Fertilizer Bin Storage Guidance

FERTILIZER CANADA

2023

Dry Fertilizer Bin Storage Guidance & Best Management Practices

Purpose

This document was developed through the efforts of Fertilizer Canada and our members, including manufacturers, distributors, and retailers of fertilizers. We recognize the need for consistent industry-wide guidance and best management practices for dry fertilizer bin storage to mitigate safety concerns related to storing dry fertilizer products. This document is intended to provide guidance for facilities that store dry fertilizer products in flat-bottom bins or in hopper-bottom bins. Specifically, this document covers best practices for preventing and managing cliffing in dry fertilizer storage bins.

Following consistent voluntary industry best management practices will help raise the bar on safety for Canada's fertilizer industry. The goal is to establish a common set of best management practices for dry fertilizer storage, that, upon adoption at the retail and farm level, will decrease the associated risks with cliffing and cliff management of dry fertilizer.

As an industry association that works to advance the safe, secure, and sustainable use of commercial grade fertilizer, Fertilizer Canada's safety stewardship programming is paramount. *The Dry Fertilizer Bin Storage Guidance & Best Management Practices* document is part of Fertilizer Canada's best-in-class safety stewardship program, Fertilize S.A.F.E. The program works to educate, enable, and empower those in the fertilizer supply chain through the use of industry enforced codes of practice, educational resources, and training tools. Fertilize S.A.F.E. helps define safety and security for all industry players.

Scope

The guidance in this document applies to bulk dry fertilizers (for example, urea, potash, monoammonium phosphate (MAP), and ammonium sulfate (AMS), among others) that are stored in flat-bottom and hopper-bottom storage bins at distribution and retail facilities. This document also applies to on-farm storage, and Section 3 contains additional recommendations specific to on-farm storage considerations. Any bulk dry fertilizer product can cake, cliff, or bridge if the conditions covered in this document exist. This document does not apply to any form of bagged fertilizer storage.

For storage of bulk ammonium nitrate (AN) and calcium ammonium nitrate (CAN), please refer to Fertilizer Canada's Agricultural Ammonium Nitrate (AN) Code of Practice and Calcium Ammonium Nitrate (CAN) Security Code of Practice.

This guidance is intended to support fertilizer distributors, retailers, and users by providing best management practices for preventing dry fertilizer from cliffing during storage as well as best management practices for dislodging cliffed/bridged fertilizer in a safe and effective manner.

How To Use This Document

This document serves two functions as both a guide to best management practices for fertilizer bin storage and as a self-assessment tool that can be used to evaluate a facilities' performance against the recommended best practices. This guidance is voluntary, and Fertilizer Canada encourages our members to consider the practices contained in this document in the context of their particular facilities, locations, and regulatory requirements.

Appendix A contains additional resources on dry fertilizer storage.

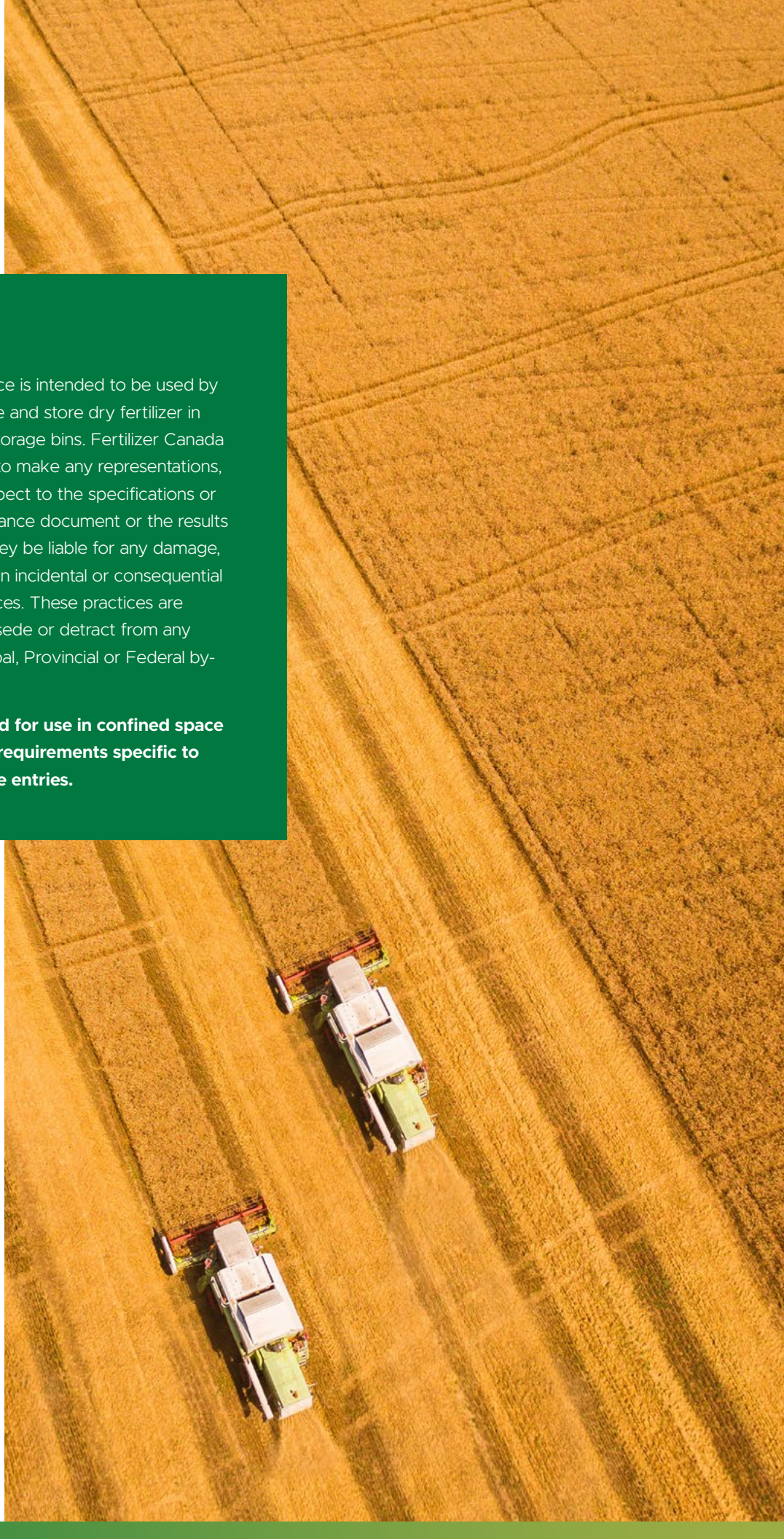
Appendix B and C contain sample Safe Work Permit systems that can be adapted and implemented at retail storage facilities.

