Best Management Practices for Liquid Chloride Storage and Pumping Systems

Task 4. Best Practices Manual

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Introduction

The goal of this project is to examine and document liquid deicer storage and pump systems currently being used by departments of transportation (DOTs) and public works agencies across the country and identify best practices for managing and maintaining these systems. The end goal is to create a concise, user-friendly manual that will present a range of liquid deicer storage and pump systems ranging from "starting simple" to "more advanced".

Building a Liquid Deicer Storage and Pump System

System Planning

Implementing new technology or equipment into a system is often daunting and overwhelming, particularly if you do not know where to begin. This manual is intended to serve as a guide for agencies when they are considering the purchase or replacement of deicing liquid storage and pump systems. Figure 1 outlines the basic steps to implementation of any new equipment or technology.

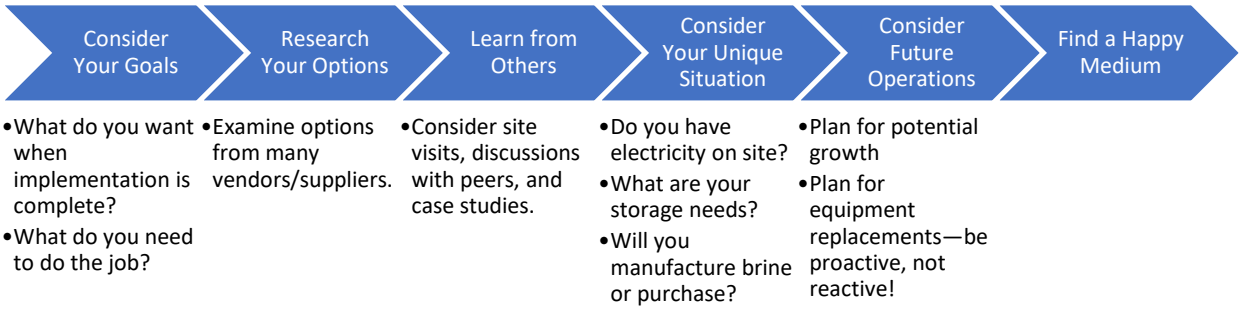


Figure 1. Steps to Implementation

The 5 Year Plan: Set Yourself Up for Success by Planning for Growth

Agencies invest time and resources into expanding and modifying operations over time, and successful agencies plan for long-term growth by considering both operational expansion and equipment maintenance. To be successful, it is imperative that there is potential for expansion in your operation.

When thinking about your initial liquid deicer storage and pump system plan, assess the availability of water, electricity, and real estate. The need for these resources may double in a season as liquid deicers are embraced by staff. Storage tanks require space, and if the tank storage increases, the demand for electricity will increase as well. More tanks may even mean another truck fill. If liquid deicer demand continues to grow, satellite depots may develop into manufacturing facilities that will also require water. Prior to purchasing or upgrading your liquid deicer storage and pump system, consider what your operations may look like in the next five years and start off on the right foot by planning for that potential growth.

To continue achieving a consistent level of service (LOS), it is important to make sure that your liquid deicer equipment is on an overhaul or replacement schedule just like all of your other fleet equipment. Maintaining the simple systems is equivalent in cost to a ½ ton pickup, and more sophisticated systems are equivalent to a Class 8 vehicle. While this equipment may not be utilized all year, it can wreak havoc on your snow fighting operation when it goes down. Proper preventative maintenance will extend the

life of your system. All agencies, but especially those with multiple depots, storage tanks, and truck fills need to keep the equipment in rotation for replacement to prevent catastrophic failure.

Manual Organization

This manual is organized as follows:

- **Liquid Deicer Storage and Pump System Considerations**: This section highlights general considerations for both storage tanks and truck fills, including typical forms of secondary containment.
- **Equipment Replacement Program**: This section describes the general life span of both storage tanks and truck fills.
- **Maintenance and Inspection**: This section includes best practices for routine maintenance and inspection, including an example inspection checklist, a suggested list of supplies to keep on hand for emergencies, storage tank condition testing methods, and safety considerations.
- **Case Studies: System Options from Starting Out to More Advanced:** Information is provided on typical equipment, system expectations, cost, and personnel and training requirements for each liquid deicer storage and pump system. This section also includes ideas for "next steps" to improve your liquid deicer storage and pump system.

Liquid Deicer Storage and Pump System Considerations

Storage Tanks

Storage tanks are used to hold liquid deicing chemicals and/or additives. These tanks can be composed of polyethylene (poly) or fiberglass. General pros and cons of each of these materials is provided in Table 1.

Table 1. Pros and Cons of Poly and Fiberglass Storage Tanks

Storage Tank Material	Pros	Cons
Poly	• Tanks are available in a variety of sizes, including small capacity. • Lifespan of around 15 to 20 years. • May be cheaper than fiberglass (depending on location and size). • High density linear poly and cross-lined poly options available to provide additional durability.	• Can fail catastrophically. • Prone to UV damage.
Fiberglass	• Available in a variety of sizes, however more common for larger capacity tanks. • Lifespan of approximately 20 years. • May be more cost effective for larger capacity tanks. • Tanks have more precise fittings. • Tanks do not fail catastrophically, will instead seep or leak.	• May be more expensive than poly (depending on location and size). • Prone to UV damage.

Storage Tank Capacity and Cost

Poly storage tanks are available in a wide variety of sizes generally up to 10,000 gallons, whereas fiberglass tanks are typically available at larger capacities of 10,000 gallons and greater. Figure 2 shares estimated storage tank costs for poly versus fiberglass tanks (transportation fees not included). At around 10,000 gallons, the cost of fiberglass tanks may be more competitive than poly tanks. However, the costs in this figure do not consider any associated transportation fees. For agencies that are located near a storage tank manufacturer, it may be most cost effective to obtain tanks from a nearby vendor.

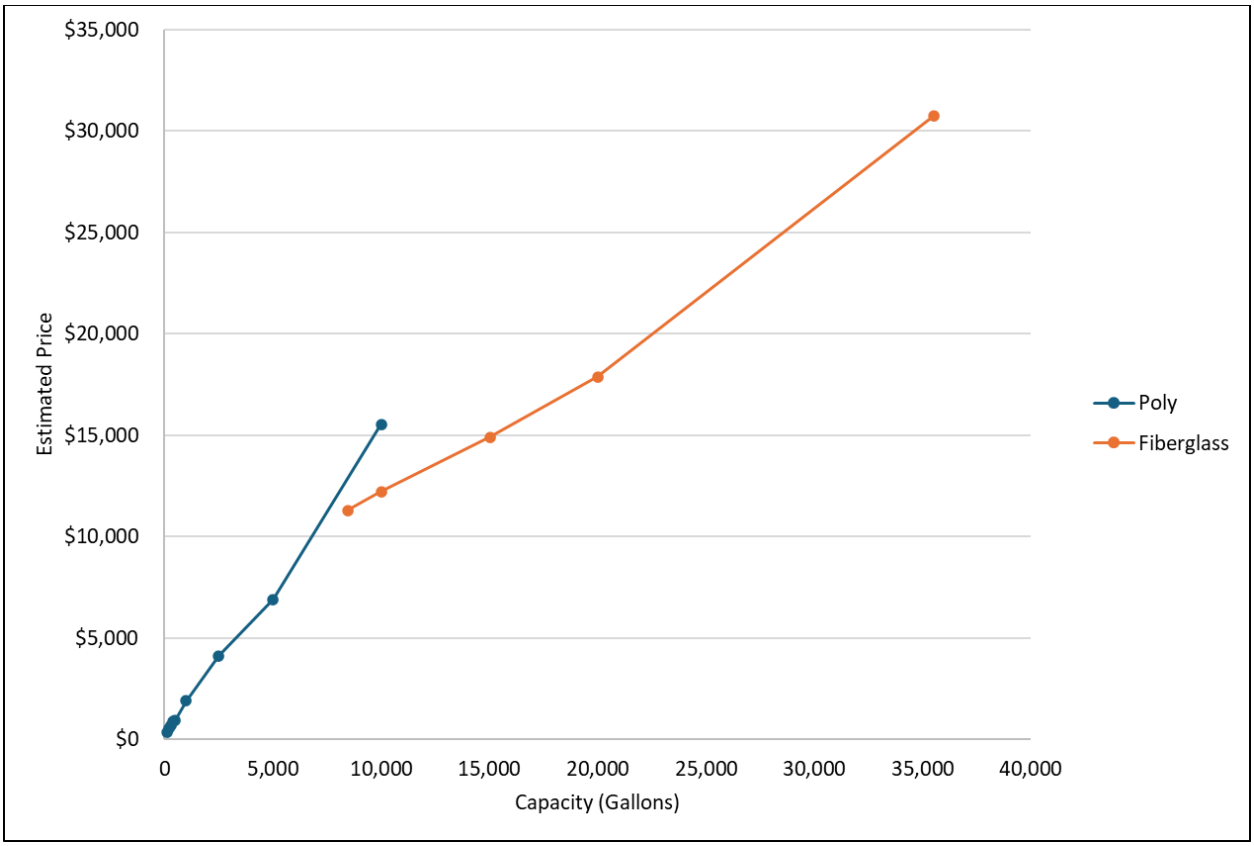


Figure 2. Estimated Price Per Storage Tank Capacity without Transportation Fees

UV Damage

Both poly and fiberglass storage tanks are prone to ultraviolet (UV) damage from exposure to the sun and harsh weather. This damage can cause the tank to become brittle and prone to breakage over time. Storage tanks located indoors are protected from UV damage, but indoor storage is not always an option due to site characteristics or cost. For tanks located outdoors, tank coverings can be utilized. Operators should regularly inspect storage tanks, particularly in areas with more sun exposure, for hairline cracking (see Tank Condition Testing Methods).

