



Knowledge grows

From Factory to Field



Properties and Handling of Yara Fertilizers



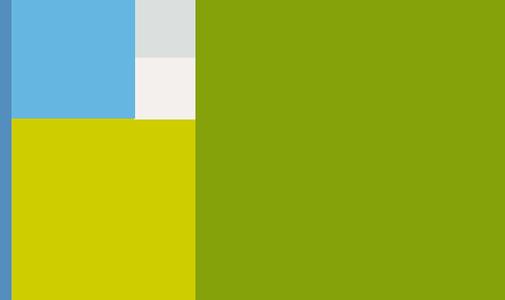
YaraMila
 Tyypin: 14N-lannoite 20-2-12, Pellon 4
 Ravinnonainosa
 Ravinnonainosa pitoisuus: 20%
 Kalsium (Ca) 2%
 Ammoniumtyppi (NH₄-N) 12%
 Fosforityppi (P₂O₅-N) 12%
 Kalsium (Ca) 2%
 Kalsium (Ca) 2%
 Magnesium (Mg) 0,4%
 Sotia (S) 2%
 Boron (B) 0,02%
 Sinkki (Zn) 0,02%

Nettopaino: 500 kg
Yhteispaino: Yara Suomi Oy, PL 80, 01811 Raisio, Akkerimäen, Suomi

MUUT OMINAISUUDET: Lannoite on rikastettu...
KÄYTTÖ: Kasvi...
PURKAUS- JA LAATITUKSET: Yara Suomi...
VAROITUS: Yara Suomi...
 Yara Suomi Oy, puh. 010 215 111



Introduction



Yara International produces high quality fertilizer products from a variety of raw materials by different production technologies. Compliance with international legislation and Yara's internal technical standards ensure a high focus on product and process safety as well as protection of personnel and environment by implemented best available techniques.

The Yara product portfolio is broad to fit market requirements. This includes straight nitrogen fertilizers, as well as composite NPK products.

Yara has adopted the Fertilizers Europe and International Fertilizer Association's Product Stewardship program that aims to:

- Take responsibility for the product through the value chain from raw material to use.
- Meet the public demands for openness and communication.
- Share experiences and knowledge.

- Provide a good structure for setting up Product Stewardship on company level.

The standards should be applied throughout the whole handling chain, thus ensuring that every person involved is trained and equipped to follow best practice handling procedures in order to maintain the high quality of Yara fertilizers from the Factory to the Field.

This brochure aims to give best practice advice to people working in the supply chain. More extensive information can be found in the Fertilizers Europe leaflet 'Guidance for the Storage, Handling and Transportation of Solid Mineral Fertilizers' (www.fertilizerseurope.com).

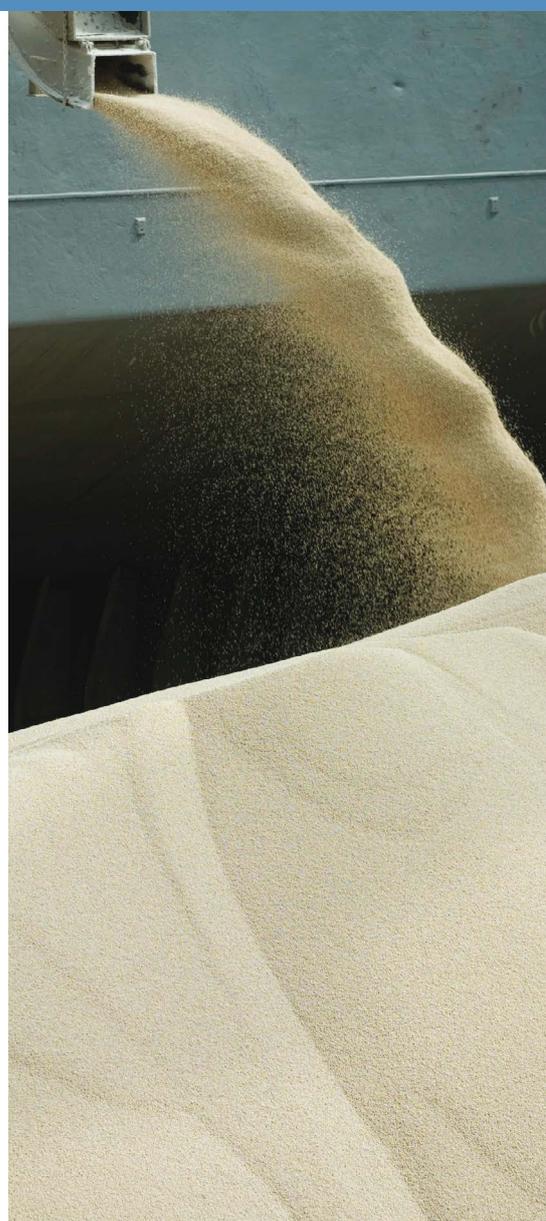
Yara's knowledge, products and solutions grow farmers and industrial customers' businesses profitably and responsibly, while nurturing and protecting the earth's resources, food and environment.

Our fertilizers, crop nutrition programs and technologies increase yields, improve product quality, and reduce environmental impact from agricultural practices. Our industrial and environmental solutions reduce emissions and improve air quality from industry and transportation, and serve as key ingredients in the production of a wide range of goods.

Founded in 1905 to solve emerging famine in Europe, Yara today has a worldwide presence with more than 12,000 employees and sales to more than 150 countries.

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Yara Fertilizer Product Ranges

YaraBela®

The YaraBela® nitrogen fertilizer range is a proven solution for the crops fertilization; products that have been tried, tested and proven over many years across a range of crops worldwide.

YaraBela nitrate based fertilizers, are pure nutrients, offering the required precision efficiency and reliability to meet the agronomic and environmental imperatives of modern agriculture. Our products are of superior quality with a balanced supply of nitrate and ammonium. More importantly, the products are easy to handle and can be applied to a wide range of crops. YaraBela fertilizers are commonly used as dry applications on large-scale field crops.



YaraLiva®

YaraLiva® fertilizers are a comprehensive range of calcium nitrates that help ensure high-value, highly marketable produce. They provide fast-acting nitrate-N, alongside strength-building calcium and boron. In combination, these nutrients fuel prolonged growth. Plants and trees treated with YaraLiva -branded fertilizers are naturally healthier and less sensitive to stress during growth. Then, critically, in the build-up to harvest, YaraLiva fertilizers improve the size, strength and appearance of the fruit, tuber, leaf or lettuce.

The end result is blemish-free produce that will store longer and which is less susceptible to damage, disease or rotting and are visibly more desirable, colorful, fresher and highly nutritious.



YaraMila®

YaraMila® is a range of compound fertilizers with a combination of nitrogen, phosphorus and potassium (NPK) - the most essential plant nutrients - which help to maximize crop yield and quality. Each YaraMila compound, whether in prill or granule form, is designed to meet specific crop requirements.

