Ethanolamines Storage and Handling

Contents

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The Dow Chemical Company manufactures high-quality ethanolamines for a wide variety of end uses. Proper storage and handling will help maintain the high quality of these products as they are delivered to you. This will enhance your ability to use these products safely in your processes and maximize performance in your finished products.

Ethanolamines have unique reactivity and solvent properties which make them useful as intermediates for a wide variety of applications. As a group, they are viscous, water-soluble liquids. In their pure, as-delivered state, these materials are chemically stable and are not corrosive to the proper containers. Ethanolamines can freeze at ambient temperatures. Low Freeze Grade products, blends of ethanolamines and water, are offered to avoid high viscosity and product freezing concerns. Other water blends are also marketed to meet specific customer needs.

Ethanolamines require care in handling. Skin or eye contact can result in chemical burns. Breathing vapors can result in irritation to the nose or throat. Ethanolamine product handling is complicated by their tendency to react with many other chemicals. They will react with carbon dioxide in the air. Ethanolamines are corrosive to certain metals and elastomers.

This booklet is intended to provide you with the data needed to establish safe storage and handling systems, while maintaining product quality. You should refer to Dow's Material Safety Data Sheets for more specific health and safety information concerning the ethanolamine products of interest. Material Safety Data Sheets are updated as new information becomes available. Physical property data and typical applications are contained in the Ethanolamines product booklet. Contact your Dow sales or customer service representative for these publications.

Throughout this document, the following abbreviations are used:

MEA	Monoethanolamine	$H_2NCH_2CH_2OH$
DEA	Diethanolamine	$HOCH_2CH_2NHCH_2CH_2OH$
TEA	Triethanolamine	$HOCH_2CH_2N(CH_2CH_2OH)CH_2CH_2OH$

The MEA and DEA products offered are essentially pure. TEA is offered typically in two grades, TEA Commercial, which is nominally 85 percent by weight TEA and 15 percent by weight DEA, and TEA-99%, which is essentially pure TEA. Where "TEA" is used in this booklet, the requirements or recommendations apply to both TEA Commercial and TEA-99% service.

Product Characteristics

This section highlights some general concerns for the handling of ethanolamine products. Specific detailed safety information is contained in the Dow Material Safety Data Sheet provided for each product.

Occupational Health

Monoethanolamine is the most strongly basic material in this family and also has the highest vapor pressure. Breathing vapors can be irritating to the respiratory tract. Eye or skin contact can result in serious chemical burns. DEA is not as serious a hazard as MEA, and TEA is even less so. Work practices should include adequate workplace ventilation to eliminate irritating vapors and proper protective equipment to prevent skin contact with these chemicals. Cover-all eye goggles should be worn whenever there is a chance material may be splashed into the eyes. Contaminated work clothes must not be taken home. If they are reusable, they should be laundered separately and stored in separate lockers from street clothing.

Reactivity

Ethanolamines react exothermically with many other chemicals. Contact with acids, organic halides, and oxidizing agents can result in vigorous reactions. Dow recommends dedicated processing equipment for all ethanolamine operations. Ethanolamine storage tanks should be segregated from these highly reactive materials in separate dike enclosures. Opportunities for cross contamination, such as multiple product hose switching stations, should be avoided. The Material Safety Data Sheet for each product includes information on reactivity hazards.

Monoethanolamine in contact with iron can form an unstable crystalline complex called tris(ethanolamino)-iron. This complex may remain as an off-white paste or “sauce” when steel equipment containing MEA is drained and then allowed to dry. The compound can ignite when heated to 130 to 160°C in the presence of air. A fire is known to have occurred in a storage tank equipped with a carbon steel heating coil using 150 psig steam when the liquid level was dropped below the coil. This complex reverts to MEA and hydrated iron species upon contact with large quantities of water.

Any steel or iron equipment in MEA service may form this complex. Dow recommends the use of stainless steel for any hot surfaces in contact with MEA, such as internal tank heating coils. Heat tracing should not be used on steel pipelines or for steel equipment in MEA service. Steel equipment should be thoroughly water-washed when it is drained or removed from MEA service. Nitrogen blankets on storage tanks will not prevent the exothermic breakdown of the complex, but may prevent any subsequent fire initiated by this ignition source.

Contact between ethanolamines and nitrosating agents (e.g., sodium nitrite) must be avoided. This contact may form nitrosamines, which are suspected cancer-causing chemicals.

Ethanolamines do not polymerize under normal conditions. Atmospheric carbon dioxide can react with ethanolamines to form carbamic acid salts and/or amine carbonates. The resulting carbamates may affect the product quality and performance. The best prevention is to provide a nitrogen blanket or other inert atmosphere for storage tanks.

Oxidation

Ethanolamines in the liquid phase will react slowly with atmospheric oxygen at ambient temperatures. This may result in discoloration of the product. The rate of color formation increases at higher temperatures. An inert atmosphere will inhibit product degradation.

Like many combustible liquids, self-heating of ethanolamines may occur by slow oxidation in absorbent or high-surface-area media, e.g., dumped filter cake, equipment insulation, spill absorbents, and metal wire mesh (such as that used in vapor-mist-eliminator elements). In some cases, this may lead to spontaneous combustion and either smoldering or a flame may be observed. Materials contaminated with ethanolamines should be washed or thoroughly wetted with water and then disposed of in closed, water-saturated containers, consistent with local and Federal regulations.

