcohol	50	NE[(3)]
Propylene Glycol Monomethyl Ether (synonym 1-Methoxy-2-propanol)	50	100
Methyl n-Amyl Ketone (MAK)	50	NE[(3)]
Methyl Ethyl Ketone (MEK)	200	300
Methyl Isobutyl Ketone (MIBK)	20	75
Toluene	20	NE[(3)]
Xylene	100	150

[(1)] TWA = Time Weighted Average

[(2)] STEL = Short-Term Exposure Limit

[(3)] NE = None established

Solid Epoxy Resins

The D.E.R.™ Solid Epoxy Resins listed in Table 3, page 11, are considered as presenting a low degree of health hazard from handling.

Skin Contact

All skin contact should be avoided. Even though they are unlikely to cause significant primary skin irritation, some solid Epoxy Resins may cause skin rashes due to sensitization in a limited number of people who come into contact with them. However, these resins are considered less likely to cause such responses than the common liquid Epoxy Resins.

Eye Contact

Eye contact with solid Epoxy Resins should result in only slight eye irritation. Mechanical injury to the eye from the physical action of the dust would pose the greatest hazard.

Inhalation

Inhalation of Solid Epoxy Resin vapors is unlikely because of their low volatility; however, they are prone to create dusts. Control of dusts through adequate ventilation and good housekeeping practices is recommended.

Ingestion

All of the solid Epoxy Resins listed in Table 3, page 11, by themselves are low in acute oral toxicity. The specific solvents used in a product composition may affect acute oral toxicity of the product so confirm such details with the specific SDS before using the product.

All Epoxy Resin Products

Mutagenicity and Carcinogenicity

The liquid and some solid Epoxy Resins have been tested in several assays for genetic toxicity, which can indicate potential for induction of heritable changes. The studies showed that *in vivo* animal mutagenicity tests have been consistently negative for the liquid resins, although the *in vitro* assays have given mixed results for liquid and solid resins.

The carcinogenic potential of diglycidyl ether of bisphenol A (DGEBA) resins has been the subject of numerous studies. Three of the studies were conducted in accordance with international /OECD Test Guidelines and reported no carcinogenicity associated with Epoxy Resin treatment in any tissue in rats or mice, either dosed dermally or orally over a lifetime. In the dermal carcinogenicity studies, bisphenol A diglycidyl ether (BADGE) was applied to rats and mice dermally for two years (rodent lifetime) and caused no apparent systemic toxicity, other than a low level of chronic hepatotoxicity at a dose well above that which might be encountered by humans. Changes in the skin at the application site were noted, but were not indicative of a carcinogenic effect. There was no treatment-related carcinogenicity in any tissue in the mice or rats in these modern, well-conducted studies. An older dermal study in mice did, however, report a weak carcinogenic response in skin of one of the two strains of mice tested, when treated dermally for 2 years. This study is not considered reliable due to the atypical composition of the test material applied to the skin.

The material tested in the older study was known to contain high levels of several impurities, including a known carcinogen. The composition of this material was grossly atypical for a commercial product, rendering the results highly questionable and not relevant to today's products. Nine dermal carcinogenicity studies have been conducted over the past 50 years, and the weight of scientific evidence indicates that DGEBA and its associated resins are not carcinogenic. In addition, investigators dosing rats orally with DGEBA for two years reported the Epoxy Resin to be non-carcinogenic by the oral route.

Prior to these more recent negative studies, a 1989 review of the available data by the International Agency for Research on Cancer (IARC) concluded that DGEBA is not classifiable as to its carcinogenicity based on limited evidence in animals and no evidence in humans (Group 3). A re-review by IARC in 1999 reached the same conclusion.

Teratogenicity and Reproductive Information

As the highest volume Epoxy Resins are primarily based on Bisphenol A diglycidyl ether (BADGE), there is a considerable amount of data on teratogenicity, reproductive toxicity, and endocrine-related effects for BADGE. A thorough hazard characterization of BADGE was conducted as part of the product registration process.

Based on data from the *in vitro* mammalian-based assays, BADGE does not interact with the estrogen receptor, nor with the androgen receptor; also, BADGE does not demonstrate *in vitro* activity related to thyroid. More importantly, BADGE has been tested extensively *in vivo*, and has not been shown to be a developmental or reproductive toxicant with *in vivo*, GLP, guideline studies in rodents and in rabbits; no *in vivo* thyroid-related effects, including no histopathology, have been identified in BADGE-treated animals. These aspects are particularly important given the WHO/IPCS definition of endocrine-modulating activity, which requires demonstration of *in vivo* adverse effects. The overall assessment of BADGE potential for endocrine-modulating activity, based on an extensive *in vitro* and *in vivo* database reviewed above, is that BADGE, and by extension DGEBA, does not demonstrate any endocrine-disrupting potential for estrogen or androgen signaling activities, or for the thyroid hormone system, relevant to human health risk assessment.

Other Epoxy Resins do not have the same depth of information available, and may have different properties. Refer to the SDS for specific products for additional information.

Exposure

There are no Occupational Exposure Limits (OELs) set for Epoxy Resins generally, although there are OELs for the solvents used in the D.E.R. Solutions Epoxy Resin products, as shown in Table 5. The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended threshold limit valves (TLV) based on time-weighted average (TWA) of an eight-hour workday for all the solvents used in these products (see Table 5).

The Derived-No-Effect-Level (DNEL) for these solvents, as well as some Epoxy Resins, as described in their respective European Chemicals Agency (ECHA) IUCLID datasets, developed under the EU Registration, Evaluation, and Authorization of Chemicals (REACH) regulation, are shown in Table 5 for long-term systemic effects. The Occupational Safety and Health Administration (OSHA) has set permissible exposure levels (PELs) for most of these solvents.

Table 5: Occupational Exposure Limits (OELs) for solvents used in D.E.R. Epoxy Resin Solutions

Solvent	ACGIH TLV	DNEL(*)	OSHA PEL
Acetone	250 ppm (2015)	1210 mg/m^3	1000 ppm
n-Butanol	20 ppm (2002)	310 mg/m^3	100 ppm
sec-Butanol	100 ppm (2002)	600 mg/m^3	150 ppm
t-Butanol	100 ppm (2001)	2.7 mg/m^3	100 ppm
Diacetone Alcohol	50 ppm (2001)	31.4 mg/m^3	50 ppm
Propylene Glycol Methyl Ether	50 ppm (2013)	369 mg/m^3	NA
MAK methyl n-amyl ketone	50 ppm (2001)	394.25 mg/m^3	100 ppm
MEK methyl ethyl ketone	200 ppm (2001)	600 mg/m^3	200 ppm
MIBK methyl isobutyl ketone	20 ppm (2010)	83 mg/m^3	100 ppm
Toluene	20 ppm (2007)	192 mg/m^3	200 ppm
Xylene	100 ppm (2001)	77 mg/m^3	100 ppm

(*)DNEL Derived-No-Effect-Level: Level of exposure to the substance above which humans should not be exposed; risk to humans is considered to be adequately controlled if the exposure levels do not exceed the appropriate DNEL. DNEL values were obtained from ECHA IUCLID database.

(NA) Not Applicable

First Aid

The following information is generic to Olin Epoxy Resins. For specific recommendations on individual products, consult the appropriate SDS.

Skin Contact

If skin contact should occur, liquid or Epoxy Resin Solutions should be promptly wiped from the skin with clean disposable cloths or paper towels[(1)]. The affected area should then be washed thoroughly with soap and plenty of water. Some resins may be sticky and difficult to remove but the use of shop solvents is not recommended because solvents may facilitate absorption of the resin through the skin.

Any contaminated clothing, including shoes, should be removed and should not be reused until the articles are thoroughly laundered and entirely free of resin. Any injuries or irritation that may occur should receive prompt medical attention.

Contact with D.E.R.™ or D.E.N.™ Liquid, Solid, or Epoxy Resin Solutions may cause skin irritation. Some may also cause skin sensitization. See pages 12 to 14 for more details. Delayed contact dermatitis may result from repeated exposure to the lower molecular weight resins; thus, all skin contact with uncured resins should be avoided.

Eye Contact

If the eyes are contaminated, they should be flushed immediately with a continuous stream of low-pressure water. Medical attention should be obtained promptly.

Some D.E.R. and D.E.N. Liquid, Solid, and Epoxy Resin Solutions may be irritating to the eyes. Contact may be quite painful and may cause both irritation of the conjunctival membranes and corneal injury. Suitable protection should be worn to protect the eyes, such as safety glasses with side shields, chemical goggles, or chemical goggles with face shields, depending on the specific Epoxy Product and work environment.

[(1)] To eliminate the possibility of secondary or tertiary exposure, be certain that these materials are disposed of properly.

Inhalation

If a person should experience any ill effects while working with these materials, he or she should be removed to fresh air and medical attention should be obtained promptly.

Inhalation of the solvent vapors of D.E.R.™ or D.E.N.™ Epoxy Resin Solutions can be hazardous to workers. Exposure guidelines, including ACGIH Threshold Limit Values (TLV), OSHA Permissible Exposure Levels (PEL), and any relevant Short Term Exposure Levels (STEL), must be consulted for specific solvents. The atmospheric levels of these materials should be maintained below the exposure guideline and, when respiratory protection is required, approved air-purifying or positive-pressure supplied-air respirators should be used.

If Solid Epoxy Resins are handled at room temperature, vapor inhalation is unlikely. Although small amounts of dusts are not expected to pose an inhalation hazard, control of dusts through adequate ventilation and good housekeeping practices is recommended. A dust mask should be used in situations where excessive dusts from solid Epoxy Resins might be inhaled.

Ingestion

If any Epoxy Resins are swallowed, vomiting should **not** be induced. You should call a physician and/or transport to an emergency facility immediately.

Solution Resins

Although D.E.R. and D.E.N. Liquid, Solid, and Epoxy Resin Solutions are low in acute oral toxicity, certain solvents (xylene, toluene, and some ketones) used in solution resins may cause chemical aspiration pneumonia if accidentally inhaled into the lung.

NOTE TO PHYSICIAN: If lavage is performed, endotracheal and/or esophagoscopic control is suggested. The danger from lung aspiration must be weighed against the toxicity of the specific solvent when considering emptying the stomach. Also, some solvents may be rapidly absorbed through the lungs and cause systemic effects.

Other Resins

If large amounts of liquid, solid, or other solution resins are ingested, get medical attention at once.