Some YaraMila formulations also contain secondary and micronutrients essential for specific crops. These may include magnesium (Mg), sulfur (S), boron (B), iron (Fe), manganese (Mn), molybdenum (Mo), and/or zinc (Zn). These formulations benefit the grower because they provide even distribution of nutrients, whether spread by hand or machine. There is no risk of nutrient segregation during shipping, handling or spreading.





YaraVita®

The range of fertilizers specifically developed for application of micronutrients to the soil, through fertigation systems, by foliar spray, and as seed treatment is called YaraVita®.

Every product is designed and formulated specifically for use in agriculture and horticulture. The YaraVita formulations deliver a specific nutrient or nutrient mix exactly when and where the crop needs it, boosting crop performance. This includes accurately applied and essential doses of micronutrients either as straight products or combinations. It also includes formulations that back up supplies of major or secondary nutrients during periods when they are unavailable from other sources.



YaraVera®

YaraVera is the global brand name for Yara's value-added urea-based product range, spanning both pure and upgraded/diversified urea products.

“Vera” is derived from the Old Norse word “vekra,” which means “to enliven or invigorate.”

YaraVera nitrogen fertilizers are cost-effective, highly concentrated and highly efficient sources of urea. With a nitrogen concentration of 46 percent, YaraVera fertilizers ensure strong, sustained growth over a prolonged period through efficient nutrient release.

They can be applied to the soil as solid granules, in solution or to certain crops as a foliar spray. When properly applied, YaraVera fertilizers support optimum-efficiency plant growth leading to some of the highest yields possible. YaraVera's superior quality and highly concentrated form also help to reduce handling, storage and transportation costs.



Physical Properties of Fertilizers



The quality of fertilizers at the end user is influenced by:

- The product portfolio handled
- The impact of the climate
- The logistical supply chain
- The correct handling of fertilizers

A product's physical properties are determined by its chemical composition and the specific production process.

The most important properties for handling, storage and spreading are:

- Hygroscopicity
- Caking
- Particle shape and size distribution
- Particle strength and mechanical resistance
- Segregation
- Tendency to generate dust and fines
- Bulk density
- Angle of repose
- Compatibility (chemical and physical)

Coating is important for preserving the quality of products by protecting these against moisture uptake and physical damage under handling.

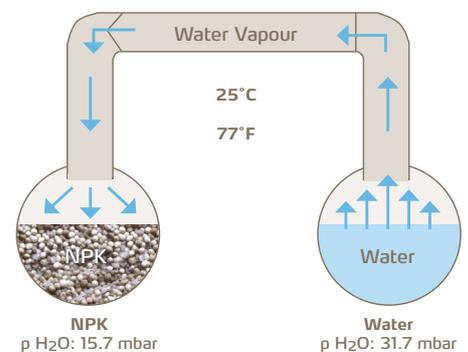
Hygroscopicity

Air contains moisture as water vapour and therefore exerts a water vapour pressure (p_{H_2O}) that is determined by humidity and temperature. Hot air can contain more water than cold air. The water content is expressed by the relative humidity (RH).

When the air is saturated with water vapour the relative humidity is 100 % and 50 % RH if half saturated.

Water vapour will move from both high to low water vapour pressure.

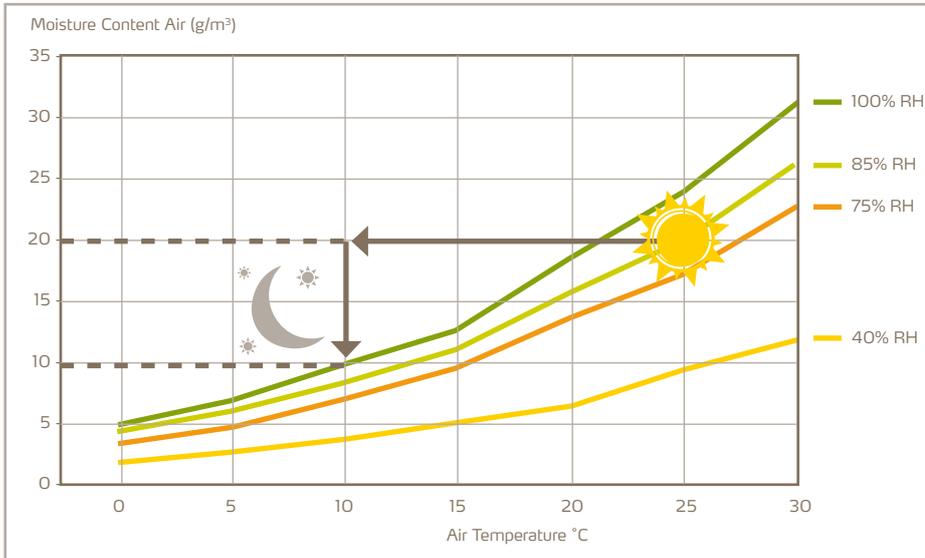
At 30 °C the air can contain 30.4 g of water per m³ (100 % RH).



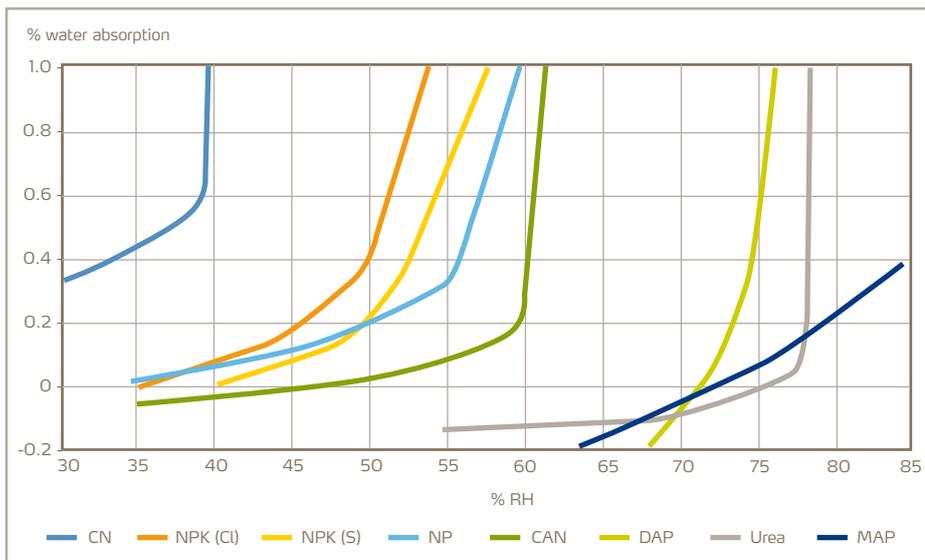
The water vapour pressure of the air varies with humidity and temperature of the air. Under tropical/summer conditions condensation may occur. **This has an impact on quality of unprotected fertilizer stored in bulk.**



Cooling Down from 25°C (day) to 10°C (night) Results in Condensation of 10 gram water/m³ air



Critical Relative Humidity of Fertilizers at 25°C



Hygroscopicity is an important property enabling prills and granules to dissolve quickly in the soil and thus supply nutrients readily to the plants after fertilizer application.