Liquid Thermal Stability

As commercially pure materials, ethanolamines exhibit good temperature stability. Above 200°C, some product breakdown may be observed. Laboratory measurements in an accelerating rate calorimeter show that ethanolamines undergo a self-sustaining exothermic reaction at temperatures as low as 260°C. Allowing the product to exceed the self-sustaining reaction temperature can cause rapidly accelerating thermal decomposition. Processes should be designed to operate well below this threshold, even during upset or abnormal conditions.

Contaminants can lower the onset temperature of decomposition. For example, the presence of caustic, alkali metals, or minerals acids will substantially reduce these temperatures. Other contaminants may have similar effects on ethanolamines. Testing for thermal stability is suggested whenever ethanolamines are mixed with other materials.

Materials of Construction

Proper selection of materials of construction for ethanolamine service is essential to assure the integrity of the system and to maintain the product quality. Both aspects must be taken into account when selecting the most economical materials of construction.

Table 1 summarizes the results of our experience and laboratory tests for materials in ethanolamine service. Galvanized steel, copper, and copper-bearing alloys are unacceptable for any ethanolamine contact because they will react with the product. Special care should be taken when selecting such items as pumps and valves to assure that no copper alloys (e.g., brass and bronze) are used in bearings or other internal components that may come into contact with the product.

Pure Ethanolamines

Carbon steel should be considered for ethanolamine service only when some degree of iron contamination and discoloration of the product may be tolerated in the final use by the customer. At storage temperatures, corrosion is very low (less than 0.001 in/yr), but the product will discolor. Due to the possibility of the formation of the tris(ethanolamino)-iron complex, internal heating coils in carbon steel tanks in MEA service must be made of 300 Series stainless steel. For the same reason, do not use external heating coils on steel tanks or pipelines containing MEA.

DEA, TEA Commercial, and TEA-99% can be stored in lined steel tanks without noticeable product quality impact. MEA will aggressively attack most common coatings and liners. Plasite™ 3070, a high-temperature (230°C) baked lining, is very good in ethanolamine service, other than for MEA. This coating is limited to shop-fabricated tanks because of the high curing temperature required. For larger tanks, Plasite 9570, a low-bake (95 to 105°C) lining, will give good service. Force-cured (60°C), air-dried epoxy/phenolics, such as Plasite 7122, are slightly less resistant to attack, but are also normally acceptable for DEA, TEA Commercial, and TEA-99% service. Plasite linings are available from Plasite, a division of StonCor, 1 Park Avenue, Maple Shade, NJ, 08052; phone 856.779.7500. 300 Series stainless steel should be specified for internal tank heating coils in lined tanks. External heating coils should not be used on lined tanks since they may cause blistering and degradation of the lining.

Either 300 Series stainless steel or aluminum is normally used for MEA service. These materials are also suitable for DEA or TEA, but lined steel is usually more cost effective. Aluminum requires some care in ethanolamine service. The presence of water in DEA and TEA above 2.5 weight percent or skin temperatures above 100°C in MEA service can cause severe pitting corrosion. Dow has successfully used aluminum in pure MEA service for large field storage tanks which are maintained at less than 45°C. Internal heating coils must not be aluminum, but may be 300 Series stainless steel. Do not use external coils for heating aluminum MEA tanks because high skin temperatures will result in accelerated corrosion.

High product velocity in carbon steel transfer lines or agitated equipment will increase the corrosion rate due to the erosion of the corrosion-inhibiting, passive film. The impact on product color will be much more severe than in storage tanks. 300 Series stainless steel should be used for transfer lines.

Table 1 • Materials of Construction for Ethanolamines

Product	Storage Temp., °C	Carbon Steel	300 Series Stainless Steel
Pure Ethanolamines			
Monoethanolamine	35	(1)	OK
Diethanolamine	50	(1)	OK
Triethanolamine Commercial	40	(1)	OK
Triethanolamine-99%	40	(1)	OK
Aqueous Ethanolamines			
MEA-LF (15 wt% H_2O)	Ambient	No	OK
DEA-LF (15 wt% H_2O)	Ambient	No	OK
TEA Comm-LF (15 wt% H_2O)	Ambient	No	OK
TEA-99%-LF (15 wt% H_2O)	Ambient	No	OK

BASIS: Based on Dow's experience and laboratory tests, these materials have shown compatibility(or incompatibility), as noted in the table, for the temperature specified. All tanks have nitrogen blankets.

NOTE: Galvanized steel, copper and copper alloys are not suitable for any ethanolamine service.
(1) Carbon steel storage tanks will not suffer excessive corrosion (less than 0.001 in/yr) in dry product service, but will discolor the product and cause a high iron content. 300 Series stainless steels are recommended for tanks. Use 300 Series stainless steel for internal tank heating coils, transfer lines, and other equipment in this service. Do not use external heating coils. Steel or iron in MEA service may result in the formation of unstable tris(ethanolamino)-iron complex; see page 3.
(2) Okay for storage tanks. Use 300 Series stainless steel for internal tank heating coils; do not use external tank heating coils. Use 300 Series stainless steel for transfer lines and other equipment in this service.
(3) Water contamination of the product (over 2.5 wt %) will greatly accelerate corrosion of aluminum. Aluminum is Okay for tanks only when the product remains dry. Use 300 Series stainless steel for internal heating coils; do not use external tank heating coils. Use 300 Series stainless steel for transfer lines and other equipment.
(4) Okay for storage. Use 300 Series stainless steel for transfer lines and other equipment.