NOTE TO PHYSICIAN: The patient should be treated symptomatically; there are no known antidotes.

Personal Protection

Conditions vary from location to location; thus, any given situation may require precautions, equipment, protective clothing, training, or ventilation beyond that which is indicated in the following discussion.

Precautions

Epoxy Resins may cause skin and eye irritation and sensitization, and may be harmful if inhaled. Epoxy Resins can also cause thermal burns when heated. Thus, exposure to, or contact with, D.E.R.™ and D.E.N.™ Liquid, Solid and Epoxy Resin Solutions and formulations should be avoided. This is best done by handling these materials in an enclosed system. If this is not possible or feasible, the following precautions and recommendations can be helpful in preventing health problems:

- Avoid skin and eye contact
- Avoid breathing dusts, mists or vapors
- Avoid working in dusty environments
- Do not take internally
- Avoid contact with clothing and shoes. Do not wear or reuse contaminated articles until they are thoroughly cleaned.
- Have all personnel maintain strict cleanliness of themselves and of their work area. There is no substitute for strict cleanliness and careful housekeeping.
- Wash hands, forearms, face and neck thoroughly before taking a break, eating, smoking, drinking or using toilet facilities

NOTE: There should be no smoking, eating or drinking in the Epoxy work area.

- Separate all Epoxy Resin work areas from other work areas to limit the exposure of employees who are unfamiliar with proper handling practices for Epoxy Resins, and who may be exposed to contaminated tools and equipment
- Educate all personnel on the potential consequences of exposure
- Use volatile agents only in properly ventilated areas

Equipment

Areas in which D.E.R.™ and D.E.N.™ Epoxy Resins are used should be equipped with:

- An eye bath in the immediate vicinity of use
- A safety shower
- Proper ventilation sufficient to safely carry away noxious fumes or odors, and to assure fresh air supply
- Fire extinguishing and personal protective equipment, including foam, CO_2, or dry chemical fire extinguishers and self-contained, positive pressure breathing apparatus
- Paper towels and soap

NOTE: Take care that contaminated disposable items do not become a source of hazard to other employees, to janitors, or to persons in charge of solid waste disposal.

Protective Clothing and Equipment

Personnel who work with Epoxy Resins in small laboratory quantities, unloading drums or tank trucks, or taking samples, etc., should use proper protective clothing and equipment. The following list is not intended to be inclusive of all possibilities, but is offered for consideration. The final choice of protective clothing and equipment should be based upon the specific Epoxy Resin properties and the operation involved. Examples of protective clothing that should be used are:

- Safety glasses with side shields
- Chemical goggles
- Face shield
- Hard hat
- Chemical resistant gloves, boots, and apron
- Dust mask
- Chemical resistant workers suit (coat and trousers)
- Self-contained, positive-pressure breathing apparatus
- Closed-toe shoes
- Chemical resistant gloves that provide thermal protection
- Long sleeves

When working with heated resins above 50°C (ca. 120°F), special thermal burn protection should be used, such as chemical resistant gloves that provide thermal protection.

All personnel should learn the proper use of protective clothing and equipment. Contaminated protective clothing can be a source of skin contact. Improper removal of gloves can result in skin contact. Care should be taken to remove gloves and other protective clothing without exposing clean skin to contact with Epoxy Resins.

Epoxy Resin Environmental Information

Environmental Information

- For unreacted resins, fate and effect in the environment vary considerably from product to product, so the specific product SDS should be consulted.
- When cured, the resins form an inert polymer.
- The most common resin, Diglycidyl ether of BPA (DGEBA/BADGE), in its unreacted form is poorly soluble in water, has very low vapor pressure, and has a moderately high log Kow.
- These properties dictate that the material has low potential to volatilize from water to air, and moderate potential for adsorption to soil and sediments. If unintentionally released to water, a significant fraction of the material will adsorb to sediment.
- When released to soil, the material will be primarily adsorbed to soil particles. Slow biodegradation of the material is expected to occur in these environmental compartments.
- DGEBA/BADGE exhibits a moderate potential for bioconcentration.

Handling and Transportation

Material Classification

Many classification systems have been established by technical societies, industrial committees, the federal governments of NAFTA and the European Union. The purpose of these classification systems is to alert industrial users, employees, transportation operators, and those in the health professions of any potential hazards associated with a specific product. Refer to the Safety Data Sheet (SDS) for the country of interest to determine the information on a specific product's classifications.

Handling and Transportation

Table 6: Handling Characteristics of Olin Liquid Epoxy Resins and Epoxy Novolac Resins

Liquid Epoxy Resins	Flash Point °C PMCC (1)/COC (2)	Flash Point °F PMCC (1)/COC (2)	Recommended Pumping Temp. Range °C	Recommended Pumping Temp. Range °F	Recommended Storage Temp. Range °C	Recommended Storage Temp. Range °F
D.E.R. 317	252/ND(7)	485/ND(7)	60 – 70	140 – 158	2 – 43	35 – 110
D.E.R. 321	121/ND(7)	250/ND(7)	ND(7)	ND(7)	< 25	<77
D.E.R. 324	177/191(3)	351/376(3)	35 – 40	95 – 104	2 – 43	35 – 110
D.E.R. 325	177/191(3)	351/376(3)	32 – 38	90 – 100	2 – 43	35 – 110
D.E.R. 329	252/ND(7)	486/ND(7)	35 – 40	95 – 104	2 – 43	35 – 110
D.E.R. 330	ND(7)/266(3)	ND(7)/511(3)	50 – 60	122 – 140	2 – 43	35 – 110
D.E.R. 331	ND(7)/264 – 268(3)	ND(7)/507 – 514(3)	50 – 60	122 – 140	2 – 43	35 – 110
D.E.R. 332	ND(7)/264 – 268(3)	ND(7)/507 – 514(3)	50 – 60	122 – 140	2 – 43	35 – 110
D.E.R. 336	ND(7)/264 – 268(3)	ND(7)/507 – 514(3)	ND(7)	ND(7)	2 – 43	35 – 110
D.E.R. 337	ND(7)/264 – 268(3)	ND(7)/507 – 514(3)	60	140	2 – 43	35 – 110
D.E.R. 351	ND(7)	ND(7)	ND(7)	ND(7)	2 – 43	35 – 110
D.E.R. 352	ND(7)	ND(7)	ND(7)	ND(7)	2 – 43	35 – 110
D.E.R. 353	177/ND(7)	351/ND(7)	35 – 40	95 – 104	<= 40	<= 104
D.E.R. 354	ND(7)/>93(3)	ND(7)/ >199(3)	50 – 60	122 – 140	2 – 43	35 – 110
D.E.R. 356	252/ND(7)	486/ND(7)	ND(7)	ND(7)	2 – 43	35 – 110
D.E.R. 358	>=100(4)	>=212(4)	ND(7)	ND(7)	2 – 43	35 – 110
D.E.R. 361	252/ND(7)	486/ND(7)	60	140	2 – 43	35 – 110
D.E.R. 383	264 – 268 3)	507 – 514(3)	50 – 60	122 – 140	2 – 43	35 – 110
D.E.R. 732(P)	194(6)/ND(7)	381(6)/ND(7)	25 – 30	77 – 86	2 – 43	35 – 110
D.E.R. 736(P)	ND(7)/170(5)	ND(7)/338(5)	25 – 30	77 – 86	2 – 43	35 – 110
D.E.N. 425	>=200(4)	>=392(4)	ND(7)	ND(7)	<25	<77
D.E.N. 431	218/264	424/507	35 – 40	95 – 104	2 – 43	35 – 110
D.E.N. 438	218/ND(7)	424/ND(7)	79 – 90	174 – 194	2 – 43	35 – 110

(1) ASTM D-93 (Pensky-Marten Closed Cup)

(2) EC Method A9 (Closed Cup)

(3) JP Fire Law Method

(4) DIN 51758 (Open Cup)

(5) ASTM D-92 (Cleveland Open Cup)

(6) ASTM D-3278 Setaflash

(7) Not Determined (ND)

Handling and Transportation

Table 7: Handling Characteristics of Olin Epoxy Resin Solutions

Liquid Epoxy Resins	Flash Point °C (°F) PMCC (1)	Percent Non-Volatile (2)	Solvent	Recommended Pumping & Storage Temp. Range °C (3)	Recommended Pumping & Storage Temp. Range °F (3)	Recommended Storage Temp. Range °C (3)	Recommended Storage Temp. Range °F (3)
D.E.R.337-X80	34 (93)	75 – 85	Xylene	43 – 60	110 – 140	2 – 43	35 – 110
D.E.R. 337-X90	30 (86)	85 – 95	Xylene	43 – 60	110 – 140	2 – 43	35 – 110
D.E.R. 538-A80	-20 (-4)	79 – 81	Acetone	30 – 38	85 – 100	2 – 43	35 – 110
D.E.R. 539-EK80	5 (41)	79 – 81	MEK(4)	43 – 60	110 – 140	<25	<77
D.E.R. 539-A80	-20 (-4)	75 – 85	Acetone	38 – 49	100 – 120	2-43	35 – 110
D.E.R. 592-A80	-14 (7)	79 – 81	Acetone	38 – 49	100 – 120	2-43	35 – 110
D.E.R. 593	-14 (7)	70 – 80	Acetone	30 – 43	85 – 110	2 – 43	35 – 110
D.E.R. 660-B80	28 (82)	79 – 81	Butanol	43 – 49	110 – 120	2 – 43	35 – 110
D.E.R. 660-X80	31 (88)	79 – 81	Xylene	43 – 49	110 – 120	2 – 43	35 – 110
D.E.R. 661-A80	12.5 (54)	79 – 81	Acetone	35 – 43	95 – 110	2 – 43	35 – 110
D.E.R. 671-MAK75	41(106)	74 – 76	Amyl methyl ketone	ND(6)	ND(6)	10 – 27	50 – 80
D.E.R. 671-PM75	31 (89)	70 – 80	Propylene Glycol Monomethyl Ether	32 – 43	90 – 110	2 – 43	35 – 110
D.E.R. 671-T75	4.4 (40)	70 – 80	Toluene	46 – 54	115 – 130	2 – 43	35 – 110
D.E.R. 671-X75	34 (93)	74 – 76	Xylene	46 – 54	115 – 130	2 – 43	35 – 110
D.E.R. 671-XM75	14 (57)	70 – 80	Xylene, MIBK(5)	38 – 49	100 – 120	2 – 43	35 – 110
D.E.R. 684-EK40	-9 (16)	30 – 50	MEK(4)	38 – 41	100 – 105	2 – 43	35 – 110
D.E.N. 438-A85	-20 (-4)	84 – 86	Acetone	24 – 32	75 – 90	2 – 43	35 – 110
D.E.N. 438-EK85	-5 (16)	84 – 86	MEK(4)	35 – 43	95 – 110	2 – 43	35 – 110
D.E.N. 438-X80	33 (80)	79 – 81	Xylene	35 – 43	95 – 110	2 – 43	35 – 110
D.E.N. 439-EK85	-9 (16)	84 – 86	MEK(4)	35 – 43	95 – 110	2 – 43	35 – 110

(1) ASTM D-93 (Pensky-Marten Closed Cup)

(2) Reference is from Section 3 of the Safety Data Sheet (SDS)

(3) Where recommended pumping temperatures are near or above the flash point of the solution resin, applicable safety precautions should be taken.