Appendix D contains sample Inspection Checklists that can be adapted and implemented at retail storage facilities.

Disclaimer

The Fertilizer Bin Storage Guidance is intended to be used by facilities and operators that handle and store dry fertilizer in flat-bottom and hopper-bottom storage bins. Fertilizer Canada has not made or hereby purport to make any representations, warranties, or covenants with respect to the specifications or information contained in this Guidance document or the results generated by their use, nor will they be liable for any damage, loss or claims, including those of an incidental or consequential nature, arising out of these practices. These practices are not in any way intended to supersede or detract from any requirements contained in Municipal, Provincial or Federal by-laws, regulations or legislation.

These practices are not intended for use in confined space entries. Consult the regulatory requirements specific to your location for confined space entries.



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Definitions

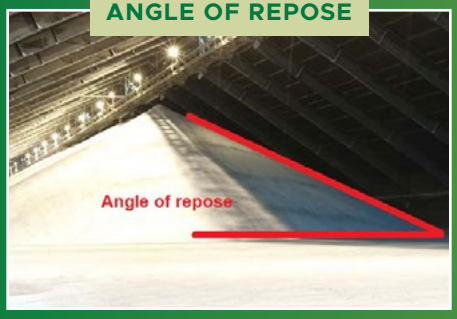
In this document, the terms below are defined as follows:

1. **Angle of repose:** The **static angle of repose** is the angle at which a dry fertilizer pile will stand without collapsing. The **dynamic angle of repose** is the angle at which granular material will move continuously down the pile. The static angle of repose is also referred to in this document as a "safe angle of repose". Both static and dynamic angles of repose can vary based on the product in question. See Appendix E, figure 1 for product-specific angles of repose.
2. **Anti-caking agents:** An additive to dry fertilizers intended to preserve the product quality (e.g. dust management, product flow), enhance storage properties, ensure product safety, and protect product durability for handling and transportation. Moreover, anti-caking agents play a crucial role in the safe storage and handling of dry fertilizers by helping to prevent cliffing or bridging in storage bins.
3. **Bridging:** Bridging occurs when friction stops the product at the wall and a neighboring particle sticks to it. The product then binds to itself until a cohesive arch is formed. Bridging tends to occur more frequently in hopper-bottom bins; however, bridging can also occur in flat-bottom bins.

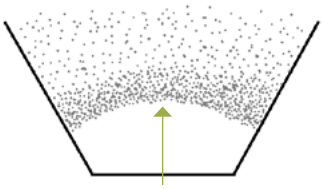
   The same environmental conditions lead to both bridging and cliffing.
4. **Caking:** Describes when fertilizer clumps together into large pieces, sometimes forming cliffs/bridges in storage bins. Caking can be caused by changes in temperature and humidity.
5. **Cliffing:** Steep piles of compacted or caked product are known as cliffs. Cliffs can collapse, potentially causing engulfment of operators or equipment damage.

   The same environmental conditions lead to both cliffing and bridging.

ANGLE OF REPOSE



BRIDGING



CAKING

CLIFFING

FLAT-BOTTOM BIN

HOPPER-BOTTOM BIN

6. **Critical relative humidity:** The relative humidity in the surrounding atmosphere at which a product begins to absorb moisture from the atmosphere. Product will not absorb atmospheric moisture below the product's critical relative humidity. See Appendix E, figure 2 for product-specific critical relative humidity values.
7. **Flat-bottom bin:** While 'flat-bottom' can refer to a number of bin styles, the term is commonly used to describe storage bins or sheds with a flat floor and that are accessible through a side door.
8. **Hopper-bottom bin:** Storage bins with an opening on the bottom to release product. These are often metal silo style bins.
9. **Pile segregation:** Pile segregation can occur in large conical piles as larger particles move down the sides and to the bottom of the pile, while finer particles settle in the middle of the pile.

Common Causes of Fertilizer Caking

Fertilizer caking is a common issue across storage facilities, retailers, and users of dry fertilizer products. In some conditions, caked fertilizer can present serious safety concerns. When caked fertilizer forms a cliff in flat-bottom storage bins, there is a high risk of engulfment of operators if adequate safety measures are not taken when dislodging the cliffed product. Similarly, in hopper-bottom bins, caked fertilizer can form a bridge within the bin, preventing product from flowing freely, requiring dislodgment.

While this list is not exhaustive, caked fertilizer is commonly caused by:

- Moisture in the storage bin, either prior to filling with fertilizer or during storage
- High product temperature upon shipment/delivery
- High levels of fine particulate within the product
- Extended time in storage
- Air temperature and humidity
- Deterioration of inner lining/coating of the storage bin as bins age

Dry fertilizers are often treated with a surface-active coating of an anti-caking compound that reduces caking tendency to ensure the product quality is maintained during transportation, storage, and handling.

Fertilizer manufacturers and facilities storing dry fertilizer should consider taking measures where possible to prevent these common causes of fertilizer caking.

