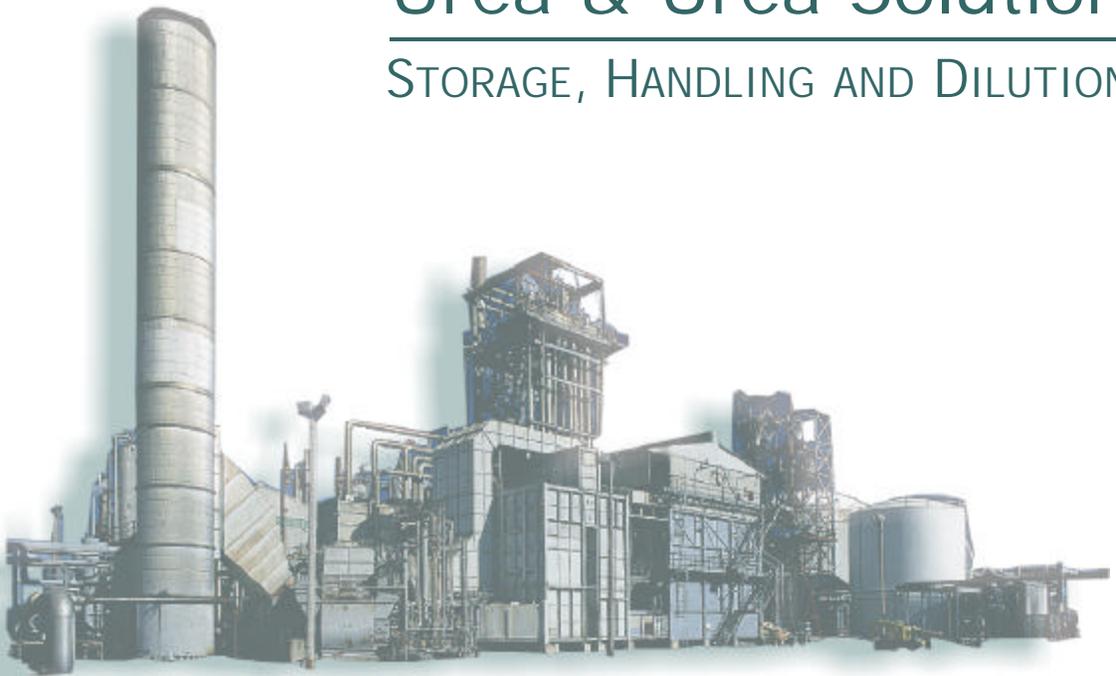


Urea & Urea Solution

STORAGE, HANDLING AND DILUTION



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Introduction

Our urea solution, or liquor, is a manufactured product of urea mixed with pure water. It contains low concentrations of biuret and free ammonia and may contain parts per million concentrations of other compounds listed in the product specification.

Our urea solutions can be ordered in quantities ranging from approximately 18 tons (4,000 gallons) to 25 tons (5,200 gallons), which are delivered by tank truck in concentrations up to 70%.

These products are of the highest quality and are made at production facilities located in Blytheville, Arkansas; Courtright, Ontario; Sergeant Bluff, Iowa; and Verdigris and Woodward, Oklahoma. Security of supply goes hand-in-hand with first-rate technical support acquired from more than 35 years' experience in the nitrogen business. This experience allows us to offer our customers seasoned technical support, covering areas such as equipment installation, choice and design; equipment maintenance and inspection services; employee training; and regulatory compliance pertaining to environmental controls, and safety and emergency response procedures.

Urea Solution

Table 1: Urea Solution Specifications

	Feed Grade	Commercial Grade
Urea strength	70% (+/- 2%)	Customer requirement up to 70% (+/- 1%)
Specific gravity	1.17-1.18	1.12-1.18
Free ammonia (at loading)	0.25% maximum	< 0.25%
Biuret	0.3-0.4%	0.3% maximum
Magnesium (Mg)		< 0.8 ppm
Calcium (Ca)		< 0.8 ppm
Phosphates as PO ₄		< 1.5 ppm
Iron (Fe)		< 0.8 ppm
pH (at 95° F)	8.4-9.5	9.0-9.5

Applications

Our urea solution has a wide range of industrial and agricultural uses, including as a:

- ◆ Chemical intermediate for the manufacture of amines, pharmaceuticals, explosives and catalysts.
- ◆ Reducing agent in SCR/SNCR processes.
- ◆ Non-protein nitrogen source used by ruminants to form proteins.
- ◆ Nutrient for fermentation processes.
- ◆ Nutrient for effluent wastewater treatment.
- ◆ Nutrient source in plant foods.

