

Mechanic/Operator Training and Training Needs for Winter Maintenance Equipment

Synthesis Report



research for winter highway maintenance

CTC & Associates LLC

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Executive Summary

In April 2017, Clear Roads released its Snowplow Operator and Supervisor Training program, a series of 22 customizable modules of presentations, course guides, exams and other training support materials covering a wide range of winter maintenance topics. The materials were well received and have been used by many transportation agencies nationwide, and Clear Roads has continued to evaluate other topics that could benefit from similar training materials. In 2018, Clear Roads released a Request for Proposals (RFP) for a project entitled “Mechanic/Operator Training for Upkeep of Winter Maintenance Equipment.” The intention was to produce a set of training materials similar to the snowplow operator training, but for the operators and mechanics responsible for the day-to-day upkeep, maintenance and (sometimes on-the-road) repair of winter road maintenance equipment. The RFP did not attract any proposals, and it may be revised and presented again.

As a corollary to and in support of that anticipated future RFP, Clear Roads initiated a synthesis project to investigate the current situation “on the ground” for snowplow operators and mechanics at state departments of transportation (DOTs). Employees in both roles are responsible in varying degrees for maintaining and repairing winter road maintenance equipment. The synthesis also focused particular attention on agency responses to breakdowns on the road.

In examining this topic, this Clear Roads synthesis project sought to identify and describe:

- The **kinds of winter equipment and nature of winter equipment failures** that are most common among Clear Roads member states.
- The range of **best practices** that Clear Roads member states employ to keep winter road management equipment maintained and running.
- The **knowledge and training required of applicants** seeking to be hired as operators and mechanics in Clear Roads member states.
- The perceived areas in which **more knowledge among mechanics/operators is needed** or is less than optimum for typical situations.
- The kinds of **existing training offered by state DOTs** for mechanics and operators.
- The kinds of **existing resources for training** of mechanics/operators outside of state DOTs (e.g., industry sources such as vendor training; nonvendor sources such as technical institutions).
- Perceived **roadblocks** to change or improvement.

This synthesis project used a practitioner survey to gather information. The survey results are presented in this report; the results of a literature search supplement the survey findings.

Survey of Practice

Through an online survey of the 36 Clear Roads member agencies, this synthesis gathered information on all of the topics described above. Participants from 23 states responded to the survey, with five states—Colorado, Illinois, North Dakota, South Dakota and Washington—represented by surveys from multiple respondents. The survey includes responses from a total of 43 respondents.

Responding states are listed below, including the number of respondents if there are more than one:

- Arizona
- Colorado—2
- Connecticut
- Delaware
- Idaho
- Illinois—15

- Indiana
- Kansas
- Maine
- Massachusetts
- Michigan
- Minnesota
- Missouri
- North Dakota—2
- Oregon
- Pennsylvania
- Rhode Island
- South Dakota—4
- Texas
- Utah
- Vermont
- Washington—2
- West Virginia

Survey findings are presented below in five topic areas:

- Equipment used and common equipment failures
- Best practices for equipment upkeep and general repair on the road
- Expected qualifications and training of operators and mechanics
- Opportunities for improvement
- Final comments

Equipment Used and Common Equipment Failures

The first section of the survey gathered information about the kinds of equipment agencies use for winter road maintenance, the kinds of equipment failures they experience, and in-house fixes agencies use to prevent or mitigate equipment breakdowns on the road.

Types of Equipment

The survey results showed that most agencies use the following equipment:

- Snowplow blade assemblies attached to/removed from trucks as needed (truck used year-round)
- Drop-in salt/sand spreaders (truck used year-round)
- Prewetting systems
- Brine application systems (sprayers)
- AVL systems
- Mobile temperature sensors

Fewer agencies (17 of 43 respondents) use the following equipment:

- Dedicated-use plow trucks not used during summer
- TowPlows
- Dedicated-use salt/sand spreader trucks not used during summer

Of the agencies that had dedicated trucks for plowing and spreading, 12 of the 17 reported that they also use blade assemblies on trucks and drop-in spreaders for trucks used all year. Thus, most agencies reported a very wide range of equipment needing routine/preventive maintenance and occasional repair. The range of knowledge and skills that could conceivably be required of operators and/or mechanics was very broad.

Equipment Failures

The equipment failures that respondents deal with most frequently on the road were:

- Electrical/wiring problems
- Mechanical problems

Respondents reported that they sometimes also have issues with:

- Plow hydraulics
- Spreader system failure
- Failure of headlights, taillights or other lights
- Plow blade/insert breakage

Corrosion and electrical/wiring issues, along with the need for proper equipment washing, were mentioned frequently throughout the survey in respondents' comments.

Regarding in-house fixes and remedies to minimize equipment breakdowns on the road, many respondents again mentioned corrosion and ways to fight it, from special tape wrap for junctions, to stainless steel nuts and bolts, to salt neutralizers in the washing regimen.

Best Practices for Equipment Upkeep and General Repair on the Road

Nearly all survey respondents reported that their agency has a full- or part-time mechanic for winter road maintenance equipment. Procedures for responding to a snowplow breaking down on the road varied; at some agencies, the operator is expected to initially try to repair the problem, while at others, contacting a mechanic is the first step.

While some respondents enumerated the simple repairs operators could be expected to perform, most described a chain of response in the case of an on-the-road breakdown that initially included the operator describing the problem to a supervisor or mechanic, then a set of actions if the operator is unable to remedy the problem with phone assistance.

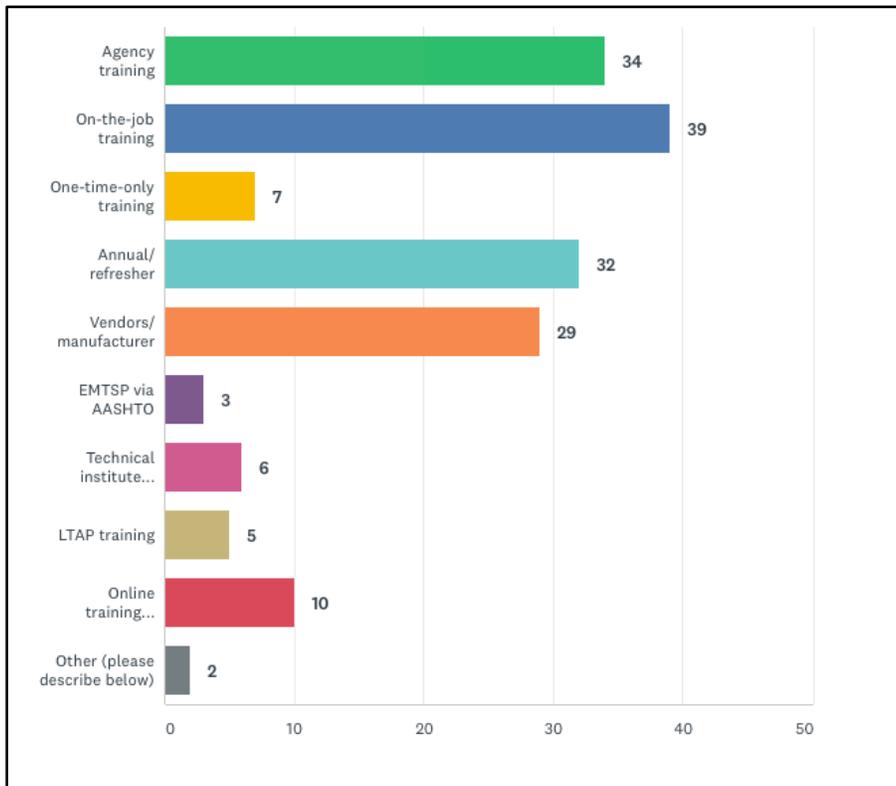
Expected Qualifications and Training of Operators and Mechanics

The survey addressed the qualifications that agencies require of applicants for work as winter maintenance equipment operators. While most respondents indicated that they would like their applicants to have a commercial driver's license (CDL), many commented that even if an applicant did not have one, it was possible to be hired and acquire one through the training process. Several respondents mentioned that when the applicant pool is small and qualified applicants are in demand in other industries (construction, for example), on-the-job training is common.

While it was not discussed in the survey, DOTs that train their operators to obtain CDLs will have to be registered as Training Providers with the Federal Motor Carrier Safety Administration (FMCSA) by February 7, 2022, to be able to legally train their new vehicle operators to acquire a Class B CDL or to move from a Class B to a Class A CDL.

The survey also discussed the methods of training provided for operators and mechanics related to equipment upkeep, maintenance or repair, and the effectiveness of those methods. The most common training methods were agency training, on-the-job training, and vendor/manufacturer training. On-the-job training was identified as the most effective training method, followed by agency training, annual refreshers and vendor/manufacturer training. Comments indicated that hands-on training was considered very effective. Figure ES1 shows the number of respondents that selected each training method as among the most effective (respondents could select multiple methods).

Figure ES1. Most Effective Training Methods



Opportunities for Improvement

Survey respondents indicated that **operators** at their agencies could benefit from additional training in the following areas:

- Pre-and post-trip inspection
- Troubleshooting minor problems on the road
- Spreader calibration
- Electrical problems

Meanwhile, respondents said their agencies' **mechanics** could use more training in:

- Electrical problems
- Troubleshooting on the road and in the garage
- Routine maintenance of all systems
- Engine repair

Respondents were asked to consider the most important changes for their agency concerning maintenance, upkeep and general repair of winter road maintenance equipment. By far, the most frequently selected areas were:

- Corrosion prevention emphasis and training
- Providing better pre- and post-trip inspection training for operators

Additional recommendations for changes included:

- More frequent preventive maintenance
- Training operators to do simple troubleshooting and minor repair
- Adding full-time dedicated mechanics for winter maintenance equipment

Finally, respondents were asked to consider the primary roadblocks to improving operator and mechanic competence in winter maintenance equipment upkeep and repair at their agencies. By a wide margin, respondents reported that the biggest roadblock is that problems with today's winter road maintenance equipment are too varied and complex to address through basic courses. For some respondents, another roadblock is that operators are temporary employees, hired only for the season.

Final Comments

The final section of the survey offered space for respondents to comment further on the topics of the survey. One extended comment from a respondent is representative of a common area of concern:

I believe the core of avoiding most winter equipment maintenance problems is good before and after operations inspections and maintenance practices, along with a robust and effective preventive maintenance (PM) program. If these procedures are taught well, enforced and sustained consistently, maintenance problems will be less of an issue. The better our PM is, the fewer unscheduled breakdowns we will have. If we just teach it and talk about it but don't enforce it through leadership, we have wasted time and money without solving the problem. (See page 34 for further details of this survey response.)

Literature Search

To supplement the survey results, a literature search was conducted that compiled representative research, guidance and other resources related to operator and mechanic training. The citations are grouped into the following categories:

- Current Clear Roads Resources
- Resources from Clear Roads Member States/Provinces
- Resources from Similar Organizations
- National Resources
- Related Resources

Relevant Clear Roads research included a 2017 project that created training materials for snowplow operators and supervisors, and a best practices manual on corrosion prevention published in 2015. Resources from Clear Roads member states included guidance from Iowa, Kansas, Minnesota, New York, Ontario and Pennsylvania.

An examination of practices by organizations other than transportation agencies included the Airport Snow Equipment Mechanic's Training conducted over four days in Buffalo, New York, in 2019. The conference featured a wide range of maintenance and repair topics for those responsible for keeping runways clear of ice and snow.

National resources include AASHTO's Equipment Management Technical Services Program (EMTSP), which offers equipment management videos and other services and resources for agency fleet management professionals. In addition, the Snow and Ice Pooled Fund Cooperative Program (SICOP) offers a Winter Operations and Maintenance training.

NCHRP Synthesis 483: Training and Certification of Maintenance Workers documents front-line maintenance worker training and certification practices for highway transportation agencies in the United States and Canada.

In addition, the literature search identified automotive technician programs available at technical colleges.

1 Introduction

Snowplow trucks operate in extreme conditions that take a toll on engines, wiring, controls, sensors, connectors, augers, conveyors, spinners and other parts exposed to extreme cold, moisture and corrosive materials. Consequently, winter maintenance equipment may break down on the road. Road maintenance agencies have various protocols for dealing with equipment breakdowns in the field, from troubleshooting via phone or radio to sending out a mechanic or towing the truck back to the station. Most agencies would benefit from more training for operators and mechanics that would enable them to more effectively address problems that can result in snowplow breakdowns on the road.

