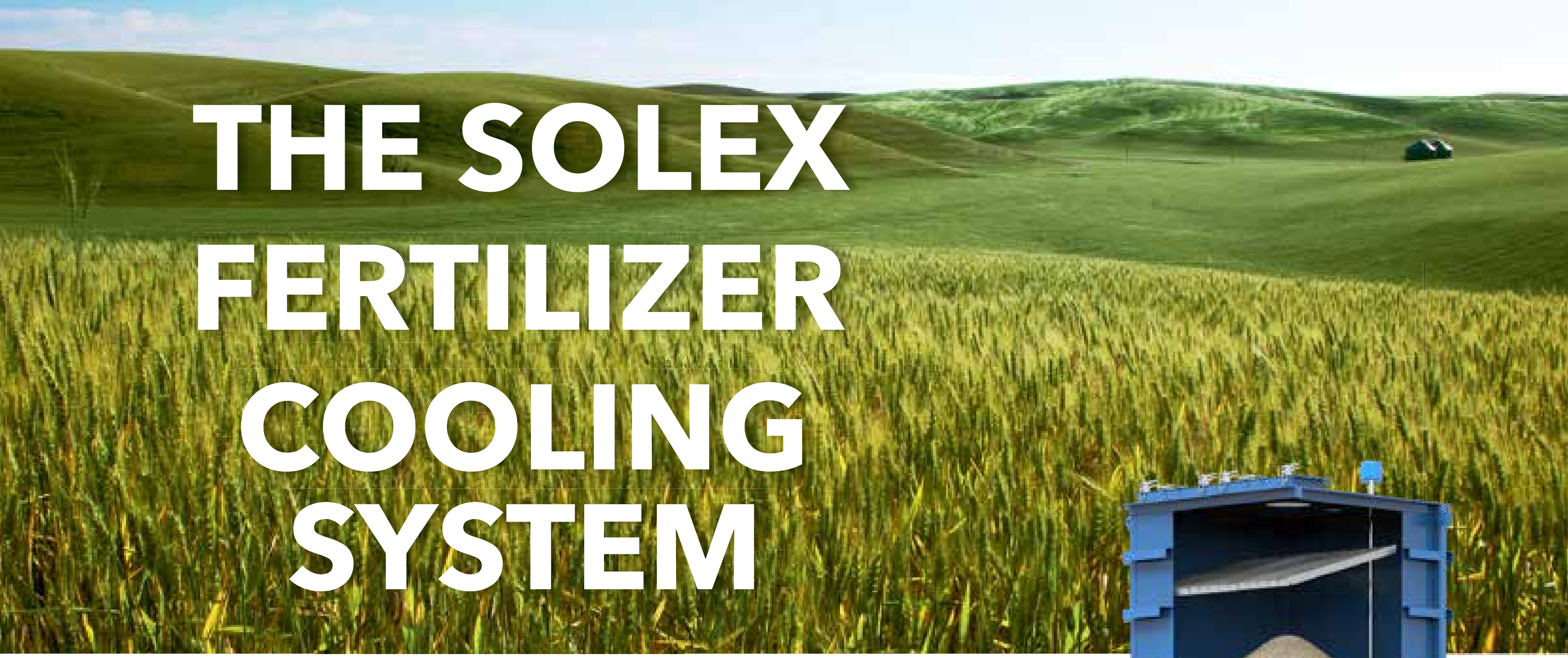
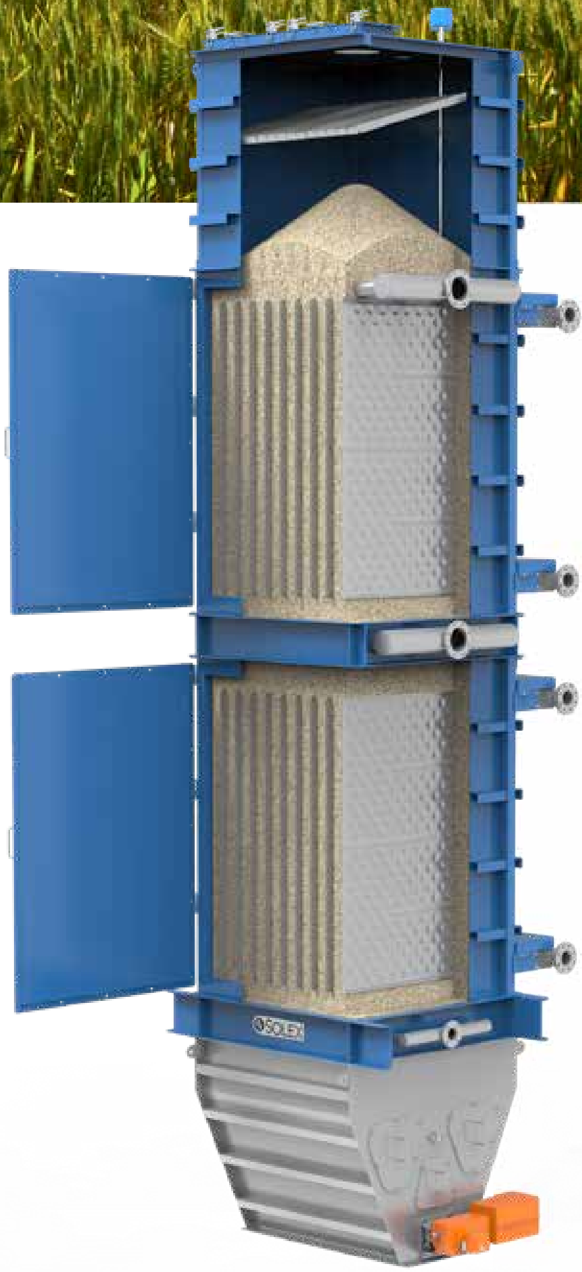