Site Location

Geographic location can significantly impact transportation fees when purchasing a storage tank. For agencies that are located near a storage tank manufacturer, it may be most cost effective to obtain tanks from a nearby vendor.

Large storage tanks may require permits during transportation due to their size. Make sure to consider load width restrictions within the states that will be traversed while transporting the storage tank to your agency.

Once the storage tank is on-site, there are several things to consider before and during offloading and siting the tank:

Existing Staff and Equipment: whether staff are trained and capable of safely lifting large objects.

- Are staff trained in safe lift planning and operation of lifting equipment (e.g., crane, forklift)?

- Lifting oversized and/or awkward objects requires experience. Understanding lift charts, rigging gear (e.g., nylon straps, shackles, lifting bars, chains) and center of gravity, are the most critical components of a lift plan. If possible, use trained professionals to perform such work to minimize risk and maximize staff safety.
- The weight of the storage tank including the rigging and actual wire rope needs to be considered when checking the safe operating working radius during the lift.

Final Location of the Storage Tank: which may determine the equipment necessary to move the tank.

- If the tank will be located **inside**, a fork truck will be utilized to set the tank in place. Some storage tanks are manufactured with D-rings for wrapping and securing the load with ratchet straps.
- If the tank will be located **outside**, a crane or a fork truck can be used to set the tank in place.

If your staff or equipment is not capable of safely lifting and maneuvering the storage tank you may consider contracting with a millwright or rigging specialist to set the tank in place. These professionals will establish a pre-lift plan and understand the mechanics involved with safely lifting and moving large objects.

Specific Gravity

Storage tanks and brine manufacturers must be built to hold liquids that are denser than water (which has a specific gravity of 1.0). Typical winter deicers, which include calcium, magnesium, or sodium chloride solutions, have a specific gravity range between 1.2 and 1.3.[1] Storage tanks should have a specific gravity rating which is higher than the specific gravity of the heaviest liquid which will be stored in the tank (generally at least one increment higher) to ensure the tank's longevity.[2] If this information is not obviously available, ask the tank vendor for specifications.

> The general rule of thumb is to purchase a tank with a specific gravity rating at least one increment higher than the product you intend to store.

Storage Tank Plumbing

When plumbing a liquid deicer storage and pump system, the plumbing should include multiple shut-off valves between tanks. This allows for storage tank isolation and creates redundancy (see Figure 3), which helps isolate any issues, prevent contamination between tanks, and can prevent loss of product during a failure. Some agencies have utilized coverings for their storage tank plumbing to help protect from breakage. The Idaho Transportation Department District 3 repurposed old traffic signs into A-frame coverings to protect the tank plumbing from snow sliding off their storage tanks (see Figure 4).

[1] Minnesota Department of Transportation. (2009) Deicing Production and Storage Tank System Guidelines. Accessed at: https://www.dot.state.mn.us/maintenance/files/salt_sustainability/Deicer%20tank%20manual%202018.pdf

[2] Purdue University. (2008) Poly Tanks for Farms and Businesses. Accessed at: https://www.extension.purdue.edu/extmedia/ppp/ppp-77.pdf

Figure 3. Storage Tank Plumbing with Valving for Shut-Off (Source: Nebraska Department of Transportation)

Figure 4. Storage Tank Plumbing Coverings (Source: City of Farmington Hills, Mi – Left, Idaho Transportation Department – Right)

Tank Level Systems

A tank level system measures the level of the liquid stored in the tank without needing to open the tank. A common tank level system is a sight tube gauge, which connects to the upper and lower section of the storage tank and creates potential weak points that could fail or leak and result in loss of product (see Figure 5). Because there is no way to isolate the sight tube from the tank, this type of level system is typically not recommended. Instead, consider investing in a radar tank level system. These systems cost less than $1,000 and provide accurate tank level information with minimal penetration of the storage tank walls (see Figure 6). One system can be used for multiple tanks as long as the tanks are plumbed together, so one radar for four 5,000-gallon storage tanks will allow you to monitor the 20,000-gallon capacity.

Figure 5. Storage Tank Sight Tube (Source: Marc Valenti)

Figure 6. Storage Tank Radar Level (Source: Marc Valenti)

Storage Tank Foundation

The recommended material for an outside storage tank foundation is concrete sand or Portland Cement. A storage tank will expand and contract with varying temperatures and concrete sand or smooth finished Portland Cement will safely allow for this expansion and contraction. Setting the storage tank on stone, especially sharp, angular trap rock, is not recommended because the material can pose a puncture risk over time.

Best Practice Example: City of Farmington Hills, Michigan

When the City of Farmington Hills, Michigan had a "liquids room" addition built onto their maintenance facility in 2015, this addition was designed with smooth concrete flooring with a hardener additive to reduce chloride deterioration and allow trucks to drive through the facility for fill ups (Figure 6).

Figure 7. City of Farmington Hills, MI Liquids Manufacturing Room—Storage Tanks (Source: City of Farmington Hills, MI)

Storage Tank Real Estate

The amount of liquid deicer storage capacity required will vary widely depending on the agency, the size of the operation, the LOS, and weather severity.

When considering your storage tank space requirements, plan for expansion as tank capacity needs can multiply quickly! Your space should accommodate the largest size tank you might purchase, even if it will not be purchased right away. Upgrading storage tanks can be slow and expensive if the tanks need to be emptied and removed and if the site needs additional preparation to fit a larger tank. Draw out your plan on paper, especially if you *think* you will have a tank farm at some point in the future. This step in the planning process will help with the prep work for pre-construction, as well as upgrades.

Secondary Containment

Secondary containment provides a safeguard to prevent spills and/or the release of hazardous substances (e.g., liquid deicers) into the environment if a storage tank fails. Secondary containment is designed to capture and hold spills in a watertight environment and may include options like double-walled storage tanks, concrete walls, or retention basins.

The general rule of thumb for secondary containment is that it must be able to accommodate 110% of the capacity of the single largest storage tank in a tank farm.

Typical Forms of Secondary Containment

Containment Basins: A secondary containment basin is a molded polyethylene basin that the storage tank "sits" in (see Figure 8). The basin is designed to hold the capacity of the storage tank with some overflow. This is a relatively low-cost option.

Figure 8. Example Image of a Containment Basin (Source: Ultratech containment sump (Grainger))

Double-walled Storage Tanks: As the name implies, this form of secondary containment involves an all-in-one design where a storage tank has a secondary wall which can provide 110% containment of the interior tank wall. This option is available on both polyethylene and fiberglass storage tanks. Note: if both walls are punctured, by the tines of a forklift for example, the tank will fail, and the product will spill out.

Concrete Containment Walls/Curbing: Concrete containment walls are cast in place around the storage tank(s) to contain any spills (see Figure 9 and Figure 10). Another method utilizes modular dike systems (Figure 11) which are affixed to the ground using fasteners and sealants. Concrete containment walls or curbing can be a good fit for small areas; however, they can be costly.

Figure 9. Concrete Containment Wall (Source: Idaho Transportation Department)

Figure 10. Concrete Containment Wall (Source: Oregon Department of Transportation)

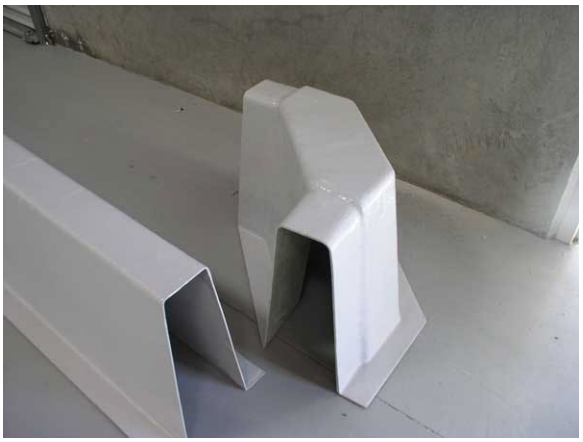


Figure 11. Modular Dike Curbing (Source: Containment Corporation)

Depressed Flooring, Building Drainage: For indoor storage tanks, the flooring can be designed to allow any spills or debris to travel down a sloped floor to a pump-out pit area or drain. This method is utilized by the City of Farmington Hills, Michigan (see Figure 12). They noted that if they were able to redesign their liquids facility, they would elevate their storage tanks on 2–3-inch-high concrete pads to accommodate more slope in the floor. This would ensure that any spills travel to the trench in the middle of the storage area and make cleanup easier.