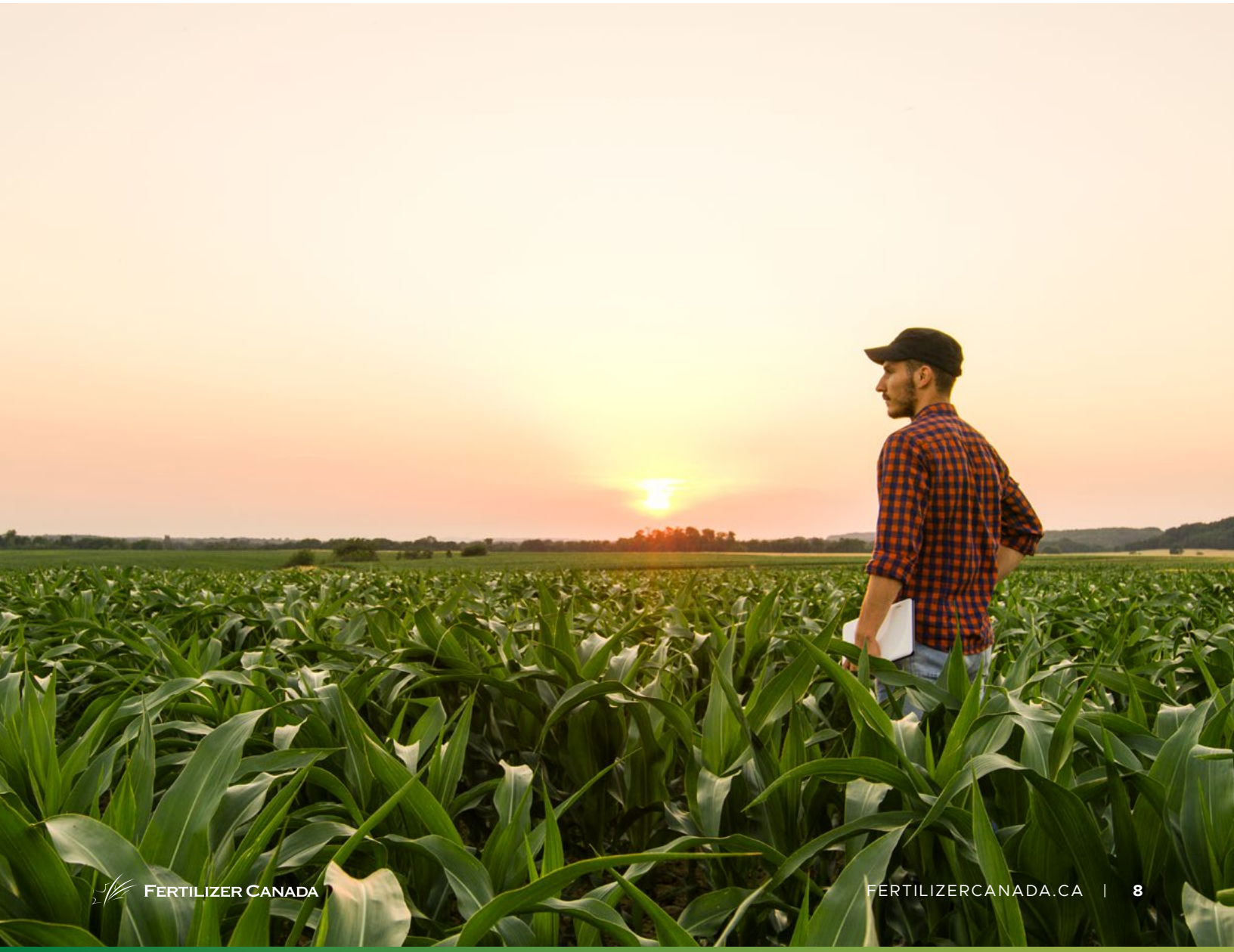
WARNING: Never attempt to dislodge cliffed/bridged fertilizer manually as risk of engulfment is high. Never attempt to dislodge cliffed/bridged fertilizer unless adequate safety measures are in place.

Product-Specific Issues

Any bulk dry fertilizer product can cake, cliff, or bridge if the conditions covered in this document exist. However, some products (e.g., ammonium sulfate, potash, and blended products) are more prone to cliffing and bridging issues than others.

Staff at distribution and retail storage facilities and on-farm product users should always be aware of the common product-specific issues associated with the products stored and handled in their facility.

See Section 1.6 and Appendix F for additional guidance for specific products.



Preventing Cliff/Bridge Development

Section 1 covers measures for preventing caking in dry fertilizer products. This section provides guidance on safety training for personnel, storage bin inspections, product management, common product-specific issues, and storage bin construction recommendations.

1.1 Safety Training

NO.	ACTIVITY	BEST PRACTICE
1.1.1	Basic Training for New Hires	Training for new hires should contain information on safe storage and handling procedures, including but not limited to guidance on hazard recognition, a review of product labels and hazard communications (warning signs and decals, Safety Data Sheets, etc.), common product-specific concerns, safety measures in case of cliffing, and incident reporting.
1.1.2	Ongoing Awareness Training	Safety training should be renewed on an annual basis or more often. All training should be documented.
1.1.3	Safe Work Permit System	**See Appendix B for a sample safe work permit system.** Implement a safe work permit system that incorporates established safe work procedures and defines the process for stopping or continuing work in the case of a hazard. This system should include defined stop points where work should be stopped and the situation assessed before continuing work. This should also define the conditions in which work can continue and provide guidance on managing hazard conditions. If implemented, all staff should be trained on the use of a safe work permit system.

1.2 Responsible Person

NO.	ACTIVITY	BEST PRACTICE
1.2.1	Designating a Safety Manager/ Person Responsible for Safety	Facilities can designate a Safety Manager or other person responsible for providing oversight of safety measures.

1.3 Inspections

See Appendix C for sample inspection checklists.

NO.	ACTIVITY	BEST PRACTICE
1.3.1	Daily Bin Inspections	At agri-retail and distribution facilities, storage bins should be inspected on a daily basis when in use (i.e., during periods when product is being loaded into or pulled from the bin and operators are entering the bin) for hazard signs and general safety concerns.
1.3.2	Inspections Pre- and Post-Seasonal Use	Storage bins should be inspected prior to filling for seasonal use and after seasonal use, or whenever the bin is emptied.
1.3.3	Documenting Inspections	Inspections should be documented with a record of any issues flagged during the inspection and how issues were addressed.

1.4 Preventative Maintenance

NO.	ACTIVITY	BEST PRACTICE
1.4.1	Facility Maintenance	Ensure that dry fertilizer storage bins are included in the facility maintenance plan. This plan should include: • Ensuring that product handling equipment is in good condition. • Ensuring that there are no moisture entry points that could affect product. • Checking for any cracks or concrete damage, wall damage, or roof damage.
1.4.2	Bin Preparation	Consult any resources made available by the bin manufacturer to ensure that the bin is prepared and used correctly and in the safest manner possible. Use an absorbent (e.g., diatomaceous earth products such as Floor-Dry) in bin and related equipment, including augers and spouting, prior to use. In hopper-bottom bins, fill bin to near top and add a layer of absorbent on top of the product. For hopper-bottom bins, use poly sheets on the exterior of the bin to block poke-holes and prevent moisture from entering. Seal lids and gates to prevent moisture from entering. Inspect all lids and lid seals to ensure they are in place and undamaged.