All fertilizers are more or less hygroscopic which means that they start absorbing moisture at a specific humidity or at a certain water vapour pressure.

Some very hygroscopic fertilizers attract moisture much more readily and at lower humidity than others. Water absorption takes place if the water vapour pressure of the air exceeds the water vapour pressure of the fertilizer.

Absorption of moisture during storage and handling will reduce the physical quality. Knowing at which humidity the grades start to absorb large quantities of water is very important.

By knowing the air temperature and humidity and the surface temperature of the fertilizer, it can be determined if water absorption will take place or not.

Typically, a water absorption curve ascends slowly at low humidity (as illustrated), but at a certain humidity or humidity range it starts to increase steeply. This humidity is called the critical humidity of the fertilizer. The critical relative humidity goes down when the temperature increases.

Significant water uptake has undesirable consequences on fertilizer products:

- Particles gradually become soft and sticky.
- Caking tendency increases.
- Formation of dust and fines increases.
- Warehouse floors become damp and slippery.
- Reduction of thermostability of stabilized straight AN.
- Quality of spreading can be affected.
- Increased risk on hampering operations, such as bagging.

Caking

During storage, fertilizers may show caking tendency. Such caking arises due to the formation of strong crystal bridges and adhesive forces between granules.



Severely caked fertilizer

Several mechanisms can be involved; those of most importance seem to be:

- Chemical reactions in the finished product that may affect physical properties of the fertilizer.
- Dissolution and re-crystallization of fertilizer salts on the particle surface.
- Adhesive and capillary forces between surfaces.

Caking is affected by several factors:

- Air humidity
- Temperature and ambient pressure
- Moisture content of the product
- Particle strength and shape
- Chemical composition

Caking tendency remains low if the parameters above are controlled. In addition, application of an appropriate anti caking agent is often needed.

Yara products normally have very low caking tendency, provided that absorption of moisture is avoided, and therefore products require protection against high humidity. This can be done by sheeting (bulk) or by bagging.



Distintegrated fertilizer due to water absorption



Crystal bridges between fertilizer particles cause caking

Particle surface, shape and size

Prills have a smooth and glassy surface, whereas the surface of the granules can vary a lot; normally granules are more rough and uneven than prills. The colour of the particle surface can vary according to raw materials applied in the process or due to inorganic or organic pigments added to colour the particles.

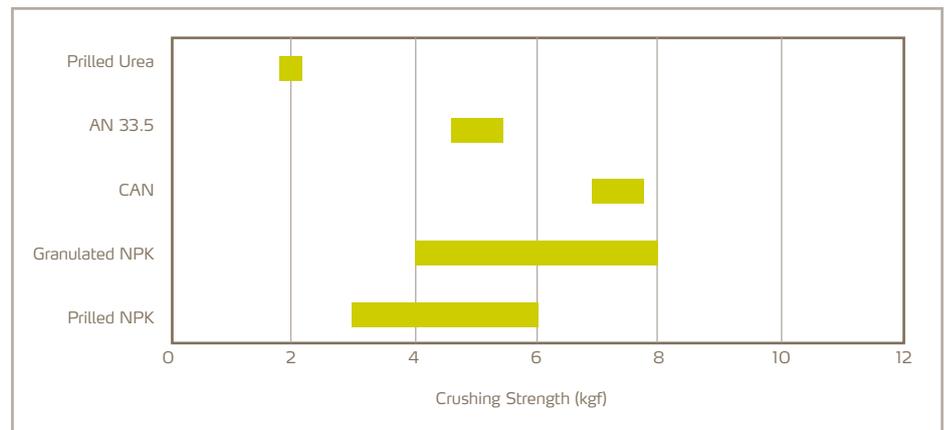
Prills have a broad size distribution, but are usually smaller than granules. Both types of products can be evenly spread in the field given a correctly calibrated spreader.

Particle strength and mechanical resistance

Crushing strength of fertilizers

The crushing strength of fertilizer particles differs greatly depending on the chemical composition and production process. Crushing strength measured for various fertilizer types is illustrated below. Please note that high-N NPK's show lower crushing strength than NPK's with high content of salts.

Crushing Strength of Fertilizers



Water absorption has negative effect on most fertilizers. Particles can become sticky or tend to disintegrate.

Mechanical resistance is the ability of the fertilizer to resist the stresses imposed upon them in the handling chain. The mechanical resistance depends on surface structure and particle strength.

Provided correct handling, fertilizers produced by Yara have high crushing strength and good mechanical resistance.

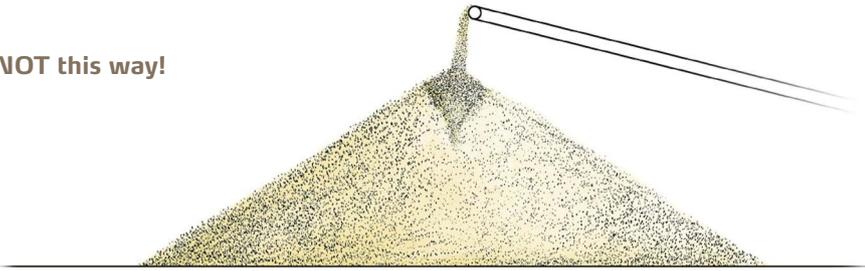
Segregation

Fertilizers consist of particles of varying size. When in motion or vibrated, the smaller and larger particles tend to separate - the fertilizer segregates.

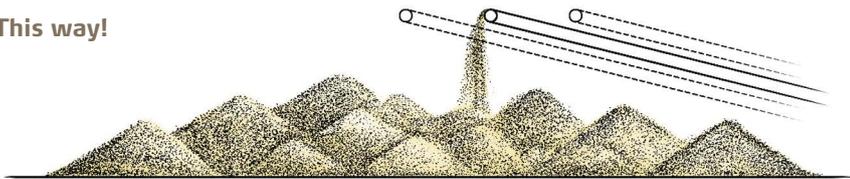
This phenomenon can take place in the entire distribution system and especially when the material is piled in big heaps. The smaller particles will be enriched in the centre of the pile. It is advisable to build up heaps by using many small ones and to ensure good mixing during reclaiming.

Minimising Segregation in a Pile

NOT this way!