This synthesis sought to identify the best practices agencies use to deal with breakdown of winter road maintenance equipment in the field, the kinds of qualifications sought by agencies in their operators and mechanics, as well as maintenance and repair areas where operators and mechanics would benefit from additional focused training. A national survey of winter maintenance practitioners at state departments of transportation (DOTs) gathered information about best practices, common equipment failures and responses to failures. In addition, the survey addressed existing methods of training for operators and mechanics, and perceived roadblocks to improvement. The results of a literature search supplemented the survey findings.

2 Survey of Practice

2.1 Overview

An online survey was distributed to the Clear Roads member state representatives. It gathered information about the varieties of winter road maintenance equipment that agencies used, the kinds of equipment breakdowns most commonly experienced, and the levels of training sought and needed for operators and mechanics regarding upkeep and repair of equipment. Participants from 23 states responded to the survey, with five states—Colorado, Illinois, North Dakota, South Dakota and Washington—represented by completed surveys from multiple respondents. The survey includes responses from a total of 43 respondents.

Responding states are listed below, including the number of respondents if there are more than one:

- Arizona
- Colorado—2
- Connecticut
- Delaware
- Idaho
- Illinois—15
- Indiana
- Kansas
- Maine
- Massachusetts
- Michigan
- Minnesota
- Missouri
- North Dakota—2
- Oregon
- Pennsylvania
- Rhode Island
- South Dakota—4
- Texas
- Utah
- Vermont
- Washington—2
- West Virginia

Note: The states with two respondents are listed in the survey detail tables as **State (1/2)** or **State (2/2)** to indicate that one of two respondents or two of two respondents from that state responded to a question. The data from states with more than two respondents, Illinois and South Dakota, include answers from several districts or areas within those states (especially

those from Illinois). These groups are sometimes presented separately throughout this survey section as they represent a larger range of responses within two very different states.

Survey findings are presented below in five topic areas:

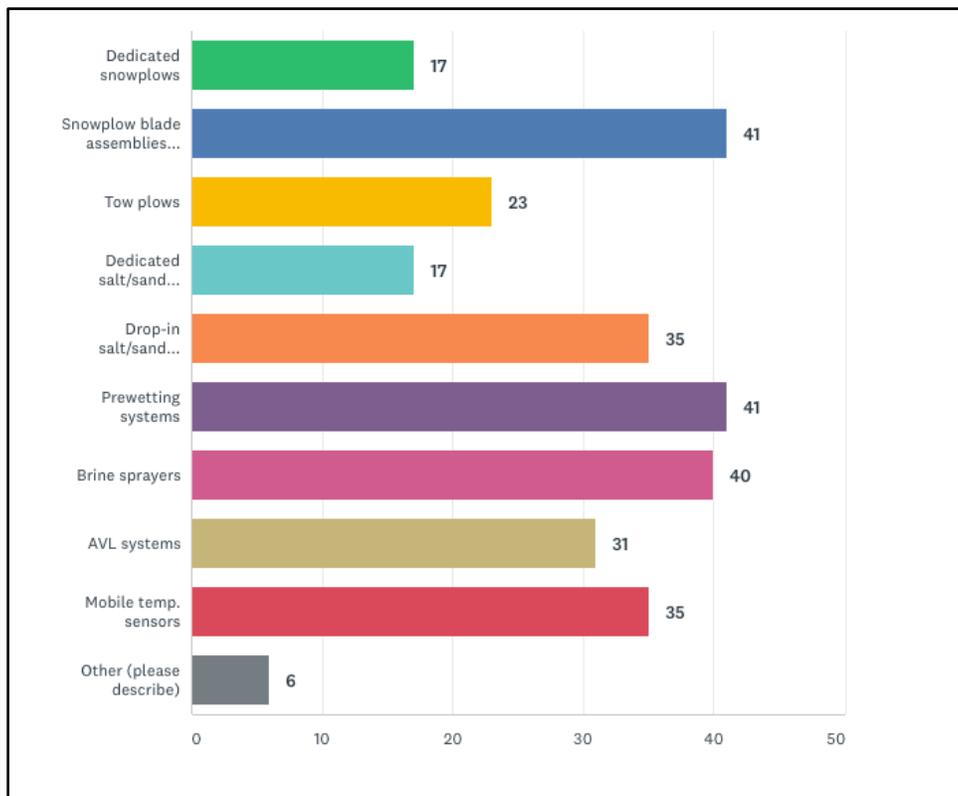
- Equipment used and common equipment failures
- Best practices for equipment upkeep and general repair on the road
- Expected qualifications and training of operators and mechanics
- Opportunities for improvement
- Final comments

The full text of the survey questions appears in [Appendix A](#). The full text of the survey responses is available as an Excel file from the Clear Roads administrator.

2.2 Equipment Used and Common Equipment Failures

Respondents were asked about the types of winter road maintenance equipment their agencies use. Response options ranged from dedicated snowplows and TowPlows to mobile temperature sensors. Most respondents' agencies work with a wide range of equipment in need of routine and preventive maintenance and potential repair throughout the winter season. Figure 2.1 graphically presents survey responses.

Figure 2.1 Winter Maintenance Equipment Used



Of the 17 respondents who indicated that their agencies had dedicated snowplows used only in the winter, 12 also use removable blade assemblies on trucks. Of the 17 respondents who indicated that their agencies had dedicated salt/sand spreaders, 12 also use drop-in salt/sand spreaders. More than a quarter of respondents use a wide range of equipment in the categories of plows and spreaders—from large dedicated plow trucks and salt/sand spreaders, to trucks with removable plow assemblies and drop-in spreaders. Nearly all agencies reported having prewetting systems and brine sprayers. More than 80% of respondents use mobile temperature sensors, and almost three-quarters have AVL systems. More than half of respondents use TowPlows.

Table 2.1 presents survey responses, with the exception of responses from Illinois and South Dakota respondents, which appear in Table 2.2.

Table 2.1 Winter Maintenance Equipment Used

Winter Maintenance Equipment	State
Dedicated snowplows (winter use only)	Colorado (2/2), Connecticut, Massachusetts, Michigan, North Dakota (2/2), Oregon, Vermont, Washington (1/2)
Removable snowplow blade assemblies	Arizona, Idaho, Indiana, Kansas, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Utah, Washington (2/2), West Virginia
TowPlows	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Utah, Washington (2/2)
Dedicated salt/sand trucks (winter use only)	Arizona, Colorado (1/2), Connecticut, Delaware, Michigan, Minnesota, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island, Texas, Washington (1/2)
Drop-in salt/sand spreaders	Arizona, Colorado (2/2), Connecticut, Delaware, Michigan, Minnesota, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Washington (2/2), West Virginia
Prewetting systems	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Indiana, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Washington (2/2), West Virginia
Brine application systems (sprayers)	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Indiana, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Washington (2/2), West Virginia
Automatic vehicle location (AVL) technology	Arizona, Colorado (2/2), Connecticut, Idaho, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Washington (2/2), West Virginia
Mobile temperature sensors	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Indiana, Kansas, Maine, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Washington (2/2), West Virginia

Winter Maintenance Equipment	State
Other equipment	Minnesota, North Dakota (1/2) (see comments below)

Respondents from Minnesota and North Dakota indicated their states used other equipment, with Minnesota’s respondent noting that the state has “salt slurry, epeke spreader, snow blowers, graders/payloaders with wings and plows.”

Responses from Illinois and South Dakota respondents are presented in Table 2.2. The number of responses for each type of equipment as compared the total responses by state are indicated next to each state name. Additional comments follow the table.

Table 2.2 Winter Maintenance Equipment Used: Illinois and South Dakota

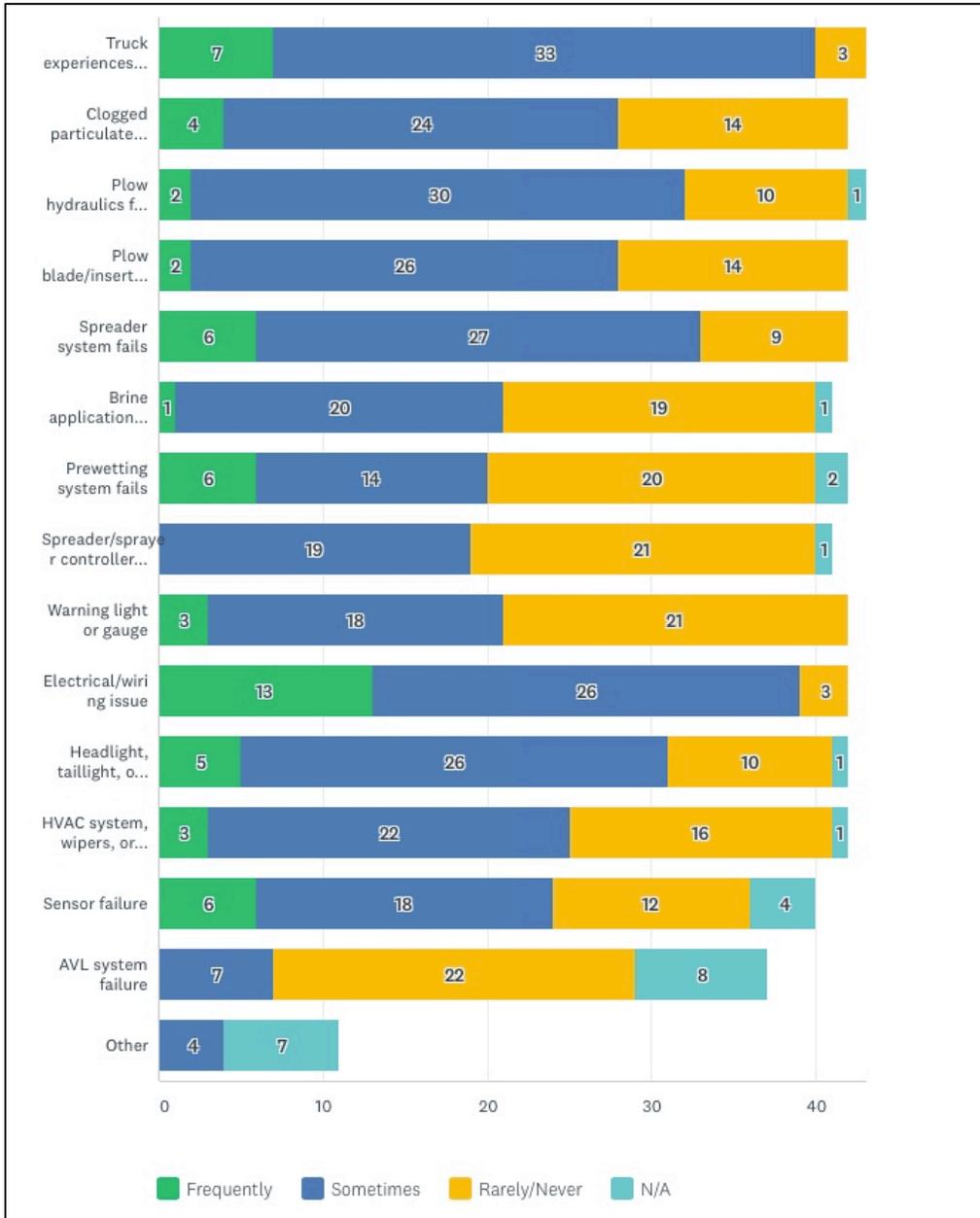
Winter Maintenance Equipment	State
Dedicated snowplows (winter only use)	Illinois (5/15), South Dakota (2/4)
Removable snowplow blade assemblies	Illinois (14/15), South Dakota (4/4)
TowPlows	South Dakota (4/4)
Dedicated salt/sand trucks (winter use only)	Illinois (4/15), South Dakota (2/4)
Drop-in salt/sand spreaders	Illinois (8/15), South Dakota (4/4)
Prewetting systems	Illinois (14/15), South Dakota (4/4)
Brine application systems (sprayers)	Illinois (14/15), South Dakota (2/4)
Automatic vehicle location (AVL) technology	Illinois (10/15), South Dakota (3/4)
Mobile temperature sensors	Illinois (10/15), South Dakota (4/4)
Other equipment	Illinois, South Dakota (equipment described below)

- Two respondents from Illinois’s District 7 reported that they have “tail gate salt spreaders” and “tailgate mounted salt augers and spinners.”
- A respondent from Illinois’s District 4 described “mid-mount wings, heavy duty benching wings, road graders with [heavy-duty] benching wings.”
- One respondent from South Dakota reported, “Our winter fleet consists of dump trucks with drop-in type spreader and combo bodies that have the ability to spread material without a drop-in spreader. The combo bodies come with a steel plate that covers the chain so we can use the trucks in the summer months.”