Product Specifications

There are two grades of urea solution, commercial and feed grade, available in concentrations up to 70%.

Concentrations may vary slightly depending on the ambient temperature and the storage conditions. (See Table 1, Page 2 for further specifications.)

Properties of Urea Solution

Our urea solution is a manufactured product of urea and pure water. It is a clear liquid having the slight pungent odor of ammonia, and a specific gravity of approximately 1.15.

Urea and water react to produce ammonia and carbon dioxide in a process called hydrolysis. The rate of hydrolysis or decomposition is mainly influenced by the temperature of the solution and the concentration of urea, with temperature being the controlling factor. Free ammonia in the liquor is minimal at the time of loading, but does evolve slowly due to the decomposition of urea. Measurable changes for the highest solution concentrations typically take several days. The rate of hydrolysis increases with concentration since these solutions must be transported and stored at higher temperatures to avoid salting out. Concentrations of 40% to 50% can be stored at temperatures of 70° F without decomposing or salting out. When storing solutions of higher concentration, temperatures should be maintained about 15° F above the salt-out or crystallization point. (See Figure 1, Page 4.)

Specific gravities, saturation temperatures and viscosities for various concentrations of urea solutions can be found in Tables 2 and 3 (pages 4 and 5). Salt-out and boiling points of various solution strengths, along with associated heat capacity and vapor pressure, can be found in Table 4 (Page 5).

Figure 1: Urea Salt-out Temperature vs. Concentration

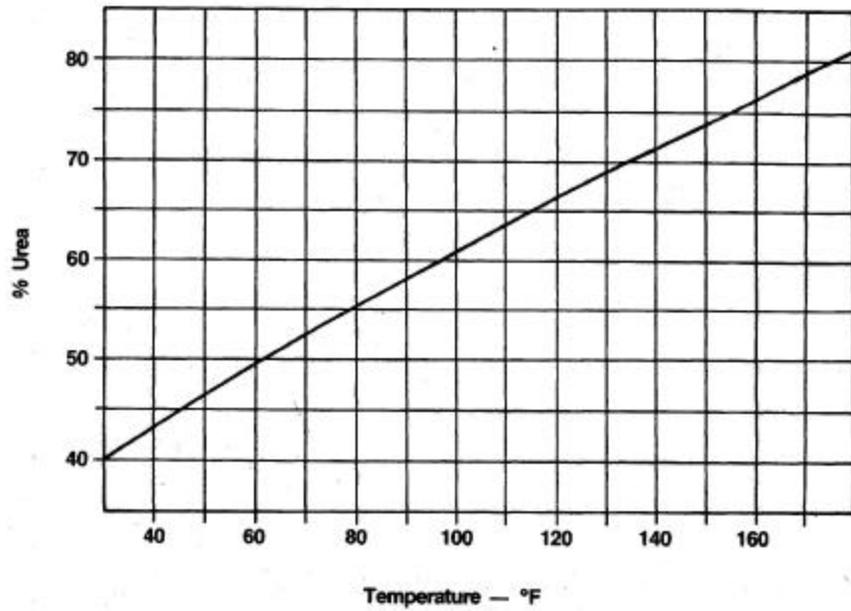


Table 2: Saturated Urea Solutions

Solubility Wt % Urea	Saturation Temp. (° F)	Specific Gravity	Viscosity (centipoise)
30	13	1.094	-
32.5	11.3	1.101	-
35	19	1.109	-
40	33	1.121	2.63
45	47	1.133	2.22
50	62	1.145	2.02
55	78	1.155	1.88
60	96	1.164	1.77
65	115	1.172	1.71
70	135	1.182	1.70

Table 3:
Specific Gravity and Pounds per Gallon of Urea Solution

	Temperature (° F)	Specific Gravity	Lbs./Gallon
40 wt % Urea Solution			
	40	1.120	9.33
	60	1.114	9.28
	80	1.107	9.22
	100	1.100	9.16
50 wt % Urea Solution			
	80	1.137	9.47
	100	1.131	9.42
	120	1.124	9.36
70 wt % Urea Solution			
	140	1.179	9.82
	160	1.172	9.76
	180	1.164	9.70

Table 4:
Properties of Urea Solution

Concentration Wt % Urea	Salt-Out Temp. (° F)	Atmospheric Boiling Point (° F)	Heat Capacity BTU/lb (° F)	Vapor Pressure Factor ⁽¹⁾
30	13	219	0.83	0.88
32.5	11.3 (Eutectic)	-	-	-
40	33	220	0.78	0.86
50	62	225	0.73	0.78
60	96	231	0.69	0.70
70	135	240	0.65	0.59

(1) Vapor Pressure Factor is the ratio of vapor pressure of the urea solution to the vapor pressure of pure water at the same temperature.