THE SOLEX FERTILIZER COOLING SYSTEM



WORLD LEADING TECHNOLOGY FOR COOLING FERTILIZERS

Complete company and product details available at
www.solexthermal.com

SOLEX
THERMAL SCIENCE

What Causes Caking of Fertilizers During the Cooling Process?

Fertilizers contain a small amount of moisture. This moisture can migrate from the product into the air in the void space between the particles, which raises the humidity of the air. Since this humid air is in contact with the cool surface of the water-cooled heat exchanger plates, condensation develops. The condensation on the plates combines with the dust from the fertilizer triggering caking of the fertilizer. The result of caking is expensive: reduced thermal performance, the need for frequent cleaning, unnecessary downtime, and product loss.

How To Avoid Caking

Caking can be eliminated by maintaining the dewpoint of the air in the void space between the fertilizer particles below the temperature of the water-cooled plates. This eliminates the possibility of condensation.

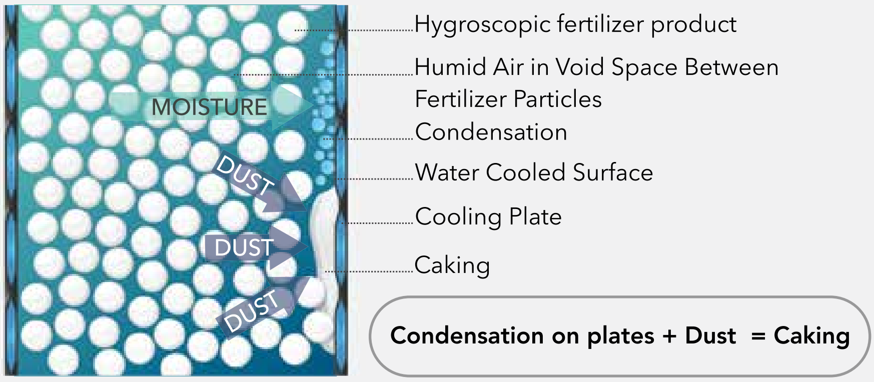
