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The purpose of this report is to serve as a synthesis of pertinent completed research and practitioner survey results to be used for further study and evaluation. This synthesis does not represent the conclusions of the authors or the Clear Roads member agencies. This document does not constitute a standard, specification or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor or consultant. Trade names of commercial products appearing in this publication are included for clarity only.

Acknowledgments

CTC & Associates LLC would like to extend our appreciation to the members of the Technical Advisory Committee of the Clear Roads pooled fund for their assistance with this project. We also extend our thanks to the many DOT employees of Clear Roads member states who participated in the project’s survey.
Abstract

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, wetness and corrosive materials. Consequently, winter road maintenance equipment may break down on the road. Road maintenance agencies have a range of protocols for dealing with equipment breakdown in the field, including troubleshooting via phone or radio, 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 snowplows breaking down 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 types of experience sought by agencies in their operators and mechanics; and the 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 gathered information about best practices, common equipment failures, responses to failures, and training approaches for operators and mechanics. The results of a literature search supplemented the survey findings.
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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
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).

### 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

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Produced by CTC & Associates LLC
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](image)

**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

<table>
<thead>
<tr>
<th>Winter Maintenance Equipment</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated snowplows (winter use only)</td>
<td>Colorado (2/2), Connecticut, Massachusetts, Michigan, North Dakota (2/2), Oregon, Vermont, Washington (1/2)</td>
</tr>
<tr>
<td>Removable snowplow blade assemblies</td>
<td>Arizona, Idaho, Indiana, Kansas, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Utah, Washington (2/2), West Virginia</td>
</tr>
<tr>
<td>TowPlows</td>
<td>Arizona, Colorado (2/2), Connecticut, Delaware, Idaho, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (2/2), Oregon, Pennsylvania, Utah, Washington (2/2)</td>
</tr>
<tr>
<td>Dedicated salt/sand trucks (winter use only)</td>
<td>Arizona, Colorado (1/2), Connecticut, Delaware, Michigan, Minnesota, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island, Texas, Washington (1/2)</td>
</tr>
<tr>
<td>Drop-in salt/sand spreaders</td>
<td>Arizona, Colorado (2/2), Connecticut, Delaware, Michigan, Minnesota, North Dakota (2/2), Oregon, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Washington (2/2), West Virginia</td>
</tr>
<tr>
<td>Prewetting systems</td>
<td>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</td>
</tr>
</tbody>
</table>
Respondents from Minnesota and North Dakota indicated their states used other equipment, with Minnesota’s respondent noting that the state has “salt slurry, epoke 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 to the total responses by state are indicated next to each state name. Additional comments follow the table.

<table>
<thead>
<tr>
<th>Winter Maintenance Equipment</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other equipment</td>
<td>Minnesota, North Dakota (1/2) (see comments below)</td>
</tr>
</tbody>
</table>