Dilution

Our urea solutions may be diluted at the customer's location to the desired concentration.

Product quality will depend on process equipment and dilution water used. The procedure is straightforward and involves the addition of the urea solution into the dilution water. Demineralized or distilled water must be used if a reagent grade product is desired. Dilution calculations are given in Table 5, below.

Large-scale applications can employ either a batch or continuous mixing process approach for diluting urea solutions. Product circulation or agitation will be needed using a batch process to ensure uniform mixing. Continuous processes must provide enough turbulence to ensure proper mixing. Controls sophistication should reflect process choice.

Table 5: Calculation of Dilution Water for Storage at Lower Strength than Received

Example: Truck shipment is 70% urea solution.
Weight of truckload received is 48,000 lbs.
Desired on-site storage concentration is 50 wt % urea solution.

Calculate: P = pounds of dilution water required.
G = gallons of dilution water required.

$P = [(wt \% \text{ Shipped} / wt \% \text{ Desired}) - 1] * \text{Shipment Weight}$

$P = [(70/50) - 1] * 48,000 = 19,200 \text{ lbs.}$

$G = P/8.33$

$G = 19,200/8.33 = 2,305 \text{ gallons}$

End Product = (48,000 + 19,200) = 67,200 lbs. of 50 wt % urea solution

Bulk Deliveries

Tankers

Bulk deliveries of urea solution are made in general purpose road tankers. They have mild or stainless steel insulated tanks to minimize heat loss, which could result in product salt-out. Products are discharged through a mid- or rear-tank bottom connection and a flexible hose usually 30-40 feet long.

Tankers vary in physical dimensions but generally follow these specifications:

- ◆ Gross weight: 40 tons
- ◆ Capacity: 25 tons
- ◆ Length: 42 feet
- ◆ Width: 8 feet
- ◆ Turning circle: 200 feet
- ◆ Overhead clearance: 13 feet

Siting

Receiving locations should be sited outdoors with adequate road access for trucks. The unloading line should be a 3" or 4" pipe terminating with a block valve and OPW fitting for connection to the truck. As an added safety precaution to prevent storage tank back siphoning, this line should be capped when not in use. The unloading line should be heat traced and insulated to avoid heat loss from any solution remaining in the unloading line.

Off-loading

Tankers are off-loaded by the driver in coordination with the customer's staff. A customer employee familiar with site equipment installations and related unloading and safety procedures must be present to supervise the off-loading activity.

We reserves the right to refuse deliveries into sites that do not meet agreed-upon standards.

Following is an example of site-specific unloading procedures.

1. Position the tanker, apply safety brakes and chock wheels.
2. Observe all site and product safety protocols.
3. Verify storage tank levels to ensure adequate space is available to accept the full load safely.
4. For pressure discharge, open the tanker blow off valve to check that it is depressurized. Close before proceeding.
5. Uncap the unloading line; connect the flexible hose between the tanker discharge point to the unloading line.
6. Open the appropriate block valves on both the tanker and installation. If the tank vent is fitted with a relief valve, then open the by-pass valve.
7. In the case of pump-discharged installations, ensure that the tanker vent is open before starting the pump.
8. In the case of compressor discharged installations, start the compressor and then slowly open the air inlet valve to start the transfer.
9. When all the contents have been transferred, in the case of pump unloading, add a small amount of flushing water to

the tanker to purge the unloading line. For tankers with compressor discharge, the residual pressure in the tanker can be used to purge the unloading line by venting to the atmosphere through the storage system. To minimize venting problems, shut down the compressor when about two-thirds of the load has been transferred so that the tanker pressure falls to 5-10 psig on completion of discharge.

10. Close the appropriate valves and drain the flexible hose before disconnecting. Cap the unloading line.
11. Stow the flexible hose on the tanker and replace blank caps on tanker discharge and storage tank filling points.