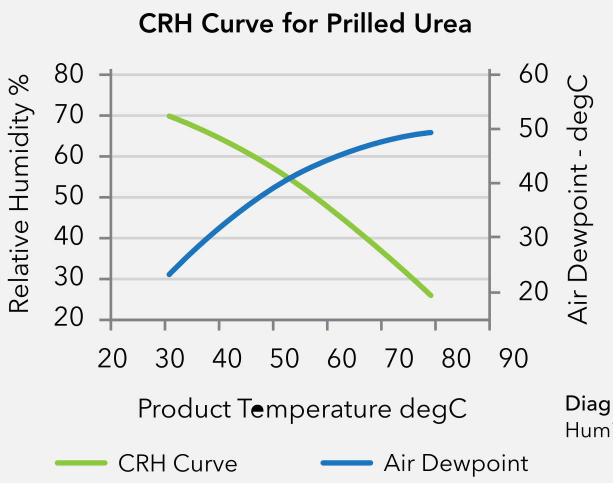


Diagram A – The Cause of Caking



The Hygroscopic Nature of Fertilizers

Fertilizer absorbs moisture from the air when the relative humidity (RH) of the air is greater than the critical relative humidity (CRH) of the fertilizer. Conversely, moisture transfers from the fertilizer to the air when the RH of the air is lower than the CRH of the fertilizer. See Diagram B.

Diagram B – Example of Critical Relative Humidity Curve for Freshly Prilled Urea.

Critical Relative Humidity of Fertilizers

The tendency for moisture to migrate either from the fertilizer to the air, or from the air to the fertilizer is defined by the critical relative humidity (CRH) of the fertilizer. The Critical Relative Humidity curve is unique for different fertilizers.

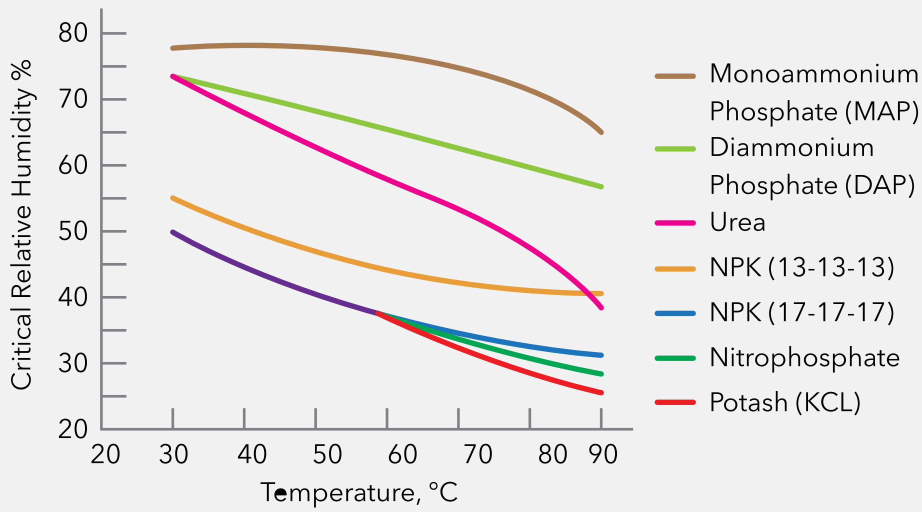


Diagram C – Critical Relative Humidity Curves for different Fertilizers

SOLEX THERMAL SCIENCE

THE FIVE KEY ELEMENTS OF THE SOLEX FERTILIZER COOLING SYSTEM

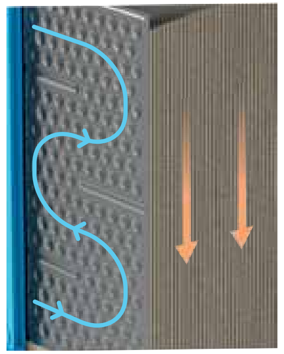
1 Thermal Modeling Predicts the Dewpoint of the Air During the Cooling Process