### Table 2.2 Winter Maintenance Equipment Used: Illinois and South Dakota

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

- 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**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Frequently</th>
<th>Sometimes</th>
<th>Rarely/Never</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck experiences...</td>
<td>7</td>
<td>13</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Clogged particulate...</td>
<td>1</td>
<td>12</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Plow hydraulics...</td>
<td>2</td>
<td>8</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Plow blade/insert...</td>
<td>2</td>
<td>10</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Spreader system fails</td>
<td>6</td>
<td>19</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>Brine application...</td>
<td>1</td>
<td>20</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Prewetting system fails</td>
<td>3</td>
<td>15</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Spreader/spreader controller...</td>
<td>19</td>
<td>21</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Warning light or gauge</td>
<td>5</td>
<td>13</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Electrical/wiring issue</td>
<td>13</td>
<td>26</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Headlight, taillight, a...</td>
<td>3</td>
<td>26</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>HVAC system, wipers, etc.</td>
<td>3</td>
<td>22</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Sensor failure</td>
<td>4</td>
<td>12</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>AVL system failure</td>
<td>7</td>
<td>22</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Equipment Problem</th>
<th>State and Problem Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck mechanical problem on route (cannot restart engine, etc.)</td>
<td><strong>Frequently:</strong> Colorado (1/2), Idaho, Maine, North Dakota (2/2), Rhode Island <strong>Sometimes:</strong> Arizona, Colorado (1/2), Connecticut, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, Oregon, Pennsylvania, Texas, Utah, Vermont, Washington (1/2), West Virginia <strong>Rarely/Never:</strong> Delaware, Washington (1/2)</td>
</tr>
<tr>
<td>Clogged particulate filter or similar</td>
<td><strong>Frequently:</strong> Arizona, Connecticut, Washington (1/2) <strong>Sometimes:</strong> Colorado (2/2), Idaho, Massachusetts, Michigan, Missouri, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island <strong>Rarely/Never:</strong> Delaware, Indiana, Kansas, Maine, Minnesota, North Dakota (1/2), Texas, Utah, Washington (1/2)</td>
</tr>
<tr>
<td>Plow hydraulics (raising, lowering blade, etc.)</td>
<td><strong>Frequently:</strong> Arizona, North Dakota (1/2) <strong>Sometimes:</strong> Colorado (2/2), Connecticut, Delaware, Idaho, Kansas, Maine, Michigan, Minnesota, Missouri, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island, Texas, Utah <strong>Rarely/Never:</strong> Indiana, Massachusetts, Vermont, Washington (2/2), West Virginia</td>
</tr>
<tr>
<td>Plow blade/insert breakage</td>
<td><strong>Sometimes:</strong> Arizona, Colorado (2/2), Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota (1/2), Oregon, Rhode Island, Texas, Utah, Washington (2/2), <strong>Rarely/Never:</strong> Connecticut, Idaho, Maine, Massachusetts, North Dakota (1/2), Vermont, West Virginia</td>
</tr>
<tr>
<td>Spreader system failure</td>
<td><strong>Frequently:</strong> Delaware, North Dakota (2/2), Rhode Island, <strong>Sometimes:</strong> Arizona, Colorado (2/2), Idaho, Indiana, Kansas, Maine, Michigan, Oregon, Pennsylvania, Texas, Washington (2/2) <strong>Rarely/Never:</strong> Connecticut, Massachusetts, Missouri, Utah, Vermont, West Virginia</td>
</tr>
<tr>
<td>Brine application system failure</td>
<td><strong>Frequently:</strong> Rhode Island <strong>Sometimes:</strong> Colorado (1/2), Connecticut, Delaware, Kansas, Maine, North Dakota (2/2), Texas, Vermont, West Virginia <strong>Rarely/Never:</strong> Arizona, Colorado (1/2), Idaho, Indiana, Massachusetts, Michigan, Minnesota, Missouri, Pennsylvania, Utah, Washington (2/2)</td>
</tr>
<tr>
<td>Prewetting system failure</td>
<td><strong>Frequently:</strong> Arizona, Delaware, Idaho, North Dakota (1/2), Rhode Island <strong>Sometimes:</strong> Colorado (1/2), Connecticut, Kansas, Maine, Oregon <strong>Rarely/Never:</strong> Colorado (1/2), Indiana, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (1/2)</td>
</tr>
<tr>
<td>Spreader/sprayer controller failure</td>
<td><strong>Sometimes:</strong> Colorado (2/2), Delaware, Idaho, Kansas, Maine, North Dakota (1/2), Oregon, Rhode Island, West Virginia <strong>Rarely/Never:</strong> Arizona, Indiana, Massachusetts, Missouri, North Dakota (1/2), Pennsylvania, Texas, Utah, Vermont, Washington (2/2)</td>