Respondents were asked how often different types of maintenance issues took snowplows out of service across their fleets, excluding scheduled or preventive maintenance. Respondents selected from

these options: frequently, sometimes, rarely/never or N/A. Figure 2.2 graphically presents the combined responses of the 43 respondents. (See Table 2.3 for a full description of each equipment problem response option.)

Figure 2.2 Frequency of Equipment Failure on the Road



The most common problems that occurred **frequently** were electrical/wiring problems, the truck stops and won't restart, spreader failure, sensor failure, and prewetting system failure. The four most common problems that occurred **sometimes** also included the truck stops and won't restart, hydraulics issues, the spreader system failing, and electrical problems. Many other problems occurred "sometimes." Table 2.3 presents the responses from agencies in each category, with the exception of responses from Illinois and South Dakota respondents, which are presented in Table 2.4.

Table 2.3 Equipment Failures

Equipment Problem	State and Problem Frequency
Truck mechanical problem on route (cannot restart engine, etc.)	<p>Frequently: Colorado (1/2), Idaho, Maine, North Dakota (2/2), Rhode Island</p> <p>Sometimes: Arizona, Colorado (1/2), Connecticut, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, Oregon, Pennsylvania, Texas, Utah, Vermont, Washington (1/2), West Virginia</p> <p>Rarely/Never: Delaware, Washington (1/2)</p>
Clogged particulate filter or similar	<p>Frequently: Arizona, Connecticut, Washington (1/2)</p> <p>Sometimes: Colorado (2/2), Idaho, Massachusetts, Michigan, Missouri, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island</p> <p>Rarely/Never: Delaware, Indiana, Kansas, Maine, Minnesota, North Dakota (1/2), Texas, Utah, Washington (1/2)</p>
Plow hydraulics (raising, lowering blade, etc.)	<p>Frequently: Arizona, North Dakota (1/2)</p> <p>Sometimes: Colorado (2/2), Connecticut, Delaware, Idaho, Kansas, Maine, Michigan, Minnesota, Missouri, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island, Texas, Utah</p> <p>Rarely/Never: Indiana, Massachusetts, Vermont, Washington (2/2), West Virginia</p>
Plow blade/insert breakage	<p>Sometimes: Arizona, Colorado (2/2), Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota (1/2), Oregon, Rhode Island, Texas, Utah, Washington (2/2),</p> <p>Rarely/Never: Connecticut, Idaho, Maine, Massachusetts, North Dakota (1/2), Vermont, West Virginia</p>
Spreader system failure	<p>Frequently: Delaware, North Dakota (2/2), Rhode Island,</p> <p>Sometimes: Arizona, Colorado (2/2), Idaho, Indiana, Kansas, Maine, Michigan, Oregon, Pennsylvania, Texas, Washington (2/2)</p> <p>Rarely/Never: Connecticut, Massachusetts, Missouri, Utah, Vermont, West Virginia</p>
Brine application system failure	<p>Frequently: Rhode Island</p> <p>Sometimes: Colorado (1/2), Connecticut, Delaware, Kansas, Maine, North Dakota (2/2), Texas, Vermont, West Virginia</p> <p>Rarely/Never: Arizona, Colorado (1/2), Idaho, Indiana, Massachusetts, Michigan, Minnesota, Missouri, Pennsylvania, Utah, Washington (2/2)</p>
Prewetting system failure	<p>Frequently: Arizona, Delaware, Idaho, North Dakota (1/2), Rhode Island</p> <p>Sometimes: Colorado (1/2), Connecticut, Kansas, Maine, Oregon</p> <p>Rarely/Never: Colorado (1/2), Indiana, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (1/2)</p>
Spreader/sprayer controller failure	<p>Sometimes: Colorado (2/2), Delaware, Idaho, Kansas, Maine, North Dakota (1/2), Oregon, Rhode Island, West Virginia</p> <p>Rarely/Never: Arizona, Indiana, Massachusetts, Missouri, North Dakota (1/2), Pennsylvania, Texas, Utah, Vermont, Washington (2/2)</p>

Equipment Problem	State and Problem Frequency
Warning lights/gauge problem	Sometimes: Arizona, Colorado (2/2), Michigan, Minnesota Missouri, Rhode Island, Utah, Washington (1/2), West Virginia Rarely/Never: Connecticut, Delaware, Idaho, Indiana, Kansas, Massachusetts, North Dakota (2/2), Texas, Vermont, Washington (1/2)
Electrical/wiring problem (corrosion, etc.)	Frequently: Arizona, Colorado (1/2), Idaho, Kansas, Michigan, North Dakota (2/2), Rhode Island, West Virginia Sometimes: Colorado (1/2), Connecticut, Delaware, Indiana, Maine, Massachusetts, Minnesota, Missouri, Oregon, Pennsylvania, Texas, Utah, Washington (2/2), Rarely/Never: Vermont
Headlight, taillight, other light failure	Frequently: Arizona, Colorado (1/2) Sometimes: Colorado (1/2), Idaho, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (1/2), Oregon, Rhode Island, Utah, Vermont, Washington (1/2), West Virginia Rarely/Never: Connecticut, Delaware, Maine, North Dakota (1/2), Pennsylvania, Texas, Washington (1/2)
HVAC system, wipers, other peripheral failure	Frequently: Connecticut, North Dakota (1/2) Sometimes: Arizona, Colorado (2/2), Delaware, Idaho, Kansas, Minnesota, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island, Vermont, Washington (2/2) Rarely/Never: Indiana, Maine, Massachusetts, Michigan, Missouri, Texas, Utah, West Virginia
Sensor failure	Frequently: Rhode Island, Washington (1/2) Sometimes: Colorado (1/2), Delaware, Idaho, Kansas, Maine, Minnesota, North Dakota (2/2), Pennsylvania, Washington (1/2), West Virginia Rarely/Never: Colorado (1/2), Connecticut, Indiana, Massachusetts, Michigan, Missouri, Texas, Vermont
AVL system failure	Sometimes: Colorado (1/2), Maine, Rhode Island, Vermont, Washington (1/2) Rarely/Never: Arizona, Colorado (1/2), Delaware, Idaho, Massachusetts, Michigan, Minnesota, Missouri, Oregon, Pennsylvania, Texas, Utah, Washington (1/2)

Many respondents offered further instances and discussion of significant issues with winter road maintenance equipment. Electrical, sensor and emission control issues were most frequently reported. Respondents' comments are provided below.

Colorado (1/2)

With about 900 plow trucks statewide, it is likely that some breakdown will occur during a storm event. Normally over 85% of our trucks are operational during a storm event.

Connecticut	The camshaft and camshaft lifter dog bone are sites of failure; particular brand of engines [International Maxforce engines].
Delaware	Sensor failures associated with the ground speed control system, such as feeder sensor and speed sensor.
Idaho	The primary sensor failure is the conveyor sensor on granular material spreaders.
Kansas	Chassis wiring corrodes on all brands frequently.
Maine	Emission controls on trucks shut the trucks down.
Michigan	Most common failures for fleet vehicles are electrical or tire-related.
North Dakota (2/2)	Corroded wiring and some sensor failure are most frequent. New trucks have recurring emission controls issues and FCR system failure.
Oregon	The most significant thing that takes trucks out of service is collisions. It takes a long time to complete repairs.
Rhode Island	Check engine lights and warning light illuminations are a regular problem: sometimes due to a problem and sometimes not. QLS sensor issues are frequent; other SCR and DOC type faults.
Washington (1/2)	Fleet standardization efforts have really helped strengthen our maintenance program. For example, if flow meters on prewet systems were not flushed out at the end of the season, they would need repair or replacement at next winter operations. We have drastically decreased such problems.
West Virginia	Emissions issues.

Table 2.4 Equipment Failures: Illinois and South Dakota

Equipment Problem	State and Problem Frequency
Truck mechanical problem on route	Frequently: Illinois (1/15) Sometimes: Illinois (13/15), South Dakota (4/4) Rarely/Never: Illinois (1/15)
Clogged particulate filter or similar	Frequently: South Dakota (1/4) Sometimes: South Dakota (2/4) Rarely/Never: South Dakota (1/4)
Plow hydraulics (raising, lowering blade, etc.)	Sometimes: South Dakota (3/4), Illinois (11/15) Rarely/Never: South Dakota (1/4), Illinois (3/15)
Plow blade/insert breakage	Frequently: Illinois (1/15), South Dakota (1/4) Sometimes: Illinois (9/15), South Dakota (1/4) Rarely/Never: Illinois (4/15), South Dakota (2/4)

Equipment Problem	State and Problem Frequency
Spreader system failure	Frequently: Illinois (1/15), South Dakota (1/4) Sometimes: Illinois (11/15), South Dakota (3/4) Rarely/Never: Illinois (2/15)
Brine application system failure	Sometimes: Illinois (8/15), South Dakota (1/4) Rarely/Never: Illinois (6/15), South Dakota (1/4)
Prewetting system failure	Frequently: South Dakota (1/4) Sometimes: Illinois (5/15), South Dakota (2/4) Rarely/Never: Illinois (8/15), South Dakota (1/4)
Spreader/sprayer controller failure	Sometimes: Illinois (7/15), South Dakota (4/4) Rarely/Never: Illinois (6/15)
Warning lights/gauge problem	Frequently: Illinois (/15), South Dakota (/4) Sometimes: Illinois (/15), South Dakota (/4) Rarely/Never: Illinois (/15)
Electrical/wiring problem (corrosion, etc.)	Frequently: Illinois (4/15) Sometimes: Illinois (8/15), South Dakota (4/4) Rarely/Never: Illinois (2/15)
Headlight, taillight, other light failure	Frequently: Illinois (2/15), South Dakota (1/4) Sometimes: Illinois (9/15), South Dakota (2/4) Rarely/Never: Illinois (2/15), South Dakota (1/4)
HVAC system, wipers, other peripheral failure	Frequently: Illinois (1/15) Sometimes: Illinois (6/15), South Dakota (2/4) Rarely/Never: Illinois (6/15), South Dakota (2/4)
Sensor failure	Frequently: Illinois (3/15), South Dakota (1/4) Sometimes: Illinois (3/15), South Dakota (3/4) Rarely/Never: Illinois (4/15)
AVL system failure	Sometimes: Illinois (2/15) Rarely/Never: Illinois (7/15), South Dakota (2/4)

The multiple respondents from Illinois and South Dakota also reported particularly frequent repair problems. Of the Illinois respondents, three reported electrical, sensor or emission controls issues. One mentioned Diesel Exhaust Fluid (DEF) sensors. The South Dakota respondents mentioned radiator sensors, fuel and DEF systems.

Finally, survey respondents were asked about best practices or shop-fabricated add-ons that can prevent common maintenance issues, especially breakdowns on the road. Their comments, edited for length and clarity, are presented below.

Colorado (2/2)	Respondents reported that they have innovative mechanics; special fixes are communicated to the organization through the Process Improvement office under the title “Lean Everyday Ideas.”
Connecticut	Thoroughly clean and lubricate trucks after storms.
Illinois (6/15)	<ul style="list-style-type: none"> • Pre-trip and post-trip inspections are very helpful. • Thorough after snow event clean up helps eliminate future corrosion. • IDOT needs truck wash bays. Corrosion is the number one problem. • Extra hose to wiper fluids is coiled around exhaust to heat fluid and help keep ice off windshield. • Work with manufacturers on demo trucks to make sure issues don’t make it downstream.
Kansas	Double carbide blade set-up on truck plows.
Michigan	MDOT up-fits/builds winter maintenance trucks in-house.
North Dakota (2/2)	Use stainless steel nuts and bolts; insulated plugs and heat shrink-wrap. Respondent notes that add-ons can make accessibility difficult.
Oregon	Use salt neutralizers when washing the trucks; wash trucks frequently.
Rhode Island	<ul style="list-style-type: none"> • Use anti-corrosion tape called Petro-Wrap, used around new hydraulic and other line fitting ends to protect from corrosion. • Use salt-neutralizing agents when washing vehicles. • Weather proof and/or shrink-wrap electrical connections. • Mechanics may not poke holes in electrical wires to test circuits. • Make valve assemblies and junctions watertight.
South Dakota (1/4)	Stainless steel sanders, truck boxes and poly plows to reduce corrosion problems.
Washington (1/2)	<ul style="list-style-type: none"> • Many changes over the years are now implemented by vendors. • High-quality electrical junction boxes. • Comprehensive analysis of truck configurations, payload capability and costs over vehicle life to identify how to maximize fleet functionality and longevity while reducing maintenance and repair costs.

2.3 Best Practices for Equipment Upkeep and General Repair on the Road

Full-Time vs. Part-Time Mechanics

All but two respondents—one of the two respondents from Washington and one of the 15 respondents from Illinois—reported that their agency has a dedicated full- or part-time mechanic on staff to take care of winter road maintenance equipment. One Washington respondent indicated that the work is performed by equipment technicians. The single Illinois respondent did not include further explanation.

Snowplow Breakdown Protocols

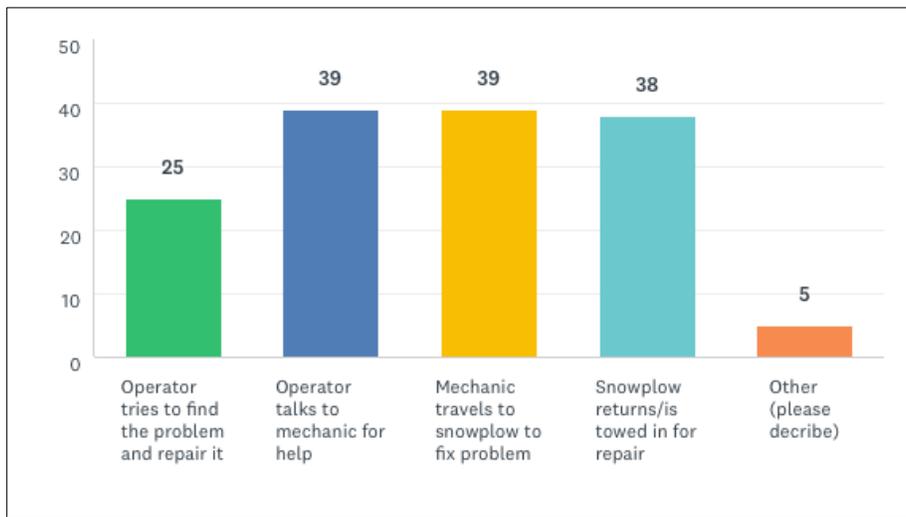
The survey examined how agencies respond to an equipment breakdown on the road. Respondents were asked to select all that apply from among four options to describe how their agencies responded to a snowplow or other equipment that breaks down on the road while in service:

- Operator tries to find problem and repair it.
- Operator talks to mechanic, who directs operator in diagnosis/repair
- Mechanic goes out to fix the snowplow
- Snow returns/is towed to garage for repairs

Respondents could also describe another type of agency response.

Respondents are least likely to have the operator find the problem and repair it. Figure 2.3 graphically illustrates all survey responses.

Figure 2.3 Agency Protocols for Snowplow Breakdown on the Road



Sixteen respondents offered commentary instead of or in addition to selecting from among the breakdown protocols identified in the survey.

While some respondents discussed the list of simple repairs that operators could be expected to perform, most respondents described the sequence of actions that would occur upon an on-the-road breakdown. In most cases, the operator contacted a supervisor or mechanic, and if the operator could not be talked through a repair via phone, a mechanic would then travel out to the disabled vehicle. The vehicle would be either repaired on the road or towed back to a garage or station.

Respondents' comments, edited for length and clarity, are presented below.

Arizona

Operator talks to mechanic for help; mechanic goes out to fix the snowplow; the snowplow is returned or towed to the garage for repairs.

Colorado (1/2)	First step is for the driver to identify the problem correctly. If it cannot be fixed by the driver, the driver calls to provide as much info as possible to the field mechanic. The field mechanic uses this info to decide what tools and parts are needed for a roadside repair, and drives to the location with a fully equipped mechanics' truck to fix the equipment on site. If on-site repair is not possible, the truck is towed to the shop where it can be repaired.
Illinois (6/15)	<ul style="list-style-type: none"> • A lot of the newer trucks cannot be repaired alongside the roadway. • If the issue is minor, the operator can fix it. If not, the operator will contact a supervisor and either the yardman or mechanic will either head out to fix it or have it brought in the shop to fix. • Our mechanic diagnoses the problem and determines whether it can be repaired on the road or needs to be towed to the yard for repair.
Indiana	Our teams perform all of the steps [in the survey question] in a linear manner. If the operator cannot fix the issue, a mechanic will be dispatched. If the mechanic cannot fix the issue, the truck is towed to the shop.
Maine	We try to get the snowplow back to the shop for repair or get it towed in.
Massachusetts	Depending on the type of breakdown, the mechanic can do the repair on the road or the vehicle will be towed into the maintenance facility
Michigan	The response varies by garage, there is no standard MDOT protocol.
North Dakota (2/2)	<ul style="list-style-type: none"> • The repair depends on the issue. • Minor problems are repaired on the roadway; major problems are taken to the district shop.
Oregon	If the truck is repaired on the road, maintenance provides traffic control.
Rhode Island	All efforts are made to repair a broken down unit on the road before a tow is executed during a storm. We have various levels of repair, ranging from in-house repairs performed by a facility mechanic, technical repair or tough diagnosis performed by the mechanical staff at our [headquarters] facility, and dealer level/warranty repairs, which will be performed by whoever is the local dealer of that product.
South Dakota1/4)	We try to find a spare truck as best we can.
Washington (1/2)	If the problem is easily identified, such as a blown hose, it is often repaired on site. If the problem is more serious, the plow is chained up and the truck is driven back to the shop. This varies greatly if the breakdown is related to the truck itself. In cold weather, poor visibility or traction conditions etc., and high-traffic areas, it's best to get the truck to the shop or a safe place for further repair efforts.
West Virginia	The operator should not try to fix it. A lot of the time they make it worse or by the time the mechanic gets there, he doesn't know what the operator caused and what was the original problem. The operator should report back with as much information as possible and wait.

Expectations of Operators: Troubleshooting and Repair

Finally, respondents addressed whether or not plow operators were expected to be able to troubleshoot and/or repair some level of equipment problems while on the road, and the types of problems operators might be responding to.

Eleven respondents reported that their agencies did not expect operators to be able to troubleshoot problems or repair equipment on the road. These include respondents from Arizona, Illinois (4/15), Maine, Massachusetts, South Dakota (1/4), Utah, Washington (1/2) and West Virginia.

Many of the 32 respondents who reported that operators were expected to be able to perform some troubleshooting and repair on the road offered clarifying descriptions and commentary on their responses.

Table 2.5 presents the range of problems respondents’ agencies expect operators to be able to address on the road.

Table 2.5 Types of Problems Operators Are Expected to Address on the Road

State	Problem Type
Colorado (2/2)	Basic problems: fix flat tires, tighten loose nuts and bolts; check, clean, reconnect electrical cables, tighten fluid and air connections, replace bulbs.
Connecticut	Want operator to give an idea of what has gone wrong: simple and accurate information.
Delaware	Basic issues: tighten loose cables, hydraulic lines; reset power cycle for ground speed control systems.
Idaho	Want operator to be able to assist in the troubleshooting to allow for a good decision about what to do.
Illinois (11/15)	Basic knowledge: able to be directed by a mechanic to walk through a repair; simple things: replace pins, re-engage electrical breakers; leaks, wiper blades, fluid levels; tire change, hydraulic hose repair. Most of the newer equipment needs a laptop to diagnose, very few can be repaired by drivers.
Indiana	Common issues that are part of a pre-trip inspection. If they are able, they are expected to try.
Kansas	Basic things: check fuses/circuit breakers, hydraulic fluid levels, check quick couplers for good connections.
Michigan	Very simple repairs, e.g., salt clogs in delivery system. Most repairs are sent to MDOT mechanic.
Minnesota	Repair/replace plow cutting edges and wing plow shear pins.
North Dakota (2/2)	Minor problems: shear bolts, pins, hoses, chains.

State	Problem Type
Oregon	ODOT has a level of service agreement with operators for cutting edges, lights etc., which operators are supposed to fix.
Pennsylvania	Simple things: plow blades, wipers, system resets, etc.
Rhode Island	Daily walk-around inspections. Simple things: plow blades, light bulbs, mirrors, wiper blades, fluid levels. Skill levels of drivers vary.
South Dakota (2/4)	Able to describe problems to mechanic: read codes on drive panel screen; handle any problem that occurs as best they can.
Texas	Very basic mechanical and electrical issues.
Vermont	Basic problems: hoses, blocked spreaders, broken bed chain.
Washington (1/2)	Basic problems: cleaning prewet filter, repair wipers, replace plow bits.
West Virginia	Operators focusing on basic preventative maintenance and being held accountable for not doing [it] would make a recordable difference in breakdowns.

2.4 Expected Qualifications and Training of Operators and Mechanics

Desired Applicant Qualifications for Winter Road Maintenance Equipment Operators

Respondents described the qualifications their agencies look for in applicants for winter road maintenance equipment operator positions, selecting from among six qualifications:

- Commercial driver's license
- Completion of snowplow operator training course
- Previous snowplow driving experience
- Previous experience driving large vehicles
- Ability to troubleshoot and diagnose mechanical/hydraulic problems on equipment
- Knowledge of spreader application systems

Forty-one of the 43 respondents indicated that operator applicants should have a commercial driver's license (CDL). The Oregon respondent, who indicated that the agency did not require it immediately, reported that the agency allows a trainee permit, which requires the holder to be accompanied by a CDL holder while plowing snow. Other agencies also described some flexibility in when the CDL must be in hand. It is noteworthy that only three agencies indicated a desire for applicants with an ability to troubleshoot and diagnose equipment problems on the road.

Almost 75% of respondents expect applicants to complete a snowplow operation training course. Respondents are least likely to expect applicants to have the ability to troubleshoot and diagnose mechanical/hydraulic problems on equipment.

While this was not directly addressed in the survey, it is important to note that DOTs that train their operators to obtain their CDL will have to be registered as Training Providers with the Federal Motor

Carrier Safety Administration (FMCSA) by February 7, 2022, to be able to legally train their new vehicle operators to acquire a Class B CDL or to move from a Class B to a Class A CDL.

Table 2.6 presents agencies' responses regarding desired qualifications in an operator.

Table 2.6 Expected Qualifications of Applicants for Operator Positions

Qualifications	State	Number of Responses
Commercial driver's license (CDL)	Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (15/15), Indiana, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (2/2), Pennsylvania, Rhode Island, South Dakota (4/4), Texas, Utah, Vermont, Washington (2/2), West Virginia	41
Completion of snowplow operator training course	Colorado (2/2), Connecticut, Idaho, Illinois (11/15), Indiana, Kansas, Maine, Michigan, Minnesota, Missouri, North Dakota (1/2), South Dakota (4/4), Texas, Utah, Vermont, Washington (2/2)	32
Previous snowplow driving experience	Connecticut, Illinois (2/15), Massachusetts, North Dakota (1/2), South Dakota (2/4), Vermont	8
Previous experience driving large vehicles	Connecticut, Idaho, Illinois (5/15), Massachusetts, North Dakota (1/2), South Dakota (2/4), Texas, Vermont, West Virginia	14
Ability to troubleshoot and diagnose equipment problems	Illinois (2/15), Indiana, South Dakota (1/4)	3
Knowledge of spreader application systems	Colorado (1/2), Connecticut, Illinois (4/15), Indiana, Massachusetts, Minnesota, Missouri, South Dakota (2/4), Vermont, Washington (1/2),	13

Many of the respondents' comments mentioned that agencies provide in-house training for new employees. Comments, edited for clarity, are presented below.

Arizona	Must have, or be able to obtain the required CDL for the position.
Colorado (2/2)	<ul style="list-style-type: none"> We are always short-staffed so qualifications are adjusted to increase applicant pool. On-the-job training provided after hire. CDOT runs a Maintenance Training Academy that provides a robust winter operations training program to all operators annually. Operators must meet basic requirements checked above before they can operate equipment. Other training is conducted based on experience level.
Illinois (2/15)	<ul style="list-style-type: none"> Operators get a training day on snowplowing techniques along with spreader knowledge; also on-the-job training with veteran operators.