Aluminum is usually not acceptable for pure ethanolamine piping because the higher pipe wall temperature from the heat tracing results in rapid erosion of the passive film, causing potentially severe corrosion.

Nonmetallic equipment is sometimes used for ethanolamine service. Ethanolamines may be safely stored in polyethylene and polypropylene containers at ambient temperatures. Glass-reinforced polyester may be attacked chemically. Ethanolamines are not known to attack chemically-resistant, glass-lined vessels.

Aqueous Ethanolamines

Ethanolamines are offered as aqueous solutions in order to depress the freezing point or viscosity for easier handling. Table 1 summarizes the results of our experience and laboratory tests for materials in aqueous ethanolamine service. Customers report that unlined carbon steel tanks are frequently used for aqueous ethanolamine service. Increases in product color or iron counts due to steel contact may occur on prolonged storage especially for some MEA solutions stored at or above ambient temperatures. Phenolic-lined steel for DEA or TEA aqueous products or 300 Series stainless steel for any of the aqueous products are the materials of choice for storage tanks; 316 stainless steel should be specified for transfer lines. Aluminum is not recommended for storage of aqueous solutions of ethanolamines.

Materials of Construction					
3000, 5000, 6000 Series Aluminum	Baked Phenolic Lined Steel	Low Temp. Epoxy or Epoxy/Phenolic Lined Steel	Polyethylene or Polypropylene	Gasket Materials	
				TFE	GRAFOIL
(2)	No	No	OK	OK	OK
(3)	(2)	(2)	OK	OK	OK
(3)	(2)	(2)	OK	OK	OK
(3)	(2)	(2)	OK	OK	OK
No	No	No	OK	OK	OK
No	(4)	(4)	OK	OK	OK
No	(4)	(4)	OK	OK	OK
No	(4)	(4)	OK	OK	OK

Gaskets and Elastomers

The recommended gaskets for ethanolamines service are:

- GRAFOIL™ Flexible Graphite GHR
- Spiralwound 316 Stainless Steel/GRAFOIL Flexible Graphite GTB
- Spiralwound 316 Stainless Steel/TFE
- Garlock Gylon Style 3500 (Fawn-Colored)
- TFE molded around perforated 316 Stainless Steel disc (i.e., Duriron Task-Line or Chemplast Sir)
- 316L Stainless Steel corrugated metal gasket (Lamons 340 or 360; or Parker Seal Style 900 or 929) with GRAFOIL Flexible Graphite GTH tape

Compressed asbestos was often used in the past for gaskets on pipe and equipment flanges. However, because of current health concerns, compressed asbestos should not be used. Laboratory evaluations indicate that non-asbestos compressed aramid fiber gaskets have similar chemical resistance and sealing properties to compressed asbestos at near-ambient temperatures. However, this material, and most other non-asbestos compressed fiber gasket materials, suffer severe loss in properties above 65°C. Consequently, their use for conditions outside typical ethanolamines storage and handling systems is limited. TFE tape should be used on threaded connections.

Dow's experience and laboratory tests for elastomers in ethanolamine service are shown in Table 2. As noted, these data are based on liquid immersion tests at 45°C for 90 days. Higher temperatures may substantially reduce elastomer resistance to the ethanolamine. TFE or GRAFOIL Flexible Graphite are usually acceptable alternatives to elastomers since they are resistant to ethanolamines. However, these materials are not true elastomers and will not always prove suitable as replacement materials.

Table 2 • Elastomers for Ethanolamine Service

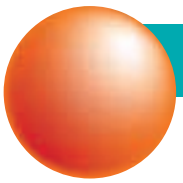
Product	Non-Specified EPDM	Parker E-740 EPDM	"Viton" A
Pure Ethanolamines			
MEA	Yes	Marginal	No
DEA	No	Yes	No
TEA Commercial	No	Yes	No
TEA-99%	No	Yes	No
Aqueous Ethanolamines			
MEA-LF (15 Wt% H_2O)	Yes	Yes	No
DEA-LF (15 Wt% H_2O)	Yes	Yes	No
TEA Comm-LF (15 Wt% H_2O)	Yes	Yes	No
TEA-99%-LF (15 Wt% H_2O)	Marginal	Yes	No

NOTES: Evaluations are based on Dow's experience and 90-day laboratory tests at 45°C.
"Yes" denotes the elastomer was compatible with the product for long-term storage at the temperature specified in Table 1.
"Marginal" means some incompatibility and loss of properties would be expected in long-term service, depending on the specific exposure conditions, but the elastomer may possibly be acceptable for short-term contact.
"No" means the material is unsuitable for that product service.

Transfer Hose

Product transfer hoses for ethanolamines are usually made from stainless steel, polyethylene, polypropylene, or TFE inner liners with stainless steel braid reinforcement or a heavy, reinforced elastomer jacket. Be sure the operating temperature limits are not exceeded when using a hose with nonmetallic liners or jackets for handling product above ambient temperatures. Liner leaks can lead to rapid deterioration of non-ethanolamine-resistant elastomers and result in hose failure under pressure.

