Introduction
Urea is produced in prills, granules, flakes, pellets, crystals and solutions, but it is traditionally marketed as prills or granules. The choice of the commercial preferred form is normally associated with its application, solubility, crushing strength and free-flowing behavior.

The pneumatic conveying and storage of urea must take into consideration the abrasive, hygroscopic and heat-sensitive characteristics of this compound.

Hygroscopicity of a compound is defined as the moisture absorption properties under specific conditions of temperature and humidity. This value is reported as critical relative humidity (CRH). Urea’s CRH value ranges from 70 to 75 at 30°C (86°F). The table below provides the CRH values of urea at different temperatures.

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRH %</td>
<td>81.8</td>
<td>79.9</td>
<td>80</td>
<td>75.8</td>
<td>72.5</td>
<td>68</td>
<td>62.5</td>
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</table>

Material
Urea is one of the most important nitrogen-containing fertilizers in the world. It is also one of the raw materials for the manufacture of urea formaldehyde resins and urea-melamine-formaldehyde glues.

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\text{NH}_3 + \text{CO}_2 \leftrightarrow (\text{NH}_4)_2\text{CO}_3
\]
\[
(\text{NH}_4)_2\text{CO}_3 \leftrightarrow \text{H}_2\text{NCONH}_2 + \text{H}_2\text{O}
\]

Solids Formation & Handling
The urea solution that results in the second reaction can be used as an ingredient of nitrogen solution fertilizers, or it can be concentrated further to produce solid urea. There are three methods for concentrating the urea solution: vacuum concentration, crystallization, and atmospheric evaporation. The most common method is evaporation. The concentration process furnishes urea *melt* for solids formation.

Urea solids are produced from the urea melt by two basic methods: prilling and granulation. Prilling is a process by which solid particles are produced from molten urea that is sprayed from the top of a prill tower. As the droplets fall through a counter current air flow, they cool and solidify into nearly spherical particles.

Pneumatic Conveying & Storage
The handling and storage of urea requires special attention to several product related properties and external factors. Most common problems are associated with moisture pick up, caking, dustiness and particle segregation. The factors that most affect the moisture absorption-penetration characteristics of urea are its chemical composition, particle porosity, particle surface area, and degree of crystallinity.

Caking is the formation of salt bridges or adhesive points of contact between the particles. Product related factors that influence caking include: chemical composition and impurity content, moisture content, size and shape of particles, mechanical strength and resistance to breakdown, hygroscopicity, and storage temperature. External factors that influence caking include: warehouse storage temperature, atmospheric humidity, length of storage and the pressure from stacking or being at the bottom of a pile.
Transportation

The majority of solid urea product is bulk shipped in trucks, enclosed railroad cars, or barges, but approximately 10 percent is bagged. The flow diagram above shows the rail-unload and in-plant transfer operations in a melamine and urea resin production facility for the production of break-resistant melamine tableware. Urea is received in railcars and unloaded into one of two storage tanks. Upon demand, the material is conveyed by pressure to one of two scale hoppers providing material to six reactors.

Rail Unload System

The system consists of a dual blower rail unload system with a filter receiver group capable of handling up to 9,000 kg/hr (20,000 lbs/hr) or more. The vacuum side of the system moves the material from the railcar to a filter receiver that effectively separates the material from the conveying air. Mounted below the receiver is a K-Tron Premier heavy-duty (HD) Aerolock™ rotary valve that meters the material into the pressure side of the system for final delivery to storage. The Aerolock™ is constructed of stainless steel and includes relieved tips to reduce material smearing.

Automatic bin vents are placed on the top of each storage tank to trap the airborne particles of material inside the tank while allowing the conveying air to escape from the tank as it is filled. The trapped particles are removed from the unit’s filter bags by timed, compressed air pulses. The conveyed material remains in the storage tank and clean air exhausts through the bin vent into the atmosphere.

After coolers are normally installed at the discharge of the pressure blowers to keep the temperature of the conveying air from reaching excessive levels and avoid changing the material’s characteristics.
Storage

Due to urea’s hygroscopic nature, the conveying line from the railcar to the filter receiver is insulated to eliminate condensation in the line that can result from ambient temperature changes.

Desiccant Bed Dryers (DBD) also provide a blanket of dry air on the material while it remains in storage. Diverter valves are used to allow a single conveying line to be used to provide the dry blanket of air and the delivery of material. During the unloading of the railcar, the valve diverts to the line conveying material. Following the unloading cycle, it automatically diverts back to the supply of dry air. Desiccant bed dryers provide fast, efficient drying while urea is stored.