(4) Methyl ethyl ketone

(5) Methyl isobutyl ketone

(6) Not Determined (ND)

Handling and Transportation

Table 8: Handling Characteristics of Olin Solid Epoxy Resins

Solid Epoxy Resins	Bulk Density[1] kg/m3/lbs/cu ft	Melt Specific Gravity/Cast Density[2] (lbs/gal)	Mettler Softening Point °C[3]	Form	Recommended Maximum Storage Temp ˚C/˚F
D.E.R.542	NA/NA[4]	1.8/14.9	52 – 62	Solid	2 – 43/36 – 109
D.E.R. 560	ND[5]	1.8/14.2	78 – 85	Flake	<18/<65
D.E.R. 6155	600/38	1.18/9.9	105 – 125	Flake	< 38/100
D.E.R.6330-A10	650/41	1.18/9.9	98 – 106	Flake	<25/<77
D.E.R. 642U	625/39	1.18/9.9	90 – 98	Flake	2 – 43/36 – 109
D.E.R. 6508	ND[5]	1.18/9.9	95 – 105	Flake	< 25/<77
D.E.R. 661	690/43	1.18/9.9	75 – 85	Flake	<30/<86
D.E.R. 6615	ND[5]	1.16/9.9	78 – 86	Flake	10 – 27/50 – 98
D.E.R. 662E	675/42	1.16/9.9	84 – 94	Flake	<16/<61
D.E.R. 662UH	675/42	1.18/9.9	90 – 98	Flake	2 – 43/36 – 109
D.E.R. 663U	650/41	1.18/9.9	92 – 102	Flake	2 – 43/36 – 109
D.E.R. 663UE	650/41	1.18/9.9	98 – 104	Flake	32/90
D.E.R. 664U	625/39	1.18/9.9	98 – 108	Flake	2 – 43/36 – 109
D.E.R. 664UE	635/39	1.18/9.9	98 – 108	Flake	2 – 43/36 – 109
D.E.R. 667-20	590/37	1.16/9.9	125 – 138	Flake	2 – 43/36 – 109
D.E.R. 667E	590/37	1.16/9.9	120 – 135	Flake	2 – 43/36 – 109
D.E.R. 669-20	590/37	1.18/9.9	142 – 162	Flake	2 – 43/36 – 109
D.E.R. 669E	590/37	1.18/9.9	142 – 162	Flake	2 – 43/36 – 109
D.E.R. 671	690/43	1.16/9.9	75 – 85	Flake	16/65
D.E.R. 672U	605/38	1.18/9.9	110 – 120	Flake	<25/<77
D.E.R.672U-20	ND[5]	1.18/9.9	110 – 120	Flake	10 – 27/50 – 98
D.E.N. 439	NA/NA[4]	1.22/9.9	48 – 58	Viscous Liquid	2 – 43/36 – 109

[1] ASTM D-1895

[2] ASTM D-792

[3] ASTM D-3104

[4] Not Applicable (NA)

[5] Not Determined (ND)

Handling and Transportation

Bulk Transportation Equipment

Liquid Epoxy Resins and Epoxy Novolac Resins

Bulk quantities of D.E.R.™ and D.E.N.™ Liquid and Epoxy Resin Solutions are shipped in tank cars, tank trucks and ISO-containers. The resin is loaded at elevated temperatures. In transit by tank truck, heat is also used to maintain a suitable pumping temperature. It is advisable, therefore, to have hot water or low-pressure steam (not over 1.72 bar [25 psig]) available if additional heating is required. Recommended maximum pumping and storage temperatures for D.E.R. and D.E.N. Liquid and Epoxy Resin Solutions are given in Tables 5 and 6 of this bulletin.

NOTE: Failure to adhere to recommended maximum pumping and storage temperatures, or using excessive heating medium, will likely cause gel formation in the bulk transportation equipment.

A filter on the discharge side of the unloading pump is not normally required because D.E.R. and D.E.N Epoxy Resins are carefully filtered prior to shipment. However, such a filter would serve to retain any foreign particles (from hoses), gels formed from heating, etc.

The suggested sampling procedure is to collect a dip sample at the time of unloading.

Epoxy Resin Solutions

Do not use steam heating for Epoxy Resin Solutions in acetone. Instead, use hot water at 54°C (129°F) maximum water temperature. This is necessary because of the high vapor pressure of the acetone. Also, an inert gas should be available to blow the unloading line clear of resin after unloading.

NOTE: If hot water or an inert gas are not available, a heated and insulated unloading line is necessary.

Figure 9: Steel tank car with outside coils and insulation for transporting epoxy resins

Tank Cars

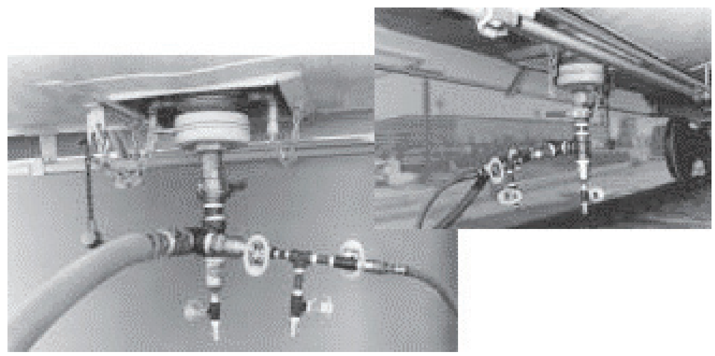
D.E.R. and D.E.N. Epoxy Resins are shipped in insulated steel tank cars (Figure 9) equipped with outside heating coils. Capacities of 40 and 80 m^3 (10,000 and 20,000 gallons) are available.

Unloading D.E.R. and D.E.N. Liquid and Epoxy Resin Solutions from tank cars requires that the customer have an unloading pump at or near the railroad siding. Figure 10, shows a typical unloading station. The resin is removed from the bottom of the car using a flexible metal hose or hose lined with PTFE resin on the suction side of the pump.

Most of the tank cars used by Olin have, on the bottom outlet, a tank car adapter with an external 50-mm (2-inch) plug valve to which the customer can connect the unloading hose. Quick coupling hose connections are commonly used, but flanged connections may also be used.

As shown in Figure 10, a bleed-down connection is recommended between the tank car adapter and the quick coupling. This connection allows the resin to be drained from the hose into a bucket rather than spilling the resin on the ground (when disconnecting the hose). The unloading hose should terminate at the suction side of the unloading pump.

Figure 10: Tank car unloading station with typical hook-up for loading or unloading epoxy resins. (A flexible unloading hose with a special tank car adapter, bleed-point and quick coupling is connected to the bottom of the tank car.)



When unloading solution resins, the rail car should be properly grounded to control static electricity.

After the unloading hose has been connected to the tank car bottom outlet and the pump suction, the internal valve should be opened, and the line should be checked for leaks. Proper venting of tank cars during unloading is necessary to prevent tank collapse. For D.E.R.™ and D.E.N.™ Liquid Epoxy Resins, leave the dome of the tank car vented when opening the internal valve.

Because of the flammability of solution resins, a low-pressure nitrogen pad of about 8.5 mbar (2 ounces/square inch) should be applied by a control valve.

For most installations, a 50-mm (2-inch) insulated and traced unloading line with a Flowserve 63-mm (2.5 inch) gear pump or equivalent is sufficient to unload at an 80 to 120 liters (20 to 30 gallons) per minute rate. To increase the flow rate, a larger pump and line would be necessary. A 5.6 kW (7.5 horsepower) electric motor turning at 1,160 rpm is an efficient way to drive the pump. Discharge pressure could be as high as 7 to 10 bar (100 to 150 psig).

After unloading, a strong explosion-proof light should be used to inspect the inside of the tank car to ensure it is empty. The internal valve should be closed, and the hatch cover should be tightly bolted. Then, with the unloading lines still open to the storage tank, the inert gas purge should be connected to the bleed-down connection of the unloading hose, and the resin should be blown from the line.

Handling and Transportation

NOTE: Because of the hazard of a possible explosion, compressed air is not recommended when unloading Epoxy Resin Solutions. However, compressed air (1.03 to 1.38 bar [15-20 psig] maximum) may be suitable when unloading liquid D.E.R.™ and D.E.N.™ Epoxy Resins.

Tank Trucks

D.E.R. and D.E.N. Liquid and Epoxy Resin Solutions may be delivered by tank truck. Both single and multiple compartment insulated stainless steel tank trailers are available. Multiple compartment trucks allow up to four different epoxy resins to be shipped at the same time, with a total capacity of approximately 20 metric tons (40,000 pounds).

During cold months, self-contained heating units are commonly used on tank trailers to ensure that the material arrives at a temperature suitable for unloading. Tank trucks may also be equipped with their own stainless steel unloading pump and with 6 meters (20 feet) of discharge hose. If more than two different liquids are received, the customer must make some provision for properly cleaning the pump after emptying each compartment.

Tank truck pumps will deliver 200 to 800 liters/minute (50 to 200 gpm) of epoxy resin when unloading. Customers should supply at least a 50-mm (2-inch) heated and insulated unloading line within 6 meters (20 feet) of the truck unloading station. Camlock-type quick couplings or equivalent are normally used by carriers.

When solution resins are unloaded, the tank trailer should be grounded. The compartment should always be vented to prevent collapse during unloading. Finally, a low-pressure nitrogen purge should be applied to protect against explosive conditions.

Tank trucks are 12 meters (40 feet) long and usually weigh about 30 metric tons (65,000 pounds) when loaded. The normal turning radius is 28 meters (90 feet), and requires a driveway width of at least 3.6 meters (12 feet). These factors should be considered when locating the unloading station.