"Kalrez" 4079	Buna S	Butyl Rubber	Buna N	Silicone Rubber	Gum Rubber	Neoprene
No	Yes	Marginal	Marginal	No	No	Marginal
Yes	Marginal	Yes	Yes	No	Marginal	Marginal
Yes	Marginal	Yes	Yes	Marginal	Yes	Marginal
Yes	No	Yes	Yes	Yes	Yes	No
No	Marginal	Marginal	Marginal	No	No	Yes
Yes	Marginal	Marginal	No	No	No	Yes
Yes	Yes	Marginal	No	No	No	Yes
Yes	Yes	Marginal	No	No	Marginal	Marginal



Preparation for Service

Stainless steel, aluminum, and lined-steel equipment should be washed and dried prior to being placed in ethanolamine service. Care should be taken in washing to prevent introducing rust particles often suspended in plant water. Where plain carbon steel is used for pure ethanolamine service, loose scale and rust should be removed with a wire brush, followed by washing, drying, and inerting. Alternatively, rust and scale may be removed by chemical cleaning with a dilute solution of ammonia and citric acid. Thorough washing, drying, and inerting must follow immediately. Even with care, some product discoloration may occur in the initial product charges. Eventually, a passive film will be formed on the surface and subsequent product should not discolor. Each time carbon steel equipment is washed or exposed to air, product discoloration is likely.

Thermal Insulation Materials

Most common thermal insulating materials used in industry are acceptable for ethanolamines service. However, porous insulation, such as calcium silicate, mineral wool, and expanded perlite, may introduce the hazard of spontaneous combustion if the insulation is saturated with ethanolamines from a leak or spill. Laboratory tests on ethanolamine-soaked, two-inch cubes of porous insulation indicate that ignition of MEA can occur at temperatures as low as 55°C. Ignition temperatures were higher for DEA (104°C) and TEA (122°C). Since ethanolamines are often handled at above ambient temperatures to prevent freezing or reduce product viscosity, the risk of a smoldering or flaming insulation fire may be present with these types of insulation. Normally, this type of combustion by itself results in only minor equipment damage, but it can be an ignition source if a nearby leak of flammable material should occur. To reduce the chances of an insulation fire, we recommend that you:

- Insist on good housekeeping. Do not spill product or allow thermal insulation to become contaminated with ethanolamines.
- Maintain the insulation weather barrier and weather seals to reduce the chance that spills may soak into the insulation and also to reduce the air that may contact saturated insulation.
- Minimize insulated flanges and other fittings that may be leak points for ethanolamines to saturate insulation.
- Train personnel to be aware of this hazard and to deal with insulation fires. If a fire does occur, saturate the insulation with water. Be aware that removing smoldering ethanolamine-saturated insulation will expose it to air, possibly causing a flare-up. Insulation should be thoroughly wetted with water prior to removal and then disposed of in a closed, water-saturated container, consistent with local and Federal regulations.

Closed cellular glass insulation is normally resistant to insulation fires since it is difficult for the product to saturate these materials and also difficult for air to get at the product. Cellular glass insulation (Pittsburgh-Corning Corporation's Foamglas, ASTM Specification C-552) is recommended as the best choice for ethanolamines service. Aluminum, stainless steel, or mastic weather barriers are commonly used. Cellular glass is resistant to external fires when used with a stainless steel jacket.

Expanded perlite (Howred Corporation's Goodtemp 1500, ASTM Specification C-610) provides good thermal insulating properties and good fire resistance. This material is also treated with a water repellent that seems to reduce the tendency of the insulation to soak up ethanolamines. Hence, the risk of an insulation fire is reduced, but not eliminated, since the long-term resistance of the water repellent to ethanolamines contact is not known. Mastic, aluminum, stainless steel, or polyvinyl chloride are common weather barriers.

Rigid polyurethane foam is sometimes used, especially on prefabricated insulated pipe. It must be limited to relatively low temperatures (120°C). Polyvinyl chloride or aluminum weather barriers are recommended. This material provides no fire protection.

Calcium silicate (several manufacturers, ASTM Specification C-533) and mineral wool (several manufacturers, ASTM Specifications C-592, C-547, or C-612) insulation with mastic, aluminum, stainless steel, or polyvinyl chloride weather barriers may be used in ethanolamine service. Although these materials are the most susceptible to the smoldering insulation fires previously described, both have excellent thermal insulation properties. Calcium silicate has excellent external fire exposure resistance. Mineral wool also has good fire resistance, especially in high-density applications.

Typical Storage and Piping System

Figure 1 depicts a typical ethanolamine storage system. The selection of various components obviously depends on the needs of the user, but typical specifications are noted for the various components. Table 3 shows typical storage conditions and considerations for various ethanolamines.

Tank and Line Heating

Table 3 also notes recommended storage temperatures. Ethanolamines are stored well above their freezing points to ease in-plant handling. The temperatures shown in Table 3, in conjunction with the Materials of Construction in Table 1 (page 6), will result in no significant deterioration of product quality for at least 90 days of storage. The selection of equipment suggested in Figure 1 assumes these storage temperatures. Continuous circulation in heated ethanolamine tanks is highly desirable to provide more even heating of the contents and to combat scorching and discoloration of the product on the heating coil surface.