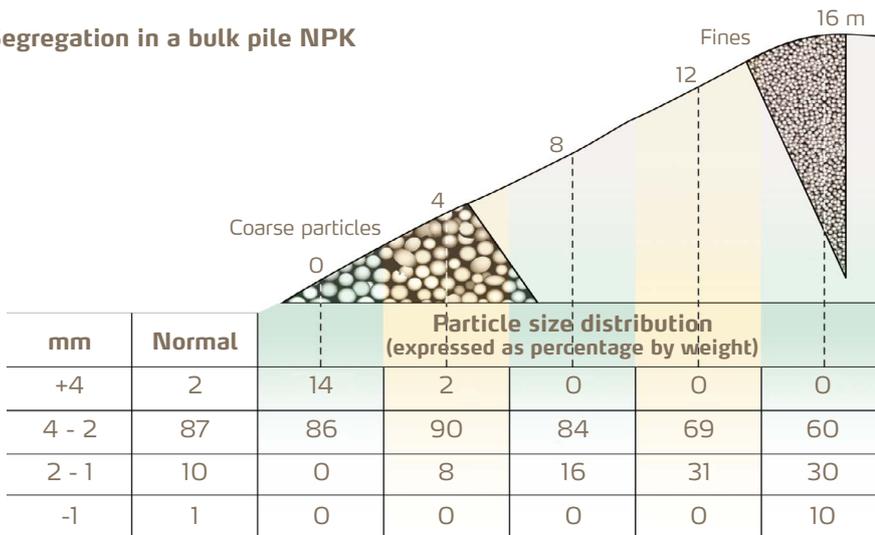


This way!



Segregation should be minimised through correct handling in order to avoid that a changing particle size distribution would induce deviating properties of the product.

Segregation in a bulk pile NPK



Segregation does not affect the distribution of nutrients in compound fertilizers produced by Yara, since each particle contains the declared content of nutrients.



Good practice: moving the tipper to avoid segregation

Dust Formation

Large amounts of fertilizer dust may cause discomfort in the work place. Therefore, in most countries dust emission from handling operations is restricted by law; as it can have a negative impact on health and on the environment.



Excessive dust during loading vessel



Loading dust free fertilizer

Dust and fines normally arise during handling from:

- Water absorption.
- Poor surface structure and particle strength.
- Low mechanical resistance.
- Mechanical stresses in the handling chain.
- Wear and tear from equipment (scrapers, screw feeders, grain trimmers etc).

Yara products have high mechanical resistance and have coating systems that suppress dust formation. Dust can still be experienced occasionally, mainly due to water absorption and abrasion in the supply chain.

Bulk Density

Bulk density or volume weight (kg/m³) differs between products. Variations in particle distribution due to segregation will influence the bulk density. For mechanical spreading it is important that variations within a specific product are minimal.

Urea	750 kg/m ³
Straight AN 35%N	1000 kg/m ³
CAN 27%N	1050 kg/m ³
NPK 15-15-15	1100 kg/m ³
CN Tropicote	1120 kg/m ³

Correct handling will minimize variation in bulk density for Yara fertilizers.

Angle of repose:

The angle of repose is the steepest angle of descent related to the horizontal plane to which solid fertilisers can be piled without slumping or sliding.



Compatibility

Compatibility primarily relates to blending of different fertilizers and cross-contamination in handling. If not taken into account, this may lead to problems in quality and/or safety; e.g. caking, weakening, dust formation and loss of resistance to thermal cycling in the case of ammonium nitrate.



Blended fertilizer

For quality reasons, Yara highly recommends not to mix same products from different origins. This is also valid to ensure traceability of the product in the supply chain.

Yara advises not to store non-compatible bulk products in adjacent storage space. Also take local legislation into account for specific storage requirements.

Fertilizer	Product	Static Angle of repose (EN)	Dynamic Angle of repose (IMO)
NPK	Granulated	32° - 35°	36° - 38°
NPK	Prilled	30° - 32°	32° - 34°
CN	Granulated	37° - 38°	40° - 41°
CAN	Granulated	29° - 30°	33° - 35°

Compatibility of Various Solid Inorganic Fertilizers

	Ammonium Nitrate	Calcium Ammonium Nitrate	Calcium nitrate (fertilizer grade)	Ammonium Sulphate nitrate	Potassium Nitrate / Sodium nitrate	Ammonium sulphate	Urea	Rock Phosphate	Partially acidulated rock phosphate	Single/Triple super phosphate	Monoammonium phosphate	Diammonium phosphate	Mono potassium phosphate	Potassium chloride	Potassium sulphate/magnesium sulphate (kieserite)	NPK, NP, NK (AN based)	NPK, NP, NK (Urea based)	Limestone/dolomite/Calcium sulphate/Calcium carbonate	Sulphur (elemental)
Ammonium Nitrate							NC										NC		NC
Calcium Ammonium Nitrate							NC										NC		NC
Calcium nitrate (fertilizer grade)																			
Ammonium Sulphate nitrate							NC										NC		NC
Potassium Nitrate / Sodium nitrate																			NC
Ammonium sulphate																			
Urea	NC	NC		NC												NC			
Rock Phosphate																			
Partially acidulated rock phosphate																			
Single/Triple super phosphate																			
Monoammonium phosphate																			
Diammonium phosphate																			
Mono potassium phosphate																			
Potassium chloride																			
Potassium sulphate/magnesium sulphate (kieserite)																			
NPK, NP, NK (AN based)							NC										NC		NC
NPK, NP, NK (Urea based)	NC	NC		NC													NC		
Limestone/dolomite/Calcium sulphate/Calcium carbonate																			
Sulphur (elemental)	NC	NC		NC	NC												NC		

Source: Fertilizers Europe

- Compatible
- Limited compatibility linked to quality issues
- Limited compatibility related to safety or regulatory issues
- NC Not Compatible

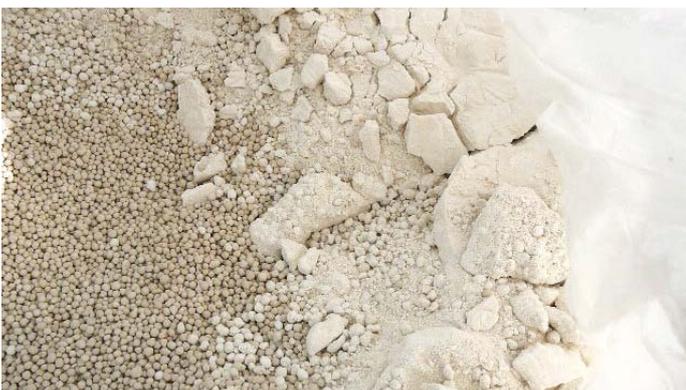
Some Don't's



Avoid use of grain trimmers; fines formation will occur due to impact.



Keep doors closed and remove spilled material immediately.



Avoid storing bagged AN-based fertilizers outdoors during the summer season; risk of thermal cycling leading to dust formation.