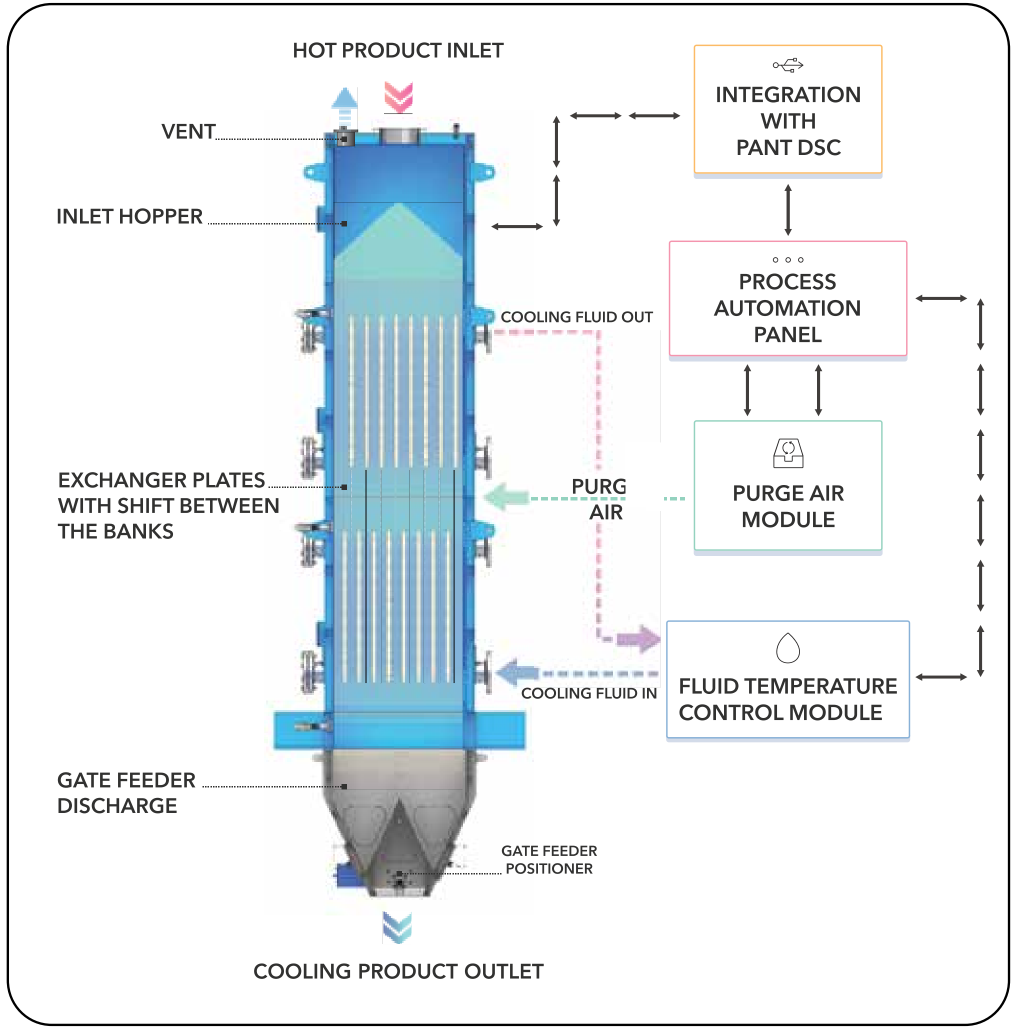
The heart of the Solex technology is accurate modeling, performed using the Solex proprietary software ThermaPro, which generates the temperature profile of both product and cooling water at each point through the exchanger.

Combining the results of accurate thermal modeling with the hygroscopic characteristic of the fertilizer, allows Solex to design the exchanger with a water temperature profile that ensures the plate temperature is above the dewpoint of the air in the void space at all points through the exchanger.