Tanks are most commonly heated using internal coils supplied with tempered water or low-pressure (15 psig) steam. 316 stainless steel coils are generally preferred for the best maintenance of product quality. Carbon steel internal tank coils must not be used for MEA service. Do not use external coils on carbon steel MEA tanks. This may result in the formation of the unstable tris(ethanolamino)-iron complex. Aluminum is not used for MEA tank internal coils or for tanks with external heating coils because corrosion at elevated temperatures is quite high. Do not use external heating coils on lined tanks because hot skin temperatures may cause lining failure. Sometimes, an external heat exchanger with pumped circulation is used for heating in amines service, but this type of installation is usually more costly.

Since tank heating will cause some product vapor to vent, the tank should be equipped with a vapor conservation relief vent to avoid excessive vapor losses, while also avoiding exceeding the tank design pressure. Transfer lines are typically heated with tempered water, low-pressure steam, or electric tracing. Both skin-effect and conventional electric tracing have been used successfully. The tracing system should be designed so that the inside pipe wall temperatures are no more than 30°C higher than the recommended storage temperatures under no-flow, line-empty conditions. This will assure that the material remaining in the line will not degrade and cause quality problems with the next product transfer. Do not use carbon steel for heat-traced MEA transfer lines to avoid the formation of the tris(ethanolamino)-iron complex (see pages 3 and 5).

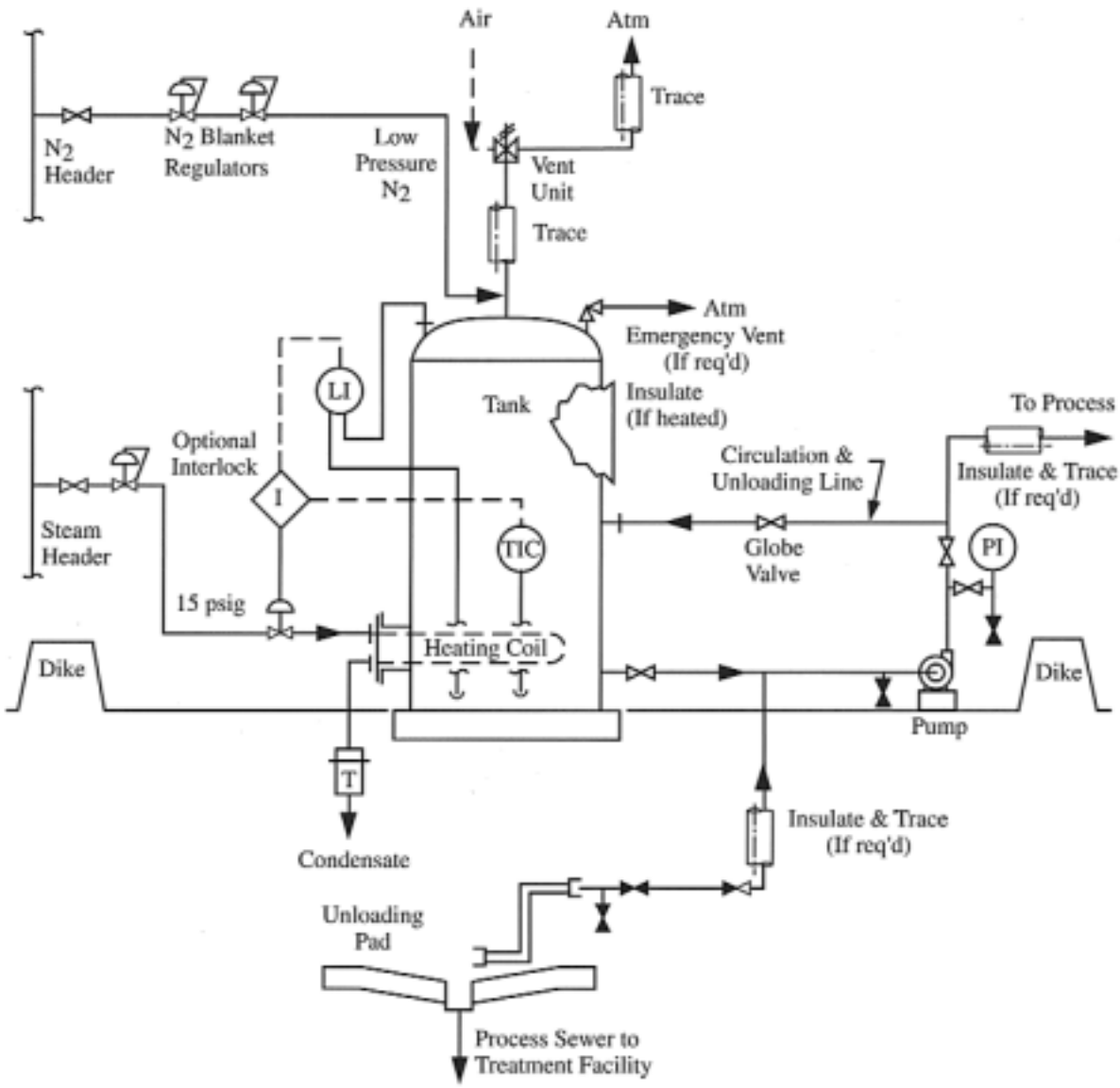
Aluminum is usually not acceptable for transfer lines since the lines are normally heat-traced and severe pitting may occur.