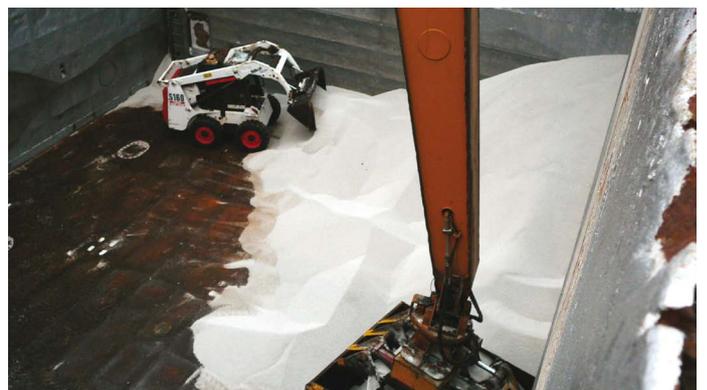
Some Do's



Insulation of roof and correct sheeting prevents condensation and water uptake.



Moving regularly the tipper will avoid excessive segregation of the product.



Correct bobcat driving during discharge operations avoids formation of extra fines and dust.

Yara Technology



Coating Systems

Yara Technology Centre has developed efficient coatings for the various grades to substantially:

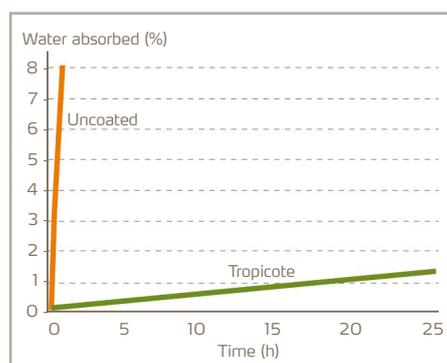
- Reduce water absorption when exposed to humid air.
- Reduce caking tendency.
- Reduce dust formation.

In addition, a pigmented coating is often used to give a certain colour to the product.

Most fertilizers are surface treated to obtain all or one of the above-mentioned effects. However, the product must be handled properly to maintain functionality of the coating applied.

Fertilizers containing coating agents are compatible with plants and soil and can be used safely.

Rate of water absorption of CN with and without Tropicote



Yara has developed a unique coating for YaraLiva Calcium Nitrate that efficiently reduces the rate of water absorption.

Anti Caking Agent

Fertilizers and salt products generally tend to agglomerate during transport and storage. This property has been of major concern to fertilizer manufacturers and considerable research has been devoted to solve the problem.

In order to prevent caking, fertilizers are treated with various agents that may include a surface active compound and a fine inert powder. The surface active compound influences crystal formation such that strong bridges are not formed, and the powder reduces the surface contact area.

Preventing Dust Formation

The amount of dust released from fertilizer products depends on several physical properties like particle strength and shape, ways of handling and the coating system applied.

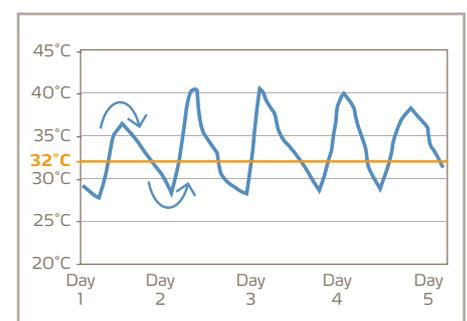
Coating systems developed by Yara can reduce dust release up to 90 % in the bulk handling chain.

Preventing Thermocycling

AN in straight AN fertilizers appears in different stable crystalline forms; changing from one to another is accompanied by volume changes. The transition at 32°C results in density

changes and can cause the product to break down into fines if the product is heated or cooled while passing this temperature. AN 33.5 and some other products high in ammonium nitrate contain stabilizers that minimise thermocycling. However, during long periods of storage these products may still degrade if the conditions for thermocycling are favourable; and consequently lead to generation of off-spec material.

Example of temperature variations in a storage warehouse under summer conditions



Thermal cycling leading to disintegrated product in the top layer of stored product

Handling and Storage of Fertilizers

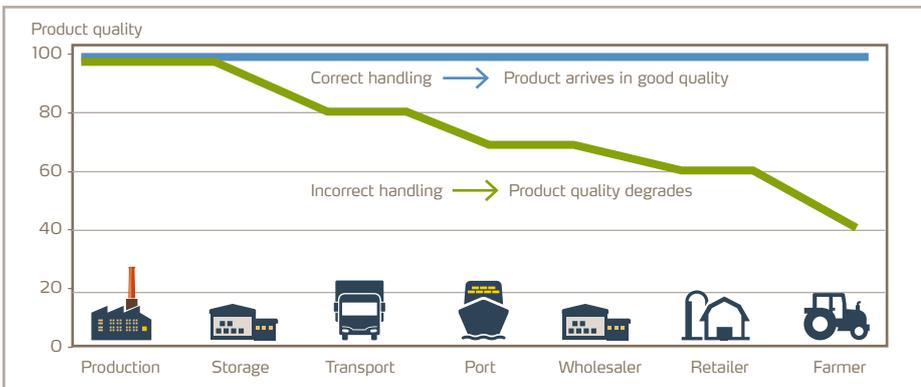


The handling chain exposes the products to multiple steps and mechanical stresses before arriving with the end user. It is crucial that upon delivery the product is of satisfactory quality to be applied readily without affecting its application or subsequently crop yield.

To minimise deterioration in quality and to avoid safety problems in transport, attention should be paid both to the initial fertilizer properties and correct handling procedures. Remember: the weakest link in the supply chain will determine the product quality.

Most Yara fertilizers are handled in bulk. To preserve top quality throughout the entire handling chain it is important to train operators to follow correct handling routines and procedures.

The Handling Chain



Safety and quality inspection of vessels and warehouses

- Vessels shall be inspected according to Yara inspection standards which include international (IMO) quality and safety procedures. Ensure no cross-contamination during transshipments or in the warehouse.
- For measurement of angle of repose: see page 8.
- No electric installation shall come in direct contact with the fertilizer.
- DO NOT SMOKE signs should be displayed and shall be respected.
- Warehouse floor, conveyor belts and equipment must be clean, dry and free of remainders.

- Keep off-specs separated from sound material. Amount of off-specs should be kept at the minimum



Testing for leaks by ULD

Precautionary measures for preserving fertilizer quality

Loading of vessels barges trucks / containers and rail wagons

- Clean, dry holds, free of contamination and loose rust.
- Tight hatch covers, sea-going vessels to be tested by using ULD.
- Repair when the hatch covering is not tight (rubber gaskets, compression bar).
- Treat tank tops with rust remover before loading technical urea and calcium nitrate.
- Cargo should be covered completely with plastic sheeting and fastened with sticks.
- Loading must not occur during precipitation or heavy fog.

- Transport by truck or wagon should be dry, clean, tight and covered.
- Avoid high product drop during loading. Cascade loading spout or conveyor belts are preferred.
- The cargo shall be trimmed according to IMO-regulations (IMSBC-code). If possible, trimming should be restricted to the end of the loading.