1.5 Product Management

NO.	ACTIVITY	BEST PRACTICE
1.5.1	Refer to Manufacturer Guidance	Consult any resources made available by the product manufacturer to ensure that the product is stored correctly and in the safest manner possible. This is highly recommended in the case of products that are commonly associated with cliffing.
1.5.2	Identify and Raise Awareness of At-Risk Products	Identify products that commonly have cliffing issues and ensure that facility staff and operators are aware of the hazards specific to the products carried in their facility.
1.5.3	Inventory Management	**All Bin Types** • Where possible, introduce inventory control measures to reduce the amount of time that products remain in storage, and manage shipment receiving times to ensure that product is received at an appropriate time relative to its intended time of use, being mindful of environmental conditions that could contribute to caking (e.g., humidity, temperature) when moving product. Where possible, work with product suppliers to determine the optimal time and conditions for moving product. • If product begins to show signs of caking but has not yet formed a cliff or bridge, loosen the product following all safety measures in place. • In both flat-bottom and hopper-bottom bins, handling or moving product too often can result in product quality issues and can contribute to caking. • Consult manufacturer guidance regarding product compatibility with other products stored in proximity. For general guidance, refer to the additional resources in Appendix A. **Flat-Bottom Bins** • In flat-bottom bins, set pile height limits based on the reach of equipment used at the facility to help ensure that any cliffing can be managed safely. **Hopper-Bottom Bins** • In hopper-bottom bins, product can be turned/moved to prevent bridge formation. Use best judgement to move product as necessary, being mindful of environmental conditions that could contribute to caking (e.g., humidity, temperature) when moving product. • Completely fill the bin all at once to prevent layering of product. Empty the bin completely before refilling, particularly with bins that have a funnel flow design.
1.5.4	Storage Temperature	Be aware of temperature conditions when moving product and use best judgement to determine timing and volume of product to move, taking the critical relative humidity of the product into consideration.

1.6 Common Product-Specific Issues

NO.	PRODUCT	BEST PRACTICE
1.6.1	Ammonium sulfate	Ammonium sulfate is hygroscopic, and the additional moisture uptake can cause product degradation, set-up, and general poor handling characteristics. Ammonium sulfate should not be stored for long periods if exposed to elevated humidity levels.
1.6.2	Potash	High storage temperatures can cause poor handling characteristics and caking in potash. Be aware of temperature in storage areas when storing potash. Over handling potash can lead to increased fines and can increase the tendency to cliff. Whenever possible, minimize handling or moving product.
1.6.3	Blended products	When storing and handling blended product, take into consideration that critical relative humidity for blended products is generally lower than that of their component ingredients.
1.6.4	Elemental Sulfur/Elemental Sulfur Blends	Over handling elemental sulfur/elemental sulfur blends can lead to increased fines and an increased tendency to cliff. Increased fines can lead to increased flammability. Whenever possible, minimize handling or moving product. Consult with the product manufacturer for specific storage and handling recommendations for the product or blend being stored.

1.7 Storage Bin Construction

NO.	ACTIVITY	BEST PRACTICE
1.7.1	Construction Standards for New Facilities	New facilities can be constructed to require minimal support rods across flat bottom sheds, which will reduce the risk to operators in the case of cliffing. Support rods can also be placed higher up in the storage area (closer to the ceiling) to allow more space for equipment, including long-reach equipment, to maneuver. Low-profile storage sheds tend to have fewer serious cliffing issues compared to high-profile sheds due to the smaller pile heights in low-profile sheds. Install a visual height indicator inside of the storage area for operators to easily reference when working in a storage area. This can facilitate setting pile height limits (as recommended in 1.5.3) as well as determining a safe distance from the pile.
1.7.2	Hopper-Bottom Bin Discharge Design	Hopper-bottom bins with expanded flow discharge designs draw on elements of funnel flow and mass flow designs. Expanded flow is intended to address common issues with funnel flow (i.e., bin warping/twisting) and mass flow (i.e., excessive wear on bin walls). Choose a bin with adequate ventilation. Air flow is key to maintaining proper product flow. Ventilation also helps regulate the temperature inside the bin, preventing product quality issues due to high storage temperatures.

Managing Existing Cliffs/Bridges

Section 2 covers measures for managing caked dry fertilizer products. This section provides guidance on recognizing hazard signs of caked/cliffed/bridged fertilizer, dislodging caked product in flat-bottom and in hopper-bottom bins, and recommendations for recordkeeping and incident reporting.

Never attempt to dislodge caked fertilizer manually. Never attempt to dislodge caked fertilizer unless adequate safety measures are in place.

See Appendices B and C for sample Safe Work Permit systems. The Safe Work Permit System encompasses the best practices recommended in this section as an actionable work process that can be adapted and implemented at facilities storing dry fertilizer.

2.1 Recognizing the Hazard

NO.	ACTIVITY	BEST PRACTICE
2.1.1	Hazard Identification	Identify incidence(s) of bridged or cliffed fertilizer, and identify all hazards associated with the bridged or cliffed fertilizer in the storage facility. Key factors to consider when determining the extent of a hazard are: • Height of pile in relation to height of equipment being used (i.e., pile should not be taller than the reach of the equipment being used) • Angle of repose • Available angles of reclaim Common hazard signs include: • The pile's angle of repose presents an engulfment risk • Cliffing is present, operators are on foot, and the cliff is higher than the reach of operators • Cliffing is present and the cliff is higher than the reach of equipment being used • Product is coming down from the pile in clumps
2.1.2	Hazard Assessment	Determine if product dislodging can be conducted in a safe manner (that does not put personnel at risk). If product dislodging cannot be conducted in a safe manner, request third party assistance. Never attempt to dislodge caked fertilizer unless adequate safety measures are in place.

2.2 Dislodging Product (Flat-Bottom Bins)

NO.	ACTIVITY	BEST PRACTICE
2.2.1	Require Supervision	Require that a second member of staff be present when operators are dislodging cliffed fertilizer.
2.2.2	Methods for Dislodging Product	**Never walk or step on a fertilizer pile.** **Never attempt to dislodge caked fertilizer manually.** **Always pull product from the top of the pile. Never undercut the base of a cliff.** **Always maintain a safe distance (at least 1.6 times the height of the pile) from the bottom of the pile.** 'POKER/PROBE' ATTACHMENT Use a long rod attached to a loader as a poker/probe to dislodge fertilizer. This should only be done with the supervision of another member of staff and only if it can be done from a safe distance. If the height of the cliff exceeds the length of the probe being used, use another method to dislodge product. Where possible, use equipment with a closed cab or reinforced windshield. DISLODGING FROM ABOVE Where it can be done safely, use a long rod to break apart the cliffed fertilizer from above (e.g, from a catwalk). REMOTE OPERATORS Where possible, use remotely operated equipment to safely dislodge fertilizer from a distance. THIRD-PARTY CONTRACTOR/EQUIPMENT If the cliff is too high to safely dislodge using a poker/prober attachment or remote operator, consider sourcing telereach or long-reach equipment (e.g., long-reach excavator) from a third-party. For appropriate products, consider contracting a third-party to use CO_2 charges in the fertilizer pile to break apart the caked product.