Storage

Liquid Epoxy Resins and Epoxy Novolac Resins

A list of liquid D.E.R.™ and D.E.N.™ Epoxy Resins and pertinent storage data are given in Table 1, page 7, and Figures 1-4, page 8. Also, Figure 11 is a diagram of a typical storage facility for liquid epoxy resins.

Although Olin Liquid Epoxy Resins stored for prolonged periods at normal room temperature can crystallize, they should show little, if any, change in quality. Even at moderately elevated storage temperatures of 50 to 55°C (122 to 131°F), little change in quality is noticed in most Olin Liquid Epoxy Resins, even after several months' storage. Storage at temperatures of 55 to 80°C (131 to 176°F)[1] is satisfactory for periods of several weeks. However, at these higher temperatures, some color increase may occur. The rate of increase depends on the storage temperature and the particular epoxy resin being stored. For prolonged storage at temperatures higher than 55°C (131°F), storage tests at the anticipated temperature are recommended to determine the effect on the resin. Many conditions have been investigated in a range of environments, and your local Olin sales representative can give you information on specific products to help you solve specific problems. For example, D.E.R. 361 Epoxy Resin should be stored at ambient temperature, however, it may be heated to a maximum of 50°C (122°F) for handling purposes.

Storage tanks should be vented to prevent excessive pressure or vacuum in the tank during filling or emptying. Venting tanks for storage of liquid epoxy resins is discussed in detail on pages 27 to 28 (Venting/Gas Padding).

Typical flash point values for D.E.R. Liquid Epoxy Resins are given in Table 6, page 19. However, if liquid resins are diluted with flammable solvents for storage, the temperatures given for Epoxy Resin Solutions in Table 7, page 20, should be followed.

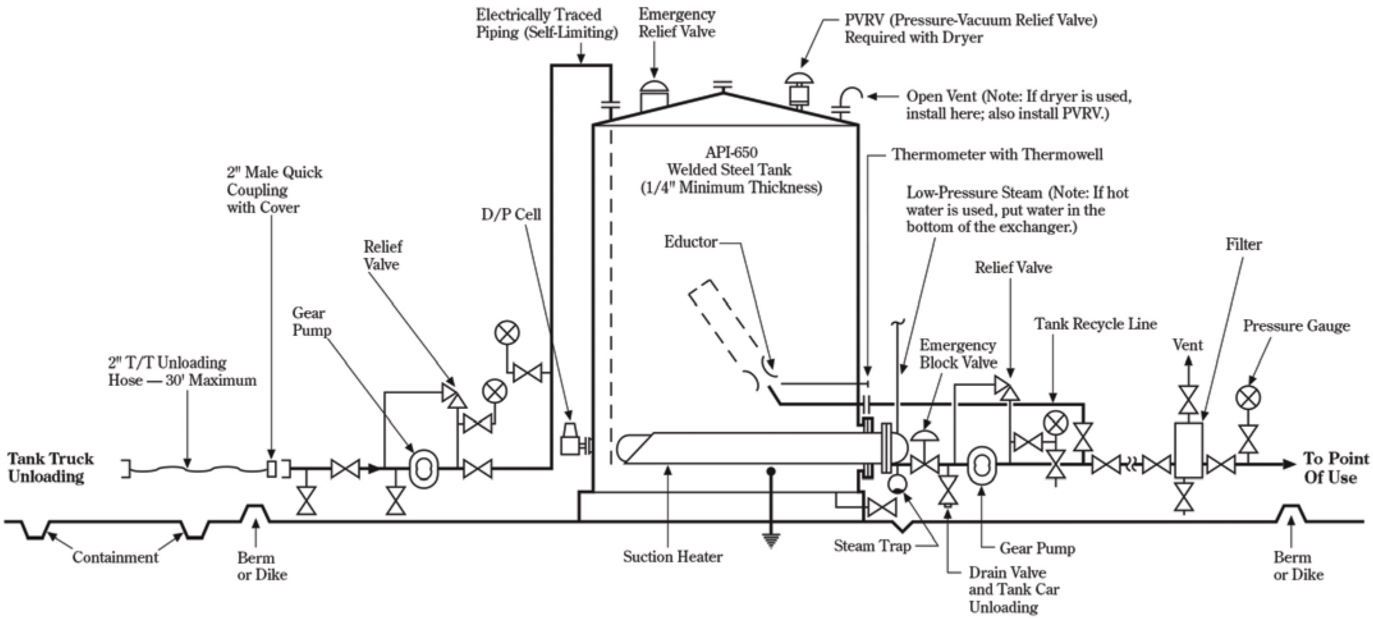
Another example: Under normal circumstances, D.E.R.™ 332 Epoxy Resin and D.E.R. 542 Epoxy Resin stored at 40 to 55°C (105 to 131°F) will remain liquid. However, because of their high purity, they tend to crystallize when stored without heat. Thus, bulk storage tanks for resins like these should be equipped to prevent any pressure build-up in the tank. For example, vertical-type pencil heaters, used to melt a path for the suction heater or heating coil to the surface of the resin, may be appropriate. Also, care should be used in the piping design to allow for the melting of the crystallized resin.

[1] 55 to 70°C (131 to 158°F) for Epoxy Novolac Resins

Storage

Figure 11: Typical Storage Facility for Liquid Epoxy Resins

This drawing is for illustrative purposes only; Olin assumes no responsibility for the actual design of any facility.



NOTE: Containments should be wide enough and deep enough to hold the entire contents of a fully loaded tank truck.

NOTE: Berms or dikes should be high enough and strong enough to contain the entire contents of a completely filled tank.

Epoxy Resin Solutions

A list of D.E.R.™ and D.E.N.™ Epoxy Resin Solutions and storage temperatures are given in Table 7, page 20. Figure 12 on page 26 illustrates a diagram of a typical storage facility for Epoxy Resin Solutions.

Most Olin Epoxy Resin Solutions, when stored at temperatures of 0 to 25°C (32 to 77°F), are generally stable for approximately one year. However, long periods of storage at elevated temperatures (i.e. 40 to 55°C [104 to 130°F]) may result in changes in the viscosity, color, and quantity of the solvent. Those changes do not usually affect the performance of the resin. Nonetheless, loss of solvent should be prevented, either by storing at ambient temperature or, if storage temperature is above 40°C (104°F), by use of a low-pressure dry gas pad of the vapor space. Olin recommends that all storage tanks for Epoxy Resin Solutions be padded with an inert gas (e.g. nitrogen) to help prevent the formation of an explosive mixture in the head space.

In heating Epoxy Resin Solutions, the flash points of both the stored resin and the solvent in the stored resin should be considered. Also, the heating process should be limited to the time necessary for withdrawal of the resin. When resin withdrawals are infrequent, heating should be discontinued and started again when the resin is needed.

Prolonged exposure to low temperatures in winter months may cause some separation of the resin and solvent. In this event, heating the resin to handling temperature and circulating it within the storage tank should return the solution resin to its original appearance and properties.

Because most of the solvents used in Epoxy Resin Solutions are flammable, the design of storage and handling equipment should take solvent requirements into consideration. Although the flash points of solution resins vary with the solvent used, most flash points are below 94°C (201°F); thus the solutions are considered flammable or combustible by the definitions of most global jurisdictions. See Table 7, page 20 for typical flash point values.

Most jurisdictions have legislation specifying requirements for the storage and handling of flammable liquids that must be complied with on a local basis (example: in the USA 29CFR1910.106 – Occupational Safety and Health Administration, Labor). Legislation is not always updated or sufficiently detailed. Good detailed advice on sound engineering practices for the handling and storage of flammable and combustible liquids is published by the U.S. National Fire Protection Association. NFPA Code 30 – Flammable and Combustible Liquids – contains thorough guidance on the precautions necessary for the safe handling of flammable liquids.

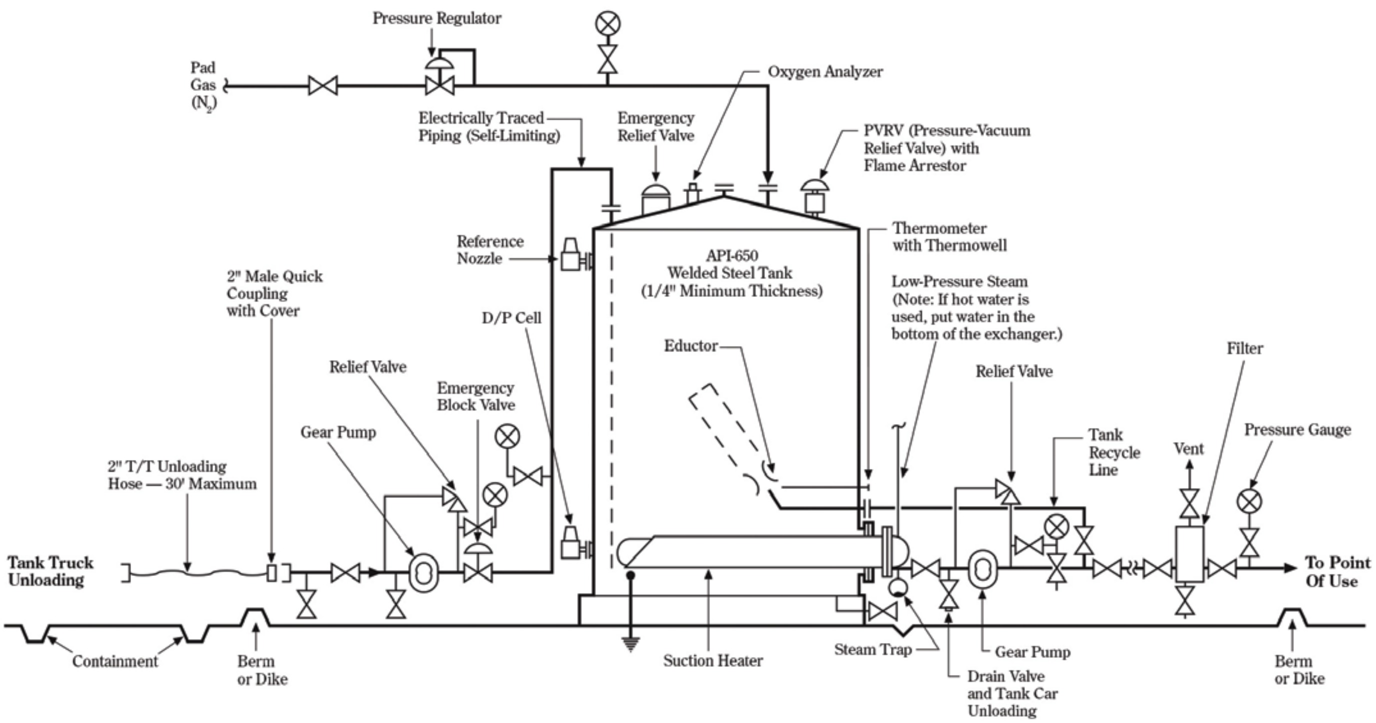
NFPA Code 30 provides detailed information on the location and size of tanks, venting requirements, electrical standards, and many other pertinent details. The physical properties of D.E.R. Epoxy Resin Solutions given in Table 7, on page 20 when related to the information in Section 1910.106, should provide data to help classify and properly handle the particular Olin Epoxy Resin Solutions being used.