Removing damaged product from cargo hold



Trimming of cargo must be done with care

Discharging

- Shore cranes or ship crane equipped with grabs are recommended.
- Inspect the cargo before start of discharge, check the hatch coamings and the cargo surface. If the product is damaged (contamination/water ingress), call for surveyors and inform the master about this decision.
- Ensure that water damaged cargo and contaminants are separated from sound product.
- Do not discharge during precipitation or heavy fog. Close the hatches.
- Do not mix spilled or wet material on the quay or deck of vessel with sound product.
- When cleaning holds, put the bobcat into the hold as soon as a significant area of the tanktop is reached.
- Minimise driving into the product to reduce formation of dust and fines.



Acceptable bobcat driving

Equipment for loading, discharge, storage and transport

- Grabs, hoppers, trucks, conveyor belts and transfer points should be clean and tight.
- Empty the hoppers and conveyor belts before breaks. Clean if necessary.
- Pneumatic conveyors, Redler (chain conveyors), screw feeders are not recommended.



Heavy equipment will crush the product

Bulk storage and handling

- Fertilizers must be stored on clean and dry floors. Traces left on the floor will soon form a solution when exposed to humid air.
- Doors should be tight fitting and other openings closed.
- Bulk walls of wood must be covered with plastic if not impregnated.
- Bulk products should be covered with plastic sheeting immediately after completed discharge.
- Coverings should overlap by at least 0.5 m, and be fastened with sticks.
- When removing product from the pile do not unnecessarily expose the product to air.
- Re-cover immediately when the operation is completed.
- First In – First Out rule should be followed.
- Avoid cross-contamination of product.
- If spillage, sweep and clean immediately.
- Avoid spillage when re-building the pile with a front-end loader; do not overfill shovel, do not drive into the pile.
- If lumps are observed in the pile, it is recommended to sieve on delivery or before dispatch.
- Avoid contact with heat sources.



Cover the fertilizer with plastic sheeting



UNACCEPTABLE driving into pile



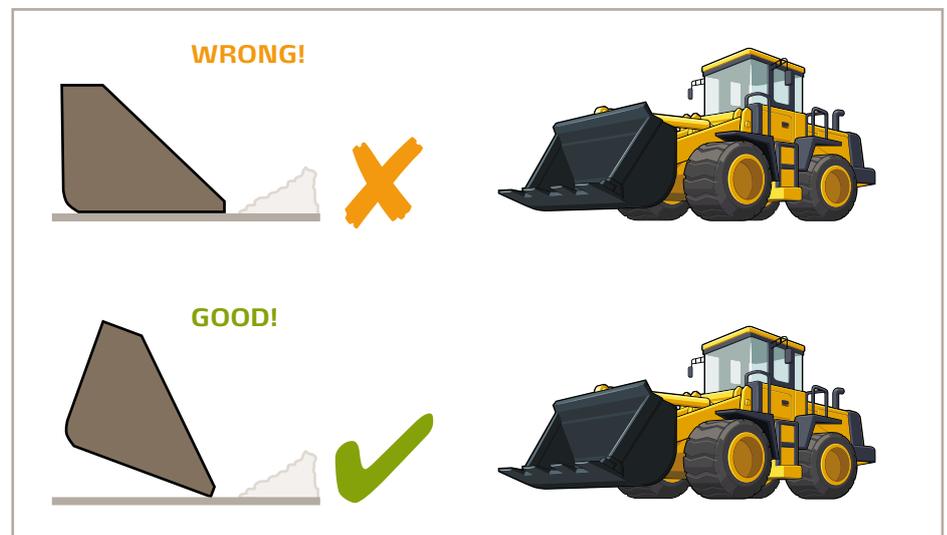
Use the right equipment for piling

Use of payloaders

A payloader is convenient to use when moving bulk material. However, to avoid damaging the material, it is advised that the following precautions are taken:

- Keep a correct angle between the bucket and the floor to minimise crushing. Do not keep it flat.
- Avoid spillage on the floor.
- Do not drive the wheels into the pile.

Correct Angle



On-farm storage

- Keep the fertilizer away from diesel, hay, grain etc.
- Where possible store the fertilizers in an enclosed, secure store.
- If outdoor storage, follow best practice recommendations; see page 16.

Bags and Bagging



Labelling and information

Important information for transport, storage and handling is printed on the bag.



Labeling fertilizer bags

Yara classifies and labels its products according to the UN Globally Harmonized System of Classification and Labeling of Chemicals (GHS), as well as other national regulations. In Europe, GHS is implemented as the Classification, Labelling and Packaging (CLP) Regulation. Transport classification and labeling is according to the UN Model Regulation for the Transport of Dangerous Goods (TDG) and/or other national transport regulations, where appropriate. The TDG regulations take precedence when transporting products by road, rail, inland waterway, sea or air; information printed on the outer packaging will be according to the transport regulation.

Other information printed on bags is in accordance with the chemical regulations, e.g. GHS. Classification according to GHS does not necessarily lead to classification for TDG purposes. Some examples:

Label elements – GHS EU		
Hazard Pictograms	Signal word Hazard statements	Precautionary statements
	Warning <ul style="list-style-type: none"> May intensify fire; oxidizer. Causes serious eye irritation. 	<ul style="list-style-type: none"> Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Store away from combustible materials and chemicals. Wear eye protection IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do so. Continue rinsing If eye irritation persists: Get medical attention In case of fire: Use flooding quantities of water to extinguish
Label elements – TDG		
TDG Pictogram	UN Number	Proper Shipping Name
	UN 2067	AMMONIUM NITRATE BASED FERTILIZER

Ammonium nitrate: YaraBela EXTRAN 33,5

Label elements – GHS EU		
Hazard Pictograms	Signal word Hazard statements	Precautionary statements
	Danger <ul style="list-style-type: none"> Harmful if swallowed. Causes serious eye damage. 	<ul style="list-style-type: none"> Wear protective gloves and eye protection. Do not eat, drink or smoke when using the product. Wash hands thoroughly after handling. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor/physician. IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell. Rinse mouth.
Label elements – TDG		
Not applicable: product is not transport regulated.		

Calcium nitrate: YaraLiva Calcinit

Storage of Bags

The bag print might also give information on how to handle and store the product. The nutrient content in the product is stated on the bag and is according to each country's national regulation. The same information is provided in the transport documents for bulk products. Local sales offices can provide additional information and assistance.

Bag quality

Bags protect against humidity and mechanical stresses. Bags made of polyethylene (PE), polypropylene (PP), or combinations of these materials are available (valve bags, fully "open" bags for melt sealing and stitching).

Bags are made after given specifications:

- Thickness of plastic foil (PE)
- Fabric weight (woven PP)
- Strength and elongation
- Dimension
- Additives like UV stabilizers

UV- stabilization of package material is important in areas with high temperature and solar radiation. For loose bags, Yara recommends using an inner-liner of good PE quality of minimum 70 micron to prevent/reduce moisture uptake.