Bulk Storage

Tank Siting

On-site bulk storage installations for urea solution may be sited at any location that is convenient for receiving the deliveries by truck. Storage tanks are best sited close to the point of use, and may be installed inside buildings for convenience and protection from cold weather. If an installation is indoors, the tank vent, overflow and delivery connections should be piped to the outside. Tank containment equal to 110% of the volume of the tank should be provided regardless of tank location.

Construction Materials

Carbon steel with an adequate corrosion allowance may be used for urea solution storage and piping systems. Stainless steel material is

Storage Tank Design

recommended for applications where iron contamination is not acceptable. The recommended construction material is 304 stainless steel.

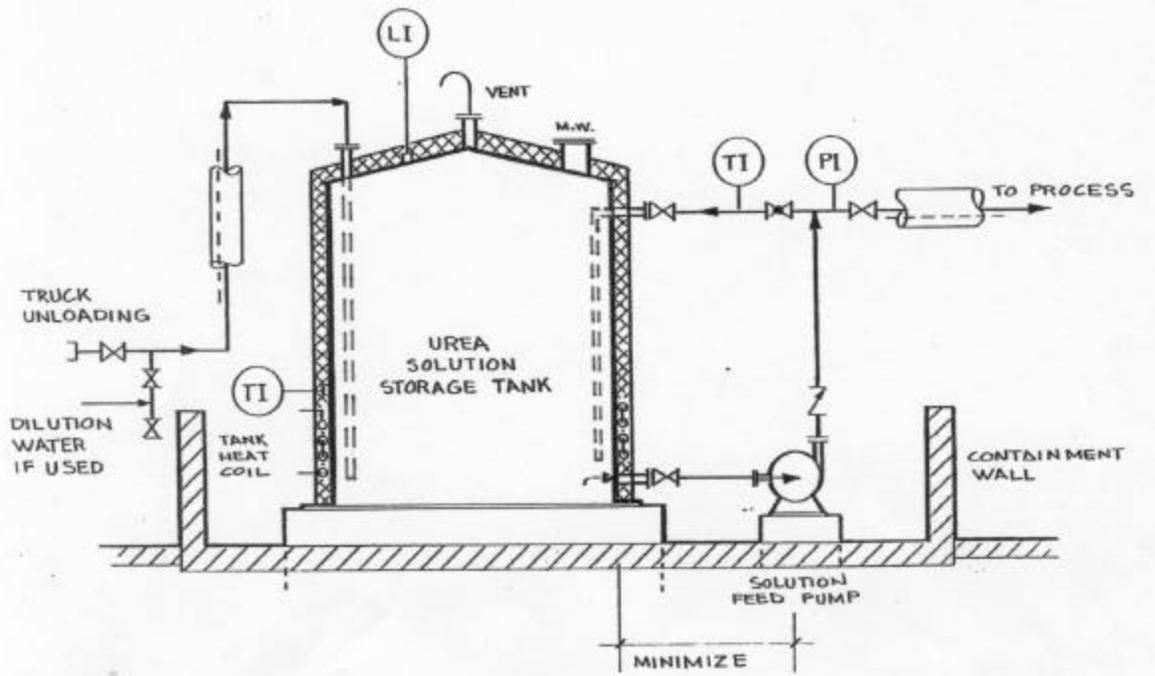
Vertical, atmospheric tanks designed to API-650 & ASME are appropriate for storing urea solutions. They are typically sized for 10,000 to 30,000 gallon capacity (50 to 150 tons of solution), but may be smaller. The smallest tank size recommended is 10,000 gallons, which would permit transfer of a full truck load when the tank is about half full, or contains two weeks' supply, whichever is greater.

Tank heating and insulation are required to maintain the stored urea solution above the salt-out temperature. External plate coil heater panels are recommended.

They may be either steam or electrically heated. If solution strength is 50% urea or lower and the tank is located inside a heated building, the tank will not need to be insulated. However, some small source of tank heating, such as a plate coil heater or internal tank coil is suggested. Figure 2 below shows a typical outdoor storage installation for urea solution.

The tank should be provided with temperature and level indication. Terra can furnish a telemetry system, which provides an effective, low-cost means of monitoring urea solution inventory and ensuring that deliveries are supplied at the right time with minimal customer effort. Details may be obtained from the Sales Department (see back cover for contact information).