</tr>
<tr>
<td>Equipment Problem</td>
<td>State and Problem Frequency</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>Warning lights/gauge problem</td>
<td><strong>Sometimes:</strong> Arizona, Colorado (2/2), Michigan, Minnesota, Missouri, Rhode Island, Utah, Washington (1/2), West Virginia</td>
</tr>
<tr>
<td></td>
<td><strong>Rarely/Never:</strong> Connecticut, Delaware, Idaho, Indiana, Kansas, Massachusetts, North Dakota (2/2), Texas, Vermont, Washington (1/2)</td>
</tr>
<tr>
<td>Electrical/wiring problem (corrosion, etc.)</td>
<td><strong>Frequently:</strong> Arizona, Colorado (1/2), Idaho, Kansas, Michigan, North Dakota (2/2), Rhode Island, West Virginia <strong>Sometimes:</strong> Colorado (1/2), Connecticut, Delaware, Indiana, Maine, Massachusetts, Minnesota, Missouri, Oregon, Pennsylvania, Texas, Utah, Washington (2/2), Rarely/Never: Vermont</td>
</tr>
<tr>
<td>Headlight, taillight, other light failure</td>
<td><strong>Frequently:</strong> Arizona, Colorado (1/2) <strong>Sometimes:</strong> Colorado (1/2), Idaho, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, North Dakota (1/2), Oregon, Rhode Island, Utah, Vermont, Washington (1/2), West Virginia <strong>Rarely/Never:</strong> Connecticut, Delaware, Maine, North Dakota (1/2), Pennsylvania, Texas, Washington (1/2)</td>
</tr>
<tr>
<td>HVAC system, wipers, other peripheral failure</td>
<td><strong>Frequently:</strong> Connecticut, North Dakota (1/2) <strong>Sometimes:</strong> Arizona, Colorado (2/2), Delaware, Idaho, Kansas, Minnesota, North Dakota (1/2), Oregon, Pennsylvania, Rhode Island, Vermont, Washington (2/2) <strong>Rarely/Never:</strong> Indiana, Maine, Massachusetts, Michigan, Missouri, Texas, Utah, West Virginia</td>
</tr>
<tr>
<td>Sensor failure</td>
<td><strong>Frequently:</strong> Rhode Island, Washington (1/2) <strong>Sometimes:</strong> Colorado (1/2), Delaware, Idaho, Kansas, Maine, Minnesota, North Dakota (2/2), Pennsylvania, Washington (1/2), West Virginia <strong>Rarely/Never:</strong> Colorado (1/2), Connecticut, Indiana, Massachusetts, Michigan, Missouri, Texas, Vermont</td>
</tr>
<tr>
<td>AVL system failure</td>
<td><strong>Sometimes:</strong> Colorado (1/2), Maine, Rhode Island, Vermont, Washington (1/2) <strong>Rarely/Never:</strong> Arizona, Colorado (1/2), Delaware, Idaho, Massachusetts, Michigan, Minnesota, Missouri, Oregon, Pennsylvania, Texas, Utah, Washington (1/2)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Equipment Problem</th>
<th>State and Problem Frequency</th>
</tr>
</thead>
</table>
| 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)  |
<table>
<thead>
<tr>
<th>Equipment Problem</th>
<th>State and Problem Frequency</th>
</tr>
</thead>
</table>
| 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)                                                               |
| 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.
### 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.
<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado (1/2)</td>
<td>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.</td>
</tr>
</tbody>
</table>
| Illinois (6/15) | 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) | 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>
<thead>
<tr>
<th>State</th>
<th>Problem Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado (2/2)</td>
<td>Basic problems: fix flat tires, tighten loose nuts and bolts; check, clean, reconnect electrical cables, tighten fluid and air connections, replace bulbs.</td>
</tr>
<tr>
<td>Connecticut</td>
<td>Want operator to give an idea of what has gone wrong: simple and accurate information.</td>
</tr>
<tr>
<td>Delaware</td>
<td>Basic issues: tighten loose cables, hydraulic lines; reset power cycle for ground speed control systems.</td>
</tr>
<tr>
<td>Idaho</td>
<td>Want operator to be able to assist in the troubleshooting to allow for a good decision about what to do.</td>
</tr>
<tr>
<td>Illinois (11/15)</td>
<td>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.</td>
</tr>
<tr>
<td>Indiana</td>
<td>Common issues that are part of a pre-trip inspection. If they are able, they are expected to try.</td>
</tr>
<tr>
<td>Kansas</td>
<td>Basic things: check fuses/circuit breakers, hydraulic fluid levels, check quick couplers for good connections.</td>
</tr>
<tr>
<td>Michigan</td>
<td>Very simple repairs, e.g., salt clogs in delivery system. Most repairs are sent to MDOT mechanic.</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Repair/replace plow cutting edges and wing plow shear pins.</td>
</tr>
<tr>
<td>North Dakota (2/2)</td>
<td>Minor problems: shear bolts, pins, hoses, chains.</td>
</tr>
</tbody>
</table>