2 Counter-Flow Design Maximizes Cooling Efficiency

The CRH curve for a fertilizer shows that the equilibrium RH increases as the temperature decreases. The corresponding dewpoint curve shows that as the temperature of the product decreases, there is a corresponding reduction in the dewpoint. This means that lower cooling water temperatures can be used as the product cools. This counter-flow arrangement is therefore the most efficient thermal design.





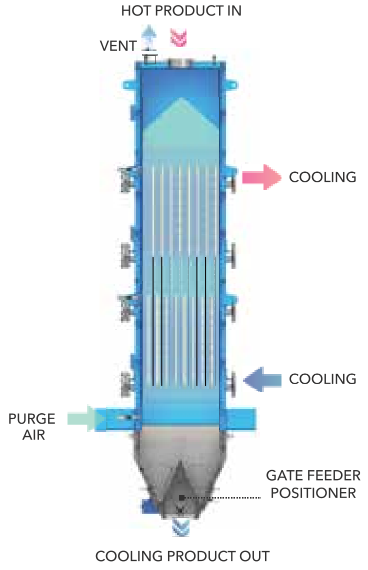
3 Tempered Water Module

The Fluid Temperature Control Module (FTCM) provides three important benefits:

(a) It controls cooling water temperatures to the Exchanger. This ensures the desired water temperature profile is maintained under different operating conditions.

(b) It provides stable product discharge temperatures for storage. Consistent storage temperatures have been shown to improve product quality. Thermal gradients will occur if the cooling water temperature and resulting fertilizer product temperatures are not controlled. When controlled, this prevents moisture migration in the stockpile resulting in improved product quality.

(c) It includes a Start-up Heater to preheat the plates on plant start-up.



Water temperature must be to the right of the dew point line to avoid condensation.

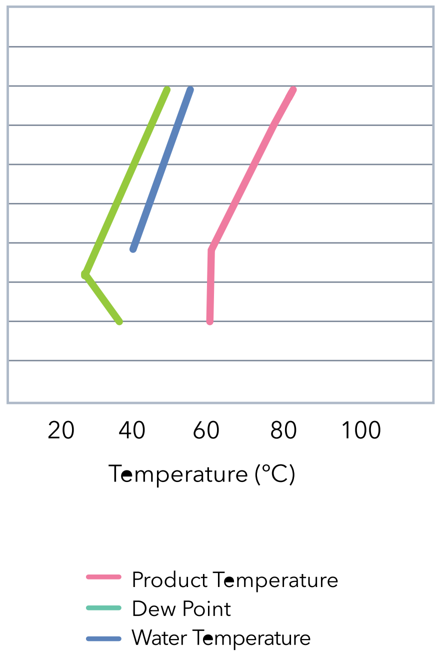
4 The Conditioned Purge Air Module

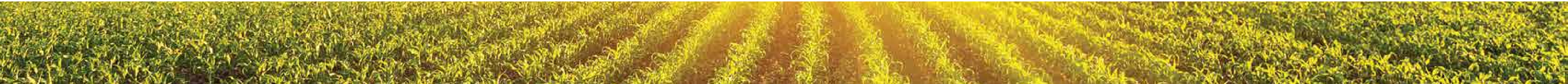
To improve heat transfer efficiency, Solex uses a low volume of purge air. The purge air helps to lower the dewpoint of the air in the void space which means that lower cooling water temperatures can be used. Solex uses accurate modeling software to determine the optimum purge air flowrate and dewpoint. Diagram D shows the product temperature, water temperature and purge air dewpoint through the exchanger, illustrating that the water temperature remains above the dewpoint of the purge air.

5 Comprehensive Instrumentation & Control

Comprehensive instrumentation is provided to control the integrated operation of the fertilizer exchanger, Fluid Temperature Control Module, and Conditioned Purge Air Module. This provides the necessary information for the critical process parameters of temperatures and flowrates of all major streams.

