



# AEM Tier 2 Worksheet

## Greenhouse – Fertilizer Storage & Handling

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### Glossary

**Alkalinity:** The amount of bicarbonate buffer in water. The pH of highly buffered water is elevated and resists change.

**Backflow Preventers:** A device that prevents the flow of chemicals injected back to the source water.

**Calibration:** Determining accuracy of equipment and methods; using standards to maintain accuracy in equipment capacity and volumes delivered. With liquids, the amount applied to a known area must be known and consistent.

**Electrical Conductivity:** A measurement of the amount of dissolved salts in the plant substrate and water which affects the ability of plants to take up nutrients. Levels considered optimum vary by analytical method, crop, and stage of crop. Optimum levels are lower for newly planted crops and near-harvest bedding and potted crops. Optimum ranges are 2-3.5 milli-Siemens/cm for saturated media extract and 1-4 for the pour-through method.

(Continued on Page 2)

### Background

Greenhouse fertilizer storage areas contain concentrated chemicals that must be stored and managed properly to prevent their potential release, through broken, damaged or leaking containers. Potential problems include the risks of spills, loss of security, accumulation of old or outdated materials, cross-contamination with volatile chemicals such as herbicides, and the risk of fire or other disaster events. These problems can be minimized through structural isolation, dry conditions, proper building security, fire prevention and suppressing equipment, inventory control, secondary containment, and good emergency planning.

Risk identification and assessment will be the management mindset.

All employees who have access to fertilizer storage will be trained in facility spill and other emergency procedures. Storage areas will be inventoried on an annual basis at a minimum. Inventory records will be shared with appropriate emergency response personnel. An inspection checklist of facility features, including systems and equipment, will be developed, completed at least annually, and kept on file for a period of 3 years.

(Continued on page 2)

### Agricultural Water Quality Principle:

Concentrated stock can pose significant impact on plant health inside the greenhouse and to surface and groundwater when accidents occur. Application equipment must be maintained for proper use rate and to prevent backflow.

The concentration of chemicals found in fertilizers makes proper storage of utmost importance for the safety of human health and the environment.

## Glossary continued ...

**Fertigation:** The addition of fertilizers to irrigation water.

**Fertilizer Injector or Proportioner:** Device that dilutes by a known ratio the amount as it injects stock solution into the irrigation line.

**Fire-resistant Materials:** Man-made materials which have been processed for flame resistance.

**Fire-Suppressing System:** A reliable system of sprinklers, hoses and extinguishers located to respond to and limit the growth of a fire.

**Growing mix:** A material formulated to provide structural support, water, nutrients and air for roots to grow.

**Impermeable Flooring:** Non-porous flooring constructed to resist absorption.

**Inventory Control:** Consistent and repeated maintenance of a manual or electronic system recording quantities of fertilizer purchased, used and reordered.

**Leaching:** Applying an overabundance of water or solution to wash toxic chemicals and concentrations away from the root zone.

**Macro and micro nutrients:** Fertilizers for greenhouse crop typically consist of macro- nutrients (nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur) which are required by plants in large amounts and micro-nutrients (copper, iron, manganese, zinc, boron, and molybdenum) which are required by plants in small amounts.

(Continued on Page 3)

## Background continued ...

Containers in storage will be inspected at least quarterly for signs of corrosion or other damage. Leaking or damaged containers will be repackaged as appropriate. Ventilation, electrical, and fire suppression systems are on periodic maintenance schedules and will be maintained as appropriate. Damaged or malfunctioning equipment will be reported as soon as identified.

The floor of the storage area will be kept free of debris. Damaged or leaking containers will be repaired and/or replaced as soon as possible, all spilled material will be cleaned up upon discovery, and cleanup materials will be discarded promptly and properly. Shelving and counters will be kept free of debris and miscellaneous items. Inventory is controlled to prevent the accumulation of excess material that may become difficult to use.

Hazard to surface and groundwater by spills from tipped, damaged, or weak storage tanks of concentrated solutions of fertilizer will be considered.

All employees who work with fertilizers or fertilizer injector equipment are trained in the proper use and maintenance of the equipment. Greenhouse staff is provided with training in the proper interpretation of nutrient analysis reports, the identification of nutrient deficiencies in plant material, and the correct selection of fertilizers and rates based on crop needs.

All fertilizer containment tanks, injector pumps, backflow preventers, monitoring equipment and fertilizer lines are inspected regularly. Records are kept on quantities (concentration, volume) of fertilizer applied by crop.

(Continued on page 3)

## Glossary continued ...

**Nutrient Analysis:** Testing growing mixes, water or plant material to determine actual nutrient content, pH, and electrical conductivity (saltiness).