	<ul style="list-style-type: none"> Operators must have a CDL and will get training before plowing. They do not necessarily need to have experience before being hired.
Indiana	Most operators are trained in-house since knowledge of plow equipment and techniques is not common.
Maine	We hire at entry-level position and train snow fighters.
Oregon	New operators are generally required to have CDL; however, if they don't have their CDL but have a trainee permit, they can plow snow but must have a CDL holder in the truck with them.
Rhode Island	Tanker truck endorsement.
Washington (2/2)	<ul style="list-style-type: none"> Our maintenance program trainers hold an annual snow and ice academy as well as refresher training events each year before the winter season. In general require a CDL for employment; however, this is changing. In some urban areas it is increasingly difficult to retain and recruit employees; we now hire employees without a CDL and train them.

Training Opportunities for Operators and Mechanics

Respondents were asked to choose among the following training methods to identify the training their agencies provide for winter maintenance operators and mechanics related to equipment upkeep, maintenance or repair:

- Agency training
- On-the-job training
- Vendor/manufacturer training
- Equipment Management Technical Services Program (EMTSP) via AASHTO
- Technical institute training
- LTAP training
- Other online training
- Other training

Note that this survey question was inadvertently laid out such that respondents were unable to indicate that their agency provided training to *both operators and mechanics* using a given training method. Many respondents used the “Other online training” box to provide a fuller picture of their training methods (see the comments that begin after Table 2.7).

In-house agency training, on-the job training, and education provided by vendors and manufacturers represent training methods used by the most agencies. Table 2.7 presents the number of respondents who reported using each training method. Respondents’ comments follow the table.

Table 2.7 Training Provided for Operators and Mechanics

Training Method	State
Agency training	Operator: Arizona, Colorado (1/2), Connecticut, Delaware, Idaho, Illinois (10/15), Kansas, Maine, Massachusetts, Minnesota, Missouri, North Dakota (1/2), Oregon, South Dakota (3/4), Texas, Vermont, Washington (1/2) Mechanic: Colorado (1/2), Connecticut, Indiana, Michigan, Pennsylvania, South Dakota (1/4), Utah, Washington (1/2), West Virginia
On-the-job training	Operator: Arizona, Colorado (2/2), Delaware, Idaho, Illinois (11/15), Kansas, Maine, Massachusetts, Minnesota, Missouri, North Dakota (1/2), South Dakota (4/4), Washington (1/2), West Virginia Mechanic: Connecticut, Illinois (2/15), Indiana, Michigan, North Dakota (1/2), Oregon, Pennsylvania, Washington (1/2)
Vendor/manufacturer training	Operator: Connecticut, Illinois (8/15), Massachusetts, Rhode Island, South Dakota (2/4), Vermont, Washington (1/2), West Virginia Mechanic: Arizona, Colorado (2/2), Delaware, Idaho, Illinois (5/15), Indiana, Kansas, Maine, Missouri, North Dakota (1/2), Oregon, Pennsylvania, South Dakota (1/4), Texas, Utah, Washington (1/2)
Equipment Management Technical Services Program (EMTSP) via AASHTO	Operator: Massachusetts, South Dakota (1/2), Massachusetts, South Dakota (1/2) Mechanic: Colorado (1/2), Illinois (3/15), Maine, Michigan, South Dakota (1/2), Vermont
Technical institute training	Operator: Illinois (1/15), Missouri Mechanic: Colorado (1/2), Illinois (2/15), Maine, Michigan, Minnesota, Rhode Island, South Dakota (1/2), Texas, Utah, Vermont
LTAP training	Operator: Colorado (1/2), Illinois (2/15), Minnesota, Missouri, Pennsylvania, Utah, West Virginia Mechanic: Arizona, Maine, Michigan, North Dakota (2), South Dakota (1/4), Vermont
Other online training	Operator: Colorado (1/2), Illinois (4/15), Kansas, Minnesota, South Dakota (2/4), Texas Mechanic: Connecticut, Idaho, Illinois (2/15), Michigan, North Dakota (1/2), Oregon, Pennsylvania, South Dakota (1/4), Washington (1/2), West Virginia

Twenty-five respondents offered descriptions of alternate or additional agency training methods. Respondent comments, edited for clarity, are presented below.

Arizona

- Winter readiness workshop held in September for all operators statewide.
- Use three portable snowplow simulators for training. All plow drivers required to log hours in the simulator annually.
- Internal training group trains equipment repair technicians.
- On-the-job training for equipment repair technicians.

Colorado (2/2)	<ul style="list-style-type: none"> • In-house training for mechanics and operators. • Work with original equipment manufacturers (OEMs) to provide specific training for mechanics. • Maintenance Training Academy (MTA) for operators. • On-the-job training from vendors. • Mechanics trained on-the-job and MTA through vendor classes and classes taught by senior equipment maintenance staff. • Mechanics may take EMTSP training modules.
Delaware	Use Certified Cirus for the ground speed controls.
Idaho	Will use mechanics' online training for new Freightliner Chassis.
Illinois (8/15)	<ul style="list-style-type: none"> • Manufacturer and equipment supplier training. • One-day yearly training on trucks (Navistar), plows, spreader/brine systems (Monroe Equipment) for operators and mechanics. • Mechanics have access to online Navistar training. • Very little training. Have not had a real class in years. • Manufacturer training: Rush Truck, International Navistar, Diamond Logic Builder, Monroe, Cummins Quick Serve, Force America.
Indiana	Operators and mechanics both get agency training, on-the-job training and training from the manufacturers.
Kansas	Spreader controller vendors: Force America and Cirus.
Michigan	<ul style="list-style-type: none"> • Annual statewide mechanics training on various topics with numerous vendors. • MDOT equipment contracts require vendors to provide on-site training to operators and mechanics.
Minnesota	<ul style="list-style-type: none"> • Vendors provide maintenance training for new equipment. • Operators trained in-house in preventive maintenance through classroom, hands-on training, video and e-learning. • Some training through websites and e-learning.
North Dakota (2/2)	<ul style="list-style-type: none"> • Force America training on controllers. • Very limited in availability.
Oregon	<ul style="list-style-type: none"> • Online training by Volvo, operator and technician course training. • Operators also provided on-the-job training.
Pennsylvania	Operator and mechanics' training in winter maintenance operations.
Rhode Island	<ul style="list-style-type: none"> • Manufacturer training for mechanics and operators. • Follow-up pre-winter trainings. • Beginning AASHTO training and on-the-job training.
Utah	Training offered for both operators and mechanics: agency, on-the-job and manufacturer training.
Washington (2/2)	<ul style="list-style-type: none"> • All trainings listed are offered for both operators and mechanics. • Brine-maker support and training. • Force America hydraulic control and calibration training.

Most Effective Training Methods

Respondents identified the most effective approaches and methods used to train operators and/or mechanics on equipment repair and upkeep. Most respondents identified agency training, on-the-job training, annual refreshers and vendor/manufacture training. Figure 2.4 graphically illustrates survey responses. (See Table 2.8 for a full description of each training method response option.)

Figure 2.4 Most Effective Training Methods

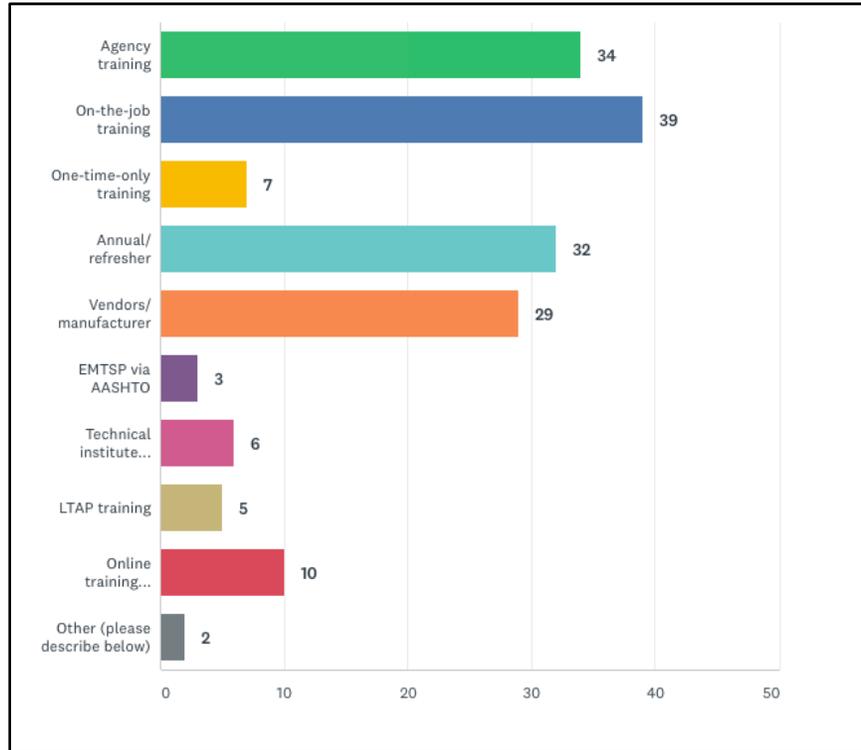


Table 2.8 provides specific agency responses.

Table 2.8 Most Effective Training Methods

Training Method	State
Agency training	Colorado (2/2), Connecticut, Delaware, Illinois (11/15), Indiana, Maine, Massachusetts, Michigan, Minnesota, Missouri, Oregon, Pennsylvania, Rhode Island, South Dakota (4/4), Texas, Utah, Vermont, Washington (1/2), West Virginia
On-the-job training	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (13/15), Indiana, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, South Dakota (3/4), Texas, Utah, Vermont, Washington (2/2), West Virginia
One-time only training	Connecticut, Illinois (3/15), Indiana, Michigan, North Dakota (1/2)

Training Method	State
Annual/refresher training	Arizona, Colorado (1/2), Connecticut, Delaware, Idaho, Illinois (12/15), Indiana, Kansas, Maine, Massachusetts, Michigan, Missouri, Pennsylvania, Rhode Island, South Dakota (3/4), Texas, Utah, Vermont, Washington (1/2), West Virginia
Vendor/manufacturer training	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (10/15), Indiana, Maine, Massachusetts, Michigan, Minnesota, North Dakota (1/2), Pennsylvania, Rhode Island, South Dakota (1/4), Texas, Vermont, Washington (1/2), West Virginia
Equipment Management Technical Services Program (EMTSP) via AASHTO	Massachusetts, Pennsylvania, South Dakota (1/4)
Technical institute training	Arizona, Illinois (1/15), Minnesota, Rhode Island, Texas, Vermont
LTAP training	Indiana, Minnesota, North Dakota (1/2), South Dakota (1/4), Vermont
Other online training	Idaho, Illinois (2/15), Kansas, Minnesota, Oregon, Pennsylvania, Vermont, West Virginia

Thirteen respondents offered comments concerning their agency's training.

Colorado (1/2)	Our drivers and mechanics are "hands-on" people. The quickest way to lose their interest is to put them in a classroom at a computer workstation to view online training or PowerPoints. Give them a knowledgeable instructor with some real equipment and a chance to actually "do" what is being taught, and they will embrace the training.
Connecticut	Hands-on in-house hydraulic training.
Delaware	Vendor training on site using our equipment seems to have the best results.
Illinois (4/15)	<ul style="list-style-type: none"> • A combination of all the above works. • Vendor/manufacturer training works. • On-the-job training in the truck they will use, on the routes they will be working on, with an experienced operator before and/or during a storm is the best operator training. • A combination of classroom and then hand-on training sessions.
Michigan	Annual statewide mechanics training is the most effective and allows for networking.
Minnesota	A combination of hands-on and e-learning works well.
North Dakota (1/2)	Hands-on training is most effective.
Oregon	Volvo training (vendor, in-person) is effective but does cost money.
Pennsylvania	Vendors have some online training to help with the newer technology.

Washington (1/2)

As our fleet still varies statewide in both age and configuration, local training on the job combined with annual refresher training works very well. When new equipment is introduced, we provide vendor/manufacturer training.

2.5 Opportunities for Improvement

Respondents reported on ways their agencies could improve their winter equipment maintenance, repair and troubleshooting on the road.

Improving Operator Training

Respondents selected from among the following training topics that could improve operators’ performance in operating and maintaining winter maintenance equipment:

- Troubleshooting equipment failures on the road
- Pre- and post-trip equipment checks
- Spreader calibration
- Clearing material jam/blockages within spreaders
- Electrical problems

Better equipping operators to conduct pre-and post-trip inspections was cited most frequently by respondents (72%). Slightly less than half of respondents identified the need to train operators to troubleshoot on the road, calibrate spreaders and address electrical problems. The fewest respondents felt that operators needed help with clearing spreader jams.

Table 2.9 provides specific agency responses. Comments about additional operator training follow the table.