The bags should be folded in the top and sewn. Alternatively, the inner-liner should be twisted, swan-necked before stitching the outer bag.

- Bags should always be stored on a dry floor, preferably inside a warehouse or on pallets placed on dry ground with good drainage. If stored outside, they should be well covered with plastic or tarpaulin that can withstand bad weather.
- For outside storage, place pallets on top of the covered fertilizer to protect against damage caused by birds to tarpaulin and bags.
- For stability and safety big bags should be stored in the form of a pyramid; preferably not higher than 3 tiers high. Pallets stack height should be not higher than 4-pallets high depending on product, stability of the pallet and handling equipment.
- For markets who deal with loose bags: consider stable stacking and include safety measures such as fall protection



Outdoor storage of bags



Outdoor storage of bags



Outdoor storage of bags

Spreading

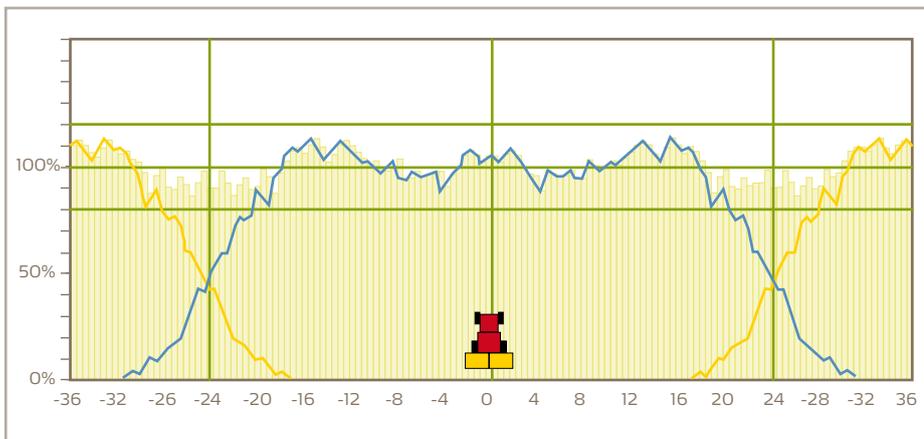


Correct spreader setting

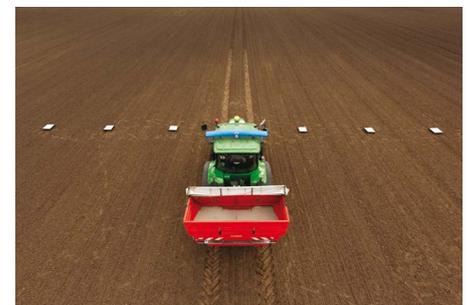
The correct setting of a spreading machine is determined by the physical properties of the fertilizer. Particle size distribution, bulk density and flow rate particularly influence the setting.

On small areas centrifugal spreaders are commonly used at 12 m working width, while both centrifugal and pneumatic spreaders are commonly used for larger working widths, 24-48 m

Overlapping spreading patterns: spreading trial at 48 m working width



Spreading tables from the manufacturers of spreading machines are based on tests under ideal conditions in test stations, and give information on how to set the spreader for optimum even spreading at the desired application rate (kg/ha) and at a specific working width. The settings vary between machines and types of fertilizers. If spreading tables are not available, it is recommended to use field trial equipment to give an estimation of the spreading, although this method is less accurate.



Spreader tray testing

Fertilizers do not harm the environment in case of correct application, but wrong application may cause run-off into waterways that increases uncontrolled growth of algae and contributes to eutrophication. The correct use of spreading machines and proper disposal of spillage and bags will prevent run-off.

Disposal of packaging material

Bags should be emptied by shaking to remove as much as possible of its contents. Empty bags may be disposed of as non-hazardous material or returned for recycling. In tests, bags emptied in this manner show only traces of residues and are considered non-hazardous.

Safety



Legislation

Over the years ammonium nitrate fertilizers have been involved in several accidents that have influenced the legislation of transport, storage and handling.

The international UN 'Recommendations on the Transport of Dangerous Goods' (www.unece.org/trans) is adopted in international fertilizer transport legislation by IMO (shipping), ADR (road), RID (rail), ADN(R) (barges) and IATA (air) regulations.

National and local regulations apply for storage of fertilizers. The SEVESO-directive gives guidance on storage volumes / risk assessment for hazardous products within the EU.

Properties related to safety

AN

AN 33.5 is classified as an oxidizer (Class 5.1) by UN due to its high AN-content. Special regulation for storage is given by National authorities.

Yara ammonium nitrate based fertilizers pass the resistance to detonation test, and have very high resistance to detonation. When a fire involves bagged fertilizer, the bags may melt and break but they will have insignificant effect on the fire. Pallets can allow heat and fire to penetrate into the interior of the stack. Proper

handling and avoiding confinement and contamination (i.e., organic material, trace metals, chloride, acids) minimize any risk in the handling chain. (More information on www.fertilizerseurope.com)

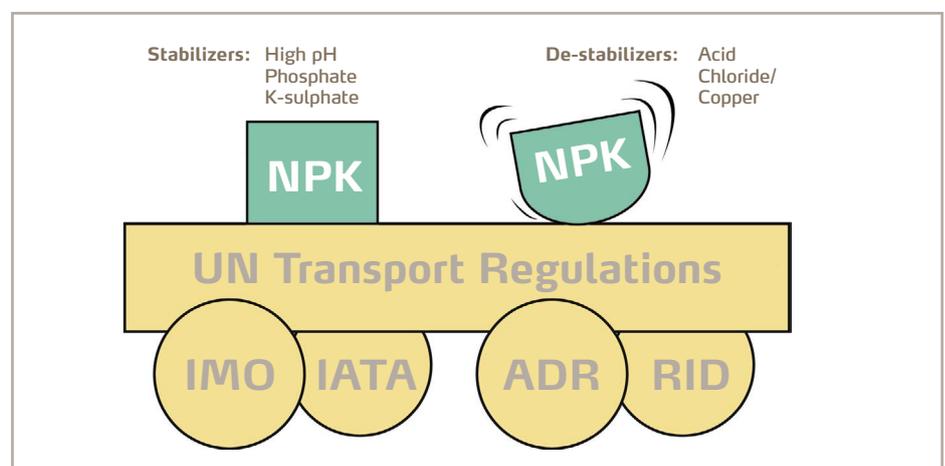
NPK

Ammonium nitrate in NPK- fertilizers can decompose when in contact with a heat source. Exothermic reactions cause evolution of heat and gases from the fertilizer after an initial period with decreasing pH. The rate of decomposition accelerates in the presence of chloride, organic substances and some metal ions – particularly copper (Cu^{2+}). The decomposition is retarded in the presence of phosphate, carbonaceous material and high pH.

