FIELD REPORT
„Hygroscopic bulk solids“, example urea

Problem-free storage, pneumatic conveying and dosing of hygroscopic bulk solids, using the example of urea

Due to its strong ability of absorbing and bonding water urea is classified as highly hygroscopic. Urea is a significant nitrogen fertiliser and is used industrially as binder in insulating boards or flake boards for example. Recently it’s used for the reduction of nitrogen oxides in power station-exhausts or when using substitute fuel in the cement industry for instance. After combustion engines urea is injected as solution in the hot exhaust gas flow, where it reduces nitrogen oxides in the downstreamed catalyser.

30 years ago the storage in bigger bins (silos) has been considered as risky. Clumping and incrustation up to block construction have been known and dreaded. The opinion that storage of urea in silos –especially in metallic external-silos– would be impossible, has been widely propagated.

After a thorough analysis of the parameters, in year 1978 the solids solutions group built the first metallic external-silos for urea and granulated sugar, in each case with pneumatic conveying and dosing. The precautions, which have been implemented at that time, led to a trouble-free operation and are valid until today. Also at such exposed places as direct closeness to the sea (high relative humidity) or in areas with immense day/night differences, this solution proved its worth.

Delivery in silo truck or bulk-container for pneumatic emptying

During the delivery in an airproof closed silo vehicle or bulk-container the hygroscopic product is in humidity balance with the circumfluent air. The water vapour pressure at the surface of the bulk solid-particle is equal to the water vapour pressure of the circumfluent air. The balancing happened during the storage period in the according airproof bin. In this status urea is stable and fluid. Now, the temperature of the dried compressed air used for the pneumatic conveying, has to come up approximately to the product temperature. For products, which are susceptible to abrasion, the solids Truck Discharge System according to the solids PULS-PNEU-technique proved itself.

PULS-PNEU® Conveying System

At the exit of the discharge vessel the continuous material column is divided into air pockets and material plugs by means of compressed air pulses (vide diagram). The air pockets act as energy sources for shifting the material plugs which are ahead of them. In the conveying line, so-called relaystations are mounted, which keep the plugs separated. These relaystations are fed with compressed air from a secondary line and are equipped with a control, which serves to automatically admit additional pressure energy into the conveying line, but only when and where it is required. Thus, blocking of the transport system is practically impossible.

The application of relaystations also serves to ensure the renewed start-up of the conveying process, after a stop caused by current or compressed air failure, in which case the conveyor line could be completely filled with material. Every relaystation in this case acts as a small emitter or dispatch vessel, the last one in the transport direction starting first of course.
The deciding condition for the preservation of the rippling and flowing ability of hygroscopic products in storage-, conveying- and dosing-systems is a closed system, which assures, that under no circumstances humidity gets into the product.

Steel-, stainless steel- and aluminium silos have proven themselves. If it’s accepted, GRP-silos are preferred, because fibre-glass reinforced polyester has a more than x150 less heat conductivity than steel and therefore in most cases special sun protection or insulation isn´t needed.

For secure extraction in mass flow the vibration bin discharger solids Extra-Vib has proven its worth thousandfold. Powered by one vibration motor - or for bigger devices by two motors- it’s put into horizontal vibrations, which transmit themselves on the particle-collective. The particles of the goods in bulk are rushed, they meet and separate themselves. Thereby the bulk solids become capable of flowing. In case of right dimensioning, mass flow is occuring in the silo without dead zones and with steady material movement over the whole silo section, as condition for segregation-free discharge. Even challenging, cohesive bulk solids are discharged securely. Due to the special shaping, grain distruction is avoided and abrasion and wearing are minimised.
For hygroscopic products, which tend to build agglomerates, clumps or crustifications, an integrated vibration grating is used. It dissolves agglomerates and breaks clumps and crustifications on such a size, that downstream devices aren’t affected in their function.

**Different types of vibration bin dischargers**

Consistent material movement in the whole silo with mass flow instead of piston flow

Breaking of clumbs and agglomerates with integrated vibration grating

Downstream dosing units, like dosing screws for instance, are completely closed as well and are flushed to the following process with dry air depending on the receiving station.

**Delivery in Big-Bags**

As well during the delivery in big-bags it is assumed, that there will be humidity balance between the product and the circumfluent air, i.e. the situation is stable and remains it, if it’s not disturbed by humidity- or temperature-influence. Hardenings by external forces rather clumpings are common. Vibration bins and tumbling devices have proven themselves as discharge units. The condition „No humidity inflow by atmospheric air“ demands special attention at this system. During the big-bag-exchange at least partially occurs an open system with inflow of atmospheric air. By systematic superposition with dry air this situation is mastered as well.

**In the vibration charger with integrated cutters crushed, massive block**

In case of block construction inside the big-bag, it is assumed, that in packaged condition, for instance, internal humidity of the grains moved to the grain-surface and humidified it. Therefore it is formed grain bond, which becomes encrusted. Another possibility is, that dry granulate has been humidified by the inflow of atmospheric air and the feeded humidity has been sufficient, to humidify the grain-surface. This in turn leads to bond. Is humidity then moving forward to the internal of the grain, it dries on the surface and the junction becomes encrusted. Especially risky are fines between the grains, because in wet condition they become extensive “glue”. Such a block can be astonishingly massive.
Industrial production of urea

A completely different situation arises in regard to the industrial production of urea. Intermediate storage in silos with hundreds tonnes of capacity are required. Urea, which initially incurred in a solution, is transformed into granulate. So-called „prilled“ urea develops in the form of pellets with a couple of millimeters diameter. Not before the single granulate grain has hard-dried, humidity balance with the circumfluent air is able to arise. This would be the precondition for a finalised physico-chemical process and therefore stability. To destroy bondings between the granulate grains consistently, urea has to be kept in motion until the occurrence of this stability.

For the intermediate storage in silos applies the device to keep the whole stored volume, in mass flow without any dead zones, in motion, or to consistently extract in mass flow a relatively small partial quantity in short time-lags and if necessary to recirculate it. Given that the mass flow for this recirculation should understandably be kept relatively small, it is difficult to set the whole stored mass in motion. For such a task the solids solutions group has recently delivered the biggest ever constructed vibration bin discharger solids Extra-Vib.

It is installed for silos with 12 m diameter.

As emptying device for such „One-block big-bags“ the vibration bin discharger with integrated cutters has proven itself. The „one-block big-bag“ is put on the top of the cutters. The cutters penetrate the block like bits by using vibrations and saw it up. The favoured grain size is generated by a downstreamed lump breaker. In this condition the product is stable again and remains it, if it isn’t destroyed by inflow of humidity again.

30 years of experience and hundreds from our customers trouble-free operated silo installations for hygroscopic products, amongst others urea, sugar, salt, soda, detergent and many others, prove the competence of the solids solutions group for such tasks.