2.3 Dislodging Product (Hopper-Bottom Bins)

NO.	ACTIVITY	BEST PRACTICE
2.3.1	Require Supervision	Require that at minimum a second member of staff be present when operators are dislodging bridged fertilizer.
2.3.2	Determine Extent of Bridging	Use a rubber mallet on the outside of the bin to determine the extent of the issue and to agitate the product inside the bin.
2.3.3	Establish Center Flow	**Never walk or step on a fertilizer pile. Never enter the storage bin to manually dislodge bridged fertilizer.** When dislodging product, aim to establish center flow. Some dislodgment techniques can cause bin damage if there is a cavity in the bin and center flow is not established. If the bin has an inspection opening or poke-hole, use a long bar/rod to break up the product from a safe distance. Never put hands/arms/or any body part into the bin. **Never stand behind the long bar/rod, which could cause injury when product dislodges.** If product cannot be safely dislodged through an inspection opening or poke-hole, consult with the bin manufacturer. Alternatively, in some regions third-party companies with specialized equipment (e.g., hydraulic whips) are available to assist with dislodging caked product.

2.4 Recordkeeping/Incident Reporting

NO.	ACTIVITY	BEST PRACTICE
2.4.1	Incident Reporting	Operators should complete an incident report every time fertilizer cliffing or bridging presents a safety risk in order to track occurrences and inform future development of safety guidelines. Records in the incident report should include a report on all known factors that contributed to fertilizer cliffing/bridging, a description of the practices used to dislodge the bridged product, and a measure of success of the practices used.
2.4.2	Hazard Reporting	Operators and other facility staff should complete a hazard report every time that a condition in the facility, the storage area, or of the product could lead to a safety risk.

Guidance for Retail Customers/ Product Users

Section 3 covers guidance for retail customers and product users. This includes farmers and other commercial fertilizer users. This section provides guidance for on-farm and other user storage. Retail customers and product users are encouraged to review the best practices listed in Sections 1 and 2, which are adaptable to on-farm storage conditions as well as to retail and distribution facilities. Retailers are encouraged to share these recommendations with their customers.

3.1 Additional On-Farm Storage Considerations

NO.	ACTIVITY	BEST PRACTICE
3.1.1	Consult with Retailers	Consult with the product retailer to identify any specific storage considerations related to the particular facility and/or product in question. If cliffing or bridging issues occur, consult with the product retailer for guidance or assistance with dislodging the cliffed or bridged product safely.
3.1.2	Consult with Bin Manufacturer	Consult with the bin manufacturer to identify any specific practices or considerations recommended for the particular bin type in question. Signage with bin manufacturer contact information should be on or near the bin in a visible location.
3.1.3	Bin Preparation	Use an absorbent (e.g., diatomaceous earth products, including Floor-Dry) in bins and related equipment before adding fertilizer to absorb any moisture.
3.1.4	Loading Product	Whenever possible, avoid loading product into storage bins in high temperatures or humid conditions.
3.1.5	Long-Term Storage	Be aware of storage conditions (including temperature and humidity levels) and how those conditions impact product handling characteristics for any product that is stored over long periods of time.

Additional Resources

Annex A provides additional resources on handling and storing dry fertilizer. Readers are encouraged to consult these resources in addition to the guidance provided in this document.

Agricultural Industries Confederation. "Protecting the Environment—The Essentials for Storing Solid and Liquid Fertilisers." Agricultural Industries Confederation, 2021. https://www.agindustries.org.uk/resource/protecting-the-environment---the-essentials-for-storing-solid-and-liquid-fertilisers.html

European Fertilizer Manufacturers Association. "Guidance for the compatibility of fertilizer blending materials." European Fertilizer Manufacturers Association, 2006. http://www.productstewardship.eu/fileadmin/user_upload/user_upload_prodstew/documents/Guidance_for_the_compatibility_of_Fertilizer_Blending_Material.pdf

Sample Safe Work Toolkit—Flat-Bottom Storage Bins

Purpose & How to Use

The Safe Work Toolkit is intended to be used at retail storage facilities by operators, inspectors, or any other individual working in a flat-bottom storage bin with a solid floor. The Permit Information and Pre-Operation Checklist should be completed prior to beginning any work in the storage bin. The Stop Work Conditions should be well-known among facility staff, and the section should be consulted during the operation if/when any stop points are identified.

Completed Safe Work Permits should be kept on record to help inform future safety measures or guidelines. Consult the requirements for recordkeeping on safety training/safe work permits in the jurisdiction in which your facility is located.

Facilities are encouraged to adapt this template to the conditions and considerations specific to the facility.

SAFE WORK PERMIT

Directions & General Operating Procedures

1. Complete the Permit Information and Pre-Operation Checklist sections at start of shift or prior to work in any storage bin. If any items on the Pre-Operation Checklist are not complete, do not work in the storage area until the item has been completed or adequate safety controls are in place.
2. If hazards are present or conditions change, stop work immediately and assess the safety measures in place in consultation with the Stop Work Conditions section. Do not continue work until all necessary safety controls for the conditions are in place. Never walk or step on a fertilizer pile.
3. Stop work immediately if any unauthorized individuals enter the storage area.
4. At the end of shift or once the task is completed, submit/save the completed permit as directed by the facility manager/supervisor for record keeping.

Please note that this Safe Work Permit is not equivalent to a confined space entry permit and is not intended to meet health and safety requirements for confined spaces. Consult the requirements in your local jurisdiction for confined space entries.