Figure 12. Sloped Flooring (Source: City of Farmington Hills, Michigan)

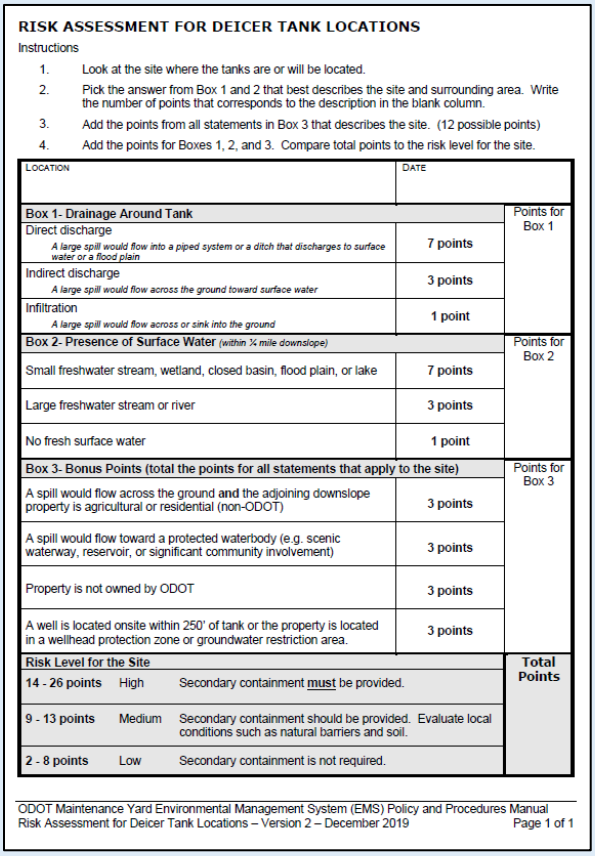
Retention Basin/Pond: A retention pond can be designed downslope from a facility to collect spills or runoff. This structure can be easy to maintain, however the pond should be designed with an impermeable liner to prevent loss of material that could cause ground contamination.

Do You Need Secondary Containment?

Every state or organization may have different requirements for secondary containment of liquid deicers, often depending on the presence of environmentally sensitive resources, such as nearby water sources. Ensure that you are meeting the requirements for all regulating agencies that apply to your organization. Guidance for secondary containment requirements may come from the Department of Transportation, occupational health and safety, or from a state or local environmental health organization. They may also be supported by risk assessments developed by agencies themselves. An example of Oregon DOT's process of determining secondary containment requirements is provided on page 12.

Best Practice Example: Oregon Department of Transportation

The Oregon Department of Transportation uses a risk assessment questionnaire to prioritize storage locations as high, medium, or low risk for spill contamination and whether secondary containment is necessary. The risk level is based on drainage around the storage tank, presence of surface water within a quarter mile downslope from the storage tank, presence of nearby agricultural or residential properties, land ownership, and presence of a well within 250 feet of the storage tank. Sites that are considered low risk do not require secondary containment, those that are evaluated as high risk must provide secondary containment. If multiple storage tanks are located at the site, the tanks must be plumbed to ensure that the complete failure of one tank will not drain the other tanks in the system. This is achieved by utilizing valves between the tanks or by installing separate plumbing systems per tank.



RISK ASSESSMENT FOR DEICER TANK LOCATIONS

Instructions

1. Look at the site where the tanks are or will be located.
2. Pick the answer from Box 1 and 2 that best describes the site and surrounding area. Write the number of points that corresponds to the description in the blank column.
3. Add the points from all statements in Box 3 that describes the site. (12 possible points)
4. Add the points for Boxes 1, 2, and 3. Compare total points to the risk level for the site.

LOCATION	DATE	
Box 1- Drainage Around Tank		Points for Box 1
Direct discharge *A large spill would flow into a piped system or a ditch that discharges to surface water or a flood plain*	**7 points**	
Indirect discharge *A large spill would flow across the ground toward surface water*	**3 points**	
Infiltration *A large spill would flow across or sink into the ground*	**1 point**	
Box 2- Presence of Surface Water *(within ¼ mile downslope)*		Points for Box 2
Small freshwater stream, wetland, closed basin, flood plain, or lake	**7 points**	
Large freshwater stream or river	**3 points**	
No fresh surface water	**1 point**	
Box 3- Bonus Points (total the points for all statements that apply to the site)		Points for Box 3
A spill would flow across the ground **and** the adjoining downslope property is agricultural or residential (non-ODOT)	**3 points**	
A spill would flow toward a protected waterbody (e.g. scenic waterway, reservoir, or significant community involvement)	**3 points**	
Property is not owned by ODOT	**3 points**	
A well is located onsite within 250' of tank or the property is located in a wellhead protection zone or groundwater restriction area.	**3 points**	
Risk Level for the Site		**Total Points**
14 - 26 points High	Secondary containment **must** be provided.	
9 - 13 points Medium	Secondary containment should be provided. Evaluate local conditions such as natural barriers and soil.	
2 - 8 points Low	Secondary containment is not required.	

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Specific guidance is provided on secondary containment by the Oregon DOT. Generally, containment must be able to hold 105% of the largest storage tank at the location. Secondary containment can vary from a low berm to cast-in-place concrete walls to eco-blocks with a spray in liner. Checking the secondary containment systems are a part of Oregon DOT's typical monthly inspection procedures, which includes ensuring the secondary containment method it is free of contamination or evidence of a spill, ensuring that all drainage control valves are operational and closed, and a visual inspection for any damage.

Truck Fill

A truck fill includes the pump, motor, and plumbing that transports liquid deicer from a storage tank to a truck which will apply the liquid deicer to a roadway. When determining appropriate pumps, motors, and piping for your operation's truck fill there are several things to consider including the unit being filled, flow rates, and worker safety.

What are you filling?

<table>
<tr>
<td>Saddle Tanks (0–500 gallons)
0–250 gallons, pre-wetting systems for granular
250–500 gallons, pre-wetting systems for granular, direct liquid application (DLA)</td>
<td> 
Source: Town of Lexington, MA Public Works</td>
</tr>
<tr>
<td>Direct Liquid Application (DLA) Units (500–5,000 gallons)</td>
<td> 
Source: Ohio Department of Transportation
 
Source: Town of Lexington, MA Public Works</td>
</tr>
<tr>
<td>Tow Units (500–1,000 gallons)
DLA
Shake & Bake use (dispensing salt from the spreader while a unit is trailering a liquid dispensing unit that is saturating the rock salt with salt brine at approximately 250 pounds of salt per lane mile wetted at 50 plus gallons per lane mile.) This process is quite effective as long as the agency has the ability to dispense heavy quantities of liquid to rock salt.</td>
<td> 

Source: West Des Moines, IA Public Works</td>
</tr>
</table>

Once your agency determines what type of equipment will be filled, the next step is to decide the best truck fill option based on funding and resources at the fill site.

Variable Flow Pumps

If you need to fill multiple sizes of truck tanks, variable flow pumps may be most effective. These pumps allow an agency to adjust the flow rate depending on the size of the unit being filled, which makes it possible to quickly fill both smaller and larger units; the pump increases or decreases the fill rate based on the truck's tank volume.

Pump capacity can range from 50 to 425 gallons per minute (GPM) based on the hose diameter. Suggested capacity based on the hose diameter is provided in Table 2. A 2-inch diameter fill hose is appropriate for tanks in the 150 gallons to 3,000 gallon range. A 3-inch diameter hose is recommended when filling tanks over 3,000 gallons.

Table 2. Capacity Based on Hose Diameter

Flow	2-Inch Hose Maximum Flow*	3-Inch Hose Maximum Flow*
Low Flow (Gravity – 20 PSI)	55 GPM	140 GPM
Average Flow (20-100 PSI)	127 GPM	273 GPM
High Flow (100+ PSI)	200 GPM	425 GPM

**NOTE: These are suggested the recommended rates to maximize liquid pumping while minimizing the risk of system failure.*

When determining fill hose diameter, it is important to remember the weight of that hose with liquid flowing through it. A 3-inch hose full of salt brine weighs around 36 pounds per 10-linear feet of hose (see Figure 13). For areas where a 3-inch hose is necessary, an agency may want to consider a mechanized unit or methods to assist with moving the hoses around (see Figure 14).

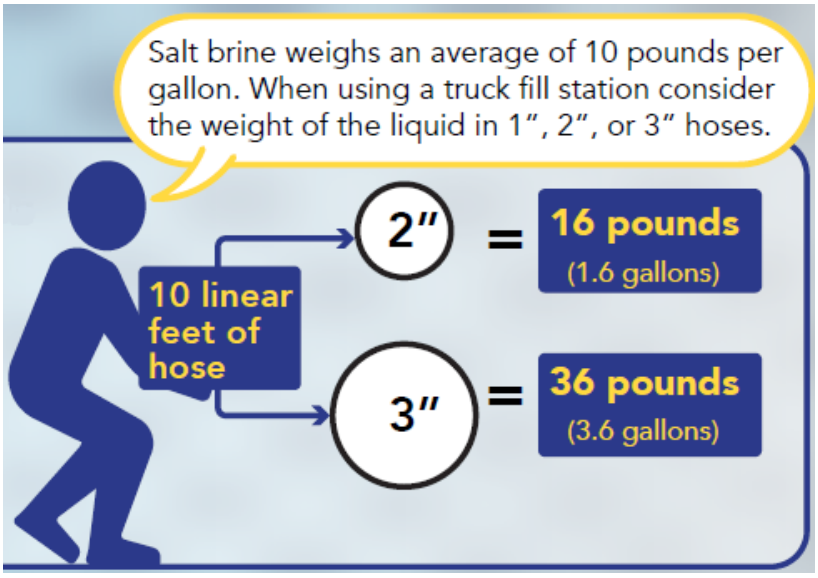


Figure 13. Safety Consideration—Hose Weight

Figure 14. Fill Point Hose Attached to Swing Gate (Source: Oregon Department of Transportation)

Your agency should work with the original equipment manufacturer (OEM) or supplier to assure that the hose diameter, requested pump flow rate, and pump size work in harmony with each other.