Drum Thawing

Customers who receive drum shipments of ethanolamines prone to freezing at ambient temperatures will occasionally need to thaw a drum. This is best done by storage in a “hot room” with a temperature 20 to 30°C above the freezing point. Alternatively, low-pressure (15 psig) steam, or hot-water or electric strap-on drum heating coils may be employed. Electric coils should be suitable for the electrical classification of the surrounding area. Long-term storage of ethanolamine drums heated with external strap-on coils may cause degradation of the phenolic liner in the drum, resulting in product quality degradation.

Drums must be vented while heating to prevent pressure build-up; if the drums are heated indoors, the workplace must be well ventilated to avoid product exposure.

Figure 1 • Typical Storage Tank System



Typical Equipment Specifications

Tank

API 650 Field Erected Tank or API 12F Shop-Fabricated, Low-Pressure Tank with at least 3 oz/in^2 pressure rating, 0.5 oz/in^2 vacuum rating. Non-heated tanks are normally not insulated. Insulated tanks typically have 2 to 2-1/2 in of insulation. The tank roof may be left uninsulated.

Pumps

Centrifugal pump, with reinforced TFE, or GRAFOIL Flexible Graphite gaskets and packing, single mechanical seal with carbon vs. silicon carbide faces. Electric motor in accordance with customer's area electrical classification. Flow rate capacity and head determined by customer. 50 GPM or more capacity is typical if used to unload tank cars or trucks.

Vent Unit

Breather vent typically sized for worst case of: (a) vapor displacement at maximum tank filling rate; (b) fire exposure relieving rate from tank; or, (c) nitrogen blowthrough where unloading cars or trucks or in cleaning lines. Set pressure 3 oz/in^2 (tank MAWP). Sometimes a separate emergency vent is provided. Use combination pressure/vacuum breather vent unit with vacuum breaker if no nitrogen blanket is provided.

Typical Equipment Specifications (cont.)

Nitrogen Blanket

Size to provide nitrogen makeup for worst case vacuum relief; typically, maximum pump out rate in combination with sudden tank cooling (i.e., hailstorm). If N_2 use rate is excessive, then provide capacity for pump out only and install a pressure/vacuum breather vent unit with air makeup under hailstorm conditions.

Heating Coil

Size based on utility conditions, storage tank size, tank insulation and target tank temperature. Steam or hot water supply may be interlocked with tank level gauge to shut off heat when product level is below top of coil. (Coils not required for aqueous Low Freeze Grade products stored at ambient temperature.)

Line Tracing

15 psig steam, hot water or electric system to maintain desired temperature in pipelines to prevent freezing or limit product viscosity. (Not required for Low Freeze Grade products.)

Table 3 • Storage Conditions

Product	Freezing Point,°C	Typical Storage Temp., °C	Vapor Pressure at Storage Temp., mm Hg	Viscosity at Storage Temp., cP
Pure Ethanolamines				
MEA	10	35	1.8	13
DEA	28	50	<.01	100
TEA Commercial	16	40	<.01	200
TEA-99%	22	40	<.001	200
Aqueous Ethanolamines				
MEA-LF(1)	-14	Ambient	4.2(2)	18(2)
DEA-LF(1)	-6	Ambient	6.6(2)	140(2)
TEA Commercial - LF(1)	-42(3)	Ambient	10.0(2)	150(2)
TEA-99% - LF(1)	-5	Ambient	10.5(2)	150(2)

(1) LF (Low Freeze) Grades are 15 wt % water.
(2) Measured at 25°C.
(3) Pour Point

Special Considerations

Several special considerations should be recognized while handling ethanolamines:

Vent Freezing

Ethanolamines freeze at low ambient temperatures. Frozen product from condensation of vapors passing through the vent unit or remaining from accidental overfilling of the tank can cause a tank vent unit to become inoperative. In an extreme case, this can result in vessel failure due to overpressure or overvacuum. Heat tracing of vent units should be considered, especially for tanks with small vent units and higher operating temperatures than those specified on Table 3. Heat-traced carbon steel vent units in MEA service may result in the formation of the unstable tris(ethanolamino)-iron complex.

Color Buildup in Traced Pipelines

When traced and insulated transfer lines are inactive, temperatures rise and discoloration may be noted in product remaining in the line. This is due to the high surface-to-volume ratio of the pipe, but can be reduced by the following actions:

- Use only the heat required to keep the product liquid.
- Use stainless steel, preferably 316 stainless steel, for transfer line construction.
- Limit steam pressures to 15 psig or, preferably, use hot-water tracing or temperature-controlled steam traps.
- Blow lines clear with nitrogen when the lines will remain inactive for long periods.

Note that if lines are blown clear, some venting will inevitably result. Also, do not use air to blow lines clear because the oxygen remaining in the line will rapidly discolor the film of product remaining in the line, causing a color problem the next time the line is used and possibly accelerating corrosion of the line.

Thermal Relief for Traced Lines

Thermal relief must always be provided for traced piping systems that can be blocked in. If a line is left full after a transfer, the product will warm up above the flowing temperature and may eventually reach the heating media temperature. This temperature rise will cause thermal expansion of the product, which must be accommodated to prevent possible failure of a gasket or other piping component.

Often, a small safety valve is used for this thermal relief. Ideally, this relief valve discharges back to the storage tank, preventing loss of material to the environment. Sometimes the discharge is to a process sewer which is routed to a treatment facility when return to the tank is difficult. The safety valve is usually set at the line pressure rating.