Permit Information

Date & Time:	
Operator Name(s):	
Supervisor(s):	
Location/Bin ID:	
Product & Task Description:	

Pre-Operation Checklist

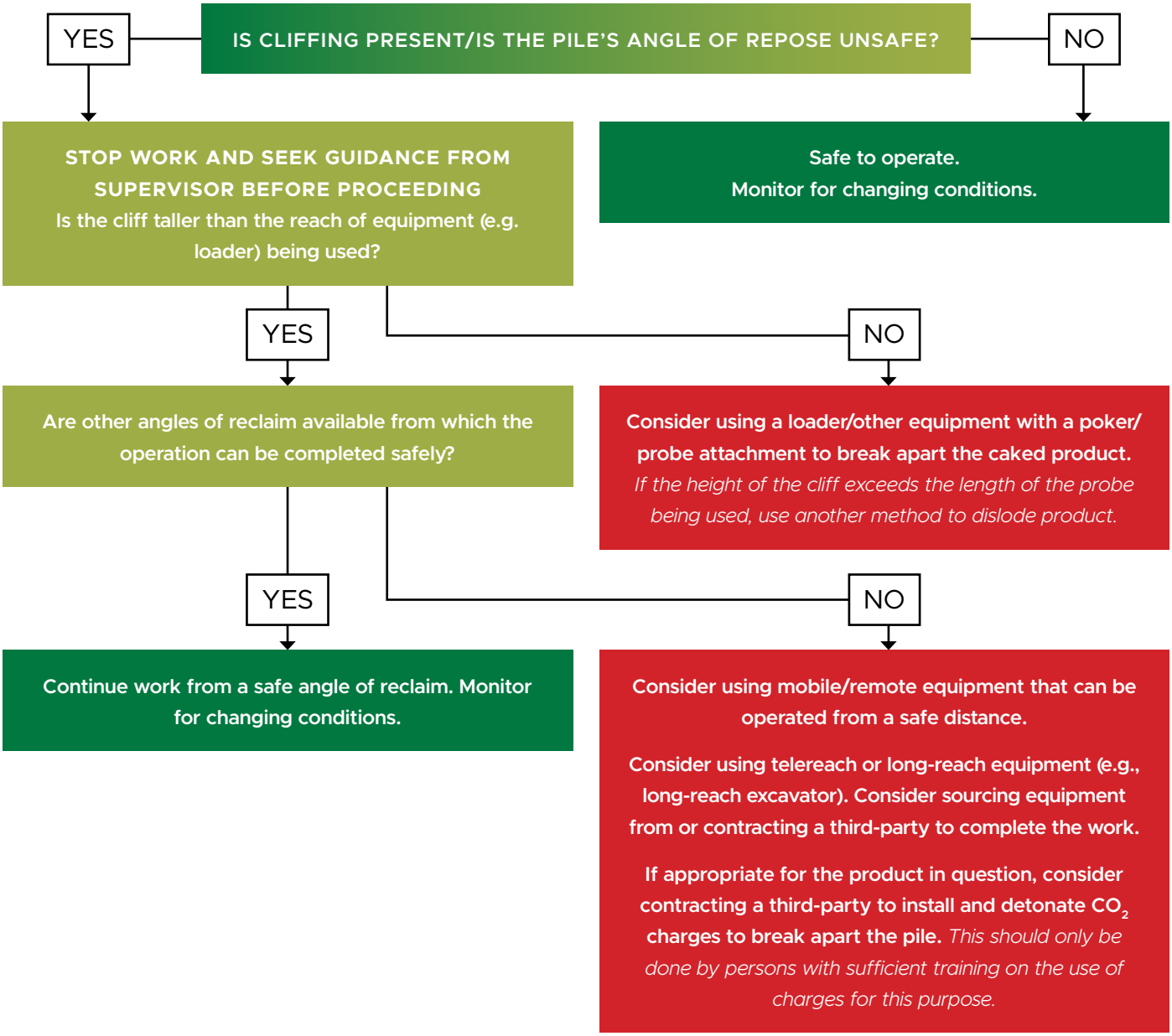
SAFETY MEASURE	COMPLETED	N/A
TRAINING		
All staff members involved in the operation are up-to-date on safety training and are fully trained on necessary safety measures	☐	☐
All staff members involved in the operation are fully trained on all critical job procedures	☐	☐
COMMUNICATION		
Plans have been developed for communication between all operators and supervisors, and all involved staff have been trained on the plans	☐	☐
Communication with the responsible supervisor is available at all times throughout work operation	☐	☐
EQUIPMENT		
All necessary PPE has been identified and inspected and is in good condition	☐	☐
PPE is being worn/used prior to beginning work	☐	☐
All necessary equipment to be used throughout work operation has been identified and inspected and is in good condition	☐	☐
All lock-out/tag-out requirements for the operation have been identified and verified	☐	☐
STORAGE AREA CONDITIONS		
Access to storage area is controlled to prevent unauthorized persons entering during the operation	☐	☐
Storage area has adequate lighting	☐	☐
Storage area has adequate ventilation	☐	☐
Temperature and other environmental conditions of the storage area are within safe working limits	☐	☐
Safe area for operator to exit equipment has been identified	☐	☐
Notes:		
Approved by:		

Safe Work Flowchart—Flat-Bottom Storage Bins

This flowchart can be used to assess whether a job procedure can be done safely and to provide guidance on what safety measures and controls can be taken in various circumstances.

When dislodging a cliff, always pull product beginning at the top of the pile. Never attempt to dislodge fertilizer by undercutting the base of a cliff.

Refer to Appendix F for product-specific information, including safe angles of repose for common dry fertilizer products.