Figure 2. Typical Urea Solution Storage Installation



<p>Pump Specifications</p>	<p>Pumps for handling urea solutions should have wetted parts made of iron, steel or stainless steel. No copper or copper alloy parts should be used. Ethylene-propylene (EPDM) is the recommended material for "O" rings. Centrifugal type pumps are recommended. Pumps in critical service should be heavy-duty, industrial service pumps intended for continuous operation. Reliable seal-less magnetic drive pumps can also be used.</p> <p>Solution feed pumps should be used to recycle the tank. Pump capacity should be specified to furnish the desired solution feed rate and to turn the tank contents every 6 to 8 hours, or every 2 to 4 hours when mixing with water.</p>	<p>the storage tank due to urea hydrolysis. Dilution water should be added below the liquid level to prevent tank damage caused by a vacuum condition that can occur if water is sprayed into the tank. Safety procedures should be followed to ensure that any tank entered for inspection or repair has adequate oxygen levels and a low ammonia concentration for safe entry.</p> <p>Refer to the urea solution Material Safety Data Sheet for additional safety information. (See "Our Products" on our web site at www.rmtech.net.)</p>
<p>Hazards</p>	<p>Burns to personnel from hot urea solution must be guarded against. Impervious gloves and eye protection should be worn. Additional protection for the face and skin should be used if there is the potential for leaking or splashing liquid. A nearby safety shower and eye-wash is recommended.</p> <p>Ammonia and carbon dioxide will be present above the liquid level in</p>	<p>Safety</p> <p>With a well-designed installation, safety is achieved through adequate operator training and strict adherence to standard operating and maintenance procedures. Training should aim to familiarize operators with the product, plant and process to produce the most appropriate reaction to an unforeseen emergency. We can offer suitable maintenance and training packages to meet the needs of our valued customers. Please contact the our Sales Department for further information.</p>

Granular Urea

Our granular urea is produced through the evaporation and granulation of urea solution, yielding a dry product with an SGN size of around 265. Product specifications can be found in Table 6, below. Physical properties of granular urea can be found in Table 7, at right.

We supply granular urea in 20-ton hopper or pneumatic tank trucks or 100-ton hopper rail cars from world-scale production facilities in Blytheville, Arkansas and Courtright, Ontario. These facilities have a combined annual capacity of more than 750,000 tons.

In addition, we can offer expert advice concerning such matters as installation design and dry urea systems operation. Due to the extreme hygroscopic nature of this product, it is recommended that advice be sought from us or other qualified technical personnel prior to installing the delivery and handling systems.

Table 6: Product Specifications (Typical Chemical Analysis)

Total nitrogen	46.0-46.3%
Conditioning agent	0.3-0.4%
Biuret	1.0-1.5%
Moisture	0.1-0.3%
Free ammonia	10-140 ppm
Iron (Fe)	0.2 ppm
pH	7.0-8.5
Turbidity, as SiO ₂	<3 APHA
Color	<3 APHA

Table 7: Typical Physical Properties of Terra Granular Urea

Molecular weight	60.05
Melting point (decomposes)	271° F
Specific gravity	1.335
Heat of solution in water	108 BTU/lb.

Tyler Mesh	US Standard No.	Cumulative Percent
+6	#6	3-6%
+8	#8	65-70%
+10	#12	95-98%
+14	#16	98-99%
+20	#20	100%

SGN: (Size Guide Number) = 260-270

Bulk Density: 46-49 lbs. per cubic foot (735-785 kg. per cubic meter)

Angle of Repose: 32°

Crush Density: 3-5 lbs.

Typical Urea Specification

AQUEOUS UREA SOLUTION FOR SCR

Urea, CAS-No. 57-13-6

Chemical formula	(NH ₂) ₂ CO
Molecular weight	60.06 g/mol
Density at 20°C	1.085 - 1.095 g/cm ³
Urea contents	32.5 ± 0.5 %by weight
pH in 10% solution at 20°C	< 10
Alkalinity as NH ₃	< 0.1 %
Carbonate as CO ₂	< 0.1 %
Biuret	< 0.3 %
Insolubles	< 10 ppm
Formaldehyde	< 10 ppm
Phosphate	< 0.5 ppm
Calcium	< 0.5 ppm
Iron	< 0.5 ppm
Copper	< 0.2 ppm
Zinc	< 0.2 ppm
Chromium	< 0.2 ppm
Nickel	< 0.2 ppm
Magnesium	< 0.5 ppm
Sodium	< 0.5 ppm
Potassium	< 0.5 ppm

For additional information or specific application, please contact us at:



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