As noted in the previous section, it is best to routinely clear traced lines when not flowing to prevent product degradation.

Product Unloading

The transportation equipment Dow uses to ship ethanolamines to the customer is not unique and is identical to that used for many similar chemicals.

Upon receipt of any equipment, the customer should carefully check all paperwork and the seals and tags on the dome and outlet lines to verify the container contents prior to unloading. Ethanolamines are reactive with a wide variety of chemicals. Unloading an ethanolamine to the wrong tank or unloading another chemical to a tank containing an ethanolamine could result in a violent reaction in an uncontrollable environment. The vehicle should also be secured to assure it is not moved while unloading is in progress.

Unloading System

Figure 1 shows how the tank transfer pump may also be used to unload the container if the pump is located close to the unloading spot. Often, separate pumps are used because of long distances between the unloading spot and the tank and also because the unloading pump typically has a high flow rate capacity while the pump used to transfer product to the customer's process is of a much lower flow rate. Hose has a much higher pressure drop than the same nominal pipe size, and this fact should be considered when evaluating the net positive suction head (NPSH) requirements of the pump.

An eyebath and safety shower should be provided at any spot where ethanolamines are unloaded.

Tank trucks may be requested to arrive at the customer's plant with an onboard truck pump for unloading. The pump is driven by a hydraulic or mechanical connection to the truck tractor engine. A Dow representative can discuss this option.

While unloading, a low-pressure nitrogen pad is usually applied to the container. Alternatively, the dome may be cracked open, but the product quality may degrade due to contact with atmospheric carbon dioxide and oxygen.

Products may arrive frozen, especially when shipped in tank cars. Ethanolamines will be shipped in equipment that has heating coils. The product may be thawed by supplying low-pressure steam (15 psig) or hot water to the coils. A tank car may take 24 hours or more to thaw completely. Progress may be monitored by checking the product temperature; when it is measured at 15 to 20°C above the freezing point, then the car is normally fully thawed, including the outlet connections. Do not rush the thawing since ethanolamines are susceptible to scorching and discoloration. The lack of circulation and high coil-skin temperature can cause quality problems. The container must be vented while it is heated to prevent pressure buildup.

Nitrogen pressure can be used on the container to unload product. If this approach is chosen, the customer must make sure the gas pressure does not exceed the safety valve set pressure stenciled on the container. At the end of the unloading, gas will blow through to the tank and out the tank vent, possibly resulting in odor complaints and exposure.

Tank trucks and portable tanks should be unloaded on a paved pad with provisions to contain spills in case a hose should rupture and to control drips and minor spills when disconnecting hoses. Tank cars require spill-collection pads or pans between the rails and along the outside edges of the cars near the center of the unloading spot. Consult local and Federal regulatory agencies for mandatory spill-containment measures that may apply. Drainage to a process sewer and provision for flushing the unloading area with water are necessary.

After unloading, hoses are usually blown clear with nitrogen and the connections are broken. Some product will remain in the hose and some minor spillage may occur. Proper personnel protective equipment, discussed later, is essential. Hoses not in service should be flushed with water or the ends capped to avoid continuing odor problems.

Shipping Vessel Description

Tank Cars

Tank cars for transfer of ethanolamines are generally 20,000-U.S. gallon capacity and are constructed of either carbon steel or aluminum, depending on the type of material transported. Carbon steel cars contain a baked-phenolic liner to protect product quality in transit. The tank cars are insulated and typically are equipped with a safety valve set for 75 psi on the carbon steel cars and 35 psi on the aluminum cars. These cars typically have a 4-in bottom outlet valve which is reduced to a 2-in screwed outlet connection. The dome area on top of the car contains:

- Purge gas connection: 1-in screwed valve.
- Safety valve.
- Top manway: 18-in diameter.

Most cars also have one or two dip tubes from the top of the car to a small sump in the bottom of the car. These usually have 2-in screwed valves in the dome area and may be used to offload product instead of using the bottom outlet, if desired. Steam coil connections are usually 1-in screwed and usually are located near the bottom outlet.

Tank Trucks

Tank trucks for shipping ethanolamines vary in design depending upon the trailer manufacturer and specific DOT design specification. Typical connections include:

- Bottom unloading connection: 3-in screwed outlet. The liquid outlet connection may be in center, beneath dome on the curb (right) side, or at the rear of the trailer.
- Top manway: 20-in diameter
- Thermometer well: 1-in thermometer well, for measuring temperature of the material.
- A few 3-in screwed “cleanout” connections along the top that may be used for a nitrogen gas connection.
- The truck will come equipped with a pump, if specified by the customer.

Portable Tanks

Portable tanks are available with capacities ranging from 5000 to 5300 U.S. gallons. Each type of portable tank has fittings unique to its style and manufacturer. Usual connections include an approximately 2- to 4-in bottom screwed or flanged outlet, an approximately 18-in diameter top manway, and an approximately 1.5-in screwed or flanged nitrogen gas inlet. Most portable tanks use metric standard fittings, and adapters to ANSI flanges or US NPT threaded connections will be required.

General Unloading Procedure

The following procedure is a general guideline for unloading ethanolamines from tank cars, tank trucks, and portable tanks. Specific operating procedures should be developed to deal with the particular unloading hardware and site conditions.