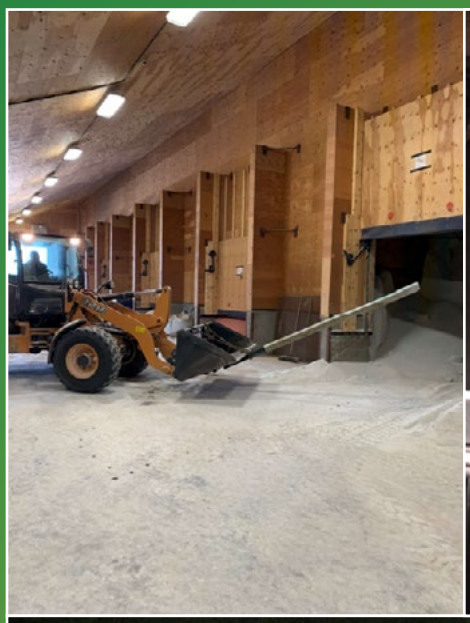


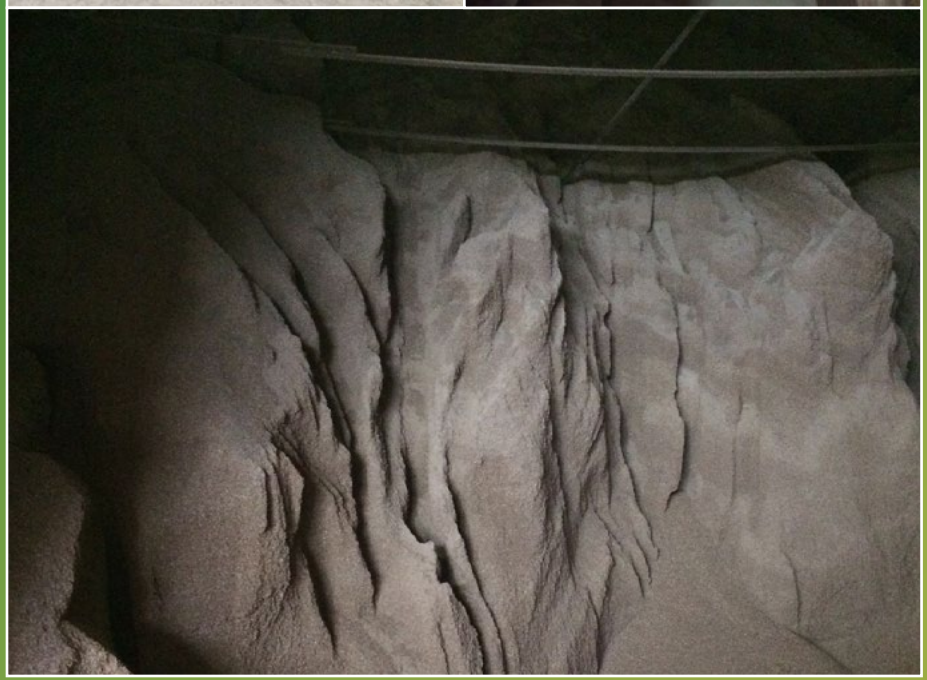
Stop Work Conditions—Flat-Bottom Storage Bins

STOP WORK CONDITIONS #1

1. If cliffing is present/angle of repose is not safe AND pile is lower than reach of the equipment being used, **STOP**.

    - Consider using a loader or other equipment with a poker/probe attachment (as shown below) to break apart the caked product. However, i**f the height of the cliff exceeds the length of the poker/probe being used, use another method to dislodge the caked product.**





STOP WORK CONDITIONS #2

2. If cliffing is present/angle of repose is not safe AND pile is higher than reach of equipment AND no other angles of reclaim are available, **STOP**.

    - Consider using mobile/remote equipment that can be operated from a safe distance.
    - Consider using telereach or long-reach equipment (e.g., long-reach excavator). If necessary, consider sourcing equipment from a third-party or contracting a third-party to complete the work.
    - If appropriate for the product in question, consider contracting a third-party to install and detonate CO_2 charges to break apart the fertilizer pile. **This should only be done by persons with sufficient training on the use of charges for this purpose.**

STOP WORK CONDITIONS #3

3. If no cliffing is present and product is coming down the pile at a safe angle of repose, **CONTINUE** work and **MONITOR** for changing conditions.

Sample Safe Work Toolkit—Hopper-Bottom Storage Bins

Purpose & How to Use

The Safe Work Toolkit is intended to be used at retail storage facilities and on-farm by operators, inspectors, or any other individual working with a hopper-bottom storage bin. The Permit Information and Pre-Operation Checklist should be completed prior to beginning any work in or around the storage bin. The Stop Work Conditions should be well-known among facility staff, and the section should be consulted during the operation if/when any stop points are identified.

Completed Safe Work Permits should be kept on record to help inform future safety measures or guidelines. Consult the requirements for recordkeeping on safety training/safe work permits in the jurisdiction in which your facility is located.

Facilities are encouraged to adapt this template to the conditions and considerations specific to the facility.

SAFE WORK PERMIT

Directions & General Operating Procedures

1. Complete the Permit Information and Pre-Operation Checklist sections at start of shift or prior to work in any storage bin. If any items on the Pre-Operation Checklist are not complete, do not work in the storage area until the item has been completed or adequate safety controls are in place.
2. If hazards are present or conditions change, stop work immediately and assess the safety measures in place in consultation with the Stop Work Conditions section. Do not continue work until all necessary safety controls for the conditions are in place. Never walk or step on a fertilizer pile. Never enter the storage bin to manually dislodge bridged fertilizer.
3. Stop work immediately if any unauthorized individuals enter the storage area.
4. At the end of shift or once the task is completed, submit/save the completed permit as directed by the facility manager/supervisor for recordkeeping.

Please note that this Safe Work Permit is not equivalent to a confined space entry permit and is not intended to meet health and safety requirements for confined spaces. Consult the requirements in your local jurisdiction for confined space entries.

Permit Information

Date & Time:	
Operator Name(s):	
Supervisor(s):	
Location/Bin ID:	
Product & Task Description:	

Pre-Operation Checklist

SAFETY MEASURE	COMPLETED	N/A
TRAINING		
All staff members involved in the operation are up-to-date on safety training and are fully trained on necessary safety measures	☐	☐
All staff members involved in the operation are fully trained on all critical job procedures	☐	☐
COMMUNICATION		
Plans have been developed for communication between all operators and supervisors, and all involved staff have been trained on the plans	☐	☐
Communication with the responsible supervisor is available at all times throughout work operation	☐	☐
EQUIPMENT		
All necessary PPE has been identified and inspected and is in good condition	☐	☐
PPE is being worn/used prior to beginning work	☐	☐
All necessary equipment to be used throughout work operation has been identified and inspected and is in good condition	☐	☐
All lock-out/tag-out requirements for the operation have been identified and verified	☐	☐
STORAGE AREA CONDITIONS		
All cliffing and engulfment hazards have been eliminated or are controlled through appropriate safety measures	☐	☐
Notes:		
Approved by:		

Stop Work Conditions—Hopper-Bottom Storage Bins

1. If product is not flowing freely from bin opening, **STOP**.

    - Never walk or step on a fertilizer pile. Never enter the storage bin to manually dislodge bridged fertilizer.
    - First, determine the extent of bridging. Use a rubber mallet on the outside of the bin to determine the extent of the issue and to agitate the product inside the bin.
    - When dislodging product, aim to establish center flow. Some dislodgment techniques can cause bin damage if there is a cavity in the bin and center flow is not established.
    - If the bin has an inspection opening, use a long bar/rod to break up the product from a safe distance. **Never put hands/arms/or any body part into the bin. Never stand behind the long bar/rod, which could cause injury when product dislodges.**
    - If product cannot be safely dislodged through an inspection opening or poke-hole, consult with the bin manufacturer. Alternatively, in some regions third-party companies with specialized equipment (e.g., hydraulic whips) are available to assist with dislodging caked product.