Additional Considerations

There are a few additional topics that need to be vetted when going through the selection process for a truck fill station, including the pump and motor material, if data is recorded, the number of fill stations needed, and power requirements.

Pump and Motor Material

Pump Impeller Housing and other guts to the unit need to be selected based on the overall budget. Consider if the pump is for short-term or long-term use, and if you need to have the capability to rebuild the pump or whether it will be thrown away when it fails.

High density polyethylene (HDPE) pumps have the benefit of being cheaper and having anti-corrosion properties, however these pumps are not effective if the liquid moving through the pump has too many solids or grit that will eat away at the parts and impede performance of the pump system.

Stainless steel pumps are an ideal choice to resist corrosion, and those made of 316 Grade stainless steel experience the least corrosion when exposed to acids and chlorides.

Data Recording

Some truck fill units have the ability to record data to track material usage. This data record can also track material use by an equipment identifier or operator identifier, which removes the need for operators to record this information themselves. An additional benefit is this data allows an agency to examine material use over time.

For locations where there are multiple agencies using a truck fill unit, a security pad that requires the entry of a vehicle or driver ID is recommended to document usage, especially if there is invoicing involved.

Things to consider when determining if you need data recording at the truck fill include:

- What data is already being collected by your agency (e.g., spreader control data collection, automatic vehicle locator (ALV) systems)? An additional data collection system may not be needed based on existing data collection systems.
- Are multiple agencies using the same truck fill? Multiple agencies pulling from the same truck fill have the most to gain by installing a data recorder: it can track, invoice, and audit each of the users independently.
- Is chloride use a concern for your agency? If your agency is working to reduce chloride use, tracking truck fill data may tell the story of usage over time.

How Many Truck Fill Stations Do You Need?

Another consideration when designing your liquid deicer storage and pump system is how many truck fill stations will you need at each specific location. Equipment varies significantly between and within agencies, so it is virtually impossible to have a one-size-fits-all recommendation.

The best option to accommodate a variety of equipment at a single location is to install a variable flow pump. With the ability to pump 10's of gallons to 100's of gallons per minute, this on-demand tool allows for smooth operation.

When determining how many truck fill stations your system will require, consider:

- How many units are filling from the location?
- How large are the tanks on each truck?
- What is the cycle time per truck?
- Is waiting time allowed in the agency?

All of these questions should be answered to determine the best truck fill operation for the specified location. If your design requires more than one unit, it could be built out over multiple seasons in a modular format. Ultimately, usage of the system and unit queue times will validate the need for expansion.

Site Power (Single Phase versus Three Phase)

The three most critical components of a salt brine operation are water, salt, and a power source.

Electricity is critical when talking about truck fill stations because there must be enough power to run the fill station pumps and motors. Specific questions to consider in the fill station design include:

- Does it need to be single phase or three phase power? Motors can be built either way, it is more based on what is available at the location. Also, when planning to add multiple units, consider early in the planning process whether there needs to be an upgrade to the electrical service.
- What are the startup AMPS for the pump motor? Same as above, can the current electrical service handle it or is an upgrade needed?

People who are proficient with electric pumps and working with dense liquids understand that the startup AMPS (initial bump of the impellor) are significantly higher than the operating amps. **Work closely with an electrician to make sure there is enough power at the source.**

Equipment Replacement Program

Storage Tank Life

Storage tank life is based on a myriad of factors but starts with tank material. The two most common tank materials are poly and fiberglass. Based on your geographic location you may find the cost of the tanks to be the same. Each material has pros and cons.

Storage Tanks

Life Span: 15-20 years

Factors to Consider:

- Indoor/Outdoor
- Covered/Protected
- UV Exposure
- Pressure Fluctuations
- Product density

Fiberglass tanks are less susceptible to damage from UV radiation, which will lengthen the life of the tank. There are size restrictions to fiberglass tanks as they are not a viable option under 10,000 gallons. Fiberglass tanks are also less prone to catastrophic failure. With the proper care and placement of a fiberglass tank, useful life approaches 20 years.

Poly tanks can last up to 20 years with proper care and maintenance. Poly tanks are prone to accelerated degradation when exposed to constant UV radiation. If the tanks are kept inside, their lifespan will increase considerably. This is also true for outdoor tanks if they are properly covered. Indoor tanks will also expand and contract on a much smaller level because the temperature fluctuations will not be as drastic as the outdoor freeze-thaw cycles of winter and the heat of summer.

A storage tank's life can be shortened due to pressure fluctuations from improper maintenance and cycling of fluids. It is important that the tank is properly ventilated during the warmer months to allow for expansion cycles.

A major oversight that can affect the life of a storage tank is improper specification. Make sure that the density of the liquid being stored is communicated to the tank vendor to ensure that the tank wall thickness is correct. All liquid deicers have different densities, so be conservative and prepare to store the densest liquid your operation may use in the future.

Truck Fill Life

Truck fill stations experience a number of challenges because they are constantly being cycled on and off for short periods of time. It is imperative that users understand the electric motor, pump shaft, and impeller will be under the greatest stress in the first 10–20 seconds of the process. The "startup" cycle of an electric motor requires much more energy to get the pump running than it does to keep them running. This means that short cycle times of fill stations put a lot of extra wear and tear on the pumps.

Truck Fill Stations

Life Span: 10–15 years before full replacement

Factors to Consider:

- Indoor/Outdoor
- Covered/Protected
- Usage
- Preventative Maintenance (PM)

Electric motor life will be longer if the motor is indoors or inside a covered storage area. Proper preventative maintenance will also extend the life of the motor. Unfortunately, the lifespan of the

motor unit is directly related to the initial investment in the unit. A properly specified self-contained and sealed motor housing will greatly increase its lifespan (up to 10 plus years in some cases). Less expensive motors will often have up to a 75% shorter lifespan.

Best Practice Example: Nebraska Department of Transportation

Nebraska Department of Transportation repurposed old railroad buildings for their pump houses (see Figure 14). These buildings insulate and protect the pump and motors from the elements. Additionally, they use a pump house heater to prevent freezing during harsh conditions.

Figure 15. Nebraska DOT Tank Farm and Pump House Utilizing Old Train Sheds

Pumps are similar to motors: you get what you pay for. They will last a lot longer if they are constructed for a highly corrosive environment and have extra thought taken into the type of materials used with respect to impellers, housings, and shafts. Chlorides in deicers create a harsh environment and if they are not taken into consideration the pumps may only last two seasons. Preventive maintenance is where the life of the pump can be drastically increased. In the off season, pumps should be cleaned and left in a state in accordance with manufacturer's specifications, such as submerged in an anti-corrosion liquid to prevent rusting from exposure to air.

> Many agencies utilize RV anti-freeze or windshield washer fluid to prevent their pumps from rusting.

When thinking about the initial investment into pumps and motors, it is a good idea to think about whether the units can be rebuilt. Good quality pumps and motors can be rebuilt for a fraction of the cost of a new unit. For example, if a pump needs a new coil, it can be replaced at a local electric motor shop. If a pump has lost its flow capacity and needs a new impeller, which is a quick and easy repair which could be completed by your in-house staff.

Pump and motor combination systems may be readily available and can likely be purchased locally. However, be prepared for shorter lifespans and always have an extra on the shelf. Initially, they may be a cheaper investment, but over time, they will cost more due to their shorter lifespan.

The other components of a truck fill station may last up to 15 years if properly maintained. During pre-season and post-season inspections, you may find a valve that is not moving correctly and might fail within five seasons. Hoses will last for 10–15 years on average, as long as they are not left outdoors and exposed to extended UV radiation during the off season. Hoses indoors will last longer than outdoor and the hoses that are picked up, handled, dropped, or driven over will have a shorter life span.

Maintenance and Inspection

Routine Inspections & Inspection Checklist

Liquid deicer storage and pump systems that include storage tanks, truck fill unit(s), and potentially a brine manufacturing unit need to be treated like any other piece of capital equipment—they require maintenance. This should include routine inspection and repairs when warranted. Otherwise, be prepared for failure. A preventative maintenance program with plenty of eyes looking for major issues will keep the system operating smoothly and need only minor repairs.

Routine inspections of the liquid deicer storage and pump system involve regularly checking for leaks and other issues, which allows for timely reporting of issues as they occur. Generally, most agencies will complete a full inspection before the winter season and again in the spring. Additional periodic checks of the system help agencies proactively catch issues as they arise instead of reacting to major issues.

An inspection checklist ensures that staff document and complete their inspections in a consistent manner. An example inspection checklist has been developed for systems with and without a brine making unit (see Follow the Liquid System Inspection Checklist). The checklist walks users through each piece of the system and provides examples of *things to look for*. The checklist is methodical and deliberate and is designed to ensure that the inspector put eyes on each component in the system.

Standalone editable versions of these checklists are also available for download at https://www.clearroads.org/project/22-02/. They include customizable and printable versions that may be adapted for any agency.

In addition to the inspection checklist, a list of methods to test poly tank condition is provided in Tank Condition Testing Methods.

Follow the Liquid System Inspection Checklist

See Appendix A: Follow the Liquid Inspection Checklist for Systems Without a Brine Making Unit for systems without a Brine Unit.