Some AN-based NPK-fertilizers exhibit the characteristics of self-sustaining decomposition (SSD). SSD can be initiated by accidental heating ($> 120\text{ }^\circ\text{C}$) over time for some fertilizers, and such decomposition will continue after the heat source has been eliminated. Be aware when decomposition occurs, the fertilizer will release toxic gas containing (e.g. Cl_2 , HCl , NO_x).

All NPK fertilizers containing ammonium nitrate shall be kept away from heat sources.

Safe transport of fertilizers under UN regulations



Prior to placing the fertilizer in storage, the operational personnel must ensure that the storage is clean and free from contamination that can initiate or accelerate decomposition, and that no heat sources (e.g. lamps, electrical cables, conveyors, transport machinery, exhaust outlet) can come in direct contact with the product. Do not overfill the storage area.

Any decomposition must be extinguished with copious amounts of water at the seat of decomposition. Victor lances are recommended to attack the decomposition seat. (Ref.: Appendix 3 of Fertilizers Europe Guidance for storage, handling and transportation of solid mineral fertilizers) Infrared cameras are useful to detect the decomposition area. Allow ventilation and use respiratory protective equipment.

Calcium Nitrate fertilizer

CN fertilizer contains approximately 15 % crystal water that minimises the oxidising properties of the material. Consequently, CN-fertilizer is not classified under international transport regulation as dangerous goods. According to criteria set by EU-legislation Yara does not label the CN fertilizer in the EU or in any other country.



Urea products

Urea-products are not classified as hazardous material according to EC Directive 67/548/EEC and the UN transport regulations, but are potentially dangerous because they can release ammonia if exposed to strong heat. Urea should not be mixed with other chemicals, mixing with Nitric acid may be particularly hazardous.

Handling of spillage and reject material containing Ammonium Nitrate

The warehouse floor should be kept clean and dry by absorbing moisture with. e.g. lavastone powder, sand, limestone, dolomite or phosphate rock.

Sawdust is combustible material and shall never be used for any kind of AN based fertilizer.

Spillage from conveyor belts or from bags should be collected quickly, handled and sold as normal product if free from contamination and meeting the requirements of the fertilizer regulations. If not, the material shall be dissolved or be made inert. If seriously contaminated, product should be treated as a waste material, and hazardous material should be handled according to local legislation. Ref. Fertilizers Europe-guidance.

Security



The fertilizer industry recognizes that nitrogenous fertilizers can be misused as precursors for making improvised explosive devices (IED's). Unfortunately, these IED's happen to be used for terrorist acts. As part of its Product Stewardship engagement, Yara shares the responsibility to help keeping these valuable fertilizers from falling in the wrong hands. Yara has included security-related measures to mitigate these risks.

For example in Europe, it is a legal requirement to report suspicious transactions, as well as significant disappearances and thefts of products, as listed in the Annexes of European Regulation (EU) 98/2013 of 15 January, 2013 on the marketing and use of explosives precursors and its guidelines.

Safe and secure storage of solid fertilizers

As a summary, Yara recommends following safety and security measurements as supported by Fertilizers Europe:

DO

- ✓ Keep a record of what is in storage (ideally a layout plan of the store and materials present).
- ✓ Report to competent authorities any thefts or disappearances.
- ✓ Have key safety information (e.g. safety data sheets) readily available.
- ✓ Train workers in safe handling and emergency response.
- ✓ Segregate, treat and dispose reject fertilizer safely.
- ✓ Display safety warning notices.
- ✓ Maintain good housekeeping practices.
- ✓ Keep access to emergency equipment and escape routes clear.
- ✓ Label fertilizer bags and bins correctly.
- ✓ Maintain segregation between incompatible fertilizers.
- ✓ For maintenance work: get manager's approval and follow correct procedures.
- ✓ Use only approved electrical equipment.
- ✓ Carry out regular safety inspections.

DON'T

- ✗ No entry for unauthorized persons.
- ✗ No heat source in contact with fertilizers.
- ✗ No smoking or use of naked flame.
- ✗ No gas bottles, oil drums, gas and oil tanks, or fuel filling station in the vicinity of fertilizers.
- ✗ No open fires or hot light bulbs close to products.
- ✗ No hot work unless authorized and done under strict control.
- ✗ No parking of vehicles close to product, including refuelling/recharging or maintenance.
- ✗ No contamination of fertilizers with combustible and organic materials, seeds, hay, straw, farm chemicals, oil and grease, acids and alkalis.
- ✗ No use of sawdust for drying wet floors (use inert materials instead).

Glossary

Angle of Repose (dynamic)	-	The angle of slide when tilting a mass of solid fertilizer
Angle of Repose (static)	-	The angle obtained when falling on a horizontal base-plate
Anhydride	-	Chemical salts without crystal water
Bulk density	-	The mass per volume of a material tipped into a container
Caking	-	Agglomeration of particles
Citrate soluble P	-	Phosphate soluble in citric acid (e.g. Ca-phosphate)
Cross-contamination	-	Accidental mixing of products influencing quality and safety
Fertilizers Europe	-	European Fertilizer Manufacturers Association
Exothermic	-	Chemical reactions generating heat
Granulation	-	Particle formation by agglomeration or layering
Granulometric spread	-	The variation in particle size of a product
Hygroscopicity	-	The ability to absorb water from the air
Nitrophosphate	-	Fertiliser process based on dissolution of phosphate rock in nitric acid
Prilling	-	Solidification of melt droplets when falling in cold air
Primary nutrient	-	N, P, K
Relative humidity	-	Humidity relative to max obtainable humidity at spec.temp.
Secondary nutrient	-	Ca, Mg, S
Segregation	-	Separation of particles due to motion or vibration
Straight N	-	Fertilizers containing only N as primary nutrient
Thermocycling	-	Interior crystal lattice changes in AN, usually at 32 °C
Transshipment	-	Transfer of fertilizer between vessels (usually to a barge)
ULD	-	Ultrasound Leak Detector
Water soluble P	-	Phosphate salts soluble in water (e.g. MAP/DAP)
Websites	-	www.fertilizerseurope.com / www.unece.org/trans

For further information contact:
Yara International ASA
Postboks 343, Skøyen
0213 Oslo
Norway
www.yara.com

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About Yara

Yara's knowledge, products and solutions grow farmers', distributors' and industrial customers' businesses profitably and responsibly, while protecting the earth's resources, food and environment.

Our fertilizers, crop nutrition programs and technologies increase yields, improve product quality and reduce the environmental impact of agricultural practices. Our industrial and environmental solutions improve air quality by reducing emissions from industry and transportation, and serve as key ingredients in the production of a wide range of goods. We foster a culture that promotes the safety of our employees, contractors and societies.

Founded in 1905 to solve emerging famine in Europe, today, Yara has a worldwide presence, with close to 13,000 employees and sales to about 160 countries. www.yara.com