Further dilution of solution resins with solvents may lower the flash point values given in Table 7, resulting in a more hazardous solution. However, additional flash point and vapor pressure data would be required to classify the hazard properly.

Government requirements may apply to combustible liquids based on their flash points, and these should be reviewed before installing a solution resin bulk storage system.

Figure 12: Typical Storage Facility for Epoxy Resin Solutions

This drawing is for illustrative purposes only; Olin assumes no responsibility for the actual design of any facility.



NOTE: Containments should be wide enough and deep enough to hold the entire contents of a fully loaded tank truck.

NOTE: Berms or dikes should be high enough and strong enough to contain the entire contents of a completely filled tank.

Solid Epoxy Resins

A list of solid D.E.R.™ and D.E.N.™ Epoxy Resins and pertinent storage data are given in Table 8 on page 21. D.E.R. and D.E.N. Solid Epoxy Resins are stable in storage. However, flakes of D.E.R. 642U, D.E.R. 661, D.E.R. 662E, and D.E.R. 671 Epoxy Resins tend to fuse during summer months unless they are stored in a cool place. Although the flakes may fuse together to form blocks of resin, the properties and performance of the resins are not altered. The blocks of solid resin are crumbly and can be easily broken into small pieces and become airborne. The only effect is some handling inconvenience. Other D.E.R. Solid Epoxy Resins do not normally fuse in storage.

Handling and transporting D.E.R. and D.E.N. Solid Epoxy Resins commonly result in the formation of dusts. Effective dust control equipment and practices, as well as good general housekeeping are essential for safe handling of Solid Epoxy Resins since this dust, when suspended in the air, can be combustible and potentially a dust explosion risk. All grinding operations and pneumatic conveying systems should be carefully designed to minimize or control dust hazards. Conveying systems, in particular, tend to pulverize the resins, increasing the fines. For additional information on dusts and their fire and explosion hazards, please refer to Fire and Explosion Hazards on page 31.

Drum Handling

Drums containing D.E.R.™ and D.E.N.™ Epoxy Resins should be covered and stored under ambient conditions. Before heating, the bungs should be loosened, and proper venting should be provided for the volatiles that may escape. Excessive heating should be avoided. Drums into which epoxy resins are being transferred should conform to U.S. DOT and European requirements.

Storage Equipment

Tanks

Tanks made of carbon steel are generally suitable for storage of D.E.R. and D.E.N. Liquid and Epoxy Resin Solutions above ground. Vertical tanks are recommended since they are usually more economical to install, occupy less space, and provide more accurate tank gauging. However, horizontal tanks may also be used.

In accordance with NFPA Rule 30. 17, Item 2-1.31 (b), a vertical tank, designed to American Petroleum Institute (API) Standard 650, is the minimum that is satisfactory for any liquid or solution D.E.R. or D.E.N. Epoxy Resin. Since vertical tanks are available in a variety of diameters, heights, and plate thicknesses, prices will vary. Before purchasing a tank, furnish the tank supplier with the required capacity and specific gravity of the epoxy resin to be stored.

Tanks that have flanged connections, and are built to API 650 specifications are acceptable, but are not mandatory for storing epoxy resins.

The capacity of the storage tank should be large enough to hold the amount of epoxy resin normally shipped in a maximum capacity tank car, tank truck or ISO-container, plus several days additional working inventory. Consider over-sizing the tank sufficiently (15-20%) to create a space to accommodate resin bubbles created by the gas flow used to clear the piping. If a suction heater is used in the tank, additional capacity should be allowed for the heel. Also, when calculating tank size, allow sufficient freeboard for liquid expansion while heating. A suitable foundation is required for all resin storage tanks.

Heating

For rapid transfer and ease of handling, the viscosity of D.E.R. and D.E.N. Liquid and Epoxy Resin Solutions should be from 200 to 400 mPa•s. This normally requires that the liquid or solution resin be heated. See “Recommended Pumping and Storage Temperatures” in Tables 6, 7, and 8 on pages 19-21. These temperatures can be achieved using low-pressure steam (1.03 to 1.72 bar [15 to 25 psig]) or hot water heaters.

NOTE: Do not use steam heating for Epoxy Resin Solutions in acetone. Instead, because of the high vapor pressure of the acetone, use hot water with a 54°C (129°F) maximum water temperature.

In the design of heaters for storage tanks, all factors pertinent to a particular application must be considered. These include: desired rate of tank warm-up; heat losses to the atmosphere; temperature and capacity of heat source available; amount of agitation available for tank contents; the geometry and space limitations of the proposed installation, etc. Internal pipe coil heaters may be appropriate where quick heat-up is not necessary, and where heat losses are small or limited by tank insulation. The coils should be located near the bottom of the tank and should be sized to give sufficient heat transfer surface, both to provide the required heat-up rate and to take care of heat losses to the atmosphere. Uniform temperature of the tank contents can be achieved by using the tank pump to circulate the contents over the tank heating coil.

For tanks that are not kept at elevated temperatures, and where quick heat-up of the material to be pumped is desired, suction heaters are recommended. A typical installation is shown in Figure 13.

Although a suction heater is expensive, it offers many advantages. It heats only the material being pumped, it permits quick withdrawal of resin from a cold tank, and it facilitates faster warm-up of the entire tank when recirculation is used.

These heaters should be properly sized if design expectations are to be realized. For rough sizing of suction heaters, the overall heat transfer coefficient can be considered to be in the neighborhood of 85 $W/m^2/°C$ (15 $Btu/hr/ft^2/°F$).

Figure 13: Traced and insulated piping connects tank suction heater to positive displacement pump

For quick tank heat-up and good mixing within the tank, the use of tank eductors should be considered, particularly for mixing when starting with cold material. The use of eductors is shown in Figures 11 and 12, pages 25 and 26. Proper sizing of the pump and the eductors is necessary to ensure sufficient velocity through the eductors. The more economical eductor models are 40 mm (1 1/2 inches) in size. The recycle flow is usually varied to give sufficient volume to effectively mix the material in the tank. The vendor can usually supply curves of pressure drop and pumping capacity. If an agitator is required, a top-entering agitator should be used.

In all heated tank systems, it is recommended that the design include provisions to keep pipe coils or suction heater coils submerged at all times. Heaters should be mounted as low in the tank as possible. In areas where temperatures are not expected to drop below freezing for extended periods, 25 mm (1 inch) dense fiberglass insulation is generally sufficient. For colder temperatures, at least 50 mm (2 inches) of insulation should be used. The insulation should be covered with an aluminum weather barrier.

Venting/Gas Padding

Storage tanks should be vented to prevent either excessive pressure or vacuum from occurring in the tank during filling or emptying. The vent opening should be so constructed that neither rain nor dirt can enter the tank.

For solution epoxy resin storage, an inert gas pad system is strongly recommended. This system requires a source of dry inert gas in sufficient volume to allow for emptying the tank, small leaks, and temperature variations. The purposes of the dry inert gas pad are: (1) to avoid the possibility of an explosion by preventing air from entering the vapor space over the liquid, and (2) to prevent the loss of appreciable quantities of solvent. It also helps to keep moisture out of the tank. A pressure regulator control valve can allow incoming dry gas to build to some preset pressure, such as 8.5 mbar (2 ounce/square inch). Then a Pressure-Vacuum Relief Valve (PVRV) with a flame arrestor can be set to bleed off the gas if the pressure exceeds, for example, 17 mbar (4 ounce/square inch). The vacuum part of the PVRV should be specified in accordance to the tank manufacturer’s recommendations.

In addition to the vent system, an Emergency Relief Valve (ERV) is also required. This relief valve might be set at 25.5 mbar (6 ounce/square inch.) pressure. Also, the emergency valve should be selected to handle the flows given in National Bureau of Fire Underwriters Bulletin No. 30. Figure 11, page 25, shows a typical storage tank set-up for liquid epoxy resins; and Figure 12, page 26, shows an inert gas padded storage tank arrangement for Epoxy Resin Solutions.

NOTE: If a desiccant-type dryer is connected to the vent line, the installation of a Pressure-Vacuum Relief Valve is also recommended. This is necessary because of the risk of plugging the dryer.

Gauging (Level Indication)

Gauging on the tank must be provided. Sight glasses are not recommended because of the possibility of leakage and increased safety hazards.

Small tanks can be installed on scales. Other methods, such as differential pressure with a pneumatic or electrical read-out system, electronic probe-type or weigh cells, also work well but are more expensive. Most applications use a 75-mm (3-inch) diameter differential pressure cell located at the bottom of the tank.

For nitrogen padded tanks, an additional 75-mm (3-inch) reference nozzle is located at the top of the tank. A spare nozzle at least 75 mm (3 inches) in diameter on the top of the tank will allow manual readings with a tape; this is an economical way to make measurements and also to check the accuracy of any gauging system used.

Knowing the temperature of the resin is necessary to calculate accurately the quantity of resin in the tank. A dial thermometer in a thermowell at least 90 cm (36 inches) from the bottom of the tank is recommended. The thermometer should extend into the tank at least 45 cm (18 inches).

Other Design Considerations

Tanks located outdoors should be insulated. The amount of insulation needed depends on the climate. There should be sufficient insulation to allow the resin to be heated and maintained at working temperatures. Tanks stored inside buildings that are kept warm during the winter may be uninsulated if ample coil heaters or suction heaters are provided; however, insulation may be required for personnel protection.