Liquid Deicer Storage & Pump System Inspection Checklist

(equipped with a brine unit)

Inspection Completed By: _____ Date: _____

Location: _____ Inspection: **Pre**-Season ☐ **Mid**-Season ☐ **Post**-Season ☐

Feed Line from Brine Unit	OK	Minor Issues	Major Issues	N/A	**Comments:**
Is anything leaking? If yes, please describe where.	☐	☐	☐	☐	
FITTINGS – *Check for tight, rusted, and/or frozen fittings.*	☐	☐	☐	☐	
Lubricate FITTINGS ***(Post-Season & As Needed)***	☐	☐	☐	☐	
VALVES – *Check for tight, rusted, and/or frozen valves.*	☐	☐	☐	☐	
Lubricate VALVES ***(Post-Season & As Needed)***	☐	☐	☐	☐	
HOSE & PIPING – *Check for cracking, weathering, and/or oxidization.*	☐	☐	☐	☐	
FLEXIBLE HOSE – *Check for anything rubbing against it when pressurized and for sharp edges.*	☐	☐	☐	☐	
RIGID PIPING – *Check for broken or rusted pipe supports.*	☐	☐	☐	☐	
HEAT TAPE INSULATION – *Check for rips or tears. Is the tape is still working and adequate?*	☐	☐	☐	☐	
AIR PURGE – *Does it work?*	☐	☐	☐	☐	
AIR PURGE – *Is the system purged?* ***(Post-Season)***	☐	☐	☐	☐	

Brine Tank	OK	Minor Issues	Major Issues	N/A	**Comments:**
INTAKE FITTING – *Check for tight, rusted, and/or frozen fittings.*	☐	☐	☐	☐	
VALVES – *Check for tight, rusted, and/or frozen valves.*	☐	☐	☐	☐	
ACCESS PORT – *Is it accessible and weather tight?*	☐	☐	☐	☐	
STORAGE TANK – *Is the TANK breathable? Is the PRESSURE PORT functioning?*	☐	☐	☐	☐	

					Comments:
STORAGE TANK – *Check whether the tank is **clean** or full of solids? Does it need to be cleaned?*	☐	☐	☐	☐	
STORAGE TANK – *Are there **visible stress cracks or discolorations** on the tank?*	☐	☐	☐	☐	
STORAGE TANK – *Check tank for **bulging or other deformations.***	☐	☐	☐	☐	
SIGHT TUBE – *Check for leaking and/or oxidation.*	☐	☐	☐	☐	
LIGHTING – *Check the bulbs, are they working?*	☐	☐	☐	☐	
OUTLET PIPING – *Check the piping for cracks, weathering, and/or oxidation. Is it rubbing against anything?*	☐	☐	☐	☐	
IF STORING ADDITIVES – *Has the tank been recirculated?*	☐	☐	☐	☐	

Truck Fill	OK	Minor Issues	Major Issues	N/A	Comments:
Is anything leaking? If yes, please describe where.	☐	☐	☐	☐	
FITTINGS – *Check for tight, rusted, and/or frozen fittings.*	☐	☐	☐	☐	
Lubricate FITTINGS ***(Post-Season & As Needed)***	☐	☐	☐	☐	
VALVES – *Check for tight, rusted, and/or frozen valves.*	☐	☐	☐	☐	
Lubricate VALVES ***(Post-Season & As Needed)***	☐	☐	☐	☐	
HOSE & PIPING– *Check for cracking, weathering, and/or oxidization.*	☐	☐	☐	☐	
FLEXIBLE HOSE– *Check for anything rubbing against it when pressurized and sharp edges.*	☐	☐	☐	☐	
RIDGID PIPING– *Check for broken or rusted pipe supports.*	☐	☐	☐	☐	
HOSE & PIPE SIZE– *Is it manageable for staff to handle without risk of injury (is it too heavy when full of liquid)?* ***(Pre-Season)***	☐	☐	☐	☐	
AIR PURGE – *Does it work?*	☐	☐	☐	☐	
AIR PURGE – *Is the system purged?* ***(Post-Season)***	☐	☐	☐	☐	
PUMP – *Is the pump flushed of corrosive product and filled with protective liquids for the off-season?* ***(Post-Season)***	☐	☐	☐	☐	

Tank Condition Testing Methods

Beyond a visual inspection of storage tanks, there are several poly tank testing methods that can be used to further examine the condition of poly tanks.

Water Testing: Damage may occur to the storage tank during shipment. Once a new tank is placed in its final location and all attachments have been installed, it is recommended that you fill the tank with *water* first in order to check for leaks.

Reading the Cracks: This method includes examining the tank for any cracks or crazing (fine lines). Common stress points include fittings, impact points, the top of the tank, and around the bottom edge of the tank (see Figure 16, Figure 17, and Figure 18).

Figure 16. Poly Storage Tank Crack Leaking Deicer (Source: Maine DOT)

Figure 17. Poly Tank Split at Flange (Source: Massachusetts DOT)

Figure 18. Pinhole Leak on Poly Tank (Source: Massachusetts DOT)

Tank Scrape Test: Maine Department of Transportation tests tank condition by scraping the tank with a screwdriver. If a powdery material is scraped off, then the tank may be suffering from deterioration. These tests are typically done where the tank sees the most damage from any UV radiation and/or weather (e.g., the top of the tank near the dome or the side of the tank more exposed to the weather).

Marker Test: The Marker Test can be used to inspect a specific area on the tank. In this test, a water-soluble marker is used to fill in a small area of concern. Before the marker dries, excess ink is wiped off with a cloth. Stress cracks will remain black after the excess ink removed.

Light Test: The Light Test can be used to inspect the entire tank; however, it is not as effective on larger tanks. In this test method, product is removed from the tank and a light is lowered into the tank, then the entire tank is examined for stress points (fine webs or lines), which will show up as areas of different light intensity.

Baseball Bat Test: The Baseball Bat Test can be used to verify damage to areas identified in other tests. For this method, all product is removed from the tank. A bat is used to strike that area where stress cracks are observed, tank sides, or areas that receive the most sunlight and/or weather. The tank should flex and rebound. After testing with a bat, the tank should be rechecked for cracking.

Storage Tank Repairs

If you find cracks or leaks on your storage tank, a repair may be possible depending on the severity. However, this may not be a long-term solution. Reach out to your storage tank manufacturer for guidance and suggestions on how to handle repairs.

Recirculation of Material Stored in Tanks

Deicer material stored in tanks should be periodically recirculated. This is particularly true for deicer products that contain fines or insolubles or contain blended chlorides or organic components. This is done because each product has a different weight (density) and can fall out of suspension and stratify in the tank or create a build up at the bottom of the tank if it is not recirculated. Circulation from the bottom to the top of the tank is recommended.

Best Practice Example: Maine Department of Transportation

Maine Department of Transportation has their maintenance shops complete a monthly building inspection that includes recirculating any liquids in the storage tanks. The time required to recirculate the material varies depending on the size of the pump, so Maine provides the following formula to determine how long to circulate material.

# of gallons in the tank / pump gallons per minute = circulation time

It is then recommended that an additional 15 minutes is added to ensure proper mixing.

Size	Gallons Per Minute
¾ HP Motor/Pump	30 GPM
1.5 or 2 HP Motor/Pump	55 GPM
5 HP Motor/Pump	100 GPM

Storage Tank Cleaning

To clean out debris at the bottom of the storage tanks, agencies commonly to use a vactor truck and pressure washer (see Figure 19). One benefit of fiberglass tanks is that they commonly have a manhole on the side that can be utilized for ease of cleaning.

Some agencies outsource tank cleaning to a contractor, such as a septic or environmental cleaning company. Hiring out the cleaning reduces the need for equipment like a vactor truck.

Many agencies clean their empty storage tanks out at the end of each season. The South Dakota Department of Transportation Sioux Falls Area cleans out their brine maker roughly every 30,000 gallons of brine or when they start to see diluted brine coming out of their brine maker.

To reduce the frequency of tank cleaning, consider using a cleaner brining salt, such as a solar salt. Solar salts can be more expensive when compared to conventional mined salt but the cost savings from reduced cleanings may offset the upfront cost.

Figure 19. Poly Storage Tank Cleaning (Source: City of Farmington Hills, MI)

Air Purging Hoses

The City of Farmington Hills, Michigan uses air to purge liquids out of their fill point hoses that fill the tanks. This idea was taken from an organics supplier who used air to clean out and purge supply hoses

from the truck to the storage tanks. In their design, all supply lines to the fill points have one-way valves to prevent back flow of liquids and prevent contamination of other liquids while utilizing the air purge system (see Figure 20). The City of Farmington noted that the air purge system needs to be watched carefully, because too high of air pressure or too much air into the supply tanks can be detrimental to the whole system. To prevent damage, ensure that your fill tanks have adequate venting. The air purge system is very helpful for 2 and 3-inch fill point hoses, which can get very heavy when filled with liquids. Typically, operators will use approximately ¼ of the air volume and watch and listen for bubbles to verify the air is all the way through the fill hoses. They will then slowly, carefully open the fittings to let the air bleed out of the fill hoses.

Figure 20. City of Farmington Hills—Air Purge for Fill Hoses (Left) and One-Way High Flow Valves (Right); (Source: City of Farmington Hills, MI)

End of Season Maintenance for Pumps and Motors

Typical end of season maintenance for pumps and motors includes flushing out the pump with water and using a salt neutralizer. Some agencies will use a corrosion preventative like RV antifreeze or windshield washer fluid in their pumps for summer storage.

Additional maintenance for pumps and motors can include things like taking apart the pump to clean and examine parts for damage and restoring paint to reduce exposed metals, which are prone to corrosion.