**Nutrient Deficiency:** Lack of one or more mineral nutrients which prevents optimum growth. When plants show signs of impairment, tests determine if one or more micro or macronutrients may be in a low level; correct assessment reduces over-fertilization and optimizes productivity.

**pH:** The measure of free hydrogen ions in solution. A pH of less than 5.5 is considered low (acidic), over 6.2 is high (basic).

**Precipitate:** The resulting solids that have separated from water in a chemical solution.

**Rinsate:** Resulting solution from triple rinsing (with clear water) containers used for chemical solutions. Rinsate can then be saved as water for future use applications.

**Structural Isolation:** The physical separation of chemicals from the rest of the greenhouse by the use of complete walls.

## Background continued ...

Secondary containment around concentrated fertilizers is routine. Fertigation equipment accuracy is inspected biannually. Inspections also include containment tanks, back flow preventers and any equipment that holds fertilizer in the dry or liquid form. Manufacturer recommendations are followed when calibrating or working on any fertilizer injector equipment.

The areas surrounding fertilizer injectors and concentrated solutions are kept clean and free of debris, as should stock solution tanks. Stock tanks are covered to prevent inadvertent debris, water, or other substances from entering the system.

<b>AEM Tier 2 Worksheet: Fertilizer Storage</b>		<b>Potential Concern</b>		
<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>2</b>	<b>3</b>	<b>Higher 4</b>
<b>Where are fertilizers stored?</b>	building dedicated to chemical storage; fertilizers separated from pesticides, storage area protected from extreme heat and flooding is unlikely	wing or corner on ground floor of a building dedicated to other purposes; some consideration given to location of storage area away from flooding concerns, extreme heat and pesticides	area within building structurally segregated from general work areas; site not considered in selecting storage area	fertilizers stored near pesticides; little consideration given to flooding, extreme heat or worker protection
<b>What lighting is used in the storage area?</b>	electrical lighting allows view into all areas and cabinets within storage area			electrical lighting, but not enough to view all contents and labels
<b>How are fertilizer spills contained?</b>	no floor drain; impermeable floor; floor provides containment in the event of a spill; secondary containment routinely used for most open containers; employees trained in proper procedure, absorbent materials and clean-up equipment available	no floor drain; secondary containment routinely used for open containers; employees trained in proper procedure, absorbent materials and clean-up equipment available	no floor drain; some secondary containment used for open containers; employees aware of proper clean-up procedures	floor not conducive to containment; employees unsure of clean-up procedures
<b>What is contained in the fertilizer storage area?</b>	storage area contains only fertilizers and various application equipment; other greenhouse chemicals stored separately; the storage area NEVER contains: food, drink, tobacco products, volatile chemicals, personal protective equipment, livestock feed, living plants, and/or seeds		storage area contains non-volatile pesticides, fertilizers, other non-volatile greenhouse chemicals, various application equipment, and general greenhouse supplies	storage area is general to all greenhouse supplies and may contain personal protective equipment as well as plant material

<b>AEM Tier 2 Worksheet: Fertilizer Storage Continued</b>		<b>Potential Concern</b>		
<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>Factors Needing Assessment</b>
<b>What containers are used in the storage area?</b>	all chemicals stored in their original containers unless damaged; labels are visible and readable; caps are secure; food or beverage containers are never used for storage			chemicals may not be in their original containers or labeled properly
<b>How are damaged containers dealt with?</b>	fertilizer containers checked often for corrosion, leaks, loose caps, or bungs; when damaged containers are noticed, contents are repackaged and labeled or placed in suitable secondary containment which can be sealed and labeled	when damaged containers are noticed, contents are repackaged and labeled or placed in suitable secondary containment which can be sealed and labeled		damaged containers may go unnoticed; repackaging does not occur consistently
<b>How is fertilizer inventory managed?</b>	inventory actively maintained as chemicals added or removed from storage; containers are dated when purchased; outdated materials removed on a regular basis	inventoried at least once per year; outdated materials removed fairly regularly (or whatever time frame is appropriate)	no inventory; outdated materials occasionally removed	fertilizer replaced when supply is low, no record of purchase date or age of product
<b>How are concentrated nutrients stored and contained?</b>	concentrated stock stored in high density polyethylene containers with extra heavy duty walls; solution stored in area away from plant material; secondary containment provided	concentrated stock stored in high density polyethylene containers with extra heavy duty walls; solution stored in area away from plant material	concentrated stock solution stored near injector in heavy-duty plastic container	concentrated stock solution stored near injector in plastic containers