Tank loading lines may connect at the top or bottom of the tank. With a top connection, the resin should be fed through a dip pipe toward the tank bottom. This will help reduce electrostatic charge. See the following section on Grounding. Steel or ductile iron block valves are recommended at the tank nozzles, which are normally submerged by the resin. A bottom drain valve is desirable for draining the tank.

Grounding

Storage tanks, reactors, and formulating vessels must be grounded to prevent static electricity build-up.

Solution resin storage tank loading lines should have a dip leg inside the tank which extends near the bottom of the tank, or the tank should be equipped with a static chain from the inlet nozzle to the tank bottom. Either of these devices will help prevent a static electric spark. Provisions should be made for positive attachment of all grounds to ensure dissipation of all static charges. Unsecured grounds should not be permitted.

Filtration

All D.E.R.™ and D.E.N.™ Liquid Epoxy Resins and Epoxy Resin Solutions are carefully filtered at the time of loading for shipment. This filtration removes suspended particles that are 25 microns or larger in size. However, even after this careful filtering, foreign particles are sometimes picked up during handling of the resins. Therefore, it is recommended that a Fulflo brand filter or equivalent be installed as close to the point of use as is practical in the pump discharge line leading from the storage tank.

NOTE: It is necessary to advise the filter manufacturer of the operating pressure of the system if it is in excess of 68 bar (100 psig).

Bag-type filters may also be suitable. They are easier to handle than cartridge filters in many cases.

Outdoor installations require heating of the filter jacket. Carbon steel is a suitable material of construction for the filter jacket.

Contact your local filter supplier for recommendations on sizes and prices.

Figure 14: Use of relief valves around a positive displacement pump handling liquid epoxy resin

Pumps

Consider the use of positive displacement rotary, gear, or screw pumps to handle liquid and Epoxy Resin Solutions in the preferred viscosity range of 200-400 mPa•s. For ease of starting, heatable jacketed or traced pumps are suggested. All positive displacement-type pumps must have either built-in or external relief valves to maintain a safe operating pressure. Relief valves and any connecting piping must also be kept heated to ensure proper operation.

Figure 14 shows relief valves and jacketed connecting piping. To minimize product leakage, the use of pumps equipped with mechanical seals is preferred.

For smaller flows, non-jacketed pumps are available and may be appropriate.

NOTE: Most manufacturers of positive displacement pumps can usually supply a suitable non-jacketed pump, and some may also have jacketed pumps available.

The proper pump can be selected by providing the pump supplier with the anticipated capacity in gallons per minute, the specific gravity and viscosity at pumping temperature, and the desired head. Additional information about the type of driver, base, coupling, etc., is needed for a supplier to assemble a ready-to-install unit. The material of construction is usually carbon steel.

Piping

Piping systems used in handling epoxy resins may be constructed of carbon steel, stainless steel, or aluminum. Carbon steel, however, is recommended. Piping systems require suitable insulation and, in most cases, low-pressure steam, hot water, or self-limiting electrical tracing.

Flanged and jacketed pipes, valves, and fittings are the most efficient, but most expensive, system that can be used. Steel pipe having welded steel fittings, wrapped with copper tube tracing and insulation, is more economical than jacketed systems, but requires more maintenance.

Threaded connections tend to leak more frequently than flanged connections. Therefore, welded and flanged connections are recommended. If threaded connections on steel pipes are used, nylon thread compound, plus a thread tape made of PTFE resin, should be used.

The design of a piping system should prevent excessive strain by including proper support for the pipe. Provisions must also be made for contraction and expansion.

The piping system should be pressure-checked before being placed in service, and the lines should be cleaned and dried before filling them with epoxy resin.

If possible, install the lines with small drain valves at the low points to make it easy to drain the lines completely.

The size of the lines depends on the quantity of material flowing, the length of the pipe line, the temperature of the material, and the head available. As a rule of thumb, for D.E.R.™ and D.E.N.™ Liquid Epoxy Resins and Epoxy Resin Solutions:

- 4 liters/minute (one gpm) is provided by a 25 mm (1 inch) line
- 40 liters/minute (10 gpm) are provided by a 40 mm (1 1/2 inch) line
- 120 liters/minute (30 gpm) are provided by a 50 mm (2 inch) line
- 500 liters/minute (125 gpm) are provided by a 75 mm (3 inch) line (when pumping at recommended temperatures and pressures)

For epoxy resin handling, flanged ductile iron plug valves having plastic sleeves made of PTFE resin are more economical than flanged ball valves. Flanged valves, of 50 mm (2 inches) or more in size, are recommended; screwed steel ball valves are best in sizes 40 mm (1 1/2 inches) or less. Gear-operated handles are recommended on plug valves over 75 mm (3 inches). Air pistons allow the valves to be operated remotely and are efficient and convenient. Standard gaskets filled with PTFE, or reinforced graphite flat ring gaskets for pipe flanges, are satisfactory. Some of the more viscous resins, such as D.E.N.™ 438 Epoxy Novolac Resin, require partially jacketed plug type valves with plastic sleeves of PTFE. The more viscous epoxy resins also require more insulation of the pipelines, valves, and other equipment.

Loading and Unloading Hoses

Stainless steel flexible hoses are generally recommended for D.E.N. Epoxy Resin Solutions. Composite hoses are typically used for loading and unloading D.E.R. Liquid Epoxy Resins.

Emergency Planning

The following section provides a brief overview of the nature of, and the need for, emergency planning. It also briefly describes the process by which effective emergency planning can be achieved. For example, it is strongly recommended that emergency plans be developed in cooperation with local fire and police departments and other appropriate community officials and organizations. The use of emergency planning materials prepared by the American Chemistry Council (ACC) is also recommended. See "References" on page 31. Finally, procedures for keeping the local media fully informed should also be included.

Planning For Emergencies

It is important to have a well-organized plan in place that will ensure a quick and effective response to any emergency situation. In short, effective emergency planning should anticipate and carefully consider every aspect of any potential emergency that might occur on or near a plant site or other company facility. Special consideration should also be given to those emergencies that might also affect the community at large. Thus, plans for cooperating with, and fully informing, local safety officials and other appropriate authorities should be included. Again, be sure also to include plans for keeping the media fully and accurately informed.

Crisis Management

The first step in emergency planning for an existing plant or other facility as outlined by the ACC is crisis management, which begins with an identification and description of the crisis or emergency to be planned. See ACC References 1 and 2. The crisis management process then proceeds through 34 additional steps related to planning, preparation, mobilization, response, recovery, and post-incident follow up.

The recommended procedures are comprehensive and cover all aspects of the potential emergency, including warning alarms, evacuation, assembly areas, escape routes, personnel accountability, communications equipment and personnel, chain of command, notification of authorities, and media relations.

Again, if your plant does not have a crisis management plan in place, one should be developed and put in place as soon as possible. It is also recommended that the plan be based on the recommendations and procedures as outlined by the ACC in References 1 and 2.

Emergency Planning For New Facilities

Plant Design

Emergency planning for a new plant or other facility starts with a proper design. For example, engineers should design storage, handling, and processing areas in such a way that the potential for accidents and other emergencies is minimized. These areas should also be designed to permit a rapid and effective response in the event an emergency should occur.

Hazard Analysis

To determine whether a particular plant design does, in fact, minimize the potential for accidents or other emergencies, the entire plan should be subjected to a hazard analysis, which should be conducted by persons with special training and experience in safety management, accident prevention, and related fields.

NOTE: For assistance in preparing and conducting a hazard analysis, consult a process safety management publication such as the one developed by the ACC (see Reference 3). This publication suggests methods for identifying, assessing, controlling, and managing hazards.

After a hazard analysis has been completed, specific procedures should be developed to ensure that the plant itself is operated safely and that the potential for accidents or other emergencies, including fires, explosions, spills, leaks and exposures are minimized. Assistance in all aspects of operating a plant or other facility safety is provided in on the American Chemistry Council (ACC) Responsible Care® website (see Reference 4).

Written Procedures

With a hazard analysis and an overall crisis management plan in hand, the next step is to develop written procedures for responding to, and controlling accidents and other potential emergencies. These procedures should be consistent with and supportive of the overall emergency plan and should cover all aspects of accident prevention and emergency response, including accidental exposures, first aid, the selection and use of personal protective equipment and clothing, spill and leak prevention, containment and clean-up, fire fighting, and the use of fire-fighting equipment. These procedures should also cover all post-emergency concerns, including waste disposal, decontamination equipment checks and repair, and the preparation of appropriate reports, etc.

Emergency Planning

NOTE: All procedures should be tested in a simulated emergency to ensure their effectiveness in an actual emergency.

Community Interaction

The next, and final, step in developing a fully comprehensive and effective emergency plan is to interact with the community, that is, the company emergency plan should be developed in cooperation with and fully integrated into the community-wide emergency response plan. If, however, your community does not have an emergency response plan that integrates civil and industrial emergencies, such as major chemical spills, fires, explosions, large numbers of exposed and injured workers, etc., consult the Community Awareness and Emergency Response (CAER) guide from the ACC or CEFIC, the European Chemical Industry Federation.

NOTE: CAER is a chemical industry initiative supported throughout the world. The CAER guide provides a step-by-step process for creating a fully integrated plan. Once the plan has been developed, however, it should be adequately tested to verify its effectiveness. Be sure the plan also includes all appropriate community officials and agencies (including the local media) in both the planning and testing phases.

References

Reference 1:
Crisis Management Planning for the Chemical Industry, CMA, 1992. (Manual and videotape – Order number 022012; ACC, 1300 Wilson Boulevard, Arlington, VA 22209, U.S.A.)

Reference 2:
Site Emergency Response Planning Guidebook, CMA, 1992. (Order number 024041; ACC, 1300 Wilson Boulevard, Arlington, VA 22209, U.S.A.)

Reference 3:
Process Safety Management Control of Acute Hazards, CMA, 1985. (Order number 047023; ACC, 1300 Wilson Boulevard, Arlington, VA 22209, U.S.A.)

Reference 4:
American Chemistry Council (ACC) Responsible Care® Website
https://responsiblecare.americanchemistry.com/process-safety-code/

Fire and Explosion Hazards

Training

Training for personnel and plant safety has value only to the extent that it is fully and properly implemented and practiced by all the people involved. Thus, a continuing training program for all personnel involved in Epoxy handling, formulation, disposal, etc., is strongly recommended.

Repeated training in handling and emergency procedures helps ensure that employees will handle Epoxy Resins properly, and that they will be prepared at all times to exercise appropriate emergency procedures. Both employees and supervisors should be familiar with:

- Health hazards
- First aid procedures
- Spill cleanup and disposal procedures
- Fire and explosion procedures
- Preventive precautions

Ventilation

Good mechanical ventilation is the standard method of controlling employee exposure to the airborne vapors of Epoxy Resins and/or solvents. Take care that the ventilation system design does not place workers between the source of vapor and the exhaust duct, causing exposure of the workers to the vapors from the resin. A constant supply of fresh, non-contaminated air should always be available to the workers.

Attention must also be given to the vapors of Epoxy Resin Solutions and to any solvents used in formulating or otherwise processing the resins. Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) should be followed for each airborne chemical. For the current TLV information please refer to the product's respective country-specific Safety Data Sheet (SDS).

Flammability

All D.E.R.™ and D.E.N.™ Epoxy Resins are organic products and will burn when sufficient heat and oxygen are supplied. D.E.R. Epoxy Resin Solutions, in particular, require precautions against fire and explosion hazards. This is because of the presence of flammable solvents. In a fire situation, drums of solution resin may rupture, and their ignition may significantly increase the magnitude of the fire. A common measure of flammability is a flash point temperature. This value indicates the minimum temperature at which flammable conditions are produced in controlled laboratory conditions at atmospheric pressure. The values and their implications for liquid and Epoxy Resin Solutions are listed in Tables 6 and 7 on pages 19 and 20.

Thermal Decomposition By-Products

Caution must be exercised in predicting the by-products of thermal decomposition. The products generated, and their concentrations, depend on whether pyrolysis or combustion or a combination of the two occurs, and at what temperature, and under what atmospheric conditions, either occurred. The by-products expected in incomplete pyrolysis or combustion of Epoxy Resins are mainly phenolics, carbon monoxide, and water. The D.E.R. 500 Series Resins also generate brominated compounds, such as hydrogen bromide. Therefore, the thermal decomposition products of Epoxy Resins should be treated as potentially hazardous substances and appropriate precautions should be taken, including the wearing of full protective clothing.

NOTE: Full protective clothing should include a helmet, a self-contained, positive-pressure breathing apparatus and a minimum of bunker coat, fireman's boots and fire-resistant gloves. See Extinguishing Fires on page 32.

Explosion Hazards

D.E.R. and D.E.N. Liquid Epoxy Resins have high boiling points and relatively low vapor pressure. Under special conditions, however, explosive mixtures can occur. As with flash point, any explosion hazard relates to the presence of solvents in the liquid and solution resins.

Emergency Planning

To prevent the accumulation of solvent vapors from Epoxy Resin Solutions, several precautions should be taken:

- Resin and formulation-handling areas should be well ventilated
- Explosion-proof equipment is recommended
- All equipment, tanks, tank cars, tank trucks, drums and hose connections should be bonded and grounded to assure safe discharge of static electricity
- Storage tanks and other containers which have been emptied of resin, and which will be entered or worked on with welding equipment, must first be flushed out with steam or water to remove vapor

NOTE: Vessel entry procedures must include testing for flammable vapors and sufficient oxygen content, along with a Confined Space Entry permit.

Solid Epoxy Resins have the risk to from combustible dust/air mixtures, when the dust is dispersed in air and reaching explosive concentrations. The particle size of flake form solid Epoxy Resin is too large to be explosive under normal conditions. However, mechanical handling and conveying of the products can cause the breaking off of combustible dust particles and can in addition lead to undesired particle size segregation. Concentration of dust particles < 500-1000µm can occur which have higher risk to form combustible clouds. Resin particles deposited as dust on equipment walls, beams etc. can be explosive when dislodged and suspended in air

NOTE: Use of airveying equipment is not recommended. If airveying is attempted, use of inert gas is highly preferred.

Extinguishing Fires

Fires involving D.E.R. or D.E.N. Epoxy Resins can be extinguished with foam, dry powder or carbon dioxide. Water is not normally an effective extinguishing agent for fires associated with these resins. Foam should not be put directly on electrical equipment. If open-type electrical equipment (such as motors, open hot plates or open electrical switches) is involved, foam should be used with caution to avoid the hazard of electrical shock. Dry powder or carbon dioxide is preferred.

When Epoxy Resins burn, they release toxic by-products. For this reason, the breathing of fumes, smoke and gas given off during burning must be avoided. Fire fighters should wear full protective clothing and equipment, and should avoid contact with both the burning resins and any smoke that may be present.

NOTE: Full protective clothing should include helmet, a self-contained, positive-pressure breathing apparatus and a minimum of bunker coat, fireman's boots and fire-resistant gloves. See Thermal Decomposition By-Products on page 31.

Static Electricity

Many operations in formulating plants generate static electricity. Static charges can cause fires and explosions in dusty areas and in areas where flammable solvents are used. The control of static electricity buildup is generally inexpensive and easy to accomplish.

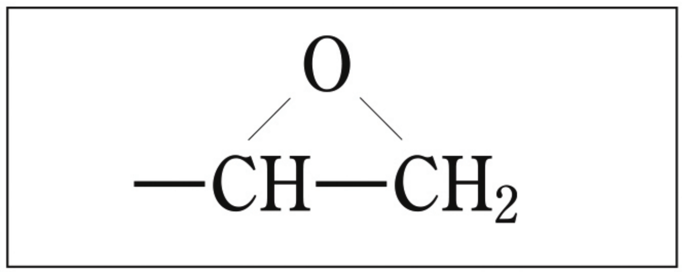
Because of their high volume resistivity, Olin Epoxy Resin Solutions can pick up and hold a static charge during unloading or use. Therefore, storage tanks and all lines used with liquid or Epoxy Resin Solutions should be well bonded and grounded.

A nitrogen pad is recommended in storage tanks that contain solution resins or resins that contain solvents. Submerged filling is required for all flammable liquids. To accomplish this, the inlet line should discharge at, or near, the bottom of the drum or tank and should make electrical contact with the drum or tank to prevent uncontrolled electrical discharge.

Operators wearing rubber-soled shoes may pick up considerable static electricity, particularly on certain composition floors made of good insulating materials. Give attention to:

- The grounding of all process equipment
- The use of static collectors and eliminators
- Adequate ventilation where necessary to reduce dust concentrations
- The use of conductive flooring materials

Reactivity



Epoxy Resins contain the reactive oxirane ring structure commonly called "Epoxy." As the molecular weight of the resins increases, another reactive site, the hydroxyl group, is introduced. Through these two sites, Epoxy Resins react spontaneously with carboxylic acids, amines, amides, and mercaptans (thiols). Epoxy Resins react slowly with anhydrides, alcohols, phenols, and other Epoxy Resins. All of these materials are used commercially to cure Epoxy Resins. Catalysts (tertiary amines, amine salts, boron trifluoride complexes, etc.) are sometimes used to accelerate the slower reactions. Because Epoxy reactions are exothermic (heat generating), take care to control excessive exotherms, which can result in overheating of the product and possible thermal decomposition. Variables that directly affect the degree of exotherm include:

- The amount and configuration of the formulated mass (determines degree of exotherm)
- Temperature of the formulation (heating or cooling system)
- Charge ratio of Epoxy: curing agent: accelerator and/or diluent
- Molar concentration of Epoxy functionality (moles or equivalents) in the molecule and reactivity of Epoxy Resin
- Reactivity of the curing agent
- Reactivity of diluents or accelerators

Before changing any one of these six variables, the process should be carefully reviewed to determine the effect of the change. For example, the potential for an excessive exothermic condition is related to batch size. While a small amount (25 to 50 grams or 0.88 to 1.76 ounces) of formulated resins rarely causes exotherm problems, even with very reactive curing agents, large batches (~40 to 80 liters or ~10 to 20 gallons) can cause problems, even with very stable curing agents. This is so because the heat of reaction builds up, causing a faster reaction rate, which can result in still greater heat generation.

Excessive exotherms can be avoided by taking two precautions:

1. Reactive chemicals testing is recommended when using new Epoxy Resins, curing agents, changing batch size, making formulation changes, and making changes in process conditions.
2. Designing the process to anticipate the worst possible conditions (e.g. having a cooling system capable of removing the heat generated by a double charge, or an agitator or pump failure). Back flow of one material into another through piping systems must also be prevented by good engineering design. It is also suggested that whenever a major formulation change is made, a small test batch be compared to the original formulation for exotherm changes.

If there is an excessive exotherm, minimize employee exposure to decomposition products and, if possible, create a heat sink. The exact procedure depends on the batch size and the timing. Emergency procedures used to cool an exotherming mass include covering the mass with water or spreading the mass over a large surface area. Take care, however, to prevent the mass from flowing down drains. To minimize employee exposure to decomposition products, evacuate personnel from the immediate area or (if possible) transport the mass to a well ventilated area.

A serious reaction hazard exists between the two products, aliphatic amines and halogenated solvents, that are commonly used in Epoxy Resin formulating. The reactivity increases with increasing halogen content. For example, D.E.H.™ 24 and D.E.H. 26 Epoxy Curing Agents react violently with methylene chloride, after a short latent period. Please ask your Olin sales representative for more information.

The proper sequence of formulating should be followed. There is no substitute for a well-trained work force in preventing dangerous and costly mishaps. Training should include knowledge of what will happen when certain equipment fails, and wrong mixtures are encountered. Proper discipline in storage, labeling and confirming raw material analyses can prevent mixing together the "wrong" materials.

Spills

Personnel must be thoroughly trained in safe techniques for the handling of spills and for the disposal of wastes.

NOTE: In disposing of any wastes, be certain all applicable federal, state and local regulations are fully met.

Spill Containment and Cleanup

Persons engaged in spill cleanup should be protected from vapors and from skin contact by wearing appropriate protective clothing and equipment.

The immediate concern in any spill is to protect personnel and to prevent a possible fire hazard. Also, personnel engaged in spill cleanup should know proper disposal techniques in advance.

For small spills of liquid or Epoxy Resin Solutions (less than 20 liters [5 gallons]), apply an absorbent material or a high surface-area material such as sand to the spill, then shovel the mass into a suitable container. The residue on the floor or dock should be removed with steam or hot soapy water.

NOTE: Use of methylene chloride, acetone or aromatic solvents in cleanup poses a distinct hazard and should be avoided.

For solution resins, keep spark-producing equipment away from the spill site. Also, if possible, shut off or remove all potential sources of ignition.