System Repairs

System repairs happen and it is necessary for an agency to be prepared to handle these repairs quickly and efficiently, so they do not disrupt winter options. Preparation includes having the parts necessary for repairs or the ability to quickly obtain these parts. Most local maintenance depots will keep a stock

of parts on hand in case of emergencies, these parts generally include hoses, clamps, fittings, and other items that may be difficult to obtain quickly in an emergency. Several agencies will also keep parts on hand at a more centralized level which can serve several maintenance depots. A central store of parts will generally include larger items like pumps and motors in addition to everyday needs. It may be beneficial for local maintenance depots to use similar parts (e.g., consistent brands, consistent pump and motor sizes) to allow for ease of repairs across several locations.

Some agencies (Maine DOT and Massachusetts DOT District 3) have found that having a single person who handles repairs and conducts regular maintenance ensures that their liquid deicer storage and pump systems are maintained in a consistent manner, eliminates downtime, and has allowed for growth in their operations with minimal failures.

Best Practice Example: Regional or Statewide Maintenance

Maine DOT has a statewide Snow & Ice Supervisor who travels around the state managing the repair and maintenance of the liquid deicer storage and pumping systems. This position also handles contracting and purchasing of storage tanks and materials, plumbing on storage tanks, and motor and pump work. In the winter the Snow & Ice Supervisor will travel onsite to repair or replace systems as needed. During the summer, the Supervisor plans out maintenance activities with a goal of visiting each location every other year for inspections. Locations are prioritized based on an inspection checklist that is completed by transportation workers at each site. This statewide Snow & Ice Supervisor position is unique, and Maine DOT has found that it reduces the number of people who are repairing and maintaining the systems. This has ensured that maintenance and repairs are completed in a consistent manner and reduces challenges, such as having the necessary tools and parts, and is a good use of time and resources.

Similar to Maine DOT, Massachusetts DOT District 3 has a single maintenance person who repairs and maintains all liquid deicer storage and pumping systems. They have found that the fewer people who touch these systems, the fewer issues they have. The maintenance person checks the liquid deicer storage and pumping systems in the spring and fall. At District 3 a single shed is used to house spare parts for repairs and if something goes wrong at a depot, the maintenance person will take parts to the depot and complete the repair.

A suggested list of parts to keep on hand at both the depot and central level is provided in The “911 Box” (Suggested List of Supplies for Agencies).

This list of supplies is provided as a standalone editable document that can be downloaded at https://www.clearroads.org/project/22-02/. This is a handy document to customize because each agency’s list of on-hand parts may differ slightly depending on operations, distance from a central facility, and distance from a parts vendor.

Best Practice Example: Maine Department of Transportation

At the Maine DOT maintenance shop, the Snow & Ice Supervisor keeps spare pump and motor setups mounted to metal plates in case of emergencies (see Figure 17). This allows the Supervisor to efficiently swap out a failing pump or motor, then take the broken system back to the maintenance shop for repairs. Repairs will include taking the system apart, repairing any broken components, sandblasting, and repainting.

Figure 21. Pump and Motor Setup (Source: Maine DOT)

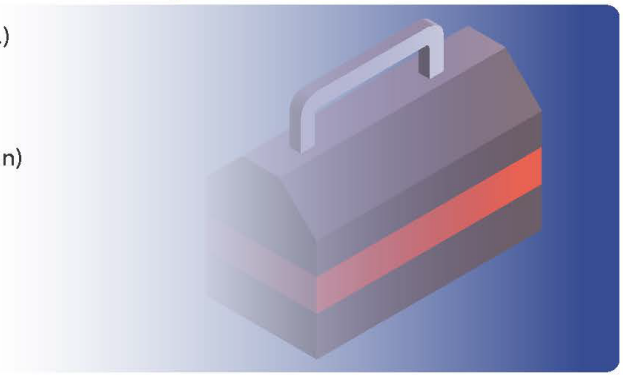
The "911 Box" (Suggested List of Supplies for Agencies)

THE "911 BOX"

Recommended Parts & Supplies to Keep On Hand

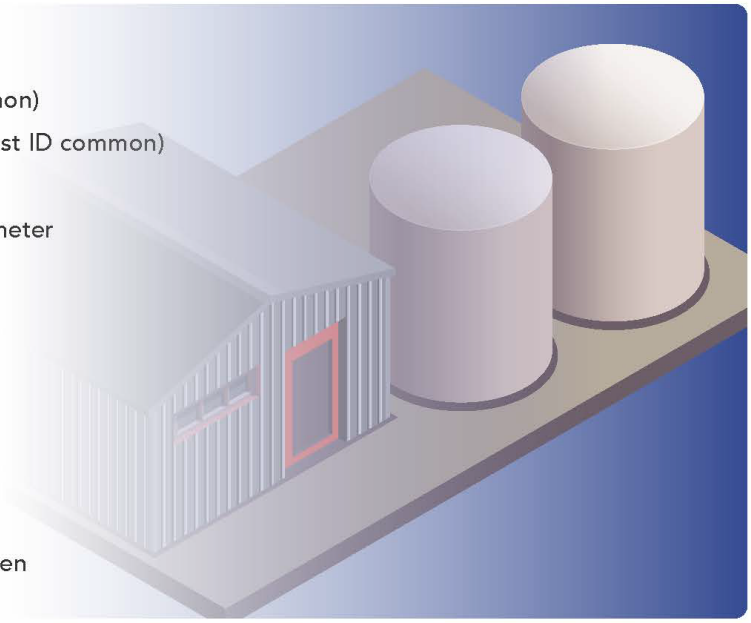
Local Depot (assume 2 tanks & 2 truck fills)

- 20 LF hose for tank (3" inside diameter (ID) min.)
- 20 LF hose for truck fill (1.5" ID min., 2" & 3" ID most common)
- 20 LF hose for brine system (2" ID most common)
- 2 EA fittings for each diameter
- 4 EA pressure clamps for each diameter
- 4 EA gaskets for each diameter
- 2 EA valves for each diameter



Central Maintenance Facility (serving 4-6 depots)

- 200 LF hose for tank (3" ID min.)
- 200 LF hose for truck fill (1.5" ID min., 2" & 3" ID most common)
- 200 LF hose for brine system (2" most ID common)
- 10 EA fittings for each diameter
- 40 EA pressure clamps for each diameter
- 40 EA gaskets for each diameter
- 10 EA valves for each diameter
- 2 EA truck fill pumps
  - new or remanufactured
- 2 EA truck fill motors
  - new or remanufactured
- 1 FULL truck fill station ready to go
  - This unit can be the "Loaner" when the issue is unknown to staff.



NOTE:

- The parts can vary based on storage capacity at each location and proximity to a Central Facility, for example a remote depot may carry a pump and motor to reduce downtime.
- Each agency should consider what duration of downtime is considered acceptable. This will help determine the amount of investment in parts for each location.

Safety Considerations

Working in winter maintenance, and particularly working with liquid deicer storage and pump systems, can be dangerous. A safety considerations flyer has been developed that describes several safety items to consider while working with these systems (see Figure 22), including:

- Personal protective equipment (PPE) to keep on hand
- Lock out/tag out
- Pinch points
- Lifting and handling equipment, including reminders on how much a fill point hose can weigh when it contains liquid
- Systems under pressure
- Sharp edges
- Slippery conditions
- Confined spaces

This checklist is provided as a standalone document which can be downloaded at https://www.clearroads.org/project/22-02/.

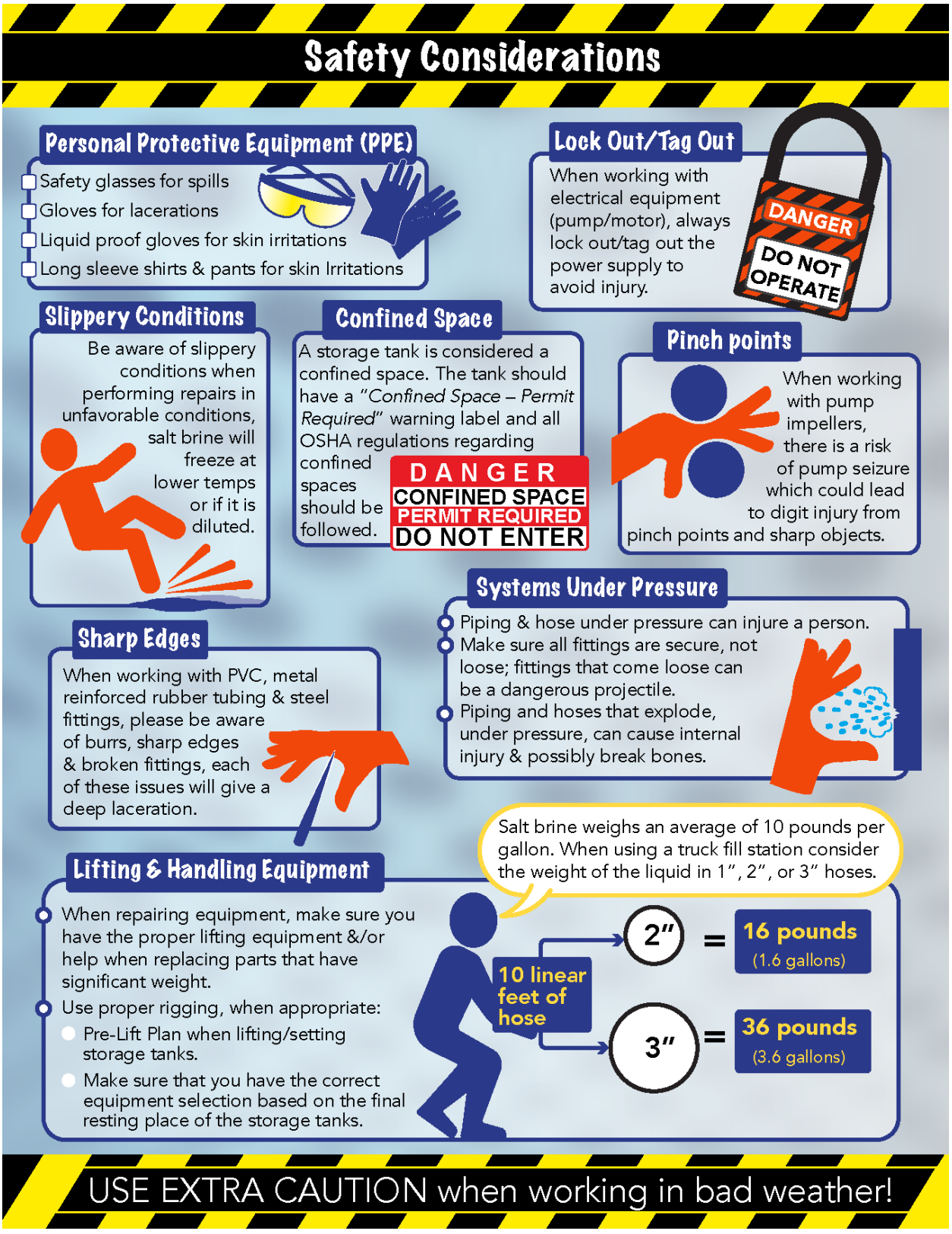


Figure 22. Safety Considerations

Case Studies: System Options from Starting Out to More Advanced

This section highlights typical liquid deicer storage and pump system options ranging from "starting out" or basic to more advanced. Each option provides general information on typical equipment, what an agency could expect to get out of that system, general cost, typical personnel and training requirements, and a discussion of steps to take your system to the next level.

System costs are generalized using the following categories as $ ($0 to $5,000), $$ ($5,000 to $20,000), $$$ ($20,000 to $40,000), and $$$$ (greater than $40,000).

A quick overview of system options is provided in Table 3.

Table 3. Liquid Deicer Storage and Pump System Options

Features	Basic	In-Between	More Advanced
Cost	$	$$	$$$ - $$$$
Storage Capacity	Every agency looks at storage capacity differently, so is no one-size-fits-all storage capacity recommendation. The storage capacity will depend on level of service, budget, available space, and future expansion plans.		
Valves	Simplistic Ability to isolate at each tank and isolate pump from tanks.	More Complex Every tank can be isolated from each other and truck fill.	More Complex Every tank can be isolated from each other and truck fill.
Pump/Motor Construction	Plastic, Limited Life/Disposable	Stainless Steel, Rebuildable	Stainless Steel, Rebuildable
Truck Fill	Off-the-Shelf Truck Fill Pump, 1 Flow Rate	Truck Fill with Manual Blending, 1 Flow Rate	Truck Fill with Automated Blending, Variable Flow Rates
Number of Truck Fills	Single	Multiple	Multiple
Variable Flow Pump Capabilities	No	Fixed with Options (50, 100, 200 GPM)	Yes (50—200 GPM)
Brine Blending Capabilities	Manual Blending	Manual Blending	Automated Blending—Stack & Real-Time On-Demand
Data Recording Capabilities	No	No	Yes
Remote Support	No	No	Yes
Training Requirements	Minimal	Requires Attention, Trained Brine Maker	Enhanced Training, OEM Training Support

Starting Out

Each agency, whether it is a state DOT or municipality, has a myriad of variables that are used to determine level of service (LOS) guidelines. Considering your agency's LOS guidelines, the next question to consider is how are you using liquid deicers to achieve your LOS? This will help you determine how much liquid deicer you plan to use and, therefore, need on hand.

What Am I Starting With?

Perform an audit of the winter liquid program and determine what is available to the operation right now without any capital investment. How many AMPs are left in the electrical service of the depot? What is the water source at the depot? What is the real estate available for tanks and a truck fill station? Can a system be modified to make it more useful for the operation?

What Do I *Want* vs. What Do I *Need*?

Wants and needs are very different for each agency because it all goes back to the LOS. It is always helpful to know what your agency wants, or what the ultimate operational goal looks like, for the agency. However, that is *not* what the agency needs to successfully maintain its LOS. It is strongly encouraged that you send staff to trade shows and conferences to understand the differences between *wants* and *needs*. These types of events will help your agency make the best decisions to maintain LOS or provide a solution to enhance the LOS. Keep in mind that "one shoe doesn't fit every foot," so networking with other agencies, colleagues, and vendors will allow your staff to find the best solution for the agency with whatever funding is available.

Typical Equipment

Examples

- Basic (see Figure 23)
    - 250-gallon toter and centrifugal pump
    - This is as simple as it gets
    - Agitation pump acts as brine pump and truck fill
    - Tote acts as brine hopper and storage tank
    - One flow rate for truck fill

Figure 23. Liquid Toter and Centrifugal Pump (Source: Alaska DOT&PF)

- Basic Plus (see Figure 24)
  * Asterisk denotes improvements from the basic example.
    - Single liquid system—no blending capabilities*
    - Storage tank(s)—up to 2*
    - Truck fill pump purchased off the shelf with On/Off*
    - One flow rate for truck fill
    - Recommended that tanks are connected so they "act as a single tank"*
    - Simplistic valve systems*
        - Ability to isolate at each tank and isolate pump from tanks

Figure 24. Oregon Department of Transportation Tank Farm, The Portland Metro Area maintenance yard pilot tested the use of salt brine in the 2023-2024 winter season.

Expectations

A Basic or Basic Plus system will provide the bare essentials of salt brine applications. An agency that uses the Basic or Basic Plus will have the ability to manufacture salt brine, store salt brine, and fill salt brine application units.

Cost: $

Personnel Requirements & Training

The Basic Systems require minimal training to operate and maintain the unit. The system is simplistic and operates similarly to a dewatering pump that is used in other facets of the industry. Extra attention is required when filling the trucks because there are no shut-off or overflow alarms; turning off the pump is based on visual inspection only. Excessive overfilling could place extreme pressure on the tanks and cause failure, especially if the bleed valve is not functioning. The rate of flow could also rupture the tank while filling: do not fill too much liquid too soon.

Next Steps

There is nowhere to go but UP! Refer to your *wants* list and start planning. It is best to think in terms of a roadmap and getting where you want to go, year after year. Plan deliberately and try to build a modular system that can be constantly improved and modified as funding allows.

In-Between

Typical Equipment

Examples

- Average (see Figure 25)
    - Two liquid system—manual blending capabilities
    - Storage tanks—up to 4
    - Valves—every tank can be isolated from other tanks and truck fill
    - Truck fill system with manifold for blending
        - Manual Blending Capabilities—operator gauges proportions by visual liquid levels or timing based on pump flow
        - "Manual Stack Blending" like a double cheeseburger: brine, additive, brine, additive
        - One flow rate for truck fill

Figure 25. Kansas DOT Tank Farm Utilizing Fiberglass Tanks (above). Kansas DOT will manually blend as needed and is uses a truck fill with a single flow rate. The fiberglass tanks have a port at the center of the base of the tank that is used for mixing or recirculation of materials (bottom left). The port has three peri jets inside the bottom of the tank to help circulate material (bottom right)

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- Average Plus
  * Asterisk denotes improvements from the average example.
    - Three liquid system with micro ingredient (e.g. anti-foaming agent)—manual blending capabilities*
    - Storage tanks—up to 6*
    - Valves—every tank can be isolated from each other and truck fill
    - Truck fill system with manifold for blending
      - Manual Blending Capabilities—Operator gauges proportions by visual liquid levels or timing based on pump flow
      - "Manual Stack Blending" like a double cheeseburger: brine, additive, brine, additive
      - One flow rate for truck fill
    - This type of system requires a lot of attention and, for the most part, has been replaced by automated systems*

Expectations

An Average truck fill system will provide an agency with the simple tools to fill liquid deicers for its fleet. It can fill straight chlorides or perform basic blending of additives by means of simple valving and multiple tanks. The liquid proportions are very simplified and are determined by visual means or timing the flow of the liquid to determine the volume dispensed. This method is referred to as "Stack Blending", like a Cheeseburger. Fill the additive and add salt brine. As it is loaded it blends itself, especially after the truck gets onto the road and the liquid and additive combination moves around in the tank.

For smaller agencies or depots, the staff may premix the products and fill a "Mix" or "Blend" tank, so the operator only has to back up and fill. This system adds to the complexity of the piping and valves but can be quite effective for staff under time constraints. The key is having enough storage capacity to meet deicing needs during a snow and ice event unless a staff member is actively mixing the products during the event. Pumps on these units run at a constant rate of anywhere from 50 GPM—200 GPM. Pump flow must be paired with the volume of the tanks being filled.