Table 2.9 Additional Training Needed for Operators

Training Needed	State
Troubleshoot equipment failures on the road	Colorado (1/2), Delaware, Idaho, Illinois (8/15), Kansas, Maine, North Dakota (1/2), Pennsylvania, Rhode Island, South Dakota (2/4), Texas, Vermont, Washington (1/2)
Pre- and post-trip equipment checks	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (10/15), Kansas, Maine, Massachusetts, Michigan, Minnesota, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, South Dakota (2/4), Vermont, Washington (2/2)
Spreader calibration	Colorado (1/2), Connecticut, Idaho, Illinois (2/15), Indiana, Maine, Massachusetts, Minnesota, Missouri, North Dakota (1/2), Rhode Island, South Dakota (3/4), Texas, Vermont, Washington (1/2), West Virginia
Clear spreader blockages	Colorado (1/2), Illinois (10/15), Michigan, North Dakota (1/2), Pennsylvania, Rhode Island, South Dakota (1/4), Texas, Vermont
Electrical problems	Colorado (2/2), Connecticut, Illinois (3/15), Kansas, Maine, Massachusetts, Missouri, North Dakota (2/2), Rhode Island, South Dakota (3/4), Texas, Vermont, Washington (1/2), West Virginia

Nine respondents offered comments concerning additional training for operators. Comments have been edited for clarity.

Colorado	<ul style="list-style-type: none">• Post-storm maintenance—washing/cleaning equipment properly and thoroughly to prevent corrosion.• To clarify on pre- and post-trip inspections: we don't need more <i>training</i> on pre- and post-trip inspection, rather we need more leadership enforcement to ensure that it is done correctly.
Connecticut	Basic and advanced training in hydraulics.
Illinois (2/15)	<ul style="list-style-type: none">• Most troubleshooting, electrical repairs and calibrations are completed by the mechanic or under the supervision of the mechanic.• Need more training in operation of different types of spreaders controls and equipment. Also need snow and ice training: when to plow, when to spread salt, when to use brine, etc.
Oregon	If operators start troubleshooting, they may start trying to fix things. ODOT has a level of service agreement between shops and operators. It is preferred that operators stick to that agreement, which outlines what the operators can/cannot touch on the truck regarding repairs.
Pennsylvania	There are always opportunities for improvement and additional training, especially with our large turnover of new employees.
Utah	Operators need to be more aware of shop safety, awareness of garage door open or closed.
Washington (2/2)	<ul style="list-style-type: none">• Most operators are not mechanically inclined and are often not experienced operators. As such, they often don't know what to watch for. Over time, they get to know their equipment well.• We are working on calibration training but still have room for improvement.

Improving Mechanic Training

Respondents selected from among the following training topics that could improve mechanics' performance in operating and maintaining winter maintenance equipment:

- Troubleshooting equipment problems in the garage and/or on the road
- Engine repair
- Spreader applicator/spinner repair
- Spreader auger/conveyor adjustments and repair
- Electrical problems
- Routine maintenance of all systems

Respondents most often cited the need for training on electrical problems, followed by the ability to troubleshoot problems on the road and in the garage. Figure 2.5 graphically illustrates survey responses. (See Table 2.10 for a full description of each training topic response option.)

Figure 2.5 Additional Training Needed for Mechanics

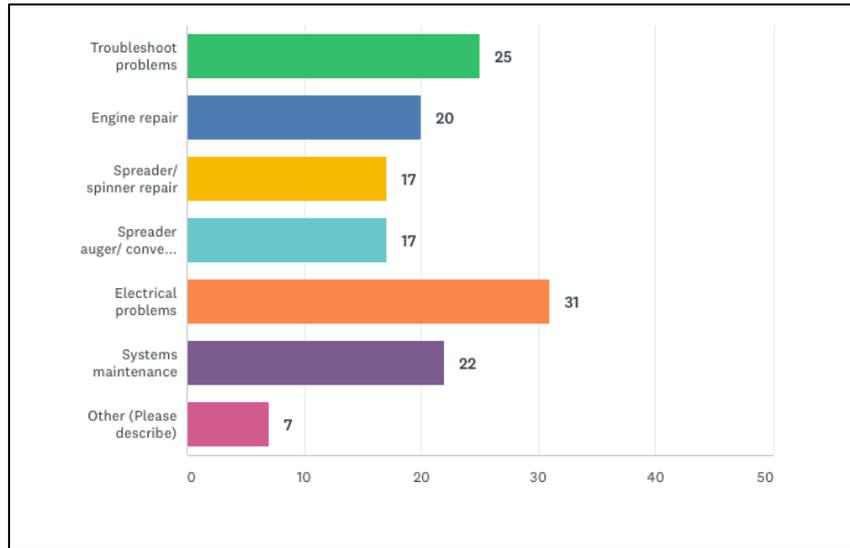


Table 2.10 provides specific agency responses. Comments about additional training for mechanics follow the table.

Table 2.10 Additional Training Needed for Mechanics

Training Topic	State
Troubleshoot equipment problems on road and in garage	Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (9/15), Kansas, Maine, Massachusetts, Michigan, North Dakota (2/2), Rhode Island, South Dakota (2/4), Vermont, Washington (1/2), West Virginia
Engine repair	Colorado (1/2), Idaho, Illinois (10/15), Kansas, Maine, Michigan, North Dakota (2/2), Rhode Island, South Dakota (1/4)
Spreader/spinner repair	Colorado (1/2), Connecticut, Idaho, Illinois (5/15), Maine, Massachusetts, Michigan, North Dakota (1/2), Oregon, South Dakota (1/4), Texas, Vermont, Washington (1/2), West Virginia
Spreader auger/conveyor adjust and repair	Colorado (1/2), Connecticut, Delaware, Idaho, Illinois (5/15), Maine, Massachusetts, Missouri, North Dakota (1/2), Oregon, South Dakota (1/4), Texas, Vermont
Electrical problems	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (11/15), Indiana, Kansas, Maine, Michigan, Minnesota, North Dakota (2/2), Pennsylvania, Rhode Island, South Dakota (1/4), Vermont, Washington (1/2), West Virginia
Routine maintenance of all systems	Arizona, Colorado (1/2), Delaware, Idaho, Illinois (8/15), Kansas, Maine, Massachusetts, North Dakota (1/2), Oregon, Pennsylvania, South Dakota (2/4), Vermont, West Virginia

Eleven respondents offered comments about additional training for mechanics, or about their agency's particular situation. Comments have been edited for clarity.

Arizona	Spreader calibration training.
Colorado (1/2)	New trucks have many new electronics, which requires training that keeps pace with the advances in on-board systems and technology.
Illinois (5/15)	<ul style="list-style-type: none">• If our mechanics can keep up with industry updates and are given diagnostic equipment to help them, our equipment will be in good working condition.• Engine, transmission and electrical problems.• Our current mechanic does well with all of this. He needs to be given reliable diagnostic equipment/software for all brands of equipment. His current laptop is not reliable and his agency does not always keep software licenses current.• Emissions and engine system training.• Continuing education on new models and advances would be beneficial.
Michigan	We are always exploring opportunities to provide new and additional training for our mechanics.
Pennsylvania	There are always opportunities for improvement and additional training; we have a large turnover of new employees.
Rhode Island	Technical issues related to new technologies are the most troubling for our mechanics.
Washington (1/2)	As technology advances, it becomes increasingly difficult to manage. Equipment gets replaced in certain areas or in a truck here and there. People in that area become familiar with it, but those in other areas don't use or see it. When something new comes into the fleet, the training needed for the equipment that is being superseded gets pushed down on the list of priorities.

Most Important Changes Needed

Respondents identified the most important changes their agencies need to make concerning maintenance, upkeep and general repair of winter road maintenance equipment from among the following options:

- Adding full-time mechanics dedicated to winter maintenance equipment
- Training for all operators on troubleshooting and repair of minor equipment issues
- More emphasis/training on preventing corrosion to wires, etc. (keeping equipment clean, etc.)
- More emphasis/training on pre-trip/post-trip inspections by operators
- More frequent preventive maintenance

By far the most frequently selected areas for change were corrosion prevention emphasis/training and providing better pre-and post-trip inspection training for operators. Approximately a quarter of respondents reported that they believed adding full-time, dedicated mechanics for winter maintenance equipment was needed. Figure 2.6 graphically presents survey responses. (See Table 2.11 for a full description of each agency change response option.)

Figure 2.6 Most Important Agency Changes Needed

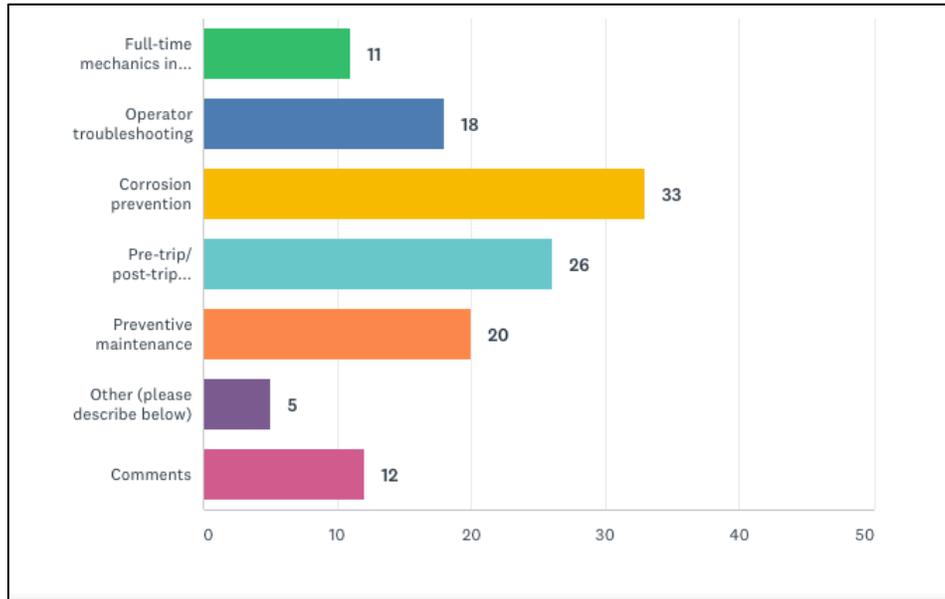


Table 2.11 provides specific agency responses. Respondents’ additional comments follow the table.

Table 2.11 Most Important Agency Changes Needed

Agency Change	State
Adding full-time mechanics dedicated to winter maintenance equipment	Colorado (1/2), Connecticut, Idaho, Illinois (5/15), Massachusetts, Michigan, North Dakota (1/2), Rhode Island, South Dakota (1/4)
Troubleshooting and minor repair training for operators	Colorado (1/2), Connecticut, Delaware, Idaho, Illinois (5/15), Kansas, Maine, Michigan, Missouri, North Dakota (2/2), Rhode Island, South Dakota (1/4), Utah
Better corrosion prevention emphasis/training	Arizona, Colorado (2/2), Connecticut, Delaware, Illinois (10/15), Indiana, Kansas, Maine, Massachusetts, Michigan, Minnesota, North Dakota (2/2), Oregon, Rhode Island, South Dakota (3/4), Texas, Utah, Vermont, Washington (1/2), West Virginia
Better pre- and post-trip operator inspections	Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Illinois (6/15), Kansas, Maine, Massachusetts, Michigan, North Dakota (2/2), Oregon, Rhode Island, South Dakota (2/4), Vermont, Washington (1/2), West Virginia
More frequent preventive maintenance	Colorado (1/2), Idaho, Illinois (3/15), Indiana, Massachusetts, Minnesota, Missouri, North Dakota (1/2), Oregon, Pennsylvania, South Dakota (3/4), Texas, Utah, Vermont, Washington (1/2), West Virginia

Twelve respondents offered further comments on this question. Comments below are edited for clarity.