In-Plant Transfer

The second phase of the system is the pressure conveying system that allows the customer to transfer urea from either of the storage tanks to one of two scale hoppers located above the reactors. The system also allows material to be conveyed from the first storage tank to the second storage tank. Bin unloaders are positioned at the discharge of each storage tank to agitate the urea, and ensure an even flow to the Aerolock feeding the pressure system. Aeropass valves, located on the top of each scale hopper, allow both hoppers to be fed with a common material line. When one destination calls for materials, the Aeropass valve diverts to the 90° position. The material and air are directed into the hopper where they separate; the material stays in the hopper and the air passes back to the source tank. When the scale hopper’s preset weight is reached, the valve returns to the straight-through position and the feeding Aerolock stops, allowing the material and air to purge to the source tank. This closed loop design requires less head room and eliminates the need to provide separate filtering on each scale hopper for a cleaner, less expensive installation.

When the reactor calls for material, the slide gate on the scale’s discharge opens. Multiple “A” valves located beneath the slide gate direct the batch to the reactor calling for material. To keep the reactor’s fumes and moisture from reaching the scale hopper and contaminating the material, additional slide gates are located directly above each reactor.

Controls

A PLC control panel, supplied by K-Tron Systems Group, provides automatic operation of both the rail unload and in-plant scaling system. Using the touch screen monitor, the operator has total control of both systems including starting and stopping, selecting sources and destinations, and inputting the scaling set points. The dynamic display screen also includes detailed system flow graphics that show the status of each system. Scrolling through the operating screens, the operator can monitor alarm conditions, visually verify which motors are on and off, and check the position of each diverter valve and slide gate. To maximize the company’s material management, the PLC panel also includes an interface with each scale instrument to provide accumulated totals that are displayed on the monitor. The PLC is also expandable to meet the customer’s future system requirements.

Equipment

The K-Tron Premier filter receiver provides automatic material-from-air separation. The tangential inlet, located in the receiver’s circular hopper, provides a cyclonic separation of the material air stream. Airborne material is trapped by the filter bags. Timed, compressed-air pulses clean the filter bags, dropping the remaining airborne material into the hopper. The filter bags are protected from the material mainstream by a deflector shield. Efficient performance of the filter receiver is achieved through the proper selection of filter media and the correct air-to-cloth ratio.

Mounted atop a storage tank, the K-Tron Premier automatic bin vent filters the exhaust air and literally allows the tank to breathe. When material is conveyed to the storage tank, the increased volume within the tank reduces the air stream velocity, the material drops, and the excess air is vented through the filter. During the venting process, airborne dust particles are trapped by the filter bags. Sequentially timed bursts of compressed air controlled by solenoid valves, pulse the bags and dislodge the dust particles. All of the product remains in the storage tank and clean air exhausts through the tank vent into the atmosphere.
The K-Tron Premier heavy-duty (HD) Aerolock™ rotary valve is engineered for metering dry bulk particulates. It is designed for heavy-duty service, and high volumetric efficiency at up to 1.0 bar (15 PSI) pressure differential and temperatures up to 107.2°C (225°F).

A variety of seals can be incorporated into the unit to accommodate even the most rigorous chemical process industry applications. A variety of sizes and design options is available upon the application and meet CE and ATEX 3D classifications.

K-Tron Premier "A" valves are used to divert a material stream into one of two destinations. They are designed for gravity drop installations where no pressure differential exists across the inlet and outlet.

Orifice slide gates are used to control gravity flow discharge from storage bins and hoppers where the gate is not closing against a head of material. In the open position, the gate’s blade is completely removed from the control opening, making a resistance-free passage for the material stream. In addition to the featured equipment listed above, K-Tron also offers a full range of pneumatic conveying auxiliary equipment, such as storage tanks, dryers, valves and accessories, piping and much more.

**Applications**

Typical applications include:
- Fertilizer (More than 90% of the entire world production goes into this application). Because the molecule contains 46% nitrogen, urea has the lowest transportation cost per unit of nitrogen nutrient.
- A raw material for the manufacture of urea-formaldehyde and urea-melamine resins used for plywood and moisture resistant particle boards
- Alternative rock salt for de-icing
- Additive to cigarettes (enhances flavor)
- In fire extinguishers as urea-potassium bicarbonate
- An ingredient in tooth whitening products
- An ingredient in creams and soaps to help soften the skin

**K-Tron Advantage**

- K-Tron’s Aerolock rotary valves are available in a variety of sizes and design options depending upon the application, and meet CE and ATEX 3D classifications
- Each pneumatic solution is custom developed for a specific process application, based on K-Tron’s extensive experience in providing material handling solutions
- The K-Tron Systems Group can supply integrated systems with both K-Tron and ancillary products, with one source management
- Trained and certified service engineers located around the world provide twenty-four hour technical support to solve your problems, any time, any day