1. Obtain necessary personal protective equipment, including (at least) coverall eye goggles and ethanolamine-resistant gloves.
2. Confirm the correct vessel and vessel contents, checking the bill of lading and the tags on the dome and outlet connections. Ensure seals on all vessel connections are still intact.
3. Ensure that the vehicle cannot be moved. Set the brakes and chock the wheels (both sides). Set a derail and provide a blue “men working” flag for tank cars.
4. Electrically ground the unloading piping to the vehicle frame. Do not use the jacket on insulated vessels, the rail trucks on tank cars, or truck bogey on tank trucks since these are not assured electrical grounds to the tank.
5. Ethanolamines may require heating to thaw or reduce viscosity. Open the caps on the heating coil connections carefully and make certain that no product has leaked into the coil. Crack the dome lid or open the vent; connect low-pressure steam or hot water to the coils. Apply heat slowly to avoid thermal shock to the coils, observe the first condensate or water that flushes through the coil and stop heating if the flush appears to contain ethanolamines. Continue to heat slowly until the desired product temperature is reached.
6. Make sure there is room in the receiving tank for the vessel’s contents.
7. Connect the unloading hose to the vessel outlet connection. If unloading a multicompartment truck, unload the front compartment first and proceed towards the rear. Make sure each compartment of the vessel is vented so that a vacuum is not pulled when unloading is started. Do not depend on the tank truck vacuum breaker. A nitrogen blanket can be provided on the vessel to retain product quality during unloading.
8. To obtain a pure, representative sample, start the pump and, when the line is properly flushed, draw a sample. If laboratory analysis is required prior to unloading, stop the pump until ready to proceed.
9. Unload the vessel contents to the tank.
10. When the vessel is empty, stop the pump. The hoses may be blown dry prior to disconnecting to reduce spillage. Close valves on the vessel and disconnect the hoses.
11. Prepare the vessel for return empty in accordance with the Department of Transportation regulations.
12. Remove chocks, blue flag, grounding cables, and derail and release the vessel.

Product Handling

Personal Protective Equipment

Impervious gloves are required for the safe handling of ethanolamines. Consult the Material Safety Data Sheet for more information.

Emergency Eye Bath and Safety Showers should be located near work sites where exposure to the product is likely. These areas would include unloading locations, hose connection switching stations, and near processing equipment, among others. Procedures should require cover-all eye goggles and gloves when undertaking operations that could result in a spill or vapor emission, such as breaking a hose connection.

As noted previously, drum or other shipping container thawing must be done only when the container is safely vented to avoid a pressure buildup.

Contaminated gloves and other clothing should be properly disposed of, consistent with local and Federal regulations.

Firefighting

For large fires, alcohol-type or all-purpose-type foams should be applied per the manufacturer's recommended techniques. CO_2 or dry chemical media should be used for small fires. Do not direct a solid stream of water or foam into hot, burning pools because this may cause splattering and increase fire intensity. When fighting amine fires, use protective clothing, eye protection, and self-contained breathing apparatus.

Equipment Cleanup

Equipment used in ethanolamine service should be emptied of as much product as possible prior to cleanup. Since the product is water-soluble, it should then be flushed with water prior to opening to the atmosphere. Introduce water at a low point in the system, so it overflows at high elevations to assure all equipment areas are well flushed. The system should then be drained and flushed a second time. After draining, open the equipment carefully. Some amines may still be trapped in pockets so care in disassembly is prudent. Minor residual odors may be removed by steaming equipment (with necessary vacuum relief). All waste water must be disposed of in a manner complying with local and Federal regulations.

Product Shipment

Reloading ethanolamines into transportation containers for reshipment is beyond the scope of this booklet. A shipper must be familiar with Department of Transportation and other governmental regulations in order to ship these products safely in full compliance with regulatory requirements.

Environmental Considerations

Ethanolamines are water-soluble. Biological waste treatment facilities can handle significant waste water loadings once they are acclimated to the product. Sudden loadings to a nonacclimated waste treatment biomass can result in very poor treatment and possibly toxic shock to the biologically-active species.

Ethanolamines in waste water may react with acidic compounds in the sewer stream, resulting in a more neutral feed to the treatment plant. These reactions in the sewer may also produce undesirable odors or create toxic materials. Therefore, the customer must be careful and segregation of sewers may be necessary.

Ethanolamine spills should be dealt with promptly. Dry absorbents should be used to soak up most of the spill. The absorbent must be disposed of consistent with environmental regulations. Disposal of ethanolamine-saturated absorbents may be controlled by provisions of the Resource Conservation and Recovery Act (RCRA). Prior to disposal, check to ascertain what regulations may apply. Under certain conditions, when the used absorbent is exposed to air, thermal degradation of the product may begin, resulting in spontaneous combustions. Consequently, the used absorbent should be put into a container (e.g., an open-top drum) and thoroughly saturated with water before sealing. Small spills may be flushed to a process sewer with copious amounts of water.

Empty ethanolamines drums should be triple-washed with water, resealed, and all labels should be removed. They may then be offered for recycling, reconditioning, or crushing and disposal in an approved landfill.

Product Safety

When considering the use of any Dow products in a particular application, you should review our latest Material Safety Data Sheets and ensure that the use you intend can be accomplished safely. For Material Safety Data Sheets and other product safety information, contact your Dow sales or customer service representative. Before handling any other products mentioned in the text, you should obtain available product safety information and take necessary steps to ensure safety of use.

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