Diagram D

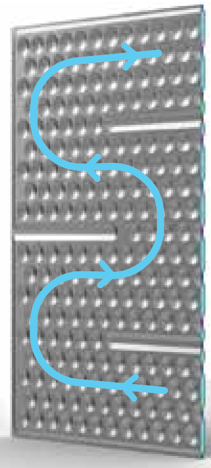




Eliminates Product Caking at the Plates Surface and Heat Exchanger Casing by:

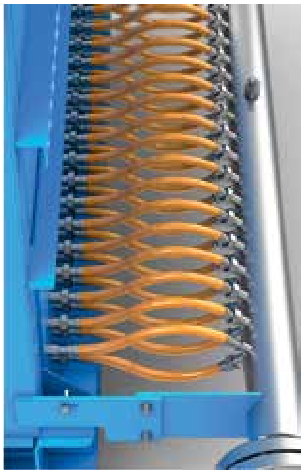
- thermal fluid temperature and flowrate calculations
- calculations of product dew point
- using water module to control thermal fluid temperature and flowrate
- targeted injection of small amounts of purge air
- heat exchanger design prevents product agglomeration

A key feature of Solex heat exchangers is the combination of a serpentine, counter-flow circulation of heat transfer fluid with patented 'shifting' of heat exchange plates, which provide unmatched conductive heat transfer rates. The resulting temperature profile within the exchanger compliments our condensation control system, enabling condensation-free operation of the exchanger.

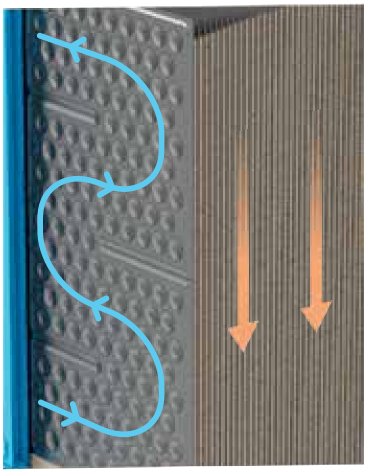


Pic.1 Heat transfer fluid circulation pattern

Pic.2 Shifted heat exchange plates



Pic.3 External hose connections



Pic.4 Counter-flow heat transfer fluid circulation

Guaranteed Final Product Temperature

Solex uses proprietary thermal modelling software to provide a dynamic model of the heat transfer process to accurately calculate product temperatures at any given point within the cross-section of the heat exchanger. The mathematical model has been verified via correlation with results from operating equipment in the field.

Heat Exchanger Design Allows for Thermal Expansion and Simple Maintenance Access (pic.3)

- Flexible stainless-steel hoses allow heat exchange plates to "move" within thermal expansion limits
- All connections are located on the outside of the heat exchanger and easily accessible for maintenance

Heat Exchange Plates – "Shift" (Pic.2)

Patent application US20180347918A1. Method of shifting thermal plates that improves thermal transfer – and subsequently heat transfer – by 20%, resulting in more compact design of the heat exchanger.

SOLEX INDIRECT COOLING TECHNOLOGY

Solex & Controlled Product Flow
Bulk solids pass slowly downward between a series of vertical hollow heat exchanger plates.

Indirect Plate Cooling
Cooling water flows through the plates to cool the material by conduction.

Mass Flow Technology
The mass flow discharge feeder creates uniform product velocity through the cooler and regulates the product flow rate.

Technology for Cooling Fertilizer That Uses 90% Less Energy

	Fluid Bed Cooler	Solex Cooler
Electrical Fan Power	400 kW	–
Electrical Pump Power	–	25kW
Bucket Elevator Power	–	20 kW
Total Power Consumption	400 kW	45 kW
Operating Hours / Years	8000 hrs	8000 hrs
Total Energy Cost / Year ($0.05/kWh)	$160,000 / Yr	$18,000 / Yr