An Average Plus system has all the capabilities of an average system with the addition of options like mixing more ingredients. In an Average Plus system, a series of valves is used to blend two or more ingredients, but a great deal of attention must be taken to ensure that the proper blend is created. Prior to automated blending, some agencies utilized "Blend Shacks" to create winter cocktails like the Super Mix, which is 85% Salt Brine, 10% Organic, and 5% Calcium Chloride. These systems require a true Lead Brine Staff member that dedicates a lot of attention to assuring the proportions are correct. These systems use blend tanks to store the cocktails, which are proportioned by estimating the available tank capacity and manually opening and closing valves. The blend tanks are filled to the appropriate volumes based on manual- or computer-based calculations. As some agencies improve their system, they may want to skip this step and move on to an automated system (see More Advanced).

Cost: $$

Personnel Requirements and Training

The Average and Average Plus systems require attention when blending. There are a lot of moving parts in these systems, and lots can go wrong when the valves are opened and closed during mixing or filling.

Brine Staff are trained to manage the system. There should always be more than one trained staff member who understands and can handle the many working parts that may become problematic without the proper training.

Next Steps

When agencies are working with Average or Average Plus units, they have likely built them out of a previous, simplified operation. Most of these units are built, over the years, like a “Frankenstein”. There are some benefits to operating such systems; they provide a great learning opportunity for staff, who develop an understanding of the units on a detailed level. They also have challenges: these units often require more repairs, more maintenance, and more care because equipment can be temperamental. These units are a great segue between a basic and an automated system because users will respect and appreciate the technology more.

More Advanced

Typical Equipment

Examples

- Advanced
    - Two or three liquid system with micro ingredient—automated blending
    - Storage tanks—2 to as many as needed
    - Valves—every tank can be isolated from each other and truck fill
    - Automated truck fill system
        - Blending—stack on-demand blending (cheeseburger style)
            - System has programed blends in the form of percentage of each product, totaling 100%
            - Touchscreen system is a simple On/Off, Start/Stop, and Volume controls for operator
            - Data logging capabilities by date, event, and truck/operator
            - Remote login interface—ability to control the unit from desktop or mobile device
            - Cellular remote access for troubleshooting from OEM
            - Truck fill rate options (e.g., 100 GPM or 200 GPM)
- Advanced Plus

  * Asterisk denotes improvements from the advanced example.
    - Two or three liquid system with micro ingredient—automated blending
    - Storage tanks—2 or more
    - Valves—every tank can be isolated from other tanks and truck fill
    - Automated truck fill system
        - Blending—stack on-demand blending (cheeseburger style)
            - System has programed blends in the in form of percentage of each product, totaling 100%
            - Touchscreen system is a simple On/Off, Start/Stop, and Volume controls for operator
            - Data logging capabilities by date, event, and truck/operator
            - Remote login interface—ability to control the unit from desktop or mobile device
            - Variable truck fill rate options based on operator/truck (e.g., 50 GPM to 300 GPM based on equipment holding tanks)*
- Advanced Premium (see Figure 26)

  Asterisk denotes improvements from the advanced plus example.
    - Two or three liquid system with micro ingredient—automated blending
    - Storage tanks—2 or more
    - Valves—every tank can be isolated from each other and truck fill
    - Automated truck fill system
        - Blending—real-time on demand blending*
            - System has programed blends in the in form of percentage of each product, totaling 100%

- Touchscreen system is a simple On/Off, Start/Stop, and Volume controls for operator
- Data logging capabilities by date, event, and truck/operator
- Remote login interface—ability to control the unit from desktop or mobile device
- Variable truck fill rate options based on operator/truck (e.g., 50 GPM to 300 GPM based on equipment holding tanks)*

Figure 26. City of Farmington Hills, MI Indoor Liquids Facility (Source: City of Farmington Hills, MI) has an indoor truck fill with two fill points (top left), storage tanks and brine maker (bottom left), and storage tank plumbing (right). City of Farmington Hills, MI uses MP pumps on "stacked" three product fill point systems, as well as their brine making system.

Expectations

Most agencies that have made the decision to invest in advanced systems are industry leaders with many years of experience. They have already worked with, and outgrown, an average system and are looking to improve their program. There is also a small percentage of agencies that investigated all the system options and realized that starting with an advanced system will make their operation and maintenance easier. One of the biggest benefits of advanced systems is that they create an easier environment for the operations staff. Another benefit is that these systems collect data for managers to

document material use by operator, truck, event, day, or month (see Figure 27), which helps agencies that are invested in chloride reduction programs.

Advanced units may also reduce the oversight and supervision required to ensure that the operations staff are using the correct products, especially if they are using blends. An advanced system gives supervisors the ability to develop custom cocktails for operators, trucks, or regions, which staff can then fill through a remote interface system. The remote interface also allows for the original equipment manufacturer (OEM) to remotely log into the system to troubleshoot the units and provide routine updates as needed (see Figure 27).

Figure 27. City of Farmington Hills Login Interface That Allows Data Recording for Vehicle, User, and Product or Blend (Left) and Automated Blending of Three Products with Anti-Foaming Agent (Right; Source: City of Farmington Hills, MI)

Advanced systems do have a level of complexity with respect to software. However, the operations benefits outweigh the potential issues that could arise.

Variable flow (VF) pumps are one of the most beneficial options in an Advanced system, particularly for agencies with a variety of tank system capacities. In an Advanced system, the software can recognize a specific truck when it gets to the fill station, and knows the maximum flow allowed for such a unit based on the data input by the agency. For example, the system will fill a 100-gallon tank at 50 GPM while it will fill the 450-gallon tank at 200 GPM. Enhancements like this create continuity for the operations staff since filling either size tank requires the same amount of time. Any enhancement that contributes to a consistent flow in operations is easier on staff and may alleviate underlying feelings of resentment about the inconvenience (i.e. additional time required) of filling a tank at a slower rate.

In larger depots, it is recommended to have multiple truck fill stations for efficiency and redundancy. For agencies that rely heavily on deicing liquids and have committed to not place any granular products onto the pavement without pre-wetting, it is prudent to have redundancy in the operation. Always have a backup method of filling.

Cost: $$$-$$$$

Personnel Requirements and Training

Choosing to install a more sophisticated truck fill system and tank farm comes with enhanced personnel requirements and training. Thankfully, the OEMs that represent such Advanced units offer training programs. It is imperative that staff understand the units and know when to reach out to the OEMs for assistance. Using the remote interface system to troubleshoot will help in these situations.

Next Steps

When agencies are in the Advanced category with their winter liquids equipment, they are looking at what will only enhance a super system. Some OEMs go to great lengths to build their equipment with modular construction in mind, which allows agencies to replace or enhance what they need instead of investing in an entirely new system.

Appendix A: Follow the Liquid Inspection Checklist for Systems Without a Brine Making Unit

Liquid Deicer Storage & Pump System Inspection Checklist

Inspection Completed By: _____ Date: _____

Location: _____ Inspection: **Pre**-Season ☐ **Mid**-Season ☐ **Post**-Season ☐

Brine Tank	OK	Minor Issues	Major Issues	N/A	**Comments:**
INTAKE FITTING – *Check for tight, rusted, and/or frozen fittings.*	☐	☐	☐	☐	
VALVES – *Check for tight, rusted, and/or frozen valves.*	☐	☐	☐	☐	
ACCESS PORT – *Is it accessible and weather tight?*	☐	☐	☐	☐	
STORAGE TANK – *Is the TANK breathable? Is the PRESSURE PORT functioning?*	☐	☐	☐	☐	
STORAGE TANK – *Check whether the tank is **clean** or full of solids? Does it need to be cleaned?*	☐	☐	☐	☐	
STORAGE TANK – *Are there **visible stress cracks or discolorations** on the tank?*	☐	☐	☐	☐	
STORAGE TANK – *Check tank for **bulging or other deformations.***	☐	☐	☐	☐	
SIGHT TUBE – *Check for leaking and/or oxidation.*	☐	☐	☐	☐	
LIGHTING – *Check the bulbs, are they working?*	☐	☐	☐	☐	
OUTLET PIPING – *Check the piping for cracks, weathering, and/or oxidation. Is it rubbing against anything?*	☐	☐	☐	☐	
IF STORING ADDITIVES – *Has the tank been recirculated?*	☐	☐	☐	☐	

Truck Fill	OK	Minor Issues	Major Issues	N/A	**Comments:**
Is anything leaking? If yes, please describe where.	☐	☐	☐	☐	
FITTINGS – *Check for tight, rusted, and/or frozen fittings.*	☐	☐	☐	☐	
Lubricate **FITTINGS** ***(Post-Season & As Needed)***	☐	☐	☐	☐	
VALVES – *Check for tight, rusted, and/or frozen valves.*	☐	☐	☐	☐	
Lubricate **VALVES** ***(Post-Season & As Needed)***	☐	☐	☐	☐	
HOSE & PIPING – *Check for cracking, weathering, and/or oxidization.*	☐	☐	☐	☐	
FLEXIBLE HOSE – *Check for anything rubbing up against it when pressurized and sharp edges.*	☐	☐	☐	☐	
RIGID PIPING – *Check for broken or rusted pipe supports.*	☐	☐	☐	☐	
HOSE & PIPE SIZE – *Is it manageable for staff to handle without risk of injury (is it too heavy when full of liquid)?* ***(Pre-Season)***	☐	☐	☐	☐	
AIR PURGE – *Does it work?*	☐	☐	☐	☐	
AIR PURGE – *Is the system purged?* ***(Post-Season)***	☐	☐	☐	☐	
PUMP – *Is the pump flushed of corrosive product and filled with protective liquids for the off-season?* ***(Post-Season)***	☐	☐	☐	☐	