STOP WORK CONDITIONS

Sample Inspection Checklists

Daily/Weekly Inspections

BIN CHARACTERISTICS			
NO.	INSPECTION ITEM	INSPECTED	ACTION REQUIRED
1	Check for signs of cliffing, caking, or excessive dust accumulation (excessive dust or product build up can contribute to caking and should be cleaned regularly)	☐	☐
2	Ensure adequate ventilation in storage area	☐	☐
3	Safety signs, decals, and Safety Data Sheets (SDS) are available and easily viewed by operators (hazard warnings should include Engulfment, Confined Space)	☐	☐
4	Ensure that product handling equipment is in good condition	☐	☐
Notes & Action Items:			
Inspected by:		**Date:**	

FACILITY CHARACTERISTICS			
NO.	INSPECTION ITEM	INSPECTED	ACTION REQUIRED
1	Emergency response kits are readily available and accessible to staff	☐	☐
2	General housekeeping (e.g., equipment & tools stowed away, combustible/ organic materials properly stored, general cleanliness, etc.)	☐	☐
3	Check for any cracks or concrete damage, wall damage, or roof damage	☐	☐
4	Electrical and lighting in good condition (e.g., check for any loose or frayed wires or other items in need of repair, ensure that lights are operational)	☐	☐
5	Fire extinguishers and hydrants inspected and in working condition	☐	☐
6	Floor and walking pathways are clear of obstructions and floor is in good condition	☐	☐
7	Ensure that there are no moisture entry points that could affect product	☐	☐
Notes & Action Items:			
Inspected by:		**Date:**	

Seasonal Inspections

PRE- AND POST-SEASONAL BIN INSPECTION (EMPTY BIN INSPECTION)			
NO.	INSPECTION ITEM	INSPECTED	ACTION REQUIRED
1	Ensure there are no moisture entry points in bin or related equipment, including spouting	☐	☐
2	Check for signs of wall damage, rusting, cracks in concrete, etc.	☐	☐
3	Check for signs of bin aging, including deterioration of inner lining/coating	☐	☐
Notes & Action Items:			
Inspected by:		**Date:**	

Sample Incident & Hazard Reports

Dry Fertilizer Storage Hazard Report

Date of report:

Employee/reporter name:

Supervisor name:

HAZARD INFORMATION
Date & time hazard was identified:
Location of hazard (be as specific as possible):
Hazard description: Include any relevant factors, such as any identified causes of the hazard or potential impacts of the hazard
Action taken/planned to eliminate or control the hazard:
Action taken/planned to prevent the hazard in the future:
Employee/Reporter Signature:
Supervisor Signature:

Dry Fertilizer Storage Incident Report

Date of report:

Employee/reporter name:

Supervisor name:

Witnesses/other persons involved:

INCIDENT INFORMATION
Date & time of incident:
Location of incident (be as specific as possible):
Incident description *(include the sequence of events leading up to, during, and after the incident as well as any other relevant factors)*:
Description of injuries *(if applicable)*:
Description of damage to facility or equipment *(if applicable)*:
Action taken/planned to prevent similar incidents in the future:
Employee/Reporter Signature:
Supervisor Signature:

Product-Specific Information

Figure 1: Static Angles of Repose of Common Fertilizer Products[1]

PRODUCT NAME & GRADE	STATIC ANGLE OF REPOSE
Granular ammonium sulfate (21-0-0)	36–38°
Granular monoammonium phosphate (11-52-0)	28–37°
Granular potassium chloride (0-0-60)	32–41°
Coarse potassium chloride (0-0-60)	31–35°
Standard potassium chloride (0-0-60)	28–32°
Granular urea (46-0-0)	34–38°
Prilled urea (46-0-0)	27–28°

[1] *International Fertilizer Development Centre, Fertilizer Manual, (Scientific Publishers: 2018), pg. 480.*

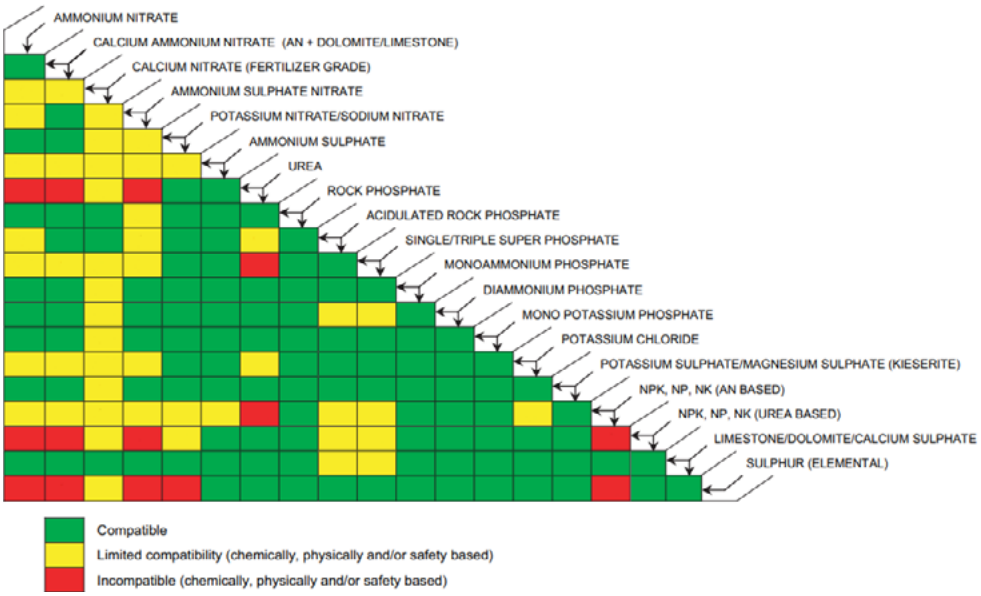
Figure 2: Critical Relative Humidity of Common Fertilizer Products[2]

PRODUCT NAME & GRADE	CRITICAL RELATIVE HUMIDITY (AT 30°C)
Granular ammonium sulfate (21-0-0-24)	75–85
Granular monoammonium phosphate (11-52-0)	70–75
Granular potassium chloride (0-0-60)	70–80
Granular urea (46-0-0)	70–75

[2] *International Fertilizer Development Centre, Fertilizer Manual, (Scientific Publishers: 2018), pg. 486.*

Figure 3: Product Storage Compatibility

Consult the product manufacturer or retailer for information on compatibility between products stored in proximity to each other. For general guidance, see the chart and resources referenced below.



Source: European Fertilizer Manufacturers Association, "Guidance for the compatibility of fertilizer blending materials," European Fertilizer Manufacturers Association, 2006. http://www.productstewardship.eu/fileadmin/user_upload/user_upload_prodstew/documents/Guidance_for_the_compatibility_of_Fertilizer_Blending_Material.pdf.