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

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>
<thead>
<tr>
<th>Qualifications</th>
<th>State</th>
<th>Number of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commercial driver’s license (CDL)</strong></td>
<td>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</td>
<td>41</td>
</tr>
<tr>
<td><strong>Completion of snowplow operator training course</strong></td>
<td>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)</td>
<td>32</td>
</tr>
<tr>
<td><strong>Previous snowplow driving experience</strong></td>
<td>Connecticut, Illinois (2/15), Massachusetts, North Dakota (1/2), South Dakota (2/4), Vermont</td>
<td>8</td>
</tr>
<tr>
<td><strong>Previous experience driving large vehicles</strong></td>
<td>Connecticut, Idaho, Illinois (5/15), Massachusetts, North Dakota (1/2), South Dakota (2/4), Texas, Vermont, West Virginia</td>
<td>14</td>
</tr>
<tr>
<td><strong>Ability to troubleshoot and diagnose equipment problems</strong></td>
<td>Illinois (2/15), Indiana, South Dakota (1/4)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Knowledge of spreader application systems</strong></td>
<td>Colorado (1/2), Connecticut, Illinois (4/15), Indiana, Massachusetts, Minnesota, Missouri, South Dakota (2/4), Vermont, Washington (1/2),</td>
<td>13</td>
</tr>
</tbody>
</table>

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)**
- 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)**
- Operators get a training day on snowplowing techniques along with spreader knowledge; also on-the-job training with veteran operators.
• 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)

• 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

<table>
<thead>
<tr>
<th>Training Method</th>
<th>State</th>
</tr>
</thead>
</table>
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  
| **Vendor/manufacturer training**       | Operator: Connecticut, Illinois (8/15), Massachusetts, Rhode Island, South Dakota (2/4), Vermont, Washington (1/2), West Virginia  
| **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  

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.
<table>
<thead>
<tr>
<th>State</th>
<th>Training Details</th>
</tr>
</thead>
</table>
| Colorado (2/2) | • 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)| • 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.  
| 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       | • 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      | • 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)| • Force America training on controllers.  
                              • Very limited in availability.                                                                                                                 |
| Oregon         | • 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   | • 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)| • 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/manufacturer training. Figure 2.4 graphically illustrates survey responses. (See Table 2.8 for a full description of each training method response option.)

Table 2.8 provides specific agency responses.

<table>
<thead>
<tr>
<th>Training Method</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-time only training</td>
<td>Connecticut, Illinois (3/15), Indiana, Michigan, North Dakota (1/2)</td>
</tr>
<tr>
<td>Training Method</td>
<td>State</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Vendor/manufacturer training</td>
<td>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</td>
</tr>
<tr>
<td>Equipment Management Technical Services Program (EMTSP) via AASHTO</td>
<td>Massachusetts, Pennsylvania, South Dakota (1/4)</td>
</tr>
<tr>
<td>Technical institute training</td>
<td>Arizona, Illinois (1/15), Minnesota, Rhode Island, Texas, Vermont</td>
</tr>
<tr>
<td>LTAP training</td>
<td>Indiana, Minnesota, North Dakota (1/2), South Dakota (1/4), Vermont</td>
</tr>
<tr>
<td>Other online training</td>
<td>Idaho, Illinois (2/15), Kansas, Minnesota, Oregon, Pennsylvania, Vermont, West Virginia</td>
</tr>
</tbody>
</table>