In the event of a larger spill (200 liters [55 gallons] or more), employees should stay up wind. Evacuate and rope off the spill area. Shut off leaks and all potential sources of ignition. The spill should be contained with a dike, and excess resin should be collected in suitable containers for final disposal. Hot soapy water or steam may be required for final cleanup.

NOTE: The use of solvents during cleanup is hazardous and should be avoided.

Epoxy Resins are often heated when handled in bulk. In spills of hot resin, care should be taken to avoid thermal burns.

For chemical usage or emergency (spill, leak, fire, exposure or accident), call emergency contact numbers on the back page of this manual. Spills of solid resin may be swept up and then shoveled into a suitable container for disposal. Workers should be protected from breathing dusts or getting dusts on the skin. Dusts can also be a flammability hazard. Solid, liquid and solution resins should be prevented from entering sewers or drains, or any body of water, including rivers, streams or lakes. If spilled material does enter drains or waterways, notify local authorities at once.

Self-Protection

Skin
Wear appropriate protective clothing. Specific clothing depends on the nature and size of the spill and on the potential for exposure, but should, at a minimum, include clothing that covers the body and protects the skin, such as rubber suits, gloves, and boots.

NOTE: If the resin has been heated, be sure to protect against the possibility of thermal burns and the inhalation of vapors.

Eyes
Wear safety glasses with side shields, chemical goggles or their equivalent, depending on the specific material.

Inhalation
Suitable respiratory equipment should be used, depending upon the potential for exposure. When exposure to unknown concentrations of Epoxy Resin vapors is imminent or anticipated, as in a spill or leak, workers should wear a self-contained, positive-pressure breathing apparatus, or its equivalent. If solvents are used to remove resinous residues, take care to avoid overexposure to solvent vapors and flammable conditions.

Fire
If possible, shut off or remove ignition sources from the spill area. Have fire-fighting equipment nearby, and all personnel trained in its proper use.

Emergency Planning

Distribution Emergency Response

Distribution Emergency Response (E/R) is the Olin system for advising and assisting carrier, warehouse, terminal or public emergency service personnel when they are confronted with an emergency that occurs in the distribution of Olin products. E/R is a part of Olin's commitment to Product Stewardship. Through E/R, timely advice can be provided in an emergency. This is essential if persons involved are to regain control of the situation and minimize harmful effects.

Key E/R personnel are:

Phone personnel: Trained in obtaining and relaying information during emergencies, and able to provide immediate response information, if needed.

Medical personnel: Knowledgeable in what to do if there have been exposures or injuries involving Olin products.

Technical personnel: Familiar with Olin products, transportation equipment and handling emergencies in public areas.

CHEMTREC, or the Chemical Transportation Emergency Center, is a public service of the ACC. It is intended to collaborate with, and enhance the effectiveness of, the organized response capabilities of individual companies. Therefore, the correct action in a distribution emergency is to call emergency contact numbers on the back page of this manual and provide the required information. After giving immediate advice to those on the scene of the emergency, CHEMTREC promptly contacts the shipper of the products involved to provide more detailed assistance. If the emergency involves an Olin Epoxy Resin, CHEMTREC will contact the Olin Distribution Emergency Response system.

Disposal

While most D.E.R.™ and D.E.N.™ Liquid Epoxy Resins and Epoxy Resin Solutions may be disposed of by controlled burning in an approved incinerator, always confirm that the method chosen is in compliance with all applicable government requirements regarding identification and disposal of wastes. An example of the government requirements involved with disposing of Epoxy Resins in the United States will be described in more detail below.

Resource Conservation and Recovery Act (RCRA)

Administered by the United States Environmental Protection Agency (EPA), the Resource Conservation and Recovery Act is designed to provide regulatory control for the generation, transportation, storage and disposal of hazardous wastes.

Under RCRA, the generator of a waste has the sole responsibility to characterize and determine the regulatory status of the waste material. Generators of hazardous waste are subject to specific requirements regarding, but not limited to, the temporary storage, packaging, labeling, identification, manifesting and shipping of the material. Generators must ensure that they are in compliance with all applicable RCRA requirements.

Several Olin Epoxy Resin products, when discarded, are classified as hazardous wastes according to RCRA regulations at 40 CFR Part 261, *Identification and Listing of Hazardous Wastes*. Products such as D.E.R. 337-X80, D.E.R. 539-A80, D.E.R. 592-A80 and D.E.R. 593 Epoxy Resins, when discarded, are classified as hazardous wastes due to their ignitability; i.e., having a flash point of less than 60°C (140°F) (PMCC).

NOTE: This list of Epoxy Resin products is not complete: (1) Olin may add new products to its offering, and (2) government requirements are subject to change. If you have questions about specific products or if you need information on disposal facilities, please contact Olin Customer Care. (See back page for additional contact information)

Laboratory Disposal

If a facility generates less than 1,000 kilograms per month of hazardous waste, it may be exempt from most RCRA requirements. However, even small quantities of D.E.R.™ and D.E.N.™ Epoxy Resins need to be disposed of properly. For example, laboratories using Epoxy Resins should have a drum for collection of wastes located away from the work area. There should be adequate ventilation for solvent vapor removal, and there should be proper grounding. Wastes should be segregated according to reactive hazards and disposal procedure. Also, when feasible, waste resin should be reacted to form non-hazardous solids. Contaminated articles, such as paper towels and plastic beakers, should be collected in a plastic lined container. All wastes should be clearly labeled to protect personnel who may be unfamiliar with the handling of Epoxy Resins.

Drum Disposal

An empty drum that has contained an Epoxy Resin should be handled with the same precautions as the original product, and all disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations.

Ecology

Epoxy Resins are only slightly soluble in water. For example, the water solubility at 25°C (77°F) of D.E.R. 331 Epoxy Resin is less than 0.5 mg per liter.

The physical properties of Epoxy Resins dictate that the material has low potential to volatilize from water to air, and moderate potential for adsorption to soil and sediments. When released to water (the most likely emission scenario), a significant fraction of the material will adsorb to sediment. When released to soil via an accidental spill, the material will be primarily adsorbed to soil particles.

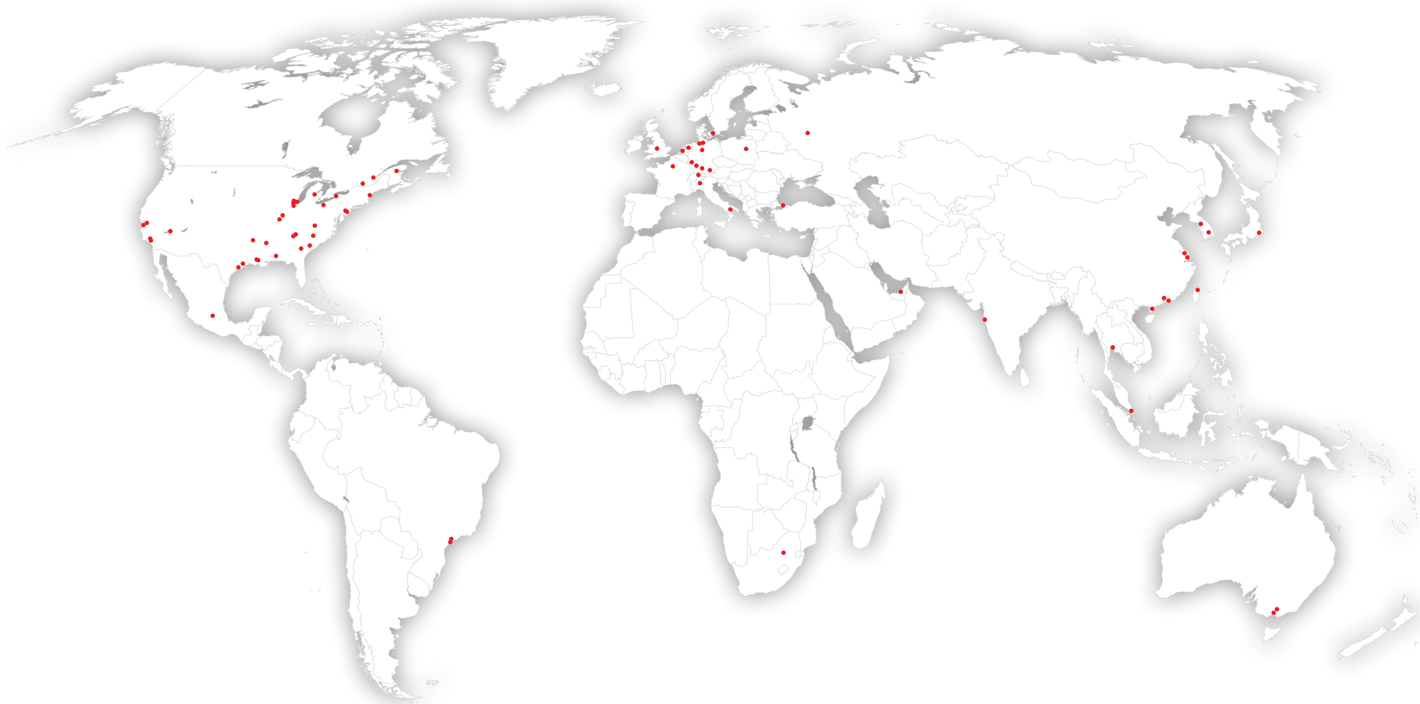
Epoxy Resins are not expected to be persistent in the environment. They have been shown to degrade by indirect photolysis (hydroxyl radical attack), with a half-life of 0.2 days. Biodegradation is also a viable degradation pathway, with 6-12% biodegradation measured in 28 days in a standard experimental design.

In aquatic systems, Epoxy Resins are moderately toxic to fish (LC_{50} = 1.75-2.4 mg/L; concentration lethal to 50% of test fish) and algae (EC_{50} = 9.1 mg/L; 50% reduction in growth) for BADGE-based Epoxy Resins. The most sensitive species appears to be the aquatic invertebrate, *Daphnia magna*, with a reported EC_{50} value of 0.96 mg/L.

Olin Product Stewardship

Olin Product Stewardship

At Olin, our Product Stewardship program is guided by our core values of Integrity, Customer Success, Innovation, and People. We are committed to the safe handling and use of our products – and enabling all of our collaborators throughout the value chain to do the same. As a Responsible Care® company, we assess the safety, health, and environmental information on our products, and then take appropriate steps to protect employees, public health, and the environment. Ultimately, the success of our product stewardship program rests with each and every individual involved with Olin products – from the initial concept and research to the manufacture, sale, distribution, use, disposal, and recycling of each product.



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