Colorado (2/2)	<ul style="list-style-type: none">• Operators must understand that preventive maintenance goes a long way to keep the vehicle running. Ignoring problems creates issues down the road.• Listen to the mechanics and shop supervisors. Leaders should value their input and apply it to improving operator performance and care of their equipment.
Connecticut	Hold operators accountable for the daily inspections and operation errors.
Illinois (4/15)	<ul style="list-style-type: none">• We need more mechanics and need to keep the trucks cleaner.• We need a knowledgeable person to oversee repairs sent out to external service and parts vendors in order to hold them accountable. There are issues with "over-fixing" equipment that is sent out—not sticking to the original complaint. If the truck is going to be taken apart, at a certain point we need common-sense decisions about replacing seals and other components related to tear-down and reassembly.• Operators and mechanics need an understanding of modern diesel engines and emissions systems.• We need better rotation of the fleet.
Kansas	We need additional mechanics.
Michigan	Our equipment-to-mechanic ratio is approximately 57:1. Most MDOT garages have a single mechanic, which proves challenging during winter and other high intensity operations.
Oregon	Priority of needs comes down to the last three choices: thoroughly washing the trucks, pre- and post-trip inspections, and more frequent preventive maintenance.
Pennsylvania	There are always opportunities for improvement and additional training; we have a large turnover of new employees.
Washington (1/2)	<ul style="list-style-type: none">• More emphasis on post-trip washdown policy would make a big difference.• Undercarriage and wheel wash stations would be great but would add environmental challenges.• Proper plow use training and enforcement would help as well. Often failures caused by operator misuse are blamed on the equipment rather than the operator. I wouldn't try to hang glide with a kite, but that doesn't mean that others won't.
West Virginia	Accountability across the board.

Roadblocks to Improvement

Respondents identified the primary roadblocks to improving operator/mechanic competence in winter maintenance equipment upkeep and general repair from among these possibilities:

- Operators are temporary employees, hired for the season.

- If operators gained mechanics’ skills, they would seek higher-paid positions.
- Problems with equipment are too varied and complex to address through basic courses.
- The agency cannot afford a mechanic solely for winter maintenance equipment.

Two-thirds of respondents reported that the biggest roadblock to improving operator and mechanic competence is that problems with today’s winter road maintenance equipment are too varied and complex to address through basic courses. Just one-third of respondents reported that the temporary nature of operators, hired only for the season, impeded the agency’s efforts to improve operator and mechanic competence. Table 2.12 presents survey responses.

Table 2.12 Possible Roadblocks to Agency Change

Possible Roadblocks	State
Operators are temporary, hired for season	Colorado (2/2), Illinois (6/15), Massachusetts, Oregon, Pennsylvania, South Dakota (1/4), Washington (2/2)
Operators would find better jobs if trained	Missouri, South Dakota (2/4)
Equipment is too complex to address with basic training	Arizona, Connecticut, Delaware, Idaho, Illinois (7/15), Indiana, Maine, Michigan, Minnesota, North Dakota (2/2), Oregon, Pennsylvania, South Dakota (4/4), Texas, Utah, Vermont, Washington (2/2), West Virginia
Winter mechanic is too costly for agency	Colorado (1/2), Illinois (1/15), Massachusetts, South Dakota (2/4), Texas, Washington (2/2)

Twelve respondents offered additional comments regarding perceived roadblocks to improving operator/mechanic competence. Comments have been edited for clarity.

Colorado (2/2)

- Decentralized control of the regions leads to inconsistency in training delivery and accountability. Operators know there are no consequences for poor quality work because the agency needs the operators on the road. Therefore, “I won’t get fired!”
- Some operators are temporary hires, so this could be a factor. However, many are full-timers. I don't think we should try to turn operators into mechanics, but there should be an expectation that they keep equipment clean and lubed, and that they be very knowledgeable in proper operation to avoid equipment damage. They should have a sense of "pride in ownership." Leaders should foster this attitude and reward/recognize those who demonstrate it.

Connecticut

We need more accountability from operators.

Illinois (2/15)

- If the operators let the mechanics know when equipment is acting up, it can be repaired before it’s needed in an emergency. It all goes back to pre-trip and post-trip inspections.
- We need more mechanics.

Kansas

There is a lack of mechanics in general.

- Minnesota**
- We need a basic ability to get/record accurate maintenance costs for equipment, and managers who can understand those costs and make sound decisions on good preventive maintenance.
 - Many currently hired new operators do not have the skills needed to properly maintain our equipment.
 - Hiring more mechanics/specialized trained technicians would help maintain equipment.

Oregon The variety of spreader controls is complex for operators and adds another level of complexity to maintain calibration. Other equipment (plow blades, basic mechanics, etc.) can be covered with basic courses and operators would benefit. Sometimes managers aren't providing adequate time for washing equipment or it's not emphasized enough.

Pennsylvania The biggest roadblock is hiring and keeping diesel mechanics. We have training programs within the commonwealth for both operators and mechanics.

Rhode Island There is both a driver and mechanic shortage in our area. We have had two open mechanic positions for over six months with few applicants. Those who applied were either not qualified or turned down the job because of the pay.

- Washington (2/2)**
- There is no single silver bullet. More equipment standardization would really help reduce the need for diverse training for mechanics, and operators could become more familiar with equipment strengths and weaknesses. Operators would better understand how not to break it and mechanics would be more able to troubleshoot and repair. We'd also cut costs in keeping parts overhead while cutting equipment downtime.
 - One of the issues is recruitment/retention due to very disparate pay between state and local agencies. There is also booming construction in this region that attracts skilled employees.

2.6 Final Comments

Presented below are additional observations or recommendations for improving the competence of operators/mechanics. Respondents' comments are edited for clarity.

Colorado (1/2) I believe the core of avoiding most winter equipment maintenance problems is good before and after operations inspections and maintenance practices, along with a robust and effective preventive maintenance (PM) program. If these procedures are taught well, enforced and sustained consistently, maintenance problems will be less of an issue. The better our PM is, the fewer unscheduled breakdowns we will have. If we just teach it and talk about it but don't enforce it through leadership, we have wasted time and money without solving the problem.

Illinois (2/15)

- Mechanics need to be able to address more electrical and computer-related issues.
- The emissions on these trucks are going to be a long-term maintenance problem and will also be costly to repair. It makes it very difficult to determine problems when each truck seems to vary in design/components each year.

Maine

Equipment failures are too complex and need special equipment/tools to repair for our basic mechanics.

North Dakota

We could use more OEM and vendor training.

Oregon

The most effective mechanic training is lecture plus a lab setting. Operator training is probably best hands-on or a good video presenting a variety of equipment (different plows, spreader controllers, etc.). Teaching the cleaning of equipment must include expectations for washing: tell them HOW to wash. Calibration training should be emphasized.

Washington (1/2)

High-level maintenance personnel have often started behind the wheel of a snowplow. They know the job and what they want, equipment-wise, to accomplish the job. They often don't understand the impact that adding extra attachments can have on equipment weights and payload capacities. They also often don't understand that the new equipment may not be designed to work the way their old equipment was. Keeping clear, open and respectful dialogue with your personnel is vital to your relationship with them. It also helps you realize that at times, you may not have understood their need when you try to supply them with a piece of equipment.

3 Literature Search

Presented below are findings from a literature search that examined the following topic areas:

- Current Clear Roads Resources
- Resources from Clear Roads Member States/Provinces
- Resources from Similar Organizations
- National Resources
- Related Resources

3.1 Current Clear Roads Resources

Training for Winter Maintenance Supervisors and Operators, Ann M. Johnson and Jim Grothaus, Project CR 12-04, Clear Roads Pooled Fund Study, February 2017, 14 p

http://clearroads.org/wp-content/uploads/dlm_uploads/FR_CR.12-04.pdf

From the abstract: Researchers created 22 modules for use in teaching maintenance workers and their supervisors on a variety of topics relating to roadway snow and ice control. ... The objective was to develop a training program for use by all member agencies that provides the flexibility for each state to modify or update the training modules as needed. To accomplish that, they developed a list of 22

priority modules, as well as a comprehensive list of materials and resources to use in their development. Researchers developed a teaching guide, summary, and pre- and post-test documents for each.

Module 2 “Truck Operations” and Module 21 “Getting Ready for Winter” address some aspects of equipment maintenance, but the training modules do not address diagnosis of problems that may arise on the road concerning engines, electronics, applicators, or any other equipment systems. The videos provide knowledge of the concepts and procedures an operator must possess in order to use normally functioning equipment effectively.

Manual of Best Practices for the Prevention of Corrosion on Vehicles and Equipment used by Transportation Agencies for Snow and Ice Control, Dave Berger, Mehdi Honarvar Nazari and Xianming Shi, Clear Roads Pooled Fund Study, April 2015, 143 p

http://clearroads.org/wp-content/uploads/dlm_uploads/Revised_Task-2_Corrosion-Manual.pdf

Corrosion is a common cause of wiring and lighting failure and other deterioration on winter maintenance equipment. This manual presents methods through which corrosion can be prevented or mitigated on equipment that is constantly exposed to salt, moisture and abrasives. *From the report abstract:*

Through this project, the research team developed a user-friendly manual that documents best practices for managing the risk of equipment corrosion, especially in the presence of chemical deicers. The audience for this manual includes operators, mechanics and garage-level supervisors. The manual defines the basic corrosion conditions, with a focus on the need for managing corrosion risks, common modes of corrosion failure, and corrosion-prone parts (priorities) on DOT [department of transportation] equipment. This manual addresses design considerations and material selection for corrosion risk management. This manual also lists some commercial products that have been used by DOTs, and presents some successful experiences of DOTs, the US Navy and private companies. It also presents preventive maintenance strategies and tactics.

3.2 Resources from Clear Roads Member States/Provinces

Many state DOT websites include links to the e-learning opportunities through AASHTO (see **National Resources** below). Training programs addressing equipment and procedures are provided by some DOTs and Local Technical Assistance Programs.

Iowa

Iowa DOT Winter Operations Training Series, Video Library, Iowa Local Technical Assistance Program, undated

<https://iowaltap.iastate.edu/videos/>

This website provides access to a “15-part video series by the Iowa Department of Transportation [that] provides valuable information about winter roadway operations. Topics covered include pre-season preparation of trucks and plows, regular equipment checks, radio procedures, proper and safe clothing, plowing techniques, anti-icing and de-icing, snow fences and more.” Two videos specifically address equipment preparation and maintenance:

- Iowa DOT Preseason Truck Preparation–Winter Operations Training Series 2 of 15
https://www.youtube.com/watch?v=kmqfJpgoH98&list=PLurY2WfsVWKn1Ekx7H_v8DjwJvXloIN9n&index=2
- Iowa DOT Regular Equipment Checks–Winter Operations Training Series 4 of 15
https://www.youtube.com/watch?v=0n17ahcBP1Q&list=PLurY2WfsVWKn1Ekx7H_v8DjwJvXloIN9n&index=4

Kansas

Kansas Rural Transit Assistance Program (RTAP) and Kansas Local Technical Assistance Program (LTAP), University of Kansas Transportation Center, Lawrence, KS, website, undated
<https://kutc.ku.edu/sites/kutc.ku.edu/files/docs/2019%20KUTC%20Services.pdf>

The services offered by these organizations include a wide range of training and assistance, and may change according to the needs of their constituencies.

Related Resource:

Calendar LTAP, University of Kansas Transportation Center, website, undated
<https://kutc.ku.edu/calendar/ltap>

This is the course list for 2019 LTAP Training and Events. Courses include *Snow and Ice Control*, which is described as a workshop that “presents practices of safe winter operations, winter weather information sources, snow and ice control road maintenance, equipment and operations, problem solving techniques, and gravel road winter weather maintenance.”

Minnesota

Snow Plow Operator Training (SPOT), Office of Maintenance, Minnesota Department of Transportation, undated
<https://www.dot.state.mn.us/maintenance/spottraining.html>

From the website: SPOT is a set of skills (standards) achieved through training, for snow plow operators. Participants are trained on how to safely inspect, drive, and operate an over-width commercial motor vehicle with front and wing plows. This training sets the minimum skill expectations needed to perform plowing procedures at MnDOT.

The program seeks to convey the following skills to attendees:

- Identify and perform required pre-trip and post-trip inspections.
- Understand and perform equipment care and maintenance.

New York

Winter Maintenance: On Demand Videos, Cornell Local Roads Program, Local Technical Assistance Program, New York, website, undated
<https://www.clrp.cornell.edu/library/videos/wm.html>

From the website: The Cornell Local Roads Program provides unbiased, timely and exceptional technical assistance and training to highway and public works departments across New York State to help improve the quality and safety of roads and streets. We support local communities through strong collaborations with partners that enhance the sustainability of local highway assets.

This LTAP website offers diverse and changing content. Among the 25 videos currently offered in the Video Lending Library that address some aspects of equipment maintenance are five of the six videos from Iowa DOT’s Winter Operations Training Program, as well as others addressing cold starts/operations and new equipment innovations in snowplows.

Pennsylvania

Pennsylvania Department of Transportation Local Technical Assistance Program, website, 2019
https://www.dot7.state.pa.us/LTAP/Public/AvailableCourses_GenInfo.aspx

Pennsylvania DOT’s LTAP offers training courses throughout the state. Of the 77 courses offered for 2019, two courses addressed equipment maintenance concerns to some extent:

Equipment & Worker Safety is a daylong course offered four times throughout the year. *From the course description:*

This course provides a basic understanding of common safety factors and practices associated with public works road maintenance operations. Specific operations discussed include trench excavation, crack sealing with hot asphalt, mowing and chain saw use, as well as winter maintenance.

Salt & Snow Management is a daylong course offered 15 times throughout the year. *From the course description:*

This course covers all aspects of winter maintenance operations. Topics include planning and organizing, public relations, material usage and application rates, equipment types and calibration as well as various operational procedures such as plowing and spreading. Other topics include CDL regulations, safety and environmental awareness. Also covered are the latest techniques in pre-wetting materials and anti-icing procedures for a more effective and economical operations.

Virginia

Maintenance Training Academy, Virginia Department of Transportation, website, November 2019
<https://www.virginiadot.org/jobs/mainttrainacademy.asp>

From the website: The Maintenance Training Academy is a state-of-the-art, innovative facility offering statewide training programs. Individuals receive hands-on equipment and highway construction instruction.

The academy delivers relevant, clear and comprehensive training on many topics including:

- Heavy equipment operation
- Preventive maintenance
- Work zone safety
- Snow operations

This training is offered to both state employees and to approved partners

Ontario, Canada

Winter Maintenance Operations Training, Courses and Events, Ontario Good Roads Association, 2016.
<https://www.ogra.org/courses-and-events/Events/winter-maintenance-operations-training.html>

From the website:

Snow School for Mechanics & Technicians

This one-day interactive training provides Mechanics and Technicians with an opportunity to experience a practical approach to troubleshooting automated controllers, hydraulics and preventive maintenance for your equipment.

The following describes a September 2019 session of this interactive training offering:

Course Objectives: This course provides mechanics with a working knowledge of modern winter maintenance vehicles and accessories with particular emphasis on automated controller and spreader systems, and the hydraulic systems used to support vehicle accessories that apply both wet and dry materials as well as plowing operations. Practical solutions to common equipment problems will be explored, along with preventive maintenance practices and troubleshooting diagnostics.

Course Content

- Environmental and salt management issues
- Do new materials mean new mechanical problems?
- Demystifying electronic spreader controllers
- Getting ahead of problems: best practices for preventive maintenance
- Equipment demonstration
- Hydraulics
- Troubleshooting

3.3 Resources from Similar Organizations

Other organizations that employ operators of vehicles, such as bus and taxi companies, may have similar equipment maintenance and repair challenges to address as winter road maintenance staff of state DOTs. One closer example, from the aviation field, is cited below.

Airport Snow Equipment Mechanic's Training, International Aviation Snow Symposium, Northeast Chapter of American Association of Airport Executives (NEC-AAAE), April/May 2019

<https://www.necaaae.org/airport-snow-equipment-mechanic-s-training>

This conference included the return of sessions dedicated to continued training of men and women who fix and maintain airfield snow removal equipment. Among the topics addressed:

- Hydraulics
- Oils/fluids updates
- Electronics/J1939
- Drivetrain/4WD
- Root cause analysis techniques
- Blower maintenance/service
- Sweeper maintenance/service
- Plow maintenance/service
- All Wheel Steer/service
- Sprayer maintenance/service

3.4 National Resources

NCHRP Synthesis 483: Training and Certification of Maintenance Workers, Nancy Laffey and Kathryn A. Zimmerman, 2015, 126 p

Report available at <http://nap.edu/23458>

From the report's preface: This synthesis documents front-line maintenance worker training and certification practices for highway transportation agencies in the United States and Canada. The information presented includes the types of topics being addressed by training and certification programs, the delivery methods used to provide the training, the sources of instruction, and whether material-sharing relationships are being utilized to access training. In addition, the synthesis captures how training is related to performance and the incentives being used by state and provincial agencies to encourage front-line maintenance workers to complete training.

Equipment Management Technical Services Program, American Association of State Highway and Transportation Officials (AASHTO) website, undated

<https://www.emtsp.org>

This AASHTO program for agency fleet management professionals offers 18 videos in its Training and Research video library, available at https://www.emtsp.org/files/video_library/Training_Research.html, that include:

- Incorporating On-Board Diagnostics into Fleet Preventive Maintenance Practices
- North Carolina Equipment Management Training

SICOP (Snow and Ice Pooled Fund Cooperative Program) Winter Operations, Maintenance, Training Detail: Equipment Maintenance, American Association of State Highway and Transportation Officials, undated

Course description at <https://store.transportation.org/Item/TrainingDetail?ID=4121>

From the course description: This course presents procedures that all winter maintenance operators should be familiar with in preparing and maintaining snow and ice control equipment. This module is presented in eight units:

Unit 1: Pre-season Preparation

Unit 2: Common Types of Winter Maintenance Equipment

Unit 3: Mounting and Inspecting Snow Removal Equipment

Unit 4: Preparing for Each Event

Unit 5: Within-event Maintenance

Unit 6: Post-event Maintenance

Unit 7: Periodic Maintenance

Unit 8: End-of-Season Tasks

3.5 Related Resources

Government Fleet: Managing Public Sector Vehicles & Equipment, Bobit Business Media, website, 2019

<https://www.government-fleet.com>

This extensive website offers articles, reviews, questions and answers, and other information on public sector fleet maintenance, safety, fuel, software, vehicle research and other topics. It includes winter maintenance equipment in its discussions.

Automotive Technician: Two Year Technical Diploma, Madison Area Technical College, Madison, WI, website, 2019

<https://madisoncollege.edu/program/automotive-technician>

As do similar technical colleges across the country, Wisconsin's Madison Area Technical College offers courses in a two-year program leading to certification as an Automotive Technician. The courses teach many of the skills that are a focus of this project. Students who complete the Automotive Technician program earn a two-year technical diploma. The Automotive Technician program is accredited through the National Automotive Technicians Education Foundation (NATEF).

Appendix A: Survey Questions

Winter Road Maintenance Equipment Used & Common Equipment Failures

1. (Required) What kinds of winter road maintenance equipment does your agency use? Check all that apply.
 - Snowplows (dedicated-use plow trucks not used during summer)
 - Snowplow blade assemblies attached to/removed from trucks as needed (truck used year-round)
 - Tow plows
 - Salt/sand spreader trucks (dedicated-use trucks not used during summer)
 - Drop-in salt/sand spreaders (truck used year-round)
 - Prewetting systems
 - Brine application systems (sprayers)
 - AVL systems
 - Mobile temperature sensors
 - Other (please describe)
2. Across your fleet, how often do the following issues take snowplows out of service? (Please focus on times when emergency or unplanned repairs are needed, rather than scheduled or preventive maintenance.) (Respondents selected from Frequently, Sometimes, Rarely/Never and N/A response options.)
3. Truck experiences mechanical problems on route (cannot restart engine, etc.)
 - Truck experiences mechanical problems on route (cannot restart engine, etc.)
 - Clogged particulate filter or similar issue
 - Plow hydraulics fail (operator cannot raise, lower, or sufficiently control plow blade)
 - Plow blade/insert breaks (requiring replacement)
 - Spreader system fails (jams, irregular application, applies more/less material than expected, stops working)
 - Brine application system fails
 - Prewetting system fails
 - Spreader/sprayer controller failure
 - Warning light or gauge malfunctions (indicating a problem where none exists)
 - Electrical/wiring issue (short, corroded wires, etc.)
 - Headlight, taillight, or other exterior lights burn out
 - HVAC system, wipers, or other vehicle peripherals fail
 - Sensor failure (please describe below)
 - AVL system failure
 - Other (please describe below)

Please provide details on the issues that are most significant to your agency. For any items where you selected "Frequently," how often does this occur?
4. Are you aware of best practices or shop-fabricated add-ons that can prevent common maintenance issues, especially breakdowns on the road? (For example: shop-fabricated housing to protect components from corrosive deicers, adding a specific area to operators' pre-trip checks, etc.) Please describe.

Best Practices for Upkeep and General Repair of Winter Road Maintenance Equipment

5. Does your agency have dedicated full-time or part-time mechanics for its winter road maintenance equipment?
 - Yes
 - No (Please describe who maintains and repairs your agency's winter maintenance equipment.)
6. Which of these steps are part of your agency's protocol when a snowplow breaks down on the road? Check all that apply.
 - Operator tries to find the problem and repair it
 - Operator talks to mechanic, who directs operator to check, repair problem
 - Mechanic goes out to snowplow to fix the problem
 - Snowplow returns/is towed to garage for repairs
 - Other (please describe)

Please describe how your agency deals with a snowplow that breaks down on a route.
7. At your agency, are plow operators expected to be able to troubleshoot and/or repair some level of equipment problems while on the road?
 - No
 - Yes (Please describe these problems.)

Expected Knowledge and Training of Operators and Mechanics in Upkeep of Winter Maintenance Equipment

8. Which of the following qualifications are required for applicants to work as winter maintenance equipment operators with your agency? Check all that apply. Please include any relevant documents or links (see question 16).
 - Commercial Driver's License (CDL)
 - Completion of a snowplow operator training course
 - Previous snowplow driving experience
 - Previous experience driving large vehicles
 - Ability to troubleshoot and diagnose mechanical/hydraulic/electrical problems on equipment
 - Knowledge of spreader application systems
 - Other (please describe below)

Please provide details on the qualifications your agency requires.
9. What kinds of training does your agency provide for winter maintenance operators and mechanics **related to equipment upkeep, maintenance or repair**? Check all that apply
(A separate set of the response options below was provided for operators and mechanics.)
 - Training offered within your agency
 - On-the-job training
 - Training provided by vendors/manufacturers
 - Equipment Management Technical Services Program (EMTSP) via AASHTO
 - Technical institute courses
 - LTAP training
 - Other online training
 - Other training (please describe below)

Which specific vendors, organizations, etc., provide the training? Please include any supporting documents or links (see question 16).

10. What approaches have you found to be most effective in training operators and/or mechanics on equipment repair and upkeep? Check all that apply; please provide details below.

- Training offered within your agency
- On-the-job training
- One-time-only training
- Annual/refresher training
- Training provided by vendors/manufacturers EMTSP via AASHTO
- Technical institute courses
- LTAP training
- Online training (please describe below)
- Other (please describe below)

Please provide details on approaches that you've found to be particularly effective or ineffective, or formats/programs that you're interested in trying.

Opportunities for Improvement

11. In which of the following areas do **operators** in your agency need additional training in order to keep your agency's winter maintenance equipment in good working condition? Check all that apply.

- Troubleshooting equipment failures on the road
- Pre-trip/post-trip equipment checks
- Spreader calibration
- Clearing material jams/blockages within spreaders
- Electrical problems
- Other (please describe below)

12. In which of the following areas do mechanics in your agency need additional training in order to keep your agency's winter maintenance equipment in good working condition? Check all that apply.

- Troubleshooting equipment problems in the garage and/or on the road
- Engine repair
- Spreader applicator/spinner repair
- Spreader auger/conveyor adjustments and repair
- Electrical problems
- Routine maintenance of all systems
- Other (Please describe)

13. What do you consider the most important change(s) your agency needs to make concerning maintenance, upkeep, and general repair of winter road maintenance equipment?

- Adding full-time mechanics dedicated to winter maintenance equipment
- Training for all operators on troubleshooting and repair of minor equipment issues
- More emphasis/training on preventing corrosion to wires, etc. (keeping equipment clean, etc.)
- More emphasis/training on pre-trip/post-trip inspections by operators
- More frequent preventive maintenance
- Other (please describe below)

14. What do you consider to be the primary roadblocks to improving operator/mechanic competence in winter maintenance equipment upkeep and general repair at your agency? Check all that apply.

- Operators are temporary employees, hired for the season
- If operators gained mechanics' skills, they would seek different, higher-paid positions
- Problems with equipment are too varied and complex to address through basic courses
- Agency cannot afford a mechanic solely for winter maintenance equipment
- Other roadblocks (please describe below)

Wrap-Up

15. Do you have anything more you would like to add to this survey?

16. Please include links to relevant documents here. Please send supporting documents as attachments to sharon.vansluijs@ctcandassociates.com.



research for winter highway maintenance

Lead state:

Minnesota Department of Transportation
Research Services
395 John Ireland Blvd.
St. Paul, MN 55155