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)**
- 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.
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>
<thead>
<tr>
<th>Training Needed</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troubleshoot equipment failures on the road</td>
<td>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)</td>
</tr>
<tr>
<td>Spreader calibration</td>
<td>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</td>
</tr>
<tr>
<td>Clear spreader blockages</td>
<td>Colorado (1/2), Illinois (10/15), Michigan, North Dakota (1/2), Pennsylvania, Rhode Island, South Dakota (1/4), Texas, Vermont</td>
</tr>
<tr>
<td>Electrical problems</td>
<td>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</td>
</tr>
</tbody>
</table>
Nine respondents offered comments concerning additional training for operators. Comments have been edited for clarity.

<table>
<thead>
<tr>
<th>State</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Colorado     | • 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 training 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) | • 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) | • 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.)
Table 2.10 provides specific agency responses. Comments about additional training for mechanics follow the table.

### Table 2.10 Additional Training Needed for Mechanics

<table>
<thead>
<tr>
<th>Training Topic</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troubleshoot equipment problems on road and in garage</td>
<td>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</td>
</tr>
<tr>
<td>Engine repair</td>
<td>Colorado (1/2), Idaho, Illinois (10/15), Kansas, Maine, Michigan, North Dakota (2/2), Rhode Island, South Dakota (1/4)</td>
</tr>
<tr>
<td>Spreader auger/conveyor adjust and repair</td>
<td>Colorado (1/2), Connecticut, Delaware, Idaho, Illinois (5/15), Maine, Massachusetts, Missouri, North Dakota (1/2), Oregon, South Dakota (1/4), Texas, Vermont</td>
</tr>
<tr>
<td>Routine maintenance of all systems</td>
<td>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</td>
</tr>
</tbody>
</table>

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)

- 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

<table>
<thead>
<tr>
<th>Agency Change</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding full-time mechanics dedicated to winter maintenance equipment</td>
<td>Colorado (1/2), Connecticut, Idaho, Illinois (5/15), Massachusetts, Michigan, North Dakota (1/2), Rhode Island, South Dakota (1/4)</td>
</tr>
<tr>
<td>Troubleshooting and minor repair training for operators</td>
<td>Colorado (1/2), Connecticut, Delaware, Idaho, Illinois (5/15), Kansas, Maine, Michigan, Missouri, North Dakota (2/2), Rhode Island, South Dakota (1/4), Utah</td>
</tr>
<tr>
<td>Better corrosion prevention emphasis/training</td>
<td>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</td>
</tr>
</tbody>
</table>
Twelve respondents offered further comments on this question. Comments below are edited for clarity.

**Colorado (2/2)**
- 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)**
- 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)**
- 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**

<table>
<thead>
<tr>
<th>Possible Roadblocks</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operators are temporary, hired for season</td>
<td>Colorado (2/2), Illinois (6/15), Massachusetts, Oregon, Pennsylvania, South Dakota (1/4), Washington (2/2)</td>
</tr>
<tr>
<td>Operators would find better jobs if trained</td>
<td>Missouri, South Dakota (2/4)</td>
</tr>
<tr>
<td>Equipment is too complex to address with basic training</td>
<td>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</td>
</tr>
<tr>
<td>Winter mechanic is too costly for agency</td>
<td>Colorado (1/2), Illinois (1/15), Massachusetts, South Dakota (2/4), Texas, Washington (2/2)</td>
</tr>
</tbody>
</table>

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/recognition 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.
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


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.

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  

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/maintrainacademy.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

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.necaaee.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 using 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.