<b>AEM Tier 2 Worksheet: Fertilizer Storage Continued</b>		<b>Potential Concern</b>		
<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>Factors Needing Assessment</b>
<b>What fertilizer injection system is in use?</b>	automatically monitored and controlled injection system	positive displacement or metering device injection, manual control		less than \$50 venturi-type injector; injector equipment is in need of replacement or overhaul
<b>Is backflow prevention equipment installed?</b>	installation exceeds legal requirements and protects municipal water supply, well-water, and non-crop water within the facility			installation meets legal requirements to protect municipal water supply, and in some cases well-water
<b>How well is equipment maintained?</b>	injector equipment is inspected weekly; stock tank is inspected weekly for deterioration and cracks	injector equipment and stock tank are inspected quarterly		injector equipment and stock tank are repaired when problems are noticed
<b>Is system calibration monitored regularly?</b>	accuracy of fertilizer injector and fertilizer measurement is tested after each preparation of new stock solution	accuracy of fertilizer injector and fertilizer measurement is tested monthly	accuracy of fertilizer injector and fertilizer measurement is tested annually	unlikely to be monitored
<b>How frequently are nutrients applied?</b>	automated controls monitor and apply fertilizers at the proper rate at each watering	fertilization at regular intervals with the proper dilution ratio and flow rate	application of fertilizer is done at irregular intervals when monitoring shows obvious need	occasional application of fertilizer at the discretion of the employees
<b>How frequently is crop nutrient status monitored by complete analytical laboratory analysis?</b>	growing mix monitored before planting; again monitor mix, water source, and foliage of each major crop two months into production	growing mix, water source, and plant monitored annually on each major crop	monitored as problems arise	unlikely to be monitored

<b>AEM Tier 2 Worksheet: Fertilizer Storage Continued</b>		<b>Potential Concern</b>		
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<b>How frequently are pH and electrical conductivity of the planting mix and water monitored in-house?</b>	water and substrate is tested every 2 weeks and as crop health problems arise; corrective fertilizer management procedures are implemented as needed	monitoring is monthly and as crop health problems arise	monitoring occurs when crop health problems arise	in-house monitoring is not done
<b>How thoroughly is in-house pH and EC monitoring equipment calibrated and maintained.</b>	calibrating solutions are refreshed quarterly, equipment is calibrated before each use, faulty equipment is repaired or replaced promptly			calibrating solutions are refreshed annually, equipment is calibrated quarterly, faulty equipment is repaired or replaced promptly
<b>Is system calibration monitored regularly?</b>	accuracy of fertilizer injector and fertilizer measurement is tested after each preparation of new stock solution	accuracy of fertilizer injector and fertilizer measurement is tested monthly	accuracy of fertilizer injector and fertilizer measurement is tested annually	unlikely to be monitored
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<b>How thoroughly is in-house pH and EC monitoring equipment calibrated and maintained.</b>	calibrating solutions are refreshed quarterly, equipment is calibrated before each use, faulty equipment is repaired or replaced promptly			calibrating solutions are refreshed annually, equipment is calibrated quarterly, faulty equipment is repaired or replaced promptly
<b>Are employees trained in nutrient usage?</b>	supervisor provides employee with operating manuals plus instruction from qualified personnel; employees trained in identifying nutrient deficiencies, monitoring crop nutrient status, selection, mixing and use of fertilizers, selection and use of fertilizer injectors	employees receive instruction from experienced users in monitoring crop nutrient status, selection and use of fertilizers, and selection and use of fertilizer injectors	employees learn through on-the-job training and are expected to expand this knowledge on their own	employees learn through experience, little or no training
<b>How elaborate is recordkeeping?</b>	inventory kept on amount of fertilizer purchased and used; location of applications recorded; records kept of media testing for total nutrient analysis; equipment inspections documented; EC and pH readings done quarterly	inventory kept on amount of fertilizer purchased and location of application; EC and pH readings monitored at least quarterly	inventory kept on amount of fertilizer purchased	inventory may not be accurately maintained

<b>AEM Tier 2 Worksheet: Fertilizer Storage Continued</b>		<b>Potential Concern</b>		
<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>Factors Needing Assessment</b>	<b>Lower 1</b>	<b>Factors Needing Assessment</b>
<b>How are precipitate solids discarded?</b>	fertilizer systems are cleaned; solids and rinsates are composted	When fertilizer systems are cleaned, solids are removed first and discarded as solid waste before rinsate is flushed to sanitary sewer	fertilizer systems are cleaned; solids and rinsate are flushed to sanitary sewer	fertilizer systems are not cleaned on a regular basis and rinsate is subject to varying disposal methods
<b>How is irrigation and leaching managed?</b>	conscious attempt to limit the amount of leaching of fertigated water to 10% using trickle tube irrigation, zero effluent systems used whenever possible	conscious attempt to limit the amount of leaching of fertigated water to 10%	little consideration for the amount of fertigated water applied; often exceeds 10%	leaching of fertigated water has not been addressed

## Other:

1. How do you dispose of empty fertilizer containers